

The Invisible Cone of the Koibal Steppe

How dewatering at the Mayrykhsky and Arshanovsky open-pit mines changed groundwater, what happened to lakes and discharges, and who is responsible for making the data accessible

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Explanatory schematic. The schematic included in the report explains the mechanism of the combined cone of depression. It is not a measured map of its boundaries or a calculated hydrogeological cross-section.

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Natalia Zubkova.

1. FROM THE AUTHOR

The Koibal Steppe is my homeland. Between Abakan and the Yenisei, dry steppe landscapes lie alongside lakes, marshy meadows and reed beds. The value of this place lies in their interconnection. Water sustains the lakes and wet depressions, plants provide shelter and food, and birds find places to nest and rest on their long journeys.

At the centre of the steppe lies the Sorokaozyorki tract—an ancient channel of the Yenisei containing a chain of small water bodies. In a 2015 study, ornithologists described more than one hundred bird species here, including 28 species listed in Red Data Books at different levels. The tract served as one of Khakassia’s key breeding sites for the Demoiselle Crane, Great Bittern and Bearded Reedling.[20]

Ruddy Shelducks, Mallards, Eurasian Coots, grebes and Grey Herons occur on the lakes. Rare birds recorded there include the Swan Goose, Bewick’s Swan and Baillon’s Crake. Steppe Polecats, European Hares, European Badgers and Muskrats live in the surrounding habitats. Behind every name is a particular need for water, food, shelter and space.[21]

In 2020, the Lakes of the Koibal Steppe protected area was established here as a regional wildlife sanctuary (zakaznik). Katanov Khakass State University, which helped prepare it, explained the choice of territory in very clear terms: the sanctuary included three Sorokaozyorki lakes that remained outside the land allotments of the coal companies—Ptichye, Sobachye and Zalivnoye.[22]

For me, those words reveal the cost of what is happening. Coal licences and land allotments appeared in a place where life already existed. Now the land is being opened up and groundwater pumped out for coal extraction, altering the system on which the lakes, pastures, animals and people depend.

On 6 January 2020, I came here to film the “coal dragons”. Dark plumes above the industrial site and dust on the snow appeared in the footage. But another change was taking place underground, beyond the camera’s reach: the cones associated with the two open-pit mines had already merged into a multi-kilometre area of lowered groundwater levels.

That day, a farmer named Denis showed us his farm. He had around three hundred sheep and several horses. He spoke not only about the dust and the land occupied by the mines. He said that water was becoming less available from wells and public standpipes.

At the time, this was the testimony of someone living next to coal mining. It can now be compared with state hydrogeological bulletins, project documents and monitoring results.

I want to understand not only how much water was pumped. I want to understand what happened to the steppe, where that water was moved, what returned to the river, what remained in the documents—and why residents cannot see the complete picture.

Abstract

This report examines the hydrogeological consequences of open-pit coal mining in the Koibal Steppe of the Republic of Khakassia. Its main subject is the combined cone of depression created by the Mayrykhsky and Arshanovsky open-pit mines: a multi-kilometre area of lowered groundwater levels officially recorded by the state subsoil-monitoring system.

The documents show that by 2018 the local cones of depression associated with the two mines had merged. Specialists could no longer distinguish the effects of their respective dewatering operations. The combined area of drawdown extended for approximately 8 kilometres from west to east and 4–4.2 kilometres from south to north. Average dewatering at Mayrykhsky rose from 7.340 thousand cubic metres per day in 2017 to 14.344 thousand in 2020. In 2018, the known combined dewatering rate of the two neighbouring mines was 20.481 thousand cubic metres per day—an estimated annual equivalent of about 7.48 million cubic metres.[1][2][3][4]

This does not mean that all the water pumped from the workings was irretrievably lost from the natural system: some may have been used, treated, discharged or reinfiltrated into the ground. The aggregate dewatering figures in the bulletins used here do not distinguish groundwater inflow from precipitation and surface runoff entering the workings. Dewatering nevertheless altered the natural hydraulic gradients: the open pits became artificial drains towards which groundwater flowed.

State bulletins also recorded changes in groundwater chemistry in the coal-mining area. At Mayrykhsky in 2017, exceedances were reported for iron, sodium, petroleum products, fluoride, total dissolved solids and several other parameters; in 2018, arsenic was recorded at 1.5 times the maximum permissible concentration (MPC). In 2022, the Government of Khakassia reported exceedances and an apparent input of phenols, sulphates, arsenic and fluoride into the Abakan River at the Mayrykhsky mine-water discharge point.[1][2][5]

At the same time, the complete primary dataset needed to answer residents' most important questions was not found in the public domain: monthly levels for every monitoring well; records for rural boreholes and wells; a pumping-and-discharge balance; lake levels; primary laboratory reports before and after treatment; and a digital model of the cumulative effects of several mines. The absence of published data is not evidence of safety. It means that it is necessary to establish what observations were made, who holds the results and how residents can obtain them.

This report does not attribute the hydrogeological effects of mine dewatering to the FGX-48A dry separators. The “coal dragons” and the cone of depression involve different technological processes within the same industrially altered landscape: the FGX units separated coal by means of an air flow at the surface, whereas the cone was created by dewatering the mine workings.

Key findings

1. **The combined cone is documented.** No later than 2018, the Mayrykhsky and Arshanovsky cones of depression had merged into a single area measuring approximately 8 × 4–4.2 kilometres.[2]

