

Global Mining and Metals Water Dataset

Contents

	Synopsis	3
01	Introduction	5
02	Insights from the Global Mining and Metals Water Dataset	10
	Insight 1	10
	Insight 2	11
	Insight 3	12
	Insight 4	13
	Insight 5	14
03	Outlook	16
04	Limitations of the Global Mining and Metals Water Dataset and Opportunities Looking Forward	18
05	Acknowledgements	20
06	Appendix: Methodology for the Global Mining and Metals Water Dataset	21

Synopsis

Water risks reflect the potential for water-related challenges to affect industry, infrastructure, and communities. They are a function of the hazard, the exposure of assets and populations to the hazard, and the vulnerability or resilience of those exposed. This report analyses the intersection between physical water risk indicators and 12,000 mining and metals facilities across 148 countries or regions. It is intended to provide robust, sector-level data to guide discussions on water issues in the mining and metals industry and inform policy, investment and industry-level decisions.

- Five physical water risk indicators are considered: two capturing acute hazards (flooding and drought), and three capturing chronic pressures (baseline water stress, baseline water depletion, and interannual variability).
- Baseline water stress is the most frequently encountered high-exposure indicator for the mining and metals sector, with 38% of facilities located in catchments experiencing high competition for water, or arid conditions. Over 70% of these facilities are also exposed to high baseline water depletion.
- Drought risk is the second most prevalent high-exposure indicator, with 27% of facilities exposed to high drought risk.
- High flood risk exposure is less common (14% of all facilities exposed). However, exposure exceeds 24% for alumina, aluminium, steel and molybdenum producing facilities.
- 16% of mining and metals facilities are exposed to high interannual variability, but it is unevenly distributed geographically, with 74% exposure in Oceania.
- Nearly two-thirds (66%) of mining and metals facilities worldwide are exposed to high levels for at least one physical water risk indicator, and 5% are exposed at high levels for three or more indicators concurrently.
- Without integrated water and land planning at a regional scale, water risk exposure, potentially exacerbated by climate-driven variability, could constrain sector expansion and disrupt supply chains. Water stewardship and the management of water in ways that are socially, economically and environmentally sustainable, is a key part of responsible mining.



Water is a shared and finite resource with social, cultural, environmental, and economic value. Access to water is recognised as a human right, and healthy water systems are essential for the wellbeing and prosperity of communities, ecosystems and industry. Water resources are under growing pressure from competition, pollution, and climate change-driven impacts such as more frequent and severe floods and droughts.

When water is scarce, availability is unpredictable or basins are depleted, the effects are felt across whole catchments. Communities, ecosystems, agriculture, governments, and industry can all be affected.

The mining and metals industry depends on, and can impact, water. Water is used across the entire mining value chain, including for extraction, processing, dust suppression, cooling, transport, and providing for worker needs. In some operating contexts, mining companies are also involved in the supply of water and sanitation to meet community needs and for wider catchment-scale collaboration. Mining and metals production can also affect water quantity and water quality, depending on local conditions, operational practices, and catchment dynamics. Each mine, plant, refinery and smelter operates within a distinct catchment, shaped by local conditions, operational practices, and patterns of water demand. These impacts and dependencies cannot be understood in isolation but need to be assessed in the context of specific catchments, communities, ecosystems, and competing water uses.

Water risks also vary across mining and metals facilities. Some operations face extremely limited water availability and have implemented technologies to utilise low quality water sources^{1,2} freeing up higher quality sources for other users. Other facilities contend with strong seasonal variability and the risk of flooding³. Although physical, social, and reputational water risks are experienced locally, broader regional and global trends are placing increasing pressure on water resources across all regions and commodities. Research at the intersection of water risk and the mining industry highlights the heterogeneous nature of water risk exposure and how it is shaped by local catchment conditions, geology, and evolving climatic pressures^{4,5,6,7,8}.

1. Barrick (2017), A World Water Day Story From The Jabal Sayid Mine, <https://www.barrick.com/English/news/news-details/2017/a-world-water-day-story-from-the-jabal-sayid-mine/default.aspx>
2. International Mining (2023), Minera Centinela achieves goal of 100% operation with seawater, <https://im-mining.com/2023/01/03/minera-centinela-achieves-goal-of-100-operation-with-seawater/>
3. Pearce, T.D., Ford, J.D., Prno, J. et al. (2011) Climate change and mining in Canada. Mitig Adapt Strateg Glob Change 16, 347–368 <https://doi.org/10.1007/s11027-010-9269-3>
4. Kunz, N. (2020) Towards a broadened view of water security in mining regions. Water Security 11, 100079 <https://doi.org/10.1016/j.wasec.2020.100079>
5. Lèbre, É., Stringer, M., Svobodova, K., Owen, J. R., Kemp, D., Côte, C., Arratia-Solar, A., & Valenta, R. K. (2020). The social and environmental complexities of extracting energy transition metals. Nature Communications, 11, Article 4823. <https://doi.org/10.1038/s41467-020-18661-9>
6. Northey, S. A., Mudd, G. M., Werner, T. T., Jowitt, S. M., Haque, N., Yellishetty, M., & Weng, Z. (2017). The exposure of global base metal resources to water criticality, scarcity and climate change. Global Environmental Change, 44, 109–124. <https://doi.org/10.1016/j.gloenvcha.2017.04.004>
7. Meißner, S. (2021). The impact of metal mining on global water stress and regional carrying capacities—A GIS-based water impact assessment. Resources, 10(12), Article 120. <https://doi.org/10.3390/resources10120120>
8. Morgan, A. J. and Dobson, R. (2020) An analysis of water risk in the mining sector. Water Risk Filter Research Series Volume 1, WWF. https://wwfint.awsassets.panda.org/downloads/analysis_of_water_risk_in_mining_sector_wwf_water_risk_filter_research_series.pdf

As demand for minerals and metals grows, water risks are becoming increasingly more important for the sector and for all those who depend on the materials that underpin energy systems, infrastructure, and everyday life. This has led to increasing attention from companies, civil society, investors, and government, and a growing emphasis on water stewardship at both corporate and site levels⁸.

Despite growing recognition of water as a material issue for the mining and metals sector, existing data is limited by commodity or region-specific analyses and differences in methodological approaches that make comparison difficult. There is no comprehensive, cross-commodity global assessment of how the mining and metals sector is exposed to water risk.

To address this gap, we use the [Global Mining Dataset](#) and global water datasets^{9,10,11} to establish a data-driven picture of where mining and metals facilities intersect with water risks. The [Global Mining and Metals Water Dataset](#) shows where facilities coincide with 19 global water risk indicators, including water quantity risks such as flooding and water stress, water quality risks such as untreated wastewater and coastal pollution, and regulatory and reputational risks such as unimproved sanitation or a country-level proxy for environmental, social and governance (ESG) risk. Most risks are calculated by considering a hazard (e.g. flood event), the populations, assets and/or economic aspects affected by the hazard, and the resilience of those to the hazard⁸.

Within this report, we have synthesised available data on five key physical water quantity risk indicators (baseline water stress and depletion, flood risk, drought risk, interannual variability) that include surface water and groundwater. The underlying Global Mining Dataset on which the intersectional analysis was completed includes 12,000 facilities, and insights are drawn from this total. However, not all facilities are able to be made publicly available due to licencing restrictions, therefore the public version of the Global Mining and Metals Water Dataset excludes 4,896 facilities.

Physical water quality risks are not included in this report, as the currently available global indicators primarily capture coastal nutrient pollution and municipal wastewater. These indicators have limited relevance for assessing water quality risks in the mining and metals context. Similarly, the reputational risks associated with sanitation and drinking water access do not provide information that is relevant to understanding mining and metals operational water risk, therefore have not been included. The physical risks examined in this report build a multi-dimensional picture of physical water risk exposure across the global mining and metals sector and provide a useful foundation for considering the mining and metals industry and water.



9. ICMM (2017) Water Stewardship Position Statement <https://www.icmm.com/en-gb/our-principles/position-statements/water-stewardship>

10. Kuzma, S., M.F.P. Bierkens, S. Lakshman, T. Luo, L. Saccoccia, E. H. Sutanudjaja, and R. Van Beek (2023) "Aqueduct 4.0: Updated decision-relevant global water risk indicators." Technical Note. Washington, DC: World Resources Institute. <https://www.wri.org/research/aqueduct-40-updated-decision-relevant-global-water-risk-indicators?auHash=74cRjEQPsH0NDpgTINqlfNpqV-QpYNR4oiPo1HRhpGs>

11. WWF (World Wide Fund for Nature). (2024). WWF Risk Filter Suite (including the Water Risk Filter). Available at: <https://riskfilter.org/>

12. FAO (Food and Agriculture Organization of the United Nations). (2021). AQUASTAT database. <http://www.fao.org/aquastat/>

Finally, this analysis is based on facility locations and publicly available geospatial datasets only. It does not capture site-level operational data, such as water withdrawals, consumption, discharge, or the water management and mitigation strategies implemented at individual operations. The analysis therefore describes facility exposure to catchment-level conditions rather than the level of risk experienced or managed at any individual facility.

We encourage readers to scrutinise the Global Mining and Metals Water Dataset in its fullness, as well as the data presented here, to use it in further research, and to collaborate with us in building a data-driven picture of the mining and metals sector.

