



Permanent Forum of  
**Binational  
Waters**

**AIDA**  
International Association  
for Water Law

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Policy Brief

# **EMERGING POLICY THEMES FOR INTERCONNECTED WATERS**

INTEGRATED APPROACHES TO SURFACE WATER-GROUNDWATER

**Authors: Paul Stanton Kibel, Raquel Neri Barranco, Rosario Sanchez, Gabriel Eckstein.**

Permanent Forum of Binational Waters and International Association for Water Law.

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**JULY 2025**



## Participants of the Seminar Series:



**Imad Antoine Ibrahim**  
Assistant Professor, University of Twente



**Paul Stanton Kibel**  
Professor, Golden Gate University



**Heping Dang**  
Assistant Professor, The Chinese University of Hong



**Carmen Julia Navarro**  
Associate Professor, Chihuahua Autonomous University



**Robyn Stein**  
Buchler-Stein Consultants



**Gabriel Eckstein**  
Professor, Texas A&M University



**Jonathan Lautze**  
Research Group Leader, International Water Management Institute



**Gilbert Anaya**  
Division Chief, U.S. International Boundary and Water Commission



**Juan Pablo Galeano**  
Environmental Lawyer

## Links to the recording of the events:

[Hydrologic Realities and Delusions at the Domestic Level: Regulating Interconnected Surface Waters and Groundwater](#)

[Hydrologic Realities and Delusions at the International Transboundary Basin Level: Regulating Interconnected Surface Waters and Groundwater](#)

**Coffee Break**

**Hydrologic Realities and Delusions at the Domestic Level: Regulating Interconnected Surface Waters and Groundwater**

**PANELISTS**

- Paul Stanton Kibel**  
California Interconnected Surface Waters and Groundwater
- Carmen Julia Navarro**  
Mexico's Interconnected Surface Waters and Groundwater
- Heping Dang**  
China's Interconnected Surface Waters and Groundwater
- Robyn Stein**  
South Africa's Interconnected Surface Waters and Groundwater

**MODERATOR**

- Imad Antoine Ibrahim**  
University of Twente, Holland

Save the date

Co-organized by: Permanent Forum of Binational Waters, AIDA International Association for Water Law

NOVEMBER 14<sup>th</sup> 9:00 AM CENTRAL TIME

zoom

THIS EVENT IS MADE POSSIBLE THANKS TO: WATER RESOURCES RESEARCH CENTER, Texas Water Resources Institute, North American Development Bank

**Coffee Break**

**Hydrologic Realities and Delusions at the International Transboundary Basin Level: Regulating Interconnected Surface Waters and Groundwater**

**PANELISTS**

- Gabriel Eckstein**  
Interconnected Waters under International Water Law
- Jonathan Lautze**  
Interconnected Waters in Transboundary Basins Shared by Botswana and South Africa

**MODERATOR**

- Paul Stanton Kibel**  
Executive Council, AIDA

Save the date

Co-organized by: Permanent Forum of Binational Waters, AIDA International Association for Water Law

DECEMBER 5<sup>th</sup> 9:00 AM CENTRAL TIME

zoom

THIS EVENT IS MADE POSSIBLE THANKS TO: WATER RESOURCES RESEARCH CENTER, Texas Water Resources Institute, North American Development Bank

## Executive Summary

Although typically regulated as if they were hydrologically distinct, there is growing recognition that surface water and groundwater are often interconnected and constitute a single, integrated natural resource. In this report, the Permanent Forum on Binational Waters (PFBW) and the International Association for Water Law (AIDA) explore emerging policy themes related to these interconnected water resources, with the goal of promoting integrated approaches that better reflect hydrological realities. The policy themes and insights presented in this report are drawn from the perspectives of speakers who participated in the Interconnected Waters webinar series organized and hosted by PFBW and AIDA in 2024.

## 1. Distinguishing Different Scenarios for Interconnected Waters



There are two primary types of hydrological interactions between surface water and groundwater: the losing stream and the gaining stream scenarios. Each scenario presents distinct concerns and requires different regulatory responses.

