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Hydropolitical Vulnerability and Resilience along International Waters
NORTH AMERICA

The main problem in North America is the location of water resources relative to large population centers where the majority of the freshwater drains away from the bulk of the population. Climate variability and change is a reality. It raises the impact on variability and availability within the continent, which is characterized by its different climatic regions.

The hydro-vulnerability of North America is tempered and governed by the agreements, laws and institutions such as International Joint Commission (IJC) and International Boundary and Water Commission (IBWC), which have been created to resolve transboundary water issues in a cooperative manner for over a century, resulting in minimal conflicts in the region. Despite short-term regional vulnerabilities, no long-term vulnerability of the transboundary basins in North America is found to exist. Water management is governed and influence by internal laws that control water use, water development projects, and other projects that may impact the environment. The internal laws of the three countries also reduce the potential impact that individual actions can have on international transboundary waters and have helped sustain cooperation between countries.

This publication will promote and disseminate assessed information and data for policy-making.

For further information

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The "Hydropolitical Vulnerability and Resilience along International Waters" project, directed by Aaron T. Wolf and managed by Lynette de Silva, both of Oregon State University (OSU), USA, is a collaboration between the United Nations Environment Program – Division of Early Warning and Assessment (UNEP-DEWA) and the Universities Partnership for Transboundary Waters. The Partnership is an international consortium of water expertise, including thirteen institutes on five continents, seeking to promote a global water governance culture that incorporates peace, environmental protection, and human security <http://waterpartners.geo.orst.edu>.

Hydropolitical Vulnerability and Resilience along International Waters: North America is the fourth of a five-part series of continental reports. This volume was compiled in collaboration between UNEP-DEWA, OSU's Transboundary Freshwater Dispute Database, OSU's Institute for Water and Watersheds (OSU-IWW), OSU's Department of Geosciences, and the University of New Mexico, Water Resources Program (UNM-WRP). "Hydropolitical Resilience and Vulnerability: Series Introduction" (Chapter 1) was authored by Aaron T. Wolf, OSU Department of Geosciences. The following chapters were authored by Alyssa M. Neir and T. Geoffrey Klise, UNM-WRP; and Michael E. Campana, OSU-IWW and OSU Department of Geosciences: "The Concept of Vulnerability as applied to North America" (Chapter 2), North America's Water Resources" (Chapter 3), "Internal Laws and Their Potential to Influence International Water Management" (Chapter 4), "International Conflicts and Cooperation that Influence Regional Hydropolitical Vulnerability" (Chapter 5), and "Conclusion" (Chapter 6). Maps throughout the report and tables in the appendices were compiled by the Transboundary Freshwater Dispute Database (TFDD) Research Team (Department of Geosciences, OSU), which includes Marloes Bakker, Melissa Carper, Ryan Dey, Nathan Eidem, Barbara Geren, Samuel Littlefield, Erick Stemmerman, Yoshiko Sano, Kendra Hatcher, and Patrick MacQuarrie.

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Cover photo: Child tossing rocks into Jenny Lake, Snake River basin, Wyoming, by Terrence E. Davis.

Title page photo: Rock Island Dam, Columbia River, Washington, by Terrence E. Davis.

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Acronyms

A-S Task Force	Abbotsford-Sumas Aquifer International Task Force
BECC	Border Environment Cooperation Commission
BWT	Boundary Waters Treaty
CEAA	Canadian Environmental Assessment Act
CEC	Commission on Environmental Cooperation
CEPA	Canadian Environmental Protection Act
GDP	Gross Domestic Product
GIS	Geographic Information System
HADCM3	Hadley Centre Coupled Model, version 3
HDI	Human Development Index
IBWC	International Boundary and Water Commission
IJC	International Joint Commission
ISARM	International Shared Aquifer Resources Management
IWW	Institute for Water and Watersheds
MCM	million cubic meters
NAAEC	North American Agreement on Environmental Cooperation
NAD	Bank North American Development Bank
NAFTA	North American Free Trade Agreement
NEPA	National Environmental Policy Act
OSU	Oregon State University
RBO	River Basin Organizations
SPRNCA	San Pedro Riparian National Conservation Area
UNEP-DEWA	United Nations Environment Program – Division of Early Warning and Assessment
UNM-WRP	University of New Mexico, Water Resources Program
WPI	Wholesale Price Index
WWTP	Wastewater Treatment Plant

Preface

When a major river, lake, or aquifer system is shared by two or more nations, decision makers and mangers face challenges in ensuring the sustainable use of water resources. Increasing demands for freshwater for multiple societal and environmental needs and intensified stresses on resources due to climate variation and climate change in many areas, has resulted in the nations involved, being vulnerable to tensions and conflict. Monitoring, predicting and pre-empting transboundary water conflicts will become ever more central to future human and environmental security.

The good news is that historically, nations across the world have often chosen cooperation over conflict through 'hydro-diplomacy' and 'hydrological cooperation'. Scientific findings are full of lessons from the past which can guide current and future policy-makers in water management decisions.

This report focuses on the challenges and opportunities facing North America - a continent with about 6.5% of its area covered by surface freshwater. The region includes the Great Lakes which hold 18% of the world's fresh lake water and boasts four of the largest transboundary rivers in terms of discharge: the Mississippi, St. Lawrence, Columbia, and the Yukon. These rivers and their basins are subject to interstate and international agreements that ensure that all basin countries get some portion of the water and that the rivers remain navigable for commerce.

Guided by the targets for safe water supply and improved sanitation set by the World Summit on Sustainable Development and the work of UN-Water, UNEP's present and future commitments and activities relating to freshwater are embodied in its Water Policy and in its Medium Term Strategy which address water resources in the context of ecosystem management and climate change.

This publication presents a comprehensive assessment of the hydropolitical vulnerabilities and resiliencies of North America's international waters, including detailed information on

existing and forthcoming cooperative agreements which inform policies at regional, sub-regional and national levels and which ensure greater cooperation across the diverse social, political, economic and environmental boundaries in North America.

ACHIM STEINER
United Nations Under-Secretary General
Executive Director,
United Nations Environment Programme

Foreword

The two primary institutions created to manage and resolve transboundary water issues and to provide an avenue for cooperation among riparian states are the International Joint Commission, covering the Canada-United States (U.S.) border and the International Boundary and Water Commission, which covers the U.S.-Mexico border.

Laws concerning transboundary freshwater conflicts between the U.S. and Canada were formulated almost a century ago with the signing of the Boundary Waters Treaty of 1909 which led to the creation of the International Joint Commission. An important aspect of the Treaty is the inclusion of the Harmon Doctrine which "gives the upstream state exclusive control over the use of all waters within its boundaries" and also "gives injured downstream interests right to legal remedies equivalent to those in effect domestically."

The International Boundary Commission was created in 1889 (changed to the International Boundary and Water Commission in 1944) to deal specifically with boundary and water issues on both sides of the USA-Mexico border. Examples of such issues include salinity from irrigation and discharges from wastewater treatment plants.

As the Regional Director of UNEP's Regional Office for North America, I welcome this publication, which demonstrates the close collaboration between the governments of North America, regional entities, UN agencies, regional stakeholders, and the international community. The report also raises awareness of the vulnerabilities affecting the regions' shared water resources and the resilience emerging from collective action at the national, sub-regional and regional levels to effectively confront the issues. We hope this work will inspire continued intergovernmental dialogue and collective action to address the shared water challenges facing this part of the world.

Amy Fraenkel

Director and Regional Representative

United Nations Environment Programme,

Regional Office for North America

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This project, exemplary of the unifying force of transboundary waters, was built on the spirit of incredible collaboration among researchers and staff at the United Nations Environment Programme, and two of the partners in the Universities Partnership for Transboundary Waters: the Oregon State University's Department of Geosciences and Institute for Water and Watersheds and the University of New Mexico's Water Resources Program, both in the United States, as well numerous other individuals from around the world who responded to our requests for data, information, and reviews.

First and foremost at UNEP, we would like to thank Achim Steiner, United Nations Under-Secretary General and UNEP Executive Director, Steve Lonergan and Peter Gilruth, the former and current directors of UNEP's Division of Early Warning and Assessment (DEWA), and Halifa Drammeh, Special Adviser to the Office of the Executive Director, for their consistent encouragement and support throughout this project. We would also like to acknowledge: Salif Diop, Senior Programme Officer and Head of DEWA's Ecosystem Section, who provided vital professional oversight; Patrick M'mayi, DEWA Programme Officer, who coordinated editorial contributions; Beth Ingraham, who provided guidance on UNEP publication rules; Audrey Ringler, who provided cartographic input and advice; Winnie Gaitho, who coordinated communication between partners; interns Martin Schaefer, Hanna Lindblom and Vinay Rajdev, who read early drafts and provided editorial support; and Arun Elhance, who assisted with the preface. A special 'thank you' goes to those UNEP staff who provided data for the report, particularly Johannes Akiwumi and Lal Kurukulasuriya.

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through multiple contracts and budget oversight. Our gratitude goes to Eva Lieberherr and Kristie Marsh for their attention to the written words in this report. A big thank you to Marloes Bakker and Yoshiko Sano for their attention to detail and mastery of the multiple tables associated with this project; special thanks to Nathan Eidem and Patrick MacQuarrie for their cheerful willingness to handle any task, from research questions to data checking to creating maps; and our gratitude is extended to Kendra Hatcher for her gracious assistance in generating additional maps as needed, and last minute assistance with references! Finally, many thanks to our former colleague, Marcia F. Macomber, who was instrumental in both spearheading and managing the "Hydropolitical Vulnerability and Resilience along International Water" project.

This was an extraordinarily data-intensive project, which relied on the generosity of many researchers around the world who are committed to open distribution of their incredibly rich data sets, among them Charles Vörösmarty and Ellen Marie Douglas, from the Complex Systems Research Center, Institute for the Study of Earth, Oceans and Space, University of New Hampshire, who generously provided their five-year-mean historical global runoff data.

Dry lakebed, Colorado River basin, Nevada. Photo credit: Brenda Miraglia.

Chapter 1. Hydropolitical Vulnerability and Resilience: *Series Introduction*

Aaron T. Wolf

Water management is, by definition, conflict management. Postel (1999) describes the roots of the problem: Water, unlike other scarce, consumable resources, is used to fuel *all* facets of society, from biologies to economies to aesthetics and spiritual practice. Moreover, it fluctuates wildly in space and time, its management is usually fragmented, and it is often subject to vague, arcane, and/or contradictory legal principles. There is no such thing as managing water for a single purpose—*all* water management is multi-objective and based on navigating competing interests. Within a nation these interests include domestic users, agriculturalists, hydropower generators, recreators, and environmentalists—any two of which are regularly at odds—and the chances of finding mutually acceptable solutions drop exponentially as more stakeholders are involved. Add international boundaries, and the chances decrease exponentially yet again (Elhance, 1999).

Surface and groundwater that cross international boundaries present increased challenges to regional stability because hydrologic needs can often be overwhelmed by political considerations. While the potential for paralyzing disputes is especially high in these basins, history shows that water can catalyze dialogue and cooperation, even between especially contentious riparians. There are 263 rivers around the world that cross the boundaries of two or more nations, and untold number of international groundwater aquifers. The catchment areas that contribute to these rivers comprise approximately 47% of the land surface of the earth, include 40% of the world's population, and contribute almost 80% of freshwater flow (Wolf et al., 1999).

