IGF

INTERGOVERNMENTAL FORUM
on Mining, Minerals, Metals and
Sustainable Development

IGF CASE STUDY

Mine Water Management:

Case Studies from Mongolia and Chile

Secretariat hosted by

IISD

Secretariat funded by

Canada

Kingdom of the Netherlands

INTRODUCTION

Water is essential to the mining industry. Moreover, access to clean water is a human right and a valuable cultural, economic, and environmental resource. This interdependency makes water security and sustainable development around water resources a shared interest among users—a topic most effectively managed at the watershed scale.

As a significant user of water resources—for ore processing, cleaning, maintenance, and staff use—and as a source of potential contaminants, mining requires effective governance at the watershed scale. Companies typically need to spend a considerable amount of time, energy, and resources managing the water that comes into and flows out of their operations. This includes constantly controlling and managing any excess water (such as rainfall, runoff, or groundwater) that may come in contact with mine operations. Governments working with mining companies to ensure that water resources are properly and effectively managed will help balance the company's needs with those of other users, including the most vulnerable, while minimizing the risk of tensions and conflict between competing users.

Significant risks to water security remain a reality in many mining jurisdictions, and if left unaddressed, these risks will only increase in the context of climate change. The impacts of climate change on water quality and availability within a watershed—a function of increasing rainfall variability, rising temperature, and intensifying extreme weather events—will directly impact all users.

Governments are uniquely placed to manage water resources at the watershed scale. This stands in contrast to the individual users, who can only manage their actions around water within the footprint of their control. The key objective with respect to mining governance within the context of watershed-level management is to ensure that mine water management practices fit within the broader management of the watershed's hydrology, hydrogeology, ecosystems, water users, cultural values, and risks to the sustainability of each. Through a holistic, long-term approach, governments can promote sustainable development in the mining sector within the larger watershed context. More support can be found in the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development's (IGF) 2021 *Guidance for Governments: Environmental Management and Mining Governance*.

Good governance is founded on strong legal frameworks. Governments should strive to build legal frameworks that aim to incorporate international standards

and best management practices built on the experience of other jurisdictions. This is, of course, not without its challenges. One long-standing legal challenge for managing water is that it is a common resource with often uncertain ownership and rights. Granting rights to nature is an emerging trend in national legal frameworks, originating from Indigenous views of the rights of nature. Bolivia has granted nature rights in its Laws on the Rights of Mother Nature, and Ecuador granted rights to Mother Earth in its constitution in 2008. Legal rights have also been granted to the Atrato River in Colombia, the Ganges and Yamuna rivers in India, and the Whanganui River in New Zealand. Legal rights allow the river to litigate for damages from pollution or use. Representatives such as individuals or communities can then work to enforce the rivers' rights.

Mongolia and Antofagasta, Chile, are two jurisdictions where governments have developed watershed-level management frameworks for their water resources. Mongolia's framework started at the country-wide level and divided up administration into management basins. Chile's water management framework is administered by states at the regional level. Mining is a crucial part of these frameworks; it plays an important role in both jurisdictions' economies, places a high demand on water use in arid environments, can generate conflicts with other water users, and is a potential source of contaminants.

Following an overview of important components of watershed management, the two case studies show how each jurisdiction has evolved and is making improvements.

KNOWLEDGE AND RISK-BASED PLANNING

To effectively manage resources at the watershed level, governments require an understanding of the watershed's meteorology, hydrology, hydrogeology, and water quality, alongside community water uses, community water values, and industrial water uses for both surface and subsurface water flows. An important step for governments is to begin to generate or acquire a comprehensive dataset on water resources. As the dataset is built, the government can adjust its water management objectives, policies, and legal requirements in response to their increased understanding of the watershed's dynamics.

Typical data collection strategies employed by governments include surveys, roundtables, and committees; physical data collection (e.g., water sampling) and analysis; and strategic environmental assessments. Once datasets are gathered to the extent required to understand watershed-level resource management requirements and associated risks, governments can develop and implement policies and management plans tailored to the watershed's unique context.

