IAF - Radioökologie GmbH

Radionuclide Laboratory | Radiation Safety | Radiological Consultants

Radiological characterisation of areas for future wind park

Mirny Project, Kazakhstan

Client:	WSP ITALIA s.r.l. Banfo43 Centre via Antonio Banfo 43 10155 Tonno Italy
Project:	Mirny Project, Kazakhstan
Project number:	240715-05
Contractor:	IAF-Radioökologie GmbH
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Radeberg, 25.08.2024

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DAkkS Deutsche Akkreditierungsstelle D-PL-11201-01-00

The accreditation is valid for the scope as listed in the annex to the certificate D-PL-11201-01-00.

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1 Executive Summary

IAF-Radioökologie GmbH (IAF) has been contracted by WSP ITALIA s.r. l. (WSP) to carry out a radiological characterisation of the area of a future wind farm to be built by Total in Southern Kazakhstan, Zhambylskaya oblast', south-west of Lake Balkhash and approximately 300 km north-west from Almaty. Due to the presence of uranium mining facilities in the wider area there are concerns over a potential radioactive contamination of the project site. Therefore, a radiological baseline study has been carried out within the project area and closer to the uranium mine.

The field work activities were carried out in the period 8-10 July 2024. For the radiological characterisation of the project area, the following steps were carried out:

- A survey of the ambient gamma dose rate H*(10) was carried out with a total of 135 measuring points,
- 15 representative soil samples were taken and analysed by gamma-spectrometry in the accredited laboratory of IAF, and
- Two water samples from local wells were taken and analysed for radionuclides regulated by the WHO in the context of drinking water, i.e., U-238, U-234, Ra-226, Pb-210, Po-210, and Ra-228, in the accredited laboratory of IAF.

Based on the site and laboratory investigations, the following conclusions can be drawn:

1. The average ambient gamma dose rate in the area (apart from the spots near the former uranium open pit mine) is 91 nSv/h. Assuming an annual exposure time of 8760 hours[1] and a dose conversion factor of H*(10) to the effective dose of 0.6 [zzz], the annual effective dose from direct exposure would be 0.47 mSv, which is well below the reference level of 1 mSv per year for members of the public.
2. The gamma dose rates are well within the natural background distribution found in other places throughout Asia, and that there are no indications of radioactive contamination. It is not surprising that the two highest gamma dose rates were measured near the open pit of the former uranium mine.
3. The specific activities of all natural nuclides are well within the natural background of 50 Bq/kg for the U-238 series and 40 Bq/kg for the Th-232 series, respectively. None of the samples shows an indication of radioactive contamination.
4. The correlation between ambient gamma dose rate at the sampling points measured in the field and the dose rate calculated from the specific activity of the soil samples is satisfactory and does not indicate any inconsistencies or outliers.
5. According to the current official WHO guidance, only water from well WS 3 is unfit for human consumption as its uranium concentration exceeds the guidance level. The uranium concentration in well water at WS 2 is below the current WHO guidance. However, since Kazakhstan has not set a definite concentration limit for uranium in drinking water but uses WHO guidance, which has changed over the past years, it is

[1] Workers are assumed to spend the full day in the project area since they would also sleep and spend their leisure time in the project area. This approach differs from the common assumption of 2000 h per year in a conservative way.

recommended to seek clarification with the Kazakh health authorities which toxicological limit for uranium should be applied.

6. The water of both wells is fit for human consumption from a radiological point of view. Neither of the well water samples exceeds the maximum total indicative dose of 0.1 mSv/a according to current WHO guidance and EU regulations.

2 Introduction and Background

IAF-Radioökologie GmbH (IAF) has been contracted by WSP ITALIA s.r. l. (WSP) to carry out a radiological characterisation of the area of a future wind farm to be built by Total.

IAF-Radioökologie GmbH is a Notified Expert Organisation according to Art. 172 (1) No. 2 of the German Radiation Protection Act for NORM workplaces, approved by the Saxon Ministry for Energy, Environment and Agriculture. Dr. Christian Kunze is a certified expert working under the notification. IAF also operates an accredited radionuclide laboratory according to ISO/IEC 17025:2018.

The future wind park will be sited in Southern Kazakhstan, Zhambylskaya oblast', south-west of Lake Balkhash and approximately 300 km north-west from Almaty, see Figure 1. The boundaries of the project site are shown in Figure 2. An access road will be leading to the site from the NE, whereas the positions of the power line pylons are not yet fully known. To the north east, an open pit uranium mine is located. Its minimum distance from the project area is approximately 20 km. The lateral dimensions of the project area in SW-NE and NW-SE direction, respectively, are approximately 56 km x 10 km.

Due to the presence of uranium mining facilities in the wider area there are concerns over a potential radioactive contamination of the project site. Therefore, a radiological baseline study has been carried out within the project area and closer to the uranium mine. The radiological baseline study is also a precondition of a radiological risk assessment for the construction and operation of the wind park.

Figure 1 Map of Kazakhstan (source: Google Maps), with the approximate location of the planned wind park (red rectangle)