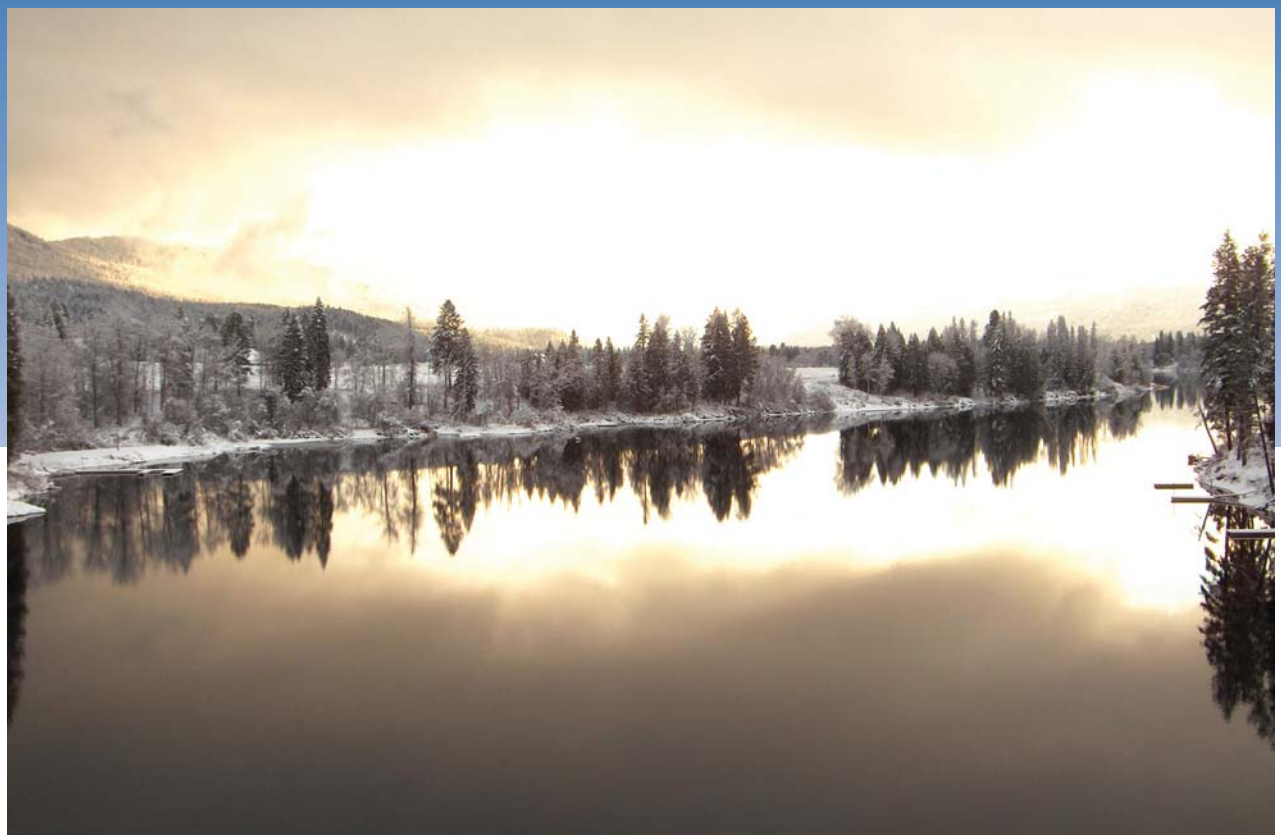
Within each international basin, allocations from environmental, domestic, and economic users increase annually, while the amount of freshwater in the world remains roughly the same as it has been throughout history. Given the scope of the problems and the resources available to address them, avoiding water conflict is vital. Conflict is expensive, disruptive, and interferes with efforts to relieve human suffering, reduce environmental degradation, and achieve economic growth. Developing the capacity to monitor, predict, and preempt transboundary water conflicts, particularly in developing countries, is key to promoting human and environmental security in international river basins, regardless of the scale at which they occur.

1.1 Hydropolitical Vulnerability and Resilience

In general, concepts of "resilience" and "vulnerability" as related to water resources are often assessed within the framework of "sustainability," (Blaikie et al., 1994), and relate to the ability of bio-physical systems to adapt to change (e.g., Gunderson and Pritchard, 2002). As the sustainability discourse has broadened to include human systems in recent years, so too has work been increasingly geared towards identifying indicators of resilience and vulnerability within this broader context (e.g., Bolte et al., 2004; Lonergan et al., 2000; Turner, 2003). In parallel, dialogue on "security" has migrated from traditional issues of war and peace toward also beginning to incorporate the human-environment relationship in the relatively new field of "environmental security" (see UNEP, 2004; Vogel and O'Brien, 2004).

Figure 1.1 International river basins in North America.

Figure 1.2 International river basins and countries, territories, and areas of North America.



Pend Oreille River, Washington. Photo credit: Kevin Davis.

The term "hydropolitics" (coined by Waterbury 1979) came about as the potential for conflict and violence to erupt over international waters began to receive substantial new attention. Hydropolitics relates to the ability of geopolitical institutions to manage shared water resources in a politically sustainable manner, i.e., without tensions or conflict between political entities. "Hydropolitical resilience," then, is defined as the complex human-environmental system's ability to adapt to permutations and change within these systems; "hydropolitical vulnerability" is defined by the risk of political dispute over shared water systems. Wolf et al. (2003) suggested the following relationship between change, institutions, and hydropolitical vulnerability: "The likelihood of conflict rises as the rate of change within the basin exceeds the institutional capacity to absorb that change."

This suggests that there are two sides to the dispute setting: the rate of change in the system and the institutional capacity. In general, most of the parameters regularly identified as indicators of water conflict are actually only weakly linked to dispute. Institutional capacity within a basin, however, whether defined as water management bodies or treaties, or generally positive international relations, is as important, if not more so, than the physical aspects of a system. It turns out, then, that very rapid changes, either on the institutional side or in the physical system, that outpace the institutional capacity to absorb those changes, are at the root of most water conflict. For example, the rapid institutional change in "internationalized" basins, i.e., basins that include the management structures of newly independent States, has resulted in disputes in areas formerly under British administration (e.g., the Nile, Jordan, Tigris-Euphrates, Indus, and Ganges-Brahmaputra), as well as in the former Soviet Union (e.g., the Aral tributaries and the Kura-Araks). On the physical side, rapid change most outpaces institutional capacity in basins that include unilateral development projects *and* the absence of cooperative regimes, such as treaties, river basin organizations (RBOs), or technical working groups, or when relations are especially tenuous over other issues (Wolf et al., 2003).

The general assumption of this series, then, which will be explored in each regional study, is that rapid change tends to indicate vulnerability while institutional capacity tends to indicate resilience, *and* that the two sides must be assessed in conjunction with each other for

a more accurate gauge of hydropolitical sustainability. Building on these relationships, the characteristics of a basin that would tend to enhance resilience to change include

- international agreements and institutions, such as RBOs
- a history of collaborative projects
- generally positive political relations
- higher levels of economic development

In contrast, facets that would tend towards vulnerability would include

- rapid environmental change
- rapid population growth or asymmetric economic growth
- major unilateral development projects
- the absence of institutional capacity
- generally hostile relations
- natural climatic variability—naturally variable rainfall patterns with frequent periods of floods and drought.

1.2 Water and Security

Water disputes revolve around one or more of three issues: quantity, quality, and timing. The dynamics of those three issues play out very differently within various scales related to water and security, whether internationally, intranationally, or regionally and indirectly. Each setting might be characterized as follows (for examples, see Table 1.1):

1. *International waters:* very little violence, but long processes from tension to cooperation, resulting in exacerbated political relations, inefficient water management, and ecosystem neglect; long, rich record of conflict resolution and development of resilient institutions; institutional capacity is at the heart of whether environmental stresses lead to conflict or cooperation.
2. *Intranational waters* (between subnational political units, including states/provinces, ethnic/religious groups, and/or economic sectors): violence potential higher than in international setting; rationale for international involvement more difficult, given greater issues of national sovereignty.
3. *Regional instability (indirect)/political dynamics of loss of irrigation water:* potential for politically destabilizing processes of mass migrations to cities and/or neighboring countries when water supplies for broadly irrigated regions are threatened due to a drop in quantity (including lowering of groundwater levels) or quality; issues of poverty alleviation and distribution of wealth are tied directly to amelioration of security concerns.

1.2.1 International Waters

Water is a unique and vital resource for which there is no substitute. It ignores political boundaries, fluctuates in both space and time, and has multiple and conflicting demands on its use—problems compounded in the international realm by the fact that the international law that governs it is poorly developed, contradictory, and unenforceable. It is no wonder, then, that water is perpetually suspect—not only as a cause of historic armed conflict, but as the resource that will bring combatants to the battlefield in the 21st century. What is the likelihood that "the wars of the next century will be about water," as some have predicted?[1]

1.2.1.1 Examining the Record

In order to cut through the prevailing anecdotal approach to the history of water conflicts, researchers at Oregon State University (OSU) undertook a three-year research project, which attempted to compile a dataset of *every* reported interaction between two or more nations, whether conflictive or cooperative, that involved water as a scarce and/or consumable resource or as a quantity to be managed—i.e., where water was the *driver* of the events,[2] over the past 50 years (Wolf et al., 2003). The study documented a total of 1,831 interactions, both conflictive and

[1] World Bank vice-president Ismail Serageldin, quoted in the *New York Times*, 10 August 1995. His statement is probably most often quoted. For fear of water wars, see Joyce R. Starr, "Water Wars," *Foreign Policy* (Spring 1991): 17–36; and John Bulloch and Adel Darwish, *Water Wars: Coming Conflicts in the Middle East* (London: Victor Gollancz, 1993).

[2] Excluded are events where water is incidental to the dispute, such as those concerning fishing rights, access to ports, transportation, or river boundaries. Also excluded are events where water is not the driver, such as those where water is a tool, target, or victim of armed conflict.

TABLE 1.1 SELECTED EXAMPLES OF WATER-RELATED DISPUTES.

QUANTITY

Cauvery River, South Asia

The dispute on India's Cauvery River sprang from the allocation of water between the downstream state of Tamil Nadu, which had been using the river's water for irrigation, and upstream Karnataka, which wanted to increase irrigated agriculture. The parties did not accept a tribunal's adjudication of the water dispute, leading to violence and death along the river.

Mekong Basin, Southeast Asia

Following construction of Thailand's Pak Mun Dam, more than 25,000 people were affected by drastic reductions in upstream fisheries and other livelihood problems. Affected communities have struggled for reparations since the dam was completed in 1994.

Okavango-Makgadikgadi Basin, Southern Africa

In the Okavango-Makgadikgadi Basin, Botswana's claims for water to sustain the delta and its lucrative ecotourism industry contribute to a dispute with upstream Namibia, which wants to pipe water from the Okavango River to supply its capital city with industrial and drinking water.

QUALITY

Rhine River, Western Europe

Rotterdam's harbor had to be dredged frequently to remove contaminated sludge deposited by the Rhine River. The cost was enormous and consequently led to controversy over compensation and responsibility among Rhine users. While in this case negotiations led to a peaceful solution, in areas that lack the Rhine's dispute resolution framework, siltation problems could lead to upstream/downstream disputes.

QUANTITY AND QUALITY

Incomati River, Southern Africa

Dams and water transfers in the South African area of the Incomati River basin reduced freshwater flows and increased salt levels in Mozambique's Incomati estuary. This altered the estuary's ecosystem and led to the disappearance of salt-intolerant plants and animals that are important for people's livelihoods.

TIMING

Syr Dar'ya, Central Asia

Relations between Kazakhstan, Kyrgyzstan, and Uzbekistan—all riparians of the Syr Dar'ya, a major tributary of the disappearing Aral Sea—exemplify the problems caused by water flow timing. Under the Soviet Union's central management, spring and summer irrigation in downstream Uzbekistan and Kazakhstan balanced upstream Kyrgyzstan's use of hydropower to generate heat in the winter. But the parties are barely adhering to recent agreements that exchange upstream flows of alternate heating sources (natural gas, coal, and fuel oil) for downstream irrigation, sporadically breaching the agreements.

Sources: Wolf et al., 2005; Jägerskog, 2003; Allan, 2001; Elhance, 1999; Bulloch and Darwish, 1993; Starr, 1991; Israeli-Jordanian peace treaty (www.israel-mfa.gov.il/mfa/go.asp?MFAH00pa0); Israeli-Palestinian interim agreement (www.mfa.gov.il/mfa/go.asp?MFAH00qd0#app-40, and www.nad-plo.org/fact/annex3.pdf).

View of the Fraser River from downtown Hope, British Columbia. Photo credit: RestfulC401 WinterforceMedia, via Wikimedia Commons.

cooperative, between two or more nations over water during the past 50 years, and found the following:

First, despite the potential for dispute in international basins, the record of acute conflict over international water resources is historically overwhelmed by the record of cooperation. The last 50 years have seen only 37 acute disputes (those involving violence); of those, 30 were between Israel and one or another of its neighbors, and the violence ended in 1970. Non-Mideast cases accounted for only five acute events, while, during the same period, 157 treaties were negotiated and signed. In fact, the only "water war" between nations on record occurred over 4,500 years ago between the city-states of Lagash and Umma in the Tigris-Euphrates basin (Wolf, 1998). The total number of water-related events between nations of any magnitude are likewise weighted towards cooperation: 507 conflict-related events, versus 1,228 cooperative events, implying that violence over water is neither strategically rational, hydrographically effective, nor economically viable.

Second, despite the occasional fiery rhetoric of politicians—perhaps aimed more often at their own constituencies than at an enemy—most actions taken over water are mild. Of all the events, some 43% fell between mild verbal support and mild verbal hostility. If the next level on either side—official verbal support and official verbal hostility—is added in, the share of verbal events reaches 62% of the total. Thus almost two-thirds of all events were only verbal and more than two-thirds of those had no official sanction (Wolf,1998).

