S U M M A R Y R E P O R T

RADIOLOGICAL EVALUATION
OF
GRAND CANYON UNIFIED SCHOOL DISTRICT
ATHLETIC FIELD

GRAND CANYON,
ARIZONA

Prepared for the

National Park Service

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List of Acronyms

µR/h	microRoentgens per hour
ASTM	American Society for Testing and Materials
cm	centimeter
CSM	Conceptual Site Model
DQOs	Data Quality Objectives
EPA	Environmental Protection Agency
Ref.	Numbered Reference
ft	feet
GCHS	Grand Canyon High School
GPS	Global Positioning System
HHRE	Human Health Risk Evaluation
ID	Identification
m	meter
MCG	MCG Geotechnical Engineering Inc.
mR/yr	milliRoentgens per year
NAD	North American Datum
NPS	National Park Service
pCi/g	picoCuries per gram
PVC	Polyvinylchloride
TAL	Target Analyte List
URS	URS Corporation
UTM	Universal Transverse Mercator

Section 1 Executive Summary

The National Park Service (NPS) recently completed a comprehensive radiological investigation of the athletic fields at the Grand Canyon High School (GCHS), located in Grand Canyon National Park, Arizona. This investigation was conducted in order to address the sporadic but recurring concerns expressed by members of the public over the years related to the possibility of elevated radiation levels existing at the fields associated with uranium-bearing waste rock from various uranium mines in the area reputedly having been used as fill for field construction.

The investigation had two components: a gamma-radiation survey and soils study (to measure radium-226). Both of these studies were conducted in July 2008 in accordance with the *Final Work Plan Radiological Evaluation of Grand Canyon Unified School District Athletic Field* (*Appendix A of Attachment 1*) (*Ref. 1*) (hereinafter "Work Plan"). The primary goals of the investigation were as follows:

- Determine whether uranium-bearing waste rock is present in the material used to construct the athletic fields, by making statistically supportable decisions regarding the likely presence or absence of uranium-bearing waste rock, and;
- If uranium-bearing waste rock is present in the athletic field soil, then to identify and evaluate associated health risks with adequate confidence to make statistically defensible decisions.

Investigation activities were focused on the soil interval from 0.0-0.6 meters (2 feet) below the ground surface. For the gamma-radiation survey, a total of 28,848 measurements were collected (using a gamma-ray scintillation detector), more than sufficient to allow a reliable statistical comparison between gamma radiation levels in the athletic field areas and gamma radiation levels in the background area (an area chosen to represent typical local conditions). For the soils study, soil from 200 locations was collected and analyzed, again more than sufficient to allow a statistically reliable comparison between the mean concentrations of radium-226 in the soils of each athletic field area and the mean concentration of radium-226 in the soils of the background area.

The following conclusions have been made from this investigation:

1. Radiological activity levels (as measured by gamma radiation and estimated mean concentration of radium-226) of soils present in the upper 0.6 m of the athletic field areas are not distinguishable from radiological activity levels of soils present in the background area, and both athletic field and background levels are typical of the Grand Canyon region as a whole.

2. There is no indication (and it is, therefore, very unlikely) that uranium-bearing waste rock is present in the soils underlying the athletic field areas.

3. Since no uranium-bearing waste rock is present at the site, there is no discernible health risk from radiological exposure for persons who use the athletic fields or for workers involved in subsurface maintenance activities on the athletic fields.

Section 2 Introduction

The National Park Service (NPS) recently completed a comprehensive radiological evaluation of the athletic fields at the Grand Canyon High School (GCHS), located in Grand Canyon National Park, Arizona (See Figure 1). This investigation was conducted in order to address the sporadic but recurring concerns expressed by members of the public over the years related to the possibility of elevated radiation levels existing at the fields associated with uranium-bearing waste rock from various uranium mines in the area reputedly having been used as fill for field construction. The primary goals for the investigation were to:

- Determine whether radiological contamination associated with uranium-bearing waste rock is present in soils underlying the athletic fields; and
- Evaluate human health risk if it is concluded that such waste rock is present.

