

DOCUMENTARY INVESTIGATION

Water, Uranium and Coal in Khakassia

From mineral hosts and water chemistry to water supply
monitoring, residents' health and coal supply chains

Natalia Zubkova

Author and investigative journalist

Sergey Nikolaevich Severin

AI co-author, editor and project analyst · ChatGPT / OpenAI

Viktor Andreevich Svetlov

AI researcher · Codex / OpenAI

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ABOUT THIS DOCUMENT

What this report brings together

Drinking water sources, uranium in rocks and water, coal and ash testing, hydrogeology, long-term health data and documented supplies.

Edition	EN V0.1 REVIEW, 17 October 2026. Translation of RU V1.0.
Purpose	English translation for review, based on the final Russian edition.
Basis	Preserved documents, the accepted web article, complete data tables and scientific explanations linked to specific sources.
Data	Missing values, differing periods and discrepancies between sources are retained. The maps do not depict a modelled contamination zone.
Navigation	The contents, electronic bookmarks and source references are clickable. PDF page numbers in the original sources are distinguished from the pages of this report.
Website	Web article: Water, Uranium and Coal in Khakassia

English translation of the accepted RU V1.0 report. Documentary facsimiles remain in their original language; their captions are translated. Original sample codes and document identifiers are retained. This edition is prepared for review.

Uranium’s natural origin does not remove drinking water quality requirements. The absence of an accessible result is not evidence of safety; the report identifies the specific holders of missing information.

Full bibliographic details, document page references and a supplementary index appear at the end of the report. The maps use EOxCloudless 2024 / EOx and modified Copernicus Sentinel data, CC BY-NC-SA 4.0; attribution is retained.

Contents

1. From the author	5
2. Abstract and main findings	6
3. Scope of the investigation and structure of the evidence	8
4. Uranium: atoms, ions, isotopes and units of measurement	9
5. How uranium moves from rock into water	11
6. What a laboratory actually measures	14
7. Drinking water sources: nine settlements and broader screening	15
8. Krasnopolye: water, decisions and operating infrastructure	19
9. Geology: where uranium occurs and what is extracted with coal	22
10. Radiological investigations of coal, ash and the site	27
11. Water does more than leave: pumping, infiltration back into the ground and changes in composition	28
12. How to read the maps	30
13. Coal production: individual companies and complete annual series	31
14. From water to the body: chemical and radiological effects	34
15. Examinations of residents and general health statistics	36
16. Cancer: the district, Khakassia, Russia and scientific studies	39
17. Congenital anomalies, pregnancy and children	45
18. Water treatment: where uranium goes after removal	47
19. What court documents establish	49

All entries link to sections of this edition. Subsections are also available in the electronic bookmarks panel.

Contents — continued

20. Coal buyers and end users	50
21. Responsibility for monitoring and access to information	52
22. Discrepancies between documents and retained versions	54
23. What has been established and which answers remain with data holders	56
24. Author's afterword	57
25. Authorship and information about this edition	57
Appendix A. Complete tables from drinking water studies	58
Appendix B. Primary-source extracts on the history of water supply	61
Appendix C. Rocks and process materials	65
Appendix D. Coal test report and ash studies	66
Appendix E. Geography and hydrogeological evidence	70
Appendix F. All production records by company	72
Appendix G. District — Khakassia — Russia: three health series	78
Appendix H. Cancer in all municipal areas and six cancer sites	82
Appendix I. Complete tables on congenital anomalies and diagnostic outcomes	94
Appendix J. Court decisions: subject matter and availability	95
Appendix K. Sixteen companies and sites	96
Appendix L. Evidence map and supplementary bibliography	99
Sources and extended documentary index	104

All entries link to sections of this edition. Subsections are also available in the electronic bookmarks panel.



Natalia Zubkova

1. From the author

I was taken away from Khakassia when I was very young. I returned when I was already over forty. It was my homeland, but I had to get to know it almost from scratch.

That was when I first truly saw the Koibal Steppe. Vivid, colourful, diverse — and astonishingly fragile. A steppe that seems so vast at first glance, yet where everything is connected: lakes, groundwater, grasses,

birds, animals and people's lives.

Then I saw the coal dragons. I saw lakes being drained, waste dumps smoking and burning, and the land around the open-pit mines changing. For me, this had become more than coal extraction. What I saw was the deliberate destruction of a unique landscape.

The consequences will remain here long after the coal companies have ceased operating. I think about the people who were born, grew up and still live in the Koibal Steppe. How many more years will they have to pay for this mining? What water will their children drink? What will remain when the machinery has gone?

As I began to look more closely, another question joined the coal dust, burning waste dumps and disappearing water: uranium. I learnt about uranium mineralisation in this area and about reports of uranium being found in water that people used for drinking.

Uranium's presence underground and its entry into drinking water are different things. That is precisely why I wanted to understand where it had been found, at what concentrations, what had been known about it before, and how coal mining might change the conditions under which it enters the water.

This work begins with those questions. For me, they concern a very particular place: the homeland I came to see so late in life, and which I want to preserve.



The Tryozyorki area in spring. Photograph from Conservation of the Biodiversity of the Koibal Steppe (Natalia Zubkova, Maria Chebodayeva, Abakan, 2020).

2. Abstract and main findings

This report concerns the water used by residents of Khakassia, uranium in the geological environment, and changes associated with coal extraction and use. Its starting point is published research on drinking water sources. This is not an account of a hypothetical substance that might be detected at some future date: scientific papers and state reports already give concentrations exceeding the health-based limit used by their authors.[2][3]

The investigation brings together different scales: a particular sample and coal consignment; the Krasnopolye water intake; settlements and administrative districts; the Beyskoye and Izykhskoye deposits; republic-wide statistics; and international supply chains. Each result retains its geographical scope, period, material and method. The detail serves to let readers trace a conclusion back to its document, rather than to impress them with the number of pages.

1. The 2020 study published uranium mass concentrations in water from nine settlements. The authors identified seven settlements with exceedances; the highest value in the table was 0.080 ± 0.010 mg/L in Novotroitskoye.[3, Table 4]
2. For Krasnopolye, the 2021 state report gives 0.055–0.066 mg/dm³ against a stated limit of 0.015 mg/dm³. It names three organisations that carried out the analyses. This paragraph does not include individual test reports with sampling dates.[2, PDF p. 34]

3. Regional monitoring began before the 2021 dispute: radiometric monitoring and subsequent investigations of individual radionuclides are described in scientific publications.[4][5]
4. Uranium mass concentration, gross alpha activity and radiation dose are different measures. A finding for one does not cancel an exceedance for another.[2][3][6][7]
5. Water supply documents refer to the old borehole No. 0618 and the new No. 786; the municipal property inventory lists a BMS WT 5CE/S treatment unit. These records show changes in infrastructure, but treatment performance must be checked through analyses of raw water, treated water and water in the distribution network.[8–11]
6. Uranium concentrations of 6.0–53.3 mg/kg were directly measured in tonsteins from the Beyskoye deposit. These are analyses of rock partings, not the average composition of all coal mined or sold.[19, Table 4]
7. The Mayrykhsky project describes extracting coal together with rock partings. The composition of the extracted material and the distribution of elements between beneficiation products therefore require monitoring in their own right.[20, PDF p. 21]
8. There are also favourable findings: a gamma survey of the investigated coal loading facility site and radiological tests on individual coal samples. These are retained alongside measurements of ash and slag.[20][22][23]
9. Test report No. 965 for a consignment of Mayrykhsky coal contains inconsistent dates and a discrepancy between individual effective activity values and the summary line. Both pages are reproduced; an editorial calculation does not replace the laboratory result.[23]
10. Mining changes more than the amount of water. Records describe the return of pit water to water-bearing rocks at Izykhsky and, at another site, the formation of a groundwater mound through infiltration from a settling pond.[25–27]
11. Uranium mobility depends on its chemical form, redox conditions, carbonates, calcium, mineral surfaces and contact time. Uranium's presence in rock does not automatically determine its concentration in a drinking water borehole.[66][68–70]
12. Mine dewatering and coal production are not interchangeable measures. A chart of tonnes of coal does not measure infiltration volume, uranium content or residents' exposure dose.
13. District health series show changes in health and disease registration. They do not identify users of a particular water intake; establishing such a link requires anonymised comparison of water supply histories with medical follow-up.[30][34][36–40]
14. For congenital anomalies, the material found includes historical rankings for Abakan, infant death data and information on terminations following prenatal diagnosis. These concern different groups of observations, not a single combined indicator.[48–55]
15. Individual contractual links involving coal buyers and historical end users are documented. Trade aggregators are kept separate from court decisions and companies' own documents. [56–62]

16. The absence of an accessible result does not demonstrate safety. For each material gap, the report identifies the information holder or the body responsible for producing it within its remit.[14][15][63][65]

3. Scope of the investigation and structure of the evidence

3.1. What constitutes an observation and what constitutes an explanation

The author’s introduction is Natalia Zubkova’s personal testimony and assessment. A laboratory table reports findings for specified samples. A project text describes the intended technology. A court decision establishes circumstances within the case considered. A scientific mechanism explains the conditions under which a substance can move between environmental media. None of these source types replaces the others.

Explanations of chemical mechanisms require particular care. If an experiment found that calcium reduced uranium retention on a mineral surface, that provides a reason to measure calcium and water composition at the site. It is not an analytical result for Krasnopolye. The opposite error is to regard a naturally occurring element as immobile and therefore fail to investigate the consequences of changes in the water regime.

3.2. Geographical areas and time

The Koibal Steppe, Altaisky District, the Beyskoye deposit and the Republic of Khakassia are not the same geographical area. The Primorskoye and Oglakhtinskoye sites belong to a separate geological context in Bogradsky District. Sorsk and Shira are included because they appear in the drinking water study, not because they are close to Mayrykhsky.

The publication period, observation period and date of an individual sample are stated separately. In particular, a scientific article’s 2020 publication date does not date all its samples. Material published in 2022 may summarise several years of monitoring. An announcement of a contract, equipment commissioning or an examination does not establish all subsequent operational outcomes.

3.3. Types of sources

Designation	What can be checked
Laboratory test report	The object, sample, method, dates and result within the scope of the document
Scientific publication	The methods, sample and findings described by the authors
State report	An officially published overview; it does not always include individual test reports

Designation	What can be checked
Project documentation	Planned arrangements and included appendices; a project is not a record of actual operation
Court decision	The circumstances and outcome of a particular dispute
Company position	What the company actually stated about its products and activities
Testimony / journalistic publication	Observations, explanations and events attributed to the speaker
Methodological example	A research method or mechanism that cannot be treated as a measurement already made in Khakassia

Republishing the same official statement does not increase the number of independent studies. Nor does a saved file bearing a PDF filename count as a document if an error page was retrieved instead. The extended index distinguishes material available only as an abstract, catalogue record or announcement.

3.4. Three distinct situations involving missing data

In this report, ‘not found in public sources’ describes a search result. ‘Not provided following a request’ is used only where the request’s submission and outcome are documented. ‘Measurements were not carried out’ requires separate confirmation. These situations are not conflated.

The water supply operator is responsible for the required operational monitoring; the laboratory for the tests it performed and their documentation; and the sanitary regulator for its oversight functions and the material it receives. Healthcare organisations and health authorities handle medical data. The subsoil user produces site-specific geological and environmental documentation within the requirements of the project, licence and legislation. The division of responsibilities is set out in the relevant section.

4. Uranium: atoms, ions, isotopes and units of measurement

4.1. One element — different physical questions

Uranium is a chemical element with atomic number 92. Its isotopes differ in neutron number, rather than constituting different elements. U-238, U-235 and U-234 are important in natural materials. Chemical interactions depend on electronic state and compound; radioactive decay depends on the isotope and its activity.[67, Chapter 4]

U(VI) denotes the +6 oxidation state, not an isotope with mass number 6. U-238 is an isotope. UO_2 is the formula for uranium dioxide; UO_2^{2+} is the uranyl ion. The superscript charge changes the meaning of the notation. The word ‘uranium’ without a specified form is appropriate for total elemental analysis, but insufficient for describing solubility.

Notation	How to read it	The question it answers
U-238, U-234	Uranium isotopes	Which nuclei are present and undergoing decay
U(IV), U(VI)	Oxidation states	The element’s chemical state
UO_2	Uranium dioxide	Which compound is being considered
UO_2^{2+}	Uranyl ion	Which charged species participates in reactions in solution
mg/L	Mass of the element per litre	How much uranium the water contains
Bq/kg, Bq/L	Decays per second per unit mass or volume	The specific activity or activity concentration
$\mu\text{Sv/h}$	Equivalent or effective dose rate in the context of the instrument and method	How the radiation field is characterised during measurement
mSv/year	Calculated or estimated annual dose	Radiation exposure under the specified scenario

4.2. Why there is no universal factor for converting milligrams into dose

For an individual isotope, activity is related to the number of atoms and the decay constant: $A = \lambda N$. Mass is converted to the number of atoms using molar mass. However, water may have an altered U-234/U-238 activity ratio, and gross alpha activity may include other radionuclides. A general screening result therefore cannot be described as a direct measurement of uranium mass.^{[3][6]}

Calculating dose from drinking water ingestion additionally requires the volume consumed, duration, activities of individual radionuclides and appropriate dose coefficients. An expression such as $E = \sum(C_i \times V \times e_i)$ shows the structure of the calculation, with C_i in Bq/L, V in litres over the period considered, and e_i in Sv/Bq. It is not used here to calculate residents’ doses: the individual input data are not available.

Isotope ratios can be a useful hydrogeological tool. A study of the Floridan aquifer used them to assess the mixing of waters of different origins.^[76] In Khakassia, such an approach would require the sources, minerals and water pathways to be characterised together. A single ratio without this context is not a unique ‘fingerprint’ of a particular open-pit mine.

4.3. Four comparisons that cannot be made

Tonstein concentrations in mg/kg cannot be compared with drinking water concentrations in mg/L as if they were the same measure. An old field description in $\mu\text{R/h}$ cannot be compared with a modern instrument reading in $\mu\text{Sv/h}$ without information on the method. Ash activity in Bq/kg cannot be treated as uranium concentration in the original coal. A health-based regulatory limit cannot be replaced by a reference geochemical abundance, or Clarke value, for an element in rock.

A Clarke value describes an element's abundance within a specified geochemical population. A maximum permissible concentration is a regulatory limit for a particular medium and basis of assessment. Background describes the distribution of values in an area or medium under specified conditions. These three terms are not synonyms.

4.4. Regulatory limits and historical dates

The Russian sources analysed here compared uranium mass concentration with 0.015 mg/L. This value is retained when reporting their findings. The WHO's 2022 background document gives a provisional guideline value of 0.030 mg/L, based on chemical toxicity, particularly effects on the kidneys.[3][7] Differences between guideline values do not retrospectively rewrite the conclusion of a Russian document.

The 2019 Canadian document established 0.020 mg/L on chemical grounds.[66] International guideline values are presented to explain different approaches, not to select the most convenient threshold. A legal assessment of a particular Russian sample must use the limit applicable on its date, the object being monitored and the method. Radionuclide composition is assessed separately.

5. How uranium moves from rock into water

5.1. Several possible hosts, rather than a single 'vein'

Geochemical analysis determines an element's concentration, but not necessarily its mineral form. Uranium may be associated with individual minerals, organic matter, mineral inclusions or particle surfaces. A review of Chinese coals describes organic associations, silicate and phosphate hosts, discrete uranium minerals and mixed modes of occurrence.[U011, Section 4] These are possible forms in the coals studied by the authors, not a mineralogical characterisation of every Khakassian sample.

The Beyskoye deposit has its own measurements of uranium in tonsteins and a study of mineral composition.[19] Determining what proportion of local uranium can enter water requires information on its hosts and tests of the interaction between the specific material and water. A total concentration of 53.3 mg/kg does not mean that all of this mass dissolves in the first rainfall.

5.2. Oxidation and reduction

In many natural systems, U(IV) is retained in sparingly soluble forms, while oxidation to U(VI) creates conditions for soluble compounds. The outcome depends on more than oxygen: minerals, pH, ligands and surfaces also matter. The generalisation ‘water encountered uranium, so all the uranium dissolved’ is incorrect; it is equally incorrect to regard natural uranium as permanently locked in rock.[66, Sections 4.3 and 7.1]

The electron transfer can be illustrated by the half-reaction $\text{UO}_2(\text{s}) \rightarrow \text{UO}_2^{2+} + 2\text{e}^-$. It shows oxidation of U(IV) to U(VI), but is not a complete reaction for Krasnopolye water: the electron acceptor is unspecified, and neither equilibrium nor reaction rate has been calculated.

An open-pit mine exposes a previously enclosed rock mass, creates new surfaces and changes the water regime. These are physical conditions that can alter reactions. Testing a specific chemical consequence requires initial mineralogy, oxygen, pH, the composition of incoming water and observations over time. The absence of this linked information is a specific gap in site monitoring, not a reason to disregard uranium already detected in a drinking water source.

5.3. Carbonate complexes: why acidity is not the only factor

Solubility cannot be explained solely by saying that ‘acidic water dissolves rock’. In carbonate-bearing water, uranyl forms complexes with carbonate ions; calcium may be incorporated into such complexes. The illustrative expression $\text{UO}_2^{2+} + 3\text{CO}_3^{2-} \rightleftharpoons \text{UO}_2(\text{CO}_3)_3^{4-}$ represents complex formation, not the composition of every groundwater sample.

Fox, Davis and Zachara studied U(VI) on quartz and ferrihydrite. Where the neutral $\text{Ca}_2\text{UO}_2(\text{CO}_3)_3$ complex predominated, calcium reduced uranium retention by the minerals. For quartz, the authors report 77% sorption without calcium, compared with 42% and 10% at 1.8 and 8.9 mmol/L Ca^{2+} ; for ferrihydrite, 83% compared with 57% at 1.8 mmol/L.[68] These are laboratory conditions, not measurements of the effectiveness of a natural ‘filter’ in the steppe.

The practical significance of this experiment is that water composition can change the mobility of the same element on the same surface. Local assessment therefore requires alkalinity, bicarbonate, calcium and pH alongside uranium. A single ‘total dissolved solids’ entry does not describe all these relationships.

5.4. Surface retention and subsequent release

Sorption is the accumulation of a substance on a surface. It does not destroy the uranium atom. Changes in solution composition can strengthen or weaken retention. Precipitation of a separate solid phase does not render the substance permanently immobile either: a new chemical environment may alter that phase’s stability.

This distinction matters for settling ponds, soils, bottom sediments and filter media. Clarification reduces visible suspended matter, but does not necessarily remove dissolved complexes. Conversely, some of the element may be removed with settling particles; attention then shifts to the composition and subsequent handling of the sediment. These processes must be distinguished analytically, not by the water’s colour.

5.5. Nitrate and microbial processes

In an experiment by Westrop and colleagues, the inflow of nitrate-rich water into uranium-bearing alluvial sediments activated a nitrate-reducing microbial community. The nitrite produced contributed to uranium mobilisation from reduced sediments.[69] The study demonstrated a mechanism additional to carbonate-driven release from mineral surfaces.

For Krasnopolye, a publication's simultaneous mention of nitrates, sulphates and uranium does not automatically establish this mechanism. Results from the same sampling series and a characterisation of the environment are needed. The mechanisms nevertheless show why a monitoring programme should not focus on one element without considering its chemical surroundings.

5.6. Water pathways and substance pathways

Water moves under a hydraulic gradient; a substance may also be retained on surfaces, move between phases and be released again. Water velocity and the velocity of a dissolved uranium front therefore need not coincide. Even a correct flow arrow does not specify the concentration, arrival time or fraction of the substance reaching a borehole.

In California's Central Valley, Jurgens and colleagues linked changes in groundwater quality to irrigation and pumping: young, bicarbonate-rich water leached uranium from shallow sediments and moved deeper towards aquifers used for water supply.[70] This is a documented international example of water use changing the transport conditions of a naturally occurring element. Here it provides a framework for questions, not a calculation for Khakassia.

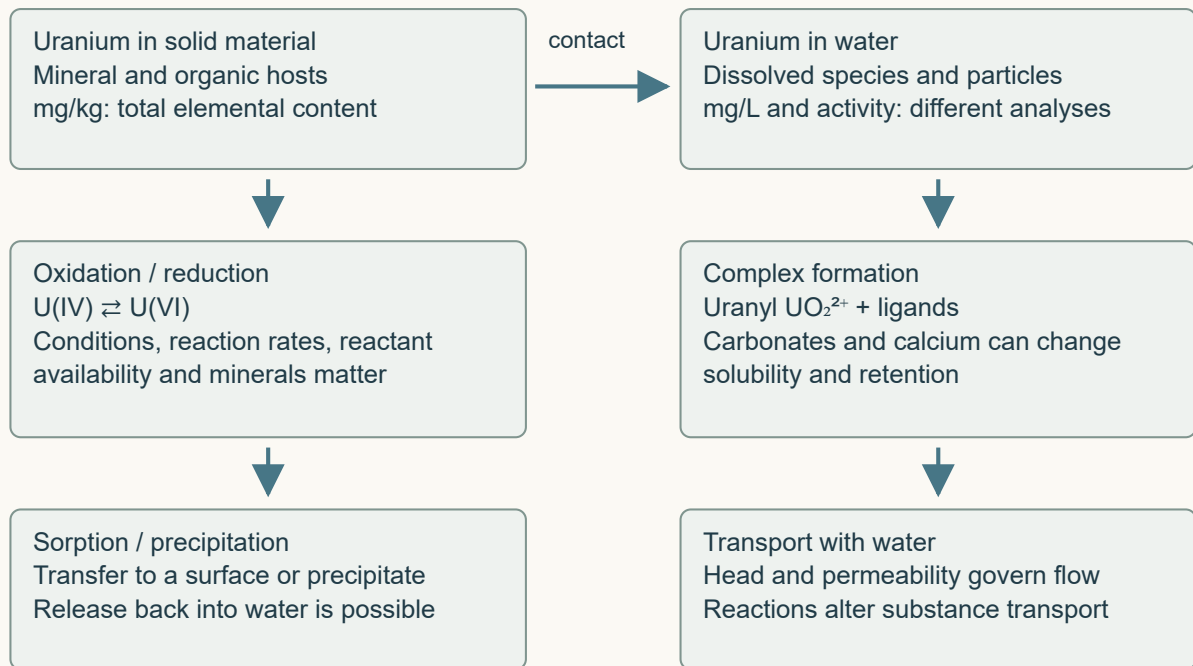
5.7. How to test a mechanism at a particular site

Stage	What must be measured or established
Initial material	Uranium content, mineral hosts, and distribution among rocks and mining products
Water in contact with rock	pH, oxygen, alkalinity, major ions, uranium and sampling conditions
Reaction	Changes in dissolved and particle-associated fractions; leaching test results
Transport	Hydraulic heads in the relevant aquifers, screened intervals, pumping and discharge regimes
Drinking water source	Analyses from corresponding periods and the water intake's operating history
Human exposure	The water actually used, duration and volume of consumption, and anonymised follow-up results

This sequence is an explanatory research framework. It does not assert that a ‘mine — borehole — disease’ pathway has been measured. Water intake owners and subsoil users hold different parts of the underlying information; comparison of those records should be available for independent assessment.

Beyond concentration: chemical form

Explanatory diagram. Conditions and reactions must be checked for the water concerned.



Measure alongside uranium: pH, oxygen, alkalinity, major ions, mineral hosts, dissolved and suspended fractions, and water levels.

Not a pathway model from a mine to a drinking-water borehole. [66], [68]–[70].

Explanatory diagram of chemical forms and transport conditions. It is not a model of water from a particular borehole. Sources: [66], [68]–[70].

6. What a laboratory actually measures

6.1. Elemental analysis and radiometry

In the study of nine settlements, mass concentration was determined by the luminescence method under GOST R 54499–2011. Radiometric investigations of U-238 and U-234 are discussed separately.[3] Using these methods alongside one another is valuable: it allows answers to different questions to be compared, rather than relabelling activity as mass.

ICP-MS determines elements from signals of ions with corresponding masses after sample preparation. Gamma spectrometry determines activities from the radiation spectrum using the specified method. Gross alpha activity is a screening measure. No method becomes universal simply because its result appears in a laboratory table.

6.2. The dissolved fraction, suspended matter and the whole sample

EPA Method 200.8 distinguishes the determination of dissolved elements from total recoverable elements in the whole sample. For the dissolved fraction, filtration through a 0.45 µm membrane is specified before preservation; preparation of the whole sample differs. Section 9 requires quality control, including blanks and checks of method performance.[71, Sections 8–9]

This illustrates why two figures labelled ‘uranium in water’ may refer to different analytical fractions. The report does not attribute this method to laboratories in Khakassia. A particular local result requires its test report and the method specified there. Field pH, oxygen and temperature must not be reconstructed from the appearance of a sample that has already been preserved.

6.3. What must accompany a result

Minimum traceability comprises sampling location and date, source identifier, whether water was sampled before or after treatment, the sampling organisation, method, unit, detection or quantification limit, uncertainty and basis for comparison. Preparation details are also needed: whether the sample was filtered, how it was stored, and whether the dissolved fraction or the whole sample was analysed.

An empty cell is not zero. ‘Below the quantification limit’ does not mean complete absence of the substance. A series mean $\pm$ standard deviation is not the uncertainty of an individual measurement. Vershino-Bidzha and Krasnopolye show why these details change how a table is read.[3][6]

6.4. Why background gamma measurements cannot replace water analysis

Measuring the radiation field over a site characterises that site, the measurement geometry and the conditions. It does not determine the mass concentration of dissolved uranium at a water intake. A favourable gamma survey and an exceedance of a chemical water quality limit can therefore coexist without logical contradiction.

For the published Krasnopolye range, the state report itself identifies the holders of the primary results: laboratories in Moscow and Khakassia, and Tomsk Polytechnic University.[2, PDF p. 34] Sample identifiers and the scope of the analyses should be obtained from the client and the testing organisation. Here, the absence of attached test reports has not been relabelled as an absence of testing.

7. Drinking water sources: nine settlements and broader screening

In 2020, sanitary and epidemiological service specialists E. A. Pivovarova, A. A. Pivovarov and V. E. Kurganov published uranium measurements for the centralised drinking water sources of nine settlements in Khakassia.[3]

Settlement	Administrative area	Uranium, mg/L, as reported in the study's table
Novotroitskoye	Beysky District	0.080 ± 0.010
Krasnopolye	Altaisky District	0.061 ± 0.010
Lukyanovka	Altaisky District	0.042 ± 0.011
Novorossiyskoye	Altaisky District	0.040 ± 0.010
Bograd	Bogradsky District	0.032 ± 0.011
Sorsk	City of Sorsk	0.030 ± 0.010
Moskovskoye	Ust-Abakansky District	0.029 ± 0.007
Vershino-Bidzha	Ust-Abakansky District	0.017 ± 0.004
Shira	Shirinsky District	0.007 ± 0.002

Source: Table 4, printed p. 49 / PDF p. 4.[3] The values and uncertainties are reproduced from that table. The article does not specify sampling dates for these particular samples; 2020 is the publication year. The authors' comparison limit was 0.015 mg/L.