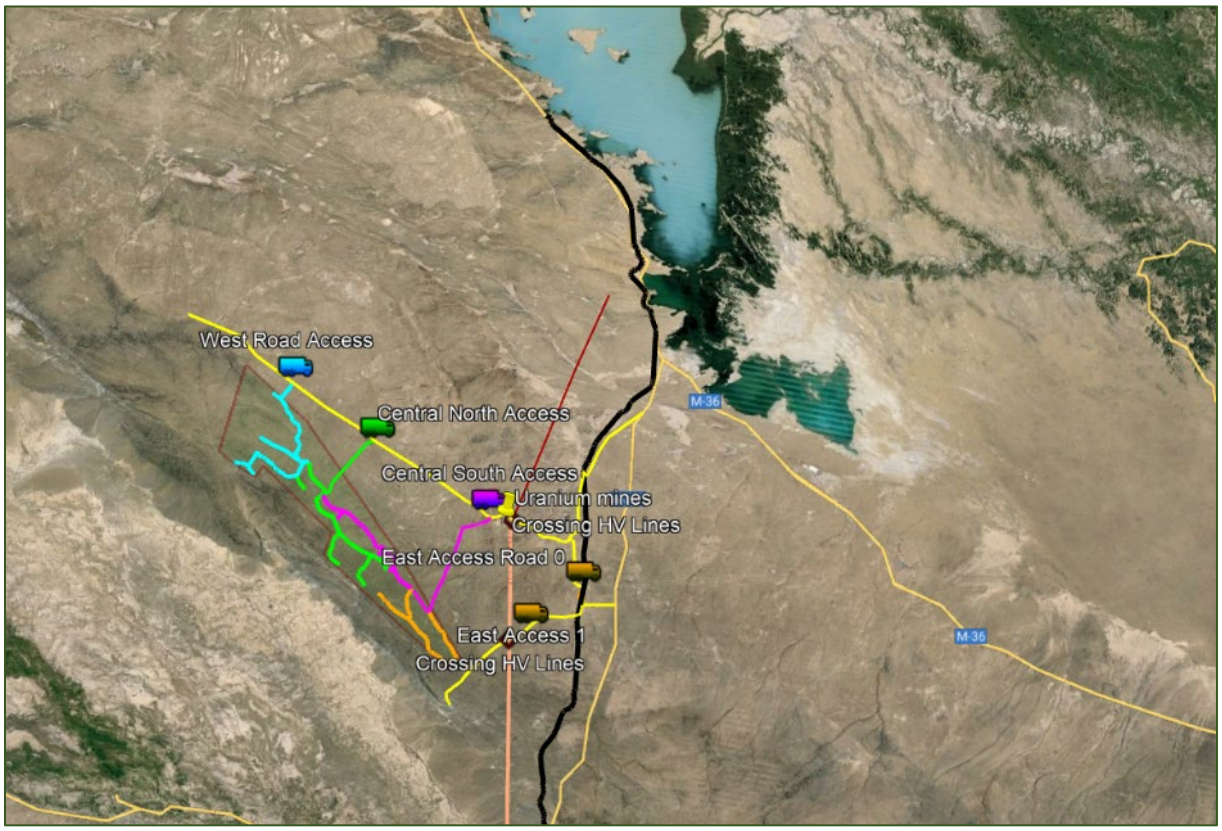

Figure 2 Project site (brown perimeter) and uranium mine (yellow pin) with a minimum distance of 20 km to the NE [1] (base map: Google Earth)

The exposure situation considered in this assessment belongs to the category of “existing exposure situations” in the terminology of the International Commission on Radiation Protection, i.e., “exposure situations that already exist when a decision on control has to be taken, such as those caused by natural background radiation” [2].

3 Field work and laboratory analyses

The field work activities were carried out in the period 8-10 July 2024. For the radiological characterisation of the project area, the following steps were carried out:

1. Survey of the ambient gamma dose rate H*(10) (in units of nSv/h); the grid size is adapted to the time available for fieldwork and the logistical requirements. The measurement points should be evenly distributed over the entire project area and include access roads. Near hot spots (if there are any) the grid size should be reduced to between 10 x 10 m² to 50 x 50 m², in order to delineate contaminated material that should be avoided or removed during future works. The dose rate is recorded together with GPS co-ordinates. For practical reasons, given the lateral extensions of the site, the survey was carried out by car.
2. 15 representative soil samples were taken. The samples were analysed by gamma spectrometry for the natural radionuclides U-238, Ra-226, Pb-210, Ra-228, Th-228, K-40.
3. Two water samples from local wells were taken and analysed for radionuclides regulated by the WHO in the context of drinking water [3], i.e., U-238, U-234, Ra-226, Pb-210, Po-210, and Ra-228.

Detailed survey and sampling instructions were given to, and discussed with, the field team prior to the site visit (see Appendix 1). The fieldwork was carried out by WISUTEC Central Asia LLC, Bishkek.

For the survey, a dose rate meter automess Teletector 6122M, calibrated in units of H*(10) was used. The radionuclide analyses were carried out in the DIN EN/ISO 17025:2018 accredited laboratory of IAF.

The following photographs provide a visual impression of the project area where the gamma dose rate surveys and soil sampling were carried out, and of the two water sampling points. Figure 5 shows the open pit of a former uranium mine.

