International in-situ gamma spectrometry intercomparison exercise „Straz 2019“

Stráž pod Ralskem, Czech Republic

17.6. – 20.6.2019

Praha, 30.10.2019

Contents

1. Introduction 4
2. Description of sites and tasks 5
   2.1. The banks of the river Ploučnice 5
   2.2. Sludge bed 6
   2.3. Calibration pads 7
   2.4. Hamr 9
   2.5. Monte – 1 (school reactor ČVUT – FJFI) 10
3. Schedule 12
4. Task and results 13
5. Conclusion and acknowledgment 43

1. Introduction

During the period from 17th to 20th June 2019 “International in-situ gamma spectrometry intercomparison exercise 2019” took place in Stráž pod Ralskem, the Czech Republic. Eight mobile groups from four countries - Germany, Austria, Slovenia and the Czech Republic attended the exercise organised by the National Radiation Protection Institute (SÚRO), public research institution. It took place in the area of Diamo, state enterprise, on the lands of Vojenské lesy a statky ČR, state enterprise, and at the experimental school reactor VR1 at the Czech Technical University, Faculty of Nuclear Sciences and Physical Engineering. The exercise took place in Stráž pod Ralskem at 3 locations. Either measurement in the fourth location or on the MONTE simulator in Prague on the VR1 school reactor was a matter of participant´s choice. The sites were selected because of the increased uranium radionuclide content due to uranium ore mining and processing.

The task was to measure dose rates (mapping), in situ spectrometric measurements at the indicated points assuming a homogeneous distribution of activities with the possibility of estimation even for non-homogeneous distribution and to estimate the mass activity of calibration plates on calibration surfaces. At the school reactor, it was possible to test dose rates and spectra in Real Fission Gamma-Ray Fields.

2. Description of sites and tasks

2.1. **The banks of the river Ploučnice**

Tasks and results:

a) dose rate mapping

b) in situ spectrometry (estimation of specific activity of natural radionuclides, assuming homogenous distribution)

2.2. **Sludge bed**

Flat area on the site of the former tailings pond at the DIAMO company land (ready for remediation):

- dose rate and in situ measurements – to measure dose rate and on 5 sites in situ spectrometry; possibility of a soil sample taking

Tasks and results:

a) dose rate mapping
b) in situ spectrometry (estimation of specific activity of natural radionuclides, assuming homogenous distribution)

2.3. **Calibration pads**

The calibration base for environmental gamma-ray spectrometer calibration is located in a hall on DIAMO premises. It is used for determining calibration constants for ground and airborne gamma-ray spectrometers. Among others, the calibration base is provided with the four calibration pads PK, PU, PTh and P0, i.e., 3 pads in which activity of one element prevails and others are suppressed (for example, PK calibration pads contains high activity concentration of ^{40}K while U-series and Th-series elements are suppressed, etc.) and one P0 background pad with low-activity sand. The standard calibration pads are described below:

Calibration pad parameters (PK, PU, PTh):

Diameter **d= 190 cm**

Height **h = 62 cm**

Vessel thickness **t = 0.5 cm**

PK, PU, PTh pad material: **Concrete ρ=1.80 g .cm^{-3}**

Vessel material : **Steel ρ=7.86 g .cm^{-3}**

Surrounding material: **Concrete**; density not available

Background pad parameters (P0):

Dimensions: **200 cm x 200 cm x 80 cm**

P0 pad material: **Low activity sand**

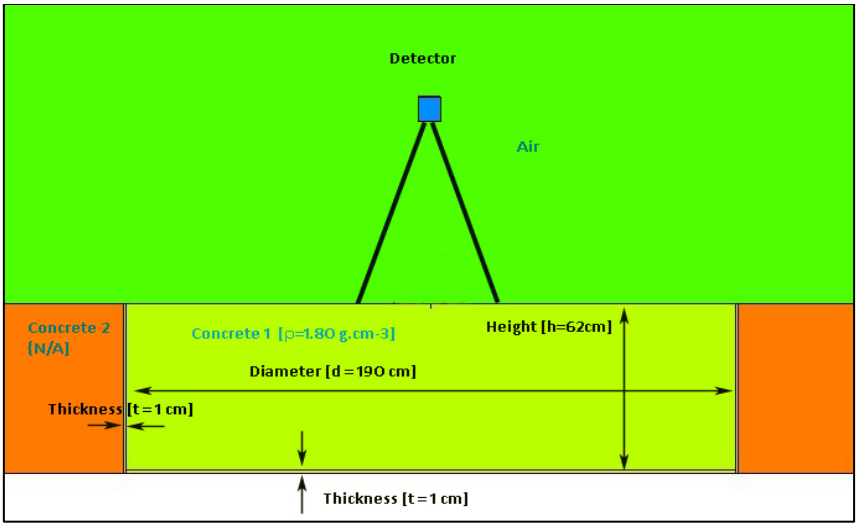
Density: **1.58 g .cm^{-3}**

Tasks and results:

- to determine activity concentrations of natural radionuclides for calibration pads (standard in-situ measurement) and to estimate activities of radionuclides in Bq in individual calibration pads.

	PK	PU	PTh
PK	**4798.3**	**29.6**	**8.5**
PU	**75.1**	**360.6**	**9.7**
PTh	**90.8**	**63.0**	**384.1**
P0	**6.3**	**3.7**	**3.7**

Tab. 1. Specific activity natural radionuclides in calibration pads [Bq/kg]


Detector
Air
Concrete 2
(N/A)
Concrete 1 [ρ=1.80 g.cm-3]
Height [h=62cm]
Diameter [d = 190 cm]
Thickness [t = 1 cm]
Thickness [t = 1 cm]


PU
© 2019 Martina Vtelenská

2.4. **Hamr**

- alternative for groups that did not measure on the reactor
- dose rate and in situ measurements – contamination is only under the pipe, the rest already has been recultivated.

Tasks and results:

a) dose rate mapping from both sides of the pipes at a distance of 1m from the pipe and within an inch of the pipe; measurements are spaced by 1 m (marking on the pipe) + 1 measurement - 2 m from the pipe in its knee from outside (50.7071008N, 14.8351942E)

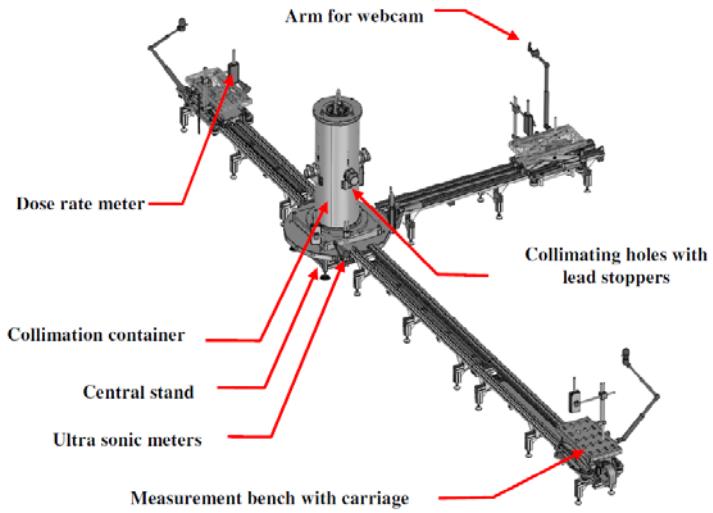
b) in situ spectrometry – 1m from the pipe from both sides, 2 measurements plus one at a distance of 2 m from the pipe in its knee (altogether 3 measurements)

2.5. MONTE – 1 (school reactor ČVUT – FJFI)

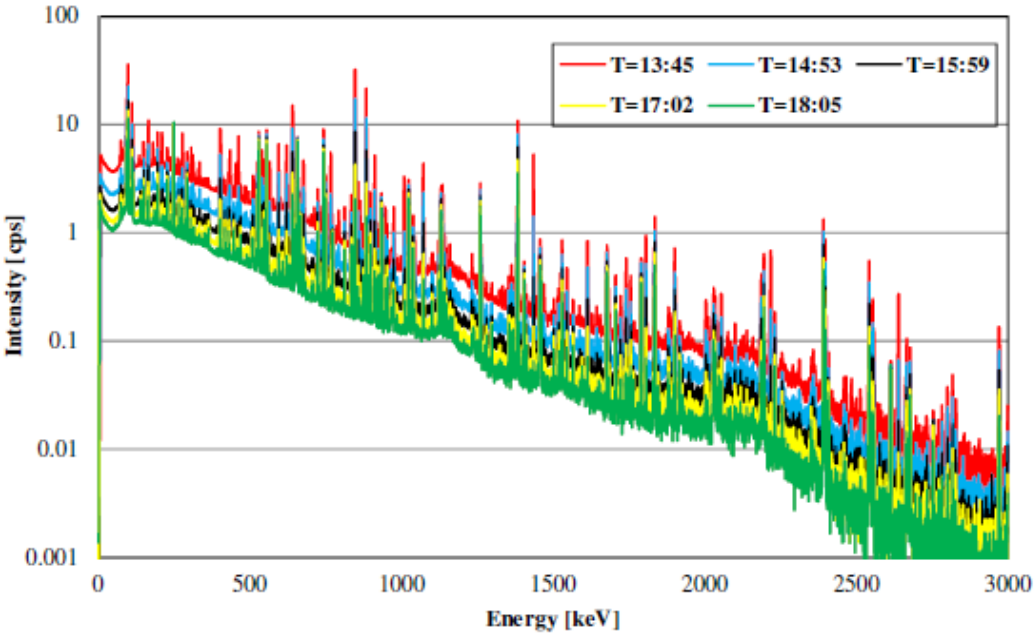
Not only during the accident in NPP Fukushima in 2011, capability of measurement in real gamma-ray fields of fission products is also increasingly important. For such a situation an experimental testing device of MONTE-1 was developed at the training reactor VR-1. The testing device MONTE-1 allows connecting up to 8 various long measurements desks equipped with a cart to hold various types of detectors. Positions of the carts with detectors are set through a web interface in a main PC. The distance of the detectors is measured by ultrasonic distance meters. In addition, each measurement desk contains a webcam and a dose meter for monitoring of the radiation field around the collimation container as well as LAN connector for connecting analysers of the detectors. Data from the webcams, dose meters, and ultrasonic distance meters are transmitted through an internal LAN network to a control program „Monte-Manager“ in the main PC." The device allows advanced testing of various detection systems in real gamma-ray fields.

There was a chance for mobile groups responding after a nuclear accident to practise analyses of spectra that may occur in the early phase of a NPP accident. Radionuclides ^{131}I, ^{132}Te, ^{135}I and ^{135}Xe should be measurable in the spectrum. The other radionuclides would have so low activity that they could not be detected at the time of measurement. Probably there were sums of different energies, whose hundreds occur in these spectra. To confirm or reject the presence of other radionuclides, it would be necessary to measure the spectrum the day after spectrum stabilization.

The results of this measurement cannot be compared.



Time responses of the HPGe detector in different time after irradiation of the EK-10 fuel rod



3. Schedule

<table>
<tr><th>Day</th><th>Locality</th><th>Hamr</th><th>Sludge bed</th><th>Ploucnice</th><th>Calibration pads</th><th>MONTE</th></tr>
<tr><td>17.6. Mo</td><td>16:00</td><td colspan="5">Registration</td></tr>
<tr><td rowspan="2">18.6.
Tu</td><td>9:00 - 12:00</td><td colspan="3" rowspan="2"></td><td>4
5
6</td><td rowspan="2">1; 2; 3</td></tr>
<tr><td>13:00 - 16:00</td><td>4
5
6</td><td></td></tr>
<tr><td rowspan="3">19.6.
W</td><td>8:30 - 11:30</td><td></td><td>4
5
6</td><td></td><td>1
2
3</td><td rowspan="2"></td></tr>
<tr><td>12:30 - 15:30</td><td>4
5
6</td><td></td><td>1
2
3</td><td colspan="2"></td></tr>
<tr><td>17:00</td><td colspan="5">Exercise dinner</td></tr>
<tr><td rowspan="2">20.6.
Thu</td><td>9:00 - 12:00</td><td></td><td>1
2
3</td><td colspan="3"></td></tr>
<tr><td>14:00 - 17:00</td><td colspan="5">Evaluation, conclusion</td></tr>
</table>

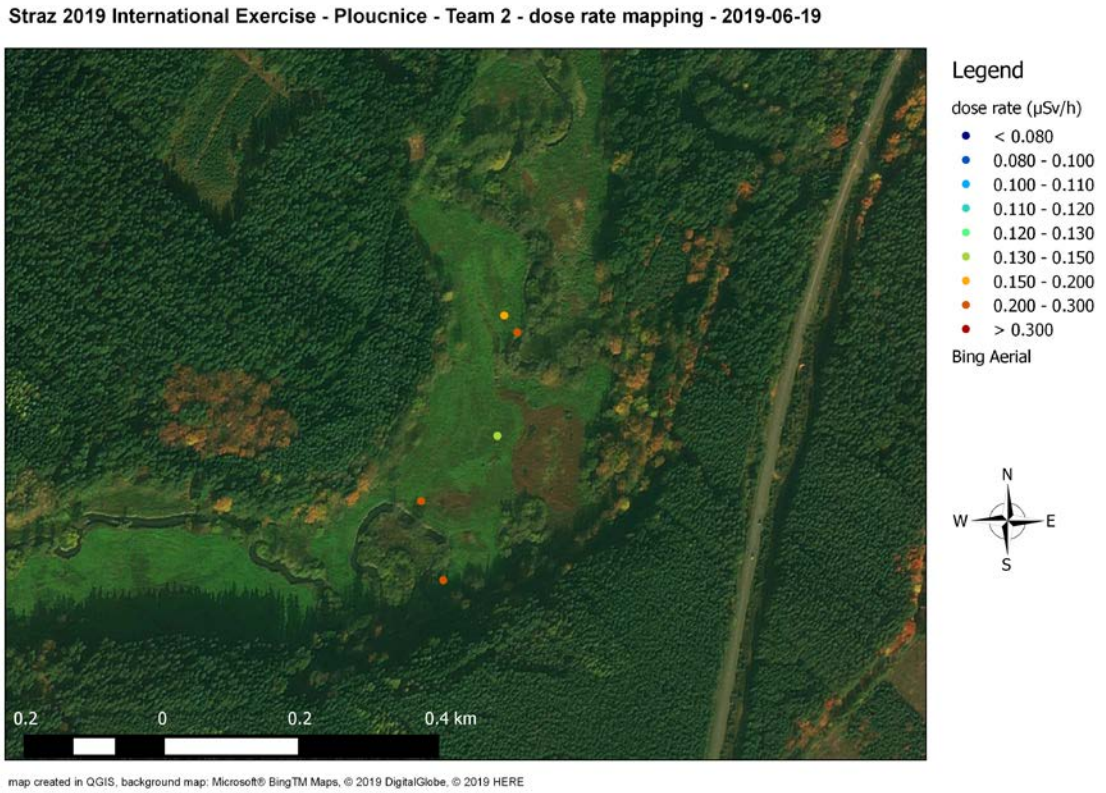
4. Task and results

The distribution of activities in all locations was very inhomogeneous. The results of soil samples measurements from the given sites obtained in the spectrometric laboratory would indicate the actual activity only at a given point, not on the measured area, which in situ measurements included. Therefore, the average of all measurements at that point was taken as an indicator of “accuracy”. In the graphs the average is shown as a solid line, the $\pm 2\sigma$ (mean $\pm 2\sigma$) interval is indicated by dashed lines

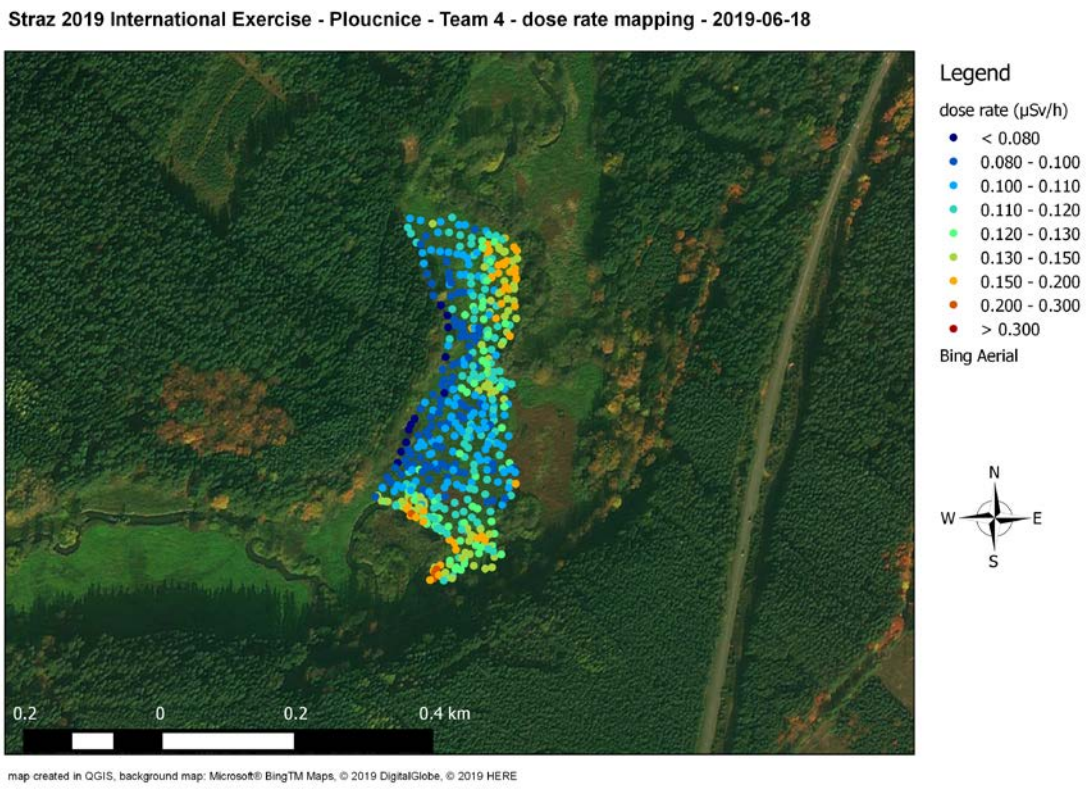
Outliers were not included in the mean (they were excluded with the Dean-Dixon test at a probability level of 95%). In the graphs, these values are marked in red.