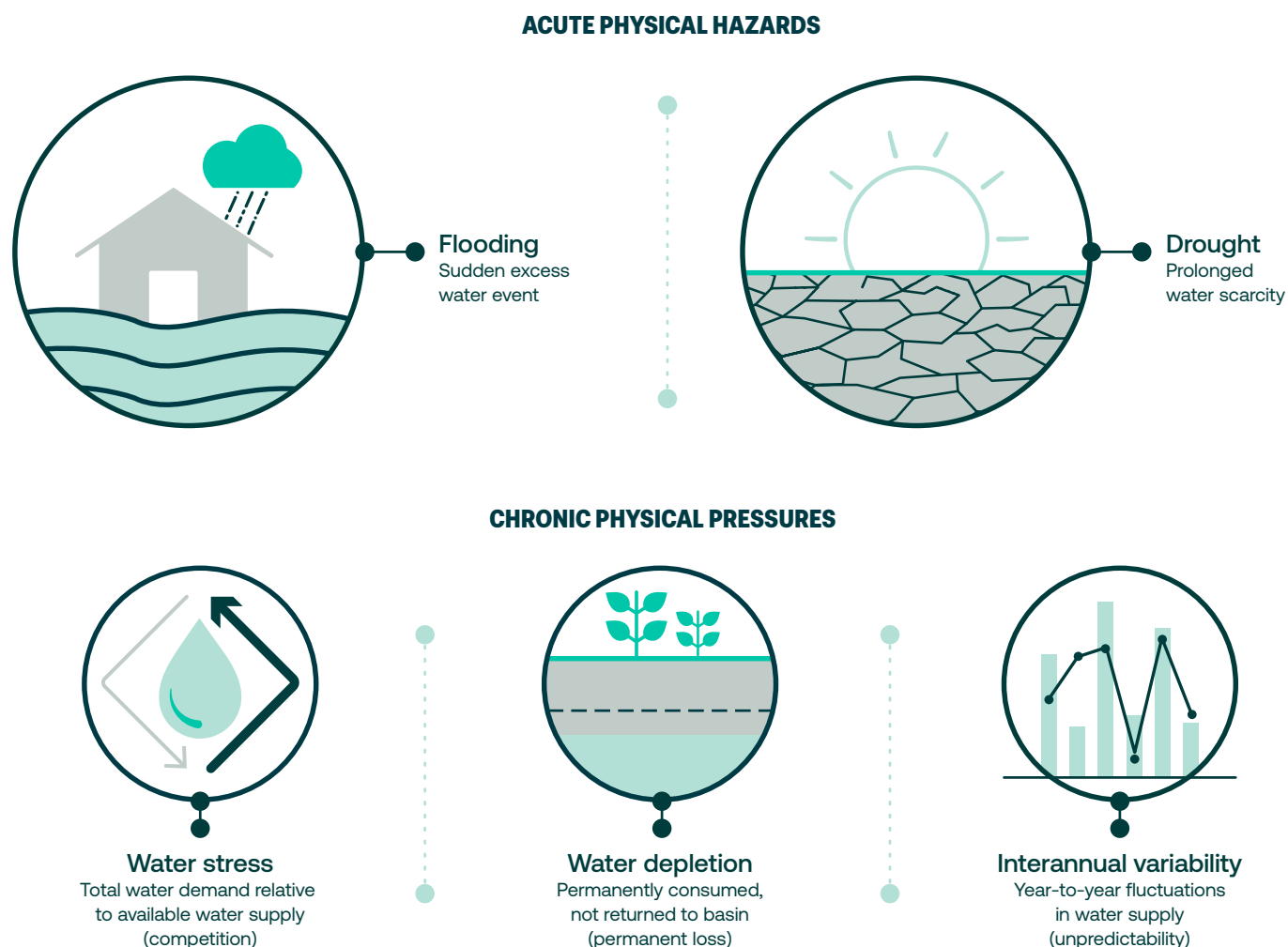


Figure 1: Overview of physical water hazards and pressures explored in this study

Definition: Water stress

‘Water stress’ refers to the ability, or lack thereof, to meet human and ecological demand for fresh water. It considers several physical aspects related to water resources, including water availability, water quality, and the accessibility of water (i.e. whether people are able to make use of physically-available water

supplies), which is often a function of the sufficiency of infrastructure and the affordability of water, among other things. Both water consumption and water withdrawals provide useful information that offers insight into relative water stress. Throughout the report, we use WRI’s indicator Baseline Water Stress to provide information on water stress¹⁰.

Interpreting Water Risk: Scope, Approach and Limitations

Water is essential to all people and to economic sectors. Yet water resources globally are under increasing pressure from competition, climate change and pollution. A water risk framework is an approach for assessing the various water pressures facing all of us – human health, livestock, infrastructure, assets, environmental flows, recreation and industrial activity. In this study we explore the intersection between several key physical water risks and mining and metal facilities, across the whole sector. How we all measure, understand and respond to water risks can underpin resilience and contribute to a sustainable future.

Note: This analysis is about the co-existence of mining and metals facilities with areas of physical water risk defined in publicly available datasets. It should not be used to infer impacts or contributions to water risk and it does not explore operational water management or site-level practices thus should not be used to predict operational risks.

Note: Many of the water risks described in the publicly available datasets are human-centric – describing hazards that could affect people, livestock, assets and infrastructure – and do not explicitly include environmental water needs. We recognise that limitation as an area where urgent data are needed.

Indicators we used

In this report, we use several indicators to build a picture of mining and metals exposure to physical water risks. This includes two indicators from the WWF Water Risk Filter¹¹ that capture risk from acute physical hazards: flooding and drought. We also use three indicators from WRI Aqueduct¹⁰ that capture risks from chronic physical catchment pressures: baseline water stress, which measures the degree to which total water withdrawals compete with available supply; baseline water depletion, which measures the share of available water that is permanently consumed and not returned to the basin; and interannual variability, which captures year-to-year fluctuations in water supply.

Baseline water stress and baseline water depletion are presented together throughout this analysis as depletion is the more severe subset of water stress, capturing consumptive loss rather than total

withdrawal pressure, and the two indicators are best understood in relation to each other. In addition to analysing each indicator individually, this report identifies facilities exposed to high risk across three or more physical indicators simultaneously. This compound risk exposure measure shows where multiple independent water pressures converge on the same operations.

A note on terminology: Throughout this report, flooding, drought, baseline water stress, baseline water depletion and interannual variability are hazards and pressures that exist at catchment level. The WRI Aqueduct¹⁰ and WWF Water Risk Filter¹¹ outputs are indicators of those hazards and pressures. Facilities are described as exposed where they are located in areas where indicators are at high levels or above (including arid areas). Indicator and dataset names (ie. 'Water Risk Filter', 'drought risk') follow the conventions of the source datasets.

Understanding Weighted Risk Exposures and Global Averages

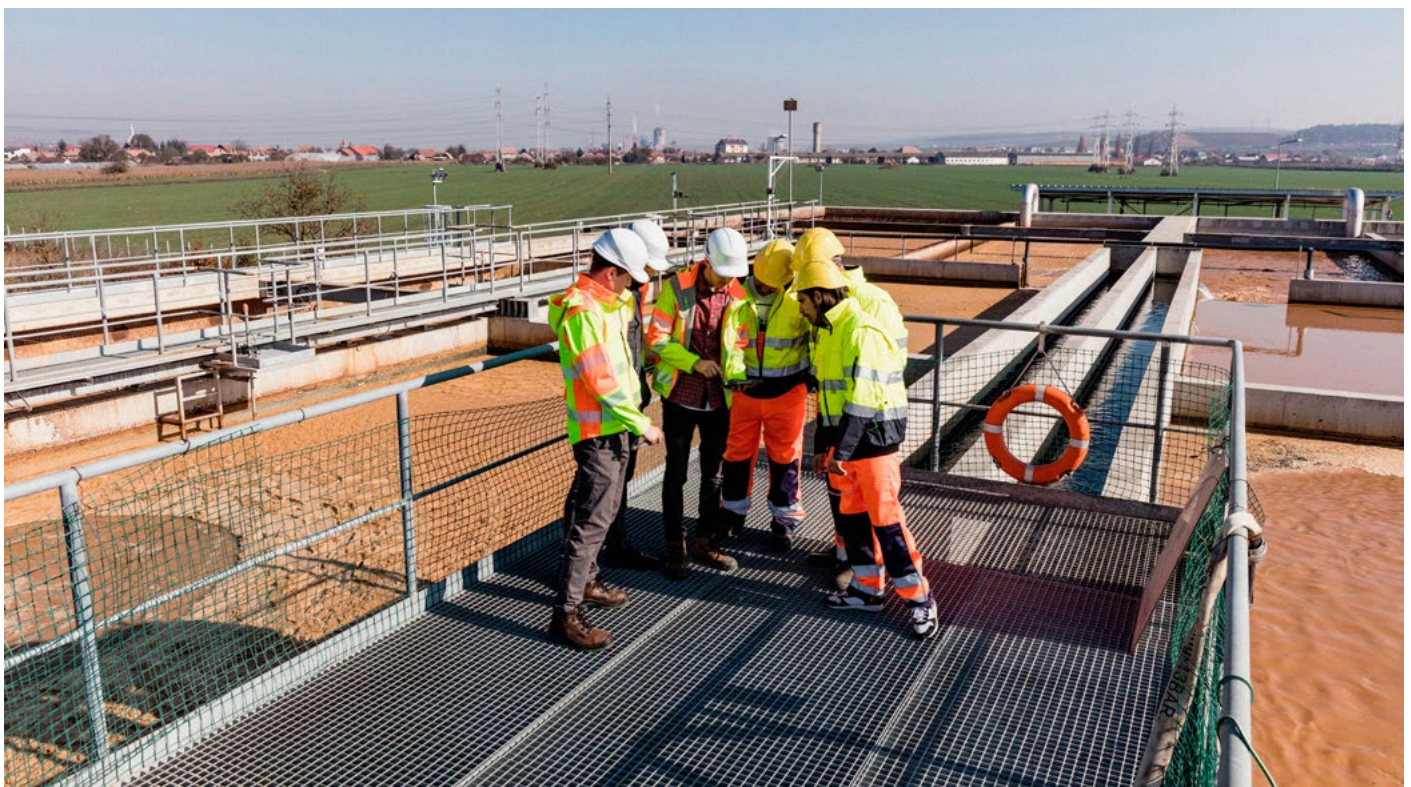
Throughout this report we use weighted exposure to account for the fact that there are different numbers of facilities by commodity and country groupings, in the Global Mining Dataset. Exposure rates show the share of facilities exposed to high risk within a commodity or regional grouping, rather than the total count. This allows meaningful comparison between