An important component in the transition from data collection to the development of policies and management plans is to apply a risk-based approach. Understanding risks specific to the watershed, including biophysical, socio-economic, and regulatory risks, is a key step to watershed-level management. Risk management should be built on the perspectives of affected stakeholders and should consider climate change impacts. This will help to ensure the sustainability of any management and mitigation practices that are developed. Climate change scenarios and sensitivity analyses should be incorporated into all aspects of water management, both at the watershed level and at the user level. Consideration should not only be placed on the direct risks resulting from changing hydrology and meteorology but also how climate change may exacerbate socio-economic risks.

Resilience and flexibility are key characteristics of a strong risk-based watershed management system. Adaptive management strategies are thus an integral component of managing and responding to risk. Adaptive management can follow many forms, including detailed, site-specific adaptive management plans or broader guidelines at the watershed level that trigger changes to management strategies based on predefined thresholds or realization of risks.

STAKEHOLDER ENGAGEMENT AND COLLABORATION

Watershed-level management is most effective when stakeholders are aligned and informed. This is accomplished through strong communication and transparency. Open discussion and engagement of stakeholders that consider individuals' priorities, plans, and risks act to promote a holistic means of planning and risk mitigation. Thus, watershed-level policy should incorporate tools and platforms to facilitate stakeholder communication, engagement, and collaboration. Policy should specify when certain collaborative practices are required and which stakeholders should participate in them.

Stakeholder engagement should be incorporated through the full mine life cycle with emphasis on early, open, and inclusive stakeholder engagement. Tools and platforms commonly incorporated within watershed-level management include:

- Working groups and watershed committees
- Consistent and transparent reporting requirements
- Involvement of community and stakeholders in environmental and social impact assessment, permitting processes, and the development of management plans
- Online tools for data sharing and communications
- Grievance mechanisms
- Participatory monitoring programs.

Guidance regarding stakeholder engagement includes the U.S. Environmental Protection Agency's *Getting in Step: Engaging Stakeholders in Your Watershed* (2013) and the International Finance Corporation and International Council on Mining and Metals' collaborative guidance, entitled *Shared Water, Shared Responsibility, Shared Approach: Water in the Mining Sector* (2017). Although the majority of these resources are directed at mining companies, many of the principles within are transferable to governments and their associated watershed-level management policies.

CLEAR POLICIES AND MANAGEMENT PLANS

Effective watershed-level management policies and plans are simple, clear, consistent, and easy to implement, as well as appropriate for the watershed's hydrological and social context. It is important to coordinate across ministries to be efficient, effective, and consistent. This may include decentralizing responsibilities to regions and watershed authorities, clarifying roles and responsibilities, allocating sufficient funding for all levels of governance, and training and education.

Policy and watershed management plans should cover a comprehensive suite of content. Similarly, legislation should be in place to ensure that requirements in the plans are embedded within legal frameworks with adequate resources for effective implementation. Policies, legislation, and management plans at the watershed level should consider the following content, as applicable:

- Roles and responsibilities in watershed management

- Watershed-level objectives and overarching goals
- Watershed-level risks and challenges (including climate change considerations)
- Current and future supply and demand
- Water protection or conservation zones
- Transboundary issues
- Stakeholder engagement, communication, and consultation
- Monitoring and evaluation programs
- Monitoring networks along with metrics or indicators
- Data-sharing programs
- Adaptive management strategies
- Requirements for user-level management plans
- Allowable water uses, extraction rates, discharge rates, effluent quality, and receiving environment objectives at the watershed level and the user level
- Setbacks from open water, significant groundwater seepages, and sensitive aquifers.

Watershed-level management also translates into actions needed for water management for individual mining projects. The following are the key actions as discussed further in the 2021 IGF *Guidance for Governments: Environmental Management and Mining Governance* (IGF, 2021):

1. Consider water management at the watershed level when setting objectives for water use and discharges.
2. Set effluent quality and quantity guidelines based on receiving water objectives and site-specific conditions.
3. Control water use and discharges through surface water and groundwater permitting.
4. Review and approve water management plans prior to permitting, and monitor the results of implementation throughout all mine phases.
5. Allocate financial and human resources for timely and effective reviews of monitoring data.
6. Enforce compliance with water permits.