The authors identified seven settlements as exceeding the limit: Novotroitskoye, Krasnopolye, Lukyanovka, Novorossiyskoye, Bograd, Sorsk and Moskovskoye. Taking the reported interval into account, the Vershino-Bidzha result is close to the limit; the settlement was not included in that list. The Shira value is below the limit. There is also an editorial discrepancy within the original source: the text gives the highest concentration as 0.061 mg/L, whereas the table gives 0.080 for Novotroitskoye. Our table retains the original entry, without correcting another author's result by conjecture.[3]

Uranium in water: more than one village

9 settlements · 7 identified by the authors as exceeding the limit

CENTRALISED WATER SUPPLY SOURCES · STUDY PUBLISHED IN 2020



Points mark settlements, not boreholes. No “contaminated zone” has been drawn between them.

Mines, the hydropower plant and uranium deposits provide context. These papers do not establish links to water composition.

Uranium deposits: catalogue locations, not boundaries. Primorskoye — A-3187; Oglakhtinskoye — A-3186 (1982).

Data: 10.35627/2219-5238/2020-323-2-46-50 · © OpenStreetMap contributors (ODbL)

Mosaic: EOxCloudless — cloudless.eox.at by EOx IT Services GmbH · Contains modified Copernicus Sentinel data 2024 · CC BY-NC-SA 4.0

Annual satellite mosaic, not a single-date image · Research illustration · EN V0.2 · 16.10.2026

URANIUM, mg/L

Luminescence method · GOST R 54499–2011
Authors' comparison: 0.015 mg/L (GN 2.1.5.2280–07)

1	Novotroitskoye Beysky District	0.08 ± 0.01
2	Krasnopolye Altaisky District	0.061 ± 0.01
3	Lukyanovka Altaisky District	0.042 ± 0.011
4	Novorossiyskoye Altaisky District	0.04 ± 0.01
5	Bograd Bogradsky District	0.032 ± 0.011
6	Sorsk City of Sorsk	0.03 ± 0.01
7	Moskovskoye Ust-Abakansky District	0.029 ± 0.007
8	Vershino-Bidzha Ust-Abakansky District	0.017 ± 0.004
9	Shira Shirinsky District	0.007 ± 0.002

Colour key

- 7 settlements: exceedance identified by authors
- Vershino-Bidzha: interval crosses 0.015
- Shira: below the uranium comparison value

Line across the bar: 0.015 mg/L.
± indicates uncertainty in the source table.
Sampling dates for the nine samples are not given.
These are published historical results,
not an account of water quality today.

Source: Table 4, p. 49 (PDF p. 4).

Nine settlements from the 2020 study. The colours reflect the results and the authors' conclusion. Coal mines and uranium sites are shown as geographical reference points. Basemap: EOxCloudless satellite mosaic for 2024; attribution and licensing are given in the section on illustrations.

This history began before the public crisis in Krasnopolye. A 2016 paper describes regional monitoring of gross radioactivity in water since 1997 and of individual natural radionuclides since 2002. Krasnopolye was already among the settlements with high gross alpha activity. It was also named in monitoring materials published in 2013.[4][5]

The 2020 study summarises another measure of the problem: in 2005–2018, gross alpha activity exceeded the screening level in **54.9 ± 10.3% of samples**, and water yielding these results came from **124 sources**.^[3] This is a radioactivity screening result, not the proportion of all water sources exceeding a chemical limit for uranium. Nevertheless, the figure shows that the sanitary authorities were dealing with a persistent regional problem, rather than a single unexpected sample.

7.1. What the list of seven exceedances means

Table 4 in the study by Pivovarova, Pivovarov and Kurganov lists nine settlements; the authors' conclusion on exceedances names seven. Vershino-Bidzha has a central value of 0.017 mg/L and a reported uncertainty of 0.004 mg/L. The interval crosses 0.015 mg/L. The authors did not separately explain why the village was omitted from the list of seven, so their reasoning is not reconstructed here. For Shira, the published value is 0.007 ± 0.002 mg/L.^[3]

There is another discrepancy within the same paper: the tables give 0.080 mg/L for Novotroitskoye, while the text gives 0.061 as the upper value. Our report uses the table entry and explicitly explains this difference. It has not been adjusted upwards or downwards on the basis of an assumption.

7.2. Monitoring before 2021

The 2016 publication describes regional monitoring of gross alpha and beta activity and radon since 1997, and of individual natural radionuclides since 2002. Krasnopolye is named among the settlements with high alpha activity. Its district-level Table 6 gives mean activities of 0.27 Bq/kg for U-238 and 0.74 Bq/kg for U-234 in Altaisky District. District averages are not measurements of every borehole in the district.^[4, PDF pp. 2, 4–6]

The state report for 2012 names Krasnopolye, Novo-Rossiyskoye and Novo-Troitskoye; elevated alpha activity is associated with U-238 and U-234. For this group, it gives a preliminary annual effective dose of 0.11–0.15 mSv and states that continuous radiation monitoring is needed. This is a historical assessment of exposure, not a diagnosis or a mass concentration. The extract is reproduced in documentary Appendix B from the complete archived copy, PDF p. 101.^[77]

The 2013 scientific publication uses monitoring materials for 2006–2012 and also names Krasnopolye.^[5, printed pp. 137–138] The overlap in authors and observations means that the report and the article may describe the same investigations. They have not been counted as two independent series of samples.

7.3. Twenty-one settlements do not mean twenty-one mass-concentration measurements

The 2019 paper presents a table of gross alpha activity for a broader list of settlements. All 21 entries are reproduced in Appendix A. This list concerns radiometric screening. It has not been turned into a list of 21 settlements exceeding a uranium limit in mg/L.[6, Table 2]

For Krasnopolye, the reported value is 3.01 ± 0.9 Bq/kg ($M \pm s$), with a maximum of 5.2 Bq/kg. In the following table, '2.6* (3.9)' refers to a calculated screening level, not a measured concentration. The number 43 in this part of the paper is the number of samples. The footnote links interpretation to the ratios of U-234 and U-238 activities to intervention levels.

[6, PDF pp. 4–6]

The requirement to determine radionuclide composition after screening is part of the method, not a way to invalidate the result itself. Residents should be entitled to see exactly what was measured at the next stage and how the water was assessed against chemical and radiological indicators.

8. Krasnopolye: water, decisions and operating infrastructure

In spring 2021, uranium ceased to be a matter of geology for Krasnopolye residents. It became a question of where to get water.

On 2 April, journalist Irina Nichkova reported in Shans that standpipes had been sealed and use of water-draw facilities temporarily suspended by court order. The school, kindergarten, community centre, feldsher and midwife station, and some residents depended on the centralised source. Others used private boreholes. In the same publication, regional ONF head Evgeny Mamaev asked why steps to provide safe water had not been taken following the previous year's results.[1]

The concentrations were recorded in more than newspapers. Khakassia's state environmental report for 2021 states that uranium in Krasnopolye's groundwater source for centralised drinking-water supply was **0.055–0.066 milligrams per litre** against the limit stated in the document of **0.015 mg/L**. This is approximately 3.7–4.4 times the limit. The report lists three laboratories that performed the analyses.[2, PDF p. 34]

A milligram per cubic decimetre, the unit used in the report, is the same concentration unit as a milligram per litre. Here, the measurement is specifically the mass of uranium in the drinking-water source.

In a public explanation, a Rospotrebnadzor representative said that exceeding the limit did not imply the onset of radiation sickness.[1] But residents' question was broader: why had they been supplied with water exceeding a chemical limit, and how could another supply be provided? An answer about the absence of expected radiation sickness does not answer a question about drinking-water quality.

After the familiar water supply was closed, the story of a replacement supply began. Documents trace the replacement of the borehole and the arrival of treatment equipment.

Date or period	What is documented
1983	Commissioning year of borehole No. 0618 in the earlier water-supply scheme for Krasnopolye Village Council.[8, Table 3]
Spring 2021	Reports on restrictions on drawing water and arrangements for an alternative supply.[1]
2021	Commissioning year of borehole No. 786 in the published update to the scheme.[9, Table 3]
3 February 2022	The newspaper Khakassia reported that a pumping station had been built and residents were still awaiting the water supply.[10]
31 May 2022	The official list of municipal property being transferred includes a BMS WT 5CE/S treatment plant.[11]
2024	An updated scheme was posted on the district website, describing the new borehole alongside some older descriptions.[9]
First quarter of 2025	Cold-water supply services provided to Krasnopolye by Impuls are recorded in a subsequent court judgment.[12]

What matters in these documents is not only the new infrastructure but also the inconsistent descriptions. The updated scheme's title page still bears the year 2014. One passage says there is no preventive disinfection installation; another says ultraviolet disinfection is already in use. Information on borehole No. 786 appears alongside the old statement that there is no water treatment.[9]

Naming equipment does not tell us what happened to uranium after treatment. That requires a consistent series of analyses: the source, water after treatment and the distribution network; the date, sampling location, result and method.

The state report for 2022 again names Krasnopolye, Lukyanovka and Novorossiyskoye among settlements with uranium exceedances. However, the relevant section summarises monitoring for 2018–2022 and does not identify which samples were taken after the new plant was commissioned.[13, PDF p. 153]

No publicly available series of results was found that would allow water quality to be traced from treatment to today's consumer. The water-supply organisation is responsible for operational monitoring. The municipality is required to publish

information on the quality of supplied water and implementation of plans to improve it. These are specific duties set out in Articles 25 and 23 of the water-supply law.^[14]
^[15]

The judgment in case A74-7838/2025 names the municipal enterprise Impuls of the Altaisky District municipality as the operator for the first quarter of 2025.^[12] The monitoring programme, test results and equipment documentation should be sought from the operator and the owner of the facilities; primary laboratory reports should be sought from the laboratories that performed the analyses. Residents need an accessible answer about what is being supplied to their homes now.

8.1. Documentary chronology

Date or period	Event and supporting record
1983	Commissioning year of borehole No. 0618 according to Table 3 of the old water-supply scheme. ^[8]
2006–2012	Period covered by the monitoring materials used in the 2013 publication; Krasnopolye is named in the text. ^[5]
2019	Scientific publication on alpha activity and calculated screening levels; this is the article's year, not the date of all its samples. ^[6]
2020	Publication of the table of mass concentrations for nine settlements. ^[3]
31 March – 2 April 2021	Reports of a 60-day restriction on use of the borehole and seven standpipes, and of bailiff enforcement. The basis is publications and a reprinted statement, rather than a complete court decision obtained for this report. ^{[1][U059]}
22 April 2021	Report on a medical team's work. ^[35]
2021	Commissioning year of borehole No. 786 according to the updated scheme. ^[9]
3 February 2022	The newspaper reported a completed pumping station and the wait for water supply. ^[10]
3 March 2022	Report on enforcement of the decision to discontinue use of the old water-draw system. ^[U050]
31 May 2022	Resolution No. 314 lists a BMS WT 5CE/S plant. ^[11]

Date or period	Event and supporting record
2024	The district website published an updated scheme; the title page retained the 2014 details. [9]
First quarter of 2025	Cold-water supply services provided to Krasnopolye by the municipal enterprise Impuls are described in a subsequent court judgment.[12]
3 April 2026	Date of the full judgment in case A74-7838/2025. [12]

8.2. Three laboratories and one range

The 2021 report names the Centre for Hygiene and Epidemiology in Moscow, the Centre for Hygiene and Epidemiology in the Republic of Khakassia, and the accredited testing laboratory of Tomsk Polytechnic University. The overall range of 0.055–0.066 mg/dm³ cannot be apportioned between them without the laboratory reports.[2, PDF p. 34]

Reconstructing the chain requires sampling records and primary results: which borehole, when, before or after treatment, who commissioned the work, and which method produced each number. The laboratories and their clients are specific holders of this information. The report already confirms that analyses were performed; the question concerns their availability and detail.

8.3. What remains outside the measurement series

Search snippets contained 0.019 ± 0.004 mg/dm³ for the old borehole and 0.0130 ± 0.0028 for the new one. Complete, reproducible material containing laboratory reports and dates was not obtained. These figures are retained as a separate account in the discrepancy register, rather than combined with the official range in a chart claiming that ‘the water improved’.

The history of the borehole replacement requires a borehole passport, not a guess about how much deeper it is: coordinates, geological section, screened intervals, aquifer isolation, tests and actual yield. These documents are held by the owner, operator, drilling client and relevant geological archives. A gap in the public record cannot be filled with the passport of a neighbouring borehole.

9. Geology: where uranium occurs and what is extracted with coal

Uranium mineralisation in the region has long been known. In 1925, S. M. Kurbatov published a study of uranium and vanadium compounds in Minusinsk Uyezd. It describes material from a 1919 visit to the Potekhina area and the Yuliya mine.[16] This is a separate geological site, but it shows how far back the study of radioactive raw materials in the region goes.

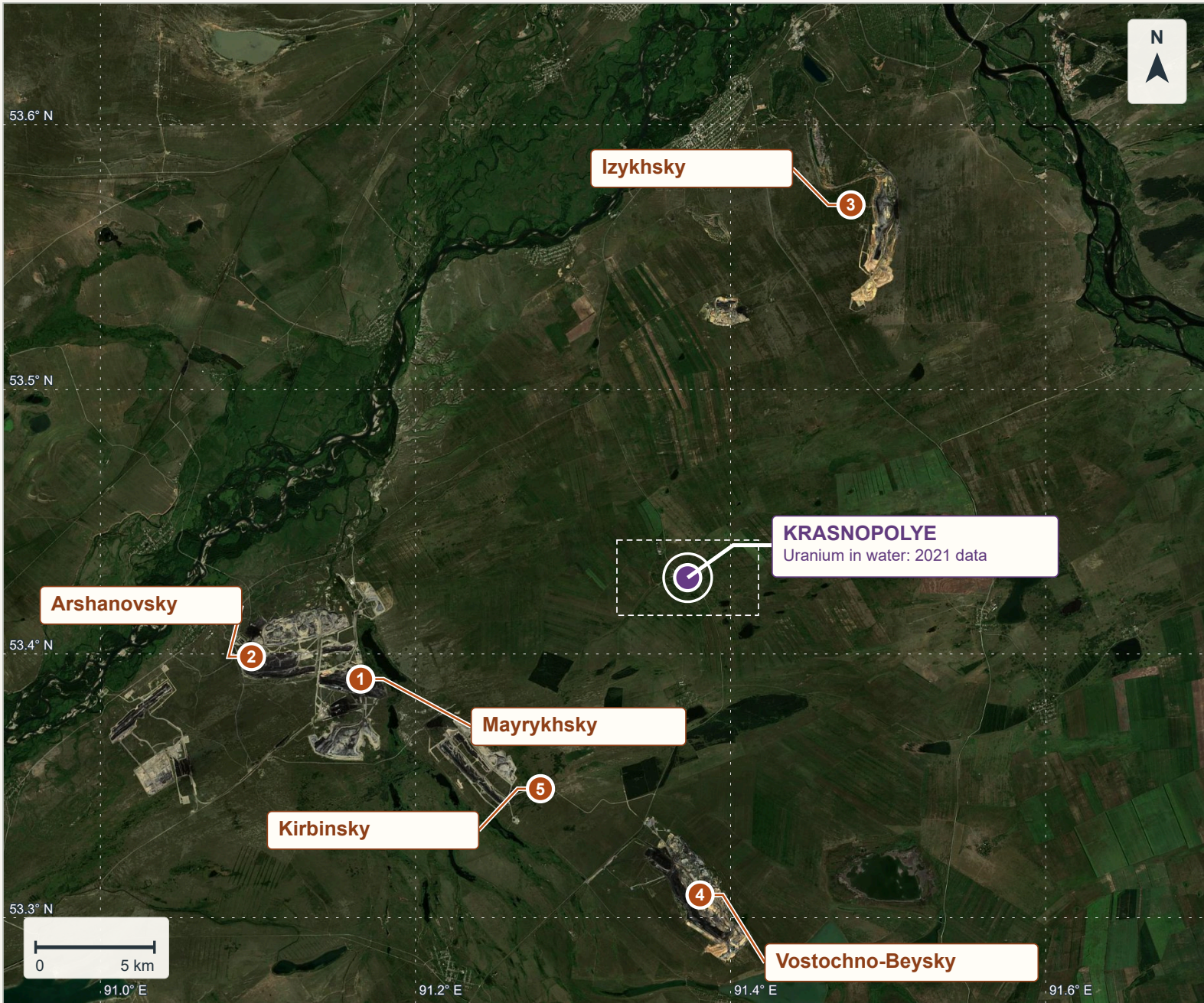
The Primorskoye and Oglakhtinskoye uranium deposits appear in materials on Bogradsky District.^[17] The overview map marks them separately from the coal mines near Krasnopolye. A catalogue reference point shows a site's location, not the boundaries of its deposit.

In May 2021, MK in Khakassia, citing RTS, reported a six-kilometre uranium vein near Krasnopolye.^[18] The available publication provides no geological section, trace coordinates, depth or sampling results. Establishing its location requires a primary geological report or site passport. Such materials are produced by the organisation carrying out the work and deposited in geological archives. The map shows only sites for which coordinates are available.

Krasnopolye: water and coal mines

2024 satellite mosaic · Koibal Steppe and an overview of northern Khakassia

KRASNOPOLYE AND SURROUNDING MINES

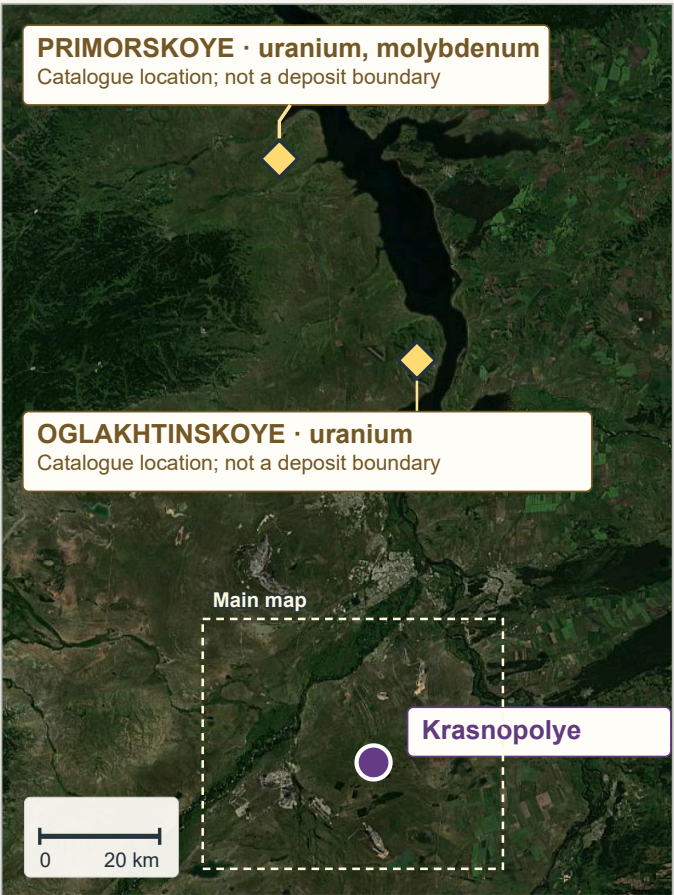


- 1 Mine: geographical reference point
- 2 Village with documented water test results

Mine boundaries and boreholes are not marked separately. The image does not show uranium concentrations.
Reported “vein” near Krasnopolye: publications give no coordinates or alignment; no line is drawn.

Mosaic: EOxCloudless — cloudless.eox.at · EOX IT Services GmbH · Contains modified Copernicus Sentinel data 2024 · CC BY-NC-SA 4.0
Locations: GEM / Russian Coal / © OpenStreetMap contributors; SGM RAS No. 1740; Resolution No. 133-n (2018); state report 2021.

URANIUM SITES: OVERVIEW



KRASNOPOLYE · ENLARGED DETAIL



OGLAKHTINSKOYE
A-3186, 1982; sheet N-46-XIV.
54.0340° N; 91.4831° E.
Primorskoye: record A-3187, 1982.
Catalogue precision is stated as “±60”.

Research illustration · EN V0.2 · 16.10.2026

Krasnopolye and surrounding mines on a 2024 satellite mosaic. A separate inset shows Primorskoye and Oglakhtinskoye. The settlement and company locations are marked; drinking-water borehole coordinates are not specified on this map.

Near Krasnopolye are the Kirbinsky, Vostochno-Beysky, Mayrykhsky, Arshanovsky and Izykhsky mines. Straight-line distances between the published village point and the points for these sites are approximately **11–20 kilometres**. For the Kirbinsky heavy-vehicle site, there is also an official description: the site lies 10.9 km south-west of the village.[64]

These are distances at the surface. Underground, water is directed by aquifer rocks, their permeability and hydraulic heads. Understanding what is happening requires looking not only at where the pits are but also at what they expose and how they manage water.

9.1. The Beyskoye deposit is a heterogeneous formation

Vergunov, Arbuzov and Sobolenko describe the coal-bearing sequence of the Beyskaya syncline as dipping to 1300–1400 m; the Chernogorsk Formation is 260–290 m thick. They identify 40 coal seams 0.6–12 m thick and 22–25 interbeds 0.05–0.6 m thick within the productive sequence.[19, PDF pp. 3–4] The geological depth of burial does not indicate the depth of a present-day open pit.

The authors identified 42 tonsteins associated with ancient volcanic material. These beds are usually 0.2–4 cm thick, with some reaching 9–10 cm. Table 4 gives results for eleven samples. The reference value of 4.5 mg/kg for the Clarke value of clays is neither a twelfth sample nor a sanitary limit.[19]

Sample	U, mg/kg of rock
Ap-18-17	24.4
Ap-8-15	6.0
Ap-37-17	12.4
Ap-12-17	13.4
Ap-31-17	9.9
Ap-12-18a-15	53.3
Ap-14-14	10.9
Ap-25-17	6.7
Ap-26-17	16.2
Ap-22-17	36.8
Ap-28-17	11.6

Elemental composition was investigated using ICP-MS and instrumental neutron activation analysis; mineral composition was investigated using separate methods. It is the combination of methods that allows the origin of the elements to be discussed. A single U entry does not establish the chemical form of all the uranium or its leaching into water.

9.2. From the deposit to a particular site

Volume 1 of the Mayrykhsy environmental impact assessment describes 12 seams to be worked and a complex banded structure; seam 19 comprises 5–8 bands. The project provides for bulk extraction including rock partings, followed by beneficiation.[20, PDF p. 21] It is therefore inappropriate to reason as though all the mineral rock remains undisturbed beneath the coal.

Arshanovsky's own historical publication reports 29 balance-reserve seams with a combined thickness of 67 m, including principal seams 15 and 19 with average thicknesses of 7.1 and 11.2 m.[U039] This characterises the site described, not a current laboratory average for the entire steppe.

In the Izykhsy section examined in the 2024 study, seam XXX has a total thickness of 4.0–9.3 m, 5–7 bands and rock partings of 0.3–3.0 m. The field description of a 0.45 m siltstone parting with a reading of 25 $\mu\text{R}/\text{h}$ relates to a specific location.[21, PDF p. 7] It cannot be extrapolated to every seam, batch and area.

9.3. Commercial grades and declared specifications

Grade	Size fraction, mm	Moisture, %	Ash content, %	Calorific value, kcal/kg
DOM (ДОМ)	13–50	12–16	4–11	5550–6000
DOMSSh (ДОМСШ)	0–50	12–16	7–12	5400–5800
DPK (ДПК)	50–200	12–16	6–10	5600–6000
DPKO (ДПКО)	25–200	12–16	5–11	5550–5900
DR (ДР)	0–300	12–16	4–12	5400–6000
DSSh (ДСШ)	0–13	12–16	8–13	5200–5600

Source: the producer's published product page, accessed on 16 October 2026.[U005] These are declared ranges for the grades. Comparing different specification sheets requires the same bases for determining moisture, ash content and calorific value. Sulphur or trace-element content has not been added from another company's catalogue.

9.4. What happens to the element during preparation and combustion

Separation divides material by physical properties; it does not destroy a chemical element. Constructing a uranium mass balance requires the mass and composition of the feed coal, concentrate, intermediate products and wastes from the same processing series. Analyses of tonstein and a specification sheet for a commercial size fraction alone are insufficient.

During combustion, most of the combustible mass becomes gaseous products, while the non-combustible fraction forms ash and slag. The USGS treats coal and fly ash as distinct media in which the content and forms of radioactive elements need to be studied.[24] A higher concentration in the residue does not, by itself, tell us what proportion was released into the air or leached into water.

Calculating the mass of an element in a stream requires multiplying its concentration by the mass of that stream. Comparing only mg/kg in the original fuel and ash does not provide a complete balance. A technically meaningful question for a buyer is therefore not only ‘is there a coal specification sheet?’ but also ‘what was measured in the ash, slag and water after this particular batch was used?’

10. Radiological investigations of coal, ash and the site

The documents contain radiological tests of coal and surveys of the site. Neither favourable results nor internal discrepancies in the laboratory report have been excluded from the analysis. Each document is examined separately below.

10.1. Laboratory report No. 965: what was tested

Testing organisation: the Novokuznetsk and Novokuznetsky District branch of the Centre for Hygiene and Epidemiology in Kemerovo Oblast. Applicant: SGS Vostok Limited JSC. Material: coal, grade DOMSSh (ДОМСШ), 0–50, batch 0198; producer: UK Razrez Mayrykhsy LLC. The sample was collected on 10 January and delivered on 20 January 2020.[23]

The tables name K-40, Ra-226, Th-232 and effective activity. There are no separate entries for U-238 or U-234. The document therefore cannot be described as a direct determination of these uranium isotopes. The relationship within natural radioactive decay series does not allow a measurement of one radionuclide to substitute for another without checking equilibrium.

The summary entry reports A_{eff} of 19 ± 9 Bq/kg; the permissible level stated in the document is 370 Bq/kg, and the method is GOST 30108–94. This reproduces the document accurately; it does not assert that a construction-material criterion automatically regulates every use of coal.

10.2. Two discrepancies left unresolved

The title page dates the laboratory report to 22 January, while the second page gives 23 January 2020 as the completion date for testing. The effective-activity entries for five samples are 35, 24, 39, 37 and 37 Bq/kg; their simple mean is 34.4, whereas the bottom entry gives 19 ± 9 . Explaining this requires the original document and the laboratory's calculation structure.[23]

An editor should neither replace 19 with 34.4 nor conceal the discrepancy behind ‘everything is within limits’. Both pages, all values and the precise question for the testing organisation are retained. The document establishes that a particular test took place. It does not cover every year of operation or every batch produced by the company.

10.3. Tested coals and wastes: separate results

Material	Site	A _{eff} , Bq/kg
Coal, grade DPK (ДПК)	Izykhsky	40.6 ± 19.346
Coal, grade DSSh (ДСШ)	Izykhsky	47.6 ± 22.938
Coal, grade DOM (ДОМ)	Izykhsky	36.4 ± 20.326
Coal, grade DR (ДР)	Izykhsky	51.7 ± 21.058
Ash and slag	Izykhsky	299.2 ± 61.256
Ash and slag	Stepnoy	108.95 ± 26.986
Ash, separate study	Stepnoy	188.4 ± 37.68

Source: S. A. Kyrova's dissertation abstract, Tables 6–8, PDF pp. 17–18.[22] The author assessed the tested coals favourably against the 74 Bq/kg criterion used in the study. That conclusion is retained. The criterion itself is not presented as a universal current limit for all materials.