Third, there were more issues of cooperation than of conflict. The distribution of cooperative events covered a broad spectrum, including water quantity, quality, economic development, hydropower, and joint management. In contrast, almost 90% of the conflict-laden events related to quantity and infrastructure. Furthermore, almost all extensive military acts (the most extreme cases of conflict) fell within these two categories (Wolf, 1998).

Fourth, despite the lack of violence, water acted as both an irritant and a unifier. As an irritant, water can make good relations bad and bad relations worse. Despite the complexity, however, international waters can act as a unifier in basins with relatively strong institutions.

This historical record suggests that international water disputes do get resolved, even among enemies, and even as conflicts erupt over other issues. Some of the world's most vociferous

Boats on the bank with oil slicks in the water; Mississippi River in distance, Venice, Louisiana. Photo credit: Lieut. Commander Mark Moran, NOAA Corps, MAO/AOC, courtesy of the National Oceanic and Atmospheric Administration/Department of Commerce.

enemies have negotiated water agreements or are in the process of doing so, and the institutions they have created often prove to be resilient, even when relations are strained.

The Mekong Committee, for example, established by the governments of Cambodia, Laos, Thailand, and Viet Nam as an intergovernmental agency in 1957, exchanged data and information on water resources development throughout the Viet Nam War. Israel and Jordan have held secret "picnic table" talks on managing the Jordan River since the unsuccessful Johnston negotiations of 1953–1955, even though they were technically at war from Israel's independence in 1948 until the 1994 treaty. The Indus River Commission survived two major wars between India and Pakistan. And all 10 Nile Basin riparian countries are currently involved in senior government-level negotiations to develop the basin cooperatively, despite "water wars" rhetoric between upstream and downstream states.[3]

The Whitemud River in Westbourne, Manitoba. Photo credit: JTbuer, courtesy of Wikimedia Commons.

In Southern Africa, a number of river basin agreements were signed in the 1970s and 1980s, when the region was embroiled in a series of local wars. Although complex to negotiate, the agreements, once established, were one of the rare arenas of peaceful cooperation between countries. Now that the wars in the area have ended, water cooperation is one of the foundations for regional cooperation (Turton, 2004). Some have identified cooperation over water resources as a particularly fruitful entry point for building

[3] Mekong Committee from Ti Le-Huu and Lien Nguyen-Duc, *Mekong Case Study*, PCCP Series No. 10 (Paris, France: UNESCO-IHP 2003); Indus River Commission from Aaron T. Wolf, "Water and Human Security," *AVISO Bulletin,* Global Environmental Change and Human Security Project, Canada (June 1999); and Nile Basin talks from Alan Nicol, *The Nile: Moving beyond Cooperation*, PCCP Series No. 16 (Paris, France: UNESCO-IHP 2003).

The Bow River near Banff in Alberta. Photo credit: Ken Thomas (www.kenthomas.us), courtesy of Wikimedia Commons.

peace; however, it is unclear what conditions are required for environmental cooperation to play a major role (Conca and Dabelko, 2002).

1.2.1.2 Tensions and Time Lags: Causes for Concern

So if there is little violence between nations over their shared waters, what's the problem? Is water actually a security concern at all? In fact, there are a number of issues where water causes or exacerbates tensions, and it is worth understanding these processes to know both how complications arise and how they are eventually resolved.

The first complicating factor is the time lag between when nations first start to impinge on each other's water planning and when agreements are finally, arduously, reached. A general pattern has emerged for international basins over time. Riparians of an international basin implement water development projects unilaterally—first on water within their own territory—in attempts to avoid the political intricacies of the shared resource. At some point, one of the riparians, generally the regional power, will implement a project that impacts at least one of its neighbors. In the absence of relations or institutions conducive to conflict resolution, the project can become a flashpoint, heightening tensions and regional instability, and requiring years or, more commonly, decades, to resolve—the Indus treaty took 10 years of negotiations, the Ganges 30, and the Jordan 40—and, all the while, water quality and quantity degrades to where the health of dependent populations and ecosystems is damaged or destroyed. This problem gets worse as the dispute gains in intensity; one rarely hears talk about the ecosystems of the lower Nile, the lower Jordan, or the tributaries of the Aral Sea—they have effectively been written off to the vagaries of human intractability. During such periods of low-level tensions, threats and disputes rage across

Apache Lake, a reservoir on the Salt River in the San Pedro basin. Photo credit: Terrence E. Davis.

boundaries with relations as diverse as those between Indians and Pakistanis and between Americans and Canadians. Water was the last and most contentious issue resolved in negotiations over a 1994 peace treaty between Israel and Jordan, and was relegated to "final status" negotiations—along with other of the most difficult issues such as Jerusalem and refugees—between Israel and the Palestinians.

The timing of water flow is also important; thus, the operation of dams is also contested. For example, upstream users might release water from reservoirs in the winter for hydropower production, while downstream users might need it for irrigation in the summer. In addition, water quantity and water flow patterns are crucial to maintaining freshwater ecosystems that depend on seasonal flooding. Freshwater ecosystems perform a variety of ecological and economical functions and often play an important role in sustaining livelihoods, especially in developing countries. As awareness of environmental issues and the economic value of ecosystems increases, claims for the environment's water requirements are growing. For example, in the Okavango Basin, Botswana's claims for water to sustain the Okavango Delta and its lucrative ecotourism industry have contributed to a dispute with upstream Namibia, which wants to use some of the water passing through the Caprivi Strip on its way to the delta for irrigation.

Water quality problems include excessive levels of salt, nutrients, or suspended solids. Salt intrusion can be caused by groundwater overuse or insufficient freshwater flows into estuaries. For example, dams in the South African part of the Incomati River basin reduced freshwater flows into the Incomati estuary in Mozambique and led to increased salt levels. This altered the estuary's ecosystem and led to the disappearance of salt-intolerant flora and fauna important for people's livelihoods (the links between loss of livelihoods and the threat of conflict are described below). The same exact situation exists on the border between the United States and Mexico, where high salinity problems have not only reduced agricultural productivity, but have severely altered ecosystems in the Colorado and Rio Grande rivers and impacted marine flora and fauna in the Gulfs of California and Mexico, where the respective rivers terminate.

A view of the Alamo River as it enters the Salton Sea. Photo credit: Andy Pernick, courtesy of the U.S. Bureau of Reclamation.

Excessive amounts of nutrients or suspended solids can result from unsustainable agricultural practices, eventually leading to erosion. Nutrients and suspended solids pose a threat to freshwater ecosystems and their use by downstream riparians, as they can cause eutrophication and siltation, respectively, which, in turn, can lead to loss of fishing grounds or arable land. Suspended solids can also cause the siltation of reservoirs and harbors: for example, Rotterdam's harbor had to be dredged frequently to remove contaminated sludge deposited by the Rhine River. The cost was enormous, and consequently led to conflict over compensation and responsibility among the river's users. Although negotiations led to a peaceful solution in this case, without such a framework for dispute resolution, siltation problems can lead to upstream/downstream disputes such as those in the Lempa River basin in Central America (Lopez, 2004).

1.2.1.3 Institutional Capacity: The Heart of Conflict Management

Most authors who write about hydropolitics, and especially those who explicitly address the issue of water conflicts, hold to the common assumption that it is the scarcity of such a critical resource that drives people to conflict. It feels intuitive—the less there is of something, especially something as important as water, the more dearly it is held and the more likely people are to fight over it.

The three-year OSU study worked to tease out just what the indicators of conflict are.

Niagara Falls, Ontario and Niagara Falls, New York. Photo credit: Ken Winters, courtesy of the U.S. Army Corps of Engineers.

A 100-layer Geographic Information System (GIS) was compiled—a spatial database of all the parameters that might prove part of the conflict/cooperation story, including physical (e.g., runoff, droughts), socioeconomic (e.g., GDP, rural/urban populations), and geopolitical (e,g., government type, votes on water-related UN resolutions) parameters. With this GIS in place, a statistical snapshot was developed of each setting for each of the events over the last 50 years of conflict or cooperation.

The results were surprising, and often counterintuitive. *None* of the physical parameters were statistically significant—arid climates were no more conflictive than humid climates, and international cooperation actually *increased* during droughts. In fact, when the numbers were run, almost no single variable proved causal—democracies were as conflictive as autocracies, rich countries as poor countries, densely populated countries as sparsely populated ones, and large countries the same as small countries.

It was close reflection of aridity that finally put researchers on the right track: institutional capacity was the key. Naturally arid countries were cooperative: if one lives in a water-scarce environment, one develops institutional strategies for adapting to that environment. Once institutions —whether defined by formal treaties, informal working groups, or generally warm relations— and their relationship to the physical environment became the focus, researchers began to get a clear picture of the settings most conducive to political tensions in international waterways.

We found that the likelihood of conflict increases significantly whenever two factors come into play. The first is that some large or rapid change occurs in the basin's physical setting—typically the construction of a dam, river

Rio Grande/Río Bravo del Norte, with Amistad reservoir and dam; Coahuila is on the left of the river and Texas on the right. Photo credit: U.S. National Park Service.

Mica Dam, Columbia River, British Columbia. Photo credit: Jonesy22, via Wikimedia Commons.

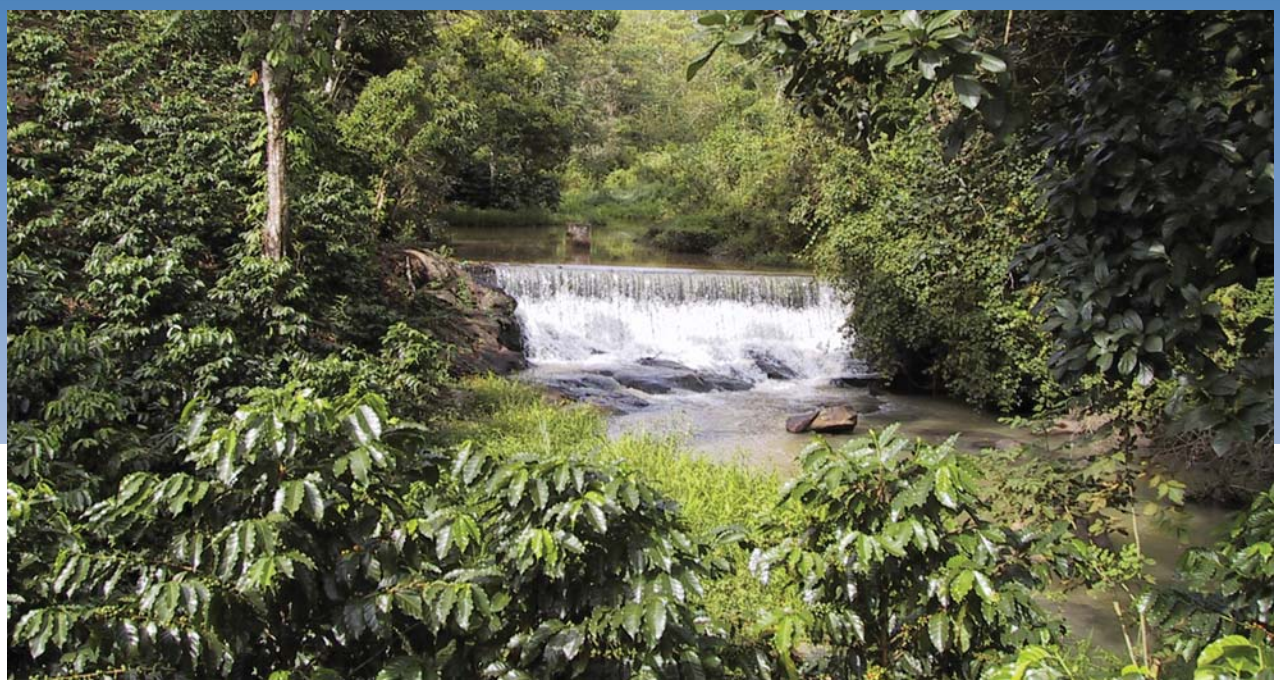
diversion, or irrigation scheme—or in its political setting, especially the breakup of a nation that results in new international rivers. The second factor is that existing institutions are unable to absorb and effectively manage that change. This is typically the case when there is no treaty spelling out each nation's rights and responsibilities with regard to the shared river, nor any implicit agreements or cooperative arrangements. Even the existence of technical working groups can provide some capability to manage contentious issues, as they have in the Middle East.