2. **The effects of the two mines became cumulative.** State monitoring expressly reported that the contributions of the two dewatering systems could not be distinguished.[2]
3. **Dewatering at Mayrykhsky almost doubled.** Between 2017 and 2020, average daily pumping rose from 7.340 to 14.344 thousand m³/day—an increase of approximately 95 per cent.[1][2][3][4]
4. **The scale amounts to millions of cubic metres per year.** Average dewatering at Mayrykhsky in 2020 corresponds to an estimated annual equivalent of about 5.250 million m³. This is the daily average multiplied by 366 calendar days, not a separate annual measurement.[4]
5. **In 2018, the two mines together pumped 20.481 thousand m³/day.** The annual equivalent of that rate is approximately 7.48 million m³. [2]
6. **The cone developed near surface-water bodies.** Mining at Mayrykhsky took place approximately 600 metres south-west of Lake Turpanye. Specialists associated the eastern and north-eastern boundaries of the cone with the lake and the R-1-1 canal, while also noting that further research and observations were required to establish that relationship reliably. [2]
7. **The Koibal Steppe is an interconnected water system.** Shallow alluvial groundwater, lakes in palaeochannels, irrigation canals and deeper aquifer systems interact. Mine dewatering therefore cannot be assessed only within the mining allotment.[6][7]
8. **The system had already been altered before modern mining.** Operation of the Koibal Main Canal since 1965 and seepage from the irrigation network recharged the alluvial aquifer and affected the Sorokaozyorki lakes. Coal mining superimposed intensive water removal on an already managed water regime.[7]
9. **Hydrochemical changes have been recorded.** Official materials report exceedances of individual parameters in groundwater at Mayrykhsky and explain a mechanism common to coal mines: dewatering promotes oxidation of minerals, while subsequent rewetting transfers substances into solution.[1][2][3][4][8]
10. **Discharge transfers the impact to another part of the system.** In 2022, the regional authorities reported inputs of several substances into the Abakan River at the Mayrykhsky mine-water discharge point. Independent verification requires the primary reports and data from upstream and downstream of the outlet.[5]

11. **A resident's testimony coincides in time with the documented cone.** On 6 January 2020, farmer Denis told Natalia Zubkova that water was becoming less available from wells and public standpipes. State documents confirm the existence of the combined cone, but the published dataset does not allow the drawdown in his particular water source to be calculated.[9]
12. **The Okelkol lakes dry out seasonally.** The project records seasonal drying; no water was present in the lakes during surveys conducted between November 2018 and January 2021. This does not amount to continuous observation on every day of that period, nor does it by itself establish why the water was absent.[6]
13. **Rare and vulnerable habitats depend on water.** More than one hundred bird species, including 28 species listed in Red Data Books at different levels, have been described in the Sorokaozyorki tract. The Lakes of the Koibal Steppe regional wildlife sanctuary protects a particular part of the system, but not the entire steppe or the entire area of possible hydrogeological influence.[20][21][22]
14. **Closing a mine does not automatically end its effects.** Once pumping stops, a prolonged rise in water levels begins. As levels recover, flow directions may change, water may emerge at the surface, and oxidation products from the rock may enter solution.[8][11][12]
15. **Recovery may be possible, but can require decades and active management.** Experience in Lusatia shows that replenishing a water deficit measured in billions of cubic metres and controlling groundwater rebound and water quality become a separate long-term programme after mining.[11]
16. **The principal gap is not the absence of an object of study, but the absence of a complete open dataset.** The cone, the rise in dewatering and the hydrochemical changes are established. Data that would trace the effects to each well, lake, pasture and water-supply point have not been published or found.
17. **Responsibility for the data is distributed.** Companies generate operational and site-specific records; the state subsoil-monitoring system compiles and holds information on groundwater; water and environmental regulators oversee water use and discharges; and public-health authorities are responsible for the relevant drinking-water and public-health-monitoring data. No single authority can be required to conduct every form of observation, but fragmented responsibilities cannot be allowed to leave residents without answers.[13][14][15]

18. **The right to reliable environmental information is established by law.** Article 42 of the Constitution of the Russian Federation applies irrespective of when an impact arose. Article 4.3 of Federal Law No. 7-FZ, introduced in 2021, supports the present-day requirement that environmental information be publicly accessible; it cannot be applied retrospectively as independent evidence of a violation in 2019–2020.[16][17]

2. Research question and method

2.1. Main question

The report's main question is:

How did dewatering at the Mayrykhsky and Arshanovsky open-pit mines change groundwater levels, flow directions and chemistry in the Koibal Steppe; how is this connected with lakes, canals, rural water supply and mine-water discharge; which consequences are already established by documents; which primary data remain inaccessible; and who is responsible for collecting, retaining and providing them?

The study does not equate the existence of the cone with every individual observation made by a resident. It constructs a testable chain:

MINE WORKINGS → WATER INFLOW → MINE DEWATERING → DRAWDOWN → CHANGE IN GROUNDWATER FLOW →
TREATMENT/USE/DISCHARGE → NEW LOCATION OF IMPACT.

2.2. Body of material

The report is based on:

- state subsoil-monitoring bulletins for the Siberian Federal District for 2017–2020, 2023 and 2024;
- the environmental impact assessment materials for the Mayrykhsky drying complex and the expansion of the coal-loading facility;
- the 2017 hydrological and hydrogeological survey of Sorokaozyorki;
- the Government of Khakassia's report on monitoring water bodies in the fourth quarter of 2021 and first quarter of 2022;
- materials concerning the sanctuary and the biodiversity of the Koibal Steppe;
- Natalia Zubkova's archival video and testimony recorded on 6 January 2020;
- Russian legal provisions governing subsoil monitoring, industrial environmental monitoring, water use and access to environmental information;
- technical and scientific materials from the USGS, SEPA and LMBV, used only to explain mechanisms and possible ways of managing the consequences.

2.3. Levels of evidence

Marker	Meaning
[PRIMARY DOCUMENT]	an official bulletin, project, inspection report, laboratory report or other document that directly contains the statement
[CALCULATION]	an arithmetic conversion of published primary data; the formula is shown
[SCIENTIFIC PUBLICATION]	a peer-reviewed paper or scientific technical report explaining a mechanism or analogue
[NATALIA'S TESTIMONY]	a personal observation by the author; it does not replace a measurement
[RESIDENT'S TESTIMONY]	an eyewitness account of a specific experience that must be compared with instrumental data
[OFFICIAL POSITION]	a published statement by a state or regional authority
[LEGAL SOURCE]	a legal provision; applying it to a particular situation requires attention to time and institutional powers
[NOT FOUND IN THE PUBLIC DOMAIN]	the material may have existed but was not located in the published body of sources; this is not equivalent to "no measurement was made"
[NOT ESTABLISHED]	the available data are insufficient for the particular conclusion stated

2.4. How gaps are described

The report distinguishes three situations:

1. **The data were not found in the public domain.** This means that a search of the assembled body of material and published sources did not produce the primary series.
2. **The data were not provided following a request.** This may be stated only when the request itself, proof of delivery and the outcome are documented.
3. **The measurements were not made.** Such a conclusion is permissible only when directly supported by documentary evidence.

