Water Management Sustainable Implementation at a Remote Water-Scarce Mine Site of Mongolia

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Abstract

Oyu Tolgoi mine, located in the remote and water-scarce Gobi Desert region of Mongolia, began operations in 2013 to produce copper concentrate. Prior to mining, extensive water exploration identified the Gunii Khooloi aquifer as the primary water source to sustain the large-scale operation. Also to support mining activities, critical water infrastructure was established, including a Water Treatment & Bottling Plant, Wastewater Treatment Plants, and Tailings Storage Facilities. To address complex water issues in-situ operation and also acquire the license to operate, an integrated Water Management system was successfully implemented.

The purpose of this study is to describe the water management practices at Oyu Tolgoi mine, focusing on the development and implementation of the Water Resources Management Plan (WRMP) ensuring sustainable water use, compliance with standards, and environmental protection in a water-scarce gobi region by managing water abstraction, quality, and monitoring across the site.

The WRMP was introduced and adjusted in relation to operations defining scope, roles, standards, procedures, monitoring, training, and references for effective water management. Mongolian and international water quality standards were compared, and the most stringent values were adopted as project standards. Water monitoring were implemented at multiple water points around the mine to assess environmental impacts and support compliance reporting. Over a decade of water quality and level data were collected from monitoring bores, springs, and herder wells, forming the basis for regulatory reports shared with Mongolian authorities and local communities. Additionally, institutional domestic water standards were introduced to close gaps between local and international requirements, enabling safe domestic water consumption at the mine site.

The successful implementation of an integrated water management system and supporting documentation has enabled Oyu Tolgoi to maintain compliance, adapt to legislative changes, and ensure sustainable water use in one of the most challenging environments globally. Continuous monitoring and timely updates to management plans have supported uninterrupted copper production while minimizing environmental impacts and fostering trust with regulators and local stakeholders.

Keywords: Oyu Tolgoi mine, water resources management plan, water monitoring

Introduction

Oyu tolgoi is a copper-gold mine situated in Khanbogd soum of the Southgobi province in Mongolia. The international Rio Tinto Group started the mining operation in 2013 of Open-pit method. After years of construction, the underground mining infrastructure started in 2023. The Oyu Tolgoi mine is currently operating in full capacity by Open pit and Underground mines and is one of the biggest copper mines in the world.

The Oyu Tolgoi mine abstracts water for its operation, from the Gunii Khooloi aquifer, located southeast of the mine license area, through 28 borewells drilled to depths of 150–400 meters. The water is temporarily stored in lagoons, from which it is supplied to the concentrator for the flotation process through process water ponds. The water recycled from the flotation process passes through the thickener, and the remaining tailings water is also recycled through the Tailings Storage Facilities.

In 2025, a total of 123,219,539 cubic meters of process water was used in the Concentrator, 86.73% water was recovered and reused from the Thickener and the Tailings Storage Facilities. 17 million cubic meter of water was abstracted from Gunii Khooloi as replenishment.

In the Gunii Khooloi abstraction area, local herders practice a traditional pastoral lifestyle, watering livestock from hand-dug wells. Because the region has very limited surface potable water—aside from a few springs and occasional short-lived flash-flood pools—these hand-dug wells serve as the primary source of drinking water for herders.

The fundamental purpose of the WRMP is to provide scientifically supported answers based on regular monitoring data to current and potential questions related to operational impacts and possible negative effects on the surrounding environment. One key issue raised by local communities, was declining changes in the shallow groundwater regime in connection to water abstraction from the deep aquifer, which is critical for their livelihoods. This paper aims to examine the potential connection between deep and shallow groundwater systems by using long-term monitoring data combined with statistical analysis with water abstraction volume and precipitation.

Methods

Prior to the start of the mining operation the Water Monitoring Procedure was introduced and implemented to study the general patterns of the natural groundwater regime, the key factors that influence it, and any actual or potential influence from mine water use and mining operations, including technogenic influences. As part of the monitoring activities, water-level fluctuations, water quality, and changes in chemical composition are monitored at observation boreholes, herder hand-dug wells, and springs located in the around Oyu Tolgoi and including Gunii Khooloi area. The collected data are compiled into a database and analyzed to support optimal groundwater resource management, to determine the extent of mining impacts on groundwater quantity, quality, and natural dynamics, and to plan mitigation measures

