

# RADIOLOGICAL SURVEY OF OBSERVATORY AT MOD WOOLWICH STATION FOR SWECO

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APRIL 2023




OFFICIAL



Aurora Health Physics Services Ltd, 3 The Terrace,  
Library Avenue, Harwell Oxford, Oxfordshire OX11 0SG.

<b>Report Title:</b>	<b>Radiological Survey of Observatory at MoD Woolwich Station London for Sweco</b>
Client Contact:	Zoe Miller, Technical Manager
Client Address:	Sweco Grove House, Mansion Gate Dr, Leeds LS7 4DN
Date of Survey:	22 September 2022
Reference:	AHP/SWE/REP/22/03
Please Contact:	Jon Taylor
Telephone:	01235 820049
Mobile:	07917 804477
Email:	jon.taylor@aurorahp.co.uk

Issue	Date	Comments
Issue 1	14 October 2022	Issued to Client
Issue 2	9 November 2022	Incorporating client comments
Issue 3	6 April 2023	Incorporates intrusive investigation results

	Name	Position	Date	Signature
Author:	Jon Taylor	Radiation Protection Adviser and Radioactive Waste Adviser (RWA)	13/10/2022	
Reviewer:	Joel Garner	RPA	14/10/2022	
Approver:	Glenn Hardcastle	RPA, RWA & Director	14/10/2022	

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## Executive Summary

Aurora Health Physics Services Limited was contracted by Sweco to carry out a radiological survey of an area of land at the MoD Woolwich Station which contains the Observatory. Radium-226 had been historically used for luminising activities on the wider MoD Woolwich site.

The radiation walkover survey of the site identified two discrete areas with elevated levels of gamma radiation detectable at the surface, a subsequent intrusive survey confirmed the elevated readings were due to naturally occurring radioactivity in clinker used as pathway infill material.

The environmental dose rate survey confirmed that radiation dose rates across the site were generally consistent with normal background dose rates expected within the UK.

No further actions with regard to radioactivity are recommended for the Observatory site.

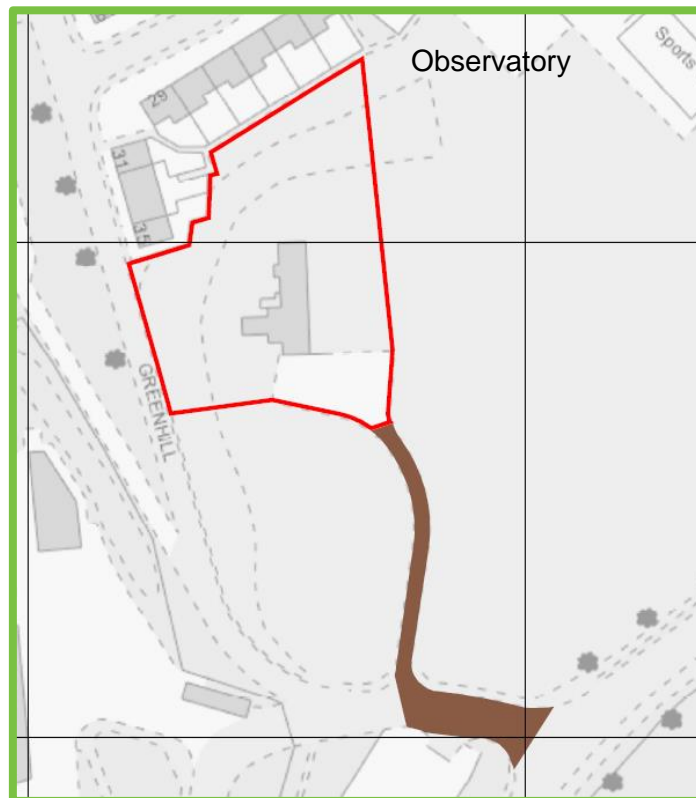
# 1 Introduction

Aurora Health Physics Services Limited (Aurora) was contracted by Sweco to provide a radiological survey of the Observatory area at MoD Woolwich Station, Repository Road, London SE18 4BB. The MoD Woolwich site was previously surveyed by Aurora (ref. 1) but this did not include a survey of the interior of the buildings.