Figure 3 Typical view of the project area

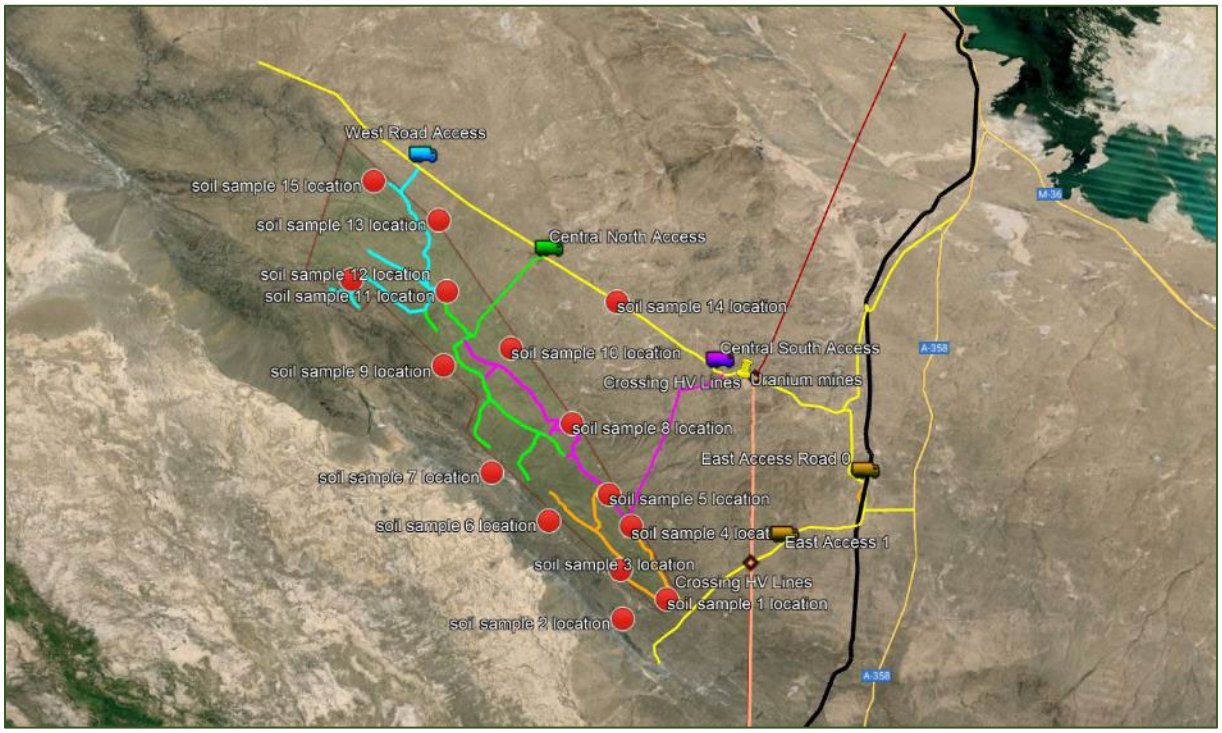

Figure 4 Map with soil sampling points

Figure 5 Open uranium mine pit

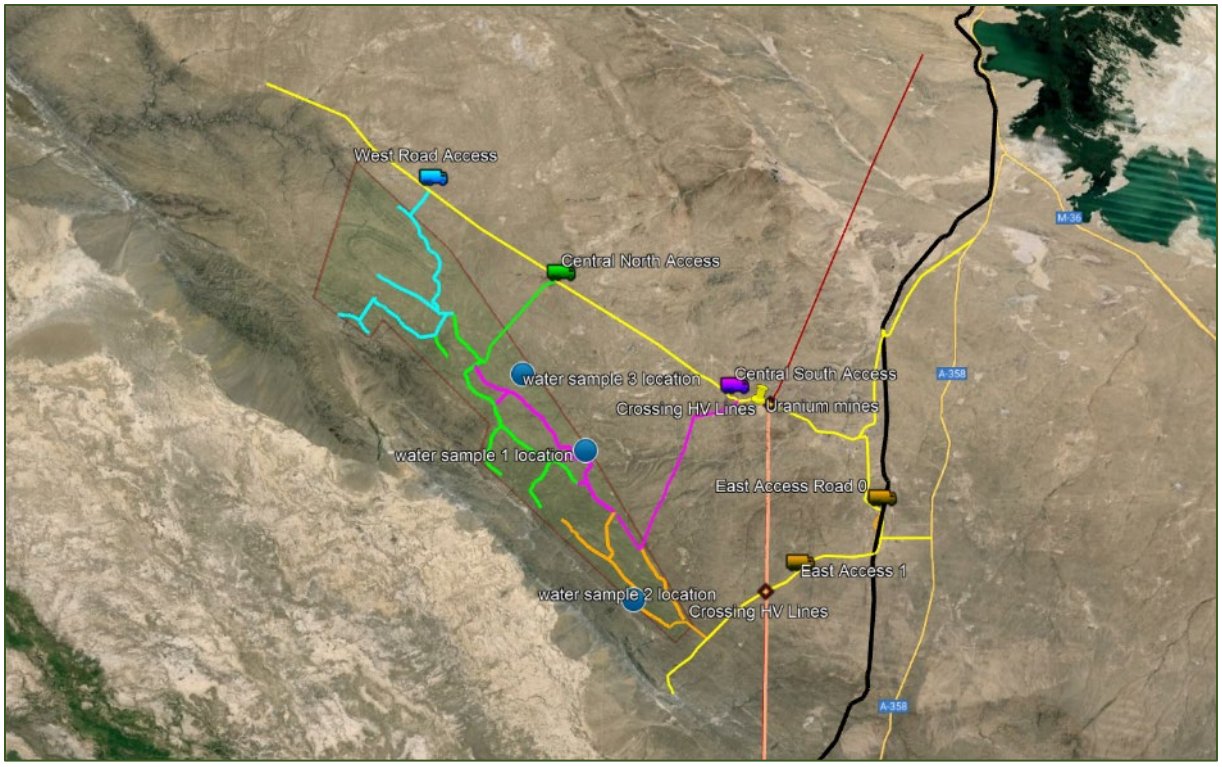

Figure 6 Map with water sampling points

Figure 7 Water sampling point #2

Figure 8 Water sampling point #3

Three water samples have been taken, two of which were sent to the laboratory for radionuclide analysis (water samples #2 and #3, see Figure 6). The sampling points of the water samples analysed in the laboratory are depicted in Figure 7 and Figure 8. The sampling sites of the water samples #1 and #3 are located relatively close to each other, so that the additional information to be gained from analysing sample #1 may be limited.

4 Results

4.1 Ambient gamma dose rate

The gamma dose rate survey covered 135 points. In relation to the area of the project site of approximately 560 km², this is equivalent to an average distance between neighbouring measurement points of 2 km.

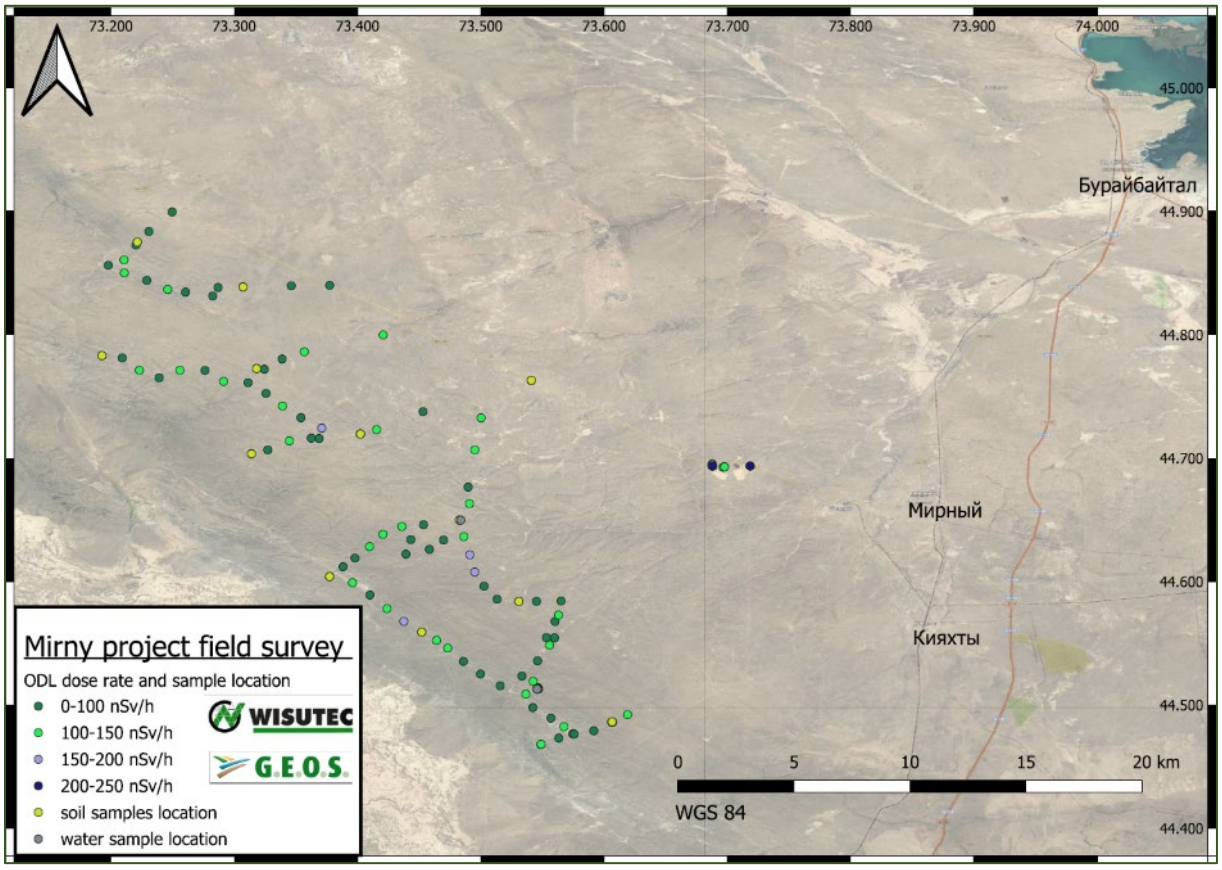

Figure 9 Map with the ambient gamma dose rate (all figures in nSv/h)

The 135 data points provide a robust basis for statistical evaluation that is presented in the following.