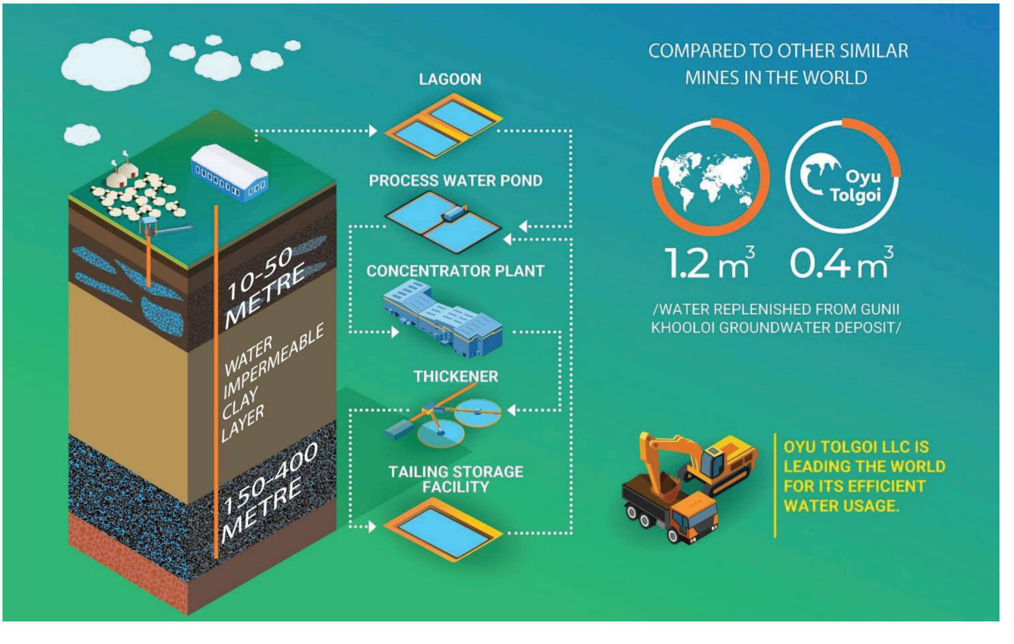

Figure 1 *Closed loop water management scheme in Oyu Tolgoi mining.*

for potential negative impacts.

The monitoring program for Oyu Tolgoi Mine includes a total 406 water points comprises of 348 boreholes, 47 hand-dug wells, and 11 springs. At these water monitoring points the water level measurements are conducted, in-situ water-quality parameters are recorded, and water samples are collected for comprehensive laboratory analysis accordance to monitoring program schedule. In the Gunii Khooloi area there are 13 herder wells are included in the active water-monitoring program. These wells are typically located within shallow, dry riverbeds and generally range from 2 to 7 meters in depth (Figure 2).

Results and discussion

The groundwater water levels of herder hand-dug wells fluctuate seasonally as a direct result of precipitation. When precipitation is high, the water level in the loose sediments of the dry riverbeds rises, and during drought periods, the water level decreases. In summer, sudden rainstorms and prolonged rainfall often cause flash floods that create temporary surface runoff, which strongly influences the water level and water quality composition of the shallow aquifer.

Figure 3 shows the long-term groundwater level measurements, expressed in meters below ground level (mbgl), for 13 herder wells situated in the Gunii Khooloi recharge zone, presented in relation to daily precipitation. The herders' wells located in the distant recharge-zone riverbeds are shown in Figure 3a, while the middle-distance and close-distance zones are illustrated in Figures 3b and 3c, respectively.

Oyu Tolgoi area total precipitation in 2025 was 97.5 mm, which is slightly below the long-term average of 102.8 mm. In 2018 following the heavy rainfall totalling 218 mm, particularly the flood event on August 3, 2018 – the water levels of hand-dug wells along dry riverbeds around the Oyu Tolgoi area inclując Gunii Khooloi abstraction area reached the highest levels recorded since the start of monitoring. During 2022–2023, precipitation was significantly below the