The independent radiological support provided by Aurora to Sweco consisted of:

- a radiological walkover survey to identify gamma radiation levels across the site's outdoor areas;
- an environmental dose rate survey to identify gamma radiation dose rates on site; and
- a radiological survey inside buildings;

The radiological walkover survey covered an area of approximately 0.5 hectares. A plan showing the survey areas (within the red lines) is shown in Figure 1, which was provided to Aurora by Sweco in advance of the works.



**Figure 1. Survey area outlined within red line.**

## 2 Health Safety and Security

Copies of the following Aurora documents were provided to Sweco and were agreed and signed off prior to commencing work:

- Aurora Risk Assessment and Method Statement ARM Survey - AHP/SWE/RAMS/22/03.
- Aurora Project Pre-Commencement Questionnaire - AHP/SWE/PPQ/22/03.

## 3 Radiological Survey Results

### 3.1 Radiological Walkover Survey

Aurora carried out a gamma radiation walkover survey using the AuroraRadMap (ARM) system. Photographs taken during the survey are shown in Appendix A. Detailed information on the ARM system used during the survey and the survey methodology are provided in Appendix B. Using a Geographical Information System (GIS) the gathered data is displayed as a colour coded map. Interpolation was carried out on the data to provide a display of the radiation contours of the site as a colour coded surface picture.

A total of 17,061 data points were recorded using the ARM system. The recorded count rates ranged from 111 counts per second (cps) to 768 cps with an average of 232 cps.

Figures 2 and 3 show the results of the radiation walkover survey, presented as a colour coded map (high (red) and low (blue) radiation readings) with interpolated data showing the radiation levels. Gaps within the colour map are due to inaccessible terrain (e.g, trees).