The report's standard formulation is:

These data were not found in the public domain. Information about environmental pollution and emissions constitutes environmental information to which access must be ensured. It is necessary to establish whether measurements were made, who holds the results and how residents can obtain them. If the necessary measurements were not made, a separate question arises: who was responsible for making them, and why were they not carried out?

3. The territory: not an “empty steppe”, but a water system

3.1. The Koibal Steppe, Sorokaozyorki and the sanctuary are not the same thing

The Koibal Steppe is a large natural and working landscape in the Minusinsk Basin. The Sorokaozyorki tract is a system of water bodies and wet depressions in an ancient channel of the Yenisei. The Lakes of the Koibal Steppe regional wildlife sanctuary is a specific protected area of 1,261 hectares established in 2020. These three concepts must not be conflated.[20][21][22]

The 2015 study describes more than one hundred bird species at Sorokaozyorki and 28 species listed in Red Data Books at different levels. Inclusion in the Ramsar Convention’s “shadow”, or prospective, list denotes conservation potential, not an international status that has already been granted.[20]

3.2. Palaeochannel lakes

The project materials describe the northern part of the steppe as a valley of ancient channels of the Yenisei and Abakan rivers. Lake Turpanye is a shallow water body no more than three metres deep. The Okelkol system comprises about ten very shallow lakes within a common valley approximately two kilometres long and 500 metres wide.[6]

The project records seasonal drying of the lakes. During surveys conducted between November 2018 and January 2021, no water was present in the lakes.[6] This record is important, but it must not be turned into a claim that specialists continuously observed every water body for all 27 months or had already established why the water was absent.

3.3. Aquifers

In this part of the steppe, the water table in the alluvial sands and gravels is generally shallow—the project reports depths of up to 3–4 metres. The high permeability of the deposits facilitates water exchange between different areas. Recharge comes from precipitation, floodwater and seepage from irrigation canals. Groundwater in the Lower Carboniferous deposits is hydraulically connected with the shallow groundwater.[6]

At the natural regional scale, groundwater flows towards the Abakan River. Mine dewatering creates a local, artificial low in the water table and alters that flow.[2]

3.4. Irrigation as an earlier factor

The Koibal Main Canal began operating in 1965. According to the 2017 survey, water delivery and seepage from the canals recharged the alluvial aquifer, raised groundwater levels and affected the Sorokaozyorki lakes.[7]

For monitoring well No. 295 near Lake Ptichye, the report gives an average depth to water of 1.86 metres for 1969–1995 and 2.02 metres for 1995–2011. For well No. 101 west of Lake Sobachye, the corresponding figures are 3.13 and 2.15 metres.[7]

These series do not describe the effects of the open-pit mines. They show that, even before intensive coal mining, the water regime depended on managed water delivery. A contemporary analysis must therefore account simultaneously for climate, canals, abstractions and mine dewatering.

4. How a cone of depression forms

4.1. An open pit as an artificial drain

When an open pit intersects water-bearing deposits, water enters the workings. It is pumped out to keep the working levels dry. The water level in the pit is held below that in the surrounding aquifer, creating a new hydraulic gradient towards the workings.

A cone of depression is a depression in the water table or potentiometric surface caused by pumping. It is not a void and does not necessarily appear as subsidence at the surface.

4.2. What determines its size

- the depth and area of the open pit;
- the rate and duration of pumping;
- the transmissivity and storage properties of the deposits;
- fractures and faults;
- the presence of confining layers;
- hydraulic connections between aquifers;
- recharge from canals, lakes, rivers and precipitation;
- neighbouring dewatering operations.

4.3. Why water may not leave a well immediately

The response propagates over time. First the level falls close to the mine, then the zone of influence expands. A shallow well loses water when the falling level reaches the particular aquifer and screened interval from which it received inflow. Temporal coincidence is therefore important, but calculating the effect requires construction details for the water source and a monitoring series.

4.4. Interception of natural discharge

Initially, part of the pumping is supplied by a reduction in groundwater storage. The mine may then intercept water that previously discharged into a lake, canal, stream, wet depression or root zone.

Where the hydraulic connection is strong, the direction of exchange may reverse: a surface-water body begins to recharge an aquifer in which flow is directed towards the mine.[10]

4.5. How the cone is measured

The following are required:

- a network of monitoring wells;
- surveyed elevations of the wellheads;
- well depths and screened intervals;
- simultaneous water-level measurements;
- dewatering rates;
- water levels in lakes, canals and rivers;
- potentiometric-surface or water-table maps for specific dates;
- a water balance and a calibrated model.

A single dewatering figure does not define the shape of the cone. A single map does not show how quickly it is changing. One dry well does not reveal the entire mechanism. A multi-year monitoring network, however, makes it possible to test the chain instrumentally.

5. A historical parallel: Prokopyevsk

The loss of local water supply as coal mining developed has a long precedent in Kuzbass.

A local-history retelling of Mikhail Nikitin and Georgy Vyatkin's 1935 book *The Pearl of Kuzbass* reports that, as deep mines developed from 1928, groundwater levels fell and water levels in the wells declined. Urgent construction of a water pipeline from the Tom River began in the summer of 1930. The system entered service in 1933. In late autumn, 17,000 workers backfilled about 36 kilometres of trenches in a single day to save the pipes from freezing.[23][24]

The entire pipeline was not built in one day—the trenches were backfilled. A scan of the book was not used for this edition, so the details are attributed to the modern retelling, while the year of entry into service is corroborated by a library chronology.

This is a historical parallel, not a calculation for Khakassia. It shows how difficult and costly replacing a water supply can become after mining has altered groundwater systems.