Covered hydro turbine generators on Wells Dam, Columbia River, Washington. Photo credit: Kevin Davis.

The overarching lesson of the study is that unilateral actions to construct a dam or river diversion *in the absence* of a treaty or institutional mechanism that safeguards the interests of other countries in the basin is highly destabilizing to a region, often spurring decades of hostility before cooperation is pursued. In other words, the red flag for water-related tension between countries is not water stress *per se,* as it is within countries, but rather the unilateral exercise of domination of an international river, usually by a regional power.

In the Jordan River Basin, for example, violence broke out in the mid-1960s over an "all-Arab" plan to divert the river's headwaters (itself a pre-emptive move to thwart Israel's intention to siphon water from the Sea of Galilee). Israel and Syria sporadically exchanged fire between March 1965 and July 1966. Water-related tensions in the basin persisted for decades and only recently have begun to dissipate.

A similar sequence of events transpired in the Nile basin, which is shared by 10 countries—of which Egypt is last in line. In the late 1950s, hostilities broke out between Egypt and Sudan over Egypt's planned construction of the High



River running through coffee plantation in Zihuateutla, Puebla, México. Photo credit: Jaontiveros, via Wikimedia Commons.

Dam at Aswan. The signing of a treaty between the two countries in 1959 defused tensions before the dam was built. But no water-sharing agreement exists between Egypt and Ethiopia, where some 55% of the Nile's flow originates, and a war of words has raged between these two nations for decades. As in the case of the Jordan, in recent years the Nile nations have begun to work cooperatively toward a solution thanks in part to unofficial dialogues among scientists and technical specialists that have been held since the early 1990s, and more recently a ministerial-level "Nile Basin Initiative" facilitated by the United Nations and the World Bank.

1.2.2 Intranational Waters

The second set of security issues occurs at the sub-national level. Much literature on trans-boundary waters treats political entities as homogeneous monoliths: "Canada feels . . ." or "Jordan wants. . . ." Analysts are only recently highlighting the pitfalls of this approach, often by showing how different subsets of actors relate very different "meanings" to water. Rather than being simply another environmental input, water is regularly treated as a security issue, a gift of nature, or a focal point for local society. Disputes, therefore, need to be understood as more than "simply" over a quantity of a resource, but also over conflicting attitudes, meanings, and contexts. Throughout the world, local water issues revolve around core values that often date back generations. Irrigators, indigenous populations, and environmentalists, for example, can see water as tied to their very ways of life, and increasingly threatened by newer uses for cities and hydropower. Moreover, the local setting strongly influences international dynamics and vice versa.

If there is a history of water-related violence, and there is, it is a history of incidents at the sub-national level, generally between tribes, water-use sectors, or states/provinces. In fact, the recent research at OSU suggests that, as the scale drops, the likelihood and intensity of violence rises.[4] There are many examples of

Moose feeding in Snake River wetlands, Wyoming. Photo credit: Terrence E. Davis.

[4] Giordano, M. A., and Wolf, A. T. 2003. Sharing waters: Post-Rio international water management. *Natural Resources Forum*. 27: 163-171.

internal water conflicts ranging from interstate violence and death along the Cauvery River in India, to the USA, where California farmers blew up a pipeline meant for Los Angeles, to inter-tribal bloodshed between Maasai herdsmen and Kikuyu farmers in Kenya. The inland, desert state of Arizona in the USA even commissioned a navy (made up of one ferryboat) and sent its state militia to stop a dam and diversion on the Colorado River in 1934.

Another contentious issue is water quality, which is also closely linked to water quantity. Decreasing water quality can render it inappropriate for some uses, thereby aggravating its scarcity. In turn, decreasing water quantity concentrates pollution, while excessive water quantity, such as flooding, can lead to contamination by sewage. Low water quality can pose serious threats to human and environmental health. Water quality degradation is often a source of dispute between those who cause degradation and the groups affected by it. As pollution increasingly impacts upon livelihoods and the environment, water quality issues can lead to public protests.

(top) Potatoes under irrigation, with wheat fields in the background, Idaho. Photo credit: Terrence E. Davis. The century-old Wenatchee Bridge, the first highway bridge over the Columbia River, still carries irrigation water in two pipelines to apple orchards in East Wenatchee, Washington. Photo credit: Kevin Davis.

One of the main causes of declining water quality is pollution, e.g., through industrial and domestic wastewater or agricultural pesticides. In Tajikistan, for example, where environmental stress has been linked to civil war (1992–1997), high levels of water pollution have been identified as one of the key environmental issues threatening human development and security. Water pollution from the tanning industry in the Palar Basin of the Indian state of Tamil Nadu makes the water within the basin unfit for irrigation and consumption. The pollution contributed to an acute drinking water crisis, which led to protests by the local community and activist organizations, as well as to disputes and court cases between tanners and farmers (Carius et al., 2003).

1.3 Regional Instability: Political Dynamics of Loss of Irrigation Water

As water quality degrades—or quantity diminishes—over time, the effect on the stability of a region can be unsettling. For example, for 30 years the Gaza Strip was under Israeli occupation. Water quality deteriorated steadily, saltwater intrusion degraded local wells, and water-related diseases took a rising toll on the people living there. In 1987, the *intifada,* or Palestinian uprising, broke out in the Gaza Strip, and quickly spread throughout the West Bank. Was water quality the cause? It would be simplistic to claim direct causality. Was it an irritant exacerbating an already tenuous situation? Undoubtedly.

An examination of relations between India and Bangladesh demonstrates that these internal instabilities can be both caused and exacerbated by international water disputes. In the 1960s, India built a barrage at Farakka, diverting a portion of the Ganges flow away from its course into Bangladesh, in an effort to flush silt away from Calcutta's seaport, some 100 miles to the south. In Bangladesh, the reduced upstream flow resulted in a number of adverse effects: degraded

Student measures stream electrical conductivity in the western Cascades during an OSU Field Hydrology class. Photo credit: Jeff McDonnell.

surface and groundwater, impeded navigation, increased salinity, degraded fisheries, and endangered water supplies and public health. Migration from affected areas further compounded the problem. Ironically, many of those displaced in Bangladesh have found refuge in India.

Two-thirds of the world's water use is for agriculture so, when access to irrigation water is threatened, one result can be movement of huge populations of out-of-work, disgruntled men from the countryside to the cities—an invariable recipe for political instability. In pioneering work, Sandra Postel identified those countries that rely heavily on irrigation, and whose agricultural water supplies are threatened either by a decline in quality or quantity. The list coincides precisely with regions of the world community's current security concerns, where instability can have profound effects: India, China, Iran, Pakistan, Uzbekistan, Iraq, Bangladesh, and Egypt (Postel and Wolf, 2001).

Water management in many countries is also characterized by overlapping and competing responsibilities among government bodies. Disaggregated decision-making often produces divergent management approaches that serve contradictory objectives and lead to competing claims from different sectors. And such claims are even more likely to contribute to disputes in countries where there is no formal system of water-use permits, or where enforcement and monitoring are inadequate. Controversy also often arises when management decisions are formulated without sufficient participation by local communities and water users, thus failing to take into account local rights and practices. Protests are especially likely when the public suspects that water allocations are diverting public resources for private gain or when water use rights are assigned in a secretive and possibly corrupt manner, as demonstrated by the violent confrontations in 2000 following the privatization of Cochabamba, Bolivia's water utility (Postel and Wolf, 2001).

Finally, there is the human security issue of water-related disease. It is estimated that between 5 and 10 million people die each year from water-related diseases or inadequate sanitation. More than half the people in the world lack adequate sanitation. Eighty percent of disease in the developing world is related to water (Gleick, 1998). This is a crisis of epidemic proportions, and the threats to human security are self-evident.

Crop irrigation, Arizona. Photo credit: Andy Pernick, courtesy of the U.S. Bureau of Reclamation.

Chapter 2. The Concept of Vulnerability as Applied to North America

Alyssa M. Neir, Geoffrey T. Klise, and
Michael E. Campana

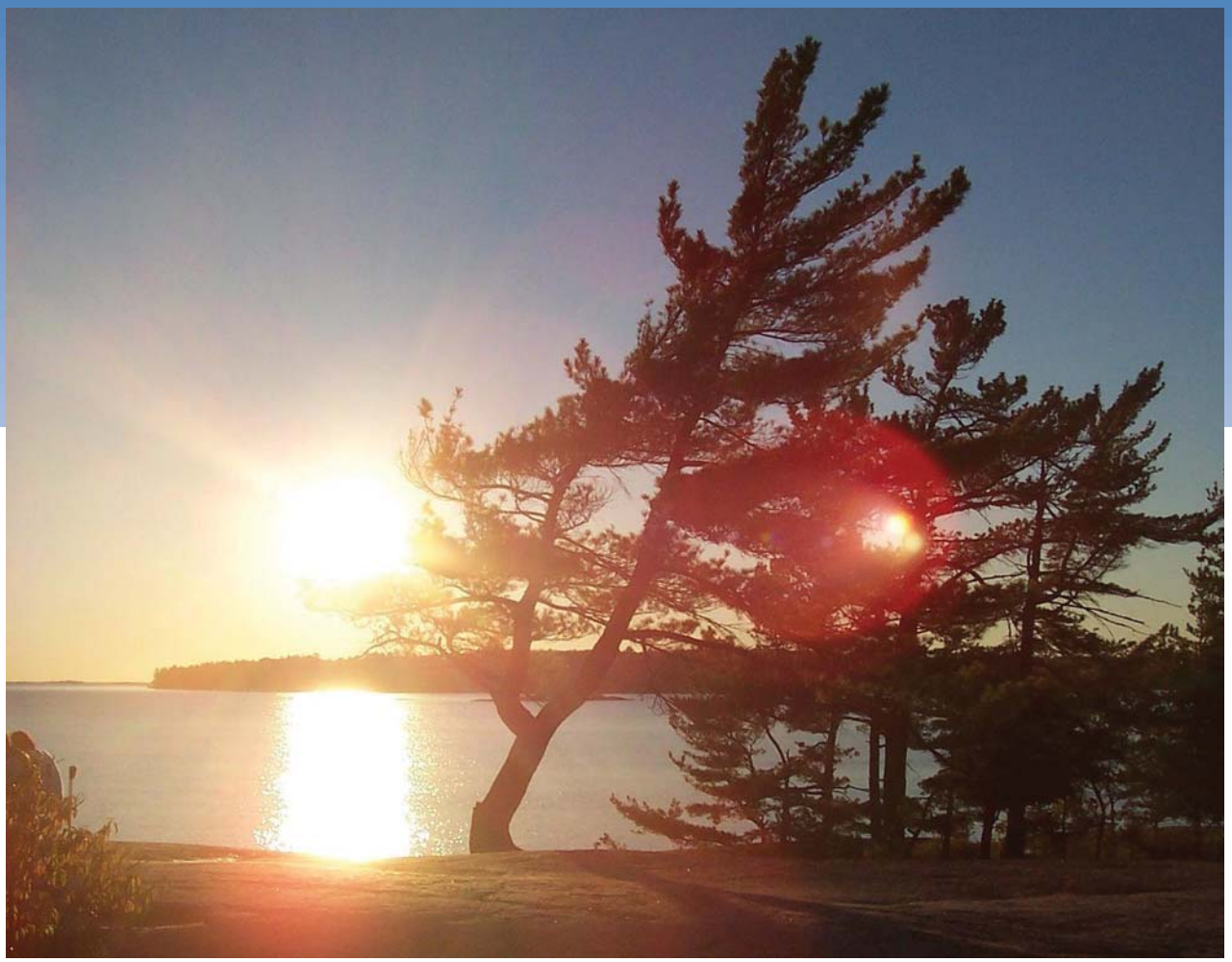
The hydrovulnerability of North America is tempered and governed by the agreements, laws and institutions that have been created to resolve transboundary water issues in a cooperative manner for over a century. The two primary institutions providing the foundation for this cooperation are the International Joint Commission (IJC), which covers the Canada-United States of America (U.S.) border and the International Boundary and Water Commission (IBWC), which covers the U.S.-Mexico border. First, background information about these two institutions and the concept of hydrovulnerability in North America are discussed. Then, the water resources of North America are delineated; including such factors as climate, water quantity, and water use. Next, internal laws (in the U.S., Canada, and Mexico) and their potential influence on international water management are depicted. Finally, international disputes that could affect regional hydropolitical vulnerability in North America (with examples of conflict and cooperation) are assessed. Despite short-term regional vulnerabilities, no long-term vulnerability of the transboundary basins in North America is found to exist.