countries and commodities. A higher exposure rate means a greater proportion of facilities are exposed. For example, 27% of steel facilities (23 of 85) are exposed to high flood risk.

We also present mean exposure rates across all facilities in the Global Mining Dataset. Comparing this to exposure rates for specific regions or commodities helps determine whether they are above or below average and makes it easier to identify unusually high or low values (outliers).

Physical Water Risk Indicators Used

- **Baseline Water Stress:** Baseline water stress measures the ratio of total water demand to available renewable surface and groundwater supplies, covering domestic, industrial, irrigation, and livestock uses. Higher values indicate greater competition among users for available water resources.¹⁰
- **Baseline Water Depletion:** Baseline water depletion measures the ratio of total water consumption to available water in rivers, lakes and aquifers, distinguishing it from baseline water stress by focusing on consumptive use rather than total withdrawals. Water that is consumed is not returned to the local basin after use, meaning higher values indicate larger impact on the local water supply and decreased water availability for downstream users.¹⁰
- **Drought risk:** The WWF WRF Drought indicator combines two sub-indicators: Drought Frequency Probability, which uses the Standardized Precipitation and Evaporation Index to assess drought frequency and severity under global warming conditions¹³, and the World Atlas of Desertification, which identifies regions where multiple signals of land degradation converge¹⁴.
- **Flood risk:** The WWF WRF Flooding indicator combines two sub-indicators: Estimated Flood Occurrence, which measures historical flood recurrence over a 35-year period (1985–2021) across all flood types¹⁵, and Flood Hazard, derived from the European Commission Joint Research Centre global 100-year flood hazard map using hydrological modelling¹¹.
- **Interannual Variability:** Interannual variability measures the year-to-year fluctuation in available water supply, capturing how unpredictable water availability is from one year to the next. Whereas baseline water stress and depletion measure water stressors under average conditions, interannual variability measures the reliability of water supply. Higher values indicate wider variations in available supply from year to year, which can impact operational resilience as it makes difficult to plan infrastructure and manage operations and water around any stable average.¹⁰



13. Vicente-Serrano, S. M., S. Beguería, and J. I. López-Moreno, (2010), A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index. *J. Climate*, 23, 1696–1718, <https://doi.org/10.1175/2009JCLI2909.1>

14. Cherlet, M. et al. (2018) 'WAD | World Atlas of Desertification' <https://wad.jrc.ec.europa.eu/>

15. Brakenridge, G.R. (2020) 'Global Active Archive of Large Flood Events.' University of Colorado, USA: Dartmouth Flood Observatory, https://floodobservatory.colorado.edu/wiki/Main_Page

Insights from the Global Mining and Metals Water Dataset02

Insight 1: Baseline water stress is the most prevalent physical water risk indicator in the dataset with 30% of all facilities operating in areas of high or extremely high water stress and a further 8% in arid areas where water is functionally unavailable.

- Of the 38% of facilities exposed to high or extremely high water stress or located in arid areas where water is functionally unavailable, over 70% are also located in areas of high or extremely high water depletion levels that affect 27% (n = 3,289) of all facilities globally. This means that not only are these facilities located in catchments facing competition for available water resources, but that the current water reserves are being used at a quicker pace than they are replenished indicating intensifying water pressures. The same forces that are driving demand for minerals such as population growth, urbanisation and economic development are also driving demand for food and non-mineral commodities in the same regions. Consistent with this, global analyses show that approximately 60% of the world’s irrigated crops (by weight) are currently grown in areas facing high or extremely high levels of water stress¹⁶.
- Global water depletion hotspots where exposure is much higher than the global average include Saudi Arabia (100% of the facilities are exposed to water depletion in country), Chile (96%), Iran (81%) and Mexico (81%).
 - China has the largest number of mining or metals facilities in water stressed basins, with 1,836 exposed facilities representing 59% of its total facilities, with 45% of all facilities in China being exposed to extremely high baseline water stress, 10% being exposed to high baseline water stress, and 4% of facilities being located in arid and low water use regions. This spans most major commodities produced in China, including coal (69%), nickel (64%), aluminium (64%), iron ore (58%), gold (56%) and copper (38%).

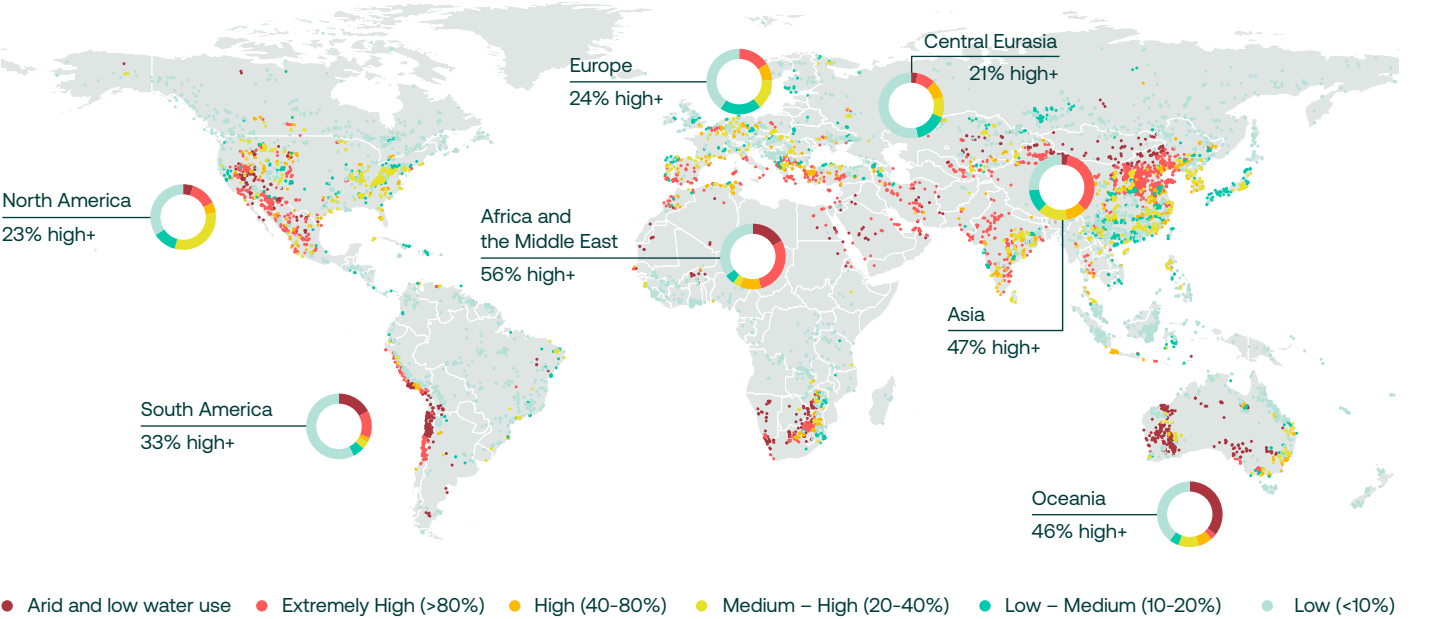
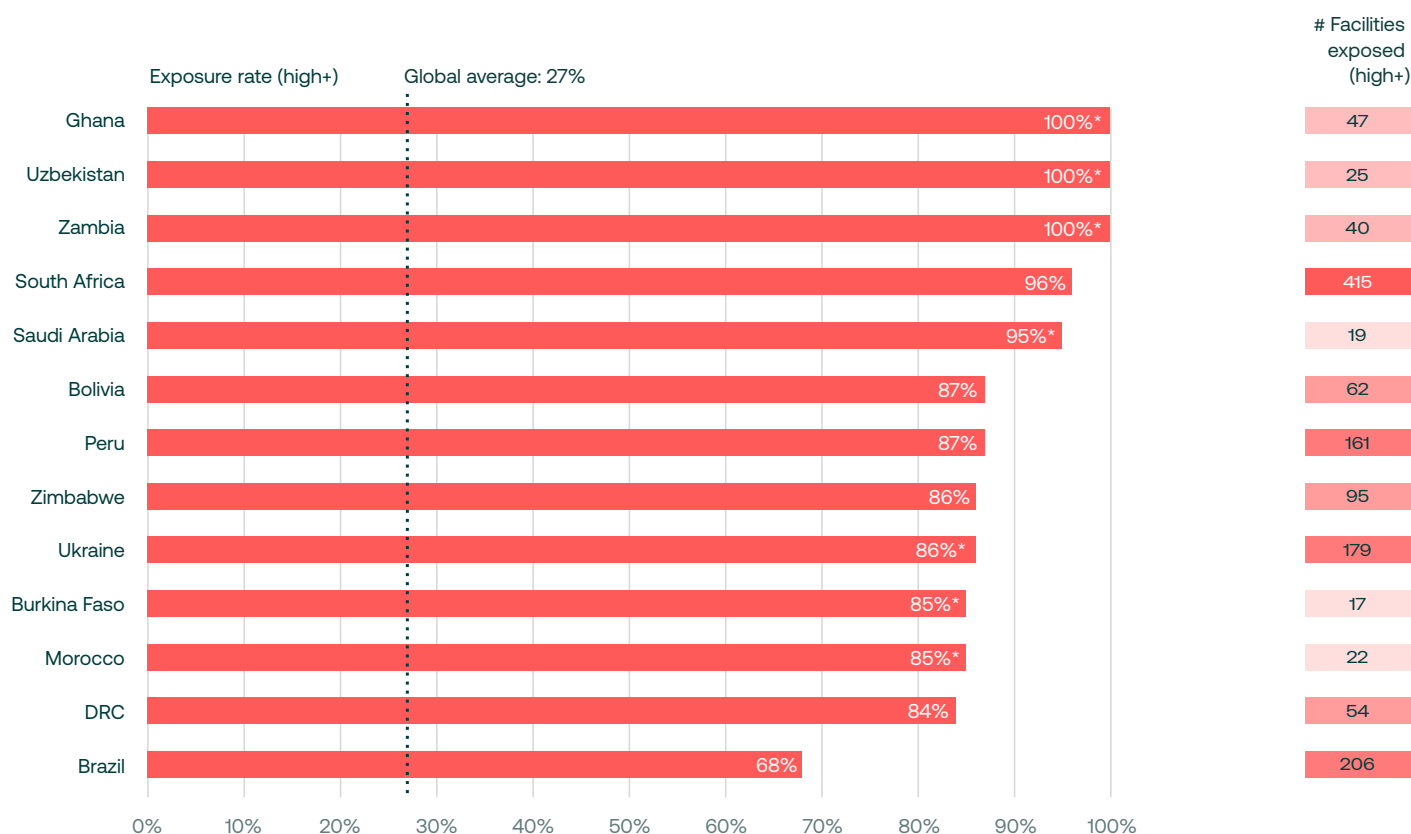