6. Chronology of dewatering and the cone

Year	Documented event	Significance
1965	the Koibal Main Canal begins operating	seepage from the irrigation network becomes an important component of recharge to shallow groundwater

Year	Documented event	Significance
1969–2011	monitoring series near Lakes Ptichye and Sobachye	confirm long-term variability in the system before intensive mine dewatering
2015–2016	a state report dates the start of mining at the two neighbouring large open pits to these years	a new major factor enters the water balance
2017	Mayrykhsky: 7.340 thousand m ³ /day; exceedances of several hydrochemical parameters recorded	the first detailed baseline point available in the assembled material
2018	Mayrykhsky: 12.364 thousand m ³ /day; the cones of the two mines have merged	the effect has become cumulative; the contributions of the mines are not separated
2019	Mayrykhsky: 13.656 thousand m ³ /day; intensive drawdown	the working face approaches monitoring wells and the pit deepens
2020	Mayrykhsky: 14.344 thousand m ³ /day; the combined cone persists	Mayrykhsky's dewatering rate is almost twice the 2017 figure; pumping at Arshanovsky fell in 2020
2021–2022	monitoring at the mine-water discharge point in the Abakan River	inputs of phenols, sulphates, arsenic and fluoride are reported
2023	local-monitoring reports submitted for several coal mines	the state bulletin describes a general mechanism of long-term hydrochemical change
2024	beryllium recorded at the “Beysky-Zapadny open-pit mine industrial site (Arshanovsky-2 area)”	three values—5.5, 4.5 and 4 MPC—in different water-bearing subdivisions; the record is not extrapolated to other sites

7. How much water was pumped

7.1. Mayrykhsky

Year	Average dewatering, thousand m ³ /day	Calendar days	Estimated annual equivalent, million m ³	Change from 2017
2017	7.340	365	2.679	—
2018	12.364	365	4.513	+68.4%
2019	13.656	365	4.984	+86.0%
2020	14.344	366	5.250	+95.4%

The annual equivalents were calculated from the average daily dewatering rate and the number of calendar days. They are calculations, not separate annual measurements.

For 2020:

$14.344 \text{ thousand m}^3/\text{day} \times 366 \text{ days} = 5,249.904 \text{ thousand m}^3 \approx 5.250 \text{ million m}^3$.

7.2. Known combined dewatering of the two mines in 2018

The state bulletin gives a combined figure of 20.481 thousand m³/day. The annual equivalent is:

$20.481 \text{ thousand m}^3/\text{day} \times 365 \text{ days} = 7,475.565 \text{ thousand m}^3 \approx 7.476 \text{ million m}^3$.

This figure represents the volume of water pumped from the workings through the dewatering system. Within the aggregate figure, the source used does not distinguish groundwater inflow from precipitation and surface runoff entering the workings. Nor is it automatically equivalent to an irretrievable loss of the entire volume from the basin: determining that would require information about use, evaporation, discharge location and reinfiltration.

7.3. Why an annual average is insufficient

An annual daily average obscures:

- seasonal peaks in inflow;
- pump shutdowns;
- changes in mine depth;
- redistribution between mining areas;
- extremely dry and wet periods;
- time lags in the response of monitoring wells;
- changes in canal operation.

Testing the connection with a particular well requires at least monthly—and preferably daily—series of groundwater levels and dewatering rates.

8. The combined cone of depression

8.1. Dimensions and direction

The 2018 bulletin recorded:

- the merger of the local Arshanovsky and Mayrykhsky cones;
- the inability to distinguish the effects of the two dewatering operations;
- an extent of approximately 8 km from west to east;
- an extent of 4.0–4.2 km from south to north;
- the regional direction of groundwater flow towards the Abakan River.[2]

These linear dimensions cannot simply be multiplied and presented as an exact area: the cone is not rectangular, and its boundary is defined by the monitoring-well network and the selected contour.

8.2. Lake Turpanye and the R-1-1 canal

In 2018, mining at Mayrykhsky took place approximately 600 metres south-west of Lake Turpanye. Specialists associated the eastern and north-eastern boundaries of the cone with Lake Turpanye and the R-1-1 canal, while noting that further research and observations were required to establish the relationship reliably.[2]

This means two things at once:

1. the lake and canal were identified by the specialists themselves as elements of a possible hydraulic boundary;

2. the published material did not complete the demonstration of the direction and magnitude of exchange.

That uncertainty should have led to more observations, not to the question disappearing.

8.3. 2019–2020

The 2019 report again described the combined cone and the most intensive effects in the eastern part of Arshanovsky and western part of Mayrykhsky. At Mayrykhsky, water levels were falling more rapidly as the working face approached the monitoring wells and the mine deepened.[3]

In 2020, the combined cone persisted and dewatering at Mayrykhsky continued to rise. Pumping at Arshanovsky fell that year. The increase at Mayrykhsky therefore cannot be described as an identical simultaneous increase at both companies.[4]

8.4. What the merger changes legally and scientifically

Once the cones had merged, assessing each site in isolation was no longer sufficient to understand the territory. A new mine or the expansion of an existing one does not operate against an “unaffected baseline”, but within an already altered groundwater-level field. This requires a cumulative model and a coordinated monitoring network. Such a basin-scale approach is also used in international studies of the cumulative hydrological effects of mining; the USGS example from the Mesabi iron-mining district is presented as a methodological analogue, not as a calculation for Khakassia.[19]