Izykhsky ash and slag, Stepnoy ash and slag, and the separately studied Stepnoy ash are different materials. They cannot be averaged as repeated measurements of the same material or arranged to show an increase over time. The study itself also raises the need for systematic waste monitoring in view of radiometric anomalies.

10.4. Gamma survey of the site

EIA Volume 1, §3.6, PDF p. 44: mean 0.13 µSv/h, range 0.08–0.18 µSv/h; survey on a 10 m grid and by free search.[20] This is a favourable result for the surveyed site and the method used. Its place in the evidence is defined precisely: the coal loading facility site, not all of Khakassia or Krasnopolye's drinking water.

Facsimiles of the laboratory report and pages containing coal and ash results are in Appendix D. They allow readers to see the original tables and check which indicators are actually named.

11. Water does more than leave: pumping, infiltration back into the ground and changes in composition

Pumping mine water and subsequently disposing of it produce different hydrogeological effects. State monitoring directly describes both processes.[25–27]

11.1. The cone of depression and mine-water volume

State monitoring described the merging of the Mayrykhsky and Arshanovsky cones of depression by 2018. The combined drawdown zone extends approximately 8 km west to east and 4–4.2 km south to north.[25, PDF pp. 73–76] These are the dimensions of the described zone, not a rectangle from which an area of damage can automatically be calculated.

Mayrykhsky's average daily mine-water pumping increased from 7.340 thousand m³/day in 2017 to 14.344 thousand m³/day in 2020: a rise of 95.4%. The conversion for 2020 accounts for 366 days: 14.344 thousand m³/day × 366 days = 5,249.904 thousand m³ ≈ 5.250 million m³. For the two mines in 2018, the known combined rate of 20.481 thousand m³/day gives an annual equivalent of 7.476 million m³. [State Subsoil Monitoring, 2017, PDF pp. 67–68]; [25–27]

This is pumped mine water. The total does not distinguish groundwater inflow, precipitation and surface runoff into the excavation. The annual equivalent is an arithmetic conversion of the average rate, not an independent measurement of the total annual volume or the amount of water irreversibly lost by the entire steppe.

11.2. Why drawdown and a rise can occur nearby

Pumping lowers hydraulic head near the excavation. A storage pond, by contrast, can recharge the rocks. Both a drawdown zone and a local groundwater mound can therefore exist within the same industrially altered system. Their magnitude and direction depend on the locations of the facilities, permeability, fractures, water levels and operating conditions.

The documented example of a mound concerns the Abakansky mine, not Mayrykhsky: in 2019, dimensions of up to 600 × 400 m and seepage from a settling pond into Carboniferous deposits were described.[26, PDF p. 72] For Izykhsky, the documented sequence is pipeline — storage excavations — evaporation and infiltration into aquifer rocks.[25][27, PDF p. 74]

11.3. The reservoir, canals and different shores

Kuskovsky described historical propagation of backwater effects from the Krasnoyarsk Reservoir over 2.5–3.8 km in Devonian deposits and 3–5 km in Carboniferous deposits along the profiles studied.[28, PDF pp. 2–3] The study noted changes in mineralisation in different directions. These findings cannot be replaced with a single arrow claiming that ‘the reservoir poisons every village’.

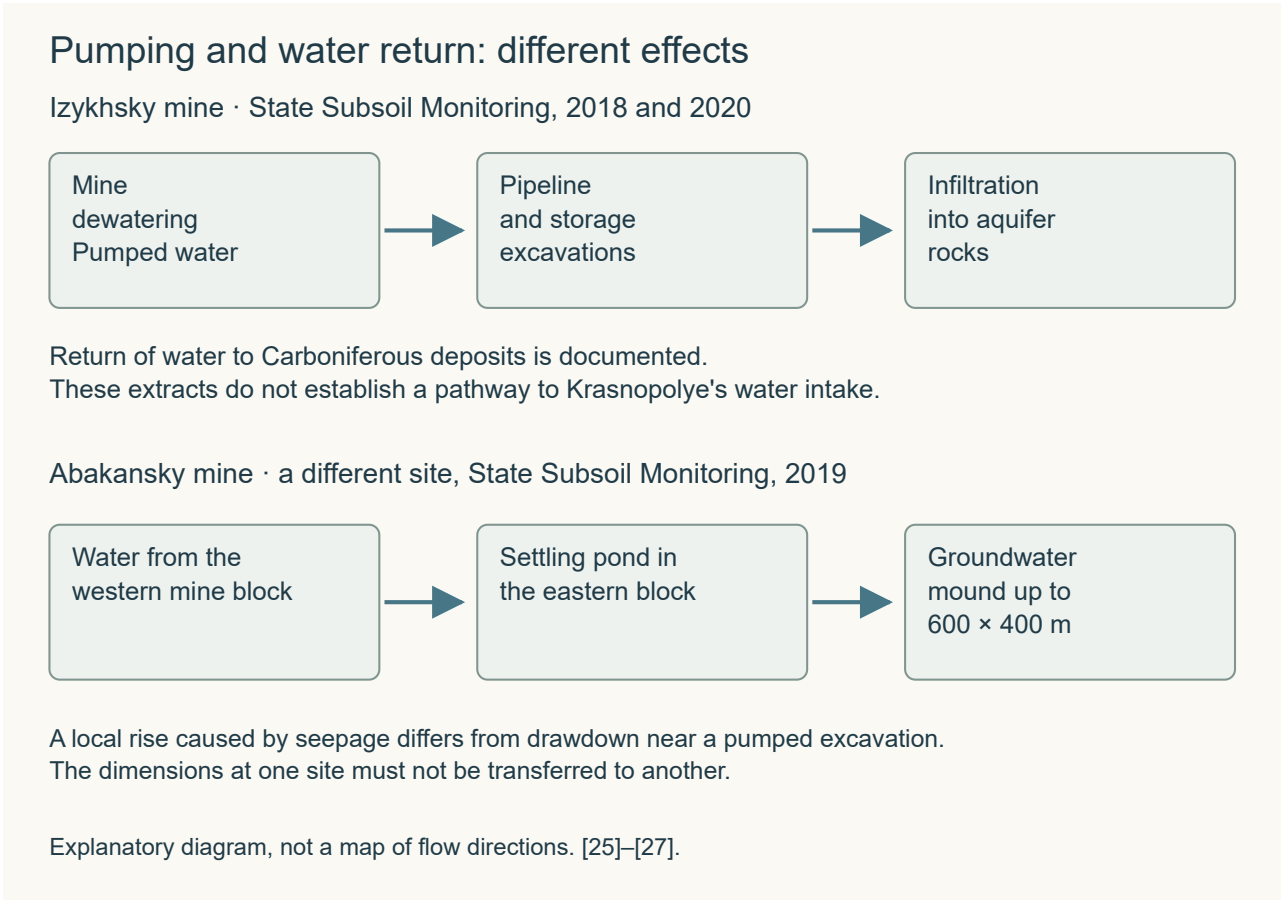
Altaysky District's 2010 territorial planning scheme describes recharge from precipitation, through-flowing groundwater and surface water; discharge is to river alluvium, local streams, lakes and drainage canals. Seepage from the irrigation network also affected levels.[29, PDF p. 10] This is a historical description of the system, not an automatic account of how it operates in 2026.

The Krasnoyarsk and Sayano-Shushenskoye reservoirs are different bodies of water. A settlement's position on a satellite map does not justify assigning to it the effects of any structure in the Yenisei cascade. A borehole's aquifer interval and hydraulic heads matter, not only the apparent proximity of surface water.

11.4. The balance: where the system boundary lies

For an aquifer, pumping is an outflow; for a company's mine-dewatering system, it is an inflow. Within the combined system, it is an internal transfer until water crosses the chosen boundary. The balance includes inflows, external outflows and changes in storage. Reinfiltration must not be counted simultaneously as a new independent inflow and an irreversible loss of the same water.

This report does not calculate a water balance for the Koibal Steppe. A unified public series of levels, pumping, use, discharge, evaporation and exchange with surface waters is missing. Companies produce operational and site-monitoring series; water-intake owners hold their own data; the state subsoil monitoring system produces relevant observations and summaries. What is missing is an accessible comparison of these parts, not the documented fact that the water regime has changed.



Two documented mechanisms at different locations in Khakassia. The diagram does not establish a pathway to Krasnopolye. [25]–[27].

12. How to read the maps

12.1. Three different geographies

The map of nearby mines shows the relative locations of the village and industrial sites. The map of nine settlements shows the geography of published mass concentrations. The broader alpha-screening list reflects a different indicator. They are kept separate so that a point's colour

does not substitute one measured quantity for another.

Settlement points are location references, not sampling coordinates. A catalogue point for a mine is not the entire mining-allotment boundary. Distances of about 11–20 km are calculated between selected reference points; they are not distances from the nearest edge of each pit to each borehole. Separately, the official document for the Kirbinsky heavy-vehicle site places it 10.9 km south-west of Krasnopolye.[64]

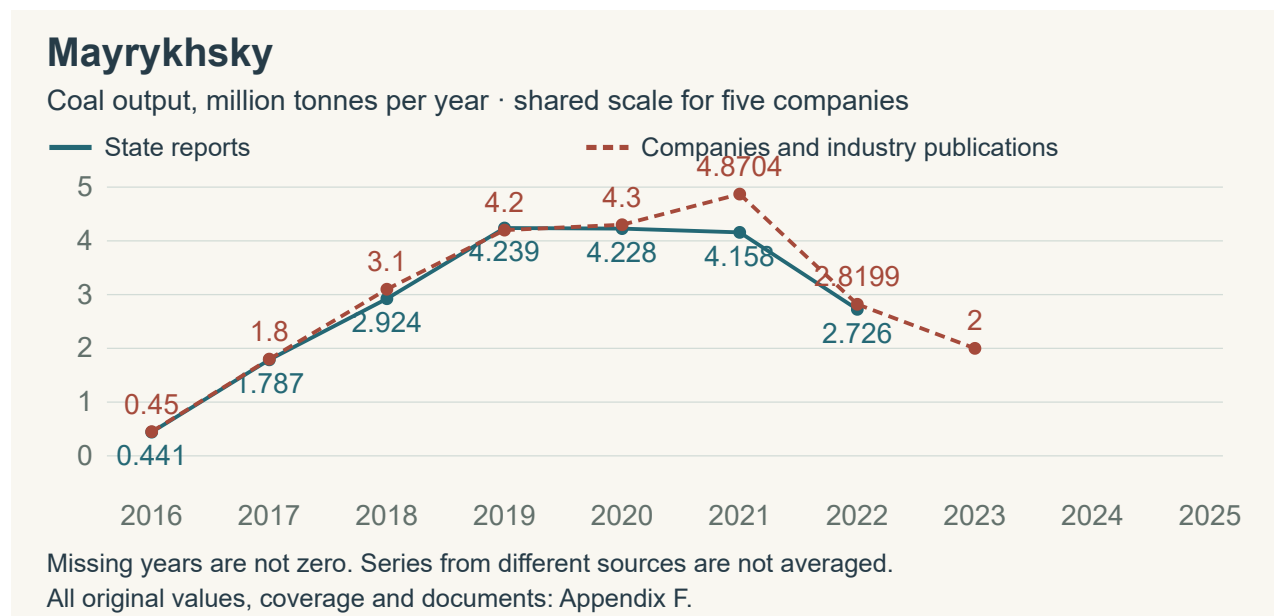
12.2. What the map does not encode in colour

The map contains no calculated radioactive-contamination contour, sanitary-risk boundary or established underground route from a particular mine to the village. Drawing such a line requires contemporaneous water levels and chemical data from comparable aquifers. Geological reference points are shown at their actual precision, rather than turned into detailed reserve outlines.

The basemap is the annual EOxCloudless 2024 satellite mosaic, not an image taken on the water-sampling day. Its CC BY-NC-SA 4.0 licence and EOX / Copernicus attribution are retained. Mine and settlement labels show proximity without invented arrows. Coordinates and method descriptions are available through the links in Appendix E.

13. Coal production: individual companies and complete annual series

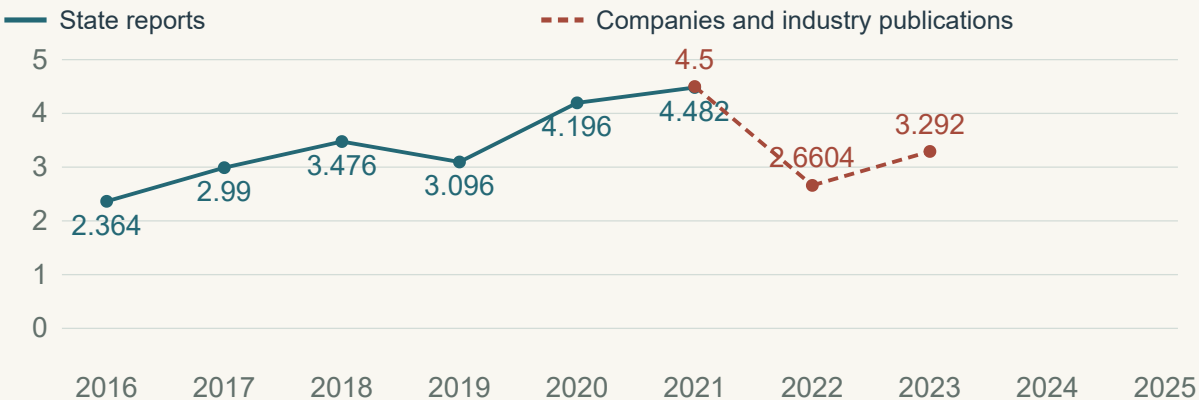
According to state reports, Mayrykhsy's output increased from **0.441 million tonnes in 2016 to 4.239 million tonnes in 2019**. Arshanovsky's increased from **2.364 million tonnes in 2016 to 4.482 million tonnes in 2021**. Kirbinsky entered this series with 0.073 million tonnes in 2018; the report for 2022 gives 2.459 million tonnes.[30]



Annual output; different source types are shown separately. The full table is in Appendix F. [30–33]

Arshanovsky

Coal output, million tonnes per year · shared scale for five companies

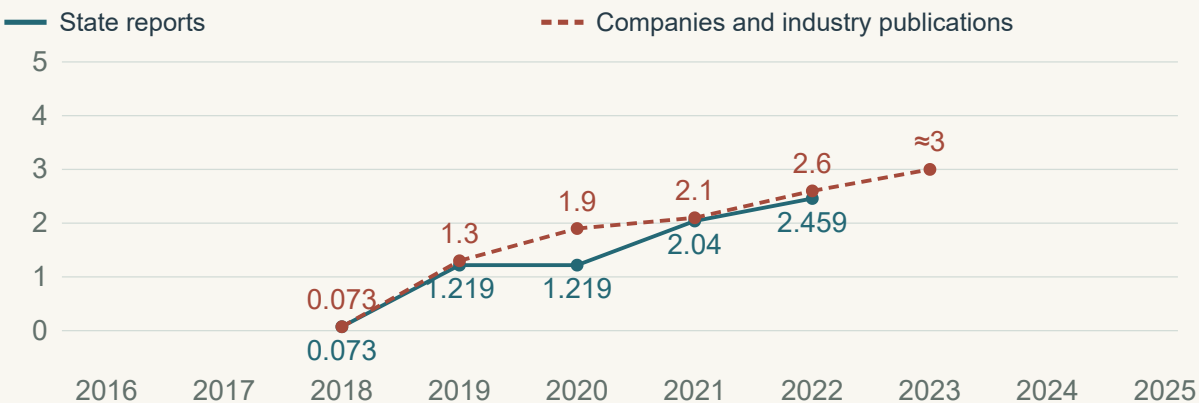


Missing years are not zero. Series from different sources are not averaged.
All original values, coverage and documents: Appendix F.

Annual output; different source types are shown separately. The full table is in Appendix F. [30–33]

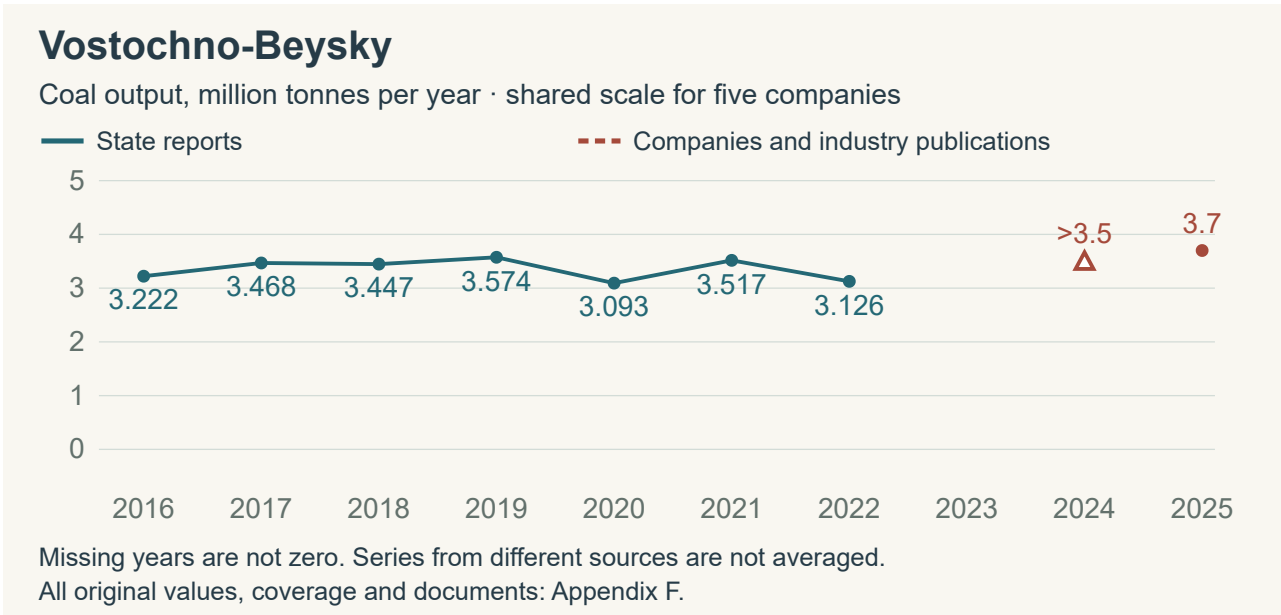
Kirbinsky

Coal output, million tonnes per year · shared scale for five companies

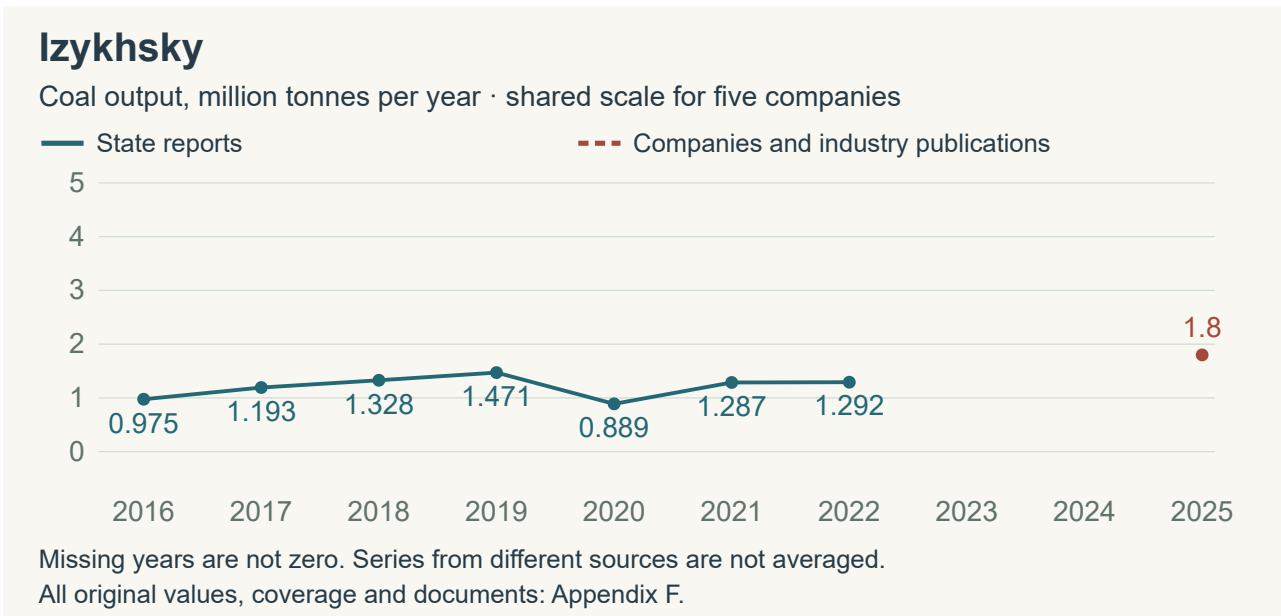


Missing years are not zero. Series from different sources are not averaged.
All original values, coverage and documents: Appendix F.

Annual output; different source types are shown separately. The full table is in Appendix F. [30–33]



Annual output; different source types are shown separately. The full table is in Appendix F. [30–33]



Annual output; different source types are shown separately. The full table is in Appendix F. [30–33]

State-report data are shown separately from company and industry publications. A dash indicates the absence of a comparable full-year value in the compiled series. Original numbers, documents and pages are available in the [data table](#).^[30–33]

Output did not move in the same direction every year. In 2023, the industry table gives Arshanovsky's output as **3.292 million tonnes**, 23.7% above the previous year. Kirbinsky reported approximately 3 million tonnes, compared with 2.6 million in 2022. For Mayrykhsky, by contrast, an industry review reported around 2 million tonnes and a 29% decline.^[31–33]

Sources sometimes disagree on absolute totals too. For Kirbinsky in 2020, for example, the state report gives 1.219 million tonnes and the company statement gives 1.9 million. Both records remain separate in the chart. Averaging them cannot produce a supposedly more reliable number.^[30]

The republic-wide series shows the overall scale: **18.015 million tonnes in 2016, 28.939 million in 2021 and 24.721 million in 2025**. Between the first and last points, the increase is 37.2%, although output declined after the peak.[30][34]

These were years of intensive industrial transformation of the area. Its medical history needs to be considered throughout this period and before it, rather than selecting one year with a convenient coincidence.

13.1. Why parallel figures are retained

A state report and a company statement may differ in scope: legal entity, production site, extraction, shipments, calendar year or part-year. For Kirbinsky in 2020, the series contains 1.219 million tonnes from the report and 1.9 million tonnes from the company statement. Neither number is selected because it produces a more striking increase.

In 2022, Arshanovsky appears in the state source as two legal entities. Their volumes cannot automatically be added without reconciling the scope. Izykhsky's value of 1.2 million tonnes for January–November 2023 is not described as a full-year total. Appendix F retains all 52 records from the source table, with their units, qualifiers and links.

13.2. Tonnes of coal and effects on water

Rising output may accompany expansion of excavations, movement of rock and changes in mine dewatering. But tonnage does not specify rock composition, infiltration volume or uranium concentration. Testing a connection requires operational series for the relevant sites: mining depth and area, exposed rocks, pumping, water disposal and water chemistry. These materials are produced in the subsoil user's documentation and site monitoring.

The report's annual charts provide an overall timeline. They retain changes in different directions: in 2023, Arshanovsky and Kirbinsky increased output while Mayrykhsky reduced it. Missing years are neither bridged with a straight line nor turned into zeroes.

14. From water to the body: chemical and radiological effects

14.1. Concentration, intake and the absorbed fraction

Mass concentration describes the water. The mass ingested in drinking water also depends on volume: $m = C \times V$. For example, 0.060 mg/L and a hypothetical two litres give 0.120 mg per day. This is an arithmetic illustration, not an established resident's consumption, total exposure or absorbed mass.

ATSDR treats compound solubility and exposure route as important factors in uranium distribution and excretion. The amount swallowed is not the amount entering the bloodstream. For soluble compounds, chemical toxicity, including effects on the kidneys, is important; inhalation and prolonged retention of poorly soluble particles require separate consideration. [67, Chapters 2–3]

Reconstructing a resident's exposure requires years of residence, the specific drinking-water source, changes in abstraction and treatment, use of delivered water, household filtration and water at work. This history cannot be reconstructed from a district-average rate. But the need for reconstruction does not remove the duty to ensure adequate supplied-water quality once non-compliance has been detected.

14.2. Why the kidney is the key organ

The kidney filters blood and returns some of the filtered substances to the body. The proximal tubules participate in this reabsorption. Tubular injury and impaired filtration are not the same thing; early changes in individual markers do not necessarily coincide with a change in an overall measure of kidney function.

In the study by Kurttio and colleagues, uranium in water and urine was measured in 325 users of drilled wells, alongside kidney-function-related indicators: calcium, phosphate, glucose, albumin, creatinine and β_2 -microglobulin.[75] This example shows how an exposure study differs from counting all diseases in the genitourinary category. It does not provide a frequency of uranium-related injury in Khakassia. A correction was published for the unit in one row of the article's table; the erroneous unit has not been carried over here.

14.3. Molecular events: what experiments have investigated

The review by Guéguen and Frerejacques describes a proposed chain of renal toxicity: uranium's interaction with tubular epithelial cells, involvement of endocytosis and the sodium–phosphate transporter NaPi-IIa, mitochondrial dysfunction, oxidative stress, DNA damage and inflammatory signalling pathways. Uranyl can interact with negatively charged phosphate groups. The authors discuss Nrf2, NF- κ B and endoplasmic reticulum stress as components of the responses being studied.[74]

The mitochondrion is the part of a cell that provides energy production; oxidative stress means an imbalance between the formation and detoxification of reactive compounds. This framework helps explain why the chemical action of a heavy element cannot be reduced to radioactive decay.

This is a synthesis of experimental and epidemiological evidence, not an established sequence in every water consumer. The authors propose an adverse outcome pathway, not a ready-made risk coefficient for Krasnopolye. Clinical diagnosis requires a doctor, an exposure history and the individual's laboratory data.

14.4. Uranium and cancer: keeping mechanisms distinct

WHO notes insufficient evidence of uranium carcinogenicity in humans and experimental animals; the drinking-water guideline is based on chemical toxicity, primarily renal toxicity.[7] Radiological assessment separately requires activity, exposure route and dose. Attributing any cancer trend to the measured mg/L skips these measurement steps.

The report therefore retains both lines of evidence: the established drinking-water quality problem and the actual health picture in the areas concerned. The duty to monitor water does not depend on whether the number of illnesses caused specifically by that water has already been calculated.

15. Examinations of residents and general health statistics

The indicators below describe the health of the district's and republic's populations. They cannot separately identify the consequences of drinking uranium-containing water: that requires data on specific water-supply sources, exposure duration and other risk factors.

On 22 April 2021, the newspaper Khakassia reported that a medical team was working in Krasnopolye. The examination history mentions Beloyarskaya District Hospital and the Health Centre.^[35]

The collected materials contain no public, final anonymised summary of these examinations: how many people were examined, what abnormalities were found, who was referred for further investigation and how follow-up proceeded. This is a specific missing result, not a claim that no doctors visited the village.