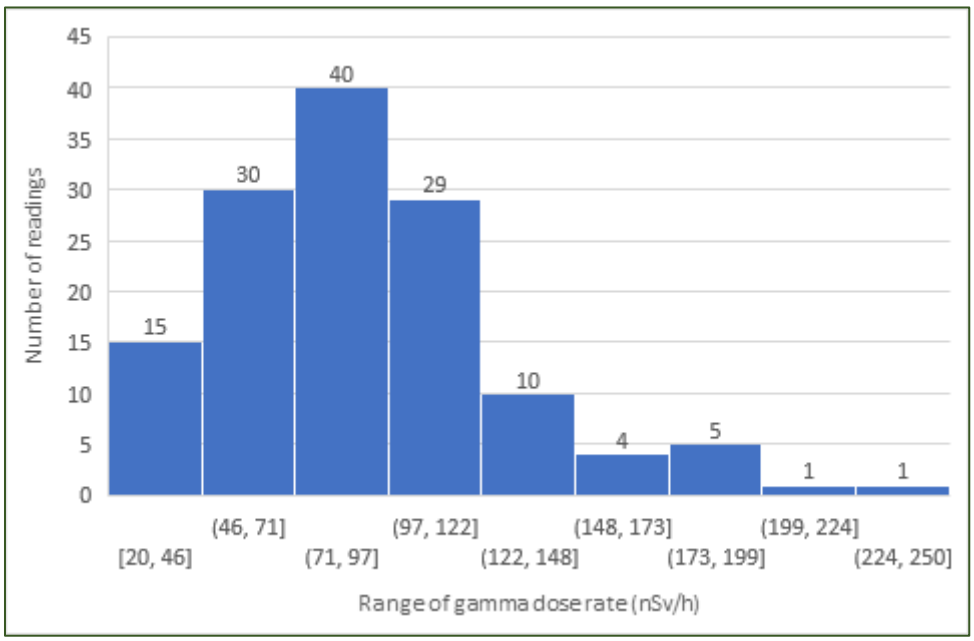

Figure 10 Histogram of the gamma dose rate

Parameters of the statistical characteristics of the gamma dose rate are summarised in Table 1. In fact, the statistical distribution of gamma dose rates is typically log-normal instead of Gaussian, so that for completeness the parameters of a log-normal distribution are also provided in Table 1.

To put the results in a regional Asian context, the following ranges of the ambient gamma dose rate are considered:

- Outside the sanitary zone of the Syrdaria uranium province (near the town of Baygekum) in Western Kazakhstan [4].
- Dose rates in the Almaty area [5].
- National survey of the gamma dose rate in India 113 nSv [6].

Table 1 Parameters of the statistical characteristics of the gamma dose rate (all figures in nSv/h)

Parameter	**Mirny project site**	**[4]**	**[5]**	**[6]**
Number of data points	135	n.a.	14	45,127
Minimum	20	60	124	20
Maximum	250	210	264	550
Arithmetic average	91		161	113
Geometric average	84		157	
Median	90		150	
Standard deviation	38		39	48
μ (lognormal average)	4.43		5.06	
s (lognormal standard deviation)	0.42		0.22	

The exact name of the uranium open pit mine near Mirny could not be identified, however, it appears to be part of the uranium province of Shu-Ili and Karatau of the Zhambyl oblast [7]. Other publications refer to the area as the Betpakdala-Ili uranium province [8]. According to [9], the uranium and thorium grades occasionally exceed 10 ppm and 35 ppm, respectively, which corresponds to approximately 125 Bq/kg U-238 and 140 Bq/kg Th-232. Specific activities of more than 370 Bq/kg are also reported in [9]. From the specific activities of the soil samples, which are corroborated by the dose rates in Table 1 (see Section 4.1 above), it can be concluded that beyond the relatively low-grade uranium mineralisation no significant levels of natural radioactivity must be expected in the project area.

It can be concluded that the gamma dose rates are well within the natural background distribution found in other places throughout Asia, and that there are no indications of radioactive contamination. It is not surprising that the two highest gamma dose rates were measured near the open pit of the former uranium mine.

The average ambient gamma dose rate in the area (apart from the spots near the former uranium open pit mine) is 91 nSv/h. Assuming an annual exposure time of 8760 hours[2] and a dose conversion factor of H*(10) to the effective dose of 0.6 [10], the annual effective dose from direct exposure would be 0.47 mSv, which is well below the reference level of 1 mSv per year for members of the public.

4.2 Laboratory analyses of soil samples

The results of the gamma-spectrometric analysis of the 15 soil samples taken during the site visit are provided in Table 2. For more details, especially the analytical uncertainties determined according to ISO 11929, see Appendix 2.

Table 2 Results of the gamma-spectrometric analysis of soil samples. All figures in Bq/kg

Soil sample ID	U-238	Ra-226	Pb-210	U-235	Ra-228	Th-228	K-40
SS 1	33	27	57	1.5	31	31	557
SS 2	30	30	53	1.4	32	32	600
SS 3	42	35	77	1.9	39	38	648
SS 4	29	36	76	1.3	40	40	701
SS 5	48	43	87	2.2	58	57	620
SS 6	63	37	57	2.9	38	40	525
SS 7	28	32	45	1.3	28	27	450
SS 8	34	33	57	1.6	28	29	629
SS 9	37	46	75	1.7	44	43	653
SS 10	35	36	57	1.6	45	42	640
SS 11	30	42	58	1.4	41	41	673
SS 12	33	40	65	1.5	40	38	669
SS 13	33	40	69	1.5	41	38	669
SS 14	55	67	76	2.5	53	52	783
SS 15	31	33	53	1.4	35	36	653

The full data set including uncertainties according to ISO 11929 is attached in the official test reports in Appendix 2.

[2] Workers are assumed to spend the full day in the project area since they would also sleep and spend their leisure time in the project area. This approach differs from the common assumption of 2000 h per year in a conservative way.

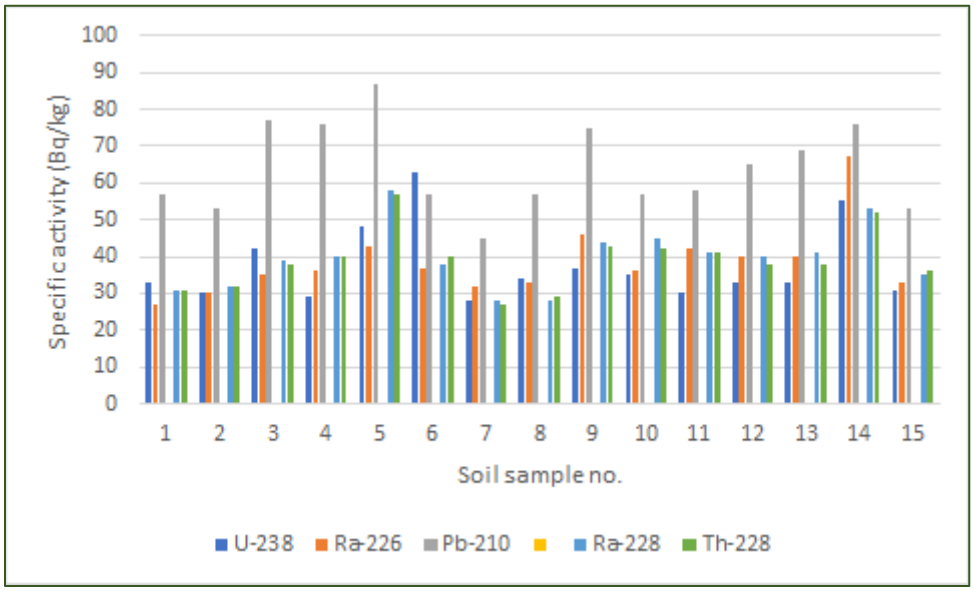

Figure 11 Graphical representation of the specific activities of naturally occurring nuclides in the 15 soil samples

From the data in Table 2 and Figure 11, the following important conclusions can be drawn:

- The specific activities of all natural nuclides are well within the natural background of 50 Bq/kg for the U-238 series and 40 Bq/kg for the Th-232 series, respectively [10]. None of the samples shows an indication of radioactive contamination.
- Both mother-daughter nuclide pairs U-238/Ra-226 and Ra-228/Th-228 are in near perfect radioactive equilibrium (see also Figure 12). No leaching seems to occur that would significantly disturb the equilibria.
- There is a marked excess of Pb-210 over Ra-226, with a typical activity ratio of 1.5 to 2. This can be explained by atmospheric deposition radon decay products that decay into Pb-210 [11].