As set forth and explained in this report, the data generated by this investigation revealed no indication (and it is, therefore, very unlikely) that uranium-bearing waste rock is present in the soils underlying the athletic fields. Since uranium-bearing waste rock was not discovered in the field soils, there is no need to proceed to an analysis of human health risk associated with use of the fields.

Site characterization activities were conducted by URS Corporation (URS) from July 24 to July 28, 2008. With some minor deviations, the investigation was conducted in accordance with the Work Plan. The investigation included both a gamma-radiation survey and soil characterization of the athletic field areas and representative background area. This report summarizes the logic, design and results of the radiological evaluation. The data files for the gamma-radiation survey and soil characterization data, as well as details about the data collection process, are contained in Attachment A – *Radiological Characterization of the Grand Canyon High School Athletic Field* (Characterization Report). Portions of the Characterization Report are used herein without additional reference.

A comprehensive characterization of the athletic field areas included gamma-radiation measurements at 28,848 surface locations and radium-226 concentration measurements utilizing soil from 200 locations (combined to create composite samples representing the 0.0-0.6 m soil interval). The large number of locations represented in this investigation reasonably assures that the presence of uranium-bearing waste rock would be discovered if it had been used as a construction material and was present in the upper 0.6 m (2 ft) of the athletic fields. The observed similarity of results between measurements in the athletic field areas and background area provides a high degree of confidence in concluding that it is very unlikely that uranium-bearing waste rock is present in the material used to construct the athletic fields.

Section 3 Area of Investigation

Grand Canyon High School and its athletic fields are located within the Grand Canyon National Park at 1 Boulder Street, Grand Canyon, Arizona (Figure 1).