Ploučnice

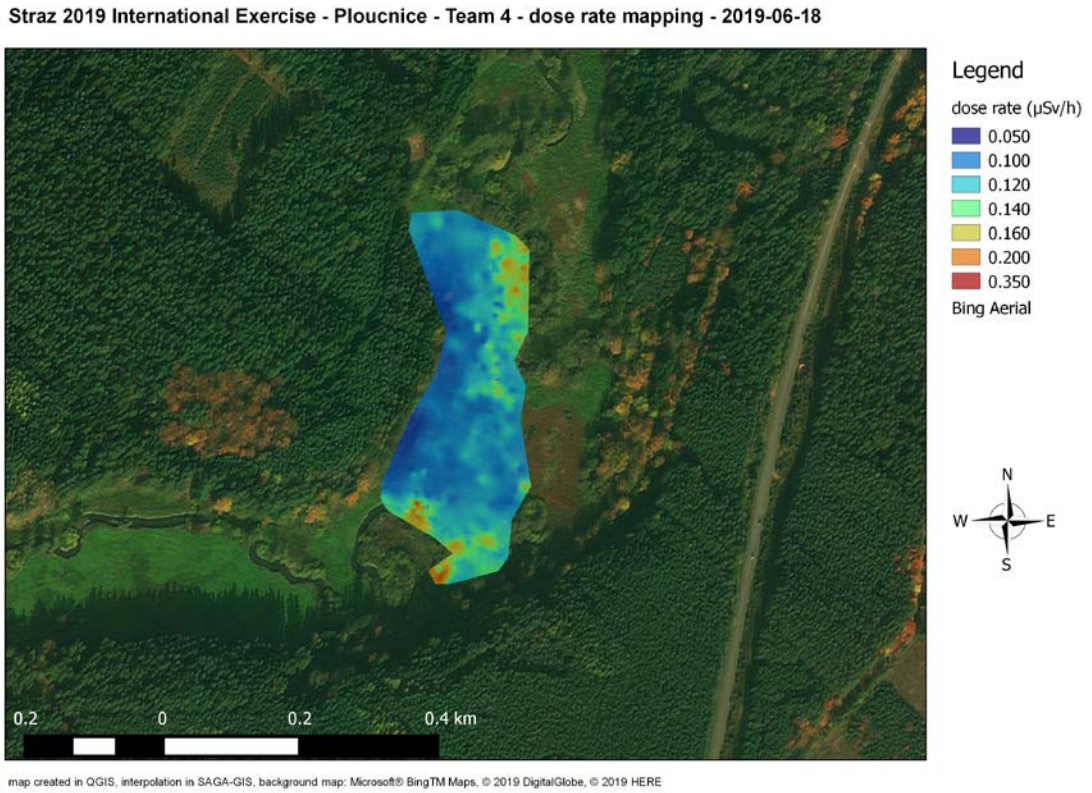
Team 2 - points



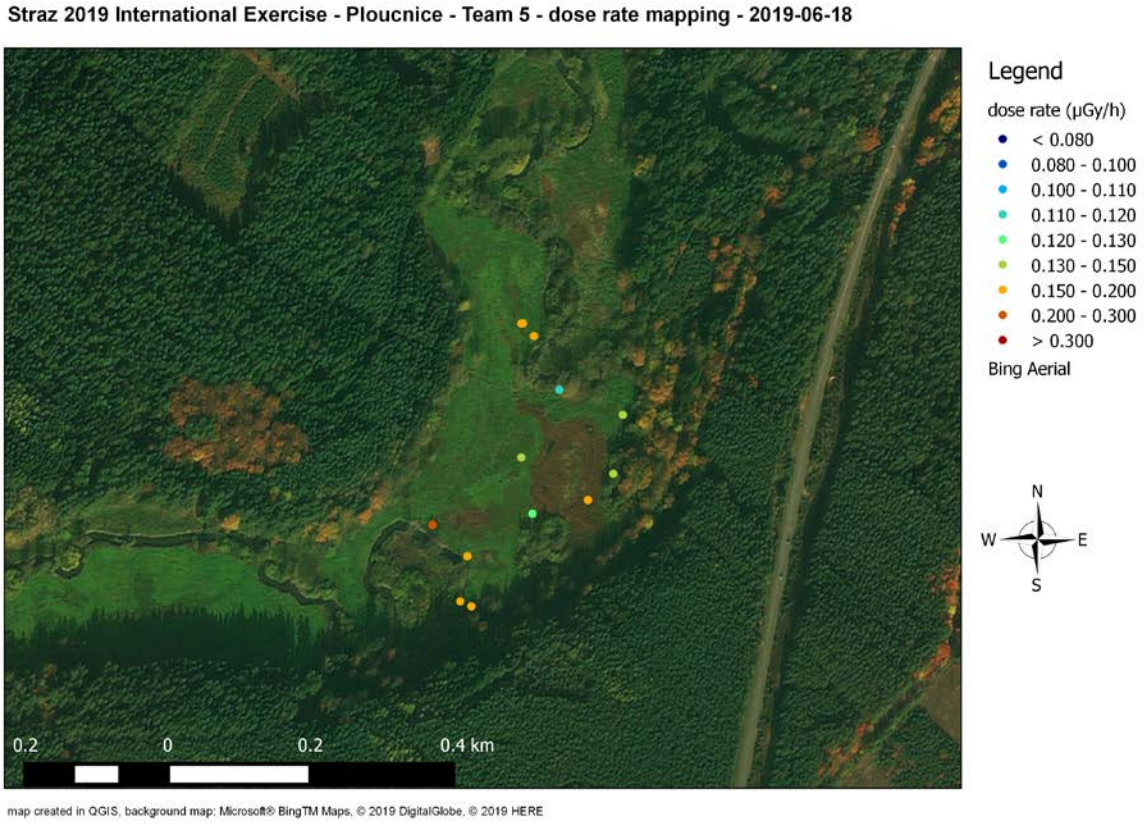
Team 4 - points



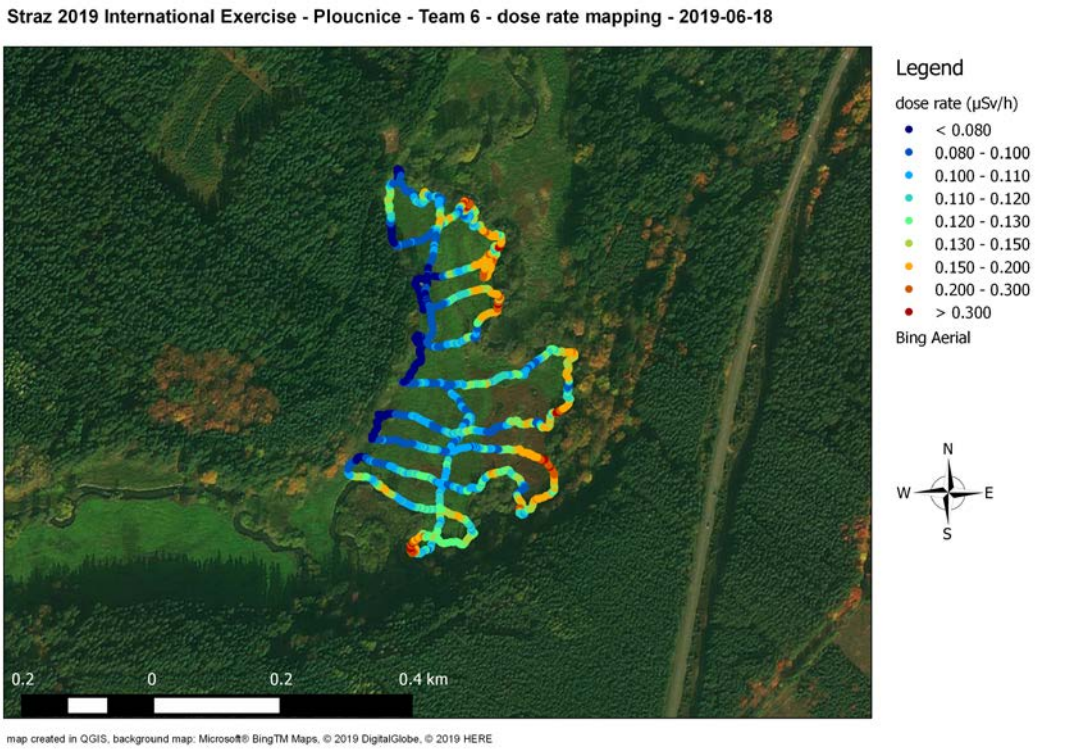
Team 4 - spline



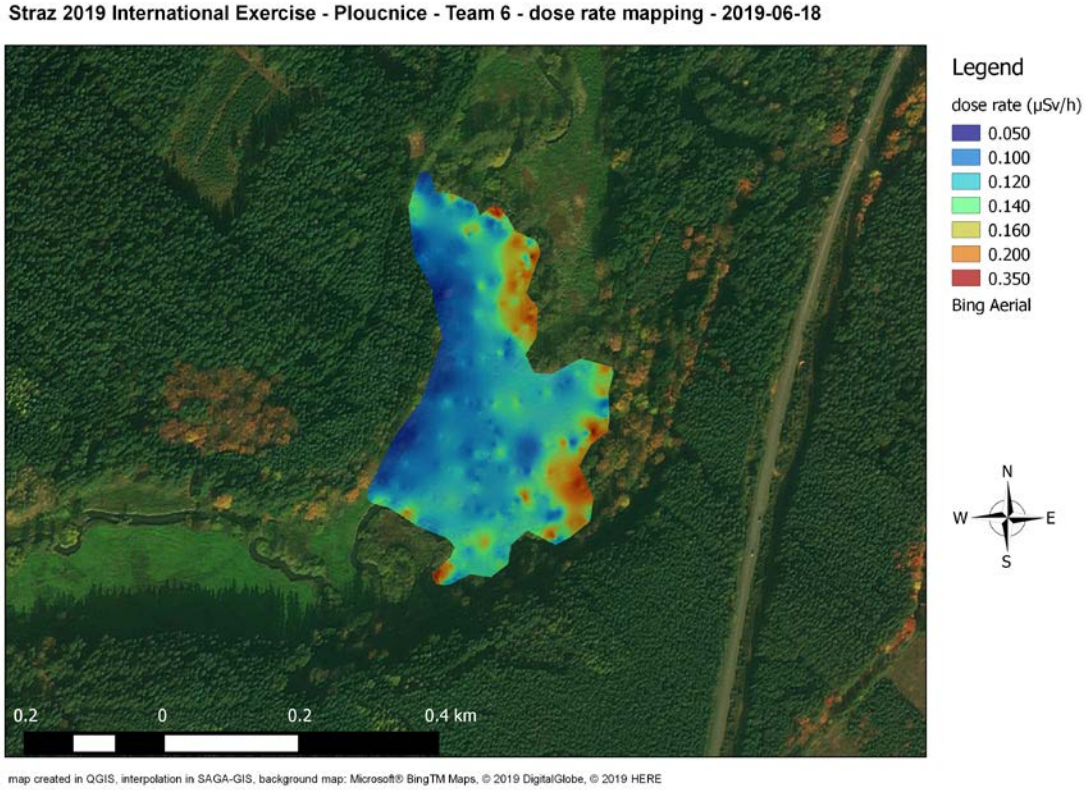
Team 5 - points



Team 6 - points



Team 6 - spline



Team 7 - points

Point 1

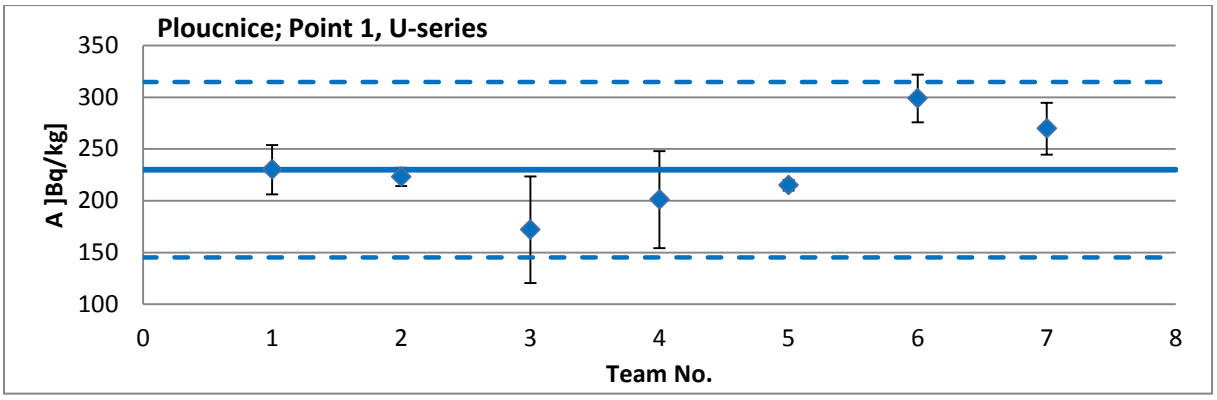


Fig 4.1.1a U-series concentration in soil; Point 1 (Mean: 230 ±84 Bq/kg)

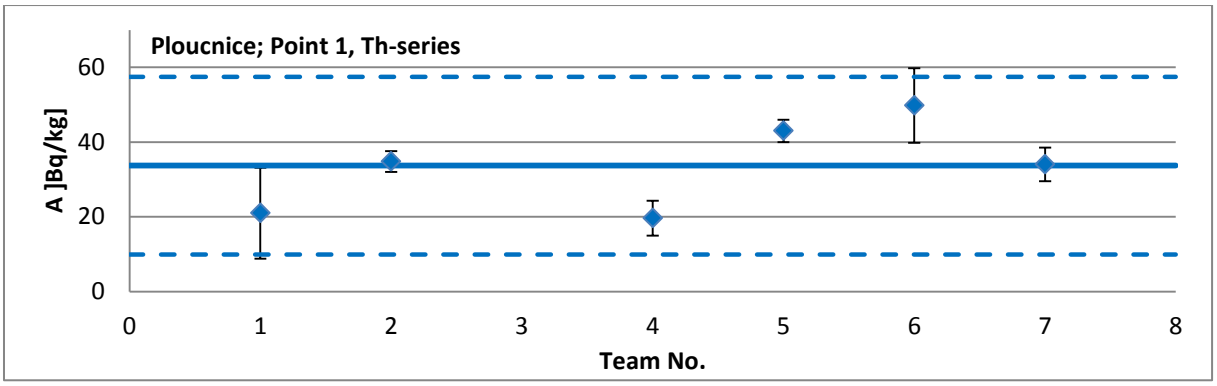


Fig 4.1.1b Th-series concentration in soil; Point 1(Mean: 34 ±24 Bq/kg)

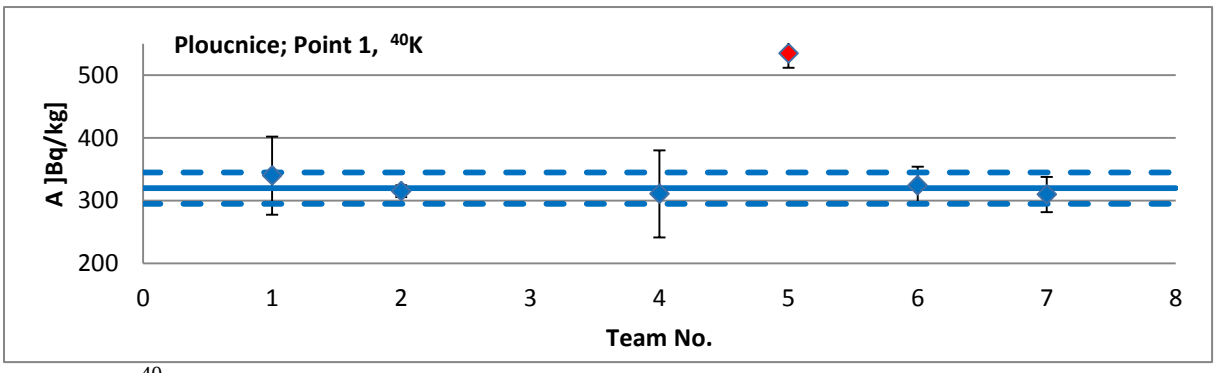


Fig 4.1.1c ^{40}K concentration in soil; Point 1(Mean: 320 ±25 Bq/kg)

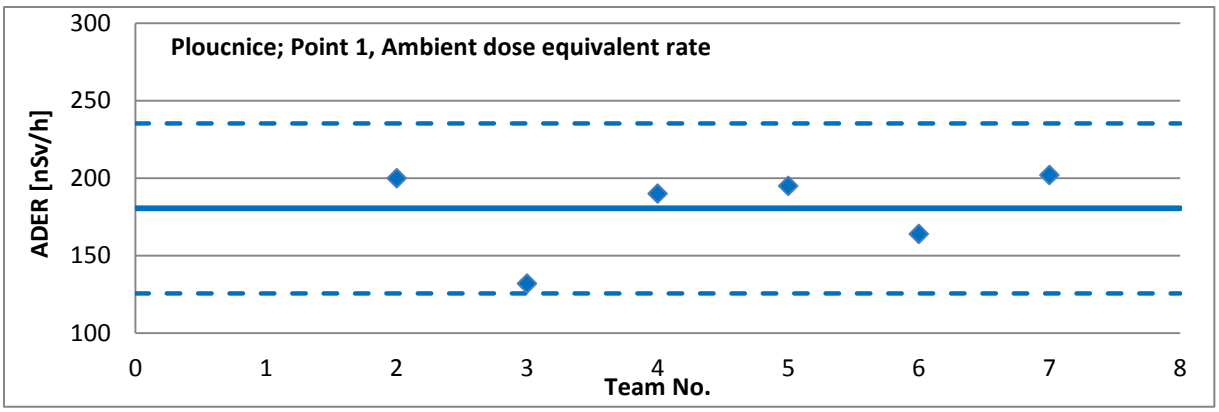


Fig 4.1.1d Ambient dose equivalent rate 1m above ground; Point 1 (Mean: 180 ±60 nSv/h)

Point 2

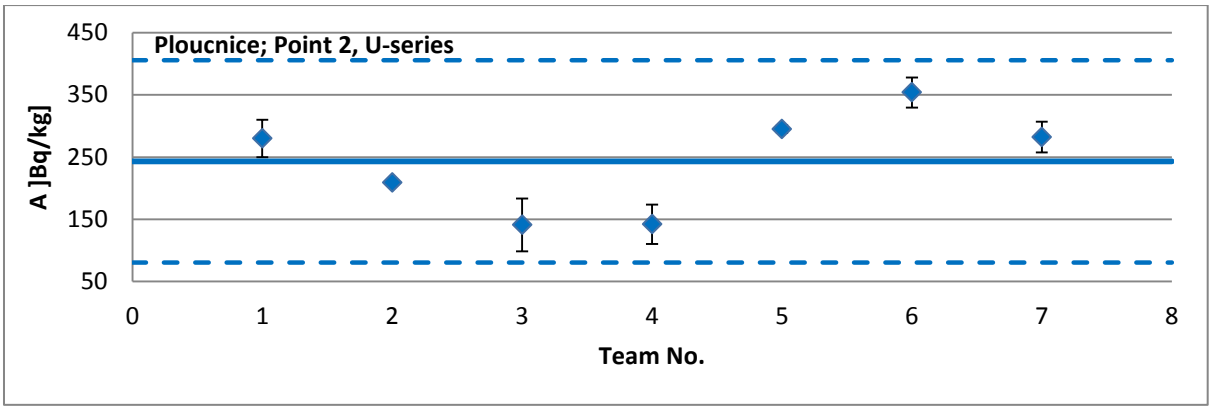


Fig 4.1.2a U-series concentration in soil; Point 2 (Mean: 240 ±160 Bq/kg)

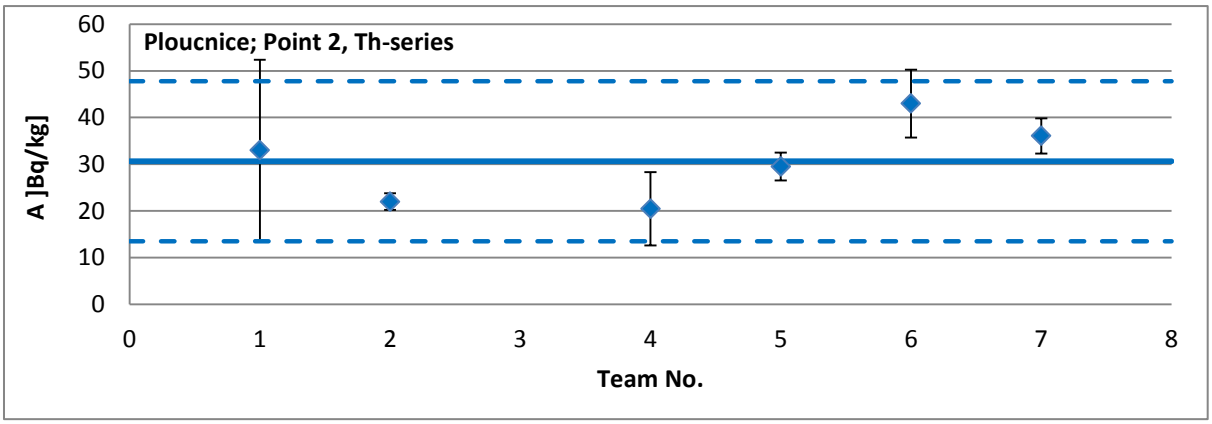


Fig 4.1.2b Th-series concentration in soil; Point 2 (Mean: 31 ±17 Bq/kg)