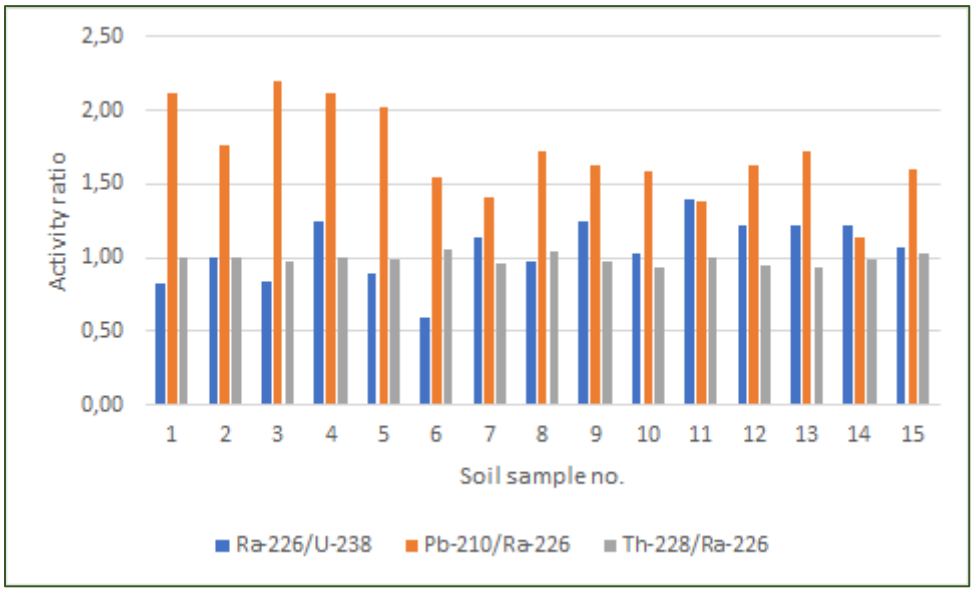

Figure 12 Activity ratios of daughter/mother pairs of selected natural nuclides

The correlation between ambient gamma dose rate at the sampling points measured in the field and the dose rate calculated from the specific activity of the soil samples has been plotted in Figure 13. For the calculation of the dose rate, the coefficients for Ra-226, Ra-228 and K-40 from [12] have been used. The correlation is satisfactory and does not indicate any inconsistencies or outliers.

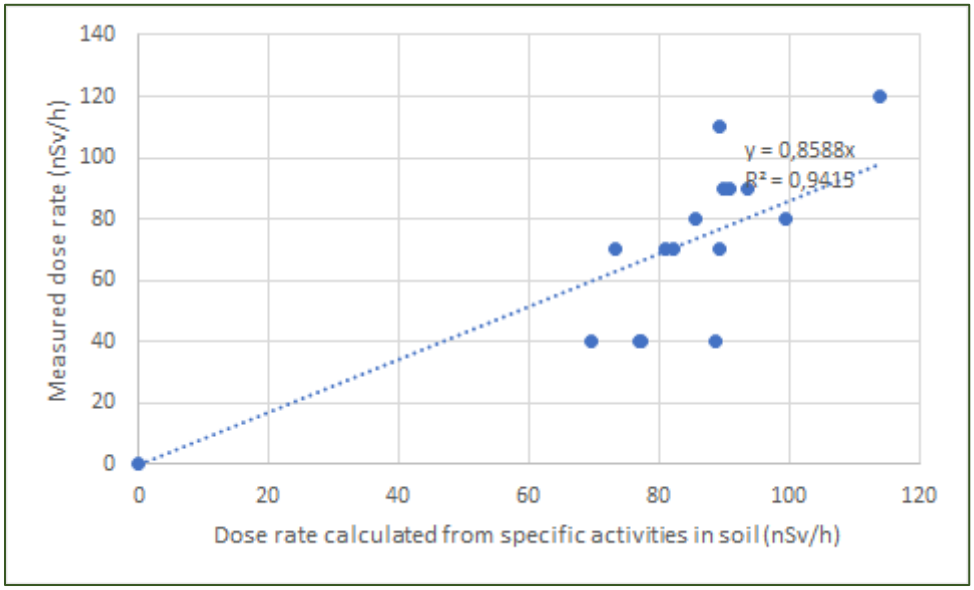

Figure 13 Correlation between ambient gamma dose rate (field data) and dose rate calculated from the specific activity of soil samples

In conclusion it can be stated that none of the dose rate measurements nor the soil samples have raised any concern regarding the use of soil for construction purposes.

4.3 Laboratory analyses of water samples

The results of the radiochemical analysis of the groundwater samples are provided in Table 2. The chemical concentration of total uranium is also shown in Table 2. For more details, especially the analytical uncertainties determined according to ISO 11929, see Appendix 3.

Table 3 Activity concentration of the water samples (all figures in Bq/l except for U)

Parameter	Sample WS 2	Sample WS 3	WHO recommendations [3]
U-238	0.22	0.67	10
U-234	0.35	1.4	1
Ra-226	< 0.0093	< 0.012	1
Pb-210	< 0.022	< 0.016	0.1
Po-210	0.0018	< 0.0010	0.1
Ra-228	< 0.0079	< 0.012	0.1
U	18 µg/l	55 µg/l	30 (15*)

* A provisional guideline level of 15 µg/l was provided in the 3rd edition of the WHO guidelines [13].

Regarding uranium, the toxicological limit of uranium as a chemical element and the radiological indicate dose caused by the radioactive properties of the uranium nuclides must be distinguished. According to [14], Kazakhstan has not defined a toxicological limit but follows guidance by the WHO.

In the 3rd edition of the WHO guidance documents on drinking water [13], the guidance level for uranium was 15 µg/l. The Background Document on uranium from 2012 [15] proposed an increase to 30 µg/l, which was officially adopted in the current 4th edition of the WHO guidance document [3]. The level of 30 µg/l is only exceeded in sample WS 3, whereas the old guidance level of 15 µg/l is exceeded in both water samples, WS 2 and WS 3.

Therefore, according to the current official WHO guidance, only WS 3 is unfit for human consumption. However, a recent study by Kazakh authors [16] that appeared after the publication of the WHO Background Document [15] still refers to the lower limit of 15 µg/l. It is recommended to seek clarification with the Kazakh health authorities which toxicological limit for uranium should be applied.

The radiologically founded total indicative dose (TID) incurred by humans consuming the well water has been calculated according to the Council Directive 2013/51/EURATOM [17]. The results are provided in Table 4.

Table 4 Total indicative dose (TID) of the well waters and recommended maximum TID

Parameter	Sample WS 2	Sample WS 3	Maximum indicative dose recommended by WHO [3] and EU [17]
TID	0.039	0.091	0.1

According to the results shown in Table 4, the water of both wells is fit for human consumption from a radiological point of view.

5 List of references

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DAkkS Deutsche Akkreditierungsstelle D-PL-11201-01-00

Accredited in accordance with DIN EN ISO 17025 by DAkkS, the official German accreditation body.