2.1 The Boundary Waters Treaty of 1909 and the International Joint Commission (IJC)

Rules concerning the boundary and transboundary waters of the 8,050 km border between Canada and the United States were created a century ago with the signing of the Boundary Waters Treaty (BWT) of 1909. Article VII of the BWT created the International Joint Commission (IJC), which is responsible for investigating and making recommendations on questions or disputes referred to it by either or both governments. In addition, absent a special agreement between the countries, the IJC may approve or disapprove and set conditions on a range of water uses, obstructions, dams, and diversions in the transboundary region (CEC, 2001). The BWT allows for unilateral (but non-binding) referral of disputes to the IJC under Article IX and requires the consent of both governments for binding referrals under Article X. While the absence of groundwater from the treaty, and consequently the IJC's jurisdiction, is a real issue, the IJC can include groundwater in its deliberations in certain situations, e.g., when the problem can be linked to a current or future surface water problem (Everts, 1991).

The 1909 Treaty also places restrictions on water pollution. Article IV of the Treaty states that "boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other." This requirement has been implemented by both countries through a variety of domestic laws and bilateral arrangements.

Groundwater has also been addressed in binational agreements such as the Great Lakes Water Quality Agreement and the 2005 Great Lakes Charter Annex Implementing Agreements between the U.S. Great Lakes States and Ontario and Quebec.

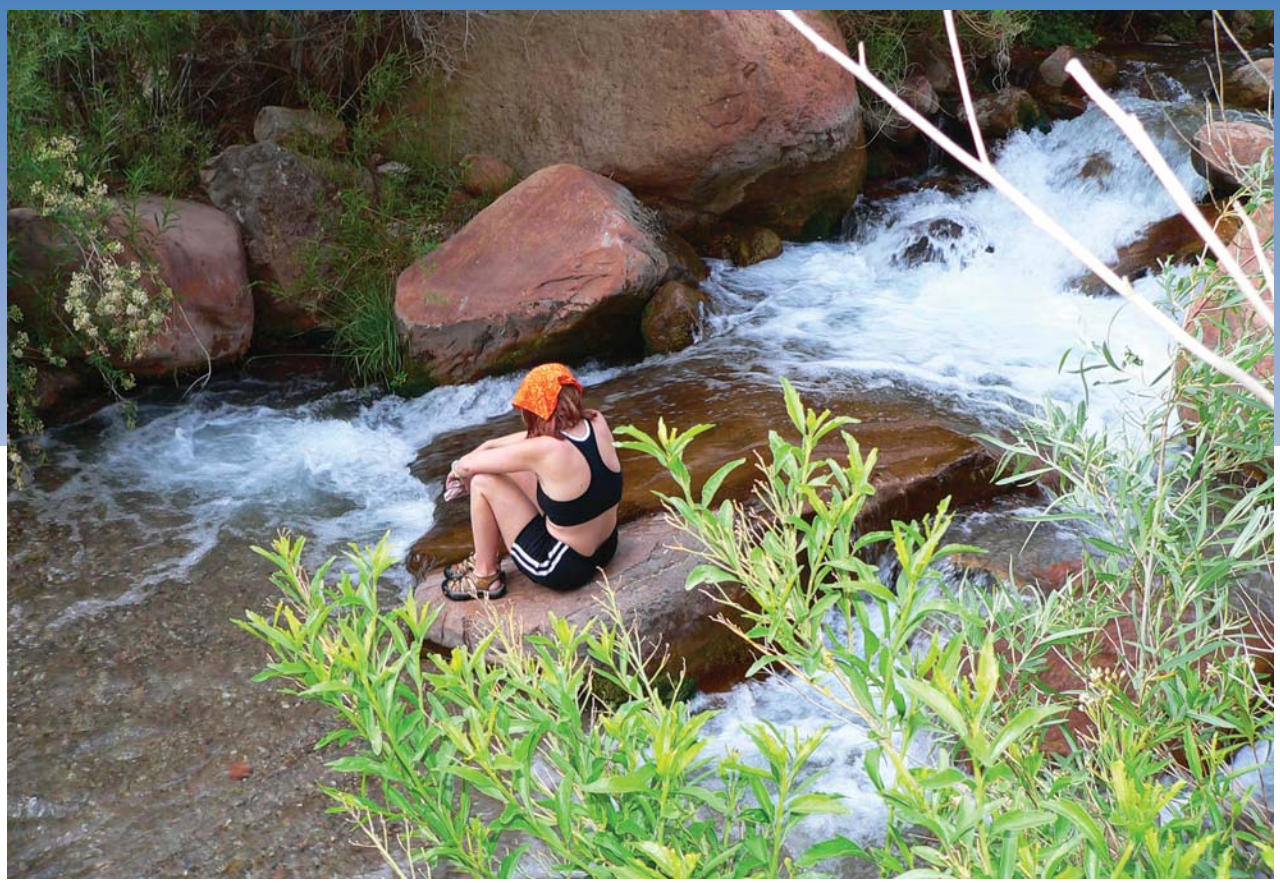


Georgian Bay shore, Lake Huron, Ontario. Photo credit: Ezekiel, courtesy of Wikimedia Commons.

The U.S. and Canada share seven transboundary aquifers, as identified in 2006 (Stephan, 2009), by UNESCO's International Shared Aquifer Resources Management (ISARM) project. Groundwater has been recognized as increasingly important in the Great Lakes Basin (Galloway and Pentland, 2005).

The U.S and Canada have also signed other binational treaties, agreements and conventions to address transboundary water management in specific basins. These include the 1972 and 1978 Great Lakes Water Quality Agreements, the 1955 Convention on Great Lakes Fisheries, the 1950 Niagara River Treaty, the 1961 and 1964 Columbia River Treaty Protocols, the 1984 Skagit River Treaty, the 1959 St. Lawrence Seaway Agreement, the 1989 Water Supply and Flood Control in the Souris River Basin, the 1925 Lake of the Woods Convention and Protocol, and the 1938 Rainy Lake Convention (CEC, 2001). The U.S. and Canada have cooperated to protect and restore the Great Lakes Basin ecosystem, specifically to fulfill the Great Lakes Water Quality Agreement, for over 35 years. For example, Environment Canada and U.S. EPA jointly manage a website (www.binational.net) to disseminate information regarding joint Great Lakes programs.

The IJC also works to prevent disputes by addressing emerging issues before they lead to conflict. For example, the IJC created the International Watersheds Initiative in response to a November 19, 1998 reference regarding international watershed boards (IJC, 2000). The purpose of the International Watersheds Initiative is to promote an integrated, ecosystem approach to issues arising in transboundary waters through more local participation and capacity. The initiative is intended to facilitate the development of watershed-specific responses to emerging challenges such as intensified population growth and urbanization, global climate change, changing uses of water, pollution from air and land, and introductions of exotic species (IJC, 2000).



Creek along trail, Grand Canyon of the Colorado River, Arizona. Photo credit: Terrence E. Davis.

2.2 International Boundary and Water Commission (IBWC)

The U.S. and Mexico share an international border of 3,100 kilometers with river boundaries making up around 66% of the border. The trans-boundary rivers include the Rio Grande/Rio Bravo that borders the state of Texas (U.S.) and the states of Chihuahua, Coahuila, Nuevo Leon, and Tamaulipas (Mexico) for 2,020 km (Borderline, 2004). Furthermore, the Colorado River separates Arizona (U.S.) from Baja California and Sonora (Mexico) for 27 kilometers of the international border.

As of 2009, ten U.S.–Mexico transboundary aquifers have been identified by UNESCO's International Shared Aquifer Resources Management (ISARM) project (Stephan, 2009; IGRAC, 2009). A study of the U.S. - Mexico transboundary aquifers has been funded by the U.S. under the auspices of the U.S. Geological Survey and the water resources research institutes in the U.S. states of Texas, New Mexico, and Arizona. The U.S. state of California is not participating in the study.

The international border between the U.S. and Mexico was first established with the Treaty of Guadalupe Hidalgo in 1848, just prior to the end of the Mexican War. The first border water issues dealt with the location of the international boundary. The Convention of November 12, 1884 was adopted to help deal with the ever-changing international boundary as a result of the meandering Rio Grande and Colorado River

Rio Grande/Río Bravo del Norte; Coahuila is on the left bank and Texas is on the right. Photo credit: U.S. National Park Service.

As water leaves the de-salting ponds at Imperial Dam on the Colorado River near Yuma, Arizona, it begins its journey in the All American Canal. Photo credit: Andy Pernick, courtesy of the U.S. Bureau of Reclamation.

(IBWC, 1884). Five years later, the International Boundary Commission was created in 1889 (changed to the International Boundary and Water Commission (IBWC) in 1944) to deal specifically with boundary and water issues (IBWC, 2005).

Since water for irrigation, which consumes a large amount of water, was important in both the U.S. and Mexico, controversies surfaced in the late 1800s and early 1900s about the equitable distribution of irrigation water. The Convention of May 21, 1906, the first treaty regarding water allocation, stated that the U.S. must deliver 74 million cubic meters (MCM) per year to Mexico via the Rio Grande (IBWC, 1906). In return for this, Mexico waived its rights to Rio Grande water from Juarez to Fort Quitman. In 1944 a more comprehensive version of the treaty allocated the Rio Grande waters between Fort Quitman, TX, and the Gulf of Mexico, and the Colorado River (IBWC, 1944). Water quality issues were also addressed through the passage of "minutes" or legally binding agreements between both countries. Specifically, water quality minutes addressed salinity from irrigation return flows and wastewater treatment plants on both sides of the border (IBWC, 2005a; IBWC, 2005b).

In 1994, the North American Free Trade Agreement (NAFTA) was adopted by Canada, Mexico, and the U.S. as a way of cooperating on trade issues. This agreement among the three countries essentially removed tariffs in order to facilitate increased trading that would lead to greater economic opportunities for all countries involved. Water is governed by this agreement when it is considered an article of commerce or economic good (Neir and Campana, 2007). Hence, NAFTA may have implications vis-à-vis transboundary water issues among the three countries.

The portions of Mexico that stood to benefit the most from NAFTA are the northern border states because any U.S. or Canadian corporation could open a factory on the Mexican side and be close to the major markets in the U.S. and Mexico. While *maquiladoras* (foreign-owned manufacturing facilities) have already been operating in Mexico since the 1960s, they were originally required to take manufacturing wastes back into the country of origin. Given the differing environmental standards between Mexico and the U.S. and Canada, many believed that the border area would become a dumping ground for U.S. and Canadian companies that would seek a cheaper way to dispose of manufacturing wastes. However, the adoptions of treaties and subsequent minutes have attempted to regulate these practices.

The 1993 trilateral environmental side agreement to the NAFTA, the North American Agreement on Environmental Cooperation's Commission for Environmental Cooperation (CEC), carries out project work which helps address water issues in Canada, the U.S., and Mexico and in U.S.-Canada border and U.S.-Mexico border regions. CEC project work and publications help the three countries address North American biodiversity and watershed ecosystem protection challenges and problems such as the introduction, spreading, and adverse effects of aquatic invasive species upon indigenous species and their aquatic habitats.

2.3 Comparison of the IJC and the IBWC

While the IJC and the IBWC are both the products of bilateral treaties between Canada and the U.S., and the U.S. and Mexico, respectively, the two institutions have different roles and powers over transboundary water resources. Despite dissimilarities, certain actions of both the IJC and IBWC require the consent of two sovereign governments, which constrains the scope of their effectiveness as institutional entities.

The IJC can make binding decisions on a range of water obstruction and diversion issues along the border, take action on, and can make non-binding recommendations on other issues referred to it by one or both countries. The IJC acts as an information-gathering body and has become involved in transboundary and boundary water management at the watershed level through the International Watershed Initiative. The IJC has contributed to decades of cooperation by the U.S. and Canada with regard to shared waterways and there have been many projects that have been constructed under either IJC authority or under separate treaties (CEC, 2001).

In contrast, the IBWC is not just a mediator but an active participant in the apportionment and utilization of transboundary water resources. The IJC operates as an active participant as well, and has the ability, for example, to prevent and regulate dams and diversions along the boundary, as well as to tell the governments how to manage such obstructions. The IBWC's decisions ("minutes") are binding when they are approved by both the Mexican and U.S. governments. The IBWC's role in constructing water storage and conveyance systems demonstrates a strong level of commitment between the U.S. and Mexico because they are two riparian countries that completely share the use of binational waters.