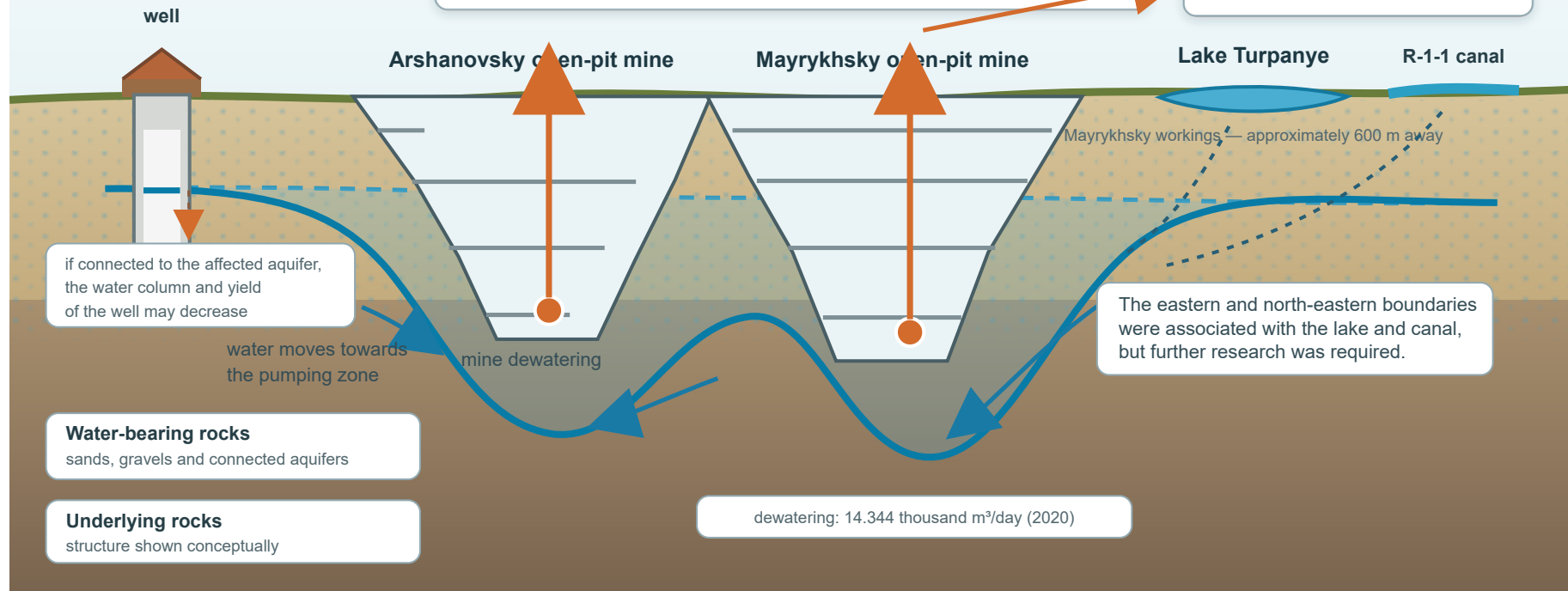
Conceptual schematic of the combined cone of depression

Koibal Steppe · conceptual cross-section · not to scale

By 2018, the cones created by two open-pit mines had merged

Plan dimensions of the drawdown area: approximately $8 \times 4\text{--}4.2$ km

After pumping to the surface
treatment / use / discharge



How to read the schematic

--- conceptual baseline groundwater level

— lowered level during dewatering

Basis: state subsoil-monitoring bulletins for 2018–2020 and project materials.

The curve's shape and depth are conceptual; this schematic does not replace groundwater-contour maps or observation-borehole data.

groundwater drawdown area
connection requiring further research

mine dewatering

NATIZDAT · 2026

Explanatory schematic. It is not a measured map of the cone's boundaries or a calculated hydrogeological cross-section.

9. Water balance: water does not disappear, but changes its route

9.1. Main flows

The system considered here is an interconnected one comprising the aquifers within the mines' zone of influence, lakes and canals, the mine workings, dewatering, water use at the industrial site and discharges to surface-water bodies. The published data do not provide a complete calculated water balance for the Koibal Steppe.

Preparing such a balance requires separate accounting of:

- **inflows:** precipitation, lateral groundwater inflow, seepage from rivers, lakes and canals, and other forms of surface-water–groundwater exchange;
- **outflows:** evaporation, plant uptake, natural discharge, water abstraction and mine dewatering;
- **changes in storage:** depletion or replenishment of water in aquifer materials and surface-water bodies over the selected period.

The listed flows concern different parts of the connected system. When separate balances are prepared, the boundaries of each control volume must be defined: pumping, for example, is an outflow from an aquifer and an inflow to the company's dewatering system. In the overall balance, internal transfers are not counted as losses from the system.

The same flows must not be counted twice. Seepage from a canal, for example, is a specific component of surface-water–groundwater exchange, while groundwater discharge is one route by which water leaves the aquifer volume under consideration. Mine dewatering may intercept part of the natural discharge. Water pumped from the workings is then used, treated, stored or discharged. Each pathway has its own location of impact.

9.2. Why “the water was returned to the river” does not close the question

Even if the entire recorded volume of water pumped from the workings were discharged into the Abakan River, that would not automatically restore the former level in a particular aquifer or lake. Such a transfer may change:

- the point at which the water emerges;
- the timing of its movement;
- its chemical composition after contact with rocks and industrial facilities;
- its distribution between the groundwater and surface-water systems;
- its availability to wells, plants and small water bodies.

9.3. Which parts of the balance have not been published in full

No single long-term series was found in the public body of material that simultaneously showed, for each mine:

- inflow into the workings;
- actual monthly pumping;
- use in production and dust suppression;
- flows to treatment facilities;
- storage volumes;
- evaporation;
- the volume and quality of every discharge;
- infiltration after discharge.

These data should be generated primarily by the subsoil user and water user; inspection and control documents may be held by the authorities responsible for subsoil use and for water and environmental regulation.

10. Groundwater chemistry

10.1. 2017: the most detailed early record for Mayrykhsky

Water-bearing subdivision	Parameter	Concentration, as multiples of the MPC reported in the bulletin
Quaternary and Permian deposits	iron	8–48 MPC
same	sodium	1.3–3.2 MPC
same	petroleum products	4.7–5.1 MPC
same	fluoride	1.1–1.7 MPC
same	total dissolved solids	1.2–1.8 MPC
individual monitoring well	nickel	1.6 MPC
individual monitoring well	permanganate index	2.6 MPC
Carboniferous deposits	magnesium	4.9 MPC
same	sodium	1.1–1.2 MPC
same	fluoride	1.5 MPC
same	ammonium	3.5–5 MPC
same	permanganate index	1.2–1.8 MPC
same	total dissolved solids	1.5–1.8 MPC

Source: the state bulletin for 2017, PDF p. 68.[1]

The values are reproduced as multiples of the MPC stated in the bulletin; the regulatory basis for comparison is not specified in the excerpt used.

This table describes groundwater at the monitored site. It is not an analysis of water from a resident's tap, and the summary bulletin does not contain complete construction details for every well. Spatial interpretation requires coordinates, screened depths, background data and the primary laboratory reports.

10.2. 2018: arsenic

Local monitoring at Mayrykhsky reported arsenic at 1.5 MPC.[2] The bulletin associates hydrochemical changes at coal mines both with industrial facilities and with the movement of water from deeper deposits induced by dewatering; concentrations decreased with distance from the mines.

The entry confirms an exceedance in the monitored groundwater. Identifying the source of the arsenic and its pathway to a particular water abstraction requires the primary laboratory report, the well identity, background data and a flow model.