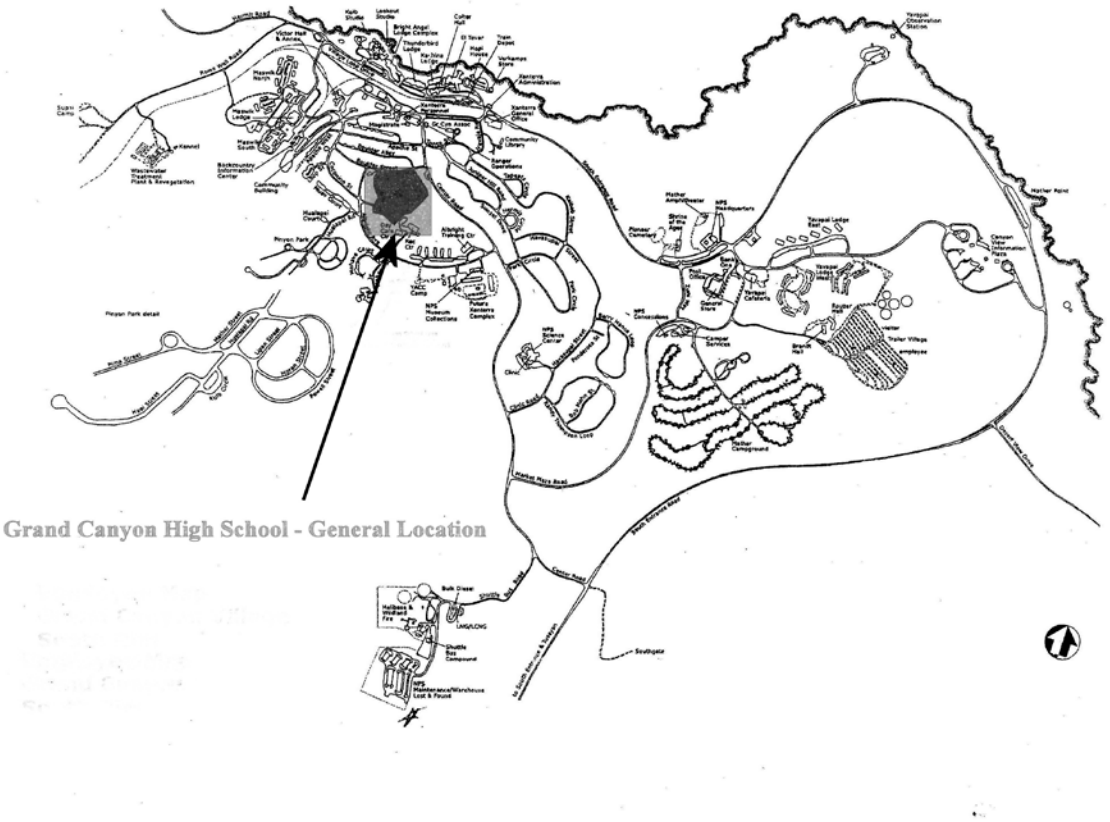

Figure 1. Location Map of Grand Canyon High School

The investigation area (shown in Figure 2 as the Track/Field Area and the Baseball/Soccer Field Area) encompasses the athletic fields as well as adjacent slopes composed of soil and rock fill. It also includes the playground area at the north end of the Track/Field Area. The Track/Field Area encompasses approximately 3.6 acres and the Baseball/Soccer Field Area encompasses approximately 2.7 acres. Both areas are located southeast of the main school building. Areas obstructed by buildings and paved areas such as the basketball court, although included within the investigation area, were not included in the soil characterization. Gamma radiation measurements were taken in paved areas but not in buildings, which cover a relatively insignificant portion of the site.

Two background areas were also part of this investigation. Field radiological measurements and soil samples collected from the background areas are used to represent typical local soil conditions for comparison to the athletic fields' measured conditions. The East Background area is comprised of undeveloped NPS land to the east of the

Baseball/Soccer Field Area, and the West Background Area is comprised of the parking lot on school property west of the Track/Field Area.

Soil samples were taken from the surface to a depth of 0.6 m (2 feet); however, deeper fill is represented by the adjacent slopes and was inherently included. Thus, measurements on fill slopes provide insight regarding the nature of deeper fill material. Slopes cut in native ground were not included in the investigation area, since such locations would involve no fill material.

Figure 2. Athletic Field and Background Areas

Section 4 Project Objectives

A data quality objective (DQO) process was used to establish performance and acceptance criteria which served as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the investigation. The approach followed U.S. Environmental Protection Agency's (EPA) *Guidance on Systematic Planning Using the Data Quality Objectives Process (Ref. 2).*

The DQO process is detailed in the Work Plan and established the following two problem statements:

- Determine if uranium-bearing waste rock is present in the material used to construct the athletic fields; and
- If uranium-bearing waste rock is present in the athletic field soil, then identify associated health risks, if any.

To acquire the necessary information to address the problem statements, the objectives and goals of this investigation were established to:

- Make a statistically supportable decision regarding the presence or absence of uranium-bearing waste rock. In other words, avoid erroneously concluding that uranium-bearing waste rock is absent when in fact uranium-bearing waste rock is present in enough abundance to cause an unacceptable health risk, and at the same time, limit the risk of erroneously concluding that uranium-bearing waste rock is present.
- In the event the conclusion is made that uranium-bearing waste rock is present, evaluate the associated human health risk with adequate confidence to make defensible decisions.

Section 5 Investigation Design

The first question to be answered in this investigation is whether uranium-bearing waste rock is present in the materials underlying the athletic fields. This section of the report explains how the investigation was designed to address this question. The second issue, whether the presence of uranium-bearing waste rock at the field creates a human health risk, was only to be addressed in this investigation if the presence of waste rock was affirmed. Since the absence of waste rock was affirmed, there was no basis for conducting a risk evaluation. Consequently, the design of that evaluation is not detailed in this report.