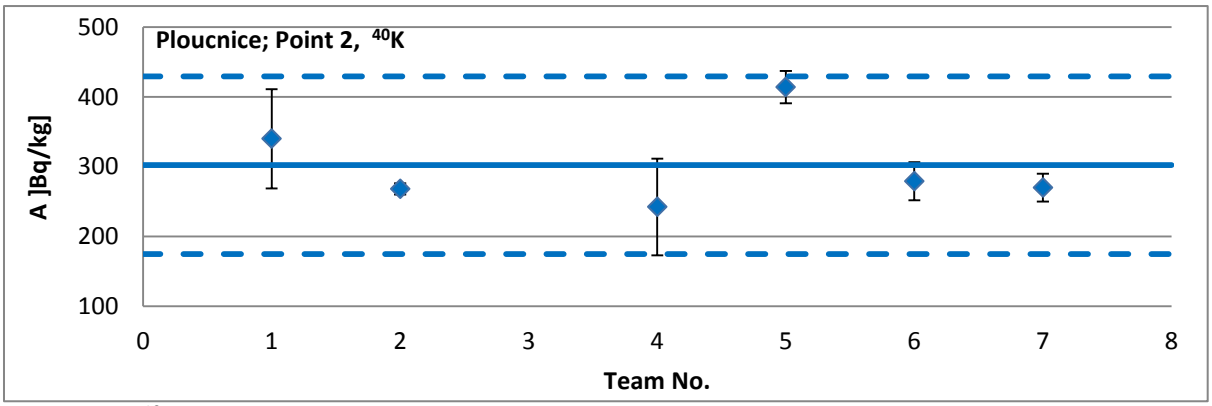


Fig 4.1.2c ^{40}K concentration in soil at Ploucnice bank; Point 2 (Mean: 300 ±120 Bq/kg)

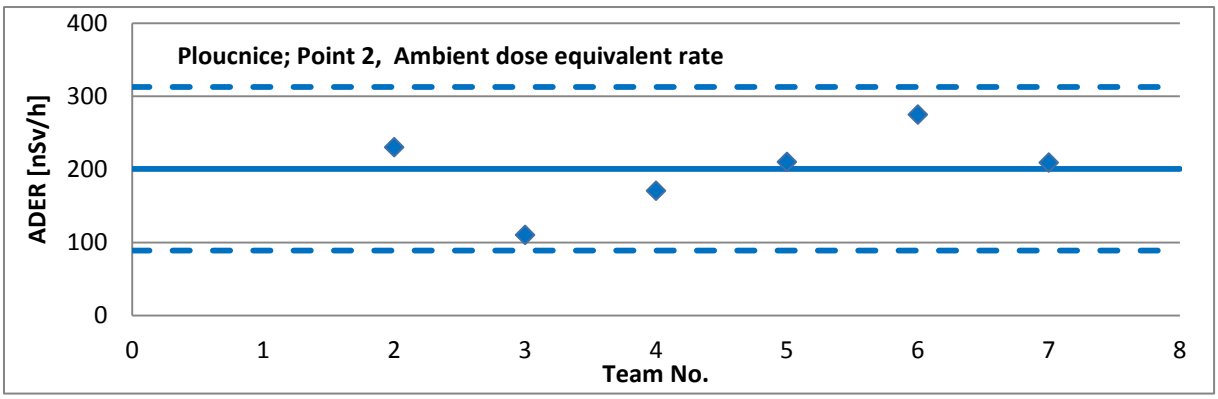


Fig 4.1.2d Ambient dose equivalent rate 1 m above ground; Point 2 (Mean: 200 ±110 nSv/h)

Point 3

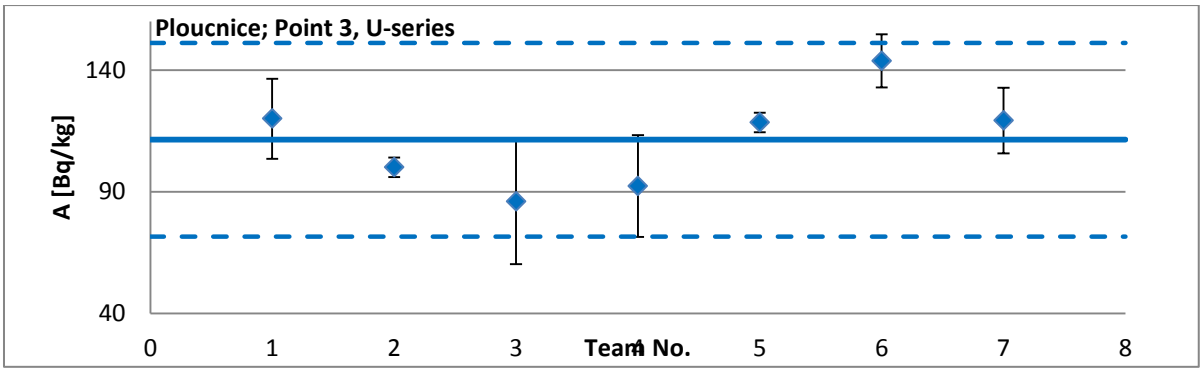


Fig 4.1.3a U-series concentration in soil; Point 3 (Mean: 111 ±40 Bq/kg)

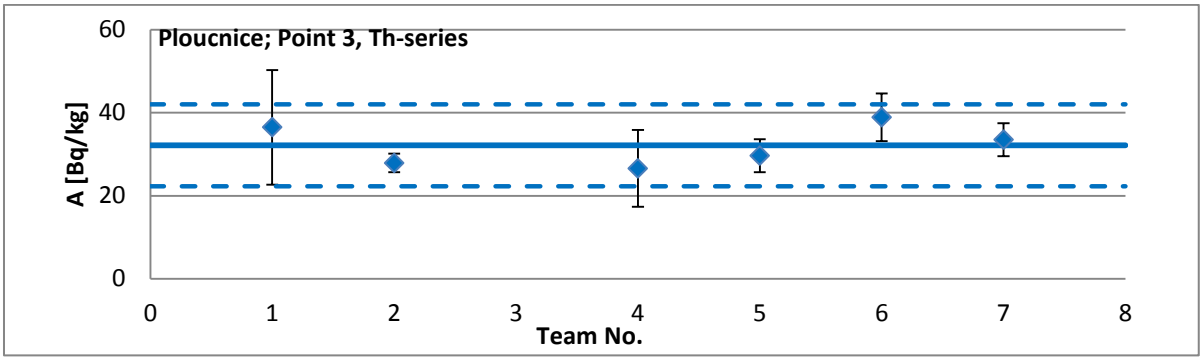


Fig 4.1.3b Th-series concentration in soil; Point 3 (Mean: 32 ±10 Bq/kg)

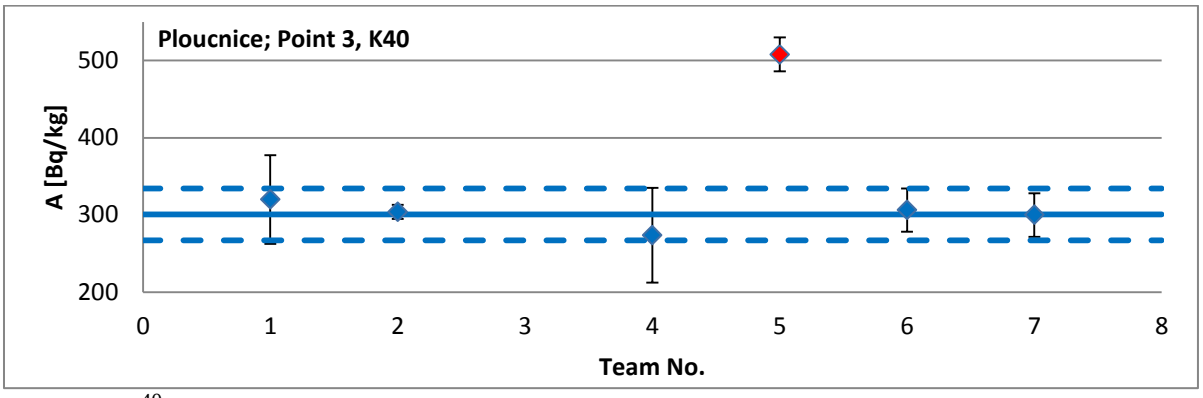


Fig 4.1.3c ^{40}K concentration in soil; Point 3 (Mean: 300 ±34 Bq/kg)

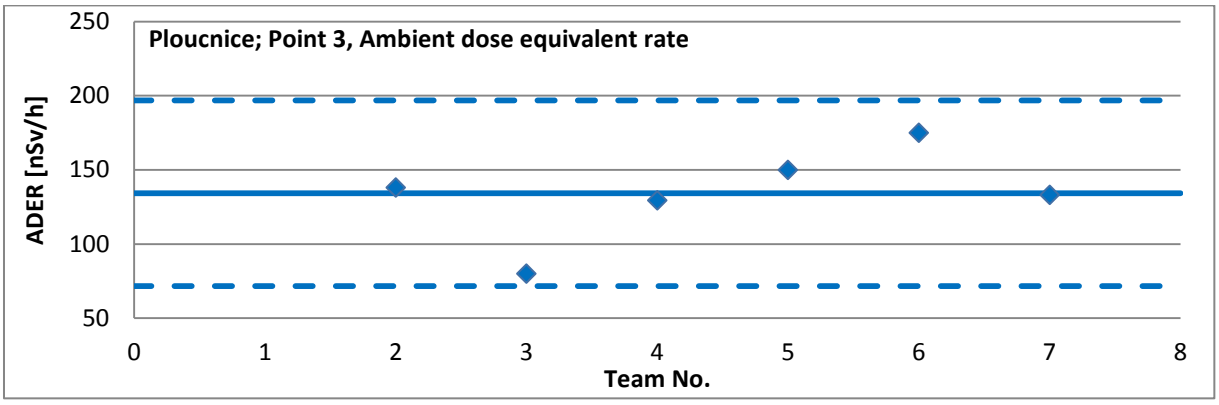


Fig 4.1.3d Ambient dose equivalent rate1 m above ground; Point 3 (Mean: 130 ±60 nSv/h)

Point 4

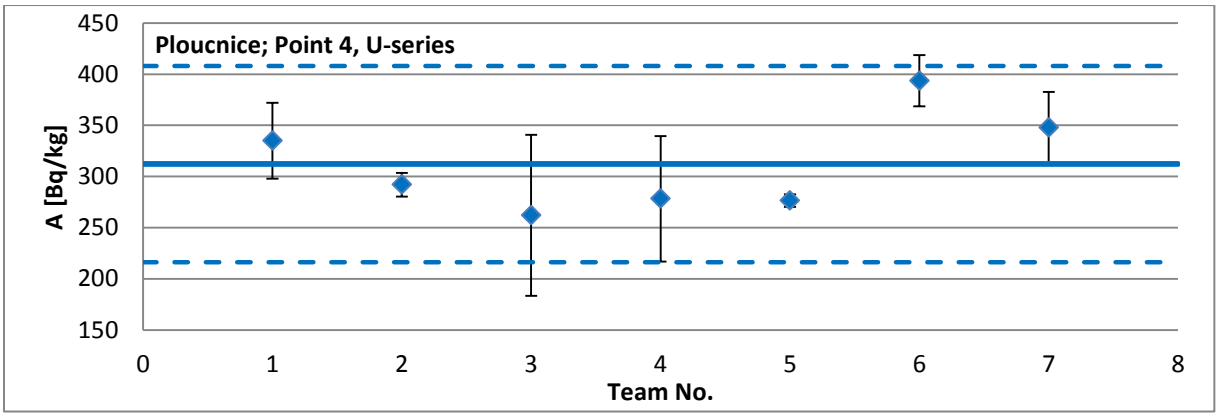


Fig 4.1.4a U-series concentration in soil; Point 4 (Mean: 310 ±100 Bq/kg)

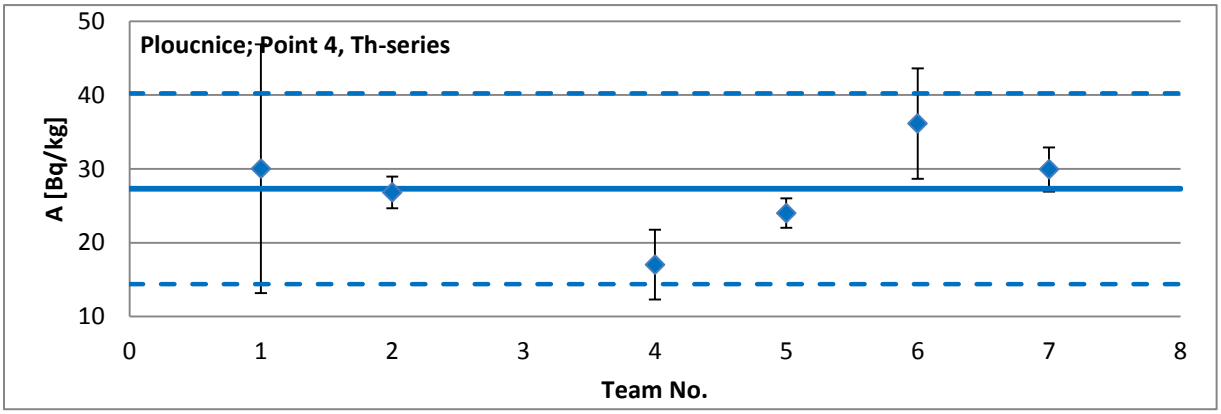


Fig 4.1.4b Th-series concentration in soil; Point 4 (Mean: 27 ±13 Bq/kg)

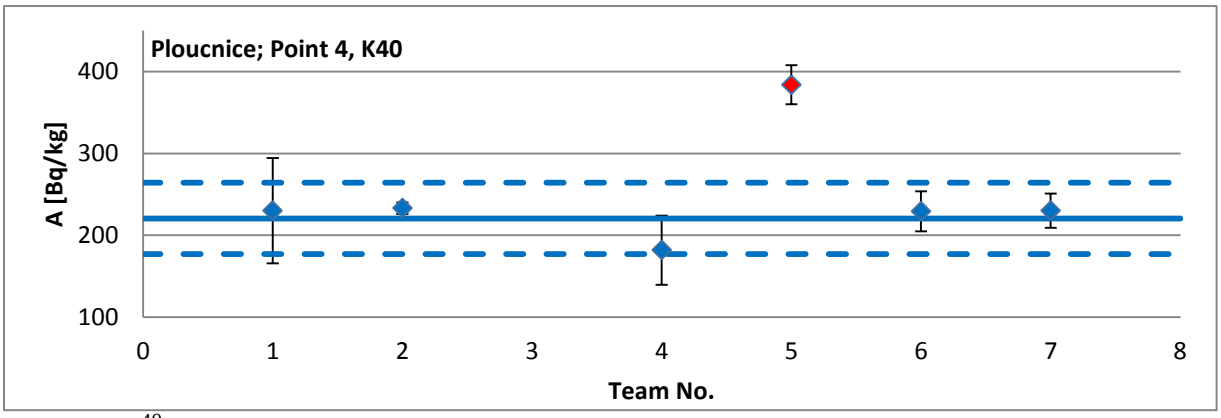


Fig 4.1.4c ^{40}K concentration in soil; Point 4 (Mean: 220 ±45 Bq/kg)

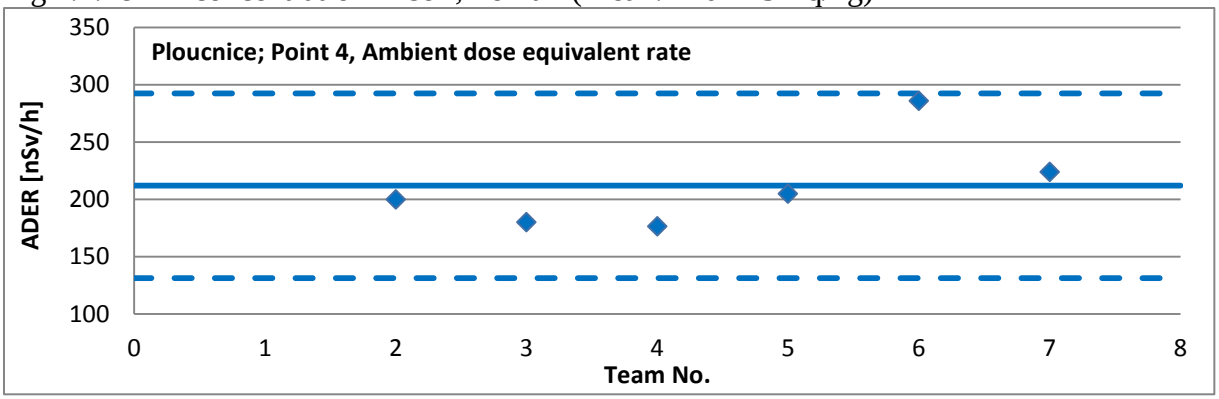


Fig 4.1.4d Ambient dose equivalent rate1 m above ground; Point 4 (Mean: 210 ± 80 nSv/h)

Point 5

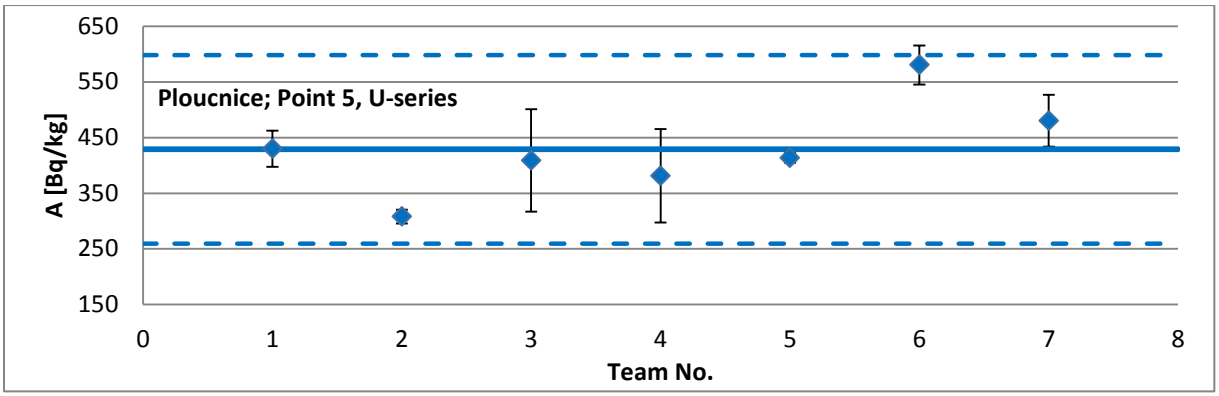


Fig 4.1.5a U-series concentration in soil; Point 5 (Mean: 430 ±170 Bq/kg)