MONITORING AND EVALUATION

Monitoring and evaluation of the implementation of a government's watershed-level management framework is key to understanding and communicating the efficacy of policies, plans, and strategies. For effective management, a government should ensure monitoring and reporting are carried out consistently and effectively. The monitoring network is usually a combination of monitoring data collected at government stations and data collected and shared by industrial users. Typically, data collection and analysis of industrial activities (e.g., mine water management) is the responsibility of the companies, as specified by their operating permits. However, it is government's role to set standards so that monitoring and reporting are effective, consistent, compatible, and shared. These requirements should be embedded in permits, regulations, policies, and guidance.

Community members can help governments track performance and identify water management issues through participatory monitoring programs (PMPs) and community-based water monitoring (CBWM) programs. These programs add resources and an additional layer to performance monitoring while also building the community's trust in government and the mine through active participation.

They should be encouraged in watershed management and supported by both government and industry.

Lastly, there are opportunities to apply technologies, such as automated and remote sensing technologies, to enhance performance monitoring. These technologies can improve the timeliness of responses to unexpected events and prevent pollutants from being released into the environment. Online tools should also be promoted to share water data, track regional trends, improve regional planning, and more fully engage communities.

Watershed management can be complex. It involves detailed technical modelling to understand seasonal and daily variability in surface waters and groundwater aquifers, multiple users with competing needs, and the impacts of a changing climate. Innovations are being made on how to measure, analyze, model, and balance water supply and demand. Governments should continue to seek technical assistance and consider innovations for continual improvement and meeting their sustainability goals.

WATERSHED MANAGEMENT IN MONGOLIA AND ANTOFAGASTA, CHILE

Two jurisdictions highlighted for their good watershed management practices are Mongolia and Antofagasta, Chile. Case studies for each are presented below. Governments can learn from the experience of these two jurisdictions, keeping in mind that there are common elements to water management and a variety of factors to consider when developing and improving a country's legal framework around water management and mining. Both case studies show the importance of:

- Having centralized leadership for a national sustainable water management vision and goals.
- Decentralized plans and administration in adapting the vision to regional plans that consider different regional hydrological and social situations.
- Gathering and sharing data.
- Reviewing and improving management strategies based on lessons learned.

CASE STUDY 1: MONGOLIA

BACKGROUND FOR WATERSHED MANAGEMENT FRAMEWORK

Mongolia has had environmental protection legislation in place since the early 1990s and began working on watershed management planning in 2012. Key legislation pertaining to water management in Mongolia includes the following:

- 1992 (last amended 2019): The Constitution of Mongolia protects human rights and the environment of Mongolia
- 1995: The Law on Environmental Protection
- 2009: The Law on Prohibition of Mineral Exploration and Mining Activities in Areas in the Headwaters of Rivers, Protected Water Reservoir Zones and Forested Areas
- 2011: Government decree (302/2011) on ecological and economic base value of water, and water use coefficients
- 2012: The Law on Environmental Impact Assessment
- 2012: The Law on Water
- 2012 (last revised 2019): The Law on Water Pollution Fee
- 2012: The Law on Natural Resource Use Fee
- 2013: Government decree (326/2013) on water use fee and rebate
- 2013: Government decree on updating water use coefficients (327/2013).

A comprehensive Integrated Watershed Management Plan (IWMP) was published in 2013 in response to requirements in Mongolia's Law on Water (2004, updated in 2012) and the Water National Programme (Ministry of Environment and Green Development, 2013). The Law on Water also established administrative bodies for the river basins. The management program decentralized the management of river basins to regional river basin organizations, comprising a river basin council and a river basin authority. Mongolia's law prohibiting mineral exploration and mining development in headwaters and protection zones is also an important piece of legislation guiding the IWMP implementation.

The IWMP is organized into the following sections (Ministry of Environment and Green Development, 2013):

- Background, including strategic goals.
- Sources of water, describing the climate, landscape, surface, and groundwater regimes.