In a losing stream scenario, water from surface sources—such as rivers, lakes, reservoirs, canals, irrigation return flows, or runoff—percolates through the soil to recharge a groundwater aquifer located beneath the surface water body. This recharge can be diminished by reductions in surface water availability or flow (e.g., increased diversions) or by structural interventions designed to limit seepage, such as canal lining. For instance, the All-American Canal in California (United States), which lies above the Mexicali groundwater aquifer that spans the Mexico–United States border, was recently lined with concrete to prevent seepage. This lining project reduces natural recharge to the binational Mexicali Aquifer, potentially harming wetlands, irrigation supplies, and drinking water sources in Mexico.

Additionally, groundwater quality in such systems may be affected by seepage and runoff originating from irrigation, mining, stormwater, and other non-point sources.

In general, when considering losing versus gaining stream scenarios, the focus lies on the relative elevations of

surface water bodies and nearby aquifers. In areas where the groundwater table lies below the water level of an adjacent surface water body, the surface water contributes to (i.e., is lost to) the aquifer. In such cases, the stream is referred to as a “losing” stream because it loses water to the underlying groundwater system. Conversely, in areas where surface waters are surrounded by steep terrain, the groundwater table may be higher than the elevation of the surface water body, causing the aquifer to discharge water into the stream. Here, the stream is termed a “gaining” stream, as it gains water from the aquifer.

However, excessive groundwater pumping can lower the water table to the extent that a stream, once gaining, can become losing within the zone of influence of the pumping well, thereby reducing instream flows. This relationship is dynamic and must be understood in relation to temporal and spatial variability in surface-groundwater interactions. Seasonality, hydrologic timescales, and water diversions from both aquifers and surface water bodies all influence the magnitude and direction of these interactions, with implications for both short- and long-term water availability.

The natural complexity of these connections presents significant regulatory challenges, particularly when the surface water and/or groundwater resources involved span interstate or international boundaries.

## 2. Land Use, Impervious Surfaces and Groundwater Recharge Zones



In addition to the way canal lining can interfere with groundwater recharge, similar disruptions occur in urban land use settings. When rain falls on natural, earthen land, it percolates into the soil and replenishes underlying aquifers. In urban environments, however, increasing portions of land are paved over with impervious surfaces—such as asphalt or concrete streets, highways, parking lots, driveways, and sidewalks—or covered by buildings. As a result, rainwater has fewer opportunities to infiltrate the soil and recharge groundwater.

Moreover, in heavily urbanized areas, rainwater runoff from these impervious surfaces is often directed into stormwater systems that discharge into urban rivers and creeks. These channels are frequently lined with concrete, further preventing infiltration. This infrastructure diverts rainwater away from the soil, reducing recharge potential and increasing flood risks.

Land use policies play a critical role in determining the balance between permeable and impermeable surfaces in cities. For example, regulations can require the preservation of natural green spaces (e.g., parks or grass areas) or mandate the use of permeable materials in driveways and sidewalks to allow some rainwater infiltration. Recognizing the importance of preserving groundwater recharge zones, some international efforts have emerged. For the international transboundary context, the International Law Commission's Draft Articles on the Law of Transboundary Aquifers define a recharge zone as "a zone which contributes water to an aquifer, consisting of the catchment area of rainfall and the area where such water flows to an aquifer by runoff and infiltration through soil." The Articles further state that parties should take "appropriate measures to prevent and minimize detrimental impacts" on recharge processes. However, no binding international treaty currently governs or protects aquifer recharge zones, despite their critical role in linking surface and groundwater systems.

Establishing urban recharge zones presents additional challenges when the aquifer is transboundary. Land use policies affecting pervious and impervious cover are typically established at the national or local level, not internationally. Furthermore, recharge zones are often asymmetrically distributed across borders—frequently located entirely or primarily within one country. In such cases, one nation bears the burden of protecting the recharge zone, while others benefit with little or no corresponding responsibility. Addressing these imbalances will require innovative negotiation strategies. As of now, however, there are no legal precedents or treaty frameworks specifically addressing this issue.

## 3. Identifying Different Stakeholders in Regulation of Interconnected Waters

Different stakeholders represent diverse interests in the regulation of interconnected waters. It is therefore essential to identify them and ensure their inclusion in management, policy-making, and decision-making efforts related to interconnected waters, whether at the national or international scale. Stakeholders may include government agencies—such as water resource management authorities, environmental protection agencies, and local municipalities—as well as private sector actors like agriculture, industry, and utilities that depend on water resources. Additionally, local communities, Indigenous groups, and non-governmental organizations play a crucial role in representing the public interest, particularly in advocating for equitable access to water and the promotion of sustainable practices.