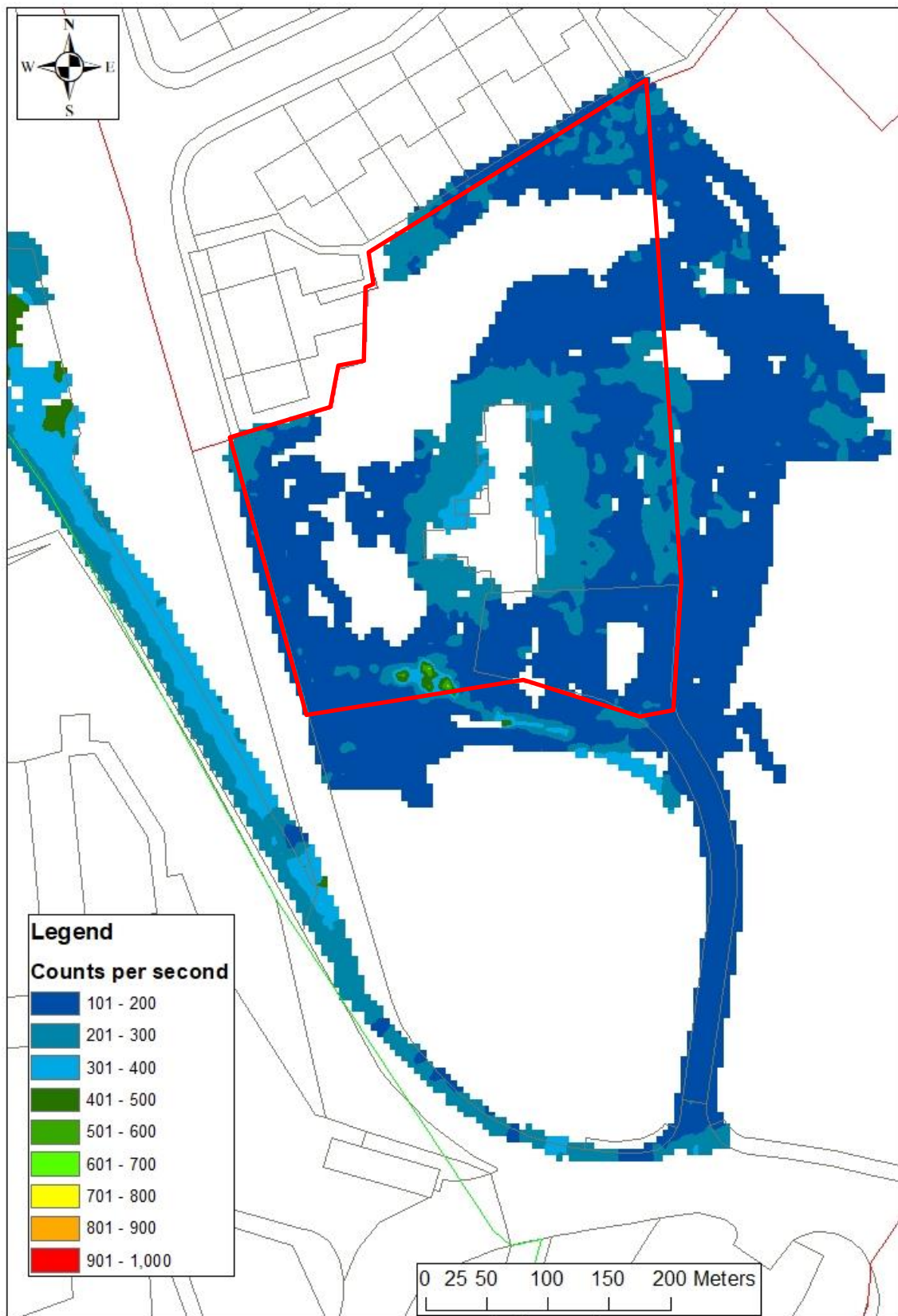
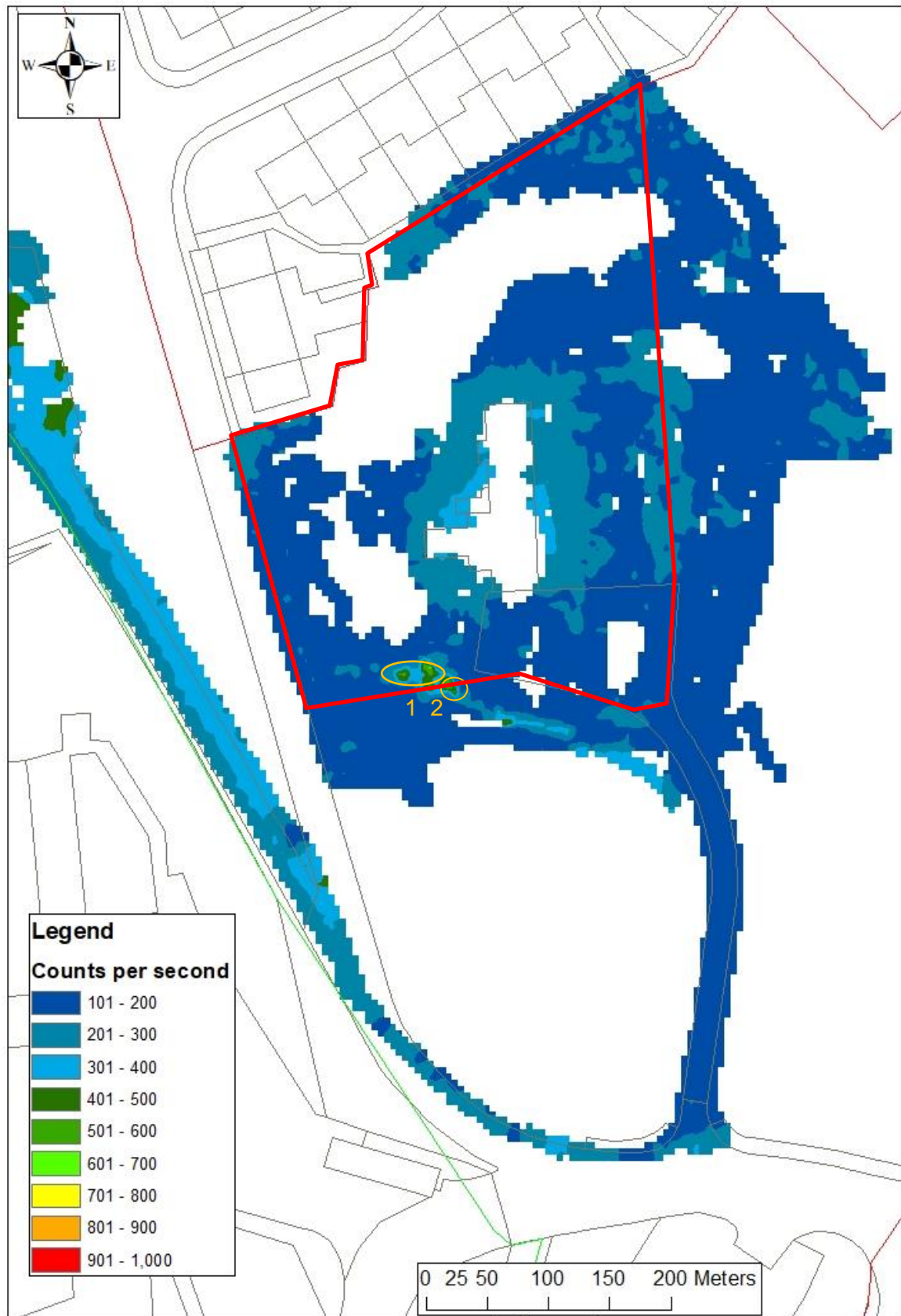