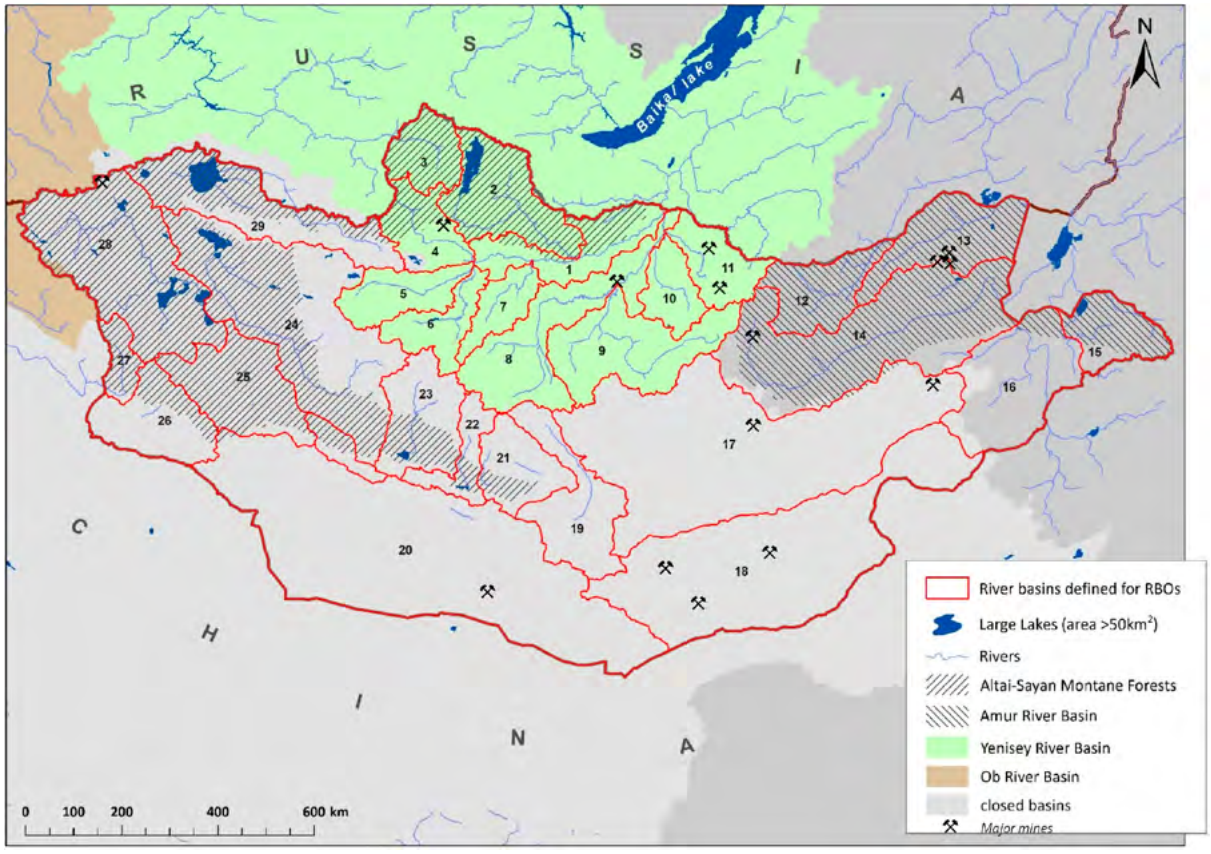
- Demand for water related to the socio-economic context and the water demands for domestic, agricultural, and industrial sectors.
- The policy and development context, including relevant legislation and priorities.
- Issues and ways to address the issues, including targets and measures for evaluation, available financial and human resources, and risks.
- Implementation of the plan, including costs, organization, and an action plan.

An interesting aspect of the 2013 IWMP is that it divides Mongolia into three types of management zones, defined as surface water, surface and groundwater, and groundwater-dominated areas. Then each area is divided into drainage basin areas (Ministry of Environment and Green Development, 2013). The watershed administration boundaries (red lines) and locations of major mines (mine icons) are shown in Figure 1.