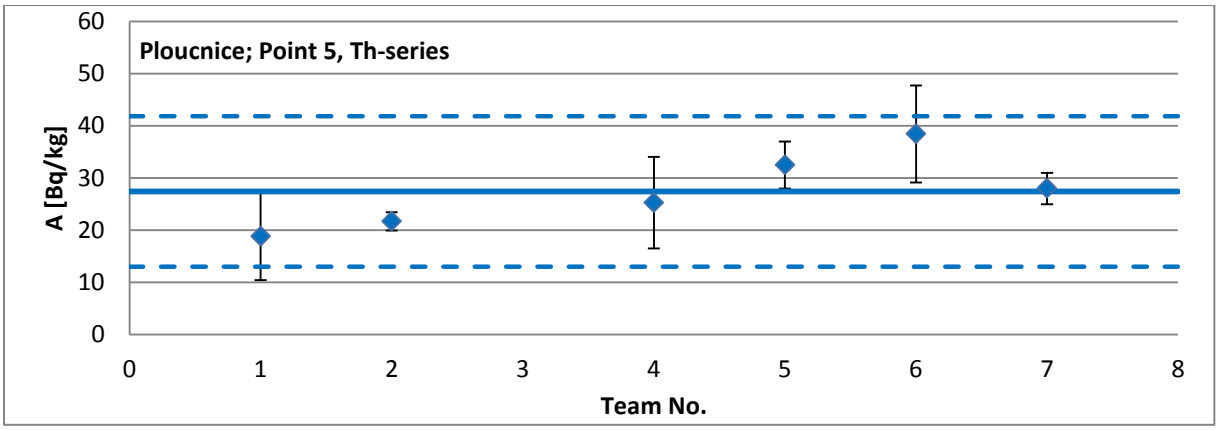


Fig 4.1.5b Th-series concentration in soil; Point 5 (Mean: 27 ±14 Bq/kg)

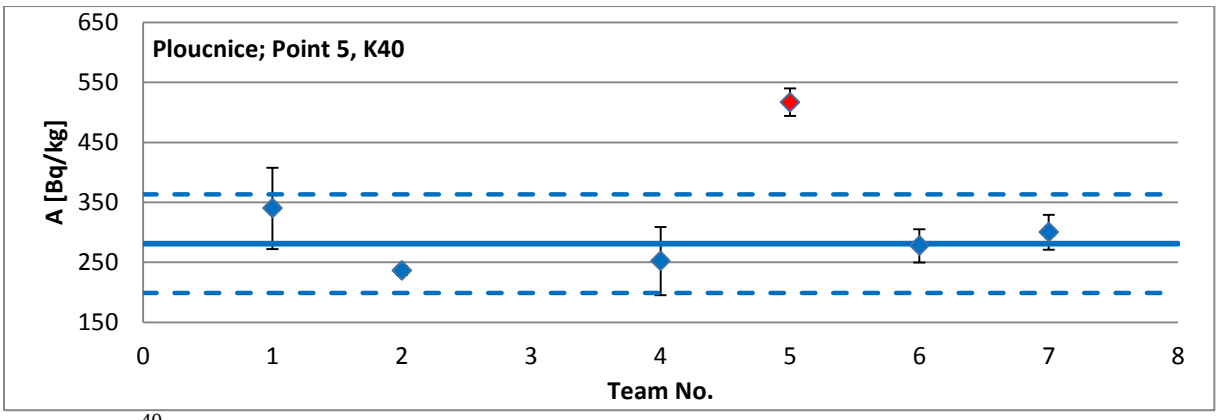


Fig 4.1.5c ^{40}K concentration in soil; Point 5 (Mean: 280 ±80 Bq/kg)

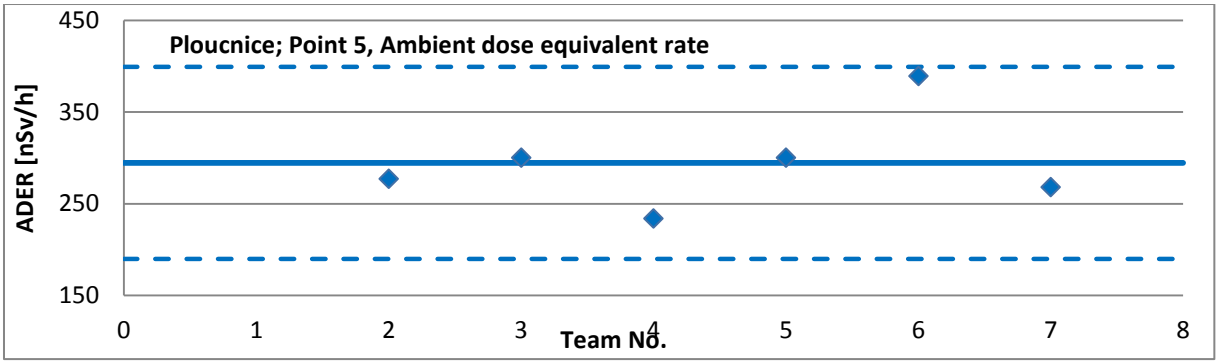


Fig 4.1.5d Ambient dose equivalent rate1 m above ground; Point 5 (Mean: 290 ± 100 nSv/h)

4.1. **Sludge bed**

Straz 2019 International Exercise - Sludge Bed; SB - overview map

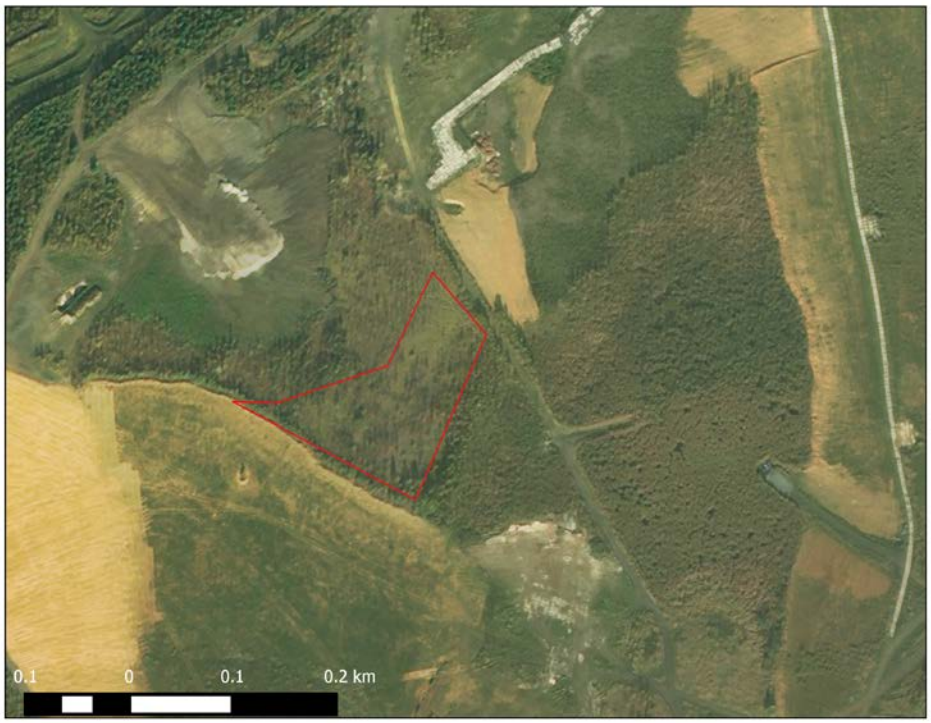
Legend
SB measurement area
Bing Aerial

N
W E
S

SÚRO

map created in QGIS, background map: Microsoft® BingTM Maps, © 2019 DigitalGlobe, © 2019 HERE

Straz 2019 International Exercise - Sludge Bed; SB - overview map



Legend
SB measurement area
Bing Aerial

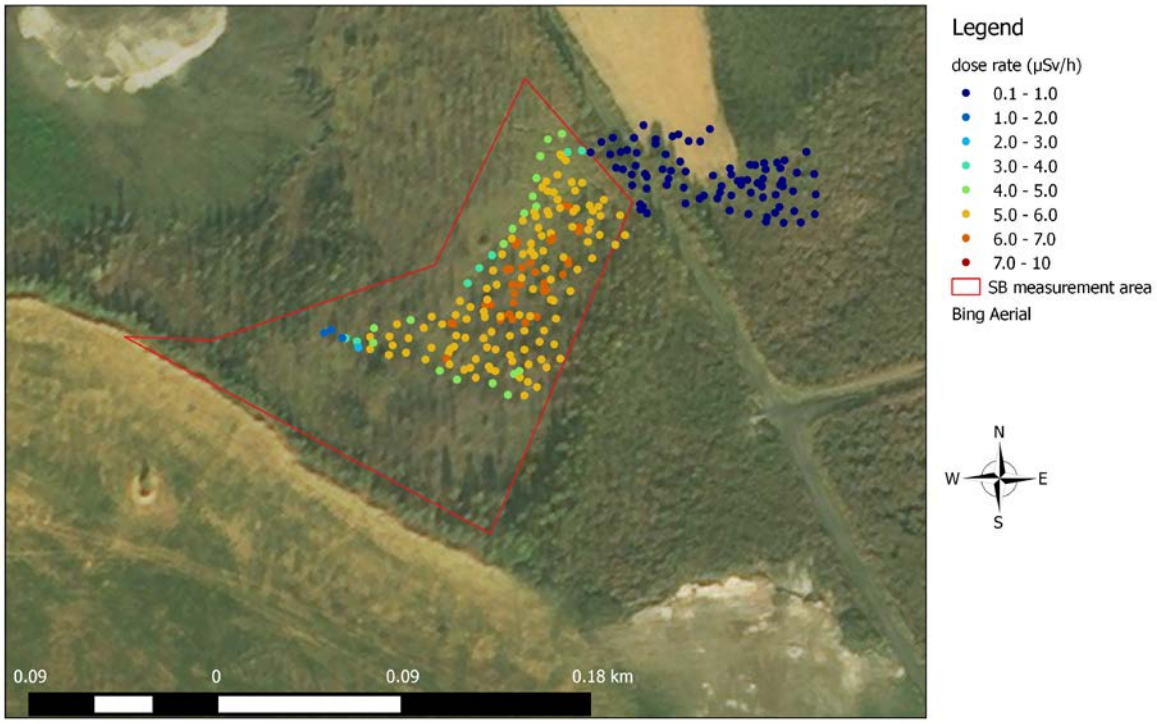
N
W E
S

SÚRO

map created in QGIS, background map: Microsoft® BingTM Maps, © 2019 DigitalGlobe, © 2019 HERE

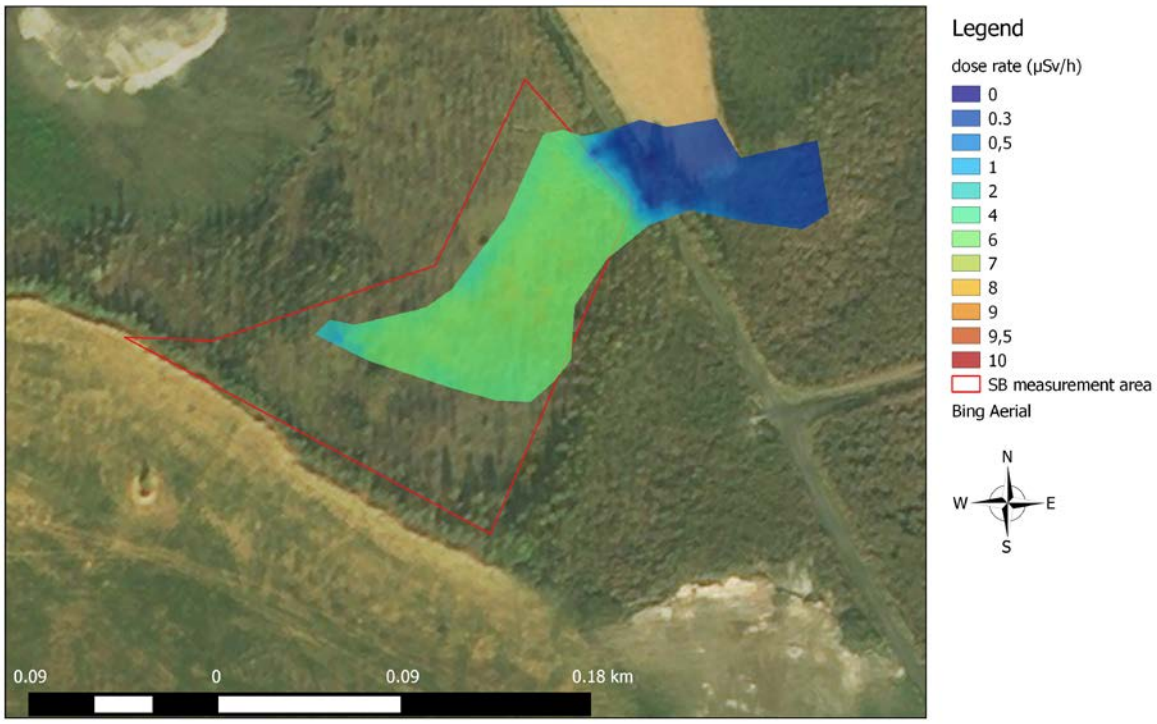
Team 4 - points

Straz 2019 International Exercise - Sludge Bed; SB - Team 4 - dose rate mapping - 2019-06-19



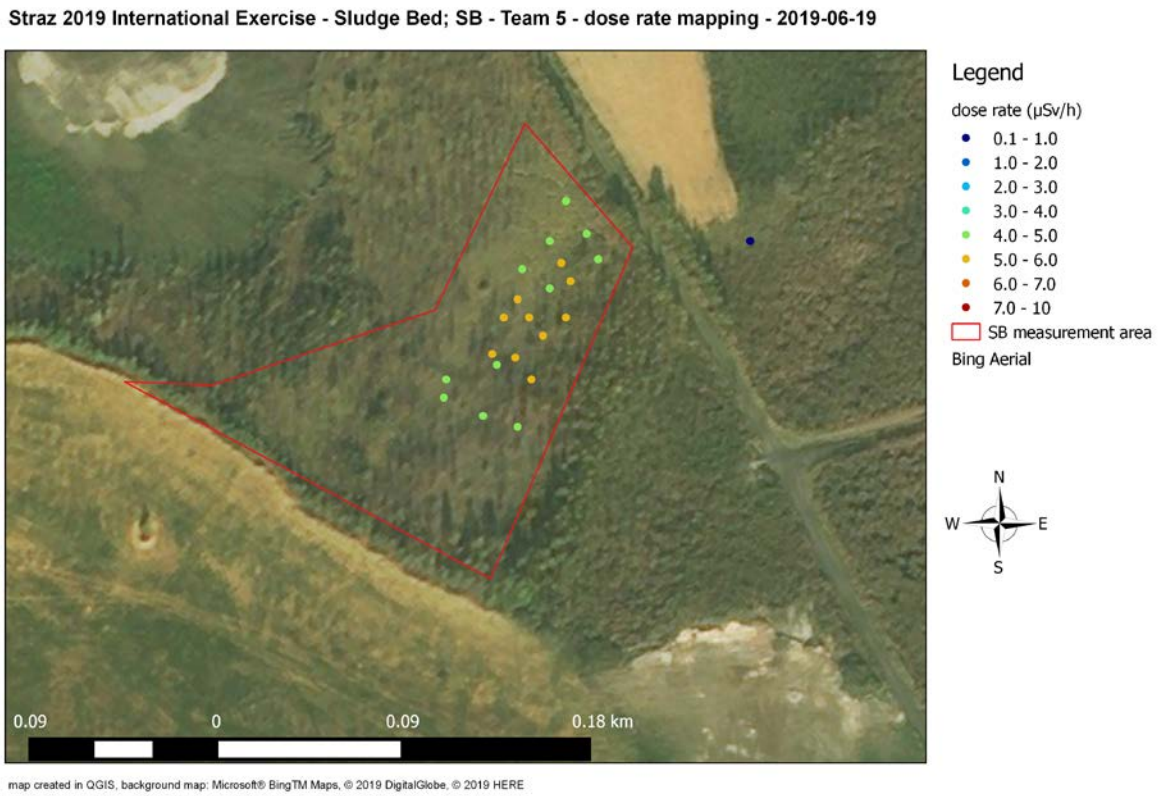
map created in QGIS, background map: Microsoft® BingTM Maps, © 2019 DigitalGlobe, © 2019 HERE

Straz 2019 International Exercise - Sludge Bed; SB - Team 4 - dose rate mapping - 2019-06-19



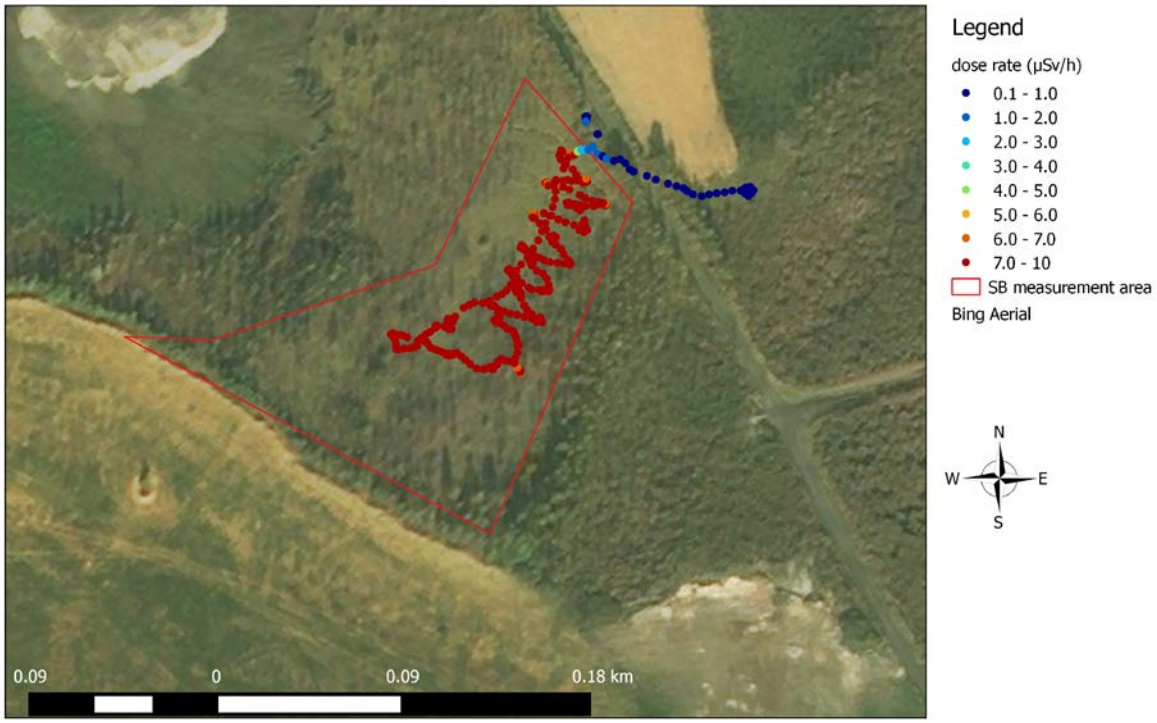
map created in QGIS, background map: Microsoft® BingTM Maps, © 2019 DigitalGlobe, © 2019 HERE