Figure 2: Global Distribution and Regional Exposure Profile of Baseline Water Stress for Mining and Metals Facilities
Dot points show the baseline water stress level at a facility level, pie charts show the distribution of baseline water stress at a regional level

16. WRI (2024), One-Quarter of World's Threatened by Water Risk, Liz Saccoccia and Samantha Kunz, <https://www.wri.org/insights/growing-water-risks-food-crops>

Insight 2: More than one quarter of all mining and metals facilities (27%) are exposed to high drought risk, making drought the second most prevalent physical water risk indicator in the dataset.

- Drought risk exposure for mining and metals facilities is geographically focused: 81% of facilities in Africa and the Middle East are in areas experiencing high or very high drought exposure compared to a global average of 27%.
- In several countries the exposure is near-total, including Zambia, Ghana and Uzbekistan where 100% of facilities are exposed to high drought risk, as well as South Africa with 96% of mining and metals facilities exposed to high or extremely high drought risk (415 out of 431 facilities in-country).
- At the commodity level globally, platinum group elements (PGEs; 74%), chromite (60%) and diamond (57%) face the highest drought exposure rates. This is because these commodities are often located in regions with endemic drought risk, such as southern Africa.



High+ = score >= 3.5 (WFF Water Risk Filter: 'High risk' label) Source: ICMM Global Mining Dataset

Figure 3: Drought Risk Exposure Rate for Mining and Metal Facilities, by Country.

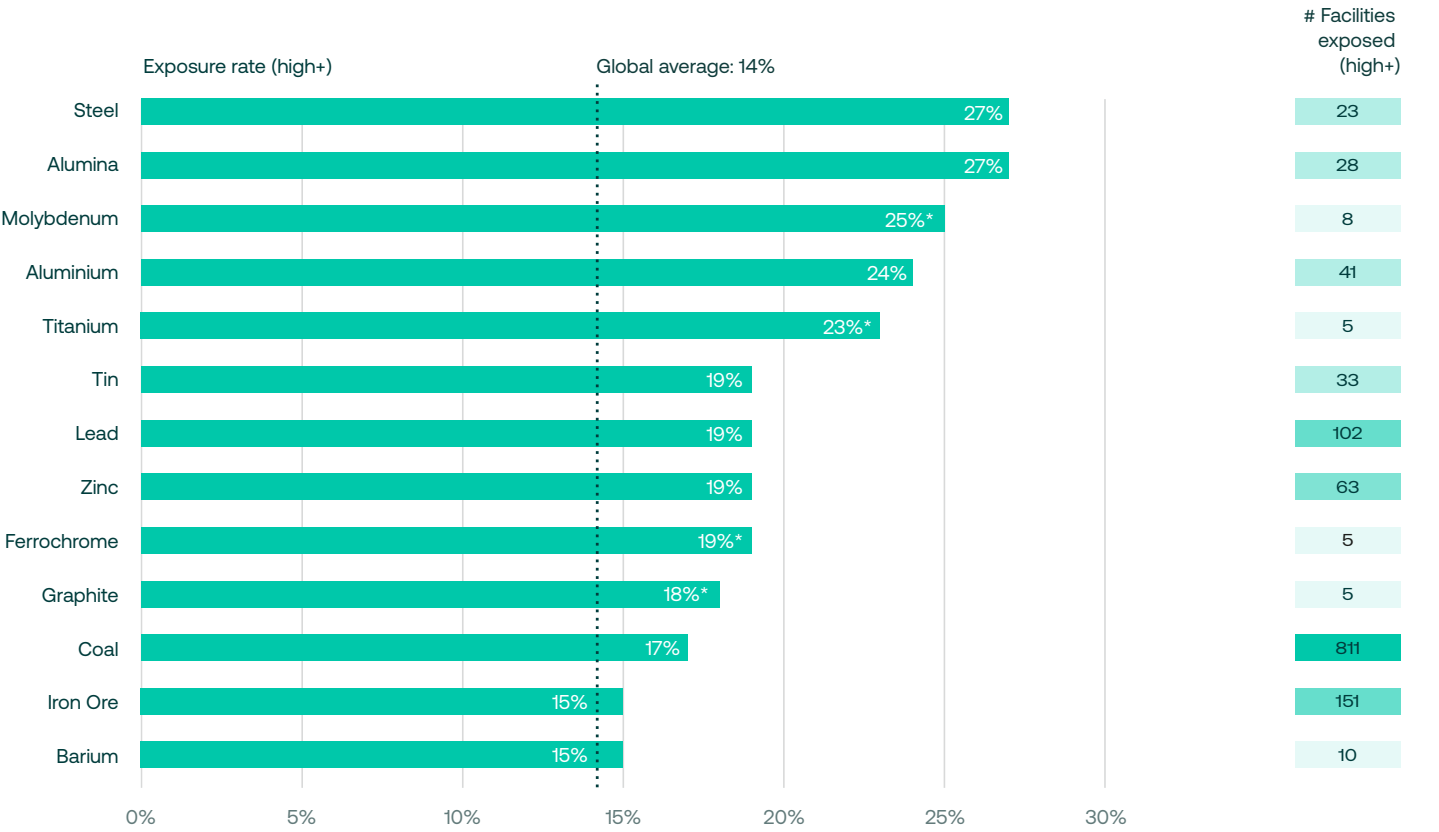
Global average 27% (dotted line)

% of each country's facilities at high or extremely high risk. Min 20 total sites, min. 5 exposed sites.

*= fewer than 50 total facilities (rate less robust).

Insight 3: 14% of all mining and metals facilities are exposed to high or extremely high flood risk, the lowest average high-risk exposure rate of the physical indicators. However, alumina refining and steel production facilities face above global average exposure.