In addition, experts and researchers increasingly contribute by advising regulators and water users based on sound, up-to-date scientific research, technical expertise, and legal knowledge, particularly in transboundary contexts. When engaged collaboratively with stakeholders, their input can help ensure that regulatory decisions are both scientifically rigorous and legally sound.

Government stakeholders—especially legislators and regulatory agency officials—also play a key role. While legislators are vital for enacting policies that support the effective management of interconnected waters, some stakeholders perceive government intervention as potentially exacerbating problems, which can lead to skepticism or resistance. Nonetheless, the involvement of legislators and regulators is critical to establishing comprehensive and enforceable water policies.

#### 4. Public Versus Private Notions of Water Ownership of Interconnected Waters



The ownership status of water—both surface and groundwater—varies significantly across countries, particularly in terms of private ownership and interests.

This status can directly affect the economic feasibility of strategies aimed at integrating surface water and groundwater management.

In China, for example, all water is considered state property, making it difficult for private interests to claim that restrictions on the right to divert or store water amount to a compensable infringement of property rights. In contrast, in Chile, many—if not most—rights to divert and use water are considered private property interests that cannot be curtailed without government compensation. The United States, in general, occupies a middle ground between these two extremes. While individuals cannot own water itself, they may acquire “usufructuary” rights to use a specified quantity of water. If the government interferes with those rights, it may be deemed a “taking” (expropriation) requiring compensation. There are, however, several U.S. states such as Louisiana and Texas that assign ownership of the groundwater exclusively to the landowner.

In the context of integrated surface water–groundwater management, treating water as private property or as a private property interest can create practical challenges for both users and regulatory agencies. For instance, to prevent a surface water body from shifting from a “gaining” stream to a “losing” stream, one policy option is to limit excessive groundwater pumping, thereby maintaining the groundwater table above the surface water level. However, if the government is required to compensate groundwater users for reducing their withdrawals, the cost of implementing such a policy may become prohibitively high and potentially unfeasible.

#### 5. Challenges to Integrated Management When Surface Water and Groundwater Are Managed by Different Agencies under Different Laws

One of the primary challenges in managing interconnected surface water and groundwater is that these resources are often governed by separate agencies operating under distinct laws and regulatory frameworks. In the case of transboundary shared waters, the situation becomes even more complex as different countries may manage its portion of the shared resource independently. This fragmented approach fosters a false perception of separation between surface water and groundwater, despite their natural interconnection. As a result, management efforts become disjointed, leading to delays in addressing critical issues, inconsistent resource planning, and the development of physical models that are difficult to integrate. These challenges ultimately hinder the creation of cohesive management policies and informed decision-making.

In California, for instance, the State Water Board generally lacks authority to regulate interconnected groundwater. While the agency is responsible for issuing and enforcing permits for surface water diversion, it often has no jurisdiction over groundwater pumping. Consequently, when groundwater extraction adversely affects surface water flows, there may be no governmental authority with the power to intervene—leaving legal action through the courts as the only available recourse. Although proposals have been made to expand the State Water Board’s authority to include interconnected groundwater, such changes have not yet been implemented. Conflicting interests also complicate the issue, as some stakeholders (not without reason) fear that regulating groundwater in connection with surface water may lead to reduced water allocations.

Efforts should focus on creating regulatory bodies with the authority to oversee both surface water and groundwater, ensuring that decisions and policies reflect their interdependence. However, establishing such agencies alone is insufficient. It is equally important to implement a unified governance framework that promotes coordination and compliance. Even in countries like South Africa and Mexico, where surface and groundwater are managed under a single institutional structure, significant challenges remain in enforcing and operationalizing existing regulations. This underscores the need for more integrated, coordinated approaches that go beyond legal frameworks to include effective implementation and enforcement.

## 6. Role of Data Collection and Information Sharing



Data availability is a critical component of integrated surface water–groundwater management, particularly in transboundary contexts. What is unknown and unmeasured cannot be effectively managed. However, data collection is rarely straightforward; it requires time, substantial financial resources, skilled personnel, and appropriate systems for data organization and storage, among other challenges. While having access to comprehensive datasets would be ideal, the reality is often more constrained raising a central question: how much data is enough? Alternatively, the question may be reframed as: what is the minimum amount of data needed to produce actionable insights for decision-makers managing interconnected waters?