Team 5 - points



Team 6 - points

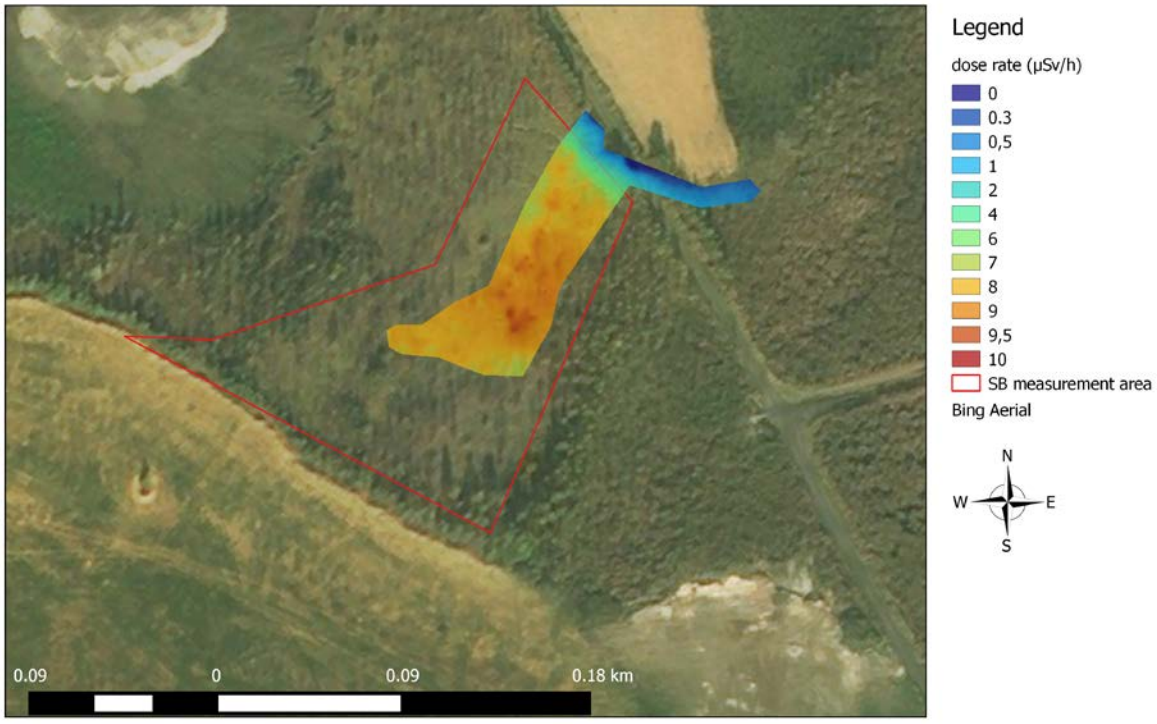
Straz 2019 International Exercise - Sludge Bed; SB - Team 6 - dose rate mapping - 2019-06-19



map created in QGIS, background map: Microsoft® BingTM Maps, © 2019 DigitalGlobe, © 2019 HERE

Team 6 - spline

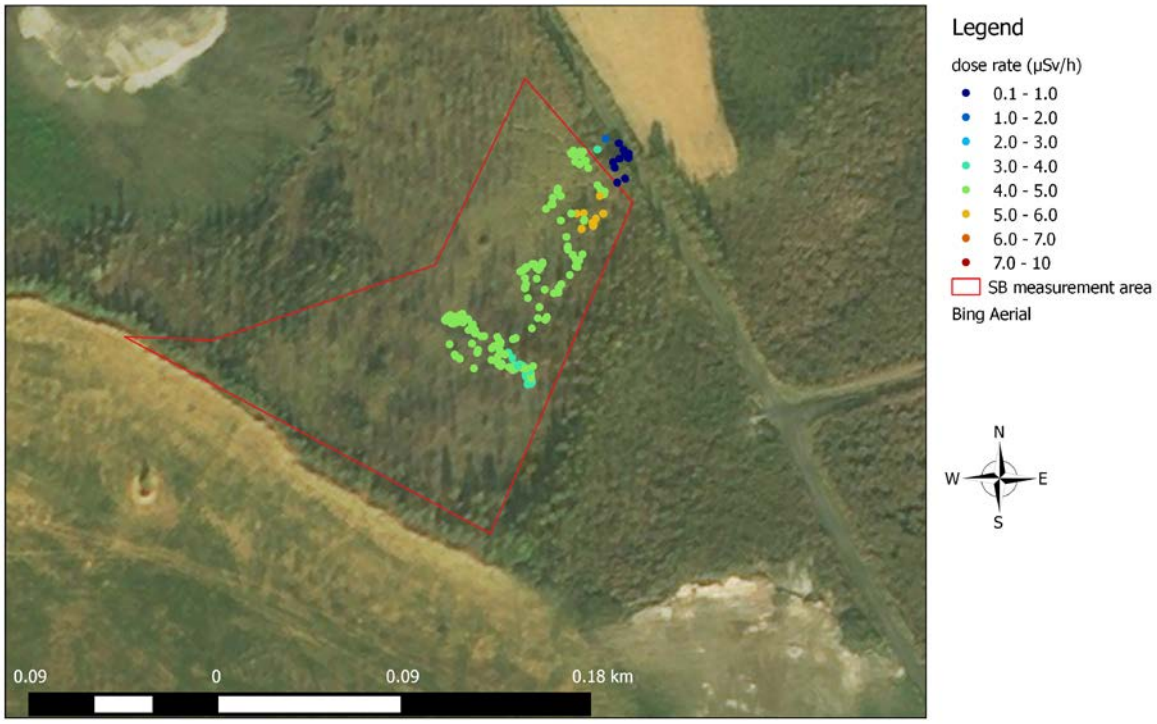
Straz 2019 International Exercise - Sludge Bed; SB - Team 6 - dose rate mapping - 2019-06-19



map created in QGIS, background map: Microsoft® BingTM Maps, © 2019 DigitalGlobe, © 2019 HERE

Team 7 – points (RT-30)

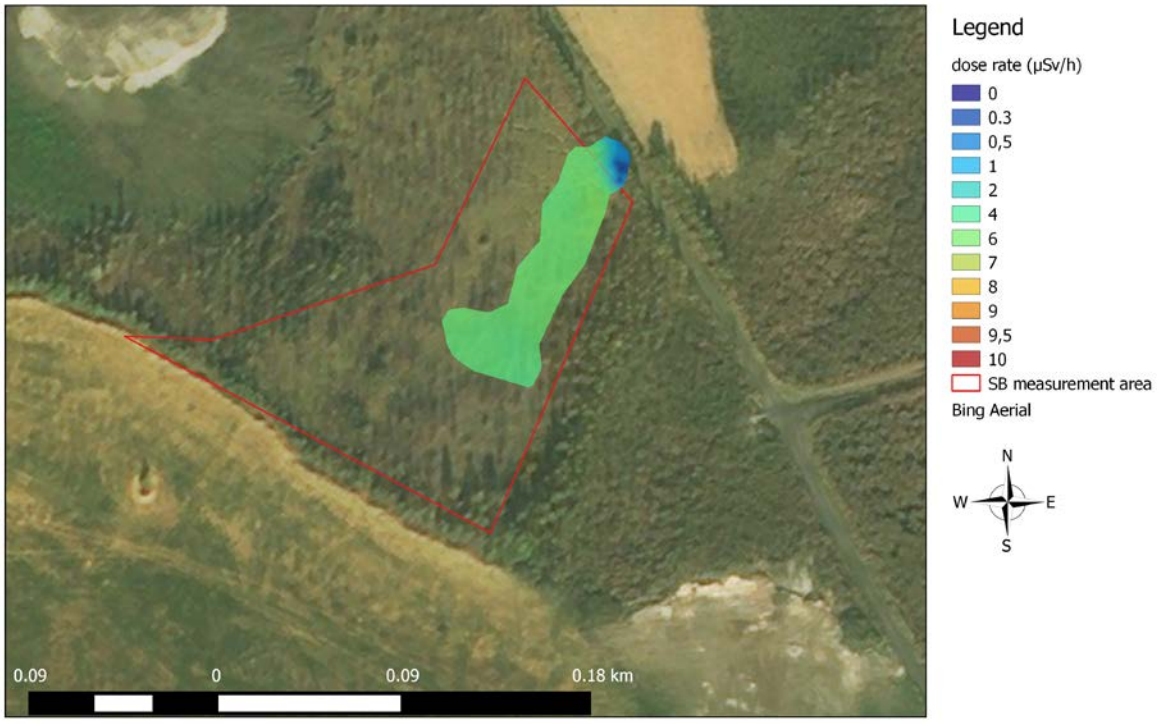
Straz 2019 International Exercise - Sludge Bed; SB - Team 7 - dose rate mapping (RT-30) - 2019-06-19



map created in QGIS, background map: Microsoft® BingTM Maps, © 2019 DigitalGlobe, © 2019 HERE

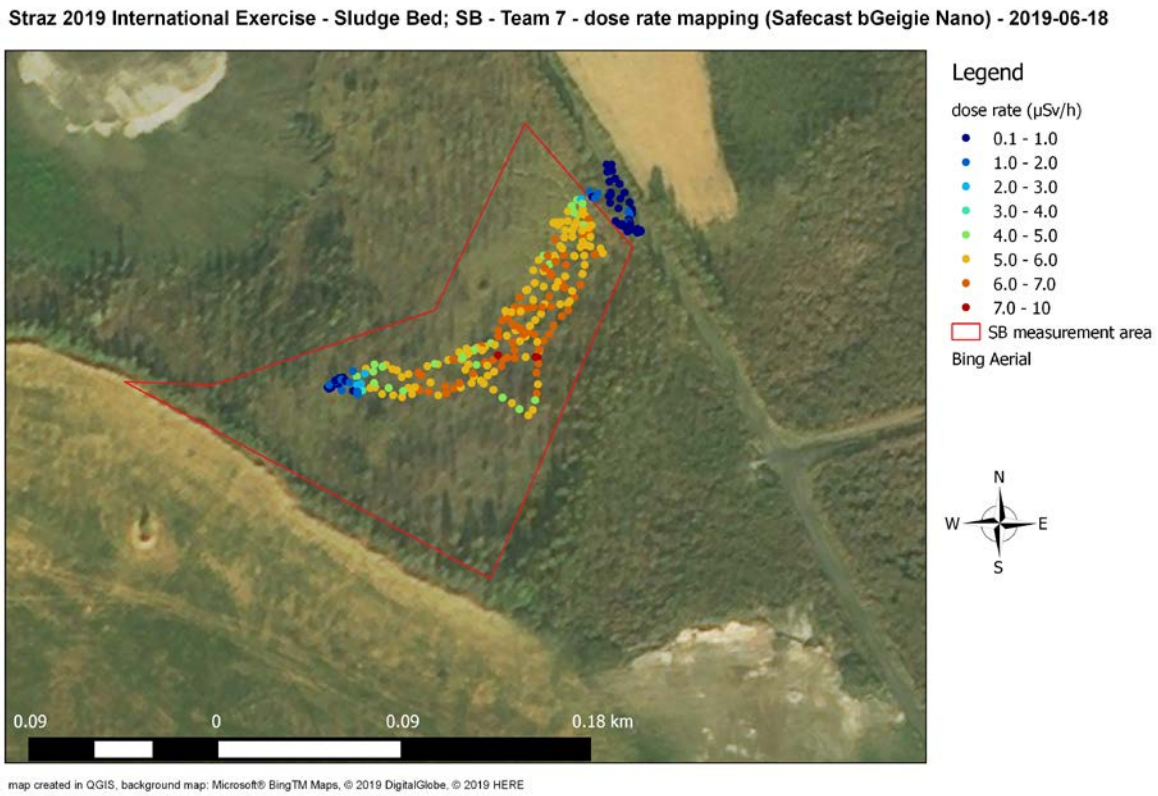
Team 7 – spline (RT-30)

Straz 2019 International Exercise - Sludge Bed; SB - Team 7 - dose rate mapping (RT-30) - 2019-06-19

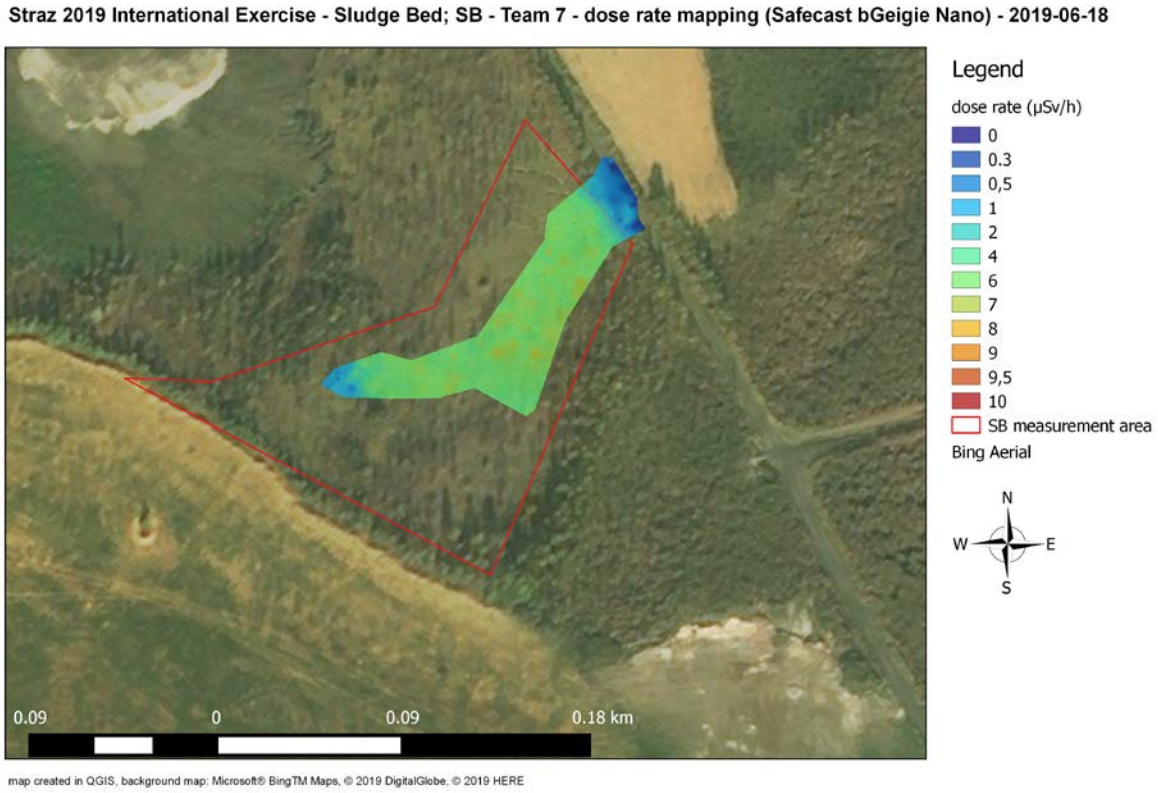


map created in QGIS, background map: Microsoft® BingTM Maps, © 2019 DigitalGlobe, © 2019 HERE

Team 7 – points (Safecast bGeigie Nano)

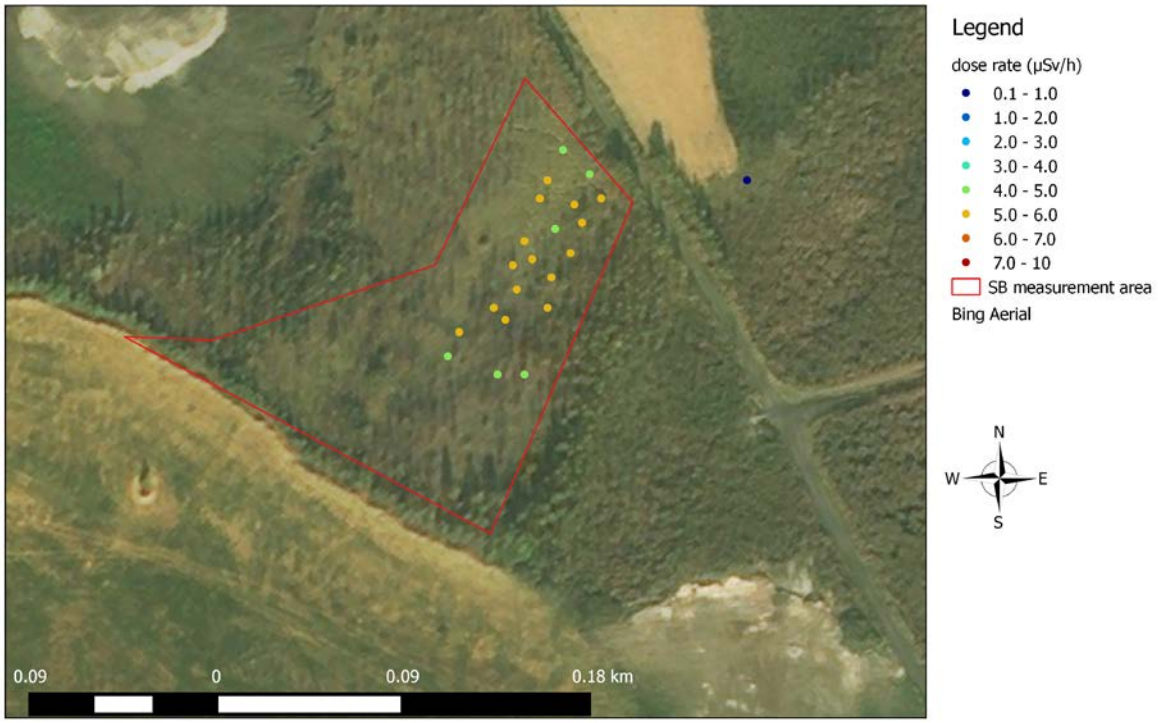


Team 7 – spline (Safecast bGeigie Nano)



Team 8 – points (FH-40)

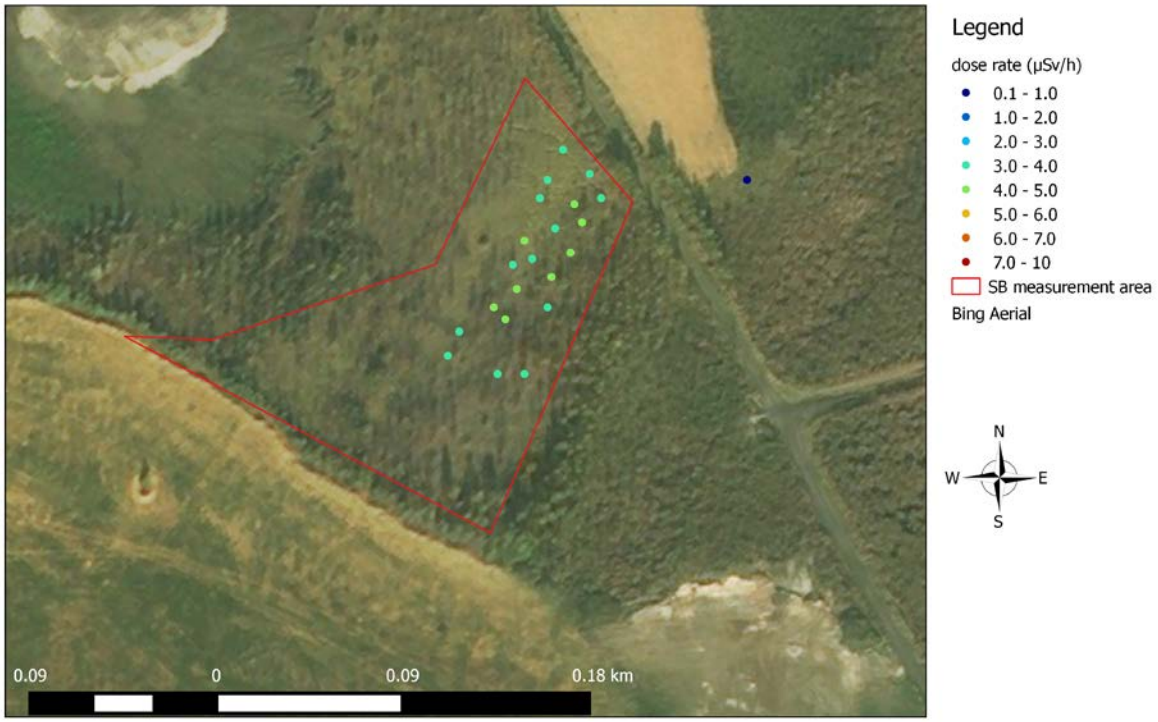
Straz 2019 International Exercise - Sludge Bed; SB - Team 8 - dose rate mapping (FH-40) - 2019-06-19



map created in QGIS, background map: Microsoft® BingTM Maps, © 2019 DigitalGlobe, © 2019 HERE

Team 8 – points (Inspector-1000)

Straz 2019 International Exercise - Sludge Bed; SB - Team 7 - dose rate mapping (Inspector 1000) - 2019-06-19



map created in QGIS, background map: Microsoft® BingTM Maps, © 2019 DigitalGlobe, © 2019 HERE