10.3. 2019–2020

Mayrykhsky was included among the sites subject to local monitoring in 2019, but arsenic was identified separately for other mines. In 2020, the general ranges of parameters related to the combined group of coal sites. They cannot be attributed to Mayrykhsky without the site-specific tables.[3][4]

This does not mean that water chemistry at Mayrykhsky was not monitored. It means that the published summary bulletin does not disclose the complete site-specific series.

10.4. 2023: a mechanism of long-term contamination

The 2023 bulletin includes graphs for Mayrykhsky covering 2015–2023 for sodium, nitrite, total hardness and total dissolved solids. Precise values cannot be read from a graph as an equivalent substitute for the underlying table.[8]

The bulletin's general text explains the mechanism: dewatering coal-bearing rocks promotes oxidation of the minerals they contain and converts elements into mobile, water-soluble forms. When the rocks are rewetted, the oxidation products enter solution. Alteration of the hydrodynamic regime can sustain contamination over a long period.[8]

10.5. 2024: “Beysky-Zapadny (Arshanovsky-2 area)”

Table 1.15 of the 2024 bulletin gives three beryllium values for different water-bearing subdivisions at the site named “Beysky-Zapadny open-pit mine industrial site (Arshanovsky-2 area)”:[18]

Water-bearing subdivision code in the source	Substance	Maximum contamination intensity, in MPC units
aQ	beryllium (Be)	5.5
C	beryllium (Be)	4.5
C ₁₋₂	beryllium (Be)	4

Exact location in the source: Table 1.15, PDF p. 104. The codes are reproduced verbatim from the table; the stratigraphic notation is not expanded in that entry.

These values relate to the specified site. They cannot be extrapolated to Mayrykhsky, the entire Koibal Steppe or drinking water without demonstrating a spatial and hydrogeological connection.

11. Discharge of mine water into the Abakan River

11.1. The 2022 report

The Government of Khakassia published the results of water-body monitoring for the fourth quarter of 2021 and first quarter of 2022. In the Abakan River near the Mayrykhsky mine-water discharge, it reported MPC exceedances and an apparent input at the discharge point of:

- phenols;
- sulphates;
- arsenic;
- fluoride.[5]

Petroleum products, nitrate and nickel were reported above background, but below their MPCs. [5]

11.2. What was established

What is established is an officially published assessment of the river near the outlet and an apparent input of several substances. The publication does not replace the primary laboratory reports. Verification requires:

- sampling dates and times;
- coordinates of the cross-sections upstream and downstream of the outlet;
- river and discharge flow rates;
- concentrations and measurement uncertainty;
- the laboratory and methods used;
- the operating condition of the treatment facilities;
- the reproducibility of the results.

The primary reports underlying this publication were not found in the public domain. Depending on the organisation of the work and the contract, they may be held by the authority that commissioned the monitoring, the laboratory and the water user.

11.3. Two sides of one system

The cone creates a deficit or drawdown in the capture zone, while the discharge creates a new artificial flow in the river. An assessment must therefore combine quantity and quality:

GROUNDWATER → OPEN PIT → TREATMENT → OUTFALL → ABAKAN RIVER .

12. Lakes, canals and wet depressions

12.1. Turpanye

The proximity of mining and the reference to the lake as a possible hydraulic boundary make Turpanye a key monitoring point. Synchronous measurements are needed of the lake level and groundwater levels in wells between the lake and the mine, together with dewatering rates, chemistry and, where necessary, isotopic data.

12.2. Okelkol

Seasonal drying is recorded in the project. Distinguishing natural seasonality from a change in groundwater support requires dates on which water appeared and disappeared, precipitation data, records of canal operation and water levels in nearby monitoring wells.

12.3. Sorokaozyorki and the irrigation network

Sorokaozyorki depends on a complex combination of the natural relief of an ancient channel and managed irrigation. Reduced canal delivery and mine dewatering may act at the same time. It is methodologically wrong to explain a change in a lake by a single factor without a water balance, but it is equally wrong to exclude the mining factor when a multi-kilometre cone is documented.

12.4. The sanctuary

The sanctuary boundary provides legal protection to a defined territory, but does not create an underground hydrogeological wall. Water moves according to the structure of the deposits and the hydraulic gradient, not the boundary of a protected area. An assessment must therefore include sources of impact outside the sanctuary.

13. Residents' testimony and Natalia's archive

13.1. Farmer Denis's testimony

On 6 January 2020, Denis told the filming team that water was becoming less available from wells and public standpipes.[9] This is specific testimony about the availability of water to a farm.

It does not replace a groundwater-level record, but nor should it disappear from the report because such a record is absent. Proper verification requires comparison of:

- the address and coordinates of the water source;
- the type and depth of the structure;
- the former and new water levels;
- the date of the change;
- any repair or deepening;
- levels in the nearest monitoring wells;
- the dewatering regime during the same period.

13.2. What the documents confirm

By the time of the testimony, the combined cone had already been recorded by state monitoring. For 2020 as a whole, Mayrykhsky's average dewatering rate was the highest in the 2017–2020 series presented here.

13.3. Which document is missing

No publicly available series was found showing the water level in Denis's particular source before and after the cone developed. This is not a basis for declaring his account incorrect. It is a reason to establish who was responsible for the rural water supply, who recorded the complaint and whether an investigation was carried out.

14. Consequences for the steppe

14.1. Wells and boreholes

If a water source is connected to an affected aquifer, drawdown reduces the water column and yield. The water may not disappear geologically, but may become inaccessible to the existing structure. The farm may then have to deepen the borehole, replace the pump or rely on delivered water.

14.2. Pastures

Wet depressions, meadow areas, canal banks and places with shallow groundwater are the most sensitive. A fall in the water table below the root zone can reduce capillary supply, accelerate drying of the grass cover and diminish fodder resources.

A quantitative assessment requires permanent vegetation plots, satellite time series, precipitation data, grazing intensity and control areas. No linked series of “water level—vegetation—pasture productivity” was found in the public domain.