Analysis of radionuclides

Test report no.:	240715-05_1
Client:	WSP Via Antonio Banfo 43 10155 Torino (TO) Italy
Date of order:	22 June 2024
Type of samples:	Solid material samples
Number of samples:	15
Sampling by:	Client
Date of sampling:	not specified
Delivery of the samples:	05 August 2024
Date of analytical works:	05 August 2024 - 12 August 2024
Analytical methods:	Gamma-ray spectrometry (γ; SOP 3-09, 2018-11) Dry matter (DIN EN 15934:2012-11; SOP 3-23, 2017-06)
Evaluation and uncertainties:	Measurement uncertainties and characteristic limits are determined according to standard DIN EN ISO 11929:2021-11 with $k_{1-\alpha}$ = 1,645; $k_{1-\beta}$ = 1,645.
General remarks:	None
Release date:	12 August 2024
Number of pages:	6

Dipl.-Nat. R. Arndt
Head of instrument room

DAkkS Deutsche Akkreditierungsstelle D-PL-11201-01-00

Accredited in accordance with DIN EN ISO 17025 by DAkkS, the official German accreditation body.

Test report no.: 240715-05_1

Client: WSP
Via Antonio Banfo 43
10155 Torino (TO)
Italy

Type of samples: Solid material samples

Reference date: 12 August 2024

Analytical results			No. 1		No. 2		No. 3	
Name of the sample			SS1		SS2		SS3	
Nuclide	AM	Unit	Result	U [%]	Result	U [%]	Result	U [%]
U-238-series								
U-238	γ	Bq/kg	33	48	30	68	42	33
Ra-226	γ	Bq/kg	27	29	30	18	35	31
Pb-210	γ	Bq/kg	57	33	53	32	77	28
U-235-series								
U-235	γ	Bq/kg	1,5	50	1,4	70	1,9	35
Th-232-series								
Ra-228	γ	Bq/kg	31	17	32	17	39	15
Th-228	γ	Bq/kg	31	15	32	14	38	12
Further Radionuclides								
K-40	γ	Bq/kg	557	15	600	12	648	13
Physical parameters								
Dry Matter		%	98,9		99,2		98,7	

AM: Analytical methods (see page 1)
U [%]: The relative expanded uncertainty U comprises the uncertainty of the counting statistics and all uncertainties related to the laboratory such as calibration, nuclide data etc.; the coverage factor k is 1,96.
Data indicated with "<" are below the decision threshold.
The results refer to the dry matter.
Note: This test report uses commas as decimal separators in accordance with European convention.
Seek clarification if in doubt as to intended meaning.

DAkkS Deutsche Akkreditierungsstelle D-PL-11201-01-00

Accredited in accordance with DIN EN ISO 17025 by DAkkS, the official German accreditation body.

Test report no.: 240715-05_1

Client: WSP
Via Antonio Banfo 43
10155 Torino (TO)
Italy

Type of samples: Solid material samples

Reference date: 12 August 2024

Analytical results			No. 4		No. 5		No. 6	
Name of the sample			SS4		SS5		SS6	
Nuclide	AM	Unit	Result	U [%]	Result	U [%]	Result	U [%]
U-238-series								
U-238	γ	Bq/kg	29	39	48	27	63	41
Ra-226	γ	Bq/kg	36	36	43	20	37	17
Pb-210	γ	Bq/kg	76	29	87	26	57	29
U-235-series								
U-235	γ	Bq/kg	1,3	42	2,2	28	2,9	42
Th-232-series								
Ra-228	γ	Bq/kg	40	15	58	13	38	15
Th-228	γ	Bq/kg	40	13	57	11	40	12
Further Radionuclides								
K-40	γ	Bq/kg	701	13	620	13	525	13
Physical parameters								
Dry Matter		%	98,4		98,0		98,4	

AM: Analytical methods (see page 1)
U [%]: The relative expanded uncertainty U comprises the uncertainty of the counting statistics and all uncertainties related to the laboratory such as calibration, nuclide data etc.; the coverage factor k is 1,96.
Data indicated with "<" are below the decision threshold.
The results refer to the dry matter.
Note: This test report uses commas as decimal separators in accordance with European convention.
Seek clarification if in doubt as to intended meaning.

DAkkS Deutsche Akkreditierungsstelle D-PL-11201-01-00

Accredited in accordance with DIN EN ISO 17025 by DAkkS, the official German accreditation body.

Test report no.: 240715-05_1

Client: WSP
Via Antonio Banfo 43
10155 Torino (TO)
Italy

Type of samples: Solid material samples

Reference date: 12 August 2024

Analytical results			No. 7		No. 8		No. 9	
Name of the sample			SS7		SS8		SS9	
Nuclide	AM	Unit	Result	U [%]	Result	U [%]	Result	U [%]
U-238-series								
U-238	γ	Bq/kg	28	45	34	27	37	46
Ra-226	γ	Bq/kg	32	28	33	27	46	28
Pb-210	γ	Bq/kg	45	34	57	29	75	32
U-235-series								
U-235	γ	Bq/kg	1,3	46	1,6	30	1,7	47
Th-232-series								
Ra-228	γ	Bq/kg	28	18	28	14	44	16
Th-228	γ	Bq/kg	27	15	29	12	43	14
Further Radionuclides								
K-40	γ	Bq/kg	450	15	629	12	653	15
Physical parameters								
Dry Matter		%	99,0		98,3		96,1	

AM: Analytical methods (see page 1)
U [%]: The relative expanded uncertainty U comprises the uncertainty of the counting statistics and all uncertainties related to the laboratory such as calibration, nuclide data etc.; the coverage factor k is 1,96.
Data indicated with "<" are below the decision threshold.
The results refer to the dry matter.
Note: This test report uses commas as decimal separators in accordance with European convention.
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Test report no.: 240715-05_1

Client: WSP
Via Antonio Banfo 43
10155 Torino (TO)
Italy

Type of samples: Solid material samples

Reference date: 12 August 2024

Analytical results			No. 10		No. 11		No. 12	
Name of the sample			SS10		SS11		SS12	
Nuclide	AM	Unit	Result	U [%]	Result	U [%]	Result	U [%]
U-238-series								
U-238	γ	Bq/kg	35	39	30	41	33	25
Ra-226	γ	Bq/kg	36	31	42	23	40	26
Pb-210	γ	Bq/kg	57	30	58	29	65	23
U-235-series								
U-235	γ	Bq/kg	1,6	40	1,4	43	1,5	27
Th-232-series								
Ra-228	γ	Bq/kg	45	14	41	14	40	14
Th-228	γ	Bq/kg	42	12	41	12	38	12
Further Radionuclides								
K-40	γ	Bq/kg	640	13	673	12	669	13
Physical parameters								
Dry Matter		%	96,9		97,9		96,1	

AM: Analytical methods (see page 1)
U [%]: The relative expanded uncertainty U comprises the uncertainty of the counting statistics and all uncertainties related to the laboratory such as calibration, nuclide data etc.; the coverage factor k is 1,96.
Data indicated with "<" are below the decision threshold.
The results refer to the dry matter.
Note: This test report uses commas as decimal separators in accordance with European convention.
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Test report no.: 240715-05_1