Point 6

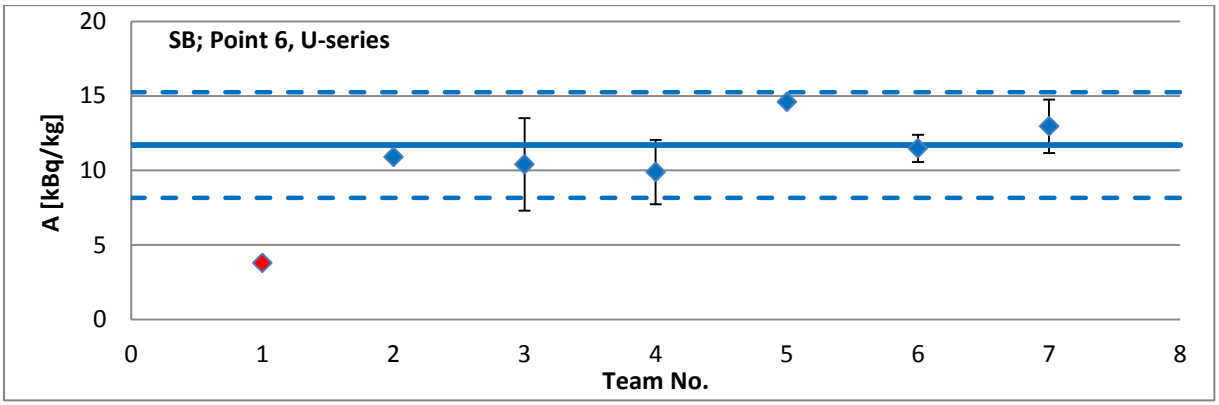


Fig 4.2.1a U-series concentration in soil; Point 6 (Mean: 11.7 ±1.8 kBq/kg)

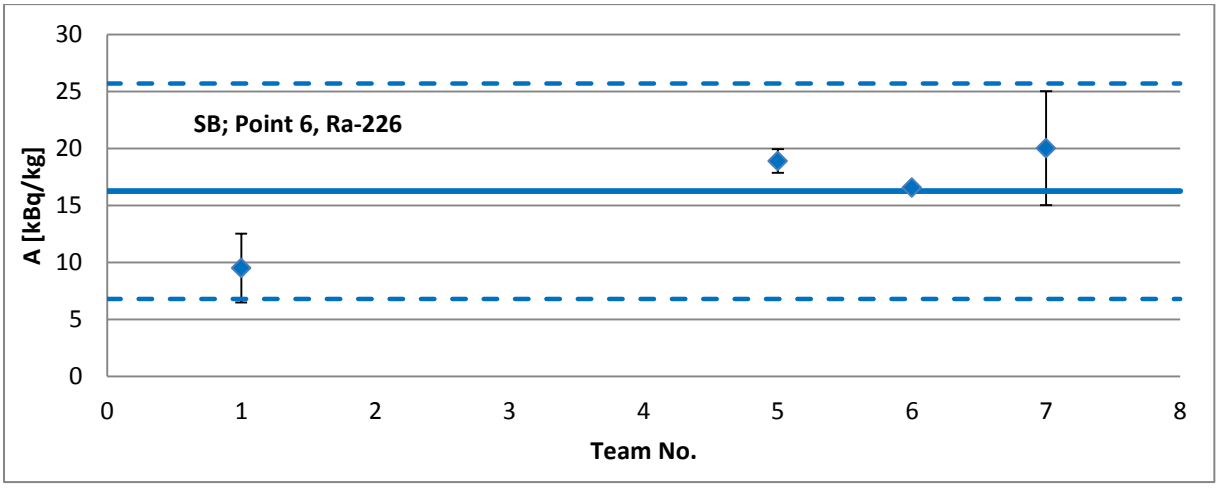


Fig 4.2.1b ^{226}Ra concentration in soil; Point 6 (Mean: 16.25 ±9.45 kBq/kg)

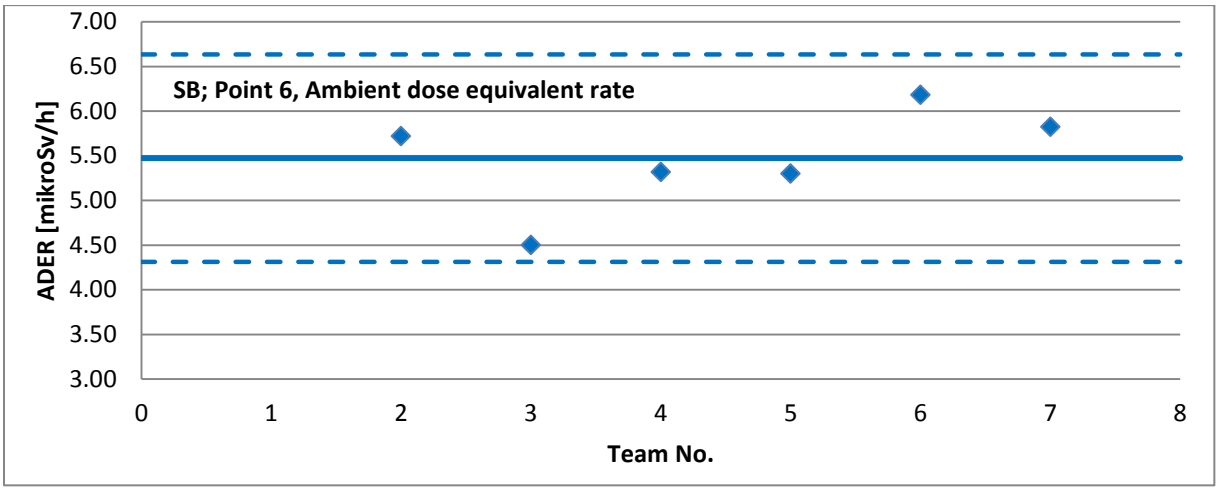


Fig 4.2.1c Ambient dose equivalent rate1 m above ground; Point 6 (Mean: 5.47 ± 1.16 mikroSv/h)

Point 15

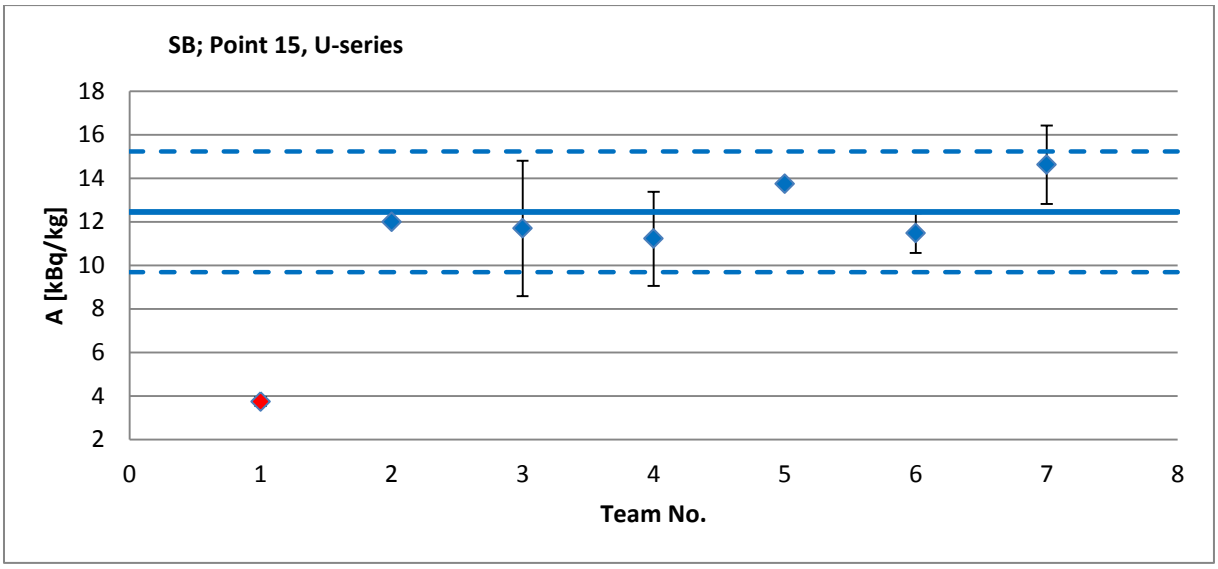


Fig 4.2.2a U-series concentration in soil; Point 15 (Mean: 12.5 ±2.8 kBq/kg)

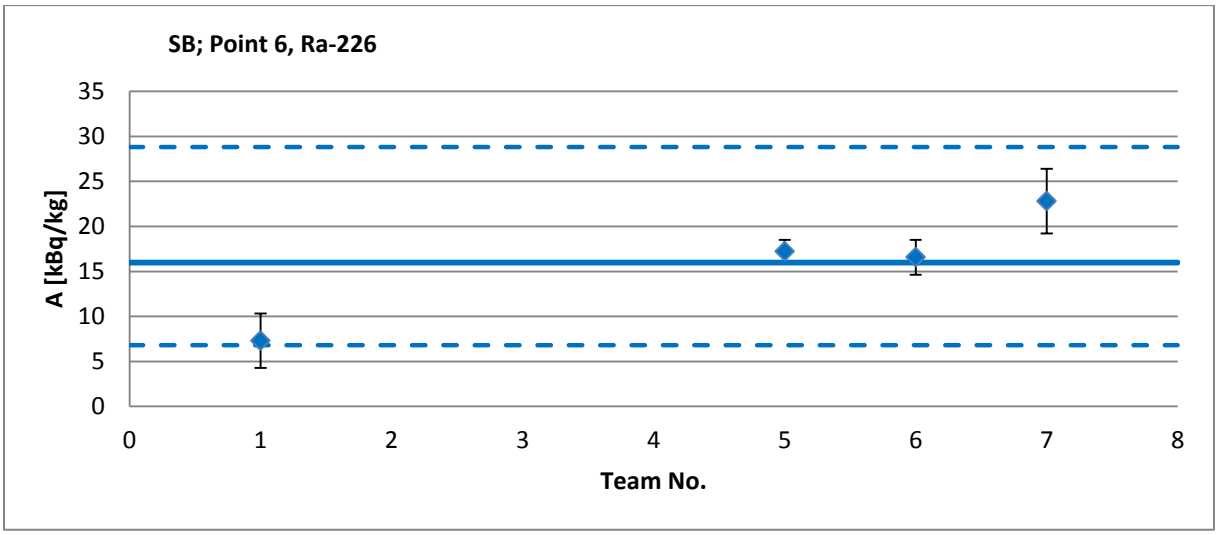


Fig 4.2.2b ^{226}Ra concentration in soil; Point 15 (Mean: 16.0 ±12.8 kBq/kg)

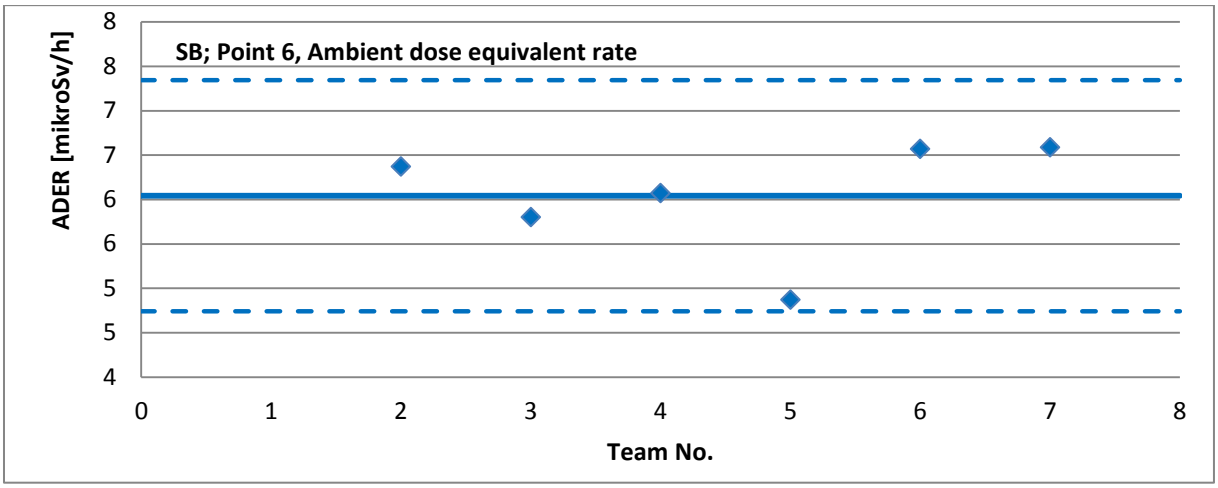


Fig 4.2.2c Ambient dose equivalent rate1 m above ground; Point 15 (Mean: 6.04 ± 1.30 mikroSv/h))

Point 23

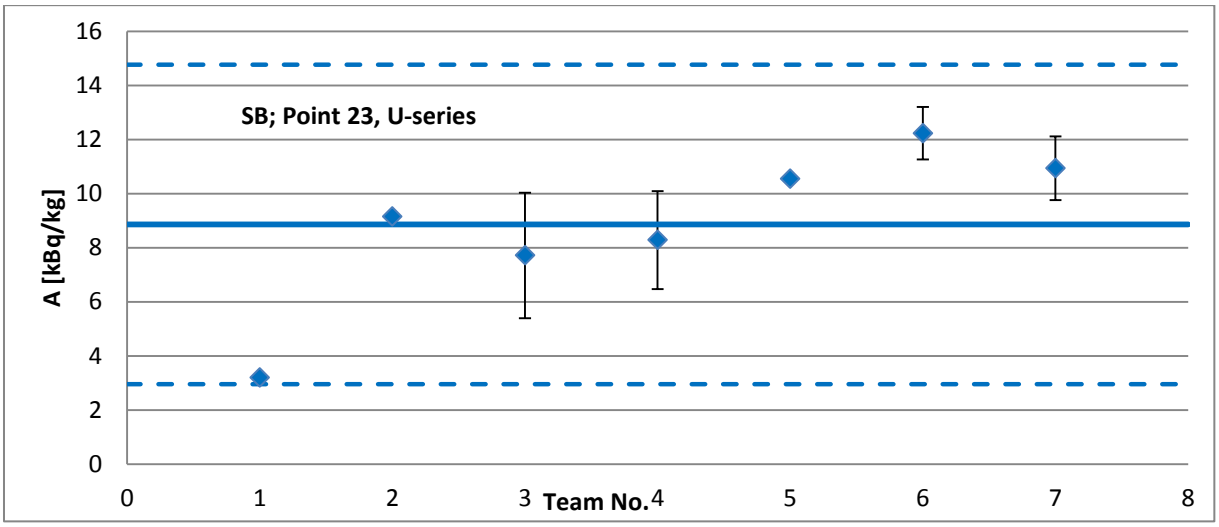


Fig 4.2.3a U-series concentration in soil; Point 23 (Mean: 8.9 ± 5.8 kBq/kg)

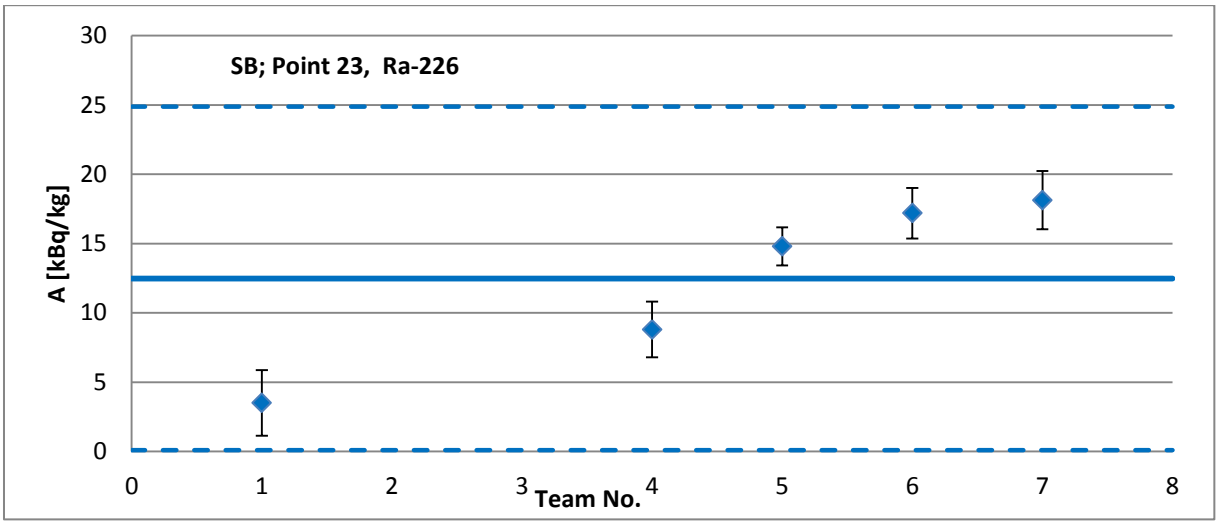


Fig 4.2.3b ^{226}Ra concentration in soil; Point 23 (Mean: 12.5 ±12.4 kBq/kg)

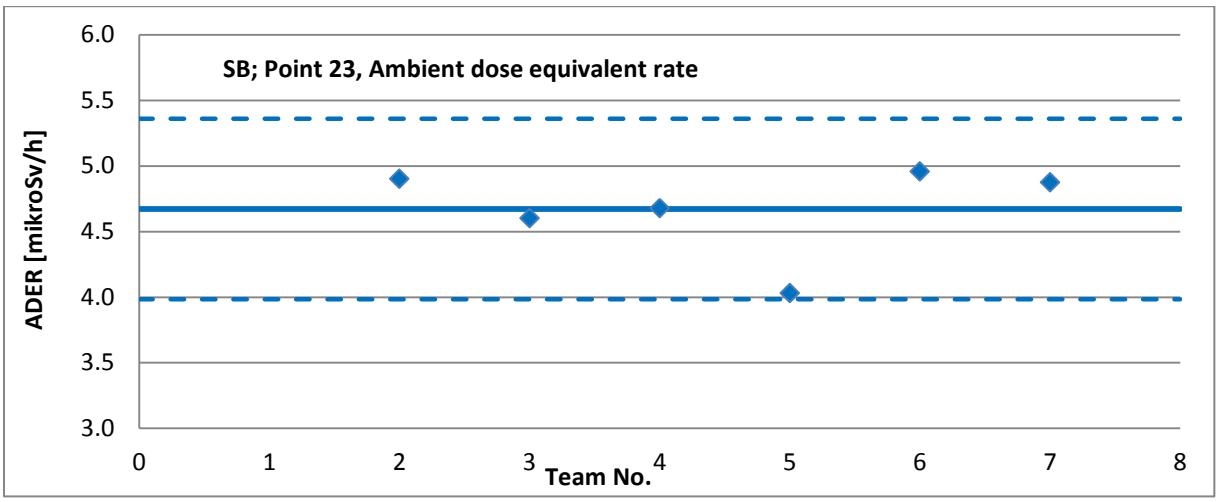


Fig 4.2.3c Ambient dose equivalent rate 1 m above ground; Point 23 (Mean: 4.67 ± 0.68 mikroSv/h)