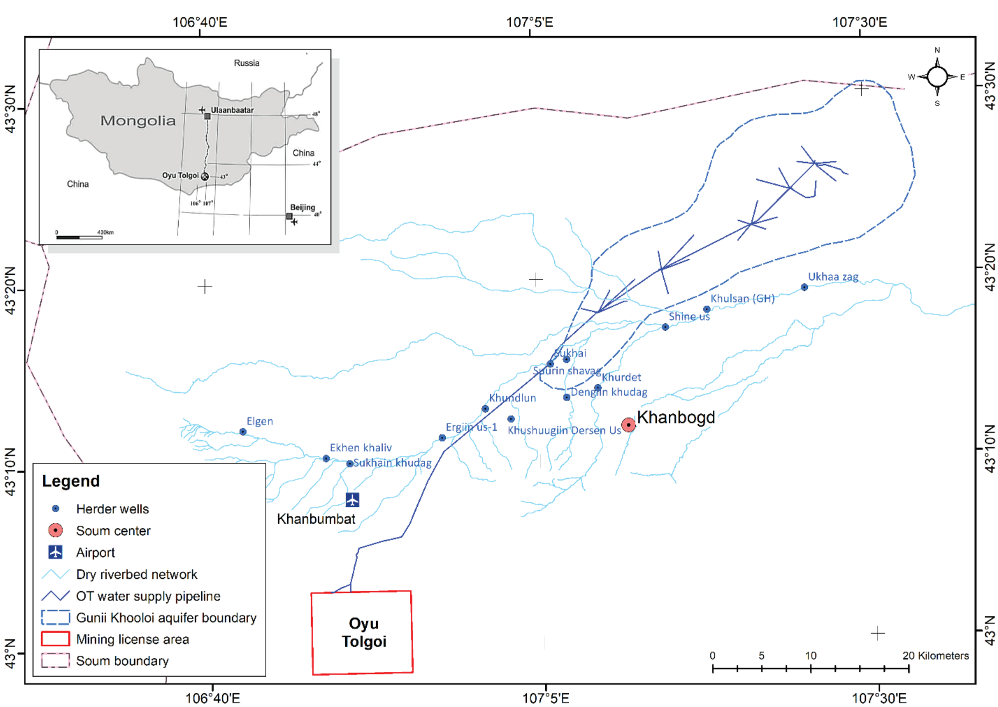

Figure 2 Herder Well Locations in dry riverbeds of the Gunii Khooloi area.