IMPLEMENTATION, EVALUATION, AND IMPROVEMENTS

Prior to the 2013 national IWMP, the Integrated Watershed Management Plan, Model Region Mongolia (IWMP-MoMo) was initiated in 2006 to develop and study watershed management strategies for the Kharaa watershed in northern Mongolia. The Kharaa watershed is dominated by surface water and supports a variety of communities and industries—including copper and gold mining. The model program was funded by the German Ministry of Education and Research (BMBF) as part of the FONA (Research for Sustainable

FIGURE 1. MONGOLIA WATERSHED ADMINISTRATION BOUNDARIES



Source: Adapted from Surenkhorloo et al., 2021, p. 2.

Development) initiative and supported by the Government of Mongolia (Karthe & Borchardt, 2012). At the end of the project, in 2018, policy briefs summarized the findings and recommendations based on 12 years of project implementation. Policy recommendations resulting from the project that can be applied to other jurisdictions building watershed management programs are summarized as follows (based on Ministry of Environment and Tourism, 2018):

For urban water management:

- Groundwater modelling and simulations should be carried out in all regions as an important tool for water management.
- Drinking water infrastructure improvements are needed, and it is recommended that metering and controls be installed in urban centres.
- Wastewater treatment improvements are needed.
- Water tariffs and fees need fair structuring.
- Technologies need to be standardized.
- Training is needed for water treatment technicians.

For environmental monitoring and data accessibility:

- Monitoring data should be standardized and merged for comparisons.
- Monitoring programs should focus on high-risk areas such as tailings dams.
- Data should be centralized and available to everyone.
- Monitoring programs should be sustainable and look to innovative methods of collection.

For free and open-source geodata management:

- All data and software for geologically referenced data should be free and open source to allow access by all users and minimize government costs.

For water education:

- Government should facilitate water management education for all stakeholders and promote research and data exchange.
- Programs should be included from kindergarten through university, vocational training, and public education.

Administrative and financial aspects of watershed implementation:

- Roles and responsibilities for the implementation of water management legislation should be clearly defined across ministries and all levels of government to avoid duplication and gaps.
- Funding programs should be clarified, formalized, and adequate to support the implementation of water management tasks at all levels of government.

Further analysis by Surenkhorloo et al. (2021) identified challenges with the implementation of the watershed management framework due to rapid development, limitations in technical capacity, and the availability of monitoring data.

Data collection, management, and modelling are of utmost importance for watershed management to be effective. Mongolia's Ministry of Environment and Tourism has developed widespread monitoring programs to collect data and shares some of the summary data on its environmental database website (https://eic.mn/). Part of the data collection includes participatory monitoring, which it promoted with training in 2017 with the support of the IFC, the Government of Canada, EXIM, and the 2030 Water Resources Group (WRG)

(Sustainability East Asia LLC & Groundwater Solutions LLC, 2017).

Groundwater-dominated hydrologic systems, which are found in much of Mongolia, are more challenging to monitor, understand, and manage than surface water due to the complex subsurface geological formations that control aquifers. The Oyu Tolgoi mine in Omnogovi province lies in the Galba–Uush–Doloodin Govi water basin in the Gobi Desert. This basin is predominantly groundwater and—in addition to mining—must meet the water needs of the area's herders and communities. Groundwater contributes approximately 82% of water use in Mongolia, even though groundwater makes up only 1.9% of the total water volume in the country. Groundwater used for mining is considered non-renewable fossil water, and the groundwater demand by mining in the Gobi Desert is predicted to exceed supply in 2021 (2030 WRG, 2021). Competing uses for a scarce resource is a source of potential conflict.

To understand available resources, a monitoring network of 273 groundwater wells provides data to government authorities (2030 WRG, 2021). The government is also working to develop an online portal for groundwater data for decision making, compliance management, and other stakeholder use. The new online tool will integrate monitoring data, machine learning, and artificial intelligence for the predictive modelling needed for effective water allocation and management (2030 WRG, 2021).

CONCLUSIONS FOR MONGOLIA

The Government of Mongolia took great initiative in developing a watershed-level approach to water management. Dividing the watersheds by surface and groundwater contributions allows each program to focus on issues that are important for the specific hydrologic regime. The approach to water management is different for a basin with a surplus of surface water compared to a basin that is water stressed and dependent on ancient groundwater sources.