Answering this question is difficult, as it depends heavily on the specific context of each case. Even the United Nations Sustainable Development Goal Indicator 6.5.2—which seeks to guide data collection and information sharing for transboundary water cooperation—remains vague. While the guidance emphasizes the importance of data exchange, it does not define which types of data should be shared, nor does it clarify parameters such as frequency, spatial density, or data quality standards. Key variables such as water quality, flow, water levels, and volumes are often not sufficiently specified. Although existing frameworks provide a starting point, the absence of universally applicable standards reflects the difficulty

of creating one-size-fits-all guidelines, given the unique characteristics of each basin and aquifer.

In some instances, the absence of data can even serve a constructive role. For example, in the Limpopo Basin—shared by Botswana, Mozambique, South Africa, and Zimbabwe—the lack of groundwater data has created a shared starting point, where all countries collect information collaboratively. This joint effort ensures that no country holds an informational advantage, fostering mutual trust. In this case, trust has been a key factor in enabling open dialogue about integrated water management and in motivating parties to exchange data.

While data is essential for building models that support sound decision-making, caution must be taken to avoid using the claim of “insufficient data” as a justification for inaction or delay. Striking a balance between the legitimate need for better data and the recognition that calls for more data can be strategically used to obstruct progress is vital. In some cases, such resistance may be unintentional. In others, it may serve to protect vested interests. For example, a large groundwater user whose withdrawals impact a nearby surface water stream may oppose data collection that reveals this connection, fearing the possibility of pumping restrictions or reduced water allocations.

## 7. Roles of Sovereignty in Transboundary Basins with Interconnected Waters



International treaties establish key principles, rights, and obligations pertaining to surface water. Notable examples include the 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses and the 1992 United Nations Economic Commission for Europe (UNECE) Convention on the Protection and Use of Transboundary Watercourses and International Lakes. These treaties articulate principles such as “equitable and reasonable utilization,” “avoidance of significant harm,” and “protection of ecosystems.”

In contrast, international legal principles, rights, and obligations governing transboundary aquifers are far less developed. For example, the International Law Commission has drafted Articles on the Law of Transboundary Aquifers, which propose extending the above-mentioned principles—“equitable and reasonable utilization,” “avoidance of significant harm,” and “protection of ecosystems”—to transboundary groundwater. However, these draft articles remain non-binding and have yet to be formally adopted as international law.

The absence of a globally recognized legal framework for transboundary groundwater creates uncertainty about how to regulate interconnected surface water and groundwater systems in the international transboundary contexts. If international law does not provide clear rules and obligations for transboundary groundwater, what

then are the legal principles that govern the regulation of interconnected water in international transboundary systems?

Even in the absence of binding global treaties on transboundary aquifers, it can be argued that the provisions of the Draft Articles may reflect principles of customary international law. However, due to limited evidence of widespread state practice specifically addressing the interconnection between surface water and groundwater, it remains difficult to establish the customary legal status of these principles with certainty.

For example, through the multilateral Limpopo Watercourse Commission, several nations in southern Africa—Botswana, Mozambique, South Africa, and Zimbabwe—have cooperated on the management of transboundary groundwater resources, including groundwater that is hydrologically connected to nearby surface water. Although this case does not constitute a binding treaty mechanism, it reflects emerging state practice recognizing the need to address the interconnection between transboundary surface water and groundwater systems. Nevertheless, the question of how to effectively manage interconnected waters remains an unresolved challenge at both national and international levels.

## Conclusion



The regulation of interconnected surface water and groundwater is becoming an increasingly critical issue for water management in both national and transboundary contexts. As surface water resources grow scarcer worldwide, understanding the interactions between surface and groundwater systems—and adopting holistic management approaches at both national and international levels—has become essential for achieving sustainable water use.

This report highlights key emerging policy themes, from identifying distinct hydrological scenarios to addressing land use impacts on recharge zones and involving a wide range of stakeholders in decision-making processes. Effective governance of interconnected waters depends

on recognizing the diverse interests of stakeholders. International legal instruments also play a pivotal role in shaping the future of water governance. However, challenges remain—fragmented regulatory frameworks, inconsistent data collection, and varying models for water ownership continue to complicate the implementation of integrated strategies.

In conclusion, a holistic and collaborative approach is essential for the successful management of interconnected surface and groundwater systems. Strengthening international cooperation, improving data-sharing mechanisms, and refining legal and institutional frameworks will be key to advancing integrated water management.