The Work Plan determined that decisions pertaining to the presence or absence of uranium-bearing waste rock would be made independently for the Track/Field and

Baseball/Soccer Field areas. Measurements must be adequate in type, quantity, and quality to support these decisions and, if necessary, risk evaluation. The type, quantity and quality of data inputs necessary to develop well-grounded conclusions in this investigation are detailed in the Work Plan. Representation of areas using mean concentrations and measurements is appropriate for these purposes.

The Work Plan also determined that the investigation would be restricted to characterizing areas to a depth of 0.6 m (2 ft) because significant human exposure to soil or fill located below the depth of 0.6 m is considered very unlikely given the current use of the athletic fields. In addition, measurements on fill slopes provide insight regarding the nature of deeper fill material.

This investigation required the following three data collection components:

- Gamma radiation measurements made in the Track/Field, Baseball/Soccer Field, and Background areas.
- Radium-226 measurements from surface soil samples (0.0-0.15 m) representing the Track/Field, Baseball/Soccer Field, and Background areas.
- Radium-226 measurements from combined depth (surface and subsurface) soil samples (0.0-0.6 m) representing the Track/Field, Baseball/Soccer Field, and Background areas.

5.1 Radium-226: Key Identifier

The primary objective of the investigation is to identify the presence (or absence) of uranium-bearing waste rock underlying the athletic fields. As detailed in the Work Plan, radium-226 is produced during uranium-238 decay and provides a strong, abundant gamma–ray source; for these reasons it is the primary focus radionuclide used herein to identify the presence of uranium-bearing waste rock. This investigation utilized two independent methods for identifying the presence of radium-226 at the athletic fields – the soil characterization and the gamma-radiation survey.

The soil characterization was designed to directly identify the presence of radium-226 in the soil. The presence of radium-226 in athletic field soil at a concentration greater than found in background soil would indicate the presence of an unusually high abundance of uranium-238 in the soil and suggest the potential presence of uranium-bearing waste rock.

The gamma-radiation survey is an indirect method of identifying the presence of radium-226 in that the gamma-ray readings reflect the total gamma exposure rate, which includes both cosmic and terrestrial components. It is natural for cosmic and terrestrial gamma radiation levels to vary considerably as a result of variances in elevation, surface materials, and concentrations of naturally occurring radionuclides in the soil (only one of which is radium-226). Consequently, if the average gamma radiation survey readings for the athletic field areas were to be above the average reading in the background area, it would be an indication that uranium-238 in uranium-bearing waste rock <u>may</u> be present;

inversely, if the average athletic field survey readings are not above the average reading in the background area, the comprehensiveness of the survey would support the conclusion that it is very unlikely uranium-238 in uranium-bearing waste rock is present.

5.2 Analytical Framework

The Work Plan determined that conclusions pertaining to the presence or absence of uranium-bearing waste rock would be made independently for the Track/Field and Baseball/Soccer areas and would be based on:

- A comparison of estimated mean gamma count-rate in each athletic field area to a similar determination for the Background area.
- A comparison of the estimated mean subsurface radium-226 concentration in each athletic field area to a similar determination for the Background area.

Mean concentrations are compared rather than individual location measurements for the following reason. People are exposed to gamma radiation and its source materials at all times and locations and the adverse effects of radiation increase as exposure accumulates. The accumulated exposure can be calculated as the product of the average rate of exposure and the time of exposure. The average rate of exposure to gamma radiation for persons that frequent the athletic fields can be represented by the athletic field surface mean gamma radiation dose rate (proportional to count-rate). Likewise the product of the athletic field mean radium-226 concentration and the frequency at which a person encounters athletic field soil can represent the average rate of exposure to uranium in the soil. Consequently, estimates of the athletic field mean concentrations are expected to be useful and appropriate representations for use in evaluating risk and for risk based decision-making.

It is known that uranium-bearing waste rock is many times more radioactive than background. Therefore it is expected that if uranium-bearing waste rock had been used in field construction, either the mean gamma radiation dose rate and/or the mean radium-226 concentration would exceed twice the mean background values.