- Alumina refining (27%), aluminium smelting (24%), molybdenum production (25%) and steel production (27%) all face above-average flood risk exposure. For aluminium specifically, both the refining and smelting stages (consecutive stages in the same production chain) face elevated flood risk exposure independently: the finding is not an artefact of facilities clustering in a single flood-prone location, but reflects flood risk exposure distributed across multiple regions and river systems.
- High flood risk exposure is unevenly distributed geographically with 21% of facilities in Asia exposed to high flood risk, compared to a 14% global average. China (n=629 facilities), Indonesia (n= 163) and India (n=131) account for the majority of globally exposed facilities, and Indonesia’s exposure rate of 32% is the highest of any large mining region.



High+ = score >= 3.5 (WFF Water Risk Filter: ‘High risk’ label) Source: ICMM Global Mining Dataset

Figure 4: Flood Risk Exposure Rate for Mining and Metals Facilities, by Commodity
Global average 14% (dotted line)

% of each commodity’s facilities at high or extremely high risk. Min 20 total sites, min. 5 exposed sites.
*= fewer than 50 total facilities (rate less robust).

Insight 4: 16% of mining and metals facilities are exposed to high or extremely high interannual variability. However, exposure is geographically variable, with 74% of facilities in Oceania facing high or extremely high interannual variability. This is more than double the exposure rate for facilities in the next most exposed region, Africa and the Middle East (28%).

- 16% of all facilities (n=1,945) are exposed to high or extremely high interannual variability.
- 74% of facilities in Oceania are exposed to high or extremely high interannual variability, with the highest rates of exposure in Australia (79%). Coal, copper, gold, iron ore and nickel all face interannual variability rates well above the global average in Australia.
- At the global commodity level, facilities producing diamonds (46%), barium (37%), heavy mineral sands (37%) and manganese (31%) all face interannual variability exposure rates well above the global average.

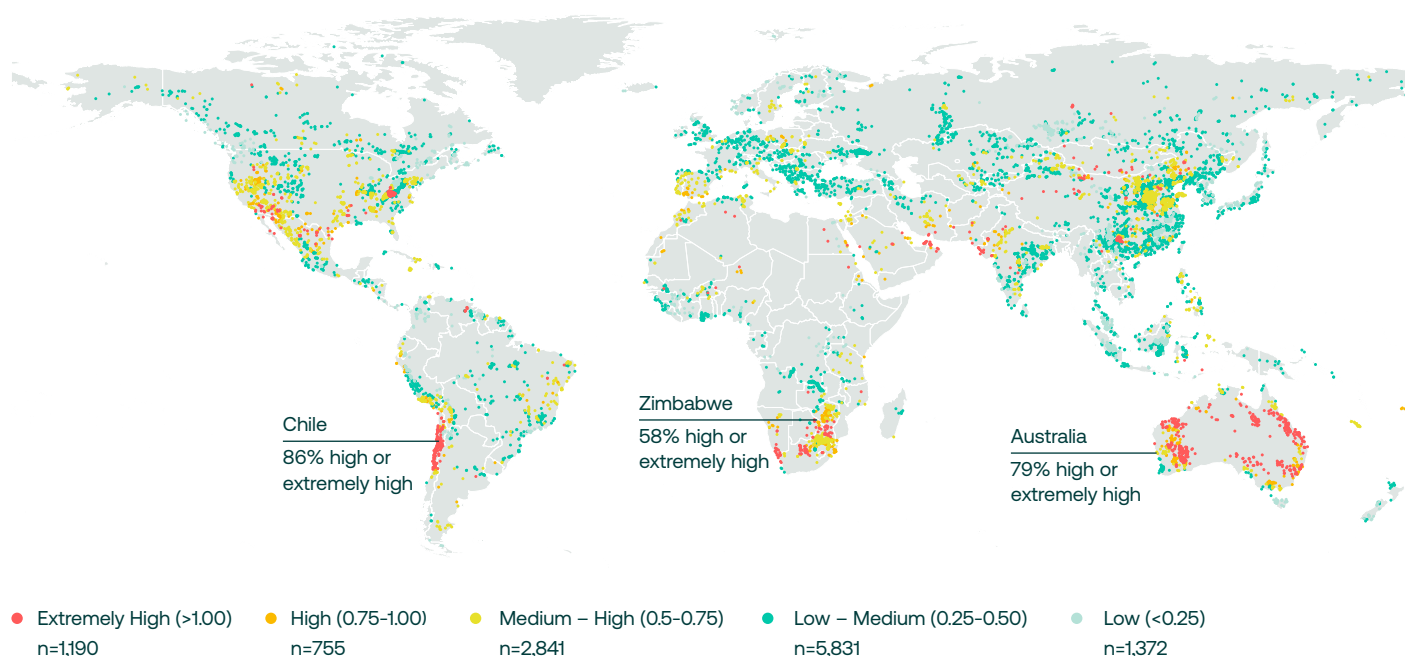


Figure 5: Global Distribution and Regional Exposure Profile of Interannual Variability for Mining and Metals Facilities
Text boxes show national hotspots

Insight 5: Almost two thirds of mining and metals facilities (66%) globally are exposed to high risk for at least one physical water risk indicator. 5% of facilities face high risk on three or more indicators concurrently, meaning multiple independent physical water pressures converge on the same facilities.

Compound exposure calculations and significance

Facilities were assessed against four physical water risk indicators independently: drought, flooding, baseline water stress and interannual variability. A facility is considered ‘compound exposed’ if it faces high-risk across at least three of these indicators at the same time. Baseline water depletion is not counted separately because it is a subset of baseline water stress so including both would double-count the same underlying risk. This method ensures that compound exposure only identifies facilities where multiple distinct water risks occur together in the same location at the same time.

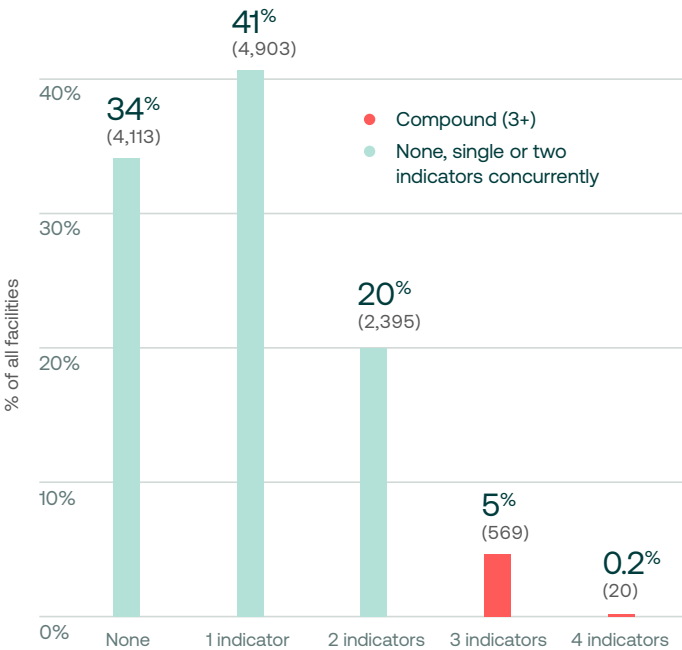
Compound exposure reveals areas where three or more physical water risks converge. Where multiple independent water pressures overlap, the overall vulnerability for an operation may be greater than any single indicator alone. A facility facing high risk across three or more independent indicators at the same time must manage multiple distinct challenges, with solutions to one pressure not necessarily addressing the others. This analysis identifies where such convergence occurs, though the distinct operational consequences will depend on site-specific factors.

- Compound-exposed mining and metals facilities cluster in specific geographies: western United States, Chile and Peru in the Americas; southern Africa; northern China and central India in Asia; and western Australia. Each cluster faces a distinct combination of risk types.
- From a commodity perspective, diamonds (31%), manganese (21%) and barium (19%) are compound-exposed well above the global average of 5%. Of these, manganese is a major battery mineral, important for clean energy technologies. Copper (9%), critical to renewable energy grids and electric vehicles, and chromite, important in emerging clean energy systems, are also exposed at almost double the global average.

Chile and the lithium triangle

Co-occurrences of physical water risks are of particular significance for the energy transition. Chile, the world’s largest copper producer and home to a significant share of global lithium reserves, faces high or extremely high baseline water stress as well as interannual variability exposure across 86% of its facilities concurrently.

Number of physical indicators (drought, flooding, baseline water stress, and interannual variability) on which each site is concurrently at high+ risk. Facilities in red are exposed at high levels for three or more independent physical water risk indicators at once.



Based on 12,000 facilities globally. Baseline water depletion (BWD) excluded as it is a subset of baseline water stress (BWS) – including both would double-count the same underlying risk (all BWD high+ facilities are also BWS high+)

Figure 6: Compound Water Risk Exposure – Concurrent exposure across indicators



Water risks are global in scope and diverse in nature. Water can act both as an enabler and a constraint on the mining and metals production required to support the global energy transition. Recognising this, water risk exposure must be treated as a critical strategic issue. Effective responses will depend on coordinated efforts across governments, investors, and industry.

Water as a binding constraint on the energy transition

Physical water risks are not peripheral. They represent a structural constraint on the expansion of the mining and metals sector, and therefore on the pace of the energy transition itself. With more than one-third of mining facilities located in areas of high or extremely high water stress – and 70% of these are located in catchments already experiencing high baseline water depletion (equating to 27% of global facilities) – competition for finite water resources is not a future concern, but a present operational reality.