Model regional watershed programs provide real-world experience to determine issues and solutions that can be adapted to management in the other watersheds in Mongolia and throughout the world. Some initiatives for improvement arising from the programs include:

- Development of a monitoring network
- Modelling of surface water and groundwater to understand and predict the water systems
- Creation of an online portal for groundwater.

Mining activity in the Gobi Desert will continue to be a challenge, given the area's water scarcity and competing demands; however, the watershed management approach that has been developed by the government and affected stakeholders provides a good foundation through which to manage the issues. All competing water demands are brought to the table to find solutions through the watershed management approach.

An overall lesson from Mongolia is that each watershed has different issues, and there are challenges with the implementation of the watershed management frameworks. It is important to build capacity, monitor the impacts, continuously analyze results, and engage with stakeholders to continue to improve the effectiveness of watershed management.

CASE STUDY 2: ANTOFAGASTA, CHILE

BACKGROUND FOR WATERSHED MANAGEMENT FRAMEWORK

Water management in Chile began with federal legislation, watershed-level planning, and administration assigned to each state. The water management area of Antofagasta, in the north of the country, covers an area of 127,221 km^2 and is divided into 10 watersheds. The government is tasked with protecting its surface waters and groundwater aquifers. There are multiple demands for water across the region, including agriculture, mining, hydroelectric power, municipal consumption, and various industrial sectors (Arcadis, 2016).

Key pieces of legislation governing water management in Chile include:

- The Water Code (DFL 1122), which protects water resources, governs water users, and requires the establishment of a surface water and groundwater flow and quality monitoring network that is available to the public.
- The Law (19,300) on General Bases of the Environment, which provides a basis for environmental protection and includes requirements for strategic environmental assessments and project impact assessments, including assessment of impacts to water.
- The Law (19,253) for Establishing Standards for Indigenous Protection, Promotion, and Development and Creation of a National Corporation for Indigenous Development, which includes the provision of an Indigenous Land and Water Fund. This law recognizes Indigenous water rights and provides funding for compensation of loss of water rights after the water has been allocated. However, Indigenous rights for water should ideally be included in the watershed management plan before the water has been allocated (Macpherson, 2017).

Water management planning in Antofagasta is headed by the Ministry of Public Works, is well developed, and has evolved over the last couple of decades to be more comprehensive and integrated. A strategic plan for water resources for the Antofagasta region was developed in 2012 (Arrau Ingenieros Consultores, 2012) and updated in 2016 (Arcadis, 2016). The plan includes all key components of an integrated and comprehensive water management plan. The first chapters set the objectives for water management and provide the background and update from the 2012 strategic plan. The 2012 strategic plan sets the basis for the plan by characterizing the background water regime, the capacity and risks of

existing infrastructure, areas requiring protection, institutional and economic constraints, potential management tools, and conservation requirements. The 2016 plan then improved on the 2012 plan by determining how the objectives fit within the national water strategy (i.e., efficient and sustainable management, institutional improvement, addressing shortages, social equality, and informed citizens) and completing a gap analysis. The 2016 plan then developed priorities, a budget, and monitoring and evaluation details. An important aspect of the 2016 plan is that it incorporated citizen consultation, including three rounds of workshops in six communities.

The water management program includes a comprehensive environmental assessment and permitting framework and is continually updated with ongoing monitoring and adaptation for climate change. Note that Antofagasta has state-level administration covering multiple watersheds. Figure 2 shows the Antofagasta state watershed boundaries, the locations of major mines, groundwater rights (yellow dots), and surface water rights (pink dots). This illustrates the challenges of managing multiple users in all watersheds. Note that a significant constraint on and challenge for water management governance is that water was allocated as rights with no expiry date rather than licences.

Within this framework, mines like Lomas Bayas (previously owned by Xstrata Copper and now owned by Glencore plc.) need to develop water management plans that meet the government's clear water protection requirements. Xstrata Copper developed the mine's water management plan with community input and helped improve local water management and agricultural activities (International Council on Mining and Metals, 2012). In this manner, the mine-level water management planning mirrors and should complement the state-level water management planning.