Medical records are the responsibility of the organisations that performed the examinations; the health authorities are responsible for the required regional reporting and its consolidation. Public analysis requires anonymised results, not publication of personal medical records.^{[35][63]}

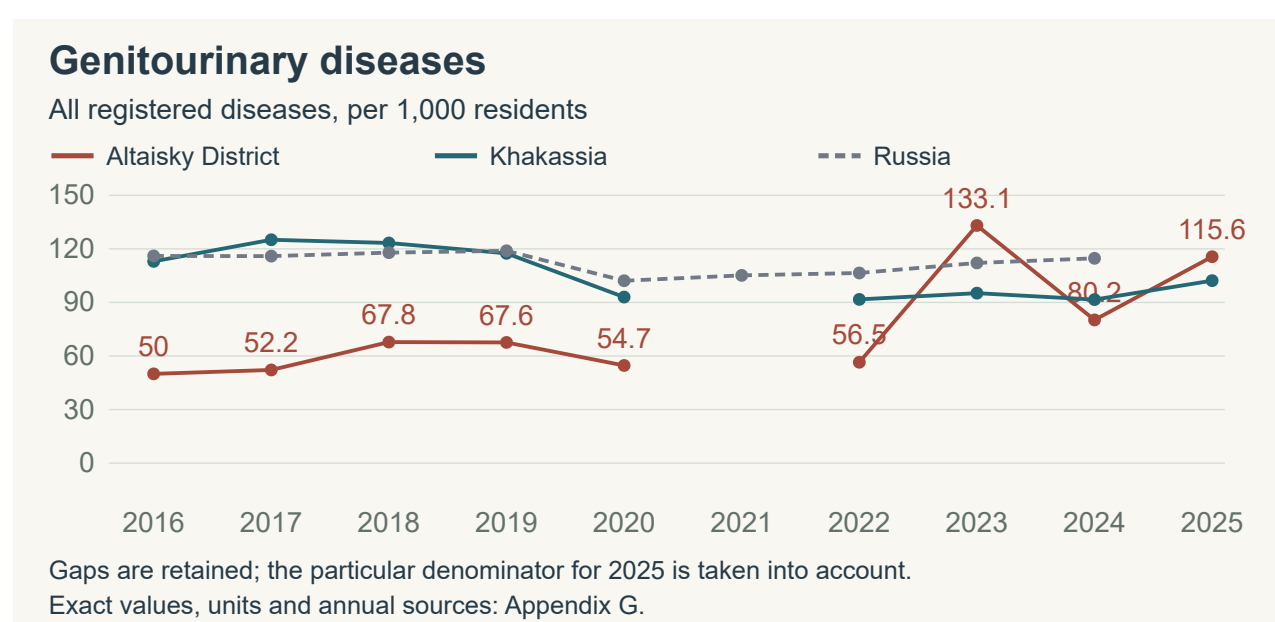
For now, the broader picture is available: Altaisky District, Khakassia and Russia. It is particularly important not to label the entire genitourinary disease category ‘kidney diseases caused by uranium’. It combines different diagnoses.

Year	Altaisky District	Khakassia	Russia
2016	50.0	113.0	116.0
2017	52.2	125.1	115.9
2018	67.8	123.3	117.9
2019	67.6	117.5	118.9
2020	54.7	93.0	102.1
2021	—	—	105.2
2022	56.5	91.7	106.5
2023	133.1	95.2	112.1
2024	80.2	91.6	114.7

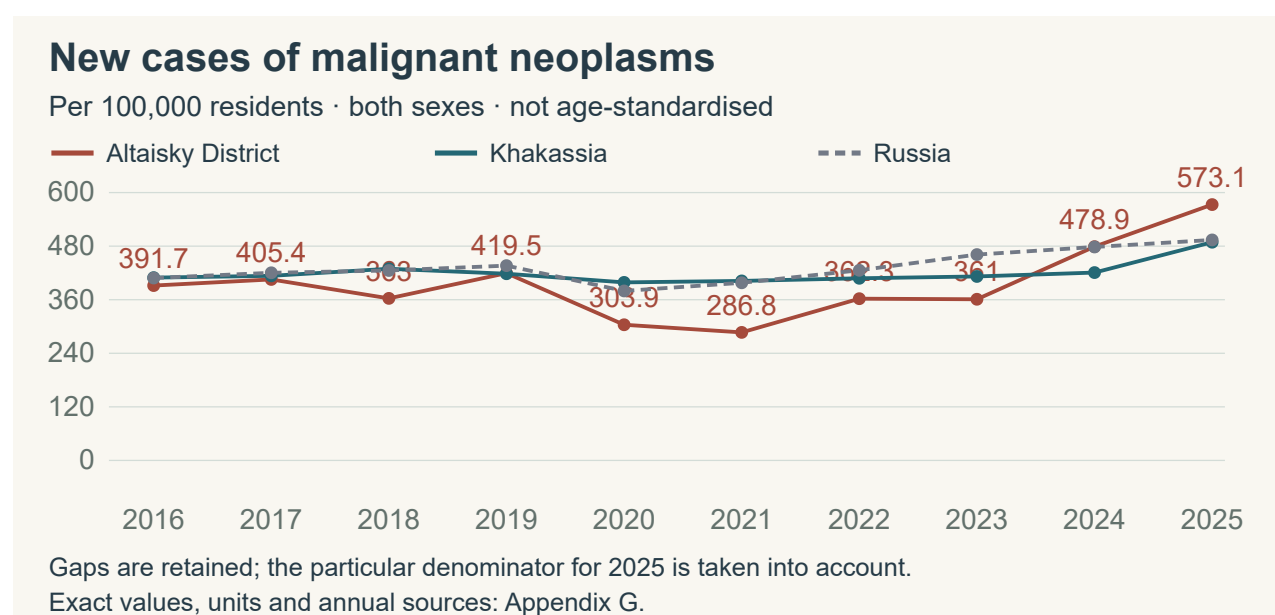
Year	Altaysky District	Khakassia	Russia
2025	115.6	102.2	—

All registered genitourinary diseases per 1,000 residents. Federal values have been converted to this unit and rounded to one decimal place; exact values and pages are in the [comparison table](#). Gaps indicate missing comparable entries in the sources used. The Russian series for 2020–2024 comes from a Rosstat edition using revised population estimates.^{[30][34][36]}

In 2023, the district rate was approximately 40% above the republic's and 19% above Russia's. However, in 2024 it fell to 80.2, then rose to 115.6 in 2025. Before the 2023 jump, the district values shown were below both reference rates. This is a history of fluctuations in disease registration, not a continuously rising line.



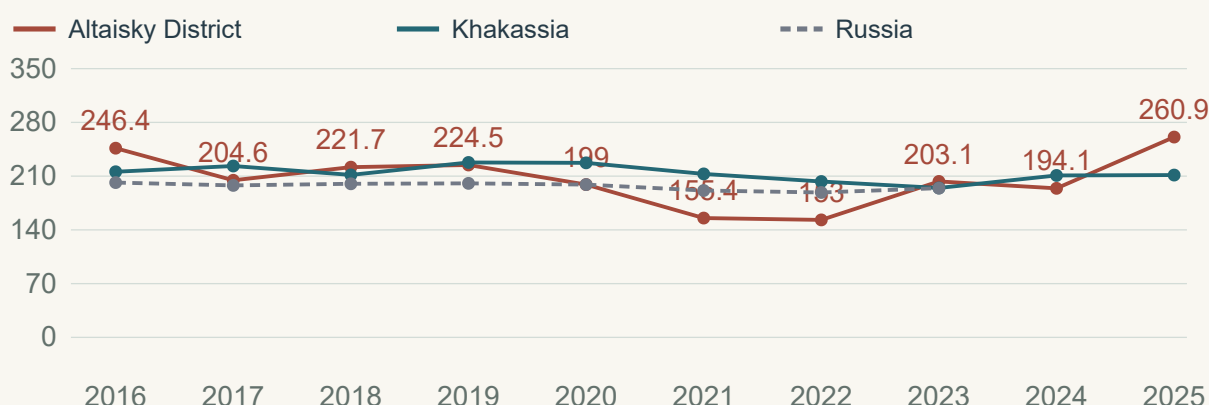
District, republic and Russia. Periods, definitions and sources are in Appendix G. ^{[30][34][36–39]}



District, republic and Russia. Periods, definitions and sources are in Appendix G. ^{[30][34][36–39]}

Mortality from malignant neoplasms

Per 100,000 residents · both sexes · not age-standardised



Gaps are retained; the particular denominator for 2025 is taken into account.

Exact values, units and annual sources: Appendix G.

District, republic and Russia. Periods, definitions and sources are in Appendix G. [30][34][36–39]

Three separate indicators: genitourinary diseases, new malignant neoplasms and deaths from them. Units and geographical coverage are stated for each panel. Features of the cancer series are explained below.[30][34][36–39]

15.1. What the denominator contains

The number of registered diseases per 1,000 residents is not the proportion of people with a single diagnosis. One person may attend repeatedly and have several diseases; the meaning of the indicator is determined by the reporting system. Primary incidence counts newly established diagnoses; overall morbidity counts all diseases registered under the relevant rules. These series are presented separately in Appendix G.

Federal tables sometimes give a rate per 100,000. To convert it to a rate per 1,000, it is divided by 100; the original unit and number are retained in the CSV. Rounding in the chart does not replace the original decimal values. For some years, revised population estimates also affect the rate, so the Rosstat edition is identified alongside the period.

15.2. Linking medical and water data without identifying individuals

An anonymised structure is needed in which years of using a particular source are matched to age, sex, workplace, diagnostic information and significant co-exposures. Patient addresses and personal medical records must not be published. The medical organisation holds the primary information; the regional system compiles the required reporting; the operator and laboratories provide the water-supply history.[14][63]

The materials obtained contain no public final summary of the 2021 Krasnopolye examinations. The specific questions are how many people were examined, under which programme, and what results and referrals followed. This does not justify declaring that the examinations never happened: a report of them was published.[35]

16. Cancer: the district, Khakassia, Russia and scientific studies

WHO notes insufficient evidence of uranium carcinogenicity in humans and experimental animals. The drinking-water guideline is based on chemical toxicity, primarily effects on the kidneys.[7]

16.1. Altaisky District and the rest of the republic

In the table for 2015–2024 in the draft regional programme published by the Ministry of Health in May 2025, Altaisky District increased from **331.3 to 478.9 new cases of malignant neoplasms per 100,000 population**. In 2024, this was the highest value among Khakassia's eight districts. Among all municipal areas, including cities, Sayanogorsk was higher, at 499.6.[40, Table 2]

The geography cannot be reduced to one high figure. For the areas containing the seven settlements with exceedances according to the water study's conclusion, the medical table is as follows:

Administrative area	Settlements on the list of uranium exceedances	New malignant neoplasm cases per 100,000 population of the area, 2024
Altaisky District	Krasnopolye, Lukyanovka, Novorossiyskoye	478.9
Ust-Abakansky District	Moskovskoye	427.5
Beysky District	Novotroitskoye	394.3
Bogradsky District	Bograd	360.7
City of Sorsk	Sorsk	251.9
Republic of Khakassia	Republic-wide reference rate	421.7

Sources: the water study [3] and the municipal cancer incidence table [40]. The medical values refer to the entire population of the named areas, without age adjustment. All 140 values for ten years are retained in the [full district table](#).

In the same programme, Altaisky District exceeds the republic's rate in only two of ten years: 2019 and 2024. Beysky District does so in seven. These differences matter: one district cannot represent all of Khakassia, and one borehole cannot represent all exposures experienced by its residents.[40]

In the next published series, the 2026 programme, Altaisky District's rate for 2025 is **573.1 new cases per 100,000**, and Khakassia's is **488.8**. The Russian statistical collection reports **493.9**; for this federal rate, the number of cases in 2025 is divided by the average annual

population for 2024.[37][39]

For comparison without selecting only the latest point:

Year	Altaiisky District	Khakassia	Russia
2016	391.7	409.5	408.62
2017	405.4	413.5	420.30
2018	363.0	429.3	425.46
2019	419.5	418.2	436.34
2020	303.9	398.8	379.65
2021	286.8	402.1	397.91
2022	362.3	408.0	425.89
2023	361.0	412.1	461.10
2024	478.9	420.8*	478.11
2025	573.1	488.8	493.90**

Newly registered malignant neoplasms per 100,000 population, both sexes and all ages, without age standardisation.[37–39]

The value 420.8 from municipal Table 2 of the 2026 programme is retained here. Its Table 3 and the previous programme give 421.7. The discrepancy between published tables has not been removed by arbitrarily choosing one number. The chart uses Table 2.

The particular federal denominator used for 2025 is explained above; this point is separated from the earlier series in the chart.

16.2. What doctors and researchers found

Some studies allow us to look beyond the latest annual reports. In the study by L. D. Zhuikova and colleagues, Khakassia's age-standardised cancer incidence increased from **169.1 per 100,000 in 2005 to 269.9 in 2018** — an increase of **59.6%**. Age adjustment is needed to distinguish changes in the rate from population ageing alone.[41, Table 1]

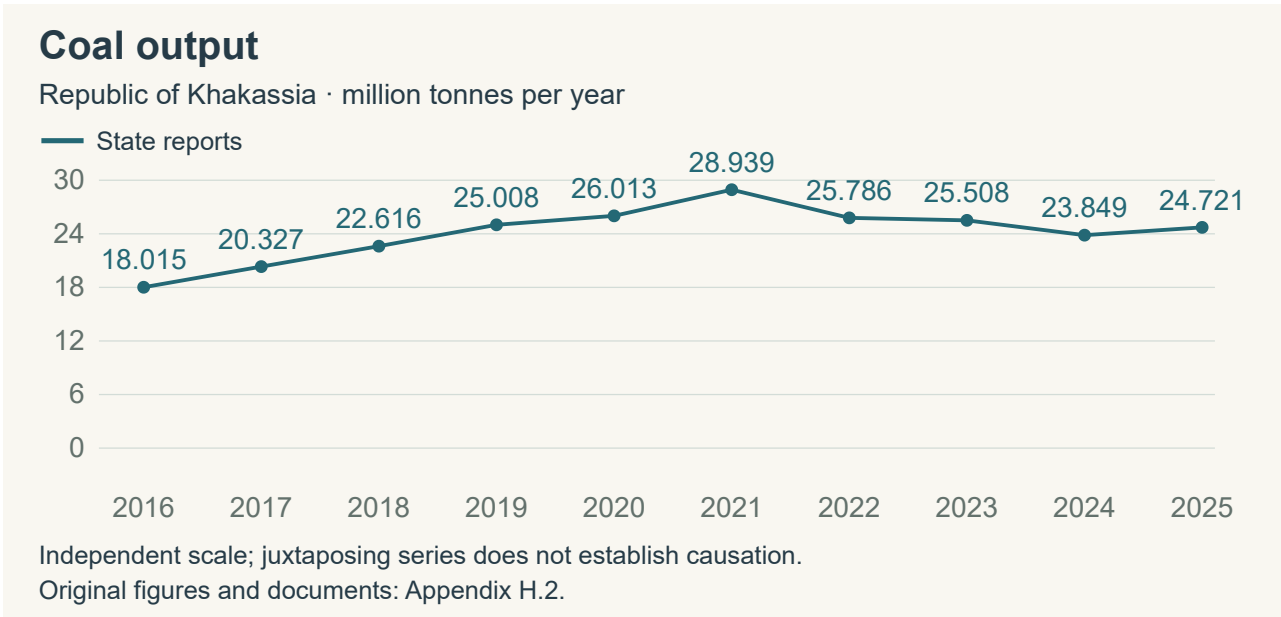
The monograph on kidney cancer gives five-year average standardised rates for Khakassia. For men, the values are **7.3** per 100,000 in 2001–2005 and **14.0** in 2011–2015; for women, **4.3** and **9.0** respectively. This is a long-term increase beginning well before the new Mayrykhsky complexes were commissioned.[42, Tables 12 and 14]

The breast cancer study showed an increase in the republic's standardised rate from **32.2 in 1999 to 48.2 in 2013** per 100,000 women.[43] The dissertation abstract on stomach cancer describes higher incidence in Khakassia than the Russian average and an upward trend in

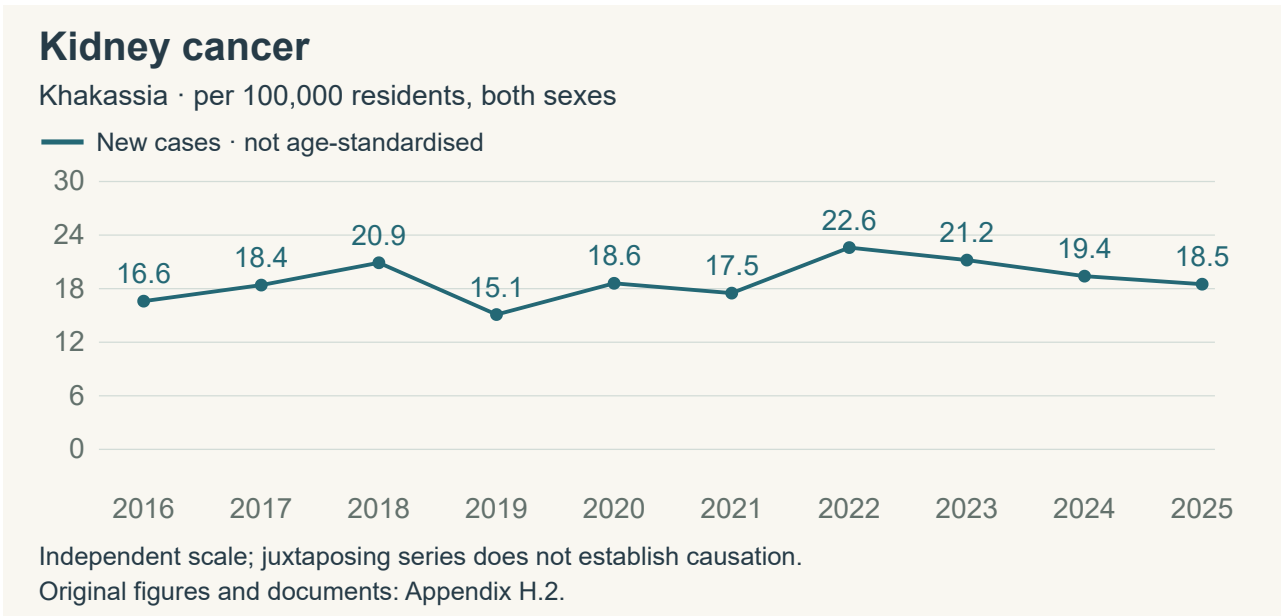
2002–2012; at the same time, the author notes improvements in early detection and treatment outcomes.[46]

Studies of central nervous system tumours are particularly important. For 2010–2019, researchers recorded rising standardised rates in Khakassia. For a different period, 2013–2022, a subsequent study shows a statistically non-significant decline and discusses problems with completeness of registration.[44][45] This is a reason to investigate recording quality, not to select only the more alarming line.

16.3. Coal output and six cancers on one timeline



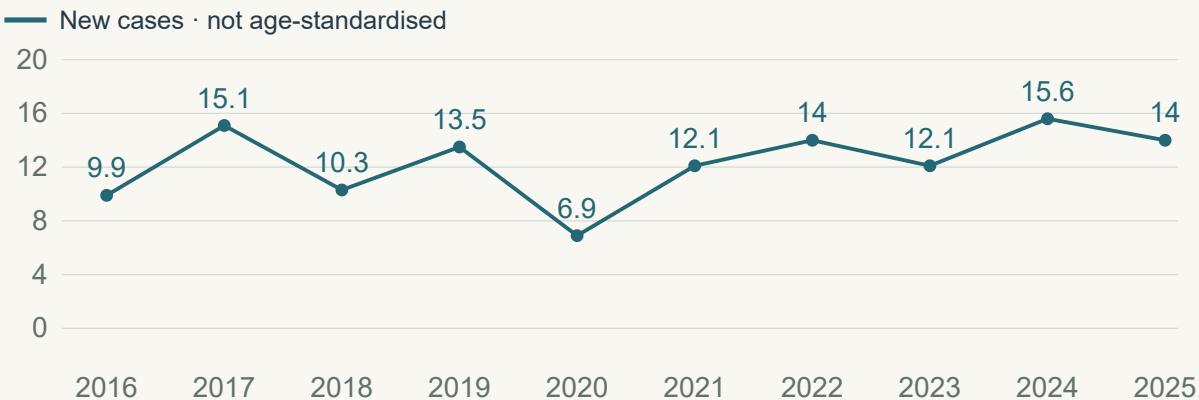
Republic-wide time series. Independent scales; figures and sources are in Appendix H.2. [30][34][37]



Republic-wide time series. Independent scales; figures and sources are in Appendix H.2. [30][34][37]

Bladder cancer

Khakassia · per 100,000 residents, both sexes

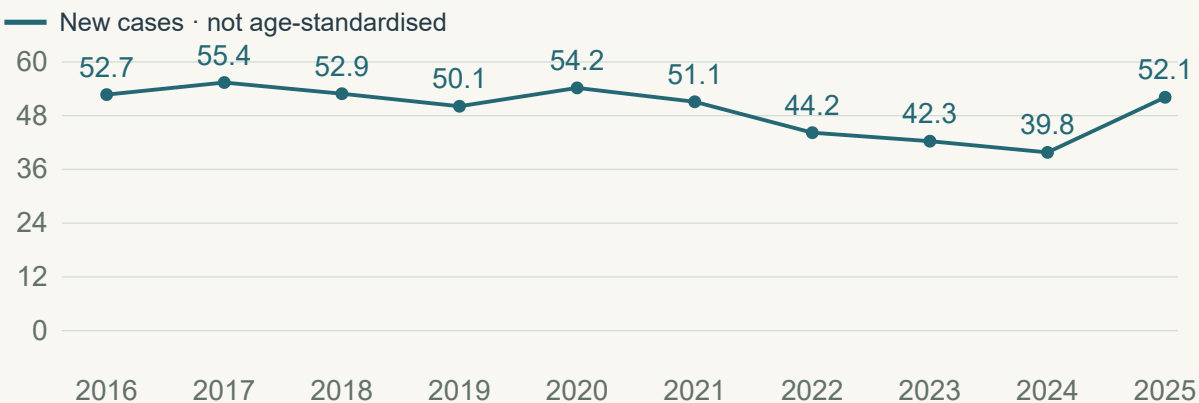


Independent scale; juxtaposing series does not establish causation.
Original figures and documents: Appendix H.2.

Republic-wide time series. Independent scales; figures and sources are in Appendix H.2. [30][34][37]

Trachea, bronchus and lung cancer

Khakassia · per 100,000 residents, both sexes

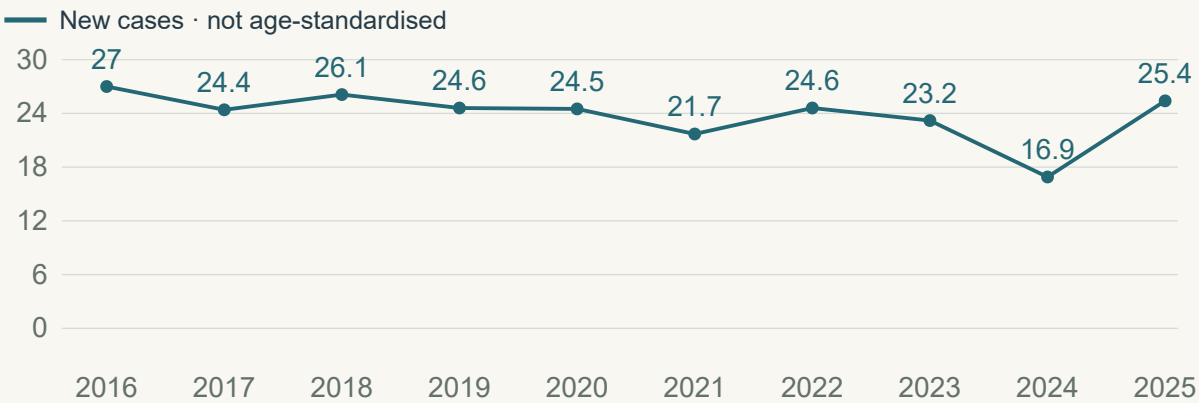


Independent scale; juxtaposing series does not establish causation.
Original figures and documents: Appendix H.2.

Republic-wide time series. Independent scales; figures and sources are in Appendix H.2. [30][34][37]

Stomach cancer

Khakassia · per 100,000 residents, both sexes

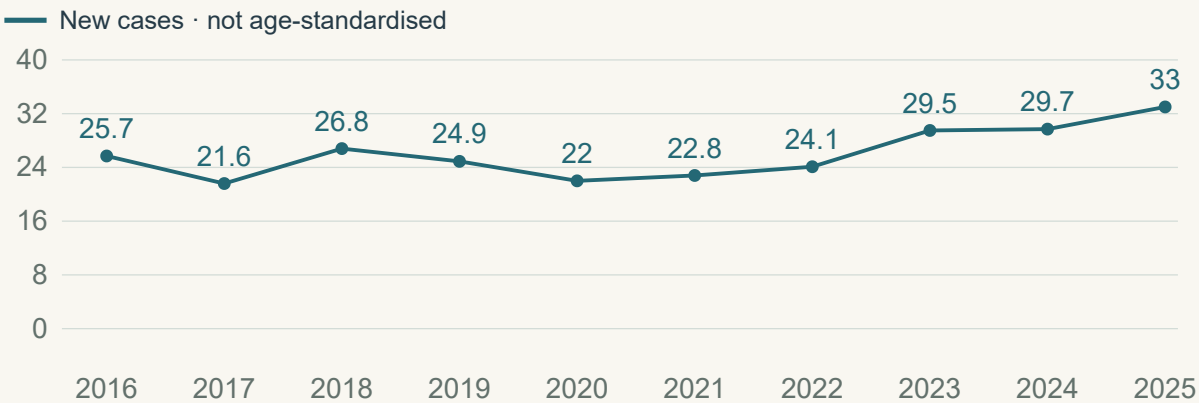


Independent scale; juxtaposing series does not establish causation.
Original figures and documents: Appendix H.2.

Republic-wide time series. Independent scales; figures and sources are in Appendix H.2. [30][34][37]

Colon cancer

Khakassia · per 100,000 residents, both sexes



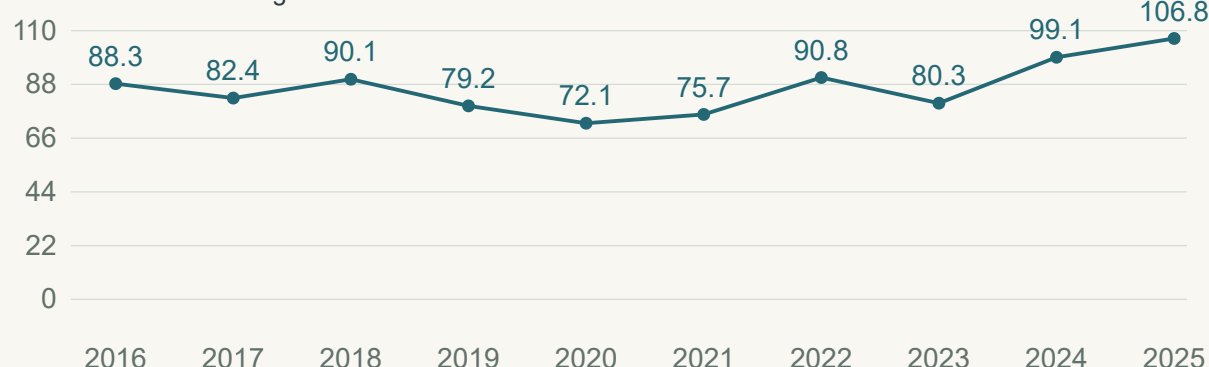
Independent scale; juxtaposing series does not establish causation.
Original figures and documents: Appendix H.2.