In many regions, water availability will limit whether and how quickly new mining capacity can be developed, particularly for minerals important in the energy transition (platinum group elements, chromium, manganese, aluminium, steel). Without coordinated action across industries and governments, water risk will increasingly act as a bottleneck on supply.



The need for integrated, forward-looking land and water planning

These dynamics elevate the importance of integrated land use and water planning at national and regional levels. As governments seek to accelerate mining and metal production to meet the energy transition demand, they will face growing trade-offs between industrial use, agriculture, community water security and ecosystem integrity. Fragmented or reactive planning approaches will be insufficient. Proactive, regional planning frameworks will be critical to allocate water efficiently across competing users, avoid over-extraction and reduce project delays, conflict, and stranded investments.

Climate-driven variability will amplify localised risk hotspots

While baseline water stress is the most prevalent of the indicators explored in this study, flooding, drought, and interannual variability are highly material in specific regions and cannot be overlooked. For example, there is elevated exposure to interannual variability in Oceania, widespread exposure to high drought risk in South Africa, and above average high flood risk exposure affecting critical supply chains such as steel and aluminium in Asia. These risks are likely to intensify as climate change drives greater variability and extremes, increasing operational uncertainty and infrastructure vulnerability. Furthermore, compound risk exposure is focused in key mineral producing regions (Western United States, Chile & Peru, southern Africa, northern China, central India, and Western Australia) and across interconnected supply chains (aluminium and steel). This data highlights that water risk is both geographically concentrated and connected across supply chains, and is not just a site-level issue.

Competitive differentiation and supply chain resilience through water stewardship

In this context where water risk is material to individual operations as well as to mining and metals supply chains globally, governments, investors and customers have a critical role to play in incentivising and recognising responsible mining where water stewardship is business as usual. Operators that embed catchment-based approaches¹⁷, and those that embrace innovative water technologies underpinning water stewardship practices will be better positioned to secure permits, maintain social licence and operate reliably in high-risk regions. Water stewardship requires integrated water resource management¹⁸, which is a multi-stakeholder process to ensure coordinated development and management of water, land and related resources to maximise economic and social welfare in an equitable manner, without compromising the sustainability of vital ecosystems.

The Global Mining and Metals Water Dataset underscores a clear message: water is a defining factor in the geography, cost structure, and resilience of the mining and metals sector. If the sector is to expand to meet the need for more metals and minerals for the energy transition and global sustainable development goals, water risk management will require coordinated action across governments, industry, investors, and supply chain actors, moving from fragmented responses toward integrated, system-level solutions.

17. ICMM (2015), A Practical Guide to Catchment-Based Water Management for the Mining and Metals Industry, <https://www.icmm.com/en-gb/guidance/environmental-stewardship/2015/catchment-based-water-management>

18. United Nations Environment Programme (2024), Integrated water resources management, <https://www.unep.org/topics/fresh-water/water-resources-management/integrated-water-resources-management>

Limitations of the Global Mining and Metals Water Dataset and Opportunities Looking Forward

This insights report provides a comprehensive view of the mining and metals sector's exposure to five global physical water risk indicators derived through commodity- and region-agnostic methodology. At the same time, important limitations and data gaps remain in our dataset. The dataset is designed to provide a sector-wide exposure analysis. It is not suitable for site-level risk assessment, corporate benchmarking or predicting operational risk at individual facilities. It does not include data on facility-level water flows and therefore cannot be used to draw conclusions about the impact or contribution of mining and metals facilities to water resources.

Data coverage and resolution

The Global Mining and Metals Water Dataset draws on four core datasets: WWF's Water Risk Filter, WRI's Aqueduct 4.0, the UN Water Stress dataset, and ICMM's Global Mining Dataset, selected for their credibility and global scope. However, coverage gaps remain. No independent validation or ground-truthing of the spatial datasets was undertaken. As a result, regional variations in data quality and uncertainty have not been systematically assessed beyond the documentation provided by the original data sources. The Global Mining and Metals Water Dataset includes data related to water quality indicators such as coastal eutrophication and municipal wastewater (see [Appendix: Methodology](#)). However, these global water quality indicators are not sufficiently relevant to mining and metals production to support meaningful sector-wide analysis. Water quality remains an important gap in the broader picture of mining and water, and more work is required on this topic alongside the release of relevant industry-specific datasets.

While the UN-Water SDG 6 Data Portal is included in the Global Mining and Metals Water Dataset, it offers only country level resolution and was excluded from the report analysis, as this scale is insufficient for capturing the catchment-specific nature of water risk. A small number of facilities fall outside polygon coverage (12 for WWF WRF polygons and 6 for WRI Aqueduct polygons), primarily at coastal locations where the water risk layers do not extend offshore. In these cases, a nearest-polygon method was applied, introducing additional uncertainty. The global water datasets also differ in spatial resolution and structure, with several indicators comprising multiple sub-indicators (see [Appendix: Methodology](#)).

The coverage, commodity composition, and geographic distribution of findings are also a direct reflection of the Global Mining Dataset v1.5. The Global Mining Dataset does not include artisanal or small-scale mining or closed, inactive or historic sites. It assigns a confidence factor to each facility; while all facilities have been spatially validated, confidence levels vary and this uncertainty is not evenly distributed across regions. Like all large-scale datasets, the Global Mining Dataset will continue to evolve and improve over time. For full detail on its methods, coverage, and limitations, we direct readers to the [Global Mining and Metals Datasets](#).

Interpretation of results

This analysis is exploratory and focuses on the spatial intersection between mining and metals facilities and physical water risk indicators.

The findings do not quantify mining's impact, threat, or pressure on water resources or ecosystems. Water-related impacts are highly context-specific and depend on site-level factors such as withdrawals, consumption, discharge, catchment dynamics and other water uses. No global datasets currently exist which capture site-level water risk management or mitigation strategies, water quality information, sector-level impacts on shared water resources, or the financial implications for specific companies or portfolios. Similarly, there is no global data on the contribution that mining and metals makes to water and sanitation globally, for example through provision of water and water-related infrastructure for communities and other water users which is common in many mining-regions globally. These are pressing and important data gaps that are vital in understanding mining's impacts on and contributions to water globally but remain challenging due to the context-specific nature of each catchment and each mining and metals facility.

Temporal scope

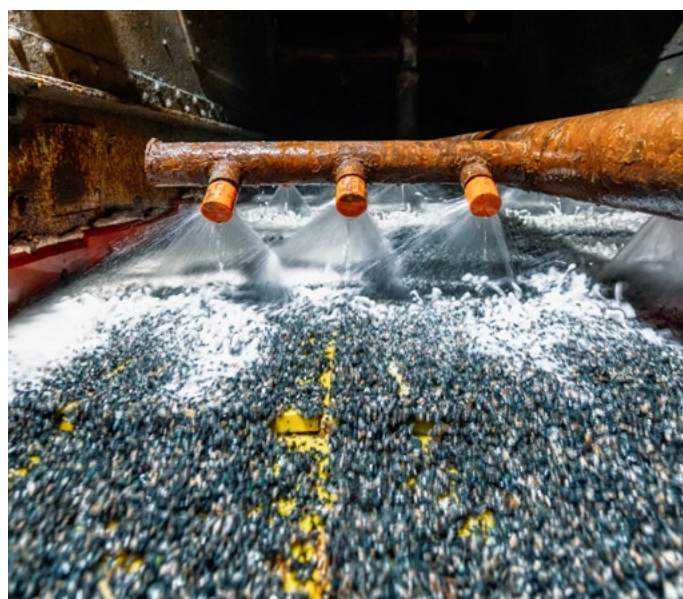
The datasets provide a snapshot in time and do not capture historical trends or future projections of water risk exposure.

This analysis uses the following dataset versions:

- [WWF Water Risk Filter \(2024\)](#)
- [WRI Aqueduct 4.0 \(August 2023\)](#)
- [ICMM Global Mining Dataset v1.5 \(July 2026\)](#)
- [UN Water Stress Dataset \(2021\)](#)

A foundation, not a conclusion

This dataset fills a vital research gap on mining and metals' global exposure to water risk using a consistent methodology across commodities and regions. It provides a baseline for understanding how businesses, governments and other interested parties can collaborate to better manage risk and it underscores the importance of water stewardship in all regions and commodities. Water risk is only one part of the story around the mining and metals sector and water. We encourage others to build upon our data, scrutinise it, use it in their own research and decision-making and ultimately collaborate with us to help inform public discourse surrounding mining and metals production.



The development of this report would not have been possible without the input and support of the individuals below. ICMM gratefully acknowledges the following contributions:

External expertise

This dataset and preliminary insights were developed by Dr Stephen Northey, Dr Saori Miyake and Dr Bernardo Mendonça Severiano (University of Technology Sydney, Institute for Sustainable Futures).

It was also reviewed by Dr Nadja Kunz as an independent academic reviewer.

Dr Laura Sonter also provided advice in the initial stages of the project.

ICMM team

Dr Sally Innis led development of the report with support from Will Wardle, Dr Emma Gagen, Marine Godard, Nic Benton, Harriet Prior, Rohitesh Dhawan, Aidan Davy, Tom Horsman, James Clark, Hayley Zipp, Danielle Martin, Dana Cartwright, and Jessica Nicholls.