The following statements specify how conclusions are made using the data acquired in this investigation:

- It will be concluded that uranium-bearing waste rock is present on the Track/Field or Baseball/Soccer Field areas only if the mean radium-226 concentration in either the surface or subsurface soils in those areas is greater than twice the mean background concentration.
- Inversely, it will be concluded that uranium-bearing waste rock is not present on the Track/Field or Baseball/Soccer Field areas if mean radium-226 concentration in either the surface or subsurface soils in those areas is less than, or equal to, twice the mean background concentration.

- If it is concluded that uranium-bearing waste rock is present in either the surface or subsurface soils in either the Track/Field or Baseball/Soccer Field areas, a risk evaluation will ensue for that area.

The statistical performance criterion for establishing sufficient certainty regarding above conclusions is presented in the Work Plan. In summary, the Work Plan requires a minimum of 3000 gamma measurements in the Track/Field Area, and likewise 3000 gamma measurements in the Baseball/Soccer Field Area. The plan also requires seventy-five locations in each area be used to represent subsurface soils.

The Work Plan provides for a staged program designed to expand in scope depending on the outcome of initial surface gamma radiation count-rate measurements and/or soil radium-226 concentration measurements. If the measurement averages of either the Track/Field Area or the Baseball/Soccer Field Area exceed twice the background average, additional soil samples would be collected and/or analyzed. If the presence of radium-226 were confirmed, then more extensive laboratory tests and risk evaluation would ensue. Expansion of the program was not necessitated because average area measurements for both radium-226 and gamma radiation were approximately equal to background average levels, as discussed in Section 6.

Section 6 Characterization Summary

The athletic field characterization process is detailed in the Work Plan and was implemented with only minor adjustments. The data collected are presented in the Characterization Report (Attachment A). A brief summary follows below.

6.1 Gamma Radiation

Gamma radiation survey measurements were collected by walking traverses across the athletic field areas and background areas with a gamma-ray scintillation detector. This created high-density coverage consisting of 28,848 measurements sufficient to allow a statistically robust comparison between gamma radiation in the athletic field areas and gamma radiation in the background areas. The individual measurements in both of the athletic field areas were indistinguishable from background measurements and thus indicated no elevated gamma radiation. The estimated mean gamma radiation emissions in the Track/Field, Baseball/Soccer Field and the Background areas are 12.6 µR/h, 11.6 µR/h, and 14.0 µR/h, respectively.

The estimated mean for all three areas are very similar and in the range reasonably expected for background. For example, it has been estimated that the sum of cosmic and terrestrial radiation for a location at an elevation of 7000 ft (2130 m) above sea level is expected to be about 102 mR/year, which is equivalent to about 11.6 µR/h. (*Ref. 3*). It is evident that the estimated means of both athletic field areas (12.6 µR/h and 11.6 µR/h) are less than twice the estimated mean of the Background area (2 x 14 µR/h = 28 µR/h).

Furthermore, it can be statistically inferred that rarely would the calculated estimates of means for the Track/Field and Baseball/Soccer Field areas be as low as 12.6 µR/h and 11.6 µR/h if the true mean measurement for either area were 28 µR/h.

Hundreds of the above-mentioned 28,848 gamma radiation measurements were made on fill slopes located around the perimeter of the athletic fields. The material forming these slopes is representative of fill material used at depths greater than 0.6 m throughout the athletic fields. The gamma radiation measurements at these locations are indistinguishable from those at other locations in the athletic fields and Background area.

The large number of gamma radiation measurement locations represented in this investigation reasonably assures that the presence of uranium-bearing waste rock would be discovered if it had been used as a construction material and present in the upper 0.15 m of the athletic fields. Hundreds of gamma radiation measurements on slopes representing deeper fill provides added assurance that the presence of uranium-bearing waste rock would be discovered if it had been used as a construction material and present in deeper fill.