2.4 Hydrovulnerability

North America has a long history of creating institutions that govern, manage, and regulate transboundary water resources. The strength of these institutions plays a vital role in their ability to promote resilience and decrease vulnerability in the river basins in North America; yet these institutions must be *used* or have the power to require their use or else they are empty symbols of resilience. The IJC and IBWC serve as resilience builders between the U.S. and Canada and the U.S. and Mexico, respectively, because they provide a framework through which conflicts can be resolved and have been consistently used throughout the past century. The two institutions have also been used to expand the scope of transboundary water management as new issues arise, as can be seen through the inclusion of groundwater in binational agreements and IBWC minutes. Campana et al. (2007) have a good selection of Canada-U.S.-Mexico transboundary groundwater management issues.

The next chapter discusses the water resources on the North American continent.

Night view of the Rio Grande/Río Bravo del Norte from Ciudad Juárez, Chihuahua. Photo credit: iose, courtesy of Wikimedia Commons.

South Falls at Silver Falls State Park, Oregon.
Photo credit: Jane McCauley Thomas.

Chapter 3. North America's Water Resources

Alyssa M. Neir, Geoffrey T. Klise, and
Michael E. Campana

The North American continent spans the northern hemisphere, from the arctic to the subtropics, containing the countries of Canada, the U.S., and Mexico (from north to south). A total of nineteen river basins and seventeen aquifers (Stephan, 2009; IGRAC, 2009) are shared among these three countries. Fifteen river basins and seven aquifers are shared between Canada and the U.S. and four river basins and ten aquifers are shared between the U.S. and Mexico. The Canada-U.S. basins cover a total surface area of about 7.3 million km^2 (Table 3.1) and the U.S.-Mexico basins cover about 1.4 million km^2 (Table 3.2).

3.1 Climate

The variability in water availability within the continent is due to the different climatic regions of the continent. The climate for the mid-east portion of the continent, located east of the Rocky Mountains, is a result of weather systems moving south from Canada and north through the Gulf of Mexico. The southern tropical air masses dominate weather patterns in the summer months whereas the northern polar continental air masses dominate weather during the winter months (Map 1(A)).

Annual precipitation in the northernmost latitudes varies from 50 mm in the far north to as much as 4,000 mm on the Pacific Coast (Water Survey of Canada, 2003). The interior plains region in the central portion of the continent, roughly between 120 and 90 degrees west longitude, receives the least amount of rainfall and has the lowest amounts of average annual runoff (see Map 1(B)). Hurricanes form off the eastern, southeastern, and southwestern coasts of the continent, providing high intensity and short duration precipitation events that result in high volumes of runoff, primarily along the eastern coastal areas. The southern tip of the continent has two separate climatic zones with the Tropic of Cancer forming the dividing line between the temperate zone north of the 24th Parallel and the tropical zone to the south (U.S. Library of Congress, 1996).

3.2 Water Quantity and Use

About 6.5% of the continent is covered by liquid surface freshwater (Natural Resources Canada, 1999; CIA, 2004). The Great Lakes, spanning the Canada-U.S. border, hold 18% of the world's fresh lake water (Environment Canada, 2004a). Canada's contribution to transboundary water sources is substantial; particularly as snow and glaciers become freshwater as they melt (Statistics Canada, 2003). The four largest transboundary rivers in terms of discharge are the Mississippi, St. Lawrence, Columbia, and the Yukon, which are located within their respective, namesake basins (Kammerer, 1990). Some of these rivers are subject to interstate and international compacts to ensure that all countries within the basin get some portion of the water and that the rivers remain navigable for commerce (TFDD, 2003; TFDD, 2003a).[1] The average yearly withdrawals of water in North America amount to 631,686 MCM, with 64,420 MCM in Canada, 477,370 MCM in the U.S., and 89,900 MCM in Mexico (Environment Canada, 2004b; Hutson, 2004; Shiklomanov, 1999).

[1] A general search in the Transboundary Freshwater Dispute Database for U.S. river basins revealed interstate and international compacts for navigation, pollution and water quantity.

The Siffleur River, tributary of the North Saskatchewan River, Alberta. Photo credit: Erik Lizee, via Wikimedia Commons.

One problem in North America is the location of water resources relative to large population centers. In Canada, approximately 60% of the country's freshwater drains to the north, away from 85% of the population living within 300 km of the southern border (Water Survey of Canada, 2003). The U.S. faces a similar problem, particularly in the arid, mountainous west. Mexico also has a comparable problem as the northern and central parts of Mexico contain around 60% of the country's total population with less than 10% of the total water resources (U.S. Library of Congress, 1996).

Surface water quality depends on the

TABLE 3.1 INTERNATIONAL RIVER BASINS OF CANADA AND THE U.S. AND THEIR AREA

River Basin	Total Area (km^2)	Area Division (%)	
		Canada	United States
Alesek	28,400	93.50	6.50
Chilkat*	3,800	43.35	56.59
Columbia	668,400	15.24	84.75
Firth	6,000	63.60	36.40
Fraser	239,700	99.74	0.26
Mississippi	3,226,300	1.54	98.46
Nelson-Saskatchewan	1,109,400	85.81	14.19
Skagit	8,000	11.54	88.46
St. Croix	4,600	29.14	70.86
St. John*	47,700	63.50	36.22
St. Lawrence	1,055,200	52.98	47.02
Stikine	50,900	98.32	1.68
Taku*	18,100	90.09	9.13
Whiting	2,600	80.06	19.94
Yukon	829,700	40.17	59.83

*It is unclear why these percentages do not add up to 100%.
Source: Wolf et al., 1999.

Typical groundwater well located in Yuma, Arizona. Photo credit: Andy Pernick, courtesy of the U.S. Bureau of Reclamation.

location and the activities occurring near water bodies. Surface water quality issues along the Canada-U.S. border are likely the result of activities by communities, agriculture, and industries, such as: point and nonpoint sources of pollution such as discharges from industrial, commercial, agricultural, urban, and transportation sectors; and the long-range transport and deposition of persistent toxic air pollutants from emission sources located outside the U.S. and Canada.

Water quality issues along the northern border between Mexico and the U.S. are the likely result of agricultural runoff and discharge from sewage treatment plants that degrade water quality.

Groundwater quality varies depending on the geology of the aquifer and its susceptibility to contamination and land use. Groundwater quality across the Canada-U.S. border is impacted by agricultural activities, e.g., in the Abbotsford-Sumas aquifer in the Fraser River Basin. Groundwater quality along the U.S.-Mexico border has been impacted by industrial activities. On both sides of each border, groundwater is pumped for irrigated agriculture.

The next chapter discusses the internal laws and conflicts within the U.S., Canada, and Mexico as well as their possible affects on international conflicts.

Table 3.2 International river basins of Mexico and the U.S. and their area

River Basin	Total Area (km^2)	Area Division (%)	
		Mexico	United States
Colorado	655,000	1.59	98.41
Rio Grande/ Río Bravo del Norte	656,100	47.90	52.10
Tijuana	4,400	70.57	29.43
Yaqui	74,700	93.87	6.13

Source: Wolf et al., 1999.

Trans Alaska Pipeline crossing tributary of Koyukuk River, Yukon Basin, Alaska.
Photo credit: Steve Hillebrand, courtesy of the U.S. Fish and Wildlife Service.

Chapter 4. Internal Laws and Their Potential to Influence International Water Management

Alyssa M. Neir, Geoffrey T. Klise, and Michael E. Campana

Water management in all three countries is governed and influenced by internal laws that control water use, water development projects, and other projects that may impact the environment. State and federal agencies are responsible for interpreting, developing and enforcing the domestic or internal laws. These laws influence the actions and the potential impact that national actions may have on neighboring countries. These laws embody common interests in many respects and provide a foundation for cooperation at the international level because they require project proponents to evaluate the impact that their actions will have on existing users and affected parties and attempt to minimize that impact. Internal environmental laws of the three countries include (CEC, 2001):

Canada

- Canada Water Act
- Canadian Environmental Protection Act (CEPA)
- Canadian Environmental Assessment Act (CEAA)
- Canada Shipping Act
- Fisheries Act
- International River Improvements Act
- Northwest Territories Waters Act
- Yukon Waters Act

Mexico

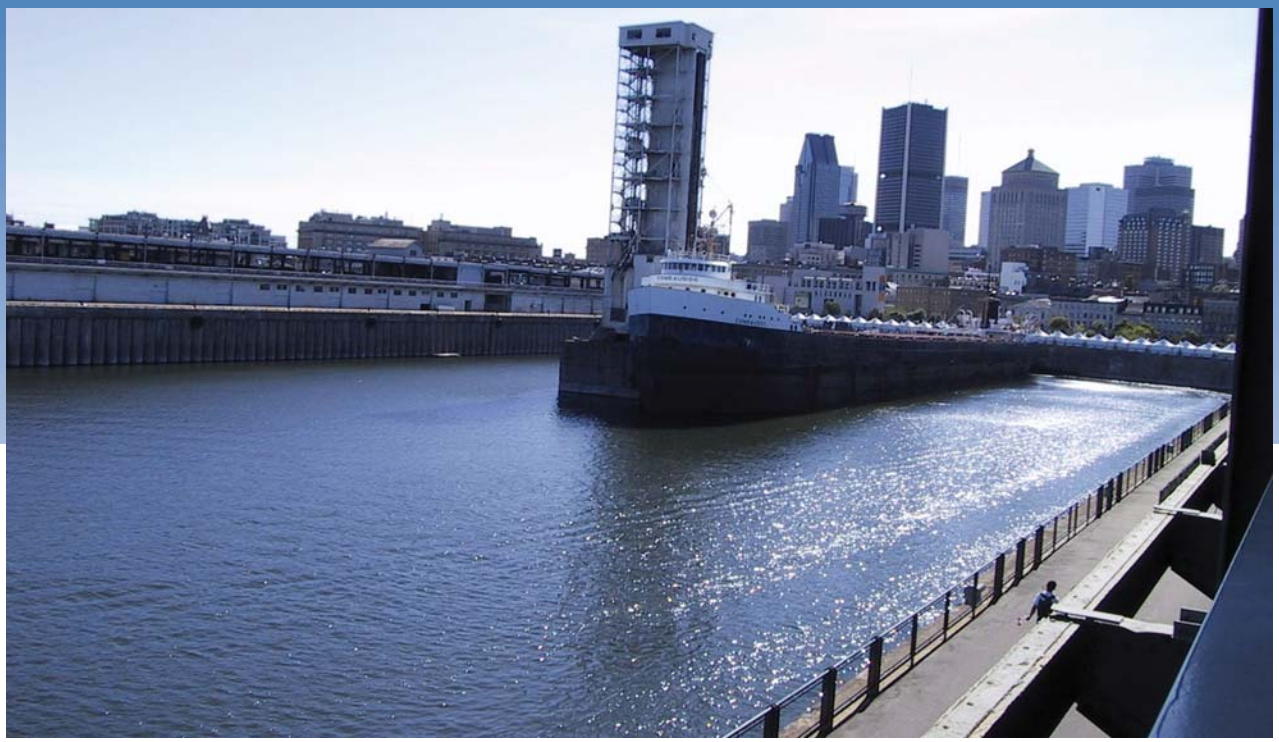
- National Water Law

United States

- Clean Water Act
- National Environmental Policy Act (NEPA)
- Safe Drinking Water Act
- Federal Endangered Species Act
- Fish and Wildlife Coordination Act
- Wild and Scenic Rivers Act
- Navigable Waters Protection Act
- Pacific Northwest Power Planning and Conservation Act
- Dakota Water Resources Act
- Great Lakes – St. Lawrence River Basin Water Resources Compact

Under the authority of Canadian laws, federal and provincial agencies are responsible for carrying out the provisions of laws and have direct involvement in: (1) forestry operations, municipal facilities, and industrial facilities that affect water quality and consumption; (2) protection of fish and habitat; (3) navigation and shipping; (4) discharge of substances into waterways; (5) regulation of dams, diversions, and other developments on international waters; (6) construction of bridges over water; and (7) consideration of the environmental consequences of specific projects (CEC, 2001).