Figure 2. Radiation colour map of the Observatory survey area





**Figure 3. Radiation colour map with the two areas of elevated counts highlighted**



The radiation walkover survey identified elevated levels of surface gamma radiation at two discrete locations away from the path and therefore inconsistent with the surrounding background levels. Table 1 below provides detail on the GPS location and highest reading of each of the features of interest noted during the survey. The levels are not high compared to other levels found on the wider site (up to 9,000 cps), and spectral measurements were inconclusive showing Ra-226, Th-232 and K-40 which could indicate naturally occurring material rather than radium contamination. The intrusive investigation confirmed this was the case (see paragraph 3.6)

**Table 1. Location of areas of elevated radiation level on the site.**

ID	OSGB Grid Reference	Maximum radiation count rate, counts per second (cps) (approx. background = 200 cps)
1	TQ 42746 78068	700
2	TQ 42755 78061	500

There are some other areas on the site where count rate is elevated however it can be seen these are associated with brick features or brick buildings where naturally occurring radioactivity (such as from potassium K-40) accounts for the elevated radiation level. All organic materials contain some level of radioactivity. Naturally occurring radionuclides include the uranium (U-238 and U-235) and thorium (Th-232) decay chains commonly found in soils and rock and radioactive potassium (K-40) commonly found in wood, clay and brick. These background levels vary between different materials (e.g. rock and soil) and in different areas of the UK.

### 3.2 Environmental Dose Rate Measurements

In addition to the radiation walkover survey, Aurora also carried out environmental dose rate measurements at five locations across the site.

The measurements were taken using a Mini Instruments MC71 compensated Geiger-Müller detector connected to a 6-80 scaler/ratemeter which meets current best practice for environmental dose rate measurements<sup>1</sup> (see Figure A1 in Appendix A).

The environmental dose rate (air kerma) results can be seen below in Table 2. The dose rates in the vicinity of the identified features of interest were not significantly elevated above the background levels across the rest of the site.

**Table 2. Environmental dose rate readings.**

ID	OSGB Eastings	OSGB Northings	Counts in 300 secs	Dose rate ( $\mu\text{Sv/h}$ )
A*	542744	178067	676	0.13
B	542778	178059	447	0.10
C	542764	178097	447	0.10
D	542771	178132	438	0.10
E	542727	178083	421	0.10

\*near known area of elevated radiation level (see location ID 1 in Table 1)

The air kerma results at the measurement locations ranged from 0.10  $\mu\text{Gy/h}$  to 0.13  $\mu\text{Sv/h}$  with an average result of 0.10  $\mu\text{Sv/h}$ .

For comparison, in 2016 Public Health England published a review summarising typical exposure to ionising radiation for the UK population. This review found that the average annual dose uptake, from terrestrial gamma radiation and cosmic radiation, to a person in the UK was 0.68 mSv. This is equivalent to a dose rate of approximately 0.08  $\mu\text{Sv/h}$ .