IMPLEMENTATION, EVALUATION, AND IMPROVEMENTS

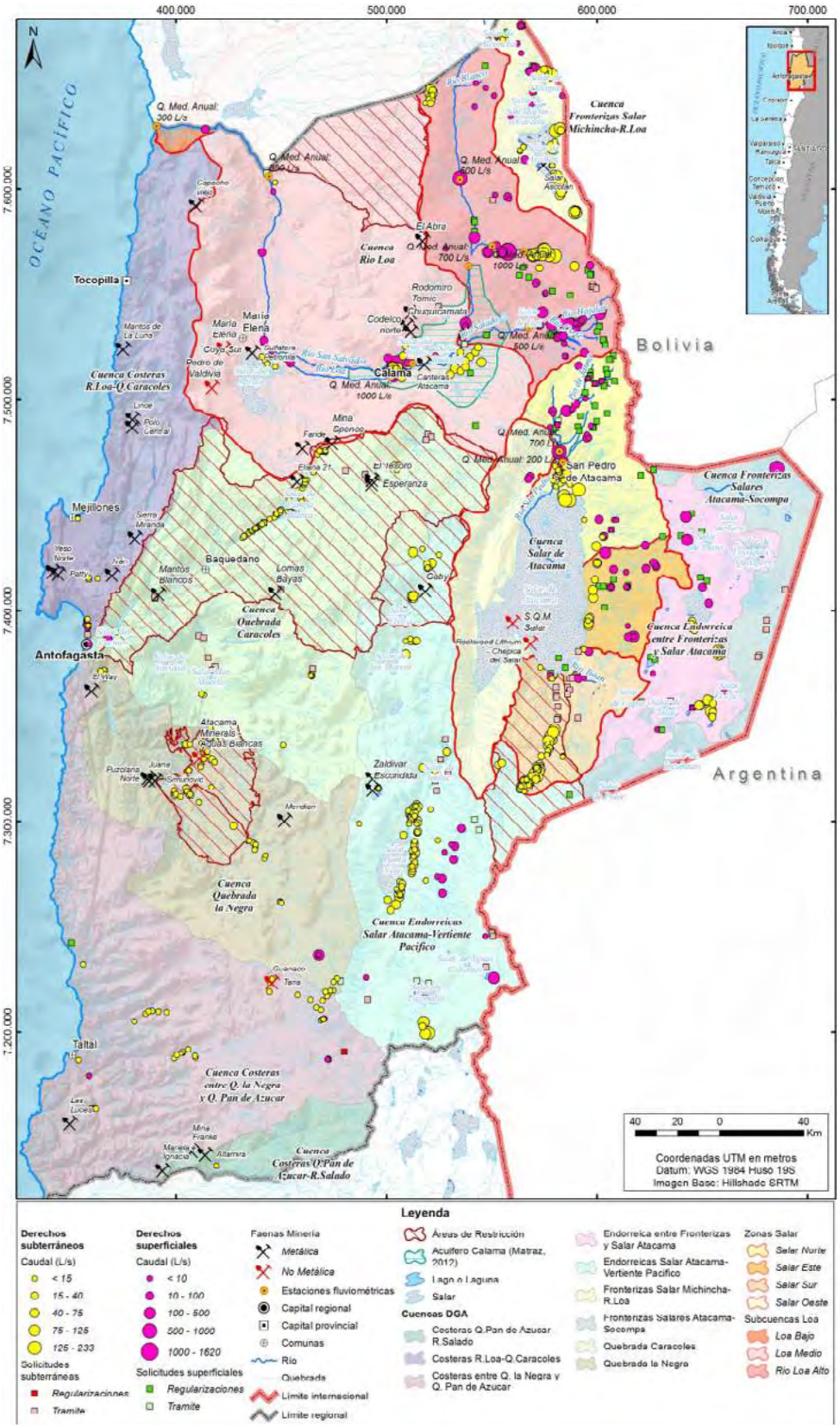
Both federal and local initiatives will further assess and improve water management in Chile broadly and Antofagasta state more specifically. At the federal level, in response to climate change, sustainability, and equality goals, Chile developed an initiative called Plan Chile 30/30, Public Works and Water for Development (Dirección de Planeamiento, 2018). Plan Chile 30/30 was based on consultations with over 10,000 participants from all areas of the country, as well as all levels of government, industry, academia, Indigenous Peoples, and civil society. A gap analysis was completed, and plans were developed for each state in response to feedback from the consultation process. Priorities identified for Antofagasta included improving the quality and continuity of potable water, especially in small communities; supporting infrastructure in isolated communities; and creating administrative bodies needed to manage development (Dirección de Planeamiento, 2018).