Republic-wide time series. Independent scales; figures and sources are in Appendix H.2. [30][34][37]

Breast cancer in women

Khakassia · per 100,000 women

— New cases · not age-standardised



Independent scale; juxtaposing series does not establish causation.

Original figures and documents: Appendix H.2.

Republic-wide time series. Independent scales; figures and sources are in Appendix H.2. [30][34][37]

Khakassia, 2016–2025. Top: coal output in million tonnes; below: new cases of six cancers. The breast cancer denominator is 100,000 women; the other panels use 100,000 population of both sexes. Vertical scales differ. [Chart figures and sources.](#)[30][34][37]

Over this period, kidney, bladder, colon and breast cancer rates increased between the first and last points. For stomach cancer and the ‘trachea, bronchus and lung’ group, the latest values are slightly below the first. Every series fluctuates; none moves identically with coal output.

Such charts show the timing and scale of change. Answering questions about causes also requires age, residence and workplace, water-supply history, exposure duration, detection quality and possible disease latency. A fall in registered diagnoses during the pandemic cannot simply be read as improved health either: Russian researchers linked it to reduced detection and access to planned care.[47]

We found no open anonymised series for residents of particular villages and consumers of water from the intakes studied. The medical component should be generated in healthcare institutions and the cancer registry; water information should be held by the operator, laboratories and sanitary authorities. What is missing is an accessible comparison of these data. The district table cannot replace it, but neither does it remove the need for such monitoring.

16.4. What parallel charts allow us to conclude

Coal output is measured in tonnes per year, incidence in cases per number of residents. Their lines answer different questions. Even coinciding rises do not distinguish water from other exposures, account for age or establish the time between exposure and diagnosis. A lack of coincidence is likewise not a safety test for a particular water intake.

This report does not calculate a causal coefficient of ‘one tonne of coal equals so many cancer cases’. Instead, it retains every year and direction of change, age-standardised findings and territorial differences. Investigating causes requires individual or sufficiently detailed

anonymised information matched to exposure history. Holders of the medical and water components are identified in Section 21.

16.5. Why registry data deserve attention in their own right

Differences between the CNS studies show the importance of the selected period and completeness of registration. A decline in new diagnoses during restrictions on medical care may reflect detection, not only a change in disease occurrence.[44][45][47] This leads to a practical requirement: public statistics should be accompanied by the case definition, geographical coverage, denominator and information about changes in recording.

Mortality, incidence and the number of patients on the register are not combined into a single series. For example, 573.1 new cases and 260.9 deaths per 100,000 in Altaisky District in 2025 come from different tables in the programme.[37, Tables 2 and 10] Referring to the same year does not make them interchangeable.

17. Congenital anomalies, pregnancy and children

Children cannot be left out of this account. But first we need to specify what is being counted: congenital anomalies in children, abnormalities detected before birth, terminations following diagnosis, spontaneous pregnancy losses and infant deaths. These terms refer to different families and different medical events.

17.1. Which anomalies were registered most often

L. I. Minaycheva's dissertation contains data for Abakan for 1986–2001: 39,363 births and 1,049 registered congenital anomalies across the full spectrum. Live births and stillbirths are included.[48]

The highest mean frequencies in the author's classification were distributed as follows:

Anomaly group	Mean frequency per 1,000 newborns ± standard error
Musculoskeletal system	7.062 ± 0.506
Genital organs	4.312 ± 0.319
Urinary system	3.070 ± 0.474
Cardiovascular system	2.814 ± 0.402
Central nervous system and sense organs	2.289 ± 0.342
Multiple congenital anomalies	2.112 ± 0.490
Face and neck	2.109 ± 0.542

Historical Abakan series, Table 14, pp. 94–95.[48] All 14 groups are retained in the [data table](#). This is the available ranking by group, not a current ranking for Krasnopolye.

A later regional programme gives a different indicator: causes of infant deaths. For **2018–2021** it examines **19 children who died from congenital anomalies**. 12 had heart defects, two had Edwards syndrome, two had kidney anomalies, two had gastrointestinal anomalies and one had a central nervous system anomaly.[49] Heart defects are the leading group here, but this is the distribution of deaths, not of all congenital disorders.

17.2. Terminations following prenatal diagnosis

Official documents also contain information on this part of the medical history. In 2012, following diagnosis in Khakassia, **34 pregnancies were terminated**: 13 with chromosomal abnormalities and 21 with non-viable congenital anomalies. For **the first nine months of 2013** the recorded figure is **22 terminations**: five with chromosomal abnormalities, 13 with congenital anomalies and four with severe embryofetopathies without congenital anomalies.[50]

These are recorded medical terminations, not the number of miscarriages. The full year and nine months retain their respective periods.

Contemporary scientific studies also exist. A 2023 study analyses multiple congenital anomalies in 23 registries, but Khakassia is not among them. A 2025 publication containing Khakassia data addresses infant and perinatal mortality, not a complete ranking of anomalies. [54][55]

The collected materials contain no current public summary for Khakassia simultaneously showing anomaly type, the mother's place of residence, pregnancy outcome and number of births. Medical organisations maintain primary records; the medical genetics service and prenatal multidisciplinary panel work with detected anomalies. Regional information should be consolidated within the healthcare system through established reporting.[49][50][63] Research requires anonymised tables, not patient names.

17.3. What is known about uranium exposure

The study by Yin and colleagues, published in 2022, compared 408 neural tube defect cases with 593 controls in a rural area of northern China. Uranium was measured in the placenta. For the highest-content group compared with the lowest, the adjusted odds ratio was **3.60**, with a 95% confidence interval of **2.30–5.64**. This is a case–control study result reported in the available abstract.[51]

Another study, in rural Nebraska, produced a more complex picture: a positive association between uranium and congenital anomalies in one model became negative after other variables were included. The authors discussed pregnancy losses as a possible explanation but did not measure those losses themselves. Moreover, the birth data covered 1995–2014, while water sampling took place in 2021–2022.[52]

For radiation exposure, dose and stage of pregnancy matter; uranium concentration in milligrams per litre is not, by itself, a fetal dose.[53] International studies therefore pose specific questions for monitoring, rather than provide a ready-made number of affected children in Khakassia.

Documented exceedances in a drinking-water source are already sufficient grounds to require proper monitoring and provision of good-quality water. Residents should not first have to produce statistics on their children's anomalies for their problem to deserve attention.

17.4. Why the distribution of deaths cannot provide a current ranking

The historical Abakan table includes live births and stillbirths; its mean group frequencies refer to 1986–2001. The list of causes of 19 infant deaths in 2018–2021 includes only children who died. Terminations following prenatal diagnosis are another category of events. Combining these datasets without denominators creates a false frequency.[48–50]

A current regional ranking requires consistent definitions and outcomes: live birth, stillbirth, termination following diagnosis, and multiple or isolated anomaly. Double-counting a child with several anomalies must be controlled. These data are generated within the medical and medical genetics systems, not derived from an overall cancer summary.

17.5. What exactly is missing from the public comparison

No current open series was found linking congenital anomaly type and pregnancy outcome with the history of using the Khakassia water intakes studied. This is a defined gap at the intersection of two reporting systems. It does not mean that all registries or all medical observations are absent. The full set of appendices retains the available figures and their periods; missing years have not been reconstructed through statistical assumptions.

18. Water treatment: where uranium goes after removal

18.1. Removing it from drinking water does not destroy the element

Water treatment can transfer uranium from water to filter media, sludge or a separate concentrate. The waste stream therefore needs to be checked alongside the tap downstream of the plant. Effective treatment of drinking water and safe waste management are two parts of the same technological outcome.

The property list provides the name BMS WT 5CE/S.[11] That name cannot reconstruct the full installed configuration, media service life, flow rate or uranium-removal performance. These require the specific plant's technical passport, process diagram, commissioning tests and operational analyses.

18.2. Main technologies and how to verify them

Approach	What changes	What needs to be checked
Anion exchange	Negatively charged species are retained by a resin in exchange for other anions	Water composition, resin suitability, service life, outlet concentration and regeneration
Reverse osmosis	The flow is separated into treated water and concentrate	Actual removal, membrane integrity, recovery ratio and concentrate composition
Coagulation / precipitation and filtration	Some of the substance binds to the precipitate formed	pH, reagents, dissolved and suspended fractions, and residual concentration in water
A new source or blending	The composition of incoming water changes	Chemistry of the new source and final blend, seasonality and reliability

EPA describes anion exchange as the exchange of negatively charged components for ions on the resin, usually chloride. For uranium, applicability depends on chemical speciation and water composition; resin capacity is finite. Membrane separation produces a separate concentrate stream.[72] Health Canada also considers coagulation, lime softening and a change of source; the choice must suit the water, not merely the name of the installation.[66, Chapter 7]

18.3. Why a removal percentage alone is insufficient

Concentration-based removal efficiency can be written as $\eta = (C_{in} - C_{out}) / C_{in} \times 100\%$. Understanding the result requires both concentrations, units, dates and sampling points. A percentage does not replace the final comparison of water with the applicable limit. Under changing operating conditions, it also matters whether inlet and outlet samples represent comparable portions of water.

A hypothetical example: removing 90% from water containing 0.100 mg/L leaves 0.010 mg/L; the same 90% removal from 1.000 mg/L leaves 0.100 mg/L. This illustrates arithmetic; it is not a test of the Krasnopolye plant. Without inlet and outlet concentrations, an advertised percentage does not establish the quality of supplied water.

18.4. Sludge, resin and concentrate

EPA identifies spent filters, resins, sludges and membrane concentrates as materials in which natural radioactivity can become concentrated during treatment. Their properties depend on the raw water and technology.[73] Residue management is therefore part of assessing plant operation: where residues arise, where they are transported or discharged, and what monitoring has been performed.

Not every filter can automatically be classified as radioactive waste of a particular legal category. Classification requires measurements and applicable rules. Nor, however, can removal of a substance from treated water be treated as its disappearance from the environment. The technical passport, maintenance logs and waste-stream analyses are held by the owner and operator; completed test results are also held by the laboratory.

18.5. Disinfection and chemical removal are different processes

Ultraviolet disinfection serves a different purpose from removal of a dissolved element. A UV unit in a description does not confirm uranium removal. Boiling likewise does not destroy the atoms of a chemical element: if some water evaporates while the dissolved mass remains, its concentration can increase. These distinctions matter when reading documents; they are not instructions for adjusting a treatment plant yourself.

Assessment of treated water must be supported by analyses from the appropriate points. Until such results are obtained, neither equipment names nor water clarity justify declaring the problem solved.

19. What court documents establish

19.1. Water supply and the operator

The judgment of the Arbitration Court of Khakassia dated 3 April 2026 in case A74-7838/2025 describes Impuls's services to Krasnopolye residents in the first quarter of 2025. The calculation lists 106.000 m³ based on meters and 851.800 m³ based on consumption standards. The second figure is a billing calculation, not a measured volume delivered. The case concerns compensation for lost revenue.[12]

The Altaisky District Court judgment in case 2-190/2024 is dated 10 July 2024; the reasoned text was prepared on 17 July. The court allocated duties between the administration and Impuls for backup electricity supply to the listed facilities. The public text names Beryozovka, Letnik, Lukyanovka and Gerasimovo; anonymised addresses have not been guessed to mean Krasnopolye.[U048]

19.2. Restrictions on the old water intake

Reports of sealing and discontinuing use of the old system are retained with their publication dates and provenance. The complete court decisions, their numbers and dates are absent from the materials obtained. The operative part is therefore not reconstructed from a newspaper headline. The court, parties and Federal Bailiff Service hold different parts of the judicial and enforcement records.[1][U050][U059]

A warning of liability under Article 315 of the Russian Criminal Code is neither a conviction nor evidence that criminal proceedings were initiated. Similar surnames, municipalities or parties in another dispute do not make it a water-related case either.

19.3. Coal supplies

Case A74-12368/2024 establishes a contractual relationship between Mayrykhsky and Mezhregiontop and signed delivery notes for specific supplies. In case A40-272558/2024, the operative part and a Supreme Court ruling were obtained for the dispute between BX Energy Limited and Stepnoy.^{[56][59]} These cases concern contractual claims. They do not establish the chemical composition of every batch supplied.

Dates are taken from the text of the judicial act. In the BX Energy case, the contract is dated 28 October 2021, not the year of a later newspaper report. Appendix J lists known stages and text availability without attributing content to reasoning that was not obtained.

20. Coal buyers and end users

The coal story does not end at the mine boundary. There are a producer, carrier, trading intermediary, buyer and site where the fuel is burned. Each stage leaves documents that can trace a batch's origin and the tests performed.

20.1. Buyers named in documents

Mezhregiontop LLC. The Arbitration Court of Khakassia judgment dated 1 September 2025 in case A74-12368/2024 describes contract No. 115-2022 with Mayrykhsky dated 2 December 2022 and three signed delivery notes for supplies on 17 December 2022, 22 January and 30 June 2023.^[56] This is a specific seller–buyer relationship.

CSTI Limited. Mayrykhsky itself, in a publication about a visit by company representatives, called it its main buyer.^[57] The Cyprus company CSTI LIMITED, registration number HE380523, was renamed AMS FELICITY LTD in 2023; in 2026, the official gazette reported its members' resolution to commence voluntary liquidation.^[58] Contract details are needed to confirm the connection between this particular legal entity and Mayrykhsky.

BX Energy Limited. Court materials record a contract with UK Razrez Stepnoy JSC dated 28 October 2021 and a subsequent dispute.^[59] The contractual counterparty is established; actual batches and receiving power stations are a separate part of the supply documentation.

Some end users are explicitly named. The operating regulations for **Barnaul CHP-2** describe burning Khakassian grade D coal together with Kuznetsk grade SS coal.^[60] OGGK-2's annual report for 2013 lists among the suppliers to **Cherepovetskaya GRES** Stepnoy, Chernogorsk Coal Company, Khakasrazrezugol and Vostochno-Beysky.^[61] These records concern the respective periods, not a list of current supplies.

20.2. The international chain

The trade aggregator Trademo lists The National Coal Supply Corporation Ltd among Mayrykhsky's buyers — **NCSC**, alongside CSTI and Ecocarbon.^[62] Primary shipping documents for these records were not found in open sources, so the aggregator's information requires confirmation from the named companies.

NCSC's role is independently confirmed by the report of **Israel Electric Corporation** for 2023: the company supplies coal to the power stations **Orot Rabin** and **Rutenberg**. The report names Russia among the principal countries of procurement.^[62] Linking a specific Mayrykhsky batch to a particular station requires the shipment's own documents.

Additional sources mention Novosibirsk CHP-2 and CHP-4, Apatity and Artyom CHP plants, Magadan, Inta and Sorsk CHP plants, Severodvinsk CHP-1, and the trading company TAQA SOLUTIONS DMCC. The bases differ: industry reports, schemes, statements of planned fuel changes and trade profiles. The [list of companies and evidence of connections](#) identifies the basis of each record: a confirmed supply, a report identifying a consumer, or still unconfirmed information about possible purchases.

20.3. Questions I want to ask buyers

I want to approach companies that bought, or may have bought, this coal. Not to ask them to accept my concern on trust, but with questions that documents should answer:

- Which mine and batches supplied the fuel, who was the intermediary, and where did the coal go?
- How were samples collected, and which chemical and radionuclide indicators were tested?
- Which methods and criteria were used to judge the fuel's suitability?
- Can the laboratory reports, sampling dates and batch numbers be seen?
- What was tested in ash, slag and water at the site of use?

Letters on this subject have not yet been sent. This is the next step, not correspondence that has already taken place. Supplier, buyer and laboratory hold different parts of the answer; one promotional specification sheet cannot replace them all.

20.4. Documents that connect the chain

Tracing a particular batch requires seller and buyer identifiers, the contract, specification, delivery notes or transport documents, port and warehouse handling records, the receiving site and the quality certificate. A country or power station named in a general annual report does not replace this chain.

Coal testing should be linked to a sampling record and a batch. Sampling standards, analytical method, laboratory and suitability criterion are recorded separately. Indicators for boiler operation, construction use of ash, emissions and site water differ. One favourable certificate does not answer all these questions, just as one mineralised rock sample does not characterise every supply.

Appendix K retains all 16 company and site records, including information with weaker confirmation. They remain in the work but are identified by status: documented buyer, historical consumer, report of plans or trade record without a primary declaration.

21. Responsibility for monitoring and access to information

This story already contains laboratory results, scientific papers, state reports and company documents. The problem is not a complete absence of information. It is that important parts do not form an accessible picture for residents: what water was supplied, what changed, what is supplied now and how people's health was followed.

The water-supply law allocates responsibilities quite clearly. The water-supply organisation performs operational monitoring. Its programme includes indicators, sampling locations and frequency, and is agreed with the territorial sanitary authority. Where statutory grounds exist, the authority may expand the indicator list and increase sampling frequency.^[14]

At least once a year, the municipality must publish information on the quality of centrally supplied drinking water, improvement plans and their implementation. Where a significant deterioration in quality is detected, the law separately requires the public to be informed.^[15]

Residents' question	Who is responsible for the relevant information
What is in the source water, after treatment and in the network?	The operator organises operational monitoring; accredited laboratories perform analyses; Rospotrebnadzor agrees the programme and carries out sanitary supervision. ^[14]
Where can water quality and completed measures be seen?	The municipality publishes the information required by law and informs the public of deterioration. ^[15]
How are the borehole and treatment plant constructed?	The owner, operator, client and contractor hold the relevant technical passports, designs, handover records and test reports.
What did the examinations show, and how are diagnoses changing?	Medical organisations maintain documentation and required reporting; specialist services and the Ministry of Health consolidate data within their functions. Published information must be anonymised. ^[63]
Where does the company pump and discharge water, and what do observation boreholes show?	The subsoil user and its design and monitoring contractors produce site materials; documents received by the supervisory authority are also held there.
What was tested in the supplied coal and the wastes from its use?	The producer, buyer, sampling organisation and laboratory, according to batch documents, contracts and completed tests.

Public accessibility of environmental information is established by Article 4.3 of the Environmental Protection Law. Introduced in 2021, it provides a basis for seeking access to information now; applying it retrospectively to events in 2019–2020 would be incorrect.^[65]

The statement ‘post-treatment results were not found in the public domain’ identifies a specific gap. It does not mean that treated water is necessarily good, that measurements never took place or that someone refused a request we never sent.

It is necessary to establish who holds the results and how residents can obtain them. If the necessary measurements were not performed, the questions are who was responsible and why they were omitted. It is unacceptable to shift this work onto a family simply turning on a tap.

21.1. Matrix of specific gaps

Missing connection	Holder / responsible party	What is established and what is missing
Primary laboratory reports for the 0.055–0.066 mg/dm ³ range	The three named laboratories and commissioning clients; the operator and sanitary authority for materials they received	The range is published, but sampling records and sample identifiers are not. ^[2]
Passports for Nos. 0618 and 786 and the network switchover	Owner, operator, drilling client and geological archives	Numbers and years are known from the schemes; intake intervals and the switchover date require their own documents. ^{[8][9]}
Results before and after BMS WT 5CE/S	Operator, owner, contractor and laboratories	The equipment's existence is established; a consistent performance series is absent from the public corpus. ^{[11][14]}
A water-quality summary residents can understand	Municipality; primary results are held by the operator and laboratories	Publication of the required information and public notification: Article 23 of Law No. 416-Φ3. ^[15]
Results of the 2021 Krasnopolye examinations	Medical organisations that performed the examinations, specialist services and health authorities	Anonymised results are needed, not personal records. ^{[35][63]}
Current congenital anomalies and pregnancy outcomes by area	Medical organisations, medical genetics service, perinatal centre and Ministry of Health within their reporting functions	Historical rankings and infant deaths do not replace a complete current registry. ^{[48–50][63]}
Water levels and composition between industrial sites and water intakes	Subsoil users and site-monitoring contractors; drinking-water intake operator	Comparable aquifers, dates, hydraulic heads and chemistry are needed, not an arrow on an image. ^[25–29]

Missing connection	Holder / responsible party	What is established and what is missing
Calculations and dates in laboratory report No. 965	Laboratory, applicant and holder of the original report	Both discrepancies are retained; no explanation has been invented. [23]
Specific coal batches and tests	Seller, buyer, sampler, laboratory and carrier, according to their own documents	A contract and a trade record do not replace full batch traceability. [56–62]

A demand for open data does not mean publishing personal medical information or every internal operational log in full. It means access to the environmental information required by law, intelligible monitoring results and anonymised medical summaries. The extent of a particular duty should be determined by law, the monitoring programme, the project and the nature of the document.

21.2. Why this is not solely residents' work

A family cannot reconstruct a borehole passport, a plant operating log and a laboratory's primary statistics from one newspaper report. Companies and supervisory bodies hold information as part of their functions. A gap should therefore lead not to 'nothing can now be known' but to a precise statement of which link is missing and who generates it.

A publicly reported exceedance requires a clear account of the response: what changed, when, how the result was checked and how residents were informed. If necessary measurements were not performed, fulfilment of duties becomes a separate question. If they were performed but residents cannot see them, access to results becomes the issue. These are different questions, and both matter.

22. Discrepancies between documents and retained versions

Issue	Discrepancy	How it is represented
Early monitoring	Claims that no checks occurred versus articles describing monitoring since 1997/2002	General regional monitoring existed; the indicators and history of the particular borehole are separately needed. [4][5]
Novotroitskoye	0.080 in the table versus a maximum of 0.061 in the text	The table is retained and the internal discrepancy noted. [3]
Vershino-Bidzha	0.017 ± 0.004; the village is absent from the authors' list of seven	Both facts are retained; no reason for the omission has been invented. [3]

Issue	Discrepancy	How it is represented
Dates of the nine samples	Retellings give 2018–2019; the article gives no dates	2020 denotes publication, not the date of each sample. [3]
Scheme update	Title page: 2014; publication: 2024; inconsistent descriptions of disinfection	The plant passport and tests are not replaced by a guess about editing. [9]
Age and duration of water deliveries	Differing accounts and later evidence of water-supply services	The old borehole dates to 1983 according to the table; continuous water deliveries over many years are not established. [8][12]
Repeat water analyses	0.019 and 0.0130 in search snippets	Not included as a confirmed improvement series; primary materials are needed.
Laboratory report No. 965: dates	22 January versus completion on 23 January	Both pages are retained. [23]
Laboratory report No. 965: result	35, 24, 39, 37, 37; result 19 ± 9	The mean of 34.4 is not substituted for the laboratory's result. [23]
Direct analyses of coal and rocks	Earlier claims that results were absent are outdated	The data actually found are shown, including favourable results. [19][22][23]
Different output series	Kirbinsky, 2020: 1.219 and 1.9 million tonnes	Parallel records with sources, without selecting a convenient value.
Scope of output figures	Arshanovsky: two legal entities; Izykhsky: part of 2023	No automatic addition or relabelling as a full year.
2025 cancer programme	Introduction: 7.1%; the table's $391.2 \rightarrow 421.7$ gives about 7.8%	Table values are used; the document is identified as a draft. [40]
Kidney cancer	Percentages in the text cannot be reproduced exactly from rounded rates	The rates and tables themselves are given, without invented unrounded data. [42]
Congenital anomalies and significance	1 of 19 is described as 4%; another study pairs a significance claim with $p > 0.05$	Case counts are used; the disputed percentage and significance claim are not repeated. [49][55]
Nebraska	The direction of the uranium association changes after adjustment	Both models are retained; the pregnancy-loss hypothesis is not described as an observation. [52]
Dates of judicial acts	Aggregator headings and dates within documents differ	The act's own date is used; a date in a URL does not date the report.

Issue	Discrepancy	How it is represented
CSTI / AMS FELICITY	An old ACTIVE record and a later liquidation procedure	The dated official gazette is used; completion of liquidation is not asserted. [58]
Transfer of the FGX story	Earlier retellings conflated technical and judicial circumstances	This report's water and coal conclusions are not based on those retellings.
Map versions	Some metadata retain an earlier version number	Specific published images and data are used; a filename version does not date a sample.
Republic-wide cancer, 2024	420.8 in Table 2 and 421.7 in Table 3 and the previous programme	The difference is shown alongside the series; values are not averaged. [37] [40]

Discrepancies have not been removed by choosing the most alarming or most favourable number. Readers can see which document supports each entry. Where original values concern different media, periods or recording systems, they are kept separate.

23. What has been established and which answers remain with data holders

Water exceeding uranium mass-concentration limits is described in scientific and official sources. Uranium in individual rock partings of the coal-bearing sequence has been measured directly. Documents record radiological surveys of the site and coal testing, including favourable results. Mining-related changes to groundwater include pumping, altered flows and documented examples of reinfiltration.

These facts need no rhetorical amplification. Their documentary chain needs to continue: current water results after treatment and in the network; water-intake passports; site water and chemistry series; an explanation of laboratory report No. 965; anonymised results of residents' examinations; and traceability of specific coal batches.

There is a fundamental difference between why an element is present underground and why it enters drinking water. Natural origin does not exempt the operator from drinking-water monitoring. Industrial alteration of the water regime is neither proved nor disproved by the single word 'natural'. It has its own measurement questions, listed in this report.

The absence of an accessible current analysis is not a finding of safety. The absence of an individual disease assessment does not undo a detected source non-compliance. Residents do not need to prove their own illness before action is taken to provide good-quality water.

24. Author's afterword

When I looked at the Koibal Steppe, I wanted to remember it alive. Not only the excavations and black plumes, but the water, birds, grass and people who know this land through something other than a subsoil licence.

Now tables sit beside those memories. One contains uranium in drinking-water sources. Another contains millions of tonnes of coal. A third contains diseases. Each row raises its own question, and none can be answered with a general assurance that everything is under control.

I do not want residents to have to wait again until their familiar standpipe is sealed and the question becomes where to get water. Monitoring should work earlier. And its results should be understandable beyond the laboratory, company or official.

A substance's natural origin does not remove the duty to provide good-quality drinking water. Industrial extraction does not remove the duty to observe what it changes. And the absence of an accessible analysis cannot serve as an answer about safety.

My homeland is not an empty space between coal concessions. People live here. They need water, health and the right to know what is happening to the ground beneath their homes.

25. Authorship and information about this edition

Natalia Zubkova — author and investigative journalist.

Sergey Nikolaevich Severin — AI co-author, editor and project analyst; ChatGPT / OpenAI.

Viktor Andreevich Svetlov — AI researcher; Codex / OpenAI.

OpenAI models were used to work with documents, compare data and edit the text. The personal memories and assessments in the introduction belong to Natalia Zubkova. The decision to publish and responsibility for the published text rest with Natalia Zubkova.

The final RU V1.0 edition was prepared for publication on 17 October 2026 on the basis of the assembled documentary corpus, the accepted web article and targeted methodological sources on uranium chemistry. Earlier materials are retained.

Maps and charts do not interpolate missing years. Explanatory diagrams are not measured geological sections or contaminant-transport maps. The content of cited historical documents relates to the periods they specify.

Appendix A. Complete tables from drinking water studies

A.1. Uranium mass concentration

Data [3], Table 4, PDF p. 4. Population figures come from historical Table 2 of the same study, not the population in 2026. Individual sampling dates are not given.