The dose rates are therefore consistent with normal UK background and present no radiological hazard to persons on site.

### 3.3 Direct Monitoring in Buildings

Targeted radiological surveys for gamma radiation and alpha and beta contamination were carried out in the Observatory. A gamma survey was carried out using a sensitive sodium iodide detector (Georadis GT40). Contamination monitors were also used to survey items such as floors, walls and windows (see Appendix B for instrument details). No radiation above normal background readings was identified and no contamination was detected in any of the areas surveyed.

### 3.4 Indirect Monitoring in Buildings

Wipes (7 in total) were taken of floors, walls, window sills, safe and handrail. The wipes were analysed in a Packard Tricarb 2900 Liquid Scintillation Counter at Aurora's laboratory at Harwell. As well as being able to monitor areas that are inaccessible by handheld probes, this technique is also capable of detecting very low levels of loose radioactive contamination present on surfaces. In addition, the analysis technique used is capable of detecting low energy beta emitting materials that cannot be detected using handheld instruments (e.g. tritium and nickel-63).

No radioactive contamination was found on any of the samples analysed. The results are provided in full in Appendix C.

### 3.5 Active Radon Measurements

Sites with known radium contamination can have elevated levels of radon gas in buildings and it is important monitor such buildings to determine whether the radon concentration exceed the threshold identified in the Ionising Radiations Regulations 2017 (IRR17). A calibrated digital radon monitor (see Appendix B) was used to take radon measurements in the Observatory over a 24 hour period with the result provided in Table 3 below. The reading was below the threshold in IRR17 of 300 Bq/m<sup>3</sup>. It is important to consider seasonal variations in radon concentration when assessing the risk from radon. Radon concentrations will vary throughout the year due to changes in atmospheric conditions and the weather. A 2012 study of radon variation in homes found that seasonal variation of radon concentrations typically varies by up to around 30%. It is not considered reasonably foreseeable that the seasonal variation in radon could result in annual average radon concentrations in the Observatory exceeding 300 Bq/m<sup>3</sup> as this would represent over a 1000% increase over the measured radon level.

**Table 3. Digital Radon Measurements.**

Room	Radon result (Bq/m <sup>3</sup> )
Observatory (basement)	19

### 3.6 Intrusive Investigation

On 20 March 2023 a trial pit investigation at the locations of elevated readings (OSGB Grid references TQ 42746 78068 (trial pit HP-OB01) and TQ 42755 78061 (trial pit HP-OB02)) was carried out by Sweco and Aurora. A layer of clinker at shallow depth was shown to be the cause of the elevated radiation levels (see Figure A2 in Appendix A). Two samples were taken from each location (ie. 4 samples in total). Sample analysis by high resolution gamma spectroscopy revealed naturally occurring radionuclides only up to 0.3 Bq/g (see Appendix E). This material is not defined as radioactive in the Environmental Permitting Regulations (England and Wales) 2016.

## 4 Conclusions and Recommendations

A radiological survey has been conducted of the Observatory building and land at Woolwich Station, London. The survey comprised of a GPS registered radiation walkover survey using a sensitive sodium iodide detector as well as environmental dose rate measurements and direct and indirect surveys inside buildings.

The radiation walkover survey identified elevated levels of surface gamma radiation at two discrete locations. Intrusive investigations at these two locations have confirmed the elevated readings were caused by naturally occurring radioactivity in fill material.

The environmental dose rate survey confirmed that radiation dose rates across the site were generally consistent with normal background dose rates expected within the UK. No areas surveyed would require access restrictions for intrusive or non-intrusive works in relation to radiological contamination.

The buildings surveys found no evidence of radiological contamination.

No further actions with regard to radioactivity are recommended for the Observatory site.

## 5 References

1. Aurora Radiological Survey Report of MoD Woolwich Station AHP/SWE/REP/22/02 May 2022



## Appendix A Photographs



**Figure A1. Location of elevated readings near the Observatory**



**Figure A2. Trial pit investigations (trial pit HP-OB01)**

## Appendix B Monitoring equipment

Table B1. Instruments used for survey.