Appendix: Methodology for the Mining and Metals Water Dataset

1.0 Overview

The objective of this analysis was to characterise the water-related risk context of each mining or metals facility in the ICMM Global Mining Dataset v1.5 by overlaying facility locations with globally consistent geospatial datasets: the WWF Water Risk Filter¹⁹, the WRI Aqueduct Water Risk Atlas²⁰, and the UN Water Stress (2021)²¹. All analyses were conducted using Python, with spatial operations performed using the GeoPandas package and ArcGIS Pro. Each dataset followed a structured, two-stage workflow:

1. **Pre-processing:** Prepare, clean, repair (e.g. geometry) and validate spatial layers, and
2. **Spatial analysis:** Link water risk attributes to facility locations.

Results were exported as structured outputs and compiled into a separate Excel spreadsheet; The Global Mining and Metals Water Dataset. Each workflow was implemented in a dedicated Jupyter Notebook to ensure reproducibility, and auditability.

Additional steps were then taken to analyse the Global Mining and Metals Water Dataset to produce this report.

2.0 Data Sources

2.1 ICMM Global Mining Dataset

The ICMM Global Mining Dataset v1.5 provides point locations and attributes for 12,000 mining and metals facilities worldwide, spanning a broad range of commodity types and asset types (mines, smelters, refineries, plants and steel plants). The Global Mining Dataset served as the primary spatial reference layer for this analysis. All water risk indicators were appended to it as additional columns. More information on the Global Mining Dataset, methodology and definitions can be found [here](#).

2.2 WWF Water Risk Filter (WRF)

The WWF Water Risk Filter (2024 release) is a global polygon dataset representing spatially defined water risk units at watershed scale. The dataset provides continuous global coverage with no spatial gaps. Each terrestrial geocoordinate falls within exactly one polygon per risk category layer.

Five risk category indicators were extracted for this analysis, spanning water availability, drought, flooding, water quality, and environmental factors (see [Table 1](#)). These were chosen as they represent the most relevant and robust indicators for understanding physical water risk exposure across the global mining and metals sector. These water-related indicators are most relevant to mining operations, particularly those that signal potential impacts on business continuity and operations.

19. World Wide Fund for Nature (WWF), (2024) Water Risk Filter <https://riskfilter.org/water/home>

20. WRI Aqueduct (2026) Water Risk Atlas. <https://www.wri.org/applications/aqueduct/water-risk-atlas/>

21. Food and Agriculture Organization of the United Nations (FAO). (2021). AQUASTAT Core Database: SDG Indicator 6.4.2 – Level of water stress. <https://data.apps.fao.org/aquastat/?lang=en>

Table 1: Risk category indicators from the WWF Water Risk Filter (2024) extracted and appended to the ICMM Global Mining Dataset

Risk Category	Definition
Water availability (RC1)	Water availability refers to the physical abundance or lack of freshwater resources, which can significantly impact business through production/supply chain disruption, higher operating costs, and growth constraints, among other mechanisms. Water availability is generally calculated as a function of the volume of surface water and groundwater available in a given area. The WWF Water Risk Filter risk category water availability integrates indicators for Water Depletion, Baseline Water Stress, Blue Water Scarcity and Groundwater levels.
Drought (RC2)	Droughts are a recurring feature of all climates and are generally defined with respect to the long term average climate of a given region. They are characterized by the absence of precipitation long enough to cause a serious hydrological imbalance, impacting various sectors of the economy slowly over time. To produce the WWF Water Risk Filter drought category the Standardized Precipitation and Evaporation Index ²² and the JRC World Atlas of Desertification ²³ were considered.
Flooding (RC3)	Flooding is when there is an overflowing of water onto land that is normally dry. Floods can happen due to overflowing rivers, lakes, or oceans, and are often caused by heavy rainfall, rapid snowmelt, when dams or levees break, or a storm surge from a tropical cyclone or tsunami in coastal areas. Flood can also be caused by the complex moving water from upstream or jammed downstream confluence, instead of just the rainfall or snowmelt on the site. Flood events can impact businesses' operations as well as across their value chain by causing closure of operations, supply chain disruptions and transportation or increased capital costs. The WWF Water Risk Filter risk category 'Flooding' considers both historical patterns of large flood events since 1985 ²⁴ and flood depth within a 100-year-flood-prone extent ²⁵ .
Water quality (RC4)	Water quality indicates whether water resources are fit for human use and ecosystems alike. The WWF Water Risk Filter risk category water quality considers parameters with well documented direct and indirect negative effects on water security for both humans and freshwater biodiversity, which are aligned to the Sustainable Development Goal 6.3.2 ²⁶ . The WWF Water Risk Filter risk category water quality is a comprehensive and robust metric as it integrates a total of 9 best available and peer-reviewed datasets covering different aspects of water quality as well as different modelling approaches: biological oxygen demand as a widely used umbrella proxy for overall water quality; electrical conductivity as proxy for salinity balance and pH alteration; coastal eutrophication potential, nitrate-nitrite concentration, periphyton growth potential, toxicity stress, mismanaged plastic waste, pesticide pollution, and total dissolved solids.
Environmental factors (RC10)	Reputational risk can be driven by negative impacts on local environmental assets and the local prevalence of freshwater biodiversity-related issues. This risk category comprises the following indicators: 1) Freshwater Endemism, 2) Freshwater Biodiversity Richness, 3) Ramsar Wetlands, 4) Ecosystem Condition, and 5) Free Flowing Rivers.

The sub indicators within each risk category cover different timeframes due to data availability. More information on the specific sub indicators can be found in [WWF's Water Risk Filter Indicators Documentation](#).

22.Vicente-Serrano, S.M. et al. (2010) 'A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index' <https://doi.org/10.1175/2009JCLI2909.1>

23.Cherlet, M. et al. (2018) 'WAD | World Atlas of Desertification' <https://wad.jrc.ec.europa.eu/>

24.Brakenridge, G.R. (2020) 'Global Active Archive of Large Flood Events.'

25.Dottori, F. et al. (2016) 'Flood Hazard Map of the World – 100-Year Return Period'

26.UN Environment Programme (2026), Indicator 6.3.2, <https://www.unep.org/goal-6-clean-water-and-sanitation/indicator-632>

2.3 WRI Aqueduct 4.0

WRI Aqueduct 4.0 is a global polygon geodatabase in which each polygon represents a hydrological catchment unit. The polygons form a complete global mosaic with no gaps or overlaps, meaning every land location falls within exactly one Aqueduct polygon. Each polygon contains 13 annual baseline indicators spanning physical water quantity and quality risks, regulatory and reputational risk dimensions, and a country-level ESG risk index.

In addition to the disaggregate indicators, the analysis incorporates the Aqueduct Aggregate Water Risk Indicator using default weightings, defined as follows:

The Overall Water Risk score is a weighted composite of all individual Aqueduct indicators across three risk categories (Physical Risk Quantity, Physical Risk Quality, and Regulatory & Reputational

Risk) applying industry-neutral default weights. It provides a single summary score representing a facility's overall exposure to water-related risks, integrating supply-side pressures (stress, depletion, variability), demand-side threats (flooding, drought), water quality concerns, and governance and reputational factors.

The default weightings used in the Overall Water Risk score can be found in [WRI's Aqueduct 4.0: Updated decision-relevant global water risk indicators](#), and are used to help combine multiple risk factors into a single, balance score that reflects the importance of each factor based on expert judgment.

Table 2 presents the 13 disaggregate indicators extracted from WRI Aqueduct 4.0 and appended to the ICMM Global Mining Dataset.

Table 2: Annual baseline indicators from WRI Aqueduct 4.0 extracted and appended to the ICMM Global Mining Dataset.

Indicator	Definition
Baseline water stress	Ratio of total water demand, covering domestic, industrial, irrigation, and livestock uses, to available renewable surface and groundwater supplies. Higher values indicate greater competition among users for available water resources. Note: This indicator is one of four sub-indicators used to calculate WWF's Water Risk Filter "Water Availability" indicator.
Baseline water depletion	Ratio of total water consumption to available blue water, distinguishing itself from baseline water stress by focusing on consumptive use rather than total withdrawals. Water consumed is not returned to the local basin, meaning higher values indicate a larger impact on local water supply and reduced availability for downstream users.
Interannual variability	Year-to-year fluctuation in available water supply, capturing how unpredictable water availability is from one year to the next. Unlike baseline water stress and depletion, which measure the level of water pressure under average conditions, interannual variability reflects the reliability of that supply. Higher values indicate wider year-to-year variation.
Seasonal variability	Within-year fluctuation in available freshwater supply.
Groundwater table decline	Rate of groundwater level decline in centimetres per year.
Riverine flood risk	Share of population potentially affected by river flooding in an average year, accounting for existing flood defences.
Coastal flood risk	Share of population potentially affected by storm-surge flooding in an average year, accounting for existing coastal defences.
Drought risk	Composite indicator measuring where droughts are likely to occur and the degree to which exposed populations and assets are vulnerable to their effects. It combines three components, hazard (derived from historical precipitation deficits), exposure (based on population and livestock densities, crop cover, and water stress), and vulnerability (a composite of social, economic, and infrastructural factors at national and sub-national levels), assessed over the period 2000 to 2014. Higher values indicate greater overall drought risk.