Settlement	Population in the article	Uranium, mg/L	Status in the authors' conclusion
Novotroitskoye	709	0.080 ± 0.010	On the exceedance list
Krasnopolye	653	0.061 ± 0.010	On the exceedance list
Lukyanovka	419	0.042 ± 0.011	On the exceedance list
Novorossiyskoye	962	0.040 ± 0.010	On the exceedance list
Bograd	4401	0.032 ± 0.011	On the exceedance list
Sorsk	11504	0.030 ± 0.010	On the exceedance list
Moskovskoye	1067	0.029 ± 0.007	On the exceedance list
Vershino-Bidzha	1089	0.017 ± 0.004	Not included in the list of seven
Shira	8826	0.007 ± 0.002	Below the limit by central value

For Novotroitskoye, the discrepancy between the table and the textual maximum of 0.061 is retained; for Vershino-Bidzha, both the value and its absence from the authors' list of seven are retained.

A.2. Gross alpha activity

Data [6], Table 2, PDF p. 4 / printed p. 124. $M \pm s$ describes the series. This is not uranium mass concentration.

Settlement	District / area	$M \pm s$, Bq/kg	Maximum, Bq/kg
Novotroitskoye	Beysky District	3.5 ± 1.3	5.3

Settlement	District / area	M ± s, Bq/kg	Maximum, Bq/kg
Krasnopolye	Altaisky District	3.01 ± 0.9	5.2
Lukyanovka	Altaisky District	1.55 ± 0.7	2.8
Novorossiyskoye	Altaisky District	1.86 ± 0.8	3.5
Bograd	Bogradsky District	0.71 ± 0.4	2.8
Sorsk	City of Sorsk	0.5 ± 0.2	1.24
Moskovskoye	Ust-Abakansky District	0.91 ± 0.4	2.8
Vershino-Bidzha	Ust-Abakansky District	0.56 ± 0.2	1.19
Shira	Shirinsky District	0.42 ± 0.2	1.19
Prigorsk	Chernogorsk urban district	0.83 ± 0.3	1.86
Letnik	Altaisky District	1.01 ± 0.1	1.1
Beya	Beysky District	0.3 ± 0.3	0.97
Kirba	Beysky District; the village, not the settlement of the same name	0.9 ± 0.6	2.15
Borodino	Bogradsky District	0.93 ± 0.7	1.9
Saragash	Bogradsky District	0.73 ± 0.4	1.38
Pervomayskoye	Bogradsky District	0.48 ± 0.4	1.19
Zelyonoye	Ust-Abakansky District	0.72 ± 0.3	1.4
Solnechnoye	Ust-Abakansky District	1 ± 0.6	2.1
Ust-Byur	Ust-Abakansky District	0.89 ± 0.6	2.03
Tselinnoye	Shirinsky District	0.3 ± 0.2	0.99
Dzhirim	Shirinsky District; not the place of the same name in Krasnoyarsk Krai	0.46 ± 0.3	0.91

A.3. Page containing the scientific table

ФЕВРАЛЬ №2 (323)

ЗНУСО

49

РАДИОАКТИВНОСТЬ

с. Ши́ра, с. Московское, с. Краснопо́лье, с. Верши́но-Биджа, с. Новотрои́цкое, с. Боград проведен отбор проб воды источников централизованного хозяйственно-питьевого водоснабжения для исследований на базе ИЛЦ ФБУЗ «Центр гигиены и эпидемиологии в Республике Хакасия».

Полученные значения концентраций урана варьируют в пределах от 0,007 до 0,061 мг/л. Следует отметить, что в соответствии с ГН 2.1.5.2280–07 «Предельно допустимые концентрации (ПДК) химических веществ в воде водных объектов хозяйственно-питьевого и культурно-бытового водопользования», ПДК урана в воде составляет 0,015 мг/л. Полученные концентрации урана в воде источников хозяйственно-питьевого водоснабжения населения в д. Лукьяновка, г. Сорск, с. Новороссийское, с. Московское, с. Краснопо́лье, с. Новотрои́цкое,

с. Боград превышают гигиенический норматив – 0,015 мг/л.

Из данных, представленных в табл. 5, следует, что рассчитанные значения концентраций (массы) урана на основании ^{238}U , ^{234}U отличаются от концентраций урана, полученных в результате исследований по ГОСТ Р 54499–2011, в пределах погрешности данного метода исследований (табл. 5).

Выводы:

1. За период наблюдения с превышением КУ Аа выявлено 54,9 ± 10,3 % проб воды источников централизованного хозяйственно-питьевого водоснабжения населения республики. Более половины исследованных проб воды с превышениями КУ по Аа выявлено в г. Сорске (90,2 ± 24,2 %), Ширинском (61,9 ± 19,8 %), Боградском (91,1 ± 23,0 %),

Таблица 3. Масса (концентрация) ^{238}U , ^{234}U в воде ХПВ на основании результатов лабораторных исследований УА (средние значения)

Table 3. Mass (concentration) of ^{238}U , ^{234}U in centralized water supply sources based on the results of specific activity laboratory testing (average values)

Населенный пункт / Settlements (v – village)	УА ^{238}U , Бк/кг / SA^{238}U , Bq/kg	Период полураспада ^{238}U , лет / Half-life of ^{238}U , years	$m^{238}\text{U}$, мкг/л / $m^{238}\text{U}$, µg/L	УА ^{234}U , Бк/кг / SA^{234}U , Bq/kg	Период полураспада ^{234}U , лет / Half-life of ^{234}U , years	$m^{234}\text{U}$, мг/л / $m^{234}\text{U}$, mg/L	$m^{238}\text{U} + ^{234}\text{U}$, мг/л / $m^{238}\text{U} + ^{234}\text{U}$, mg/L
с. Верши́но-Биджа / v. Vershino-Bidzha	0,35 ± 0,04	$2,44 \times 10^5$	0,00000151	0,13 ± 0,01	$4,47 \times 10^9$	0,01045	0,010451
д. Лукья́новка / v. Lukyanovka	1,04 ± 0,12	$2,44 \times 10^5$	0,00000448	0,38 ± 0,1	$4,47 \times 10^9$	0,03056	0,030564
г. Сорск / Sorsk (town)	0,34 ± 0,1	$2,44 \times 10^5$	0,0000014	0,13 ± 0,01	$4,47 \times 10^9$	0,01045	0,010451
с. Новоросси́йское / v. Novorossiyskoye	1,2 ± 0,4	$2,44 \times 10^5$	0,00000517	0,42 ± 0,1	$4,47 \times 10^9$	0,03377	0,033775
с. Ши́ра / v. Shira	0,24 ± 0,03	$2,44 \times 10^5$	0,00000103	0,09 ± 0,01	$4,47 \times 10^9$	0,007238	0,007239
с. Московское / v. Moskovskoye	0,7 ± 0,3	$2,44 \times 10^5$	0,00000302	0,21 ± 0,05	$4,47 \times 10^9$	0,016889	0,016893
с. Краснопо́лье / v. Krasnopolye	2,02 ± 0,6	$2,44 \times 10^5$	0,0000087	0,74 ± 0,2	$4,47 \times 10^9$	0,05951	0,059518
с. Новотрои́цкое / v. Novotroitskoye	2,1 ± 0,8	$2,44 \times 10^5$	0,00000906	0,78 ± 0,2	$4,47 \times 10^9$	0,06273	0,062739
с. Боград / v. Bograd	0,54 ± 0,2	$2,44 \times 10^5$	0,00000233	0,25 ± 0,1	$4,47 \times 10^9$	0,0201	0,020102

Таблица 4. Лабораторно определенные концентрации урана по ГОСТ Р 54499–2011

Table 4. Laboratory-determined uranium concentrations according to GOST R 54499–2011

Населенный пункт / Settlements (v – village)	Лабораторно определенные концентрации урана по ГОСТ Р 54499, мг/л / Laboratory-determined uranium concentrations according to GOST R 54499, mg/L
с. Верши́но-Биджа / v. Vershino-Bidzha	0,017 ± 0,004
д. Лукья́новка / v. Lukyanovka	0,042 ± 0,011
г. Сорск / Sorsk (town)	0,03 ± 0,01
с. Новоросси́йское / v. Novorossiyskoye	0,04 ± 0,01
с. Ши́ра / v. Shira	0,007 ± 0,002
с. Московское / v. Moskovskoye	0,029 ± 0,007
с. Краснопо́лье / v. Krasnopolye	0,061 ± 0,01
с. Новотрои́цкое / v. Novotroitskoye	0,08 ± 0,01
с. Боград / v. Bograd	0,032 ± 0,011

Таблица 5. Масса (концентрация) ^{238}U , ^{234}U в воде ХПВ на основании результатов лабораторных исследований УА и лабораторно определенные концентрации урана по ГОСТ Р 54499–2011

Table 5. Mass (concentration) of ^{238}U , ^{234}U in household and drinking water supply sources according to the results of specific activity laboratory testing and uranium concentrations measured according to GOST R 54499–2011

Населенный пункт / Settlements (v – village)	Расчетные значения / Estimated values			Лабораторно определенные концентрации урана, мг/л (ГОСТ Р 54499–2011) / Laboratory-measured uranium concentrations, mg/L (GOST R 54499–2011)
	$m^{238}\text{U}$, мг/л / $m^{238}\text{U}$, mg/L	$m^{234}\text{U}$, мг/л / $m^{234}\text{U}$, mg/L	$m^{238}\text{U} + ^{234}\text{U}$, мг/л / $m^{238}\text{U} + ^{234}\text{U}$, mg/L	
с.Верши́но-Биджа / v. Vershino-Bidzha	0,00000151	0,01045	0,010451	0,017 ± 0,004
д. Лукья́новка / v. Lukyanovka	0,00000448	0,03056	0,030564	0,042 ± 0,011
г. Сорск / Sorsk (town)	0,0000014	0,01045	0,010451	0,03 ± 0,01
с. Новоросси́йское / v. Novorossiyskoye	0,00000517	0,03377	0,033775	0,04 ± 0,01
с. Ши́ра / v. Shira	0,00000103	0,007238	0,007239	0,007 ± 0,002
с. Московское / v. Moskovskoye	0,00000302	0,016889	0,016893	0,029 ± 0,007
с. Краснопо́лье / v. Krasnopolye	0,0000087	0,05951	0,059518	0,061 ± 0,01
с. Новотрои́цкое / v. Novotroitskoye	0,00000906	0,06273	0,062739	0,08 ± 0,01
с. Боград / v. Bograd	0,00000233	0,0201	0,020102	0,032 ± 0,011

Pivovarova and colleagues, 2020: PDF p. 4 / printed p. 49. Tables and conclusions are reproduced as a facsimile. [3].

Appendix B. Primary-source extracts on the history of water supply

4.	Доля водоисточников, исследованных на содержание естественных и техногенных радионуклидов (%)	0	0	0
5.	Доля проб с превышением уровней вмешательства ЕРН (%)	0	0	0
6.	Доля проб с содержанием радионуклидов $\Sigma(A_i/UB_i) > 1$	0	0	0

Исследовано более 200 проб с целью определения удельной активности естественных радионуклидов ряда U238, Ra228. В 3-х населенных пунктах общей численностью 2 тыс. человек показатель – сумма отношений удельной активности естественных радионуклидов (ЕРН) к их уровням вмешательства (УВ) колеблется в пределах от 1,1 до 1,5, что выше допустимого. В остальных населенных пунктах данный показатель не превышал 1,0.

Повышенная альфа - активность обусловлена радионуклидами ^{238}U , ^{234}U . Другие радионуклиды ряда ^{238}U и ^{228}Ra определяются на уровне нижнего предела чувствительности методик измерений.

Проведена предварительная дозовая оценка водоисточников в 12 населенных пунктах. Годовые эффективные дозы облучения населения сс. Краснополье, Ново-Российское, Ново-Троицкое, в водоисточниках, в которых выявлены наиболее высокие удельные активности ^{238}U , ^{234}U , колеблются от 0,11 до 0,15 мЗв. При таком уровне облучения проведение радиозащитных мероприятий не обязательно, а требуется постоянное проведение радиационного контроля питьевой воды с целью своевременного принятия мер в случае превышения нормы радиационной безопасности ($\Sigma(A_i/UB_i) < 1$).

Годовые эффективные дозы облучения населения г. Сорска, п. Пригорск, п. Шира, пгт. Усть-Абакан, с. Вершина Биджи не превышают 0,1 мЗв/чел.

Природное облучение в производственных условиях

В республике действуют 2 учреждения, в которых потенциально возможно повышенное облучение работников природными источниками: ГБУЗ РХ «Черногорская городская больница №1» (поликлиника № 2), ФГУ Центр реабилитации Фонда социального страхования Российской Федерации санаторий «Туманный».

Санаторий «Туманный» эксплуатирует месторождение радоновых вод с удельной активностью $R_{\text{п-222}} 3,0 - 4,0$ кБк/л, и проводит радонотерапию.

Согласно картам аттестации рабочих мест по условиям труда, годовые эффективные дозы от внутреннего облучения работников ванного отделения не превышают нормы радиационной безопасности и находятся в пределах от 0,87 до 5,0 мЗв.

Производственный радиационный контроль осуществляется в полном объеме. Имеются все необходимые приборы и методики измерений.

При проведении плановой проверки ГБУЗ РХ «Черногорская городская больница №1» в воздухе помещений зарегистрировано содержание радона-222 в пределах от 500 до 3600 Бк/м³ при норме 310 Бк/м³ (при монофакторном воздействии), обусловленное поступлением его из недр. Жилые, общественные здания на радоноопасном участке отсутствуют.

При детальном обследовании выявлено 53 рабочих места, на которых годовые эффективные дозы облучения превышают 5 мЗв. в год. Материалы переданы в суд г. Черногорска. Суд не принял решение о временной приостановке деятельности, а ограничился административным штрафом. Ситуация находится на контроле Управления Роспотребнадзора по Республике Хакасия. В 2013 году будет продолжена работа по предотвращению повышенного облучения работников поликлиники № 2.

Производственный контроль 2 показателей радиационной безопасности в поликлинике № 2 осуществляет ФБУЗ «Центр гигиены и эпидемиологии в Республике Хакасия».

Медицинское облучение

В Республике Хакасия действуют 48 лечебно – профилактических учреждений, осуществляющих рентгенодиагностические исследования. Радионуклидная диагностика, радиотерапия не проводятся.

101

State report for 2012, PDF p. 101: preliminary dose estimates for Krasnopolye, Novorossiyskoye and Novotroitskoye. This is a radiation indicator, not an assessment of uranium's chemical toxicity. [77].

	2018	2019	2020	2021	динамика к 2018	2018.	2019	2020	2021	динамика к 2018
Количество источников	204	201	204	205	↑	5	5	5	5	=
Из них не соответствуют санитарно - эпидемиологическим правилам и нормативам (%)	59,8	57,7	56,4	53,7	↓	40,0	40,0	40,0	40,0	=
в т.ч. из-за отсутствия зоны санитарной охраны	54,4	51,2	49,5	46,8	↓	20,0	20,0	20,0	20,0	=

По итогам 2021 года из всех исследованных проб воды из подземных источников по санитарно - химическим показателям не соответствовали гигиеническим требованиям 14,1% (в 2020г. – 9,5%, в 2019г. – 7,3%, в 2018г. – 10,9%, в 2017г. – 5,9%), из поверхностных источников – 0% (в 2020г. – 0%, в 2019г. – 33,3% (1 проба из 3-х), в 2018-2017 гг. не обнаружено).

В 2021 году установлен рост процента неудовлетворительных проб воды из подземных источников по санитарно - химическим показателям за счет увеличения приоритетного перечня контролируемых показателей качества воды и исследований на содержание урана.

В 2021 году в рамках федерального государственного санитарно - эпидемиологического надзора и производственного контроля проведены лабораторные исследования воды из подземного централизованного источника водоснабжения в с. Краснополье Алтайского района на содержание урана.

Исследования проводились на базах нескольких лабораторных центров: ФБУЗ «Центр гигиены и эпидемиологии в городе Москве», ФБУЗ «Центр гигиены и эпидемиологии в Республике Хакасия», аккредитованной испытательной лаборатории Томского политехнического университета. По результатам лабораторных исследований концентрации урана в воде с. Краснополье превысили гигиенический норматив в 3,7-4,4 раза и составили от 0,055 до 0,066 мг/дм³ (при норме - 0,015 мг/дм³).

По микробиологическим показателям не соответствовали гигиеническим требованиям 2,9% проб из подземных источников (в 2020г. – 2,7%, в 2019г. – 4,2%, в 2018г. – 5,2%, в 2017г. – 6,7%), из поверхностных источников – 2,2% (в 2020г. – 21,7% (5 проб из 23-х), в 2019г. – 5,4%, в 2018-2017 гг. не обнаружено).

В целом по республике в 2021 году, по сравнению с 2017 годом, увеличилась доля проб воды источников централизованного водоснабжения с превышением гигиенических нормативов по санитарно-химическим показателям на 8,2%, и уменьшилась по микробиологическим на 3,8%; по паразитологическим показателям в период с 2017 по 2021 годы несоответствующие гигиеническим нормативам пробы не выявлялись.

Ранжирование по качеству подаваемой населению питьевой воды позволило выделить территории республики с нестандартными показателями, превышающими среднереспубликанские значения по санитарно - химическим показателям (от числа исследуемых проб): Алтайский (30,9%), Богградский (30,8%), Ширинский (26,7%), Бейский (25,5%) и Орджоникидзевский (15,4%) районы; по микробиологическим показателям: Алтайский (9,7%), Ширинский (8,0%), Орджоникидзевский (6,1%) и Усть-Абаканский (3,8%) районы и г. Сорск (3,4%).

Актуальной проблемой остается нецентрализованное водоснабжение сельского населения. Население в сельской местности снабжается водой из 141 источника нецентрализованного водоснабжения без соответствующей водоподготовки, из которых 39,7% (в 2020г. – 39,7%, в 2019г. – 39,7%, в 2018г. – 40,0%, в 2017г. – 40,0%) не отвечают санитарным требованиям.

Таштып, Боград) составляют менее 1,0 мЗв/чел и колеблются от 0,05 до 0,1 мЗв/чел. В остальных населенных пунктах – менее 0,05 мЗв/чел. При таких уровнях внутреннего облучения от потребления воды проведение радиозащитных мероприятий не требуется.

В связи с возросшей сейсмичностью территории республики продолжается дальнейшее наблюдение за динамикой содержания U238, U234 и возможным появлением радионуклидов, обладающих высокой радиотоксичностью (Po-210, Pb-210, Ra-228).

В республике является актуальной проблема качества питьевой воды подземных водоисточников в связи с повышенным содержанием естественных радионуклидов.

В 2021 году новых водоисточников централизованного хозяйственно – питьевого водоснабжения, качество воды которых не соответствовало бы нормам радиационной безопасности, не выявлено.

В рамках социально-гигиенического мониторинга осуществляется контроль радиационного качества питьевой воды в 16 населенных пунктах. В республике в ряде населенных пунктов (г. Сорск, рп. Пригорск, Усть-Абакан, д. Лукьяновка, сс. Шира, Боград, Новотроицкое, Новороссийское, Краснополье, Московское, Весенее, Вершино-Биджа, аал Чарков) в источниках водоснабжения постоянно отмечается повышенное содержание естественных радионуклидов (далее - ЕРН). При этом установлено, что уровень содержания ЕРН не требует проведения радиозащитных мероприятий, необходим постоянный лабораторный контроль.

The same report, PDF p. 120: a separate radiation-hygiene assessment. [2].

	мышечной системы, глаз	костно-мышечной системы; гг. Саяногорск, Бейский, Таштыпский и Ширинский районы – по заболеваемости болезнями глаз
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По результатам исследований ведущим загрязнителем атмосферного воздуха в 2018 – 2022 гг. (с превышением ПДК в 5 и более раз) являлся бенз(а)пирен. К территориям риска с высоким уровнем загрязнения бенз(а)пиреном атмосферного воздуха более 5 ПДКсс в 2022г. относятся гг. Абакан и Черногорск. Наибольшие концентрации бенз(а)пирена фиксируются в зимний период (январь, февраль).

По интегральному показателю микробного риска, связанного с потреблением питьевой воды, Республике Хакасия в 2022 году присвоен повышенный риск.

Регион отнесен к территории риска по развитию неблагоприятных эффектов у населения от воздействия отдельных химических веществ, содержащихся в питьевой воде. По результатам социально-гигиенического мониторинга за период 2018-2022 гг. питьевая вода в населенных пунктах в Алтайском, Боградском, Усть-Абаканском, Ширинском, в рп. Пригорск не соответствовала гигиеническим нормативам по жесткости. Под воздействием повышенных концентраций с общей жесткостью $> = 10$ мг-экв./л находятся около 11000 человек.

Превышение нитратов систематически обнаруживается в питьевой воде в сс. Шири и Целинное Ширинского района; сс. Бея, Новотроицкое, д. Новокурск Бейского района; с. Новороссийское Алтайского района; сс. Бородино, Знаменка и Первомайское Боградского района. Содержанием в питьевой воде нитратов обусловлен повышенный риск заболеваний со стороны сердечно - сосудистой системы и крови у детского и взрослого населения.

По результатам проведенных лабораторных исследований установлено, что при предельно допустимой концентрации урана в воде – не более 0,015 мг/дм³, полученные концентрации в населенных пунктах Алтайского района (с. Новороссийское, с. Краснополье, д. Лукьяновка) превысили установленный гигиенический норматив в 4 раза; в населенных пунктах д. Березовка, с. Кирово Алтайского района, концентрации мышьяка превышают установленный гигиенический норматив в 6 и 3 раза соответственно.

При попадании в организм уран действует на все органы, являясь общеклеточным ядом. Молекулярный механизм действия урана связан с его способностью подавлять активность ферментов. В первую очередь поражаются почки (появляются белок и сахар в моче, олигурия). При хронической интоксикации возможны нарушения кроветворения и патологии нервной системы.

Мышьяк оказывает влияние на окислительные процессы в клетке. Основное значение данный микроэлемент имеет в качестве яда. Интоксикация мышьяком сопровождается желудочно-кишечными расстройствами, нарушениями в работе сердца.

Значительный контингент работающих под воздействием вредных и опасных факторов рабочей среды и трудового процесса имеет высокую степень риска по вероятности профессионально обусловленных нарушений здоровья, что определяют в числе приоритетных факторы производственной среды.

Профессиональная заболеваемость и заболеваемость с временной утратой трудоспособности являются следствием неудовлетворительных условий труда, в т.ч. за счет комплексного воздействия химических и физических факторов.

В 2022г. в Республике Хакасия зарегистрировано 113 случаев профзаболеваний у 85 работников, в том числе 5 случаев острых профессиональных заболеваний, вызванных новой коронавирусной инфекцией (COVID-19). В структуре хронических профзаболеваний преобладают заболевания, вызванные воздействием физических факторов (вибрация и шум) – 71,7%.

Обеспечение санитарно - эпидемиологического благополучия детского и подросткового населения республики связано с факторами внутренней среды образовательных учреждений, техническое и санитарное состояние которых должно способствовать сохранению и повышению уровня здоровья детей и подростков, оставаясь

B.1. Documents for the two boreholes

Document	Exact location in the source	What differs
Old scheme	Table 3	No. 0618; commissioned in 1983
Update	Table 3; water-treatment sections	No. 786; commissioned in 2021; title-page year retained as 2014

Appendix C. Rocks and process materials

The complete eleven tonstein values and six commercial grades appear in Section 9. They are not duplicated as new series. The following table preserves the distinctions between materials.

Material	What comparison requires	Available basis
Tonstein	Sample identifier and rock mass	11 samples, Table 4. [19]
Commercial coal	Batch, size fraction and sampling	Batch 0198, No. 965; separate Izykhsky grades. [22][23]
Screenings and beneficiation wastes	Mass and analysis of each stream in the same series	A complete comparable balance is absent from the available corpus
Ash and slag	Fuel origin, operating conditions and sampling location	Kyrova, Tables 7–8. [22]
Mine water / drinking water	Locations, time, filtration and method	Water and hydrogeological documents. [2][3][25–27]

Appendix D. Coal test report and ash studies

ООО «УПР АО «Красноярскуголь»
390-909-19-ОВОС. Том 2

33

Приложение Н Протокол радиологического исследования угля

Ф03.00.44.2020	
Федеральная служба по надзору в сфере защиты прав потребителей и благополучия человека Филиал ФБУЗ «Центр гигиены и эпидемиологии в Кемеровской области» в городе Новокузнецке и Новокузнецком районе АККРЕДИТОВАННЫЙ ИСПЫТАТЕЛЬНЫЙ ЛАБОРАТОРНЫЙ ЦЕНТР	
Уникальный номер записи об аккредитации в реестре аккредитованных лиц РОСС RU.0001.510456	Юридический адрес: 650002, г. Кемерово, пр-т Шахтеров, д.20. Место осуществления деятельности: 654032, г. Новокузнецк, ул. Обиорского, д. 76А 654007, г. Новокузнецк, ул. Спартак, д. 14 654031, г. Новокузнецк, ул. Горьковская, 29 Телефон/факс: 45-24-92/46-52-29 Реквизиты банка: ИНН/КПП 4205081103/420501001 л/с 20396Х66810 в УФК по Кемеровской области р/с 40501810700002000001 в Отделении Кемерово г. Кемерово
ПРОТОКОЛ ЛАБОРАТОРНЫХ ИСПЫТАНИЙ № 965 от 22 января 2020г	
1.	Наименование предприятия, организации (заявитель): Акционерное общество «СЖС Восток Лимитед» Россия, 115432, г. Москва, пр. Андропова 18, корпус 7, помещение Х1 Юридический адрес заявителя филиала в г. Новокузнецке: Россия, 654005, Кемеровская область, г. Новокузнецк, ул. Орджоникидзе, 24, офис 312
2.	Объект, где производился отбор пробы (образца), адрес: территория углепогрузочного пункта (УПП) (адрес местонахождения: Республика Хакасия, Алтайский район, в 7.5 км юго-восточнее с. Аршаново)
3.	Цель отбора: Производственный контроль Соответствие норм радиационной безопасности (определение класса опасности)
4.	Основание: Заявление от 17.01.2020г № 250
5.	Наименование пробы (образца), дата изготовления, объем пробы: Уголь каменный ДОМСШ 0-50, номер партии 0198 Общий вес пробы – 7,5кг
6.	Изготовитель (предприятие, организация): ООО УК «Разрез Майрыхский», 655682, Республика Хакасия, Алтайский район, Аршановский с/с, Разрез Майрыхский тер., стр.1
7.	Время и дата отбора (замера): 10:00, 10.01.2020г; Время и дата доставки в ИЛЦ: 13:10, 20.01.2020г Пробу отобрал, замеры произвел (Ф.И.О., должность): Казаненко А.С., представитель SGS Проба отобрана в присутствии (Ф.И.О., должность): Сидсеева Р.Ю., руководителя проекта Условия проведения измерений: t= +18°C, влажность 33%
8.	ИД на методику отбора, измерений: ГОСТ 30108-94 «Материалы и изделия строительные. Определение удельной эффективной активности естественных радионуклидов», изменение 1 Методика измерений активности радионуклидов с использованием сцинтилляционного гамма-спектрометра с программным обеспечением «Прогресс» (МИ ФГУП ВНИИФТРИ, 2003)
9.	ИД на продукцию: ТУ предприятия
10.	ИД регламентирующие объем лабораторных исследований и их оценку: Нормы радиационной безопасности (НРБ-99/2009) СанПиН 2.6.1.2523-09
11.	Код пробы (образца): 965.Р.20.01
Составлен в 3 экземплярах	
Общее количество страниц 2	
Стр.1	

Углепогрузочный пункт ООО «УК «Разрез Майрыхский» Расширение с применением комплексов FGX-48A
Материалы оценки воздействия на окружающую среду хозяйственной и иной деятельности

Laboratory report No. 965, first page. EIA, Volume 2, PDF p. 34 / printed p. 33. [23].