Instrument	Used for monitoring	Asset number	Instrument Test Due Date	Background reading on site
Exploranium GR-135	Gamma radiation	AHP0053	07/01/2023	50-100 cps
Automess 6150 AD2	Gamma dose rate	AHP0061	07/10/2022	0.1 $\mu$ Sv/hr
Thermo Electra Ratemeter with DP6	Alpha and beta contamination	AHP0086	21/07/2023	4 - 6 cps beta 0 cps alpha
Mini 680/MC71	Environmental gamma dose rate	AHP0122	28/02/2023	0.1 $\mu$ Sv/hr
GT-40L	Ground gamma radiation	AHP382	22/02/2023	150 - 300 cps
GT-40	Ground gamma radiation	AHP411	09/12/2022	150 - 300 cps
Radon gas monitor	Radon gas concentration	AHP414	12/08/2023	< 30 Bq/m <sup>3</sup>
Radon gas monitor	Radon gas concentration	AHP415	12/08/2023	< 30 Bq/m <sup>3</sup>



## Appendix C ARM Survey

**Table B1. Instruments used for survey.**

Instrument	Used for monitoring	Asset number	Instrument Test Due Date	Background reading on site
ARM 3" NaI GPS system	Gamma radiation	AHP382	22/02/2023	180 - 250 cps
ARM 3" NaI GPS system	Gamma radiation	AHP411	09/12/2022	180 - 250 cps

The radiation walkover survey was undertaken using the AuroraRadMap system (ARM). The ARM instrument consists of a sensitive gamma radiation detector linked to a Global Positioning System (GPS) enabling accurate gamma radiation contour mapping of the site. The survey either used two detectors set 1 m apart and attached to a trolley or a single detector was hand carried.

### ARM positioning system

The ARM system is configured using real time differentially corrected GPS to provide continual spatial reference information allowing the survey unit to be operated at sub-metre accuracy. Radiation and position information is displayed and collected autonomously in the systems data logger.

### ARM detector and ratemeter

The ARM detector unit is configured with a 75 mm by 75 mm high-sensitivity sodium iodide detector mounted in a protective case carried at a height of approximately 200 mm above ground level. The detector has a built-in multi-channel analyser (MCA) which is configured to provide gross gamma counts per second (cps), every second, to its data logger. The ARM system is capable of detecting radioactive material of regulatory interest up to a depth of approximately 300 mm, depending upon the surface materials. The methodology meets the regulatory expectations required for walkover gamma radiation surveys (Guidance on monitoring for heterogeneous radium-226 sources resulting from historic luminising or waste disposal sites, Scottish Environment Protection Agency, October 2019, NB: there is no equivalent guidance from the Environment Agency).

### Survey methodology

The survey methodology involved traversing the site using the survey equipment. Data was accumulated at the rate of one reading per second and recorded in the data logger, resulting in one radiation reading per 1 m<sup>2</sup> of the accessible areas of the site. GPS information is automatically linked to the radiological data for ease of interpretation.

## Background Readings

Typical background readings for the ARM system vary from 100 counts per second (cps) to 250 cps. All organic materials contain some level of radioactivity. Naturally occurring radionuclides include the uranium ( $^{238}\text{U}$  and  $^{235}\text{U}$ ) and thorium ( $^{232}\text{Th}$ ) decay chains commonly found in soils and rock and radioactive potassium ( $^{40}\text{K}$ ) commonly found in wood, clay and brick. These background levels vary between different materials (e.g. rock and soil) and in different areas of the UK. Background readings were taken for each instrument during equipment set up and function testing, this is carried out at the edge of the site to be surveyed.

## Appendix D Liquid Scintillation Sample Analysis Results

Liquid Scintillation Counter information and details of test conditions	
<b>Packard Tri-Carb Liquid Scintillation Counter (LSC), Model TR2900, Serial number 431291.</b>	
Count Time	10 minutes per sample
Counting windows	Window 1: Tritium [0 – 18.6 keV]
	Window 2: Carbon-14 [18.6 – 156 keV]
	Window 3: Other [156 – 2000 keV]
Area wiped	10 - 100 cm <sup>2</sup>
Assumed pick up factor for wipes	10%

Counting of the samples was carried out in accordance with Aurora's procedure 'Liquid Scintillation Counting' (AHP/H&S/INS/LSC/01 – Issue 1.3).