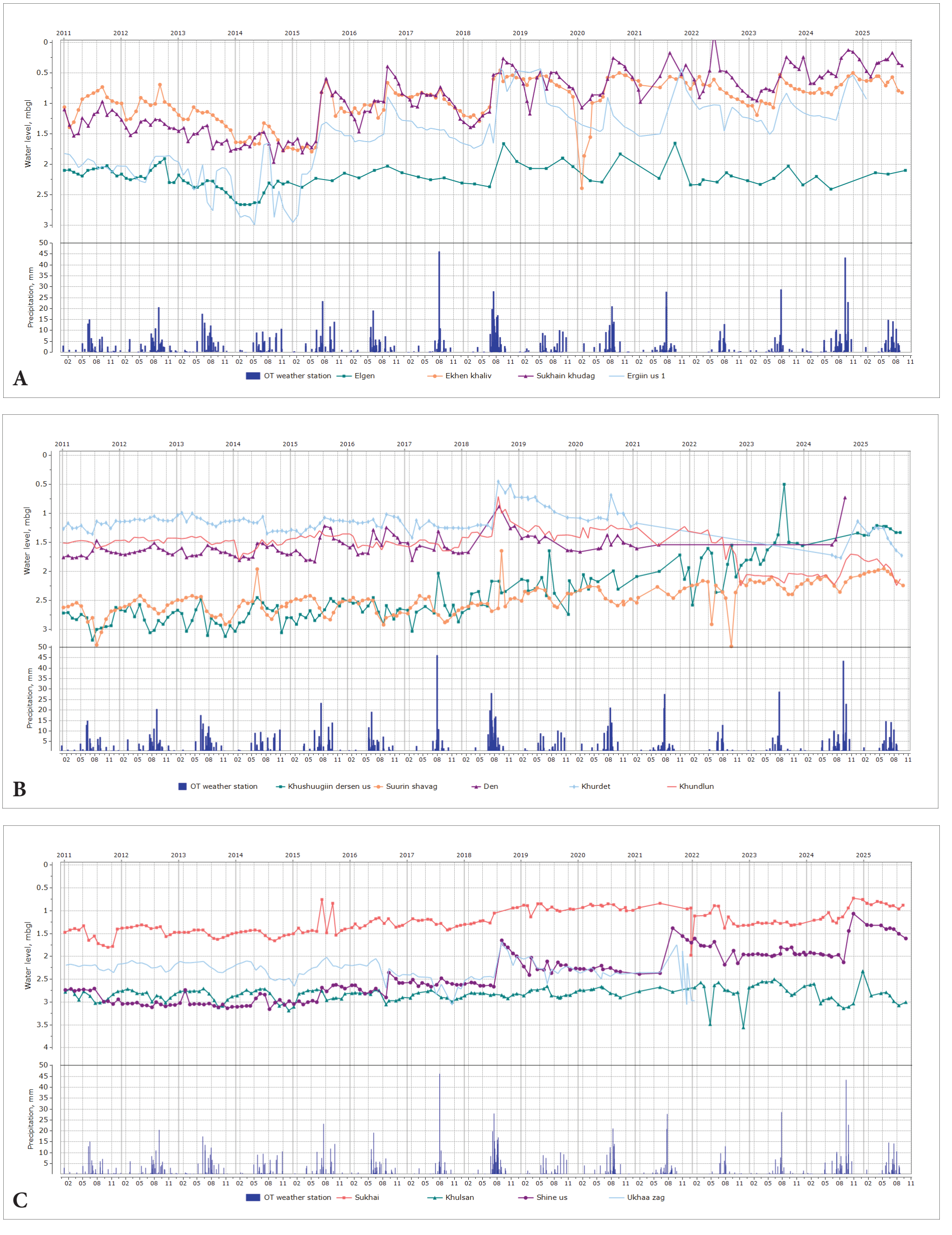

***Figure 3** Herder wells long term water monitoring data versus precipitation in Gunii Khooloi area.*

average and drought conditions prevailed, leading to a gradual decline in groundwater water levels. (Figure 3).

The figure 4 is a box-and-whisker plot showing the distribution of Static Water Levels (SWLs) measured in herder wells across the Gunii Khooloi area. The SWL values are expressed in meters below ground level (mbgl – meaning lower values represent shallower water (closer to surface).

Ergiin Us-1 and Sukhain khudag has the widest water level fluctuation, because it is

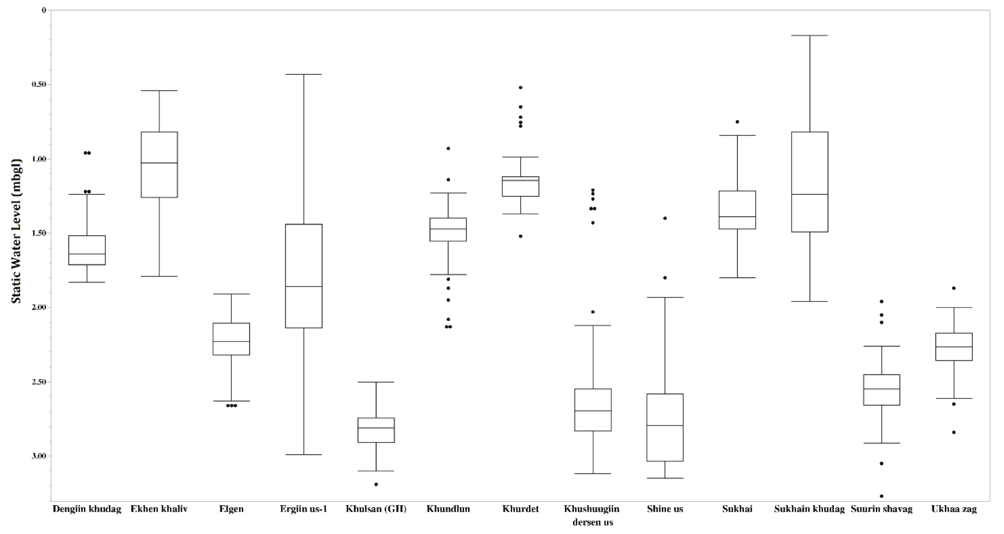

Figure 4 *Distribution of Static Water Levels in Herder Wells across the Gunii Khooloi area.*

Table 1 *Statistical Summary of Groundwater Levels in Herder Wells (*significant).*

No	Herder well name	N	Depth (mbgl)	Min	Max	Mean	Std Dev	Slope (cm)	R2	P value
1	Suurin shavag	85	6.84	1.96	3.27	2.56	0.19	0.32	0.42	<.0001*
2	Khulsan (GH)	70	6.43	2.5	3.19	2.83	0.12	0.04	0.02	0.11
3	Ekhen khaliv	102	5.43	0.54	1.79	1.07	0.34	0.34	0.25	<.0001*
4	Shine us	70	4.66	1.4	3.15	2.73	0.38	0.92	0.81	<.0001*
5	Khushuugiin dersen us	74	3.82	1.21	3.12	2.58	0.44	0.98	0.75	<.0001*
6	Elgen	68	3.75	1.91	2.66	2.24	0.18	0.13	0.06	0.0260*
7	Ergiin us-1	92	3.72	0.43	2.99	1.83	0.57	0.85	0.51	<.0001*
8	Ukhaa zag	70	3.09	1.87	2.84	2.28	0.17	-0.16	0.07	0.0025*
9	Khundlun	95	2.72	0.93	2.13	1.5	0.18	-0.26	0.24	<.0001*
10	Sukhai	86	2.69	0.75	1.8	1.33	0.24	0.33	0.47	<.0001*
11	Dengiin khudag	78	2.66	0.96	1.83	1.59	0.18	0.27	0.41	<.0001*
12	Sukhain khudag	101	2.65	0.17	1.96	1.14	0.44	0.72	0.62	<.0001*
13	Khurdet	79	1.9	0.52	1.52	1.15	0.15	-0.07	0.02	0.09

located in a highly recharge-responsive shallow alluvial setting, active dry riverbed with high permeability. This makes the well more sensitive to seasonal rainfall, flash-flood events and local usage compared to other herder wells in the Gunii Khooloi area. Khurdet shows the narrowest water-level fluctuation, which corresponds to its shallowest depth.