Point 26

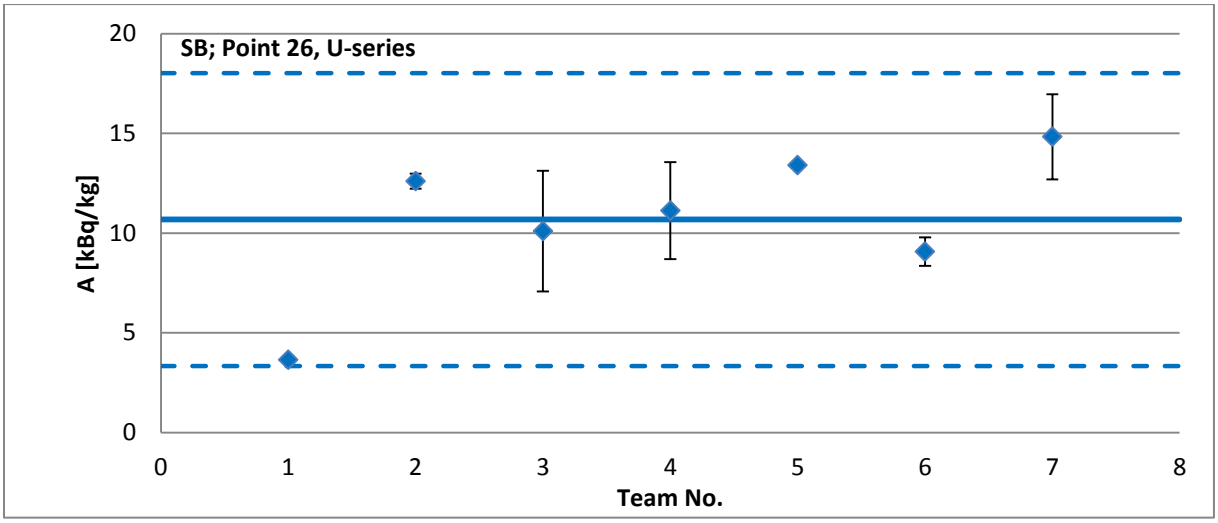


Fig 4.2.4a U-series concentration in soil; Point 265 (Mean: 10.7 ±7.3 kBq/kg)

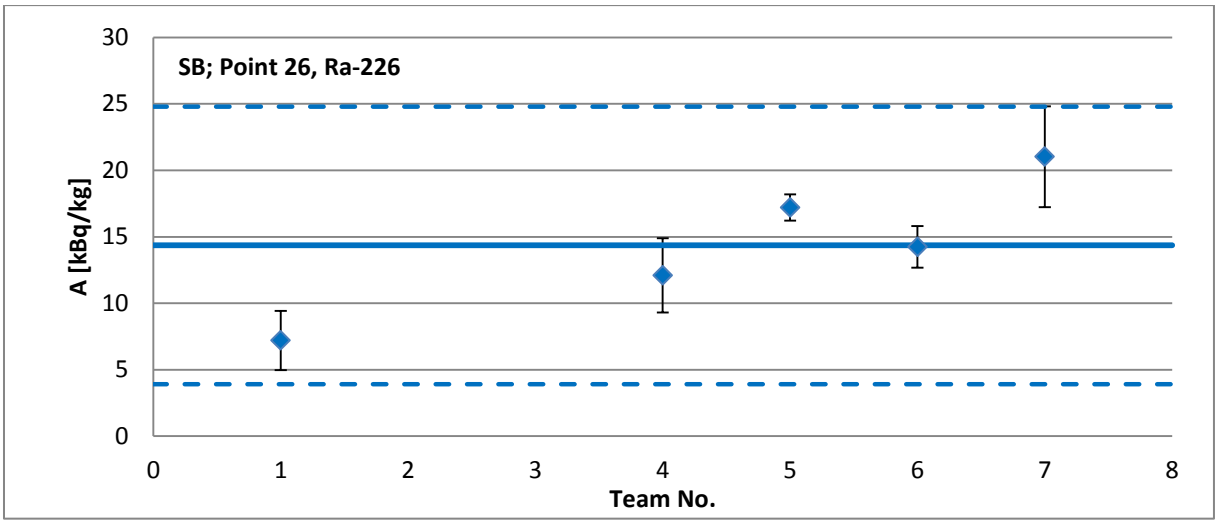


Fig 4.2.4b ^{226}Ra concentration in soil; Point 26 (Mean: 14.4 ±10.4 kBq/kg)

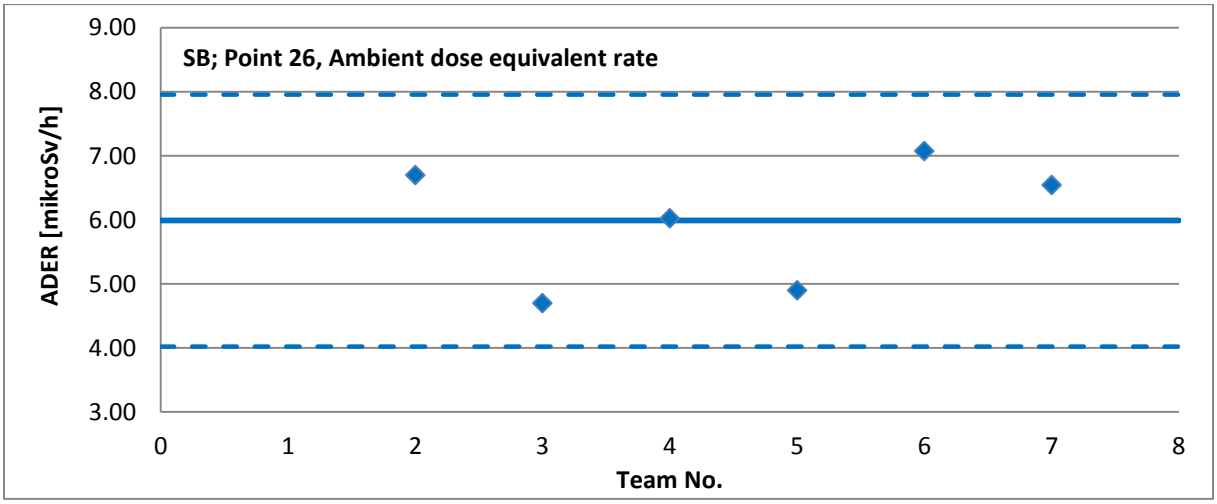


Fig 4.2.4c Ambient dose equivalent rate1 m above ground; Point 26 (Mean: 5.99 ± 0.98 mikroSv/h)

Point 30 (background)

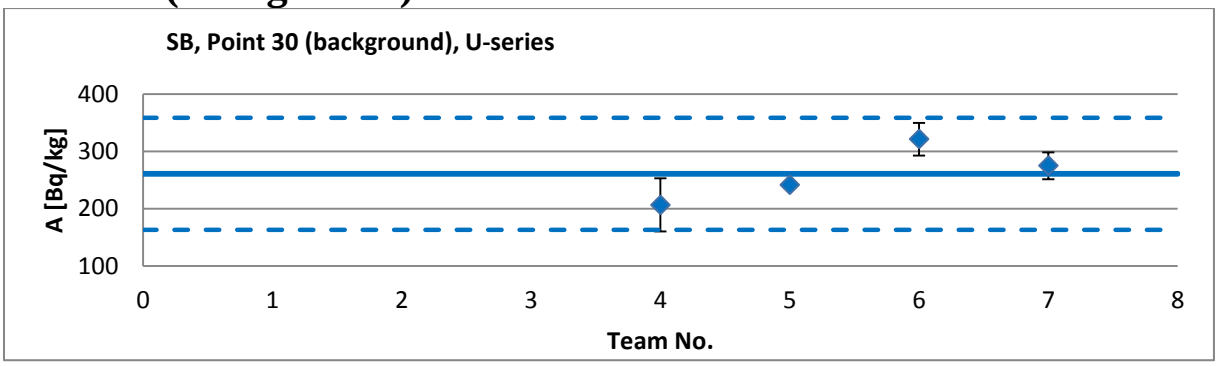


Fig 4.2.5a U-series concentration in soil; Point 5 (Mean: 260 ± 100 Bq/kg)

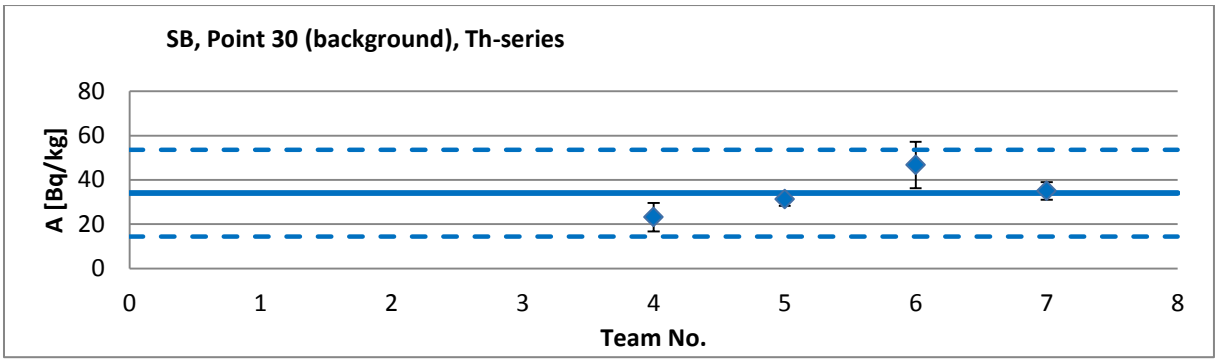


Fig 4.2.5b Th-series concentration in soil; Point 5 (Mean: 34.1 ± 19.6 Bq/kg)

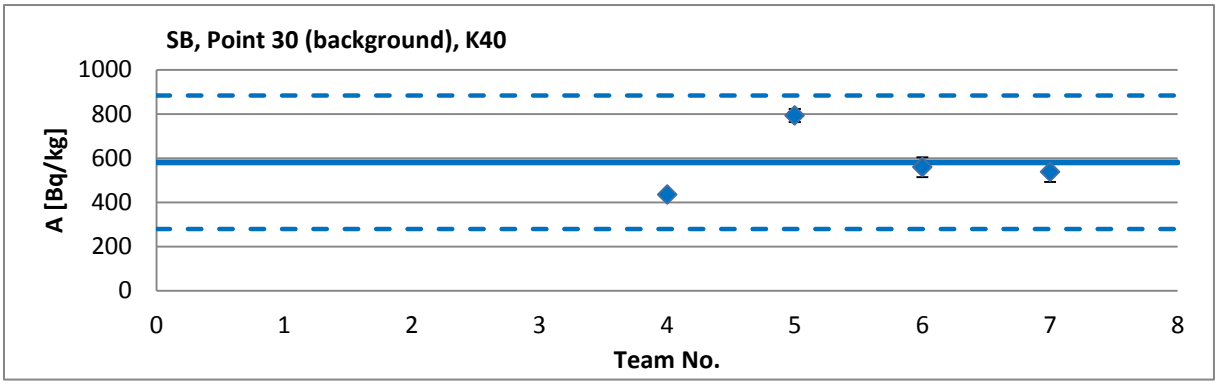


Fig 4.2.5c ^{40}K concentration in soil; Point 5 (Mean: 580 ± 300 Bq/kg)

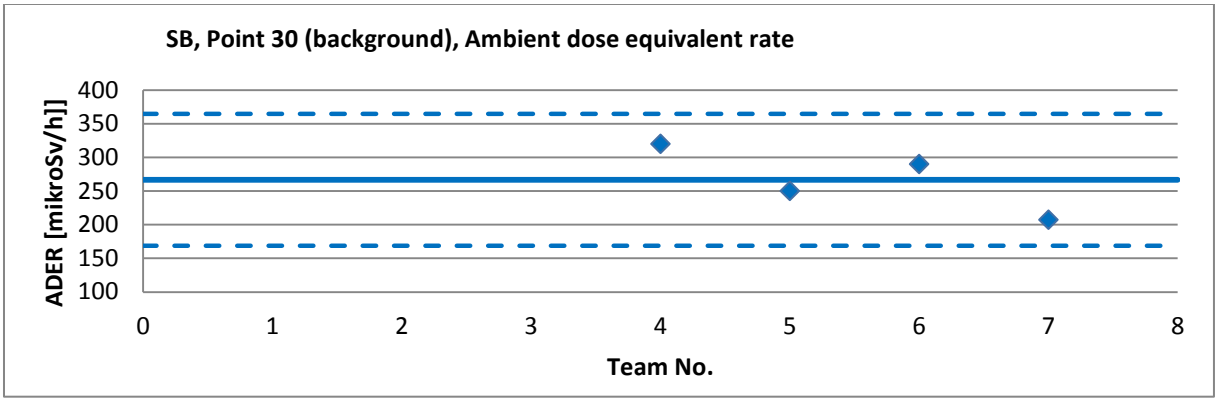


Fig 4.2.5d Ambient dose equivalent rate 1 m above ground; Point 5 (Mean: 270 ± 100 nSv/h)

4.2. Calibration

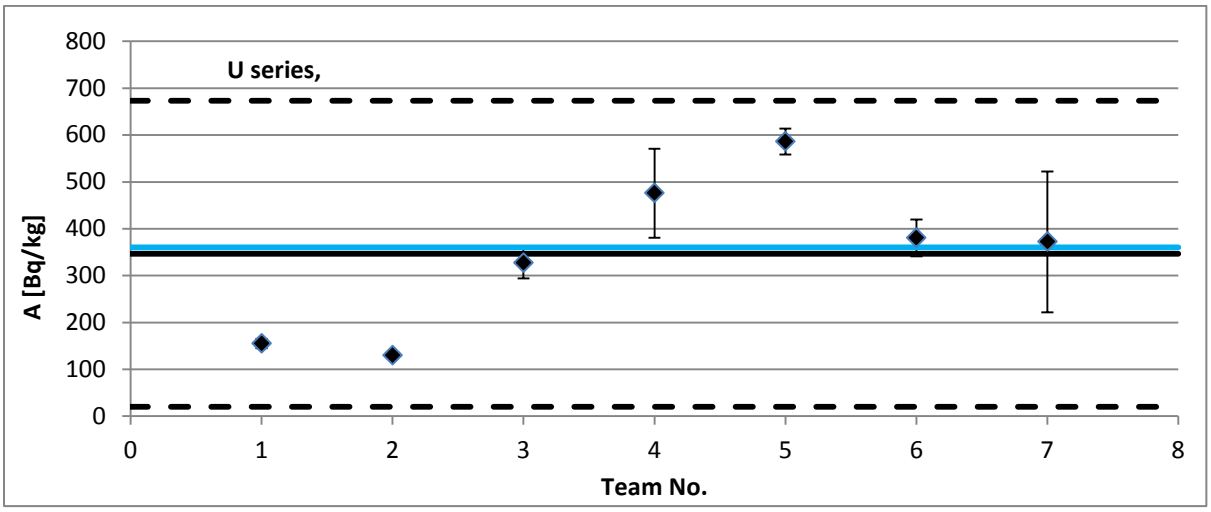


Fig 4.3.a U-series concentration in calibration pad

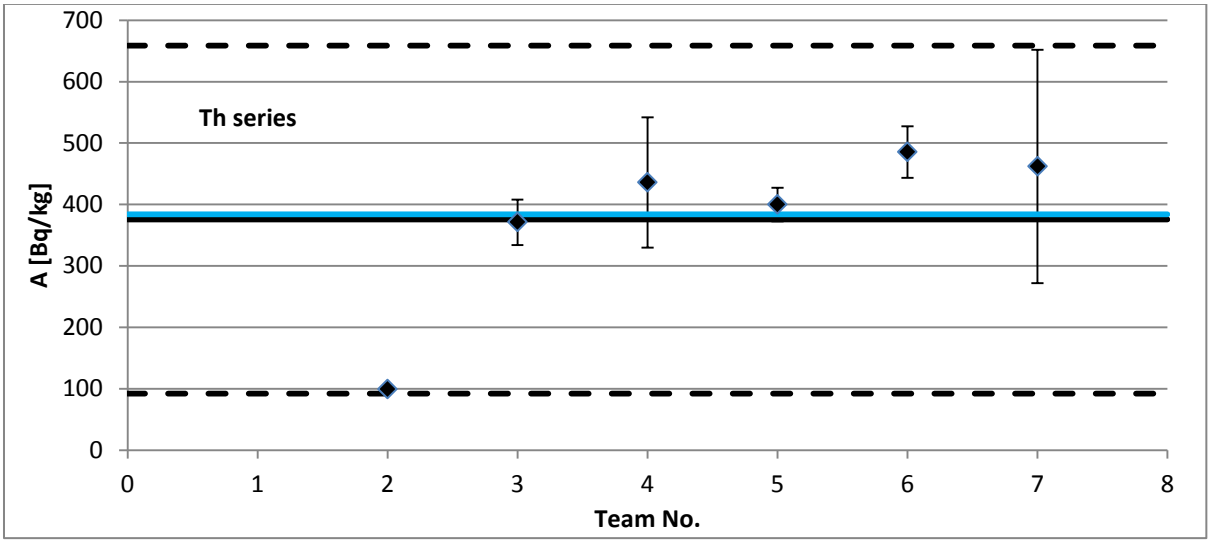
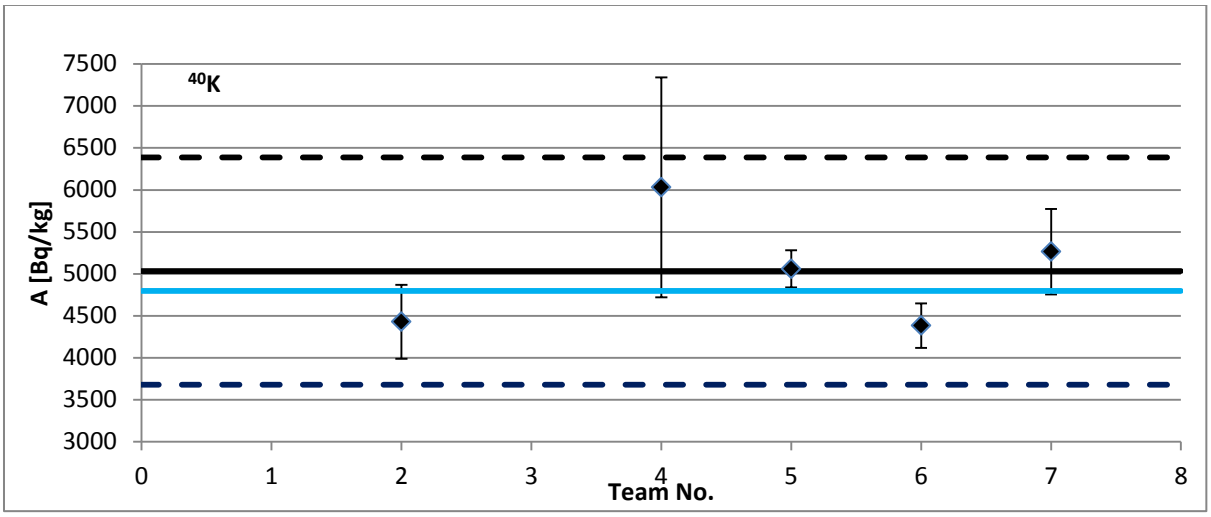