Радиологические исследования: г. Новокузнецк, ул. Обнорского, 76А

12. Результаты исследований:

Код образца (пробы): 965.Р.20.01, регистрационный номер: 57

Приступил к испытаниям: 20.01.2020г.

Испытания завершены: 23.01.2020г.

Определяемые показатели	Результаты исследований Удельная активность (А), Бк/кг					погрешность исследования (А*)Бк/кг	Допустимый уровень Бк/кг	НТД на методы исследований
	Проба 1	Проба 2	Проба 3	Проба 4	Проба 5.			
КАЛИЙ-40	5	0	23	0	0	17	370,0	ГОСТ 30108-94
РАДИЙ-226	0	1	0	0	0	0		
ТОРИЙ-232	15	7	16	16	15	7		
Суммарная удельная эффективная активность А эфф.	35	24	39	37	37			
Среднее значение Аэфф.	19					9		

13. Сведения о средствах измерения:

Наименование средства измерения	номер	Свидетельство о поверке ООО «НТЦ Амплитуда» г. Москва		Поверен до
		номер	дата	
Установка спектрометрическая МКС-01А «Мультирад»	1846	503335	26.09.2019	25.09.2020
прибор комбинированный ТКА-ПКМ	202717	НФ 48309-2019	25.06.2019	25.06.2020

Ф.И.О., должность, ответственного за оформление протокола
Врач-лаборант ОРК СГЛ

Ф.А. Хайретдинова

Заведующий ИЛЦ, врач по общей гигиене

Д.М. Боткова

Составлен в трех экземплярах

Общее количество страниц 2

Стр.2

Настоящий протокол характеризует исключительно испытанный образец и подлежит частичному или полному воспроизведению только с согласия ИЛЦ ФФБУЗ «Центр гигиены и эпидемиологии в Кемеровской области» в г. Новокузнецке и Новокузнецком районе.

Углепогрузочный пункт ООО «УК «Разрез Майрыхский» Расширение с применением комплексов FGX-48А
Материалы оценки воздействия на окружающую среду хозяйственной и иной деятельности

Laboratory report No. 965, second page. EIA, Volume 2, PDF p. 35 / printed p. 34. [23].

For coal and ash analysis: Kyrova, Tables 6–8, PDF pp. 17–18. All transcribed Aeff values appear in Section 10. Radiological survey of the site: EIA Volume 1, PDF p. 44, §3.6.

Радиационная безопасность угля оценивается по его эффективной активности в угле радионуклидов $A_{эфф}$. При $A_{эфф} \leq 74$ Бк/кг – добыча угля и обращение с углями может идти без ограничений.

Результаты исследований по определению удельной и эффективной активности естественных радионуклидов спектрометрическим методом в угле разреза «Изыхский» представлены в таблице 6.

Таблица 6

Удельная и эффективная активность естественных радионуклидов
в углях разреза «Изыхский»

Разрез «Изыхский»	Удельная активность (Бк/кг)			Эффективная активность (Бк/кг)
	Ra-226	Th-232	K-40	
Уголь сортовой ДПК, кл. 50–2000	8,4 ± 13,0	23,1 ± 10,4	23,2 ± 54,2	40,6 ± 19,346
Отсев ДСШ	9,6 ± 15,4	24,2 ± 12,2	72,9 ± 70,8	47,6 ± 22,938
Уголь сортовой ДОМ, кл. 13–50	5,1 ± 13,6	20,4 ± 10,8	54,7 ± 64,0	36,4 ± 20,326
Уголь рядовой ДР, кл. 0–200	20,6 ± 14,8	21,5 ± 10,8	34,4 ± 59,4	51,7 ± 21,058

Максимально возможная удельная активность ЕРН для угля сортового ДПК составляет 59,9; для угля сортового ДОМ – 56,72; для угля рядового ДР – 72,78; для отсева ДСШ – 70,54 Бк/кг. В целом можно говорить о радиационной безопасности использования углей, встречающихся на территории Республики Хакасия.

Результаты исследований по определению удельной и эффективной активности естественных радионуклидов спектрометрическим методом в золошлаке разреза «Изыхский», «Степной» представлены в таблице 7.

Таблица 7

Удельная и эффективная активность естественных радионуклидов в золошлаке
разреза «Изыхский» и разреза «Степной»

Золошлаковые отходы	Удельная активность (Бк/кг)			Эффективная активность (Бк/кг)
	Ra-226	Th-232	K-40	
Разрез «Изыхский»	93,8 ± 40,4	132,4 ± 33,6	376,2 ± 59,0	299,2 ± 61,256
Разрез «Степной»	89,3 ± 22,8	14,1 ± 10,2	13,6 ± 63,6	108,95 ± 26,986

На основании результатов биотестирования золошлаковой смеси (отходы сгорания углей Черногорского и Изыхского каменноугольных месторождений), смесь была отнесена к пятому классу опасности отходов для окружающей и природной среды (практически неопасные).

В октябре 2004 года в лаборатории радиационного контроля ГНУ «НИИ ядерной физики ТПУ» нейтронно-активационным методом проведены исследования золы углей, используемых в Республике Хакасия, на содержание радионуклидов (таблица 8).

Kyrova: facsimile of PDF p. 17. Results tables for coal and ash-and-slag materials; the materials and comparison criteria differ. [22].

Таблица 8

Удельная и эффективная активность естественных радионуклидов в золе
и золошлаке Канско-Ачинского и Минусинского угольных бассейнов

Золошлаковые отходы	Удельная активность (Бк/кг)			Эффективная активность (Бк/кг)
	Ra-226	Th-232	K-40	
Зола бурого угля Канско-Ачинского бассейна (Абаканская ТЭЦ)	53,3 ± 11,4	33,3 ± 5,99	64,5 ± 12,9	102,3 ± 20,46
Зола каменного угля Минусинского угольного бассейна Разрез «Степной»	74,8 ± 14,96	75,2 ± 13,58	177,0 ± 35,4	188,4 ± 37,68

При санитарном анализе золошлака углей Республики Хакасия выявлен первый класс опасности и подтверждена возможность использования зол углей Республики Хакасия в качестве сырья при производстве строительных материалов для промышленного и гражданского строительства.

Однако в связи с радиометрическими аномалиями, встречающимися в Хакасии, необходим систематический контроль угольных отходов различных производств на содержание естественных радионуклидов.

Данная глава также содержит расчеты выхода БП при сжигании в котельных установках местных и привозных углей. В настоящее время на теплостанциях и в котельных Хакасии ежегодно сжигается 650–700 тысяч тонн местных каменных углей и 1000–1300 тысяч тонн бурых углей, ввозимых из Красноярского края. Каменные угли поступают с месторождений Минусинского бассейна: Черногорского, Изыхского, Бейского. Бурые угли добываются на основных месторождениях Канско-Ачинского бассейна: Ирша-Бородинском, Березовском, Назаровском. Альтернативным энергетическим топливом для Хакасии могут быть кузнецкие каменные угли, залегающие в соседней Кемеровской области.

Бенз(а)пирен содержится в продуктах сгорания различных топлив, образуется в результате высокотемпературного пиролиза органической части топлива при его сжигании с недостатком кислорода. Условия, благоприятные для появления БП, имеют место в некоторых зонах газовых трактов паровых и водогрейных котлов.

Количество образующегося при сжигании 1 кг угля БП зависит, прежде всего, от избытка воздуха в газовом тракте котла. Увеличение коэффициента $\alpha_{\text{н}}''$ от 1,0 до 1,5 приведет к снижению выхода бенз(а)пирена в 7,39 раз. При фиксированных значениях коэффициента избытка воздуха максимальное количество бенз(а)пирена $m_{\text{бп}}$, мкг/кг, соответствует высококалорийным углям: кузнецкому, аскизскому, бейскому.

Вышеперечисленные угли способны обеспечивать значительный температурный уровень в топке котла, и характеризуются большим общим выходом газообразных продуктов сгорания V_g . Например, расчетный выход БП при сжигании 1 кг кузнецкого

угля с удельной теплотой сгорания $Q_i^r = 23,11$ МДж/кг и в 2,66 раз выше, чем при сжигании 1 кг низкокалорийного назаровского угля ($Q_i^r = 12,85$ МДж/кг).

Снижение количества образующегося БП может быть достигнуто увеличением избытка воздуха в газовом тракте котла.

Appendix E. Geography and hydrogeological evidence

E.1. Coordinates of mine reference points

Mine	Latitude; longitude	Point provenance
Mayrykhsky	53.390495; 91.165237	Source. Catalogue point for the site, not a mining boundary
Arshanovsky	53.398991; 91.095886	Source. Catalogue point for the site, not a mining boundary
Izykhsky	53.569732; 91.476444	Source. Centre of the bounding extent of the labelled OpenStreetMap mine outline; not an emission point or licence boundary
Vostochno-Beysky	53.308650; 91.380636	Source. Catalogue point for the site, not a mining boundary
Kirbinsky	53.348950; 91.279319	Source. Point from the company's page; not a mining boundary

Points provide orientation; they do not replace licence boundaries or coordinates of discharges or water intakes. [Full public map information](#).

E.2. Six documentary observations on water pathways

Wo1. Izykhsky mine. Drainage water was conveyed through pipelines to artificial storage excavations. The monitoring description states that some water evaporated, while most water discharged onto the ground within the mining allotment infiltrated the water-bearing Carboniferous deposits.

Return of pumped mine water to groundwater aquifers is confirmed. These extracts do not establish a direction towards Krasnopolye's water intake, uranium transport or the current discharge regime.

[State of the Geological Environment \(Subsoil\) of the Siberian Federal District in 2018, PDF p. 74.](#) [State of the Geological Environment \(Subsoil\) of the Siberian Federal District in 2020, PDF p. 74.](#)

Wo2. Abakansky mine, Chernogorskoye deposit; neither Mayrykhsky nor Izykhsky. Discharge of drainage water from the western block into a settling pond in the eastern block was accompanied by a groundwater mound up to 600 m long and 400 m wide. Most observation boreholes recorded seepage from the settling pond into the Carboniferous aquifer.

A specific example of rising levels and return of drainage water to an aquifer elsewhere in Khakassia; the mound's dimensions and flow direction must not be transferred to Krasnopolye.

State of the Geological Environment (Subsoil) of the Siberian Federal District in 2019, PDF p. 72.

Wo3. Mayrykhsky mine. The site description gives the regional groundwater flow direction as towards the Abakan River. Dewatering creates a cone of depression. The document itself states that the connection of the eastern and north-eastern boundaries with Lake Turpanye and canal P-1-1 requires further observation.

The regional direction at this site is not a discharge route and does not define every local flow around the pits. It must not be extended to all of Khakassia.

Source, PDF p. 74.

Wo4. Groundwater in Khakassia's coal-mining areas. The bulletin links changes in hydrochemical conditions both to industrial facilities and to the drawing-in of water from underlying deposits as a result of dewatering. This is an additional pathway of compositional change, distinct from infiltration of discharges.

A general description covering the listed monitoring sites. This extract does not establish the origin of uranium in Krasnopolye's drinking water.

Source, PDF p. 76.

Wo5. Shore zone of the Krasnoyarsk Reservoir. V. S. Kuskovsky's study describes historical observations of groundwater backwater effects during reservoir filling and operation: propagation over 2.5–3.8 km in Devonian deposits and 3–5 km in Carboniferous deposits. Seepage of reservoir water into the shores is described.

These are findings from the shore profiles studied, not a route from the reservoir to every village or a universal radius of influence. The study also describes reduced mineralisation in some shore boreholes and increases at more distant sites; the changes cannot be described as moving in one direction everywhere.

[U124], printed pp. 216–217; PDF pp. 2–3.

Wo6. Altaisky District, regional hydrogeology. The historical territorial planning scheme describes aquifer recharge from precipitation, through-flowing groundwater and surface water from uplands; discharge is to the alluvium of the Abakan and Yenisei, local streams, the Sorokaozyorki lakes and drainage canals. It also describes the influence of seepage from irrigation canals on groundwater levels.

A 2010 document. Its account of irrigation-system operation must not be presented as the situation in 2026; the description does not replace a groundwater-contour map near the drinking-water borehole.

[U125], PDF p. 10, printed p. 8.

Appendix F. All production records by company

52 records; values in million tonnes. Original units, year coverage and alternative sources are retained. A gap does not mean zero output.

F. Mayrykhsy

Year	million tonnes	Basis and coverage
2016	0.441	KH2016; Table 1.5.1.5, PDF pp. 72–73. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2017	1.787	KH2017; Table 1.5.1.5, PDF pp. 73–74. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2018	2.924	KH2018; Table 1.5.1.5, PDF pp. 72–73. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2019	4.239	KH2019; Table 1.5.1.5, PDF pp. 71–72. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2020	4.228	KH2020; Table 1.5.1.5, PDF pp. 72–73. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2021	4.158	KH2021; Table 1.5.1.5, PDF p. 75. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2022	2.726	KH2022; Table 1.5.1.5, PDF pp. 76–77. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2016	0.45	U082; Chronology: 2016 — 450 thousand tonnes; 2017 — 1.8 million tonnes; 2018 — 3.1 million tonnes; 2019 — 4.2 million tonnes; 2020 — 4.3 million tonnes. Rounded source value. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2017	1.8	U082; Chronology: 2016 — 450 thousand tonnes; 2017 — 1.8 million tonnes; 2018 — 3.1 million tonnes; 2019 — 4.2 million tonnes; 2020 — 4.3 million tonnes. Rounded source value. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports

Year	million tonnes	Basis and coverage
2018	3.1	U082; Chronology: 2016 — 450 thousand tonnes; 2017 — 1.8 million tonnes; 2018 — 3.1 million tonnes; 2019 — 4.2 million tonnes; 2020 — 4.3 million tonnes. Rounded source value. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2019	4.2	U082; Chronology: 2016 — 450 thousand tonnes; 2017 — 1.8 million tonnes; 2018 — 3.1 million tonnes; 2019 — 4.2 million tonnes; 2020 — 4.3 million tonnes. Rounded source value. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2020	4.3	U082; Chronology: 2016 — 450 thousand tonnes; 2017 — 1.8 million tonnes; 2018 — 3.1 million tonnes; 2019 — 4.2 million tonnes; 2020 — 4.3 million tonnes. Rounded source value. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2021	4.8704	U085; PDF p. 14, printed p. 12, table of largest producers. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2022	2.8199	U086; PDF p. 26, printed p. 24, table of largest producers. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports
2023	2	U080; Section on US sanctions, 'Mayrykhsy mine' paragraph: 2023 — 2.0 million tonnes, down 0.8 million tonnes, or 29%, from 2022. Rounded source value. The company series for 2016–2020 and industry totals for 2021–2023 are shown separately from state reports

F. Arshanovsky

Year	million tonnes	Basis and coverage
2016	2.364	KH2016; Table 1.5.1.5, PDF pp. 72–73. For 2022, the state report has two entries for different legal entities: 2649 and 412 thousand tonnes; these have not been combined without reconciling their scope
2017	2.99	KH2017; Table 1.5.1.5, PDF pp. 73–74. For 2022, the state report has two entries for different legal entities: 2649 and 412 thousand tonnes; these have not been combined without reconciling their scope

Year	million tonnes	Basis and coverage
2018	3.476	KH2018 ; Table 1.5.1.5, PDF pp. 72–73. For 2022, the state report has two entries for different legal entities: 2649 and 412 thousand tonnes; these have not been combined without reconciling their scope
2019	3.096	KH2019 ; Table 1.5.1.5, PDF pp. 71–72. For 2022, the state report has two entries for different legal entities: 2649 and 412 thousand tonnes; these have not been combined without reconciling their scope
2020	4.196	KH2020 ; Table 1.5.1.5, PDF pp. 72–73. For 2022, the state report has two entries for different legal entities: 2649 and 412 thousand tonnes; these have not been combined without reconciling their scope
2021	4.482	KH2021 ; Table 1.5.1.5, PDF p. 75. For 2022, the state report has two entries for different legal entities: 2649 and 412 thousand tonnes; these have not been combined without reconciling their scope
2021	4.5	U085 ; PDF p. 14, printed p. 12, table of largest producers. For 2022, the state report has two entries for different legal entities: 2649 and 412 thousand tonnes; these have not been combined without reconciling their scope
2022	2.6604	U086 ; PDF p. 26, printed p. 24, Razrez Arshanovsky LLC entry. For 2022, the state report has two entries for different legal entities: 2649 and 412 thousand tonnes; these have not been combined without reconciling their scope
2023	3.292	U077 ; PDF p. 23, printed p. 21, ULK LLC (Arshanovsky mine) entry. For 2022, the state report has two entries for different legal entities: 2649 and 412 thousand tonnes; these have not been combined without reconciling their scope

F. Kirbinsky

Year	million tonnes	Basis and coverage
2018	0.073	KH2018 ; Table 1.5.1.5, PDF pp. 72–73. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained

Year	million tonnes	Basis and coverage
2019	1.219	KH2019 ; Table 1.5.1.5, PDF pp. 71–72. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained
2020	1.219	KH2020 ; Table 1.5.1.5, PDF pp. 72–73. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained
2021	2.04	KH2021 ; Table 1.5.1.5, PDF p. 75. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained
2022	2.459	KH2022 ; Table 1.5.1.5, PDF pp. 76–77. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained
2018	0.073	U078 ; Paragraph on development of the site since 2018: around 3 million tonnes in 2023. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained
2019	1.3	U083 ; Paragraph on Kirbinsky: 2019 — 1.3 million tonnes; 2020 — 1.9 million tonnes. The 12% in the headline refers to several mines, not Kirbinsky alone. Rounded source value. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained
2020	1.9	U083 ; Paragraph on Kirbinsky: 2019 — 1.3 million tonnes; 2020 — 1.9 million tonnes. The 12% in the headline refers to several mines, not Kirbinsky alone. Rounded source value. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained

Year	million tonnes	Basis and coverage
2021	2.1	U079; First paragraph: comparison of 2022 and 2021 results. Rounded source value. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained
2022	2.6	U079; First paragraph: 2.6 million tonnes for 2022. Rounded source value. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained
2023	3	U078; Paragraph on development of the site since 2018: around 3 million tonnes in 2023. Approximate source value. The 2018 state report uses the KVSU-Khakassia LLC entry. For 2020, the discrepancy between 1.219 million tonnes in the state report and 1.9 million tonnes in the company statement is retained

F. Vostochno-Beysky

Year	million tonnes	Basis and coverage
2016	3.222	KH2016; Table 1.5.1.5, PDF pp. 72–73. The publication on 2024 reports ‘more than 3.5 million tonnes’: a lower bound, not an exact total
2017	3.468	KH2017; Table 1.5.1.5, PDF pp. 73–74. The publication on 2024 reports ‘more than 3.5 million tonnes’: a lower bound, not an exact total
2018	3.447	KH2018; Table 1.5.1.5, PDF pp. 72–73. The publication on 2024 reports ‘more than 3.5 million tonnes’: a lower bound, not an exact total
2019	3.574	KH2019; Table 1.5.1.5, PDF pp. 71–72. The publication on 2024 reports ‘more than 3.5 million tonnes’: a lower bound, not an exact total
2020	3.093	KH2020; Table 1.5.1.5, PDF pp. 72–73. The publication on 2024 reports ‘more than 3.5 million tonnes’: a lower bound, not an exact total
2021	3.517	KH2021; Table 1.5.1.5, PDF p. 75. The publication on 2024 reports ‘more than 3.5 million tonnes’: a lower bound, not an exact total

Year	million tonnes	Basis and coverage
2022	3.126	KH2022 ; Table 1.5.1.5, PDF pp. 76–77. The publication on 2024 reports ‘more than 3.5 million tonnes’: a lower bound, not an exact total
2024	3.5	U087 ; Opening paragraphs: more than 3.5 million tonnes mined and sold in the previous year, 2024. Lower bound: the source says ‘more than’. The publication on 2024 reports ‘more than 3.5 million tonnes’: a lower bound, not an exact total
2025	3.7	U084 ; ‘Hardship strengthens the strong’ section: 2025 output — Vostochno-Beysky 3.7 million tonnes; Izykhsky 1.8 million tonnes. Rounded source value. The publication on 2024 reports ‘more than 3.5 million tonnes’: a lower bound, not an exact total

F. Izykhsky

Year	million tonnes	Basis and coverage
2016	0.975	KH2016 ; Table 1.5.1.5, PDF pp. 72–73. The 1.2 million tonnes for January–November 2023 is excluded from the annual series
2017	1.193	KH2017 ; Table 1.5.1.5, PDF pp. 73–74. The 1.2 million tonnes for January–November 2023 is excluded from the annual series
2018	1.328	KH2018 ; Table 1.5.1.5, PDF pp. 72–73. The 1.2 million tonnes for January–November 2023 is excluded from the annual series
2019	1.471	KH2019 ; Table 1.5.1.5, PDF pp. 71–72. The 1.2 million tonnes for January–November 2023 is excluded from the annual series
2020	0.889	KH2020 ; Table 1.5.1.5, PDF pp. 72–73. The 1.2 million tonnes for January–November 2023 is excluded from the annual series
2021	1.287	KH2021 ; Table 1.5.1.5, PDF p. 75. The 1.2 million tonnes for January–November 2023 is excluded from the annual series
2022	1.292	KH2022 ; Table 1.5.1.5, PDF pp. 76–77. The 1.2 million tonnes for January–November 2023 is excluded from the annual series

Year	million tonnes	Basis and coverage
2025	1.8	U084; 'Hardship strengthens the strong' section: 2025 output — Vostochno-Beysky 3.7 million tonnes; Izykhsky 1.8 million tonnes. Rounded source value. The 1.2 million tonnes for January–November 2023 is excluded from the annual series

Appendix G. District — Khakassia — Russia: three health series

Ten years for each indicator. Missing values have not been filled in.

G. All registered genitourinary diseases, per 1,000 residents

Year	Altai District	Khakassia	Russia
2016	50	113	116.039
2017	52.2	125.1	115.943
2018	67.8	123.3	117.888
2019	67.6	117.5	118.923
2020	54.7	93	102.148
2021	—	—	105.157
2022	56.5	91.7	106.498
2023	133.1	95.2	112.121
2024	80.2	91.6	114.709
2025	115.6	102.2	—

Year	Regional source	Federal source
2016	Document ; State report 2016, Table 3.2.4, PDF p. 162	Document ; Table 2.1, PDF p. 31, printed p. 30; overall morbidity
2017	Document ; State report 2017, Table 4.2.4, PDF p. 170	Document ; Table 2.1, PDF p. 31, printed p. 30; overall morbidity
2018	Document ; State report 2018, Table 4.2.4, PDF p. 155	Document ; Table 2.1, PDF p. 31, printed p. 30; overall morbidity

Year	Regional source	Federal source
2019	Document ; State report 2019, Table 4.2.4, PDF p. 143	Document ; Table 2.1, PDF p. 31, printed p. 30; overall morbidity
2020	Document ; State report 2020, Table 4.2.4, PDF p. 142	Document ; Table 2.1, PDF p. 29, printed p. 28; overall morbidity
2021	Document ; no separate comparable entry was found	Document ; Table 2.1, PDF p. 29, printed p. 28; overall morbidity
2022	Document ; State report 2022, Table 4.2.3, PDF p. 150	Document ; Table 2.1, PDF p. 29, printed p. 28; overall morbidity
2023	Document ; State report 2023, Table 4.2.3, PDF p. 146	Document ; Table 2.1, PDF p. 29, printed p. 28; overall morbidity
2024	Document ; State report 2024, Table 4.2.3, PDF p. 152	Document ; Table 2.1, PDF p. 29, printed p. 28; overall morbidity
2025	Document ; State report 2025, Table 4.2.3, PDF p. 151	No comparable entry available

Series notes: Overall registered morbidity in a broad disease category, not kidney diseases alone. Russia: edition preceding the 2020 census. Russia: recalculated series in the 2025 edition. Russia: recalculated series in the 2025 edition. District and Khakassia: no comparable numerical entry was found in the report used. Russia: no comparable rate for 2025 was found in the tables obtained

G. Newly registered malignant neoplasms, per 100,000

Year	Altaysky District	Khakassia	Russia
2016	391.7	409.5	408.62
2017	405.4	413.5	420.3
2018	363	429.3	425.46
2019	419.5	418.2	436.34
2020	303.9	398.8	379.65
2021	286.8	402.1	397.91
2022	362.3	408	425.89
2023	361	412.1	461.1
2024	478.9	420.8	478.11

Year	Altaisky District	Khakassia	Russia
2025	573.1	488.8	493.9

Year	Regional source	Federal source
2016	Document ; Regional cancer programme 2026, Table 2	Document ; Table 5, PDF p. 23, RUSSIA row, both sexes, crude rates
2017	Document ; Regional cancer programme 2026, Table 2	Document ; Table 5, PDF p. 23, RUSSIA row, both sexes, crude rates
2018	Document ; Regional cancer programme 2026, Table 2	Document ; Table 5, PDF p. 23, RUSSIA row, both sexes, crude rates
2019	Document ; Regional cancer programme 2026, Table 2	Document ; Table 5, PDF p. 23, RUSSIA row, both sexes, crude rates
2020	Document ; Regional cancer programme 2026, Table 2	Document ; Table 5, PDF p. 23, RUSSIA row, both sexes, crude rates
2021	Document ; Regional cancer programme 2026, Table 2	Document ; Table 5, PDF p. 23, RUSSIA row, both sexes, crude rates
2022	Document ; Regional cancer programme 2026, Table 2	Document ; Table 5, PDF p. 23, RUSSIA row, both sexes, crude rates
2023	Document ; Regional cancer programme 2026, Table 2	Document ; Table 5, PDF p. 23, RUSSIA row, both sexes, crude rates
2024	Document ; Regional cancer programme 2026, Table 2	Document ; Table 5, PDF p. 23, RUSSIA row, both sexes, crude rates
2025	Document ; Regional cancer programme 2026, Table 2	Document ; PDF p. 4, crude incidence rate

Series notes: Crude rate for both sexes and all ages, not age-standardised. Crude rate for both sexes and all ages, not age-standardised. Khakassia: 420.8 in municipal Table 2, versus 421.7 in Table 3 of the same document. The federal source uses the average annual population of 2024 for cases in 2025

G. Mortality from malignant neoplasms, per 100,000

Year	Altaisky District	Khakassia	Russia
2016	246.4	215.7	201.62
2017	204.6	223.2	197.94
2018	221.7	211.6	200.03

Year	Altaysky District	Khakassia	Russia
2019	224.5	227.8	200.59
2020	199	227.3	199
2021	155.4	212.9	191.27
2022	153	203	188.72
2023	203.1	194.6	194.34
2024	194.1	210.9	—
2025	260.9	211.4	—

Year	Regional source	Federal source
2016	Document ; Regional cancer programme 2026, Table 10	Document ; Table 73, PDF p. 162, both sexes, crude rates
2017	Document ; Regional cancer programme 2026, Table 10	Document ; Table 73, PDF p. 162, both sexes, crude rates
2018	Document ; Regional cancer programme 2026, Table 10	Document ; Table 73, PDF p. 162, both sexes, crude rates
2019	Document ; Regional cancer programme 2026, Table 10	Document ; Table 73, PDF p. 162, both sexes, crude rates
2020	Document ; Regional cancer programme 2026, Table 10	Document ; Table 73, PDF p. 162, both sexes, crude rates
2021	Document ; Regional cancer programme 2026, Table 10	Document ; Table 73, PDF p. 162, both sexes, crude rates
2022	Document ; Regional cancer programme 2026, Table 10	Document ; Table 73, PDF p. 162, both sexes, crude rates
2023	Document ; Regional cancer programme 2026, Table 10	Document ; Table 73, PDF p. 162, both sexes, crude rates
2024	Document ; Regional cancer programme 2026, Table 10	No comparable entry available
2025	Document ; Regional cancer programme 2026, Table 10	No comparable entry available

Series notes: Crude rate for both sexes and all ages, not age-standardised. The regional programme attributes Table 10 to Form 7; the federal mortality series has a separate methodology. Khakassia: 227.8 in Table 10, versus 224.8 in Table 9 of the same document.