14.3. Wetland habitats

A reduction in the area of shallow water and the duration of inundation changes feeding and breeding habitats for birds, invertebrates and riparian vegetation. This is particularly significant at Sorokaozyorki because many species are concentrated within relatively small wet areas.[20][21][22]

14.4. Dust and deflation

If vegetation becomes sparse, more soil is exposed to the wind. This creates a secondary pathway of impact: hydrological drying may increase surface dust emissions. The mechanism is well founded, but its magnitude here has not been measured in a dedicated study.

14.5. Salts and water chemistry

The consequences may operate in different directions. Lowering shallow saline groundwater can sometimes reduce the capillary rise of salts, whereas drawing mineralised water from another aquifer can impair groundwater quality. Discharge transfers salts to a surface-water body. The formula “drawdown always causes salinisation” is therefore incorrect; analyses are required for the specific pathways.

14.6. Land subsidence

Lowering the water table can compact compressible, water-saturated deposits. The assembled body of material contains no levelling, satellite or geotechnical data confirming subsidence of the Koibal Steppe as a result of the cone studied here. This risk should be investigated separately, not declared to have already occurred.

15. What happens when the pumps stop

15.1. Rising water levels

When dewatering ends, water begins to fill the drained pores, fractures and mine void. The rise slows as the gradient decreases. In an arid system with limited natural recharge, the process may take years or decades.

15.2. Changing quality

Dewatering exposes minerals to oxygen. When water returns, oxidation products enter solution. Recovery of water levels and recovery of water quality are therefore separate tasks.[8]

15.3. New discharge locations

Rising water may emerge in depressions, old workings, canals or watercourses. The locations, flow rates and composition of such discharges must be predicted.

15.4. What international practice requires

Section H2.4 of SEPA's 2009 policy provides that open-cast coal developments should assess subsequent groundwater rebound, predicted water quality, the location at which groundwater may discharge into surface waters, and the effectiveness of protective measures.[12]

16. Can the steppe be restored?

16.1. What restoration means

Backfilling a slope and sowing grass are not enough. For a water system, restoration includes:

- safe management of rising water levels;
- monitoring the quality of mine water and groundwater;
- preventing contaminated discharges;
- restoring the connection between lakes and wet depressions and their water supply;
- monitoring rural water sources;
- restoring soils and vegetation;
- securing long-term funding after mining ends.

16.2. Lusatia

According to an LMBV statement dated 22 September 2025, approximately 6.4 billion of the roughly 7 billion m³ water deficit created by mining in Lusatia had been replenished.[11]

This is not a model that can be transferred directly to Khakassia: the climate, geology, scale and management differ. It does show, however, that the water deficit left by open-pit mining is treated as a separate, long-term engineering task; it does not disappear with the last excavator.

16.3. A minimum programme for the Koibal Steppe

1. A single digital model covering all neighbouring mines.
2. Public monthly groundwater levels for all monitoring wells.
3. A water balance for the lakes and canals.

4. An inventory of rural water sources.
5. Water-quality monitoring before, during and after groundwater rebound.
6. A plan for funding monitoring after closure.
7. Trigger levels at which the company must provide an alternative water source or protective measures.

17. Who is required to know and provide the data

17.1. The subsoil user

Within its allocated site, the subsoil user organises monitoring of the state of the subsoil in accordance with Article 36.2 of the Law *On Subsoil*.^[13] The company also conducts industrial environmental monitoring under Article 67 of Federal Law No. 7-FZ.^[14]

Its primary records should contain information relating to:

- operation of the dewatering system;
- monitoring wells;
- the condition of the subsoil within the site;
- water treatment and discharge;
- industrial monitoring.

This does not automatically create a duty to publish every internal log on the internet. But a company cannot use the non-public nature of its logs as evidence that no impact occurred.

17.2. State subsoil monitoring

The authorities and organisations within the state subsoil-monitoring system receive, compile and publish information on groundwater conditions. The summary bulletins have already confirmed the cone. Independent verification requires the site-specific appendices and digital data on which the summary conclusions are based.

17.3. Water and environmental regulation

Water-use conditions, protection of water bodies, discharges and compliance with requirements fall within the powers of the relevant water and environmental authorities. Their remit does not replace the subsoil user's site monitoring, but inspection materials can show which data were supplied and how a discharge was assessed.^[15]

17.4. Public-health authorities and local government

Rospotrebnadzor and participants in public-health monitoring hold data, within their respective powers, on drinking-water quality and environmental factors. Local authorities and water-supply organisations should know the condition of specific rural water sources, supply arrangements and service failures. Medical information is published in anonymised form.

17.5. A map of data holders is needed

Dataset	Likely primary holder	Who needs it
pump operation and dewatering	company	state subsoil monitoring, regulators, residents in aggregated form
levels in site monitoring wells	company / local-monitoring contractor	state subsoil monitoring, subsoil authorities
combined cone	state subsoil-monitoring system	public, municipalities, experts
discharge permits and compliance data	water user and competent authorities	regulators, residents
primary laboratory reports	commissioning body and laboratory; copies held by the authority where part of state monitoring	public, subject to the applicable legal regime
rural boreholes and public standpipes	water-supply organisation / municipality	residents, public-health authorities
drinking water	water-supply organisation / Rospotrebnadzor within its powers	residents
anonymised health statistics	health authorities	researchers and the public

18. The right to information

Article 42 of the Constitution of the Russian Federation guarantees everyone the right to reliable information about the state of the environment.[16]

Article 4.3 of Federal Law No. 7-FZ defines environmental information as publicly accessible and provides for its disclosure and publication by authorities that hold the relevant information.[17]

Article 4.3 was introduced in 2021. It is therefore not used here as evidence of a separate violation in 2019–2020. It establishes the present-day requirement that environmental information already accumulated be made accessible.

Refusing to exaggerate does not mean abandoning accountability. If data are not available on a website, it is necessary to establish:

1. whether measurements were made;
2. who commissioned them;
3. who holds the primary results;
4. on what basis and in what form residents can obtain them;

5. if no measurements were made, whose monitoring programme should have provided for them.

19. What is established, what must be disclosed, and what is not established

19.1. Established

- the existence of the combined cone;
- its approximate extent;
- the inability, on the basis of the 2018 data, to separate the effects of the two dewatering operations;
- the rapid rise in Mayrykhsky's dewatering rate between 2017 and 2020;
- the proximity of mining to Lake Turpanye;
- hydrochemical exceedances at monitored sites;
- the discharge of mine water into the Abakan River and the official report of inputs of several substances;
- the dependence of Sorokaozyorki on the irrigation network;
- the presence of valuable wetland habitats.