Indicator	Definition
Untreated connected wastewater	Share of sewer-connected households discharging untreated wastewater.
Coastal eutrophication potential	River-borne nutrient loading that may trigger harmful algal blooms in coastal waters.
Unimproved/no drinking water	Share of population relying on unsafe or unimproved drinking water sources.
Unimproved/no sanitation	Share of population without access to safe sanitation facilities.
Peak RepRisk country ESG risk index	Country-level ESG risk score indicating exposure to environmental, social, and governance issues.

More information can be found in [WRI Aqueduct 4.0 Technical note](#).

2.4 UN Water Stress (2021)

The UN Water Stress dataset is a country-level dataset on the UN's Sustainable Development Goal Indicator 6.4.2 (Level of water stress: freshwater withdrawal as a proportion of available freshwater resources (%)). This indicator is not spatially explicit and is instead reported at a national level, with attribute data only, disaggregated by country, activity and year.

Country attribution was undertaken using Natural Earth Admin 0 polygons as the primary spatial reference. Facility geocoordinates were spatially joined to country polygons using an intersection approach. Where facility points did not intersect a country polygon (for example, at coastal or near-boundary locations), a nearest-country fallback was applied within a 1 km threshold. In cases where spatial inference is not possible or incomplete, the country reported in the ICM dataset was used as a secondary lookup.

The attributed ISO3 country codes were then mapped to UN M49 country codes using a standard lookup table. Where ISO3 to M49 mapping was unsuccessful, a secondary text-based matching process was applied using normalised country names. The final M49 code was used to append the UN Water Stress (2021) indicator to each facility record.

The resulting dataset includes additional fields capturing the inferred country, M49 code, assigned water stress value, and a series of quality assurance flags describing the attribution method and any limitations encountered. For records where UN Water Stress could not be assigned, diagnostic reason codes are included to ensure transparency.

The UN Water Stress Indicator is only available by country, and it does not capture sub-national or catchment-scale variation in water stress. All country

assignments are based on point locations and do not account for operational footprints or cross-boundary hydrological influences.

More information on the UN Water Stress Dataset can be found [here](#).

3.0 Data Preparation

Prior to spatial analysis, each source dataset underwent a structured pre-processing workflow to ensure geometric validity, coordinate system consistency, and suitability for intersection with the Global Mining Dataset v1.5. The following steps were applied to both the WWF WRF, WRI Aqueduct, and UN Water Stress datasets:

1. Data loading and attribute review: source datasets were loaded and inspected to verify completeness of attribute fields, metadata, and spatial extent.
2. Geometry validation and repairs: systematic checks were performed for polygon dataset to identify and flag invalid, empty, or corrupted geometries. Where geometric issues were detected, appropriate repairs were applied to the spatial layers, such as topology repair, and removal of self-intersections.
3. Coordinate reference system (CRS) alignment: both datasets were verified and, where necessary, reprojected to EPSG:4326 (WGS 84 geographic coordinates) for consistency with the GMD.
4. Export of clean spatial outputs: validated datasets were saved as GeoPackage files (.gpkg) for use in subsequent spatial analysis steps.

In addition, a second version of each dataset was prepared in EPSG:3857 (Pseudo-Mercator, unit in metres). This projected version was used exclusively for distance calculations in the nearest-polygon fallback procedure.

4.0 Spatial Analysis

4.1 Approach

Water risk indicators were linked to Global Mining Dataset facility locations using a point-in-polygon spatial join via the GeoPandas python package. Both the WWF WRF and WRI Aqueduct datasets provide continuous global polygon coverage, meaning each facility is expected to fall within exactly one polygon in each dataset. The primary join was performed using the intersects predicate in geographic coordinates (EPSG:4326).

For each facility point, the relevant risk exposure attributes attached to the intersecting polygon were extracted and appended as new columns to the GMD. A dedicated Jupyter Notebook was used for each dataset, following a standardised workflow:

- Load the ICMM Global Mining Dataset.
- Load the pre-processed geospatial source data (GeoPackage).
- Perform the spatial join (point-in-polygon).
- Apply the nearest-polygon fallback for any unmatched points (see Section 4.2).
- Conduct validation checks and maintain an audit log.
- Export structured output files as a comma separated value (CSV) file.

4.2 Nearest-Polygon Fallback

Although both datasets are designed to provide global coverage, a small number of facilities did not intersect any polygon during the primary spatial join (12 facilities for the WWF WRF polygons, and 6 for the WRI Aqueduct polygons). This can occur due to minor geometric inconsistencies at polygon boundaries or coastlines. For any such points, a nearest-polygon fallback procedure was applied:

- Unmatched points were identified following the primary spatial join.
- Both the unmatched points and the source polygons were reprojected to EPSG:3857 to enable planar distance computation in metres.
- The nearest polygon to each unmatched point was identified, and its attributes were assigned to that point.
- The planar distance (in metres) from the facility point to the nearest polygon boundary was recorded.

5.0 Validation

Once the output CSV file was generated from the spatial analysis (steps 4.1 & 4.2), visual validation of the CSV file was conducted with selected sampling points using 'create random points' function' on ArcGIS Pro. Initially 30 points were selected to visually validate the results of the spatial join (point-in-polygon) analysis on Jupyter Notebook. Based on the feedback of this validation process, the python code used for data preparation and the spatial analysis processes were refined to improve accuracy of point-to-polygon distance calculations for complex spatial polygons and the nearest-polygon fallback procedure.

6.0 Report Analysis

These insights were chosen as the most relevant for understanding mining and metals facilities intersection with global water risk exposure.

The UN Water Stress Dataset was not included in the analysis as the country-level granularity of the dataset limited its usefulness when understanding water risk, which is most effectively understood through a catchment-based approach. ICMM is committed to making its research as transparent and accessible as possible, and the full dataset, including the UN Water Stress Dataset, is published so that users can explore additional indicators and conduct their own analysis beyond what is presented in the report.

6.1 Indicators used

The report focuses on five indicators selected in consultation with experts as the most relevant and robust for understanding physical water risk exposure across the global mining and metals sector. We focused on the water-related indicators most relevant to mining operations, particularly those that signal potential impacts on business continuity and operations: flood risk and drought risk (WWF WRF) and baseline water stress, baseline water depletion and interannual variability (WRI).

ICMM stands for mining with principles.

We bring together a third of the global metals and mining industry, along with key partners to drive leadership, action and innovation for sustainable development, ultimately delivering a positive contribution to society.

Through collaboration, ICMM member companies set the standard for responsibly produced minerals and metals in a safe, just and sustainable world.

Disclaimer

This publication contains general guidance only and should not be relied upon as a substitute for appropriate technical expertise. Although reasonable precautions have been taken to verify the information contained in this publication as of the date of publication, it is being distributed without warranty of any kind, either express or implied. This document has been prepared with the input of various International Council on Mining and Metals ('ICMM') members and other parties. However, the responsibility for its adoption and application rests solely with each individual member company. At no stage does ICMM or any individual company accept responsibility for the failures or liabilities of any other member company, and expressly disclaims the same.

Each ICMM member company is responsible for determining and implementing management practices at its facility, and ICMM expressly disclaims any responsibility related to determination or implementation of any management practice. Moreover, although ICMM and its members are committed to an aspirational goal of zero fatalities at any mine site or facility, mining is an inherently hazardous industry, and this goal unfortunately has yet to be achieved.

In no event shall ICMM (including its officers, directors, and affiliates, as well as its contributors, reviewers, or editors to this publication) be liable for damages or losses of any kind, however arising, from the use of or reliance on this document, or implementation of any plan, policy, guidance, or decision, or the like, based on this general guidance. ICMM, its officers, and its directors expressly disclaim any liability of any nature whatsoever, whether under equity, common law, tort, contract, estoppel, negligence, strict liability, or any other theory, for any direct, incidental, special, punitive, consequential, or indirect damages arising from or related to the use of or reliance on this document.

The responsibility for the interpretation and use of this publication lies with the user (who should not assume that it is error-free or that it will be suitable for the user's purpose) and ICMM. ICMM's officers and directors assume no responsibility whatsoever for errors or omissions in this publication or in other source materials that are referenced by this publication, and expressly disclaim the same.

Except where explicitly stated otherwise, the views expressed do not necessarily represent the decisions or the stated policy of ICMM, its officers, or its directors, and this document does not constitute a position statement or other mandatory commitment that members of ICMM are obliged to adopt.

ICMM, its officers, and its directors are not responsible for, and make no representation(s) about, the content or reliability of linked websites, and linking should not be taken as endorsement of any kind. We have no control over the availability of linked pages and accept no responsibility for them.

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of ICMM, its officers, or its directors concerning the legal status of any country, territory, city or area or of its authorities, or concerning delimitation of any frontiers or boundaries. In addition, the mention of specific entities, individuals, source materials, trade names, or commercial processes in this publication does not constitute endorsement by ICMM, its officers, or its directors.

This disclaimer should be construed in accordance with the laws of England

ICMM
53-64 Chancery Lane
London, WC2A 1QS
United Kingdom
+44 [0] 20 7467 5070
info@icmm.com
icmm.com

July 2026