Under the authority of U.S. federal laws, federal, state and tribal agencies are responsible for carrying out the provisions of the laws and have direct involvement in: (1) the discharge of pollutants into navigable waters; (2) logging, water diversions or development projects; (3) management of natural resources; (4) protection of endangered species; (5) municipal and industrial water services; (6) irrigation systems; (7) hydropower generation; (8) flood control; (9) river regulation; (10) fish and



The Old Port of Montréal, Québec, on the Saint Lawrence River. Photo credit: Krestavilis, via Wikimedia Commons

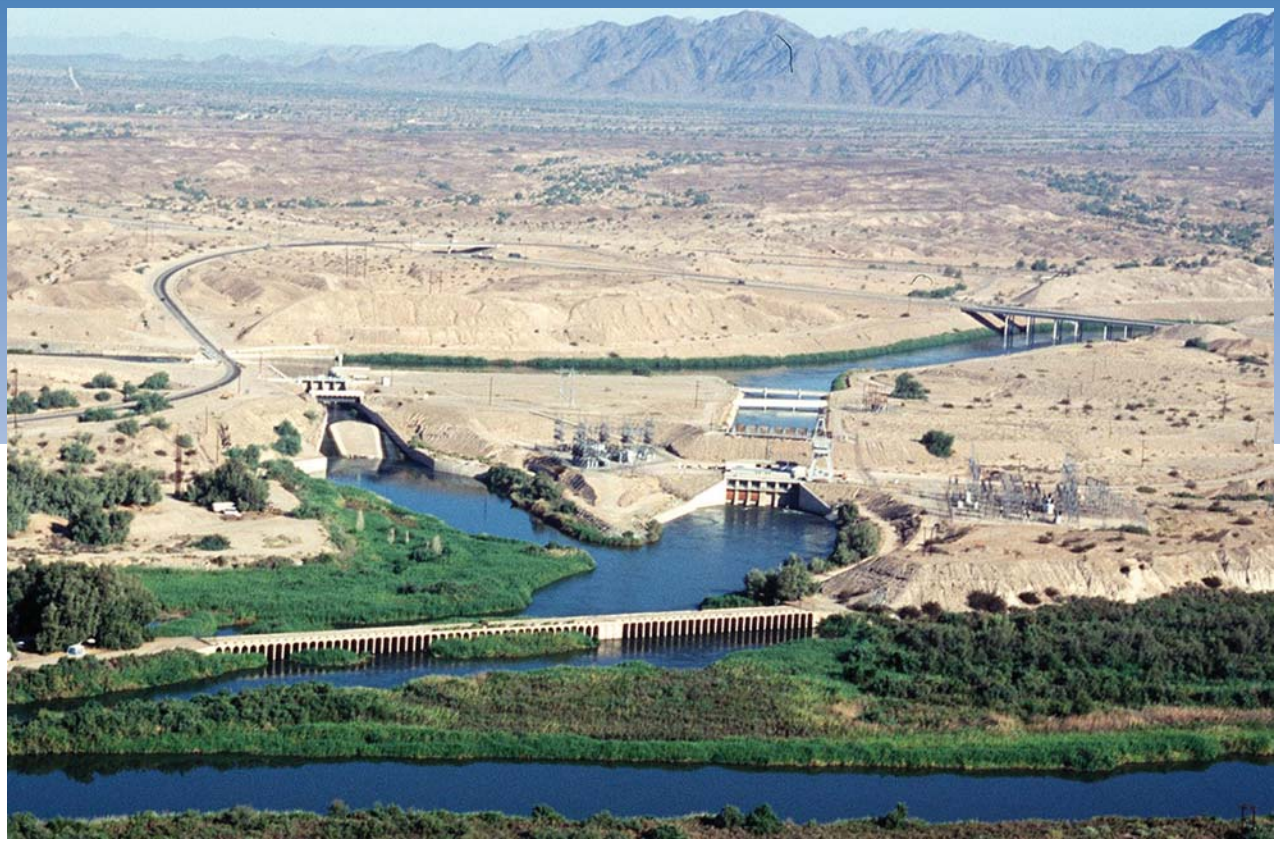
wildlife enhancement; (11) recreational opportunities; and (12) consideration of environmental consequences of specific projects (CEC, 2001).

No discussion of U.S. internal laws that could affect international water management is complete without mentioning the Great Lakes-St. Lawrence River Basin Water Resources Compact. Known simply as the Great Lakes Compact, it became U.S. law in December 2008 and is the regional policy success story of the decade (Great Lakes Environmental Law Center, 2009). The Compact is a legally binding agreement among the eight U.S. Great Lakes states—Minnesota, Wisconsin, Indiana, Illinois, Michigan, Ohio, Pennsylvania, and New York—that prevents most diversions of Great Lakes water out of the region and establishes new water conservation and environmental protection standards for water use within the region (Great Lakes Environmental Law Center, 2009). Under the Great Lakes Compact, the world's second-largest fresh lake water resource is protected and managed pursuant to minimum standards administered primarily under the authority of individual states. The Great Lakes Compact puts riparian water use rules and environmental protection standards into a proactive public law regime. The standards represent numerous advances in the development of water use law, including uniform treatment of groundwater and surface water withdrawals, water conservation, return flow, and prevention of environmental impacts (Great Lakes Environmental Law Center, 2009).

Swan goose (Anser cygnoides), Woods Canyon Lake, White Mountains, Arizona. Photo credit: Terrence E. Davis.

There is also a non-binding companion agreement that includes the Canadian Great Lakes–St. Lawrence River Basin provinces of Ontario and Quebec. There already is a Great Lakes–St. Lawrence River Water Resources Regional Body, which includes the Canadian provincial premiers in addition to the Great Lakes states' governors.

The significance of the Great Lakes compact goes beyond water protection. It sets a precedent for the region coming together around common values and interests. The states set aside their differences and supported a common vision for



Siphon Drop Power Plant on the Yuma Canal (offshoot of the All American Canal). Photo credit: Andy Pernick, courtesy of U.S. Bureau of Reclamation.

the future of the Great Lakes. The companion agreement signals the support of the provinces of Ontario and Quebec, signifying a binational vision for the Great Lakes.

Under authority of Mexico's National Waters Act, the National Water Commission (CAN) has "…direct involvement in: (1) the administration of water supply and sanitation in border states and *municipios*; (2) the management of national irrigation districts; (3) the creation of river basin councils; (4) the maintenance of water supply and treatment infrastructure; and (5) the maintenance of a public registry of public water rights" (CEC, 2001).

The internal laws of the three countries reduce the potential impact that individual actions can have on international transboundary waters and have helped sustain cooperation between countries. This can be seen through the way that the internal laws help filter proposed projects and provide an avenue for international entities to comment. For example, the U.S.'s plan to line the All American Canal went through the NEPA process and Mexico had the chance to comment on the project (USBOR, 2006), and the proposed water supply project in the Red River Basin went through the NEPA process and Canada had the opportunity to comment as part of that process (USBOR, 2007). In addition, a proposed mine (the Galore Creek Gold-Silver-Copper mine) went through the CEAA process and the U.S. had the opportunity to comment (Transport Canada, Environment Canada, Fisheries and Oceans Canada and Natural Resources Canada, 2007).

The following chapter addresses international conflicts and cooperation between the U.S. and Canada, and the U.S. and Mexico, assessing how conflict and cooperation can affect regional hydropolitical vulnerability in North America.

Irrigated wine grapes in Valle de Guadalupe, Ensenada, Baja California. Photo credit: Hlecuanda, via Wikimedia Commons.

Grand Canyon of the Colorado River, Arizona. Photo credit: Terrence E. Davis.

Chapter 5. International Conflicts and Cooperation that Influence Regional Hydropolitical Vulnerability

Alyssa M. Neir, Geoffrey T. Klise, and
Michael E. Campana

5.1 Background Information on Conflict and Cooperation

For our purposes, the term "conflict" refers to a situation where one government has taken a unilateral action, inciting protests from the other government. "Cooperation" is defined as both governments working together and using all the institutional avenues available to resolve the situation. There are also situations that exemplify conflict leading to cooperation. There is a long history of cooperation between Canada and the U.S. regarding transboundary water resources under the BWT and other binational agreements. There is also a long history of cooperation between the U.S. and Mexico under the oversight of the IBWC. Currently, examples of conflict, cooperation, and a combination of the two exist, which have taken place in the Fraser River Basin, Missouri-Mississippi River Basin, St. Lawrence River Basin, Colorado River Basin, Rio Grande Basin, and Tijuana River Basin.

5.2 The Hydropolitical Situation in Selected North American Basins

5.2.1 Examples of Conflict and Conflict leading to Cooperation

5.2.1.1 Rio Grande/Río Bravo del Norte Basin

There has been much controversy over the Rio Conchos and other Mexican tributaries of the Rio Grande (Figure 5.1). Waters from these Rio Grande tributaries are apportioned between both countries by the Treaty of February 3, 1944. According to this treaty, Mexico gets approximately two-thirds and the U.S. gets approximately one-third of the six tributary rivers' water (IBWC, 1944).

A recent conflict involves delivery of water to the U.S. due to the prolonged drought that started in 1993. Mexico fell behind in its delivery to the U.S. due to what has been termed an "extraordinary drought" that lasted longer than the five-year accounting cycle outlined in the 1944 treaty (Texas Center, 2002). This drought impacted irrigators on both sides of the border. According to the treaty, by 2002, Mexico's accumulated debt was 1,263 MCM of water that should have been delivered to the U.S. Mexico agreed to

Wetlands of the Rio Grande/Río Bravo del Norte in Alamosa/Monte Vista National Wildlife Refuge, Colorado. Photo credit: Robert Sanders, Ducks Unlimited, courtesy of the U.S. Fish and Wildlife Service.

Figure 5.1 Rio Grande/Río Bravo del Norte Basin.

deliver some water under Minute 307 but the amount was not enough to cancel the entire debt (Texas Center, 2002). To help deal with this conflict, the North American Development Bank (NADBank), along with the Mexican government, funded efficiency improvements in Mexico to increase water delivered to the U.S.

Despite the efforts by both countries to solve this conflict, Mexico was still short on water deliveries to the U.S. Since the 1944 treaty prescribes delivery of a certain amount of water and does not account for what has been described as "extraordinary drought", it leaves Mexico vulnerable to U.S. demands (Kelly, 2002).

Rio Grande/Río Bravo del Norte between Mexico and the United States, with Big Bend National Park, Texas, on one bank, and Chihuahua on the other. Photo credit: Gary M. Stolz, courtesy of the U.S. Fish and Wildlife Service.

As evidenced in the conflict, many Mexican irrigators went without water because their reservoirs were too low (Texas Center, 2002). However, this hardship did not change delivery calculations as the debt continued to accrue during the drought years.

A claim was filed against Mexico by water-rights holders in Texas under NAFTA to explore whether NAFTA extends to economic losses suffered during the period that the deficit was still outstanding. The claim was dismissed.

Rio Grande cutthroat trout (Oncorhynchus clarkii virginalis) is found in tributaries of the Rio Grande/Río Bravo del Norte. Photo credit: Lloyde Hazzard, courtesy of the U.S. Fish and Wildlife Service.

5.2.1.2 Tijuana River Basin

A major water quality issue has existed for quite some time on the U.S.-Mexico border in the Tijuana Basin (Figure 5.2). The Tijuana River originates in Mexico and flows across the international border into San Diego, California (U.S.). The river then discharges into the Pacific Ocean just south of Imperial Beach. Raw sewage was dumped into the Tijuana River in Mexico, which led to closures of Imperial Beach due to health concerns. This created conflict between both countries that resulted in the 1997 installation of a wastewater treatment plant (WWTP) in the U.S. to treat municipal discharge before it enters the ocean (Sign On San Diego, 2005a). However, since effluent from this treatment plant does not meet U.S. water quality standards, this led to a U.S. Federal Court order mandating construction of a newer sewage treatment plant by 30 September 2008 capable of treating wastewater to secondary standards.

The South Bay International Wastewater Treatment Plant has undergone U.S. National Environmental Policy Act (NEPA) review (Parsons, 2004). The plan involves the construction of a

Sweetwater Marsh National Wildlife Refuge, Imperial Beach, California. This bit of salt-marsh habitat, just 315 acres, is all that's left of the huge salt marshes surrounding San Diego Bay. The refuge, a satellite of Tijuana Slough Refuge, is home to the endangered least tern, Belding's savannah sparrow, and light-footed clapper rail. Photo credit: John and Karen Hollingsworth, courtesy of the U.S. Fish and Wildlife Service.

new WWTP to treat sewage to secondary quality standards, as mandated by the U.S. Federal Court, in Mexico, with effluent piped directly to the existing South Bay outfall. Even though this may mitigate the water quality problem near Imperial Beach, it does not entirely deal with the source of sewage since WWTPs treat only wastewater transported by existing sewage infrastructure. New developments near the Tijuana River in Mexico have no sewer infrastructure and raw sewage can still affect the river and cause water quality concerns near Imperial Beach (Sign On San Diego, 2005b). Mexico is working to remedy this situation.