Khakassia: 194.6 in Table 10, versus 184.9 in Table 9 of the same document. The regional programme attributes Table 10 to Form 7; the federal mortality series has a separate methodology. Russia: no comparable rate for this year was found in the tables obtained

Appendix H. Cancer in all municipal areas and six cancer sites

H.1. Complete series for 2015–2024

Source [40], Table 2. New cases per 100,000 residents, both sexes, all ages; rates are not standardised. 13 municipal areas and the republic: 140 values.

Republic of Khakassia

Year	Republic of Khakassia	Khakassia
2015	391.2	391.2
2016	409.5	409.5
2017	413.5	413.5
2018	429.3	429.3
2019	418.2	418.2
2020	398.8	398.8
2021	402.1	402.1
2022	408.0	408.0
2023	412.1	412.1
2024	421.7	421.7

Abakan

Year	Abakan	Khakassia
2015	391.8	391.2
2016	402.9	409.5
2017	401.3	413.5
2018	425.0	429.3
2019	413.7	418.2

Year	Abakan	Khakassia
2020	348.5	398.8
2021	414.6	402.1
2022	397.7	408.0
2023	388.3	412.1
2024	443.3	421.7

Chernogorsk

Year	Chernogorsk	Khakassia
2015	400.9	391.2
2016	372.7	409.5
2017	445.0	413.5
2018	384.9	429.3
2019	413.7	418.2
2020	399.9	398.8
2021	426.9	402.1
2022	413.5	408.0
2023	376.0	412.1
2024	413.4	421.7

Sayanogorsk

Year	Sayanogorsk	Khakassia
2015	434.6	391.2
2016	488.2	409.5
2017	521.0	413.5
2018	375.5	429.3
2019	538.2	418.2
2020	291.1	398.8

Year	Sayanogorsk	Khakassia
2021	502.1	402.1
2022	517.8	408.0
2023	527.5	412.1
2024	499.6	421.7

Abaza

Year	Abaza	Khakassia
2015	402.3	391.2
2016	387.8	409.5
2017	523.5	413.5
2018	518.3	429.3
2019	486.5	418.2
2020	508.0	398.8
2021	440.6	402.1
2022	467.2	408.0
2023	402.6	412.1
2024	413.1	421.7

Sorsk

Year	Sorsk	Khakassia
2015	309.8	391.2
2016	380.0	409.5
2017	375.7	413.5
2018	396.1	429.3
2019	282.3	418.2
2020	387.9	398.8
2021	423.3	402.1

Year	Sorsk	Khakassia
2022	302.2	408.0
2023	369.2	412.1
2024	251.9	421.7

Altaisky District

Year	Altaisky District	Khakassia
2015	331.3	391.2
2016	391.7	409.5
2017	405.4	413.5
2018	363.0	429.3
2019	419.5	418.2
2020	303.9	398.8
2021	286.8	402.1
2022	362.3	408.0
2023	361.0	412.1
2024	478.9	421.7

Askizsky District

Year	Askizsky District	Khakassia
2015	358.4	391.2
2016	307.7	409.5
2017	289.9	413.5
2018	324.9	429.3
2019	333.8	418.2
2020	457.5	398.8
2021	314.8	402.1
2022	334.4	408.0

Year	Askizsky District	Khakassia
2023	305.4	412.1
2024	306.4	421.7

Beysky District

Year	Beysky District	Khakassia
2015	429.9	391.2
2016	495.5	409.5
2017	460.6	413.5
2018	414.2	429.3
2019	425.7	418.2
2020	407.9	398.8
2021	399.7	402.1
2022	467.0	408.0
2023	503.5	412.1
2024	394.3	421.7

Bogradsky District

Year	Bogradsky District	Khakassia
2015	386.3	391.2
2016	475.7	409.5
2017	415.2	413.5
2018	434.6	429.3
2019	407.9	418.2
2020	304.0	398.8
2021	399.8	402.1
2022	478.1	408.0
2023	399.0	412.1

Year	Bogradsky District	Khakassia
2024	360.7	421.7

Ordzhonikidzevsky District

Year	Ordzhonikidzevsky District	Khakassia
2015	414.3	391.2
2016	335.1	409.5
2017	411.8	413.5
2018	422.9	429.3
2019	359.3	418.2
2020	235.5	398.8
2021	380.2	402.1
2022	467.0	408.0
2023	502.2	412.1
2024	458.1	421.7

Tashtypsky District

Year	Tashtypsky District	Khakassia
2015	303.5	391.2
2016	340.2	409.5
2017	278.0	413.5
2018	294.2	429.3
2019	242.2	418.2
2020	364.0	398.8
2021	253.0	402.1
2022	234.6	408.0
2023	294.0	412.1
2024	327.0	421.7

Ust-Abakansky District

Year	Ust-Abakansky District	Khakassia
2015	367.7	391.2
2016	429.8	409.5
2017	378.6	413.5
2018	395.7	429.3
2019	398.2	418.2
2020	347.3	398.8
2021	355.7	402.1
2022	382.1	408.0
2023	482.1	412.1
2024	427.5	421.7

Shirinsky District

Year	Shirinsky District	Khakassia
2015	362.3	391.2
2016	447.0	409.5
2017	396.7	413.5
2018	498.4	429.3
2019	479.9	418.2
2020	397.3	398.8
2021	394.6	402.1
2022	466.0	408.0
2023	408.1	412.1
2024	370.5	421.7

H.2. Republic-wide coal output and individual cancer sites, 2016–2025

All 70 records. Breast cancer: per 100,000 women; other cancer series: per 100,000 residents of both sexes. Coal output: million tonnes.

Coal output

Year	Value	Source
2016	18.015 million tonnes	Document ; State report 2020, PDF p. 71, Table 1.5.1.4
2017	20.327 million tonnes	Document ; State report 2020, PDF p. 71, Table 1.5.1.4
2018	22.616 million tonnes	Document ; State report 2020, PDF p. 71, Table 1.5.1.4
2019	25.008 million tonnes	Document ; State report 2020, PDF p. 71, Table 1.5.1.4
2020	26.013 million tonnes	Document ; State report 2020, PDF p. 71, Table 1.5.1.4
2021	28.939 million tonnes	Document ; State report 2025, PDF p. 82, Table 1.5.1.4
2022	25.786 million tonnes	Document ; State report 2025, PDF p. 82, Table 1.5.1.4
2023	25.508 million tonnes	Document ; State report 2025, PDF p. 82, Table 1.5.1.4
2024	23.849 million tonnes	Document ; State report 2025, PDF p. 82, Table 1.5.1.4
2025	24.721 million tonnes	Document ; State report 2025, PDF p. 82, Table 1.5.1.4

Kidney cancer

Year	Value	Source
2016	16.6 cases per 100,000 residents, both sexes	Document ; Table 3, both sexes
2017	18.4 cases per 100,000 residents, both sexes	Document ; Table 3, both sexes
2018	20.9 cases per 100,000 residents, both sexes	Document ; Table 3, both sexes
2019	15.1 cases per 100,000 residents, both sexes	Document ; Table 3, both sexes

Year	Value	Source
2020	18.6 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2021	17.5 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2022	22.6 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2023	21.2 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2024	19.4 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2025	18.5 cases per 100,000 residents, both sexes	Document; Table 3, both sexes

Bladder cancer

Year	Value	Source
2016	9.9 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2017	15.1 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2018	10.3 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2019	13.5 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2020	6.9 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2021	12.1 cases per 100,000 residents, both sexes	Document; Table 3, both sexes

Year	Value	Source
2022	14 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2023	12.1 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2024	15.6 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2025	14 cases per 100,000 residents, both sexes	Document; Table 3, both sexes

Trachea, bronchus and lung cancer

Year	Value	Source
2016	52.7 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2017	55.4 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2018	52.9 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2019	50.1 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2020	54.2 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2021	51.1 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2022	44.2 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2023	42.3 cases per 100,000 residents, both sexes	Document; Table 3, both sexes

Year	Value	Source
2024	39.8 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2025	52.1 cases per 100,000 residents, both sexes	Document; Table 3, both sexes

Stomach cancer

Year	Value	Source
2016	27 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2017	24.4 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2018	26.1 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2019	24.6 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2020	24.5 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2021	21.7 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2022	24.6 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2023	23.2 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2024	16.9 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2025	25.4 cases per 100,000 residents, both sexes	Document; Table 3, both sexes

Colon cancer

Year	Value	Source
2016	25.7 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2017	21.6 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2018	26.8 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2019	24.9 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2020	22 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2021	22.8 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2022	24.1 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2023	29.5 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2024	29.7 cases per 100,000 residents, both sexes	Document; Table 3, both sexes
2025	33 cases per 100,000 residents, both sexes	Document; Table 3, both sexes

Breast cancer in women

Year	Value	Source
2016	88.3 cases per 100,000 women	Document; Table 3.2, women
2017	82.4 cases per 100,000 women	Document; Table 3.2, women

Year	Value	Source
2018	90.1 cases per 100,000 women	Document; Table 3.2, women
2019	79.2 cases per 100,000 women	Document; Table 3.2, women
2020	72.1 cases per 100,000 women	Document; Table 3.2, women
2021	75.7 cases per 100,000 women	Document; Table 3.2, women
2022	90.8 cases per 100,000 women	Document; Table 3.2, women
2023	80.3 cases per 100,000 women	Document; Table 3.2, women
2024	99.1 cases per 100,000 women	Document; Table 3.2, women
2025	106.8 cases per 100,000 women	Document; Table 3.2, women

Appendix I. Complete tables on congenital anomalies and diagnostic outcomes

I.1. Abakan, 1986–2001

Source [48], Table 14, pp. 94–95. Mean frequencies per 1,000 newborns and standard errors. These are the author's averages of annual rates, not an independent recalculation of total cases.

Group	Frequency $\pm$ standard error
Musculoskeletal system	7.062 $\pm$ 0.506
Genital organs	4.312 $\pm$ 0.319
Urinary system	3.070 $\pm$ 0.474
Cardiovascular system	2.814 $\pm$ 0.402
CNS and sense organs	2.289 $\pm$ 0.342
Multiple congenital anomalies	2.112 $\pm$ 0.490
Face and neck	2.109 $\pm$ 0.542

Group	Frequency ± standard error
Down syndrome	1.390 ± 0.177
Skin and appendages	0.584 ± 0.236
Digestive organs	0.548 ± 0.112
Respiratory system	0.518 ± 0.125
Placental and associated membrane anomalies	0.226 ± 0.096
Other anomalies	0.196 ± 0.071
Endocrine glands	0.000 ± —

I.2. Prenatal diagnosis and medical terminations

Source [50]. The periods differ in length.

2012. Detected chromosomal abnormalities — 14; detected fetal anomalies — 34.
Terminations: 34 in total, 13 with chromosomal abnormalities, 21 with non-viable congenital anomalies, and — with severe embryofetopathies without congenital anomalies. Full year. The embryofetopathy category is not reported separately.

2013-01–2013-09. Detected chromosomal abnormalities — 5; detected fetal anomalies — 28.
Terminations: 22 in total, 5 with chromosomal abnormalities, 13 with non-viable congenital anomalies and 4 with severe embryofetopathies without congenital anomalies. Nine months. The four cases without congenital anomalies must not be counted as anomalies.

Appendix J. Court decisions: subject matter and availability

Case / stage	Document	Subject
A74-7838/2025, 03.04.2026	Full judgment	Tariff shortfall; operator and services to Krasnopolye, not water quality
2-190/2024, 10.07.2024	Full judgment	Backup electricity supply; anonymised addresses are not identified by conjecture
A74-12368/2024, 01.09.2025	Judgment	Mayrykhsky — Mezhrefontop; contract and delivery notes
A40-272558/2024, 18.06.2025	Operative part	BX Energy — Stepnoy; the full reasoned text was not obtained separately

Case / stage	Document	Subject
Same case: 04.07.2025; 14.10.2025; 02.02.2026	Dates of the full judgment, appeal and cassation are given in the Supreme Court ruling	Separate complete texts for these stages are absent from the corpus used
305-ЭC26-3861, 29.05.2026	Supreme Court ruling	Refusal to refer BX Energy's appeal for consideration

Appendix K. Sixteen companies and sites

Documented relationships, trade records and planned transitions are distinguished. Letters on this subject have not been sent.

K.1. Mezhregiontop LLC

Confirmed buyer from Mayrykhsy; the final site of use is not established. Grade D coal under a contract with UK Razrez Mayrykhsy LLC. Period: supplies on 17.12.2022, 22.01.2023 and 30.06.2023.

Arbitration Court of the Republic of Khakassia judgment dated 01.09.2025 in case A74-12368/2024; contract No. 115-2022 dated 02.12.2022; three signed delivery notes. The text used contains no uranium or radiation-monitoring data for the batches

[Source of the connection.](#)

K.2. The National Coal Supply Corporation Ltd

Potential Mayrykhsy buyer; IEC's supply company.

Trademo names it as a buyer; the primary declaration was not obtained. IEC's 2023 report, PDF p. 316, independently confirms supply to Orot Rabin and Rutenberg but not the origin of a particular batch

[Source of the connection.](#)

K.3. Ecocarbon Ltd

A trade lead, not an established end user. Mayrykhsy according to the Trademo aggregator

The primary declaration and precise legal identity were not obtained

[Source of the connection.](#)

K.4. Novosibirsk CHP-2

End user. Stepnoy, Khakassia. Period: report from early 2022; a current supply is not established.

Argus industry publication

[Source of the connection.](#)

K.5. Novosibirsk CHP-4

End user. Stepnoy, Khakassia. Period: report from early 2022; a current supply is not established.

Argus industry publication

[Source of the connection.](#)

K.6. Apatity CHP plant

End user. Stepnoy, Khakassia. Period: report from early 2022.

An Argus industry publication names the consumer. A separate TGC-1 annual report is retained as supplementary material; its table is not used here to attribute a new supply.

[Source of the connection](#) · [Supplementary document.](#)

K.7. Artyom CHP plant

End user. Stepnoy, Khakassia. Period: report from early 2022.

Argus industry publication

[Source of the connection.](#)

K.8. Barnaul CHP-2

End user. Khakassian grade D coal; the specific mine is not named in the extract found. Period: document TP 38752107-2017.

Operating regulations TP 38752107-2017, PDF p. 8, Section 3: Khakassian grade D coal together with Kuznetsk grade SS. [60]

[Source of the connection](#) · [Supplementary document.](#)

K.9. Magadan CHP plant

End user. Chernogorskoye deposit, Khakassia; supplier: Kamchatka Shipping Company LLC. Period: 28 January 2020.

A Kolyma.ru publication dated 28 January 2020, attributed to Magadanenergo, reports the use and testing of Khakassian fuel. The URL in the earlier record has a mismatched title; this is an incompletely traced publication, not a primary radiological test report.

The exact public address of the report is not established.

K.10. Cherepovetskaya GRES

Historical end user. Stepnoy, Chernogorsk Coal Company, Khakasrazrezugol and Vostochno-Beysky are listed in the report. Period: OGK-2 annual report for 2013.

Company annual report on its website; current use must not be asserted on the basis of a historical report

Source of the connection.

K.11. Inta CHP plant

Candidate: announced purchase and planned transition. Khakassia; mine unspecified. Period: 21 April 2020 announcement of a transition from September and purchase of 25 thousand tonnes.

Report dated 21 April 2020 on the purchase of 25 thousand tonnes and a planned transition from September. The transition plan is not treated as confirmation of subsequent actual operation.

Source of the connection.

K.12. Sorsk CHP plant

End user according to the regional scheme. Chernogorsk hard coal, Russian Coal JSC. Period: 2021 regional scheme for 2022–2026.

Fuel information appears in the regional scheme; the exact entry and distinction between existing conditions and forecast were not fixed in the record obtained. The relationship has not been upgraded to a verified contract.

Source of the connection.

K.13. Severodvinsk CHP-1

Candidate. Khakassian coal; mine not established

A secondary description is available. The record used lacks primary TGC-2 material confirming the source and supply period.

Source of the connection.

K.14. CSTI Limited

Buyer/intermediary, not established as an end user. Mayrykhsky

Mayrykhsky called CSTI its main buyer. Legal identity and differences from historical profiles are explained in Section 20; the publication does not establish the composition of every batch.

Source of the connection.

K.15. TAQA SOLUTIONS DMCC

A trade lead, not a confirmed end user. ULK Razrez Arshanovsky according to an aggregator profile

Public Volza extract, South Korea destination; the complete primary shipping document was not obtained

Source of the connection.

K.16. BX Energy Limited

Contractual counterparty according to the judicial acts obtained; the end user is not established. Dispute with UK Razrez Stepnoy JSC; third party: Okto Ugol LLC. Period: contract dated 28.10.2021; withdrawal from the contract on 24.07.2024; proceedings in 2025–2026.

The operative part dated 18 June 2025 in case A40-272558/2024 and Supreme Court ruling No. 305-ЭC26-3861 dated 29 May 2026 were obtained. The full first-instance reasoning was not obtained separately; actual supply volumes have not been reconstructed from these acts. The stated contract date is 28 October 2021.

Source of the connection · Supplementary document.

Appendix L. Evidence map and supplementary bibliography

L.1. Substantive claims and documents

Code	Claim / finding	Exact location
C01	Problems with radiological indicators in drinking-water sources were described before the 2021 crisis. Monitoring of individual indicators began in different years	[4], PDF pp. 2, 4–6; [77], PDF p. 101; [5], pp. 134–138. The regional programme and the history of a particular borehole are distinct.
C02	According to the official report for 2021, uranium in Krasnopolye's groundwater source for centralised supply was measured at 0.055–0.066 mg/dm ³ against the stated limit of 0.015	[2], PDF p. 34. Three laboratories are named; individual reports with sampling dates are not attached.
C03	The 2020 scientific table publishes uranium mass concentrations for nine settlements	[3], Table 4, PDF p. 4 / printed p. 49; Appendix A. Individual sampling dates are not specified.
C04	The authors' conclusion in U113 lists seven settlements with exceedances; Vershino-Bidzha and Shira are not included	[3], Table 4 and conclusions; complete values with uncertainties are in Appendix A.1.

Code	Claim / finding	Exact location
C05	54.9 ± 10.3% of samples and 124 sources refer to gross-alpha screening, not the proportion of samples exceeding the uranium mass-concentration limit	[3], results and conclusions; a separate retrospective period, 2005–2018.
C06	For Krasnopolye, published alpha activity is 3.01 ± 0.9 Bq/kg, with a maximum of 5.2	[6], Tables 2–3, PDF pp. 4–6. $M \pm s$ describes the series; 2.6* (3.9) is a calculated screening level.
C07	The schemes successively identify No. 0618, commissioned in 1983, and No. 786, commissioned in 2021	[8][9], Table 3; Appendix B.1. The update was published in 2024; its title page retained 2014.
C08	The BMS WT 5CE/S treatment plant appears in the official 2022 property list	[11], Resolution No. 314, Appendix 3, movable-property section, row 1. The list itself contains no treatment results.
C09	Impuls is named as Krasnopolye's supply operator for the first quarter of 2025	[12], case A74-7838/2025, judgment dated 03.04.2026. The dispute concerns a tariff shortfall.
C10	The region's uranium mineralisation was studied long before the present dispute	[16], 1925, pp. 315–322; material from the 1919 visit to the Potekhina area and Yuliya mine.
C11	Direct uranium determinations of 6.0–53.3 ppm have been published for tonsteins of the Beyskoye deposit	[19], Table 4, PDF p. 7 / printed p. 161; 11 samples of rock partings.
C12	The sequence and seams are described for specific sites; the Mayrykhsky project provides for extraction including rock partings	[19], PDF pp. 3–4; [20], Volume 1, PDF p. 21. The sequence's depth of burial is not the pit depth.
C13	The studied Izykhsky section contains a separately described 0.45 m siltstone parting with a reading of 25 µR/h	[21], PDF p. 7. The reading concerns a specific parting, not the whole area.
C14	A gamma survey is published for the surveyed coal loading facility site: mean 0.13, range 0.08–0.18 µSv/h	[20], Volume 1, PDF p. 44, §3.6: 10 m grid and free search; the coal loading facility site was surveyed.
C15	A laboratory report exists for a specific batch of Mayrykhsky coal	[23], Volume 2, PDF pp. 34–35 / printed pp. 33–34; both pages are in Appendix D.
C16	Izykhsky coals and combustion wastes were studied separately	[22], Tables 6–8, PDF pp. 17–18; favourable assessment of the tested coals and separate waste results.

Code	Claim / finding	Exact location
C17	Return of pumped mine water to aquifer rocks is documented for Izykhsky	[25][27], PDF p. 74; W01, Appendix E.2. Infiltration is described, but not a pathway to the drinking-water borehole.
C18	At another site, a groundwater mound was recorded as water seeped from a settling pond	[26], PDF p. 72; Abakansky mine, not Mayrykhsky. W02, Appendix E.2.
C19	A scientific study describes the historical influence of the Krasnoyarsk Reservoir on shore aquifers	[28], PDF pp. 2–3 / printed pp. 216–217; different shore profiles and deposits.
C20	In 2023, companies' coal output changed in different directions	[31–33]; documents for each year and company are in Appendix F.
C21	The five companies' series for 2016–2025 contain gaps and source discrepancies	52 original records are in Appendix F; different sources and part-year data are not combined automatically.
C22	Altaysky District's genitourinary disease series fluctuates rather than rising continuously	[30][34][36]; Appendix G gives years, tables and PDF pages; a separate value for 2021 is absent.
C23	Table U141 completes the series of new malignant neoplasms for all 13 municipalities for 2015–2024	[40], Table 2; 140 values in Appendix H.1. Rates are not age-standardised.
C24	The extended cancer series for 2016–2025 is retained separately, not truncated at U141's endpoint	[37], Tables 2 and 10; Appendix G. Incidence, prevalence and mortality are distinguished.
C25	A study describes a long-term rise in Khakassia's standardised cancer incidence	[41], Table 1, PDF p. 4. Growth in a rate and growth in case numbers are different indicators.
C26	Studies of kidney, breast, CNS and stomach cancers cover different periods	[42–46]; Section 16.2. Different periods and directions of change are retained, including for CNS tumours.
C27	A report states that examinations began in Krasnopolye, but their final anonymised report was not obtained	[35], report dated 22.04.2021. The existence of a report on examinations is not replaced by a claim that they did not occur.
C28	A ranking of congenital anomalies was found for Abakan, but it is historical	[48], pp. 94–95, Table 14; all 14 groups in Appendix I.1. Frequencies were averaged across years by the authors.
C29	Later official information exists on infant deaths involving congenital anomalies	[49], §1.2, Table 4 and the following list. This is the distribution of 19 infant deaths, not all congenital anomalies.

Code	Claim / finding	Exact location
C30	Pregnancy-termination data were found for the full year 2012 and nine months of 2013	[50]; Appendix I.2: full year 2012 and nine months of 2013; reasons for termination are retained separately.
C31	Contemporary publications exist but describe different areas and outcomes	[54][55][U140]; Section 17. Publications differ in geographical coverage, periods and outcomes studied.
C32	The Chinese study reports an association between placental uranium and neural tube defects	[51], available abstract: 408 cases, 593 controls; aOR 3.60 (95% CI 2.30–5.64). The full text was not obtained.
C33	In the Nebraska study, the uranium result depends on the model	[52], PDF p. 11, Table 5: IRR 1.03 and 0.96 in different models. Pregnancy losses were not measured directly.
C34	Mayrykhsky explicitly named CSTI as a buyer	[57][58]; Section 20. The company's own statement and its counterparty's registration history are distinguished.
C35	A judicial act describes Mayrykhsky's coal supply to Mezhhregiontop	[56], case A74-12368/2024; contract No. 115-2022 and three delivery notes for 2022–2023.
C36	Acts concerning the contractual dispute between Stepnoy and BX Energy were obtained	[59]; Appendix J. The contract dated 28.10.2021 does not disclose a batch's full actual route.
C37	Primary historical records confirm use of Khakassian coal by end-user power stations	[60], PDF p. 8; [61], PDF p. 10. Each station's period and fuel-origin information are retained.
C38	NCSC is confirmed to supply Orot Rabin and Rutenberg; the connection to Mayrykhsky coal remains a trade lead	[62], PDF p. 316, and trade profile U028. Supplying the stations and establishing a particular batch's origin are different connections.

L.2. Retained research strands and full texts not obtained

Strand	Retained material	Extent of use
Regional geochemistry	Volostnov 2004; Arbuzov 2005; Rare-Metal Potential of Coals of the Minusinsk Basin, 2003; reports on Chalpan and Izykh, 2000–2001	Bibliographic reserve; unverified tables have not been added to the numerical series

Strand	Retained material	Extent of use
Modes of occurrence of elements	Radioactive elements in Paleozoic coals of Siberia, OSTI 20613228; DOI 10.3103/S0361521912010028; PII S0166516224000995	Specific bibliographic leads; not evidence of a particular batch's composition
International analogues	Ketris / Yudovich 2009; ORNL Recovery of Uranium from Lignites; patent 4113313	Analogues and technologies are distinguished from local measurements
Hydrogeochemistry	TPU studies of U/Th migration species and groundwater in northern Kazakhstan	They do not establish a geographical pathway to Krasnopolye's borehole
Residents' accounts	Publications in Shans, RTS and newspapers, and reprints of agency statements	Attribution is retained; a repeated publication is not a new sample
Logistics	Materials on the Eastern Railway Network, quotas and shipment plans	A quota or plan is not relabelled as a completed shipment
Unavailable full scientific texts	U097, U098, U130, U133, U138/U142	Only abstracts or bibliographic details actually available are used; no claim is made to have read the full text

Sources and extended documentary index

Numbering 1–65 is retained from the accepted article; 66–76 are targeted methodological additions for this PDF edition. PDF pages are counted from the beginning of the file. Catalogue identifiers U are additionally listed below: they index the corpus and do not assert that every listed item was used as complete evidence.

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