Based on monthly data from 2011, ten of thirteen herder wells' water level show a slight increasing trend in over time, with monthly slopes ranging from 0.98 cm to 0.04 cm monthly, and with explanatory power (R^2) varying from strong to weak (0.81 to 0.02).

The remaining three wells; Ukhaa zag has a significant but weak decreasing trend (R^2 = 0.07, p = 0.0025), while Khurdet's slight decrease is not statistically significant (R^2 = 0.02, p=0.092). Long-term monthly monitoring data indicate a statistically significant decreasing trend in the groundwater level at the Khundlun herder well.

Based on long-term water level and water abstraction volume datasets, statistical analyses were done for all herder wells (Table 2). For the Khundlun herder well, the linear relationship between water abstraction and well water level is weak and not statistically significant ($R^2 = 0.02$, $p = 0.09$).

Based on the statistical analysis of the long-term water level and abstraction datasets, three close-distance herder wells and two far-distance herder wells showed statistically significant relationships ($p < 0.05$) between water abstraction and well water level; however, the explanatory power of these models remained low ($R^2 = 0.03–0.09$).

Conclusion

Long-term monitoring results from the Oyu Tolgoi Water Resources Management Program demonstrate that shallow groundwater used by herder communities in the Gunii Khooloi region is primarily controlled by **natural climatic conditions**, especially precipitation and episodic flood events. Water-level fluctuations in the 13 monitored herder wells consistently correlate with rainfall patterns, rising during wet years and declining during drought periods. Statistical analyses show **no strong or widespread evidence** that deep-aquifer abstraction for mining operations has caused significant declines in shallow groundwater levels.

Although five herder wells exhibit statistically significant relationships with abstraction volume, the explanatory power of these correlations remains **very low ($R^2 = 0.03–0.09$)**, indicating that abstraction is not a dominant factor influencing shallow groundwater behavior. In contrast, most wells show slight increasing long-term trends or stable conditions, with only one well (Khundlun) presenting a statistically significant decreasing trend.

Overall, the combined hydrological data, water-level trends, and statistical evaluations indicate that **deep-aquifer pumping for Oyu Tolgoi operations has minimal measurable impact on the shallow hand-dug wells relied upon by herders**. The shallow aquifer continues to respond mainly to **natural recharge processes**, seasonal variability, and riverbed hydrodynamics. Continuous monitoring remains essential to ensure sustainable water management and to address ongoing community concerns.

References

B.Shikhtulga, G.Dolgorsuren, U.Borchuluun et all (2021), 2021 audit report on "Oyu Tolgoi" mine's water utilization

Otgonbaatar. S, Batdemberel.B, Tamir.P et all (2025), Oyu Tolgoi LLC water usage report 2025.

Uugankhuu.B, Tamir. P, Sod-Erdene.B et all (2025), Oyu Tolgoi LLC water monitoring report 2025.

Tseveenjav.B, Bataa.D (2025), OT mine site general condition report

Mijiddorj. P. (1992). Climate characteristics of Gobi desert of Mongolia. Ulaanbaatar.

Buyankhishig. N, Jadambaa.N, Oyun.D. (2008). Impact of Water compumption of Gunii khooloi groundwater deposits. Geology journal, 18, p 28-140.

*Table 2 Statistical relationship of herder water level between Gunii Khooloi water abstraction volume (*significant).*

N	Herder well name	P value	R^2	N	Herder well name	P value	R^2
1	Khundlun	0.09	0.02	8	Elgen	0.98	0
2	Khushuugiin dersen us	0.13	0.02	9	Ukhaa zag	0.003*	0.09
3	Khurdet	0.15	0.02	10	Shine us	0.007*	0.05
4	Ekhen khaliv	0.19	0.01	11	Sukhain khudag	0.016*	0.04
5	Suurin shavag	0.2	0.01	12	Ergiin us	0.017*	0.04
6	Dengiin khudag	0.24	0.02	13	Khulsan	0.038*	0.03
7	Sukhai	0.24	0.01				