Fig 4.3.a Th-series concentration in calibration pad

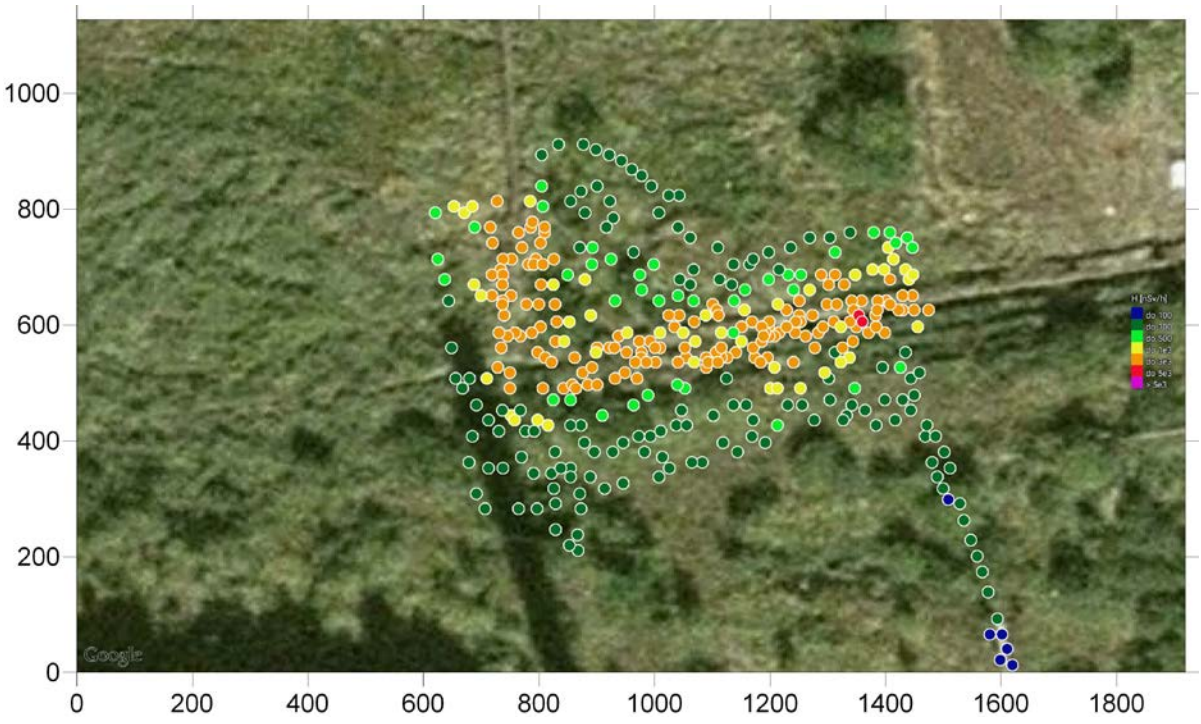


4.3.Fig 4.3.a ^{40}K concentration in calibration pad

4.4. Hamr

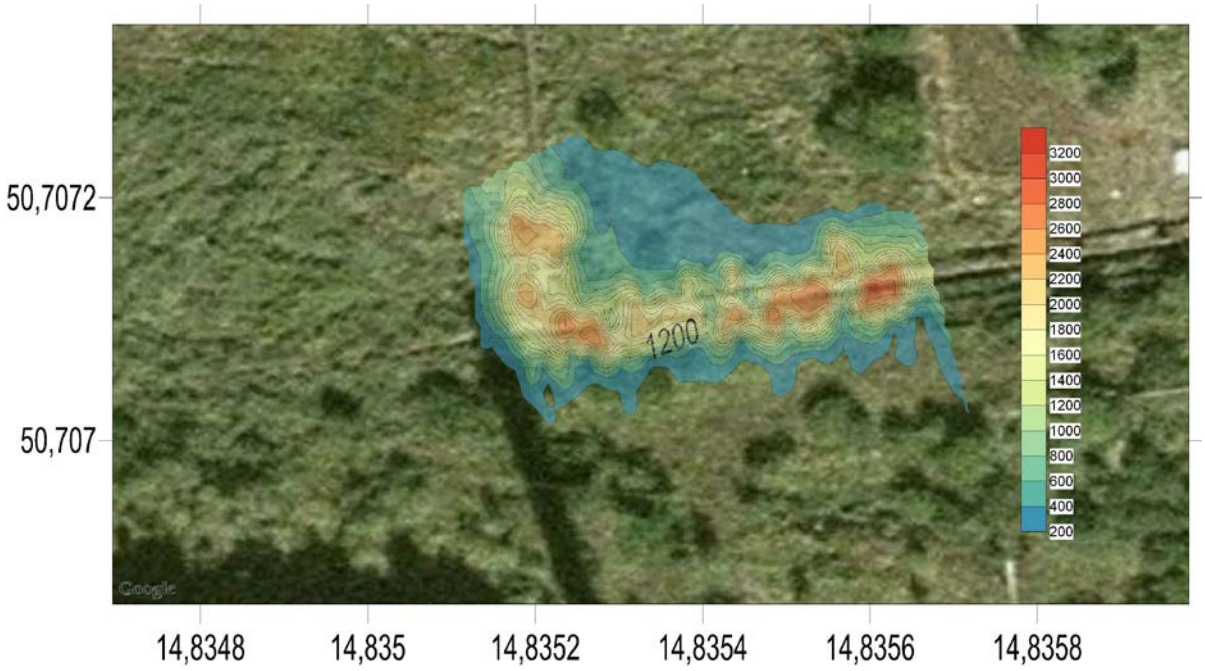
Team 4 – points

Team 4 - points

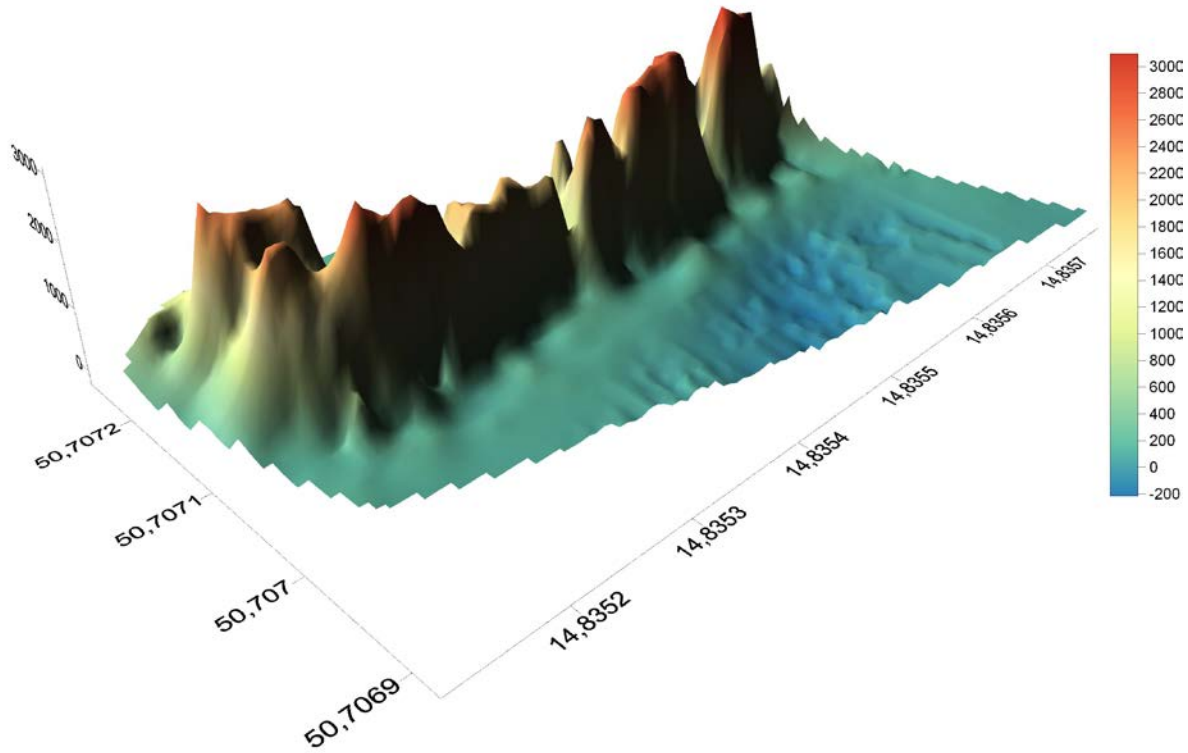


Team 4 – spline

Team 4 - interpolation

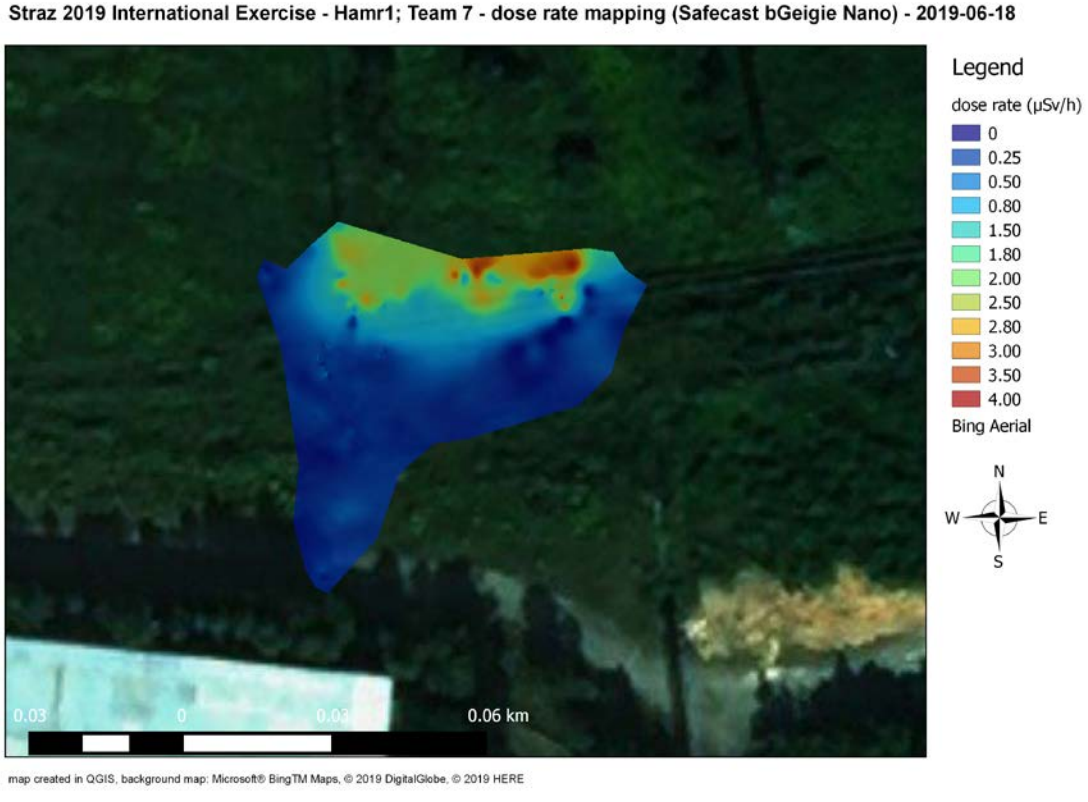


Team 4 – 3D view

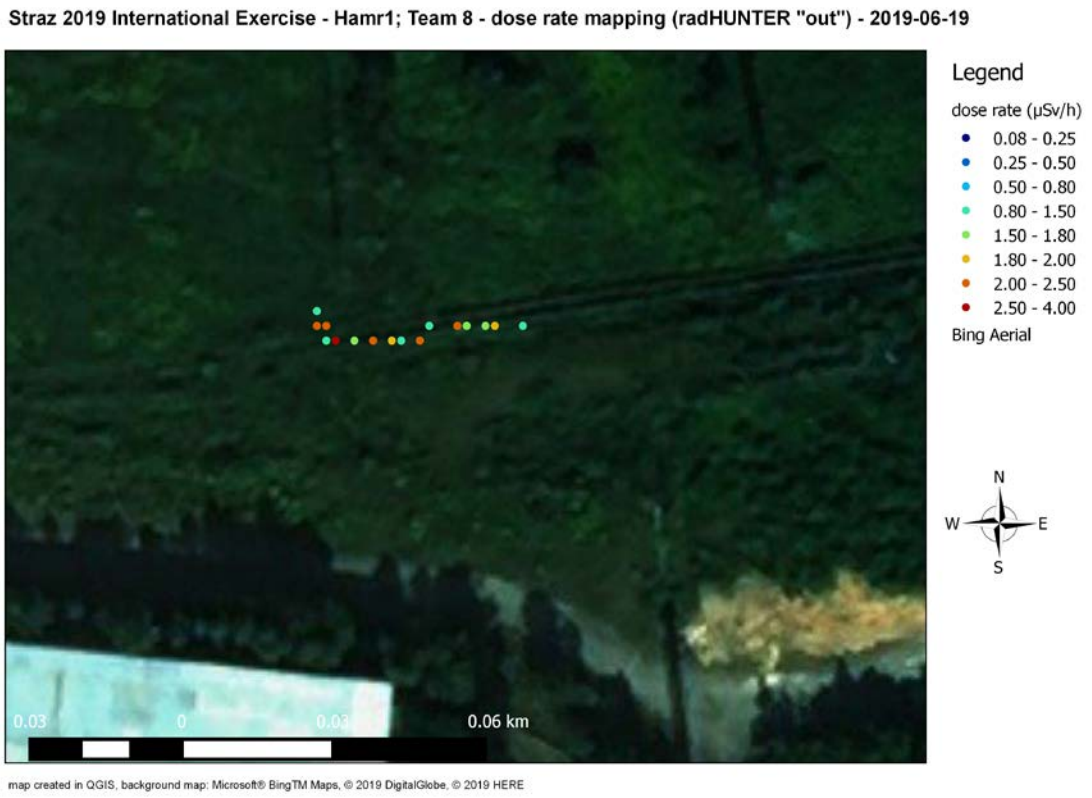


Team 7 – points (Safecast bGeigie Nano)

Team 7 – spline (Safecast bGeigie Nano)



Team 8 – points



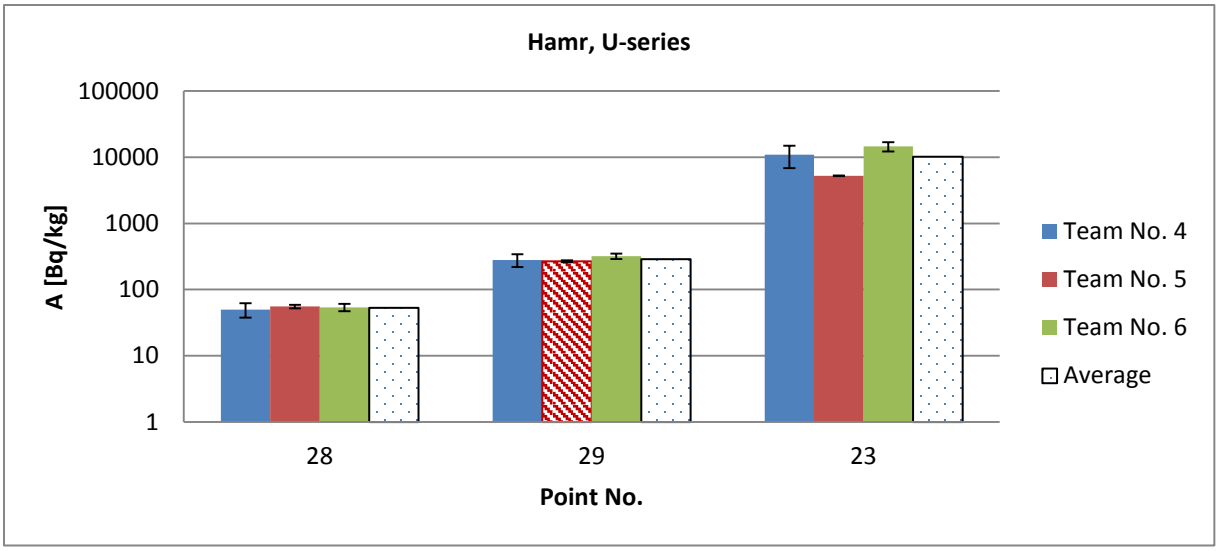


Fig 4.4.a U-series concentration in soil

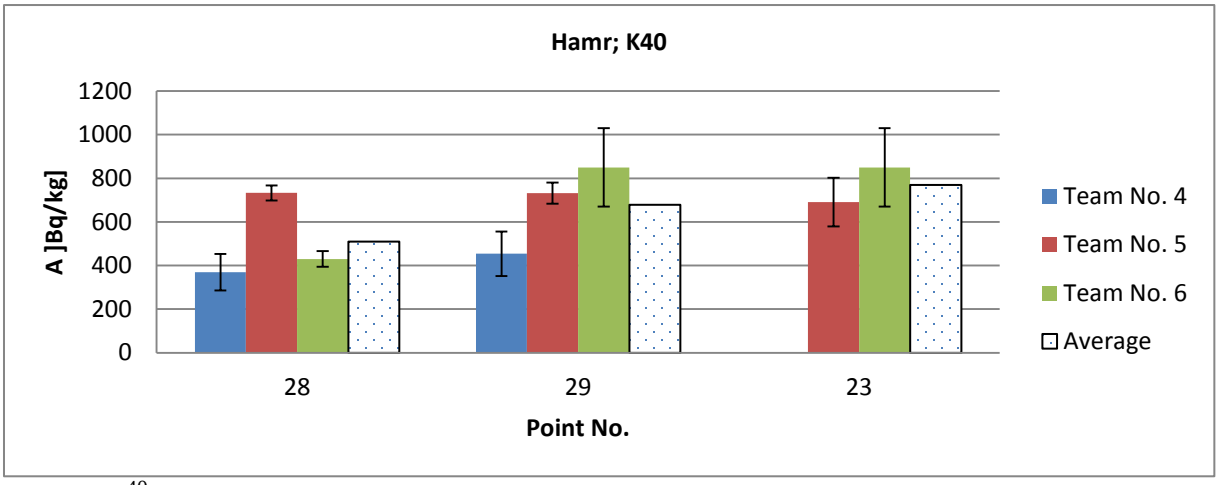


Fig 4.4.b ^{40}K concentration in soil

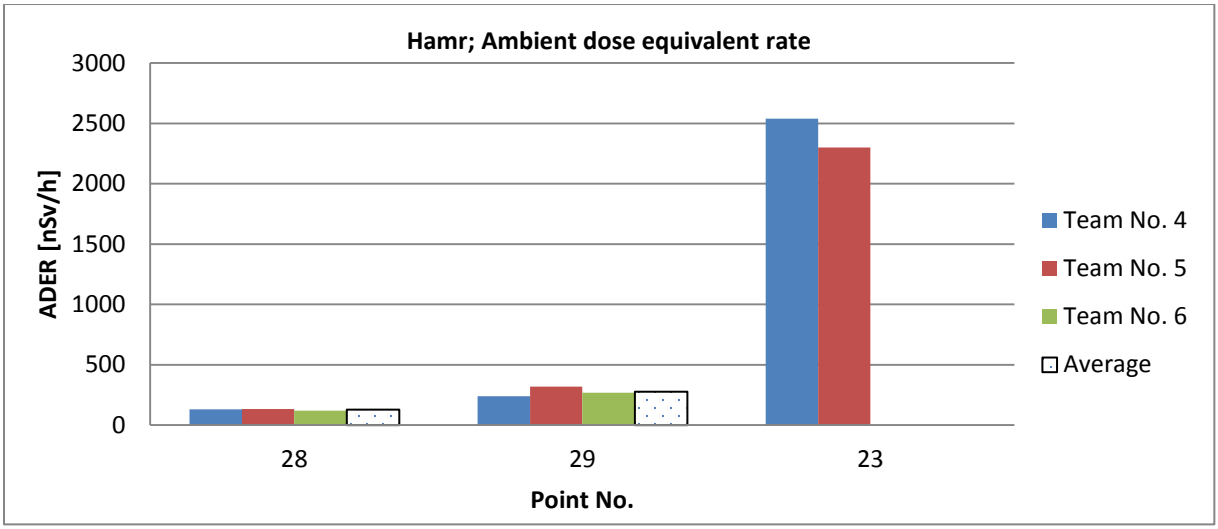


Fig 4.4.c Ambient dose equivalent rate 1m above ground

5. Conclusion and acknowledgment

8 monitoring groups from 4 EU countries - Austria, Germany, Slovenia and the Czech Republic attended the “Straz 2019” Exercise. During the exercise the groups measured 3 sites affected by earlier uranium ore mining. A part of the exercise was measurement on calibration pads in Diamo Company and on the school reactor.

The report summarizes the measurement results of all monitoring groups.

Finally, we would like to thank:

- Diamo, state enterprise, for enabling measurements
- Military Forests and Farms of the Czech Republic, state enterprise, for enabling measurements
- Czech Technical University, Faculty of Nuclear Sciences and Physical Engineering for providing possibility to measure on the MONTE simulator at the school reactor in Prague
- CANBERRA-PACKARD spol. s. r. o. for organization Exercise dinner