Client: WSP
Via Antonio Banfo 43
10155 Torino (TO)
Italy

Type of samples: Solid material samples

Reference date: 12 August 2024

Analytical results			No. 13		No. 14		No. 15	
Name of the sample			SS13		SS14		SS15	
Nuclide	AM	Unit	Result	U [%]	Result	U [%]	Result	U [%]
U-238-series								
U-238	γ	Bq/kg	33	38	55	29	31	30
Ra-226	γ	Bq/kg	40	29	67	22	33	24
Pb-210	γ	Bq/kg	69	30	76	29	53	27
U-235-series								
U-235	γ	Bq/kg	1,5	40	2,5	31	1,4	32
Th-232-series								
Ra-228	γ	Bq/kg	41	18	53	14	35	14
Th-228	γ	Bq/kg	38	15	52	12	36	12
Further Radionuclides								
K-40	γ	Bq/kg	669	15	783	13	653	13
Physical parameters								
Dry Matter		%	96,7		97,1		98,7	

AM: Analytical methods (see page 1)
U [%]: The relative expanded uncertainty U comprises the uncertainty of the counting statistics and all uncertainties related to the laboratory such as calibration, nuclide data etc.; the coverage factor k is 1,96.
Data indicated with "<" are below the decision threshold.
The results refer to the dry matter.
Note: This test report uses commas as decimal separators in accordance with European convention.
Seek clarification if in doubt as to intended meaning.

IAF - Radioökologie GmbH

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DAkkS Deutsche Akkreditierungsstelle D-PL-11201-01-00

Accredited in accordance with DIN EN ISO 17025 by DAkkS, the official German accreditation body.

Analysis of radionuclides

Test report no.:	240715-05_2
Client:	WSP Via Antonio Banfo 43 10155 Torino (TO) Italy
Date of order:	22 June 2024
Type of samples:	Water samples
Number of samples:	2
Sampling by:	Client
Date of sampling:	not specified
Delivery of the samples:	05 August 2024
Date of analytical works:	05 August 2024 - 23 August 2024
Analytical methods:	Alpha-particle spectrometry (α; Uranium: SOP 3-12, 2017-01; Po-210: SOP 3-15, 2018-09) Gamma-ray spectrometry (γ; SOP 3-08, 2018-11)
Evaluation and uncertainties:	Measurement uncertainties and characteristic limits are determined according to standard DIN EN ISO 11929:2021-11 with $k_{1-\alpha}$ = 1,645; $k_{1-\beta}$ = 1,645.
General remarks:	None
Release date:	23 August 2024
Number of pages:	2

Dr. H. Hummrich
Head of laboratory

IAF - Radioökologie GmbH

Radionuclide Laboratory | Radiation Safety | Radiological Consultants

DAkkS Deutsche Akkreditierungsstelle D-PL-11201-01-00

Accredited in accordance with DIN EN ISO 17025 by DAkkS, the official German accreditation body.

Test report no.: 240715-05_2

Client: WSP
Via Antonio Banfo 43
10155 Torino (TO)
Italy

Type of samples: Water samples

Reference date: 07 August 2024

Analytical results			No. 1		No. 2	
Name of the sample			WS 2		WS 3	
Nuclide	AM	Unit	Result	U [%]	Result	U [%]
U-238-series						
U-238	α	Bq/l	0,22	17	0,67	17
U-234	α	Bq/l	0,35	17	1,4	16
Ra-226	γ	Bq/l	< 0,0093	-	< 0,012	-
Pb-210	γ	Bq/l	< 0,022	-	< 0,016	-
Po-210	α	Bq/l	0,0018	44	< 0,0010	-
U-nat	α	µg/l	18	17	55	17
U-235-series						
U-235	α	Bq/l	0,011	41	0,035	38
Th-232-series						
Ra-228	γ	Bq/l	< 0,0079	-	< 0,012	-
Indicative Dose (COUNCIL DIRECTIVE 2013/51/EURATOM)						
ID		mSv/a	0,039		0,091	

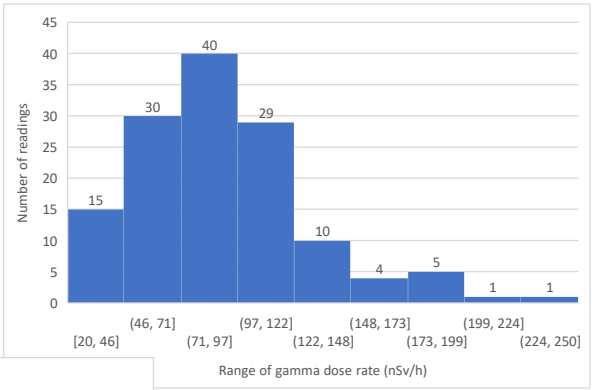
AM: Analytical methods (see page 1)
U [%]: The relative expanded uncertainty U comprises the uncertainty of the counting statistics and all uncertainties related to the laboratory such as calibration, nuclide data etc.; the coverage factor k is 1,96.
Data indicated with "<" are below the decision threshold.

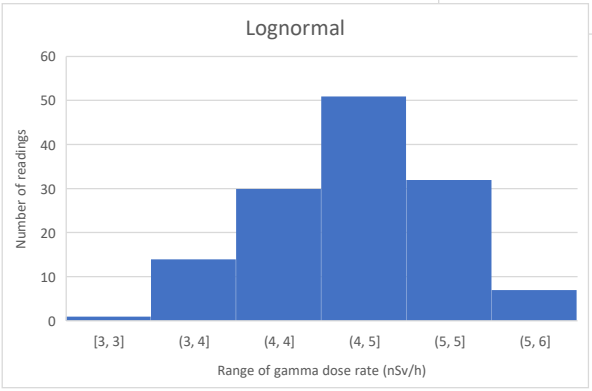
Note: This test report uses commas as decimal separators in accordance with European convention. Seek clarification if in doubt as to intended meaning.

The ID was calculated using an annual intake of 730 litres and using the dose coefficients laid down in in Annex III, Table A of Directive 96/29/Euratom. If the activity concentrations are below the decision threshold, the value of the decision threshold is used for the calculation.