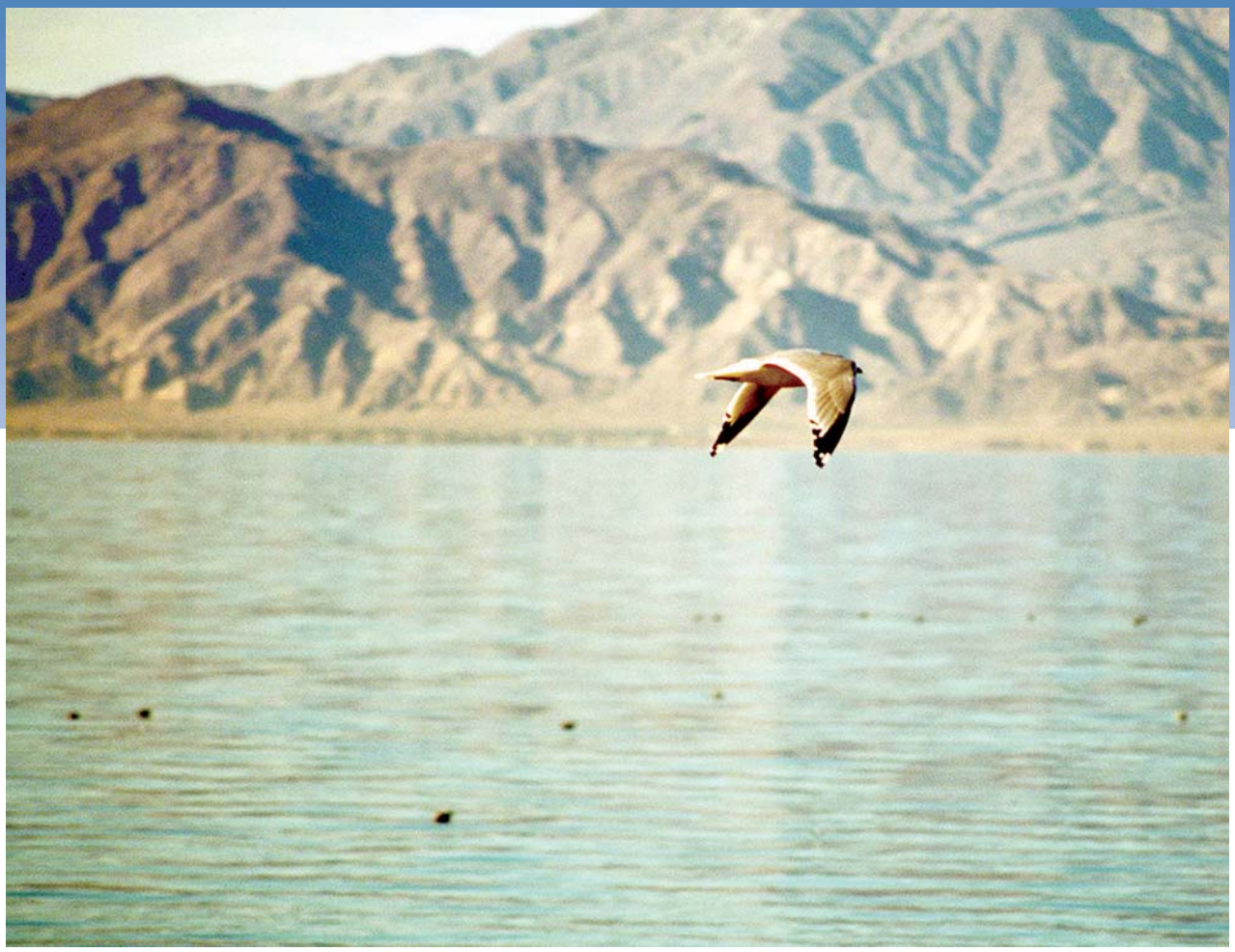
One consequence of pollution in the Tijuana River Basin is the impact on the underlying aquifer. While Tijuana uses only about 5% of available groundwater supplies, the quality is found to be poor due to surface pollution and salt-water intrusion. At best, the aquifer could be used to augment existing surface water supplies or be used to store treated wastewater for future use (U.S. EPA, 2005). On the U.S. side, San Diego has plans to develop approximately 3.1 MCM of water from the San Diego Formation in the lower Tijuana River Valley (SDCWA, 1997).

To help assist in the planning process, San Diego State University published an atlas of the Tijuana River watershed to help decision makers have access to the same information (Sign On San Diego, 2005b). The atlas was created through collaboration with universities and agencies on both sides of the border and will help those involved with the international watershed who deal with environmental issues ranging from water quality to ecosystems (SDSU, 2005).

Cooperation in the Tijuana River basin has led to efforts that have helped clean up surface water in the Tijuana River in Mexico and near Imperial Beach in the U.S. With completion of the new secondary-treatment WWTP, water quality near Imperial Beach should continue to improve, as sewage will be treated to secondary standards. One problem that remains is the lack of sewer

Figure 5.2 Tijuana River Basin.

connections on the Mexico side of the Tijuana River watershed. Unless new development is connected to a WWTP, there will be continued degradation of surface water and groundwater. At present, municipalities on both sides of the border rely primarily on surface water; however, municipalities may start relying on groundwater as the population increases. Unless pollution issues are dealt with, this source may not be available to either country.



View of part of the Salton Sea, east of San Diego in California. Photo credit: Andy Pernick, courtesy of the U.S. Bureau of Reclamation.

A view of the agricultural drains located near the Salton Sea, California. Photo credit: Andy Pernick, courtesy of the U.S. Bureau of Reclamation.

5.2.1.3 Colorado River Basin — Salton Sea

A solution to a recent conflict is emerging between the U.S. and Mexico over raw sewage discharge to the Salton Sea via the New River, located in Mexicali, Baja California (Figure 5.3). In 2004, the countries came to a binational agreement to procure funding for a WWTP, which is the final phase in this project (U.S. EPA, 2004).

The start of this process was the 1980 signing of Minute 264 by both the U.S. and Mexico, which called for Mexico to stop discharging raw sewage into the New River at the International Boundary (CALEPA, 2003). Next, Minute 288 was signed by both countries in 1992, which involved the development of a long-term plan to deal with the wastewater problem as Minute 264 was not being followed by Mexico. The results of Minute 288 were an improvement in sewage collection and septic systems in Mexicali and construction of a new WWTP.

Figure 5.3 Colorado River Basin.

However, the WWTP was delayed due to the effective opposition by Mexican residents in El Choropo (CALEPA, 2003). The WWTP was then moved to a location outside of the Salton Sea transboundary watershed (CALEPA, 2003) and will flow towards the Gulf of California via a tributary of the Colorado River (U.S. EPA, 2005). While water quality should improve as a result of this project, it will result in decreased flows into the Salton Sea.

Hoover Dam, on the Colorado River between the states of Nevada and Arizona. Photo credit: Terrence E. Davis.

5.2.1.4 Colorado River Basin — Upper San Pedro Basin

The Upper San Pedro Basin, in the Colorado River Basin, is the location of a unique desert ecosystem that has international importance (Figure 5.3). The watershed originates in Sonora, Mexico, and flows north across the international border into the U.S. state of Arizona. The majority of the basin lies in the U.S.; 4,500 km^2 lie in the U.S. and 1,900 km^2 in Mexico (Arias, 2000).

Cattle on irrigation-flooded pasture, Nevada. Photo credit: Brenda Miraglia.

Groundwater in the basin flows from Mexico to the U.S. (Arias, 2000). This watershed has a large number of migratory birds that utilize the riparian area of the San Pedro River before continuing their journey. Due to the importance of this ecosystem, a portion of the riparian area in the U.S. has been given special status as the San Pedro Riparian National Conservation Area (SPRNCA). Current water use in the basin on both sides of the border is for irrigation, mining, municipalities, and domestic purposes. These uses are primarily satisfied by groundwater and exceed recharge by an estimated 6 to 12 MCM (Varady et al., 2001).

This transboundary basin is the subject of a multi-national study spearheaded by the Commission on Environmental Cooperation (CEC), which is under the North American Agreement on Environmental Cooperation (NAAEC)–the environmental side-agreement to NAFTA. This study has two main purposes: One is to determine the impacts of groundwater pumping on riparian areas of the San Pedro River and the other is to come up with a way to protect the migratory bird corridor (Varady et al., 2001).

Hassayampa River, Arizona. Photo credit: Terrence E. Davis.

This area is undergoing large population growth, especially within the U.S., and is a case study for trying to balance ecological values with increasing human needs; the situation is made more complicated due to the transboundary nature of the basin.

The CEC report came up with solutions based on three types of acceptability. The first category involves "measures that are hydrologically effective and economically achievable" (CEC, 1999), which prove to be the most controversial due to calls for reduction of irrigation on both sides of the border (Arias, 2000). While the CEC recognized that there are large data gaps on water use and aquifer properties on the Mexican side of the border, it believes that it should not stop conservation initiatives (restricting development and irrigation) in both countries (CEC, 1999).

The initiation of this CEC study created a great deal of conflict among groups in the U.S. because they felt that growth should not be restricted and irrigation should not be curtailed. Some of the largest water uses on the U.S. side, other than irrigation, include municipal and military uses. On the Mexican side, the largest water use is by a copper mine. Mexico is seen as having less of an interest in protecting habitat for migratory birds than the U.S. (CEC, 1999).

While no major decisions have been implemented as a result of this study, it has helped stakeholders on both sides of the border to understand the tradeoffs of protecting one "use" of water for another and brought about binational communication and cooperation between local agencies and advocacy groups (Varady et al., 2001). The IBWC has limited capacity to regulate groundwater. Furthermore,

Water feature at casino, Las Vegas, Nevada. Photo credit: Brenda Miraglia.

Irrigation sprinklers on golf course at Tuscon, Arizona, resort. Photo credit: Brenda Miraglia.

Mexican groundwater is regulated by the federal government whereas in the U.S. the states regulate groundwater. It has been mentioned that the IBWC has been unwilling to apply Minute 242, written in 1973 (Varady et al., 2001). However, Minute 242 applies specifically to the Colorado River, and the IBWC lacks capacity or jurisdiction over the San Pedro River Basin (Brandt, IBWC, written communication, 2008). This minute calls for consultation between both countries if groundwater development in one country may "adversely affect the other country" (IBWC, 1973).

Giving the assist at a drinking fountain. Photo credit: Brenda Miraglia.

Since Mexico is the upstream state, it holds an advantage over the U.S. in terms of water use. However, if U.S. groups that support riparian habitat conservation via the reduction of groundwater pumping advocate for the implementation of Minute 242, the result may significantly reduce future development of groundwater in Mexico. Minute 242 would have different applications in the U.S. because it is the downstream state and groundwater use does not currently threaten Mexican water supplies; yet if Mexico becomes more concerned about protecting riparian habitat and views U.S. groundwater pumping as a future threat, then it could argue for the application of Minute 242, which would negatively affect groundwater development in the U.S.

5.2.1.5 Conflict and Conflict leading to Cooperation Summary

The proposed regulation of groundwater pumping in the San Pedro River Basin (Colorado River Basin) has a certain degree of conflict present, but has no real, tangible consequences or solutions at this time. Some of the recent

White pelicans and recreationists, Columbia River, Washington. Photo credit: Sandra Arbogast.

examples of conflict leading to cooperation involve the treatment of surface water flowing into the U.S. from Mexico, specifically in the Tijuana River Basin and Mexicali (Colorado River Basin). These projects, funded by specific agencies (BECC and NADBank) tasked with dealing with border issues, require money to implement a technological fix. Some of these projects were officially handled through minutes passed by the IBWC. In addition to the projects mentioned above, cross-border agencies such as the NADBank are implementing many other wastewater treatment plans on both sides of the border. This type of solution to water quality problems is relatively easy to implement as long as the money is available to build treatment systems. As the border regions increase in population, there will always be a need to ensure that wastewater is treated; this concern is partially offset because the existing institutions are equipped to handle transboundary water quality issues such as wastewater effluent and its treatment.

The example of the Rio Conchos (Rio Grande Basin) controversy shows that despite the ability of an existing institution (IBWC) to settle a water allocation dispute between the U.S. and Mexico, the presence of NAFTA may undermine the efforts made by the IBWC. Using NAFTA to settle disputes may be an alternative dispute resolution tool as it has the ability to give relief in terms of lost economic opportunity, rather than receiving water that should have been delivered years earlier. However, it would be best to use one system (i.e., either the IBWC or NAFTA) because the presence of two separate ways to find solutions may cause more conflict in the future.

5.2.2 Examples of Cooperation

Below are some recent examples of cooperation between the U.S. and Canada and the U.S. and Mexico. The examples show that the countries are

Working together on a water project. Photo credit: Brenda Miraglia.