**Table D1. Liquid scintillation counting results.**

Sample No*	Building	Location	Area description	Results (Bq/cm <sup>2</sup> )
1	Observatory	Room 1	Walls of Observatory Basement	< 0.1
2	Observatory	Room 2	Floor	< 0.1
3	Observatory	Room 3	Doors	< 0.1
4	Observatory	Room 4	Window Sill	< 0.1
5	Observatory	Corridor	Walls of Observatory Basement	< 0.1
6	Observatory	Hallway	Safe Internal Surfaces	< 0.1
7	Observatory	Stairs	Handrail	< 0.1

## Appendix E High Resolution Gamma Spectroscopy Analysis Results

Samples analysed using Ortec Trans-SPEC-DX-100 detector AHP 283 at the Aurora Harwell Laboratory

Isotope	Co-60		Cs-137		Tl-208		Pb-212		Pb-214		Bi-214		Bi-212		Ra-226	
Report name	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)
Sweco Woolwich SWW1.rpt HP-OB01	< 10.089		< 7.5861		104.77	± 22.336	32.343	± 21.169	46.859	± 23.471	61.536	± 19.133	< 49.403		65.299	± 21.389
Sweco Woolwich SWW2.rpt HPOB01	< 6.8523		< 6.4286		< 29.587		21.869	± 16.339	44.742	± 18.215	62.608	± 16.358	86.461	± 52.787	66.789	± 20.833
Sweco Woolwich SWW3.rpt HP-B02	< 12.287		< 11.341		152.24	± 29.715	160.5	± 26.304	94.018	± 28.163	109.78	± 24.153	167.52	± 89.9	111.34	± 27.929
Sweco Woolwich SWW4.rpt HPOB02	< 9.3392		< 8.7653		111.76	± 23.562	47.786	± 21.573	58.152	± 25.529	76.013	± 20.091	< 69.296		83.72	± 24.496

Isotope	Ac-228		U-235		Pa-234		Th-234		Pb-210		Eu-152		Co-57		Am-241	
Report name	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)	Activity (Bq/kg)	Uncertainty (Bq/kg)
Sweco Woolwich SWW1.rpt HP-OB01	68.484	± 25.604	< 82.07		< 41.18		< 457.76		< 2146.2		< 25.654		< 84.875		< 66.696	
Sweco Woolwich SWW2.rpt HP-OB01	85.457	± 26.761	< 76.668		< 31.478		< 426.55		< 2022.6		< 23.11		< 78.143		< 58.949	
Sweco Woolwich SWW3.rpt HPOB-02	174.63	± 46.893	< 111.63		< 48.971		< 589.99		< 2707.6		< 31.771		< 103.11		< 89.845	
Sweco Woolwich SWW4.rpt HP-OB02	117.44	± 33.161	< 90.533		< 37.823		< 483.41		< 2099.3		< 25.829		< 87.204		< 68.257	



## Analysis of Soil Samples

Client: Aurora Health Physics Services Ltd  
3 The Terrace  
Library Avenue  
Harwell Oxford  
Oxfordshire  
OX11 0SG

Testing Facility: SOCOTEC UK  
Unit 12, Moorbrook  
Southmead Industrial Park  
Didcot  
Oxfordshire  
OX11 7HP

Laboratory Reference: 23-0330

Customer Reference: Sweco Rotunda and Observatory investigations

Quote Number: ENR-ANU-11170

PO Number: PO002052

Samples Received: 04 April 2023

Sample Condition: Satisfactory; Ambient

Analysis Completed: 17 April 2023

Report Author: 

Author's Name: John Foster

Job Title: Reporting Analyst

Approved By: 

Approver's name: Trevor Harding

Job Title: Senior Analyst

Report Date: 20 April 2023



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### Sample Summary

Customer Reference	Laboratory Reference	Matrix	Sampling Date
SWW01	NC1664	Soil	20/03/2023 12:00
SWW02	NC1665	Soil	20/03/2023 12:00
SWW03	NC1666	Soil	20/03/2023 12:00
SWW04	NC1667	Soil	20/03/2023 12:00

### Experimental

#### Gamma Spectrometry

ANU/SOP/2029 – Each sample was placed in a container to match the appropriate calibration geometry and then measured by high-resolution gamma ray spectrometry.