The overall new vision looking forward to 2030 includes some key improvements:

- Decentralization and better coordination among all levels of government, including in capacity building and investment.
- Standardized data collection, improved access to information, and additional support for data analysis.
- Strengthened funding for and enforcement of the Water Code.
- Development of infrastructure and institutions to improve water security for all citizens and to minimize the risks from climate change and natural disasters.

Detailed implementation of water management happens at the state level. The Regional Government of Antofagasta commissioned a technical study on the

FIGURE 2. ANTOFAGASTA WATERSHED BOUNDARIES, MAJOR MINES, GROUNDWATER AND SURFACE WATER RIGHTS



Source: Arcadis, 2016, p. 33

Loa River watershed, which covers an area of 33,081 km^2. The Loa River is a principal watercourse from the Atacama Desert and is an important watershed in the Antofagasta water management zone. Mining comprises 60% of the water demand in the Loa River watershed, which must be balanced with the water needs and rights of Indigenous communities and demands from municipalities and the agricultural sector (Centro de Ecología Aplicada Ltda, 2020). Centro de Ecología Aplicada Ltda's 2020 study objectives were to assess environmental flow needs and ecosystem services, complete a cost-benefit analysis, and develop a management system that contributes to the sustainability and protection of aquatic resources. Calculating the environmental flows and completing the valuation of ecosystem services proved a complex undertaking; however, the resulting cost-benefit analysis provides a strong tool for watershed managers to assess the efficiency of alternative scenarios for allocating water sources (e.g., desalinization plant versus river water) and charging fees to industrial water users. As part of the study project, training and capacity-building programs will be designed and delivered so the state government can continue to implement the management tool.

Further changes in water management may be coming, as current constitutional reforms will be addressing rights to water (MacPherson & Salazar, 2020). Changing water use to a licensing system with expiry dates and protecting Indigenous and community rights to clean water would improve the ability of governments to effectively manage their water resources.

CONCLUSIONS FOR ANTOFAGASTA, CHILE

Antofagasta has completed comprehensive watershed planning to manage water use in areas with high potential for conflict: in an arid climate with extensive mineral resources, remote communities, agriculture, and other industries. Lessons learned from Antofagasta that could be considered in other jurisdictions that are developing and improving their water management are as follows:

- Establishing a national vision and initiatives for sustainable water management is crucial—supported by decentralized and coordinated management at the watershed or state level. Regular, renewed vision and consultation initiated at the federal level for Plan Chile 30/30 provided a strong impetus for continuing to make improvements at the state level.
- There are common challenges to overcome in watershed management, which include availability and analysis of technical data, government coordination, and funding.
- Watersheds have diverse needs and goals. Extensive consultations with stakeholders, similar to those conducted to develop Plan Chile 30/30, help address these diverse needs and priorities.
- Complex watersheds with many users require highly technical planning. Detailed technical cost-benefit analyses using environmental flows and ecosystem services are one tool used to help build the robust technical capacity needed for complex watershed management.
- The legal framework of water rights and use and discharge licensing is fundamental for efficient water management.

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Published by the International Institute for Sustainable Development

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IGF

The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) supports more than 70 nations committed to leveraging mining for sustainable development to ensure negative impacts are limited and financial benefits are shared. It is devoted to optimizing the benefits of mining to achieve poverty reduction, inclusive growth, social development and environmental stewardship.

The IGF is focused on improving resource governance and decision making by governments working in the sector. It provides a number of services to members including: in-country assessments; capacity-building and individualized technical assistance; guidance documents and conferences which explore best practices and provide an opportunity to engage with industry and civil society.

The International Institute for Sustainable Development has served as Secretariat for the IGF since October 2015. Core funding is provided by the governments of Canada and the Netherlands.

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