19.2. Data that must be disclosed

- levels in every monitoring well;
- well records and coordinates;
- monthly dewatering volumes;
- the complete balance of use and discharge;
- lake levels and canal operation;
- primary water-analysis reports;
- rural water-supply data;
- a cumulative-impact model;
- the closure and groundwater-rebound plan.

19.3. Not established by the published data

- the precise contribution of each of the two mines to the combined cone;
- the magnitude of drawdown in Denis's particular well;
- the share of recharge lost by a particular lake;
- the area of pasture whose productivity changed specifically because of the cone;
- whether land subsidence has occurred;

- a causal link between the cone and a particular disease in a person or animal;
- the time required for full recovery of groundwater levels after closure.

These limitations do not turn the established cone into a hypothesis. They define the boundaries of the dataset that has been published.

20. Programme for independent verification

20.1. Groundwater-level network

- obtain digital series for all monitoring wells;
- verify surveyed elevations and screened intervals;
- identify gaps and changes in methods;
- prepare maps for the same season in each year.

20.2. Wells and rural boreholes

- compile a register of water sources in Arshanovo and Shalginov;
- record their construction and repair history;
- measure water levels monthly using one method;
- record yield and water quality separately.

20.3. Lakes and canals

- install water-level gauges;
- obtain canal-delivery data;
- measure evaporation and precipitation;
- distinguish seasonal drying from the long-term trend.

20.4. Chemistry and tracing

- use a common suite of parameters upstream and downstream of discharges;
- conduct repeat sampling by an independent laboratory;
- measure field parameters on site;
- where necessary, use isotopic and hydrochemical tracers to identify water sources.

20.5. Open database

The data should be published in machine-readable form together with method documentation, coordinates, units, detection limits and information about missing observations. A scan of a table without the underlying values limits verification.

21. Conclusion

An officially documented, multi-kilometre area of lowered groundwater levels has formed beneath the Koibal Steppe. It arose from the combined influence of at least two open-pit coal mines. By 2018, their local cones had merged and specialists could no longer distinguish the companies' contributions. Dewatering at Mayrykhsy continued to rise and by 2020 was almost twice its 2017 level.

This is not an abstract technical detail. In the steppe, groundwater is connected with wells, canals, palaeochannel lakes, wet meadows and pastures. Water pumped from the workings may have been used at the industrial site, sent for treatment, stored, discharged to a surface-water body or partly reinfiltrated. The effects therefore cannot be assessed only at the mine edge. The established changes in composition relate to specific groundwater-monitoring data and to the report concerning the Abakan River near the outlet—not automatically to the entire dewatering volume.

Official documents recorded not only falling water levels but also hydrochemical changes. At the mine-water discharge point in the Abakan River, regional monitoring reported inputs of phenols, sulphates, arsenic and fluoride. These facts require open primary laboratory reports, a water balance and long-term observation—not reassuring generalities.

No publicly available series was found that connects mine dewatering with every rural well and every lake. That gap cannot be turned into evidence of safety. Companies, the state subsoil-monitoring system, and water, environmental and public-health authorities hold different parts of the information required. Their responsibility is not to pass the question from one institution to another, but to show which measurements were made, where the results are held and what will be done where observations were insufficient.

From the author

In January 2020, I came to film what could be seen: black plumes above the white steppe.

But the greatest change was invisible.

Underground, water was already moving along new paths. Two mine cones had merged. Every year, pumps raised millions of cubic metres of water from the workings. Residents said that water was becoming less available from wells and public standpipes, while official documents recorded rising dewatering rates and changes in groundwater.

Khakassia is my homeland. To me, the Koibal Steppe is not vacant land between coal licences. People live here, graze animals, make hay and use wells, canals and lakes. Water connects all of this into one system.

If a company changes that system, residents have a right to know more than how much coal was extracted. They have a right to know how much water was pumped, where it went, what entered the river, what happened to their water sources and who will restore the water regime after mining ends.

The cone cannot be seen from the road. But it must not be hidden in technical tables.

22. Appendices and navigation through the evidence

Appendix A. Mayrykhsky dewatering table, 2017–2020

The calculation table and formulae are provided in [Section 7.1](#). The combined annual equivalent for the two mines in 2018 is given in [Section 7.2](#). The figures are not duplicated here, avoiding discrepancies between the main table and the appendix.

Appendix B. Chronology of hydrogeological events

The chronological table for 1965–2024 is in [Section 6](#). Pages in the primary documents are specified in entries [1]–[8] of the source list.

Appendix C. Register of hydrochemical parameters

The register, divided by year, site and water-bearing subdivision, is presented in [Section 10](#). The 2017 table concerns Mayrykhsky; the 2024 entry concerns only the “Beysky-Zapadny open-pit mine industrial site (Arshanovsky-2 area)”.

Appendix D. Schematic of the combined cone

The full-size explanatory schematic is provided in [Section 8.1](#). It is not a measured map of the cone’s boundaries or a calculated hydrogeological cross-section.

Appendix E. Map of responsibility for data

The matrix of datasets, their likely primary holders and users is in [Section 17.5](#).

Appendix F. Primary data to be disclosed

1. Coordinates, surveyed elevations, depths and screened intervals of every monitoring well.
2. Monthly groundwater levels from the beginning of observation.
3. Annual potentiometric-surface or water-table maps.
4. Daily and monthly dewatering volumes.
5. A complete water balance.
6. Permits and conditions governing discharges.
7. Primary laboratory reports.
8. Levels in Lakes Turpanye, Mayrykhkol and Okelkol, and records of canal operation.
9. Records for rural water sources in Arshanovo and Shalginov.
10. Drinking-water monitoring for each source.
11. A cumulative-impact model.
12. A plan for flooding the workings and post-project monitoring.

Appendix G. Biodiversity material

The separate report *Conservation of Biodiversity in the Koibal Steppe* is available to view and download in its [English edition](#) and [Russian original](#).^[25]

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Artificial-intelligence models were used to search a large body of documents, recognise text, build registers and conduct initial analytical processing. Substantive claims were checked against the preserved sources. Natalia Zubkova is responsible for the published text.

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