6.2 Radium-226

The comprehensive characterization of the athletic field areas included radium-226 concentration measurements for soil collected from 200 locations representing the 0.0 to 0.6 m depth interval of both athletic field areas and the Background areas. Nine composite soil samples were formed utilizing soil collected from the 200 locations. These were processed and analyzed to evaluate and compare the average radium-226 levels in the Background areas soil samples with those from the Track/Field and Baseball/Soccer Field areas. The inclusion of soil from numerous locations within each area allows a statistically robust comparison.

The estimated mean radium-226 concentration in the Track/Field, Baseball/Soccer Field and the Background areas are 1.1 pCi/g, 0.8 pCi/g, and 1.0 pCi/g, respectively. As with the gamma radiation measurements, the investigation of subsurface soils indicated no elevated concentrations of radium-226 in either athletic field area. Again, it is evident that the estimated means of both athletic field areas (1.1 pCi/g and 0.8 pCi/g) are less than twice the estimated mean of the Background areas (2 x 1.0 pCi/g = 2.0 pCi/g). The estimated mean for all three areas are very similar and in the range reasonably expected for background. For example, these soil analytical radium-226 concentrations are within the range of Arizona regional background as prepared by Dragun and Chekiri (*Ref. 4*).

The large number of radium-226 concentration measurement locations represented in this investigation reasonably assures that the presence of uranium-bearing waste rock would have been discovered if it had been used as a construction material and present in the upper 0.6 m of the athletic fields.

Section 7 Investigation Results and Analysis

A dataset representing radiological conditions at the athletic fields was acquired to support statistically-based decisions. This dataset consists of gamma radiation and soil radium-226 concentration measurements. The gamma radiation survey generated 28,848 measurements, sufficient to allow a statistically robust comparison of gamma radiation in each of the athletic field areas with gamma radiation in the background area. Composite soil samples representing the 0.0-0.6 m soil interval at 200 locations supported the comparison of the mean concentration of radium-226 in soil in each of the athletic field areas with the mean soil concentration of radium-226 in the background area soil.

The athletic field radiological characterization results are summarized below:

- The estimated mean gamma radiation levels in the Track/Field and Baseball/Soccer Field areas were not elevated above the estimated mean gamma radiation level in the Background area.

- The estimated mean concentrations of radium-226 in the Track/Field and Baseball/Soccer Field areas were not elevated above the estimated mean concentration of radium-226 in the Background area.

- There were no significantly elevated individual measurements of gamma radiation or radium-226 in the athletic field areas.

- There were no significantly elevated individual measurements of gamma radiation on slopes that represent fill materials used at depths greater than 0.6 m throughout the athletic field areas.

- Gamma radiation measurements and radium-226 concentrations were in the range expected for background values.

Project goals and objectives have been achieved and the following conclusions have been made:

- Radiological activity levels (as measured by gamma radiation and estimated mean concentrations of radium-226) of soils present in the upper 0.6 m of the athletic field areas are not distinguishable from radiological activity levels of soils present in the background areas, and the levels in both athletic field areas and the background area are typical of the Grand Canyon region as a whole.

- There is no indication (and it is, therefore, very unlikely) that uranium-bearing waste rock is present in the soils underlying the athletic fields.
- Because there is no discernible difference in radiological activity levels between the athletic field areas and background, the health risk from radiological exposure for persons who use the athletic fields or for workers involved in subsurface

maintenance activities on the athletic fields is no greater than health risk from background radiological exposure.

Section 8 Numbered References

1. National Park Service (NPS) 2008. *Final Work Plan Radiological Evaluation of Grand Canyon Unified School District Athletic Field Work Plan.* July.

2. U.S. Environmental Protection Agency (EPA). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process.* EPA QA/-4, Office of Environmental Information, Washington, EPA/240/B-06/001. February.

3. American Nuclear Society, La Grange Park, IL 60526, http://www.ans.org/pi/resources/dosechart/

4. Dragun, J. and K. Chekiri. 2005. *Elements in North American Soils*. Second Edition. Amherst Scientific Publishers, Amherst, MA. 274 pp.