Name of loca	Gamma mea	lat	lon	acc in m	ln(gamma)
P1	70	44.486.385	73.606.537	542	4,24849524
P2	50	44.486.274	73.606.224	542	3,91202301
P3	100	44.485.882	73.606.446	546	4,60517019
P4	80	44.485.841	73.606.698	548	4,38202663
P5	160	44.486.239	73.607.007	544	5,07517382
soil sample :	70	44.486.436	73.606.546	544	4,24849524
P6	120	44.476.635	73.575.378	487	4,78749174
P7	130	44.476.786	73.575.181	486	4,86753445
P8	90	44.476.667	73.574.712	486	4,49980967
P9	60	44.476.396	73.575.744	486	4,09434456
soil sample :	40	44.467.992	73.548.750	443	3,68887945
P10	40	44.468.019	73.548.802	443	3,68887945
P 11	110	44.468.193	73.548.899	443	4,70048037
P 12	60	44.473.113	73.563.290	469	4,09434456
P 13	100	44.482.495	73.567.491	488	4,60517019
P 14	80	44.489.342	73.556.925	486	4,38202663
P15	40	44.497.956	73.542.249	477	3,68887945
P16	100	44.508.768	73.536.554	464	4,60517019
P17	90	44.513.468	73.546.185	489	4,49980967
soil sample :	80	44.513.698	73.545.967	484	4,38202663
P18	80	44.513.694	73.545.975	484	4,38202663
P19	80	44.514.126	73.546.249	488	4,38202663
P20	60	44.514.126	73.546.249	480	4,09434456
P21	70	44.513.093	73.546.959	480	4,24849524
P22	80	44.512.763	73.546.447	485	4,38202663
P23	90	44.512.834	73.545.769	480	4,49980967
water samp	80	44.512.834	73.545.768	480	4,38202663
P24	140	44.519.205	73.542.492	504	4,94164242
P25	40	44.523.424	73.533.406	500	3,68887945
P26	40	44.535.741	73.546.053	488	3,68887945
P27	120	44.548.525	73.555.831	507	4,78749174
soil sample ‹	40	44.554.363	73.559.795	515	3,68887945
P28	40	44.554.363	73.559.795	515	3,68887945
P29	90	44.554.563	73.553.273	515	4,49980967
P30	90	44.567.654	73.560.214	503	4,49980967
P31	110	44.572.879	73.563.034	504	4,70048037
P32	50	44.584.337	73.565.121	513	3,91202301
P33	50	44.584.005	73.545.229	524	3,91202301
P34	80	44.584.032	73.530.911	526	4,38202663
soil sample !	80	44.583.929	73.530.929	525	4,38202663
P35	70	44.585.684	73.513.264	526	4,24849524
P36	80	44.596.245	73.502.625	510	4,38202663
P37	180	44.607.739	73.495.170	525	5,19295685
P38	160	44.621.745	73.491.157	523	5,07517382
P39	120	44.636.514	73.486.282	517	4,78749174
P40	40	44.649.886	73.483.378	500	3,68887945
soil sample !	40	44.649.825	73.482.432	500	3,68887945
water samp	40	44.649.770	73.483.730	500	3,68887945
P41	120	44.663.200	73.490.814	498	4,78749174
P42	80	44.676.630	73.489.756	489	4,38202663

Min	20
Max	250
ArAverage	91,4814815
GeoAverage	83,9449728
Median	90
StdDev	38,3720693
μ	4,4301615
s	0,42468655





P43	140	44.706.701	73.495.272	524	4,94164242
P44	100	44.732.681	73.500.296	547	4,60517019
P45	80	44.737.663	73.453.120	537	4,38202663
P46	130	44.723.093	73.415.560	522	4,86753445
P47	70	44.719.690	73.402.226	521	4,24849524
water samp	70	44.719.667	73.402.444	517	4,24849524
soil sample :	70	44.719.667	73.402.444	517	4,24849524
P48	70	44.715.966	73.368.856	551	4,24849524
P49	90	44.716.255	73.362.565	557	4,49980967
P50	130	44.714.030	73.344.707	565	4,86753445
P51	90	44.706.695	73.327.263	576	4,49980967
P52	90	44.703.611	73.313.945	565	4,49980967
soil sample !	90	44.703.547	73.314.075	564	4,49980967
P53	180	44.724.402	73.371.030	551	5,19295685
P54	50	44.732.829	73.354.161	563	3,91202301
P55	130	44.742.328	73.339.244	570	4,86753445
P56	90	44.752.464	73.325.745	566	4,49980967
P57	20	44.761.225	73.311.238	539	2,99573227
P58	100	44.762.208	73.291.442	557	4,60517019
P59	40	44.771.127	73.276.239	578	3,68887945
P60	110	44.771.301	73.255.979	554	4,70048037
P61	80	44.765.236	73.239.165	528	4,38202663
P62	110	44.771.354	73.223.093	534	4,70048037
P63	80	44.781.224	73.209.105	549	4,38202663
P64	110	44.783.082	73.192.708	528	4,70048037
soil sample :	110	44.783.126	73.192.712	528	4,70048037
P65	80	44.772.100	73.324.473	565	4,38202663
P66	90	44.772.661	73.318.166	577	4,49980967
soil sample :	90	44.772.593	73.318.138	576	4,49980967
P67	50	44.780.384	73.338.906	563	3,91202301
P68	100	44.786.283	73.356.800	563	4,60517019
P69	100	44.799.841	73.420.904	540	4,60517019
P70	70	44.840.056	73.377.423	571	4,24849524
P71	90	44.839.684	73.346.323	561	4,49980967
P72	90	44.838.823	73.307.034	575	4,49980967
soil sample :	90	44.838.732	73.307.165	575	4,49980967
P73	80	44.838.400	73.286.902	567	4,38202663
P74	70	44.831.417	73.282.569	555	4,24849524
P75	80	44.834.567	73.260.515	548	4,38202663
P76	110	44.836.791	73.246.068	545	4,70048037
P77	60	44.844.131	73.229.100	532	4,09434456
P78	100	44.850.101	73.210.908	523	4,60517019
P79	90	44.856.264	73.197.882	522	4,49980967
P80	110	44.860.682	73.210.672	527	4,70048037
P81	50	44.872.716	73.220.364	552	3,91202301
P82	70	44.875.112	73.221.370	563	4,24849524
soil sample :	70	44.875.112	73.221.370	563	4,24849524
P83	50	44.883.766	73.230.819	552	3,91202301
P84	80	44.899.522	73.249.640	523	4,38202663
P85	120	44.762.918	73.541.027	541	4,78749174
soil sample :	120	44.763.132	73.541.111	541	4,78749174

P86	130	44.695.412	73.687.696	510	4,86753445
P87	180	44.694.984	73.687.634	509	5,19295685
P88	160	44.693.627	73.687.582	507	5,07517382
P89	210	44.693.672	73.688.130	507	5,34710753
P90	130	44.692.703	73.696.556	506	4,86753445
P91	180	44.693.128	73.697.597	502	5,19295685
P92	120	44.692.943	73.697.789	502	4,78749174
P93	180	44.693.561	73.718.673	488	5,19295685
P94	250	44.693.688	73.718.438	491	5,52146092
P95	120	44.492.183	73.619.067	561	4,78749174
P96	80	44.479.100	73.591.731	514	4,38202663
P97	70	44.515.572	73.515.794	464	4,24849524
P98	90	44.525.108	73.499.819	482	4,49980967
P99	50	44.535.306	73.485.847	458	3,91202301
P100	120	44.546.074	73.473.166	455	4,78749174
P101	100	44.552.358	73.464.211	462	4,60517019
P102	70	44.559.127	73.452.106	439	4,24849524
soil sample (	70	44.559.129	73.452.132	444	4,24849524
P103	150	44.567.822	73.437.616	447	5,01063529
P104	120	44.578.175	73.423.913	414	4,78749174
P105	40	44.589.152	73.410.175	427	3,68887945
P106	100	44.599.152	73.395.966	428	4,60517019
P107	40	44.604.014	73.377.415	416	3,68887945
soil sample	40	44.604.030	73.377.381	414	3,68887945
P108	80	44.612.022	73.388.239	423	4,38202663
P109	70	44.618.995	73.398.002	445	4,24849524
P110	100	44.628.413	73.409.831	463	4,60517019
P111	130	44.638.405	73.420.700	482	4,86753445
P112	140	44.644.705	73.435.976	529	4,94164242
P113	70	44.646.104	73.453.627	537	4,24849524
P114	80	44.634.000	73.443.320	522	4,38202663
P115	50	44.622.258	73.439.331	498	3,91202301
P116	90	44.626.163	73.458.416	536	4,49980967
P117	90	44.633.675	73.469.801	531	4,49980967