The measurement technique is based on the use of high purity germanium (HPGe) detectors coupled to an Ortec gamma ray spectroscopy system. The gamma ray spectra are stored on a computer and analysed using the software programme Fitzpeaks for photopeak identification and quantification. The detectors are calibrated for efficiency using a mixed radionuclide standard, which covers an energy range of approximately 30-2000 keV. The efficiency of gamma rays between 30 keV and 120 keV are determined on an individual basis.

Application of decay corrections for the naturally occurring daughter radionuclides of uranium and thorium assumes that the series daughter radionuclides are all in secular equilibrium and therefore decay with the half-life of the first radionuclide in the series. ( $^{226}\text{Ra}$  is not UKAS accredited)

### Results

Results are presented in the following tables.

Any opinions and interpretations expressed herein are outside the scope of our UKAS accreditation.

The results in this test report relate only to the items tested, and test portions taken thereof. This test report must not be reproduced except in full, without written approval of the laboratory.



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### Results Summary – Gamma Spectrometry

Customer Reference	Laboratory Reference	Be-7	K-40	Co-60	Cs-134	Cs-137	Tl-208	Pb-210	Bi-212	Pb-212
SWW01	NC1664	<12	83 ± 22	<1.5	<1.5	<1.3	2.9 ± 1.1	<24	<18	5.7 ± 1.6
SWW02	NC1665	<11	55 ± 17	<1.3	<1.5	<1.2	<1.2	<22	<16	<1.8
SWW03	NC1666	<22	230 ± 35	<2.3	<3.1	<2.2	51.6 ± 3.9	<48	177 ± 30	154 ± 11
SWW04	NC1667	<13	92 ± 26	<1.7	<1.8	<1.5	6.7 ± 1.3	<17	<21	14.7 ± 2.2

### Results Summary – Gamma Spectrometry

Customer Reference	Laboratory Reference	Bi-214	Pb-214	Ra-224	Ra-226 *	Ac-228	Pa-234m	Th-234	U-235	Am-241
SWW01	NC1664	6.9 ± 2.2	6.8 ± 2.2	<29	<21	<6.1	<150	<24	<1.4	<2.4
SWW02	NC1665	<2.6	<2.4	<23	<19	<5.2	<130	<21	<1.2	<2.1
SWW03	NC1666	53.9 ± 5.3	62.2 ± 5.2	<110	108 ± 35	143 ± 11	<240	<54	<12	<5.4
SWW04	NC1667	10.2 ± 2.7	11.1 ± 2.0	<30	<20	18.4 ± 4.2	<180	<21	<1.3	<1.8

#### Notes:

- Analyses and/or samples marked with an asterisk are not UKAS accredited under schedule 1252.
- Results are presented as Bq.kg<sup>-1</sup> of sample as received and are decay corrected to the sampling date provided.
- For results below the Limit of Detection, the LoD is rounded up to 2 significant figures. Results above the LoD are reported with expanded (2σ) uncertainties based on a total uncertainty budget. Uncertainties are rounded to 2 significant figures; results are rounded to the same precision.
- Detector calibrations are based upon homogeneous standard solutions. For quantification purposes the samples are assumed to be homogeneous.
- <sup>226</sup>Ra has only one gamma ray at 186 keV and the major gamma ray from <sup>235</sup>U also occurs at 186 keV. <sup>235</sup>U can be measured by the lower abundance gamma ray at 144 keV and if a positive result for <sup>235</sup>U is reported, the <sup>226</sup>Ra result will be unreliable and overestimated. However even if <sup>235</sup>U is below the LoD there may still be a contribution to the <sup>226</sup>Ra from <sup>235</sup>U and the <sup>226</sup>Ra result may be unreliable and overestimated. If an accurate result for <sup>226</sup>Ra is required this is better obtained by radiochemical analysis.

- End of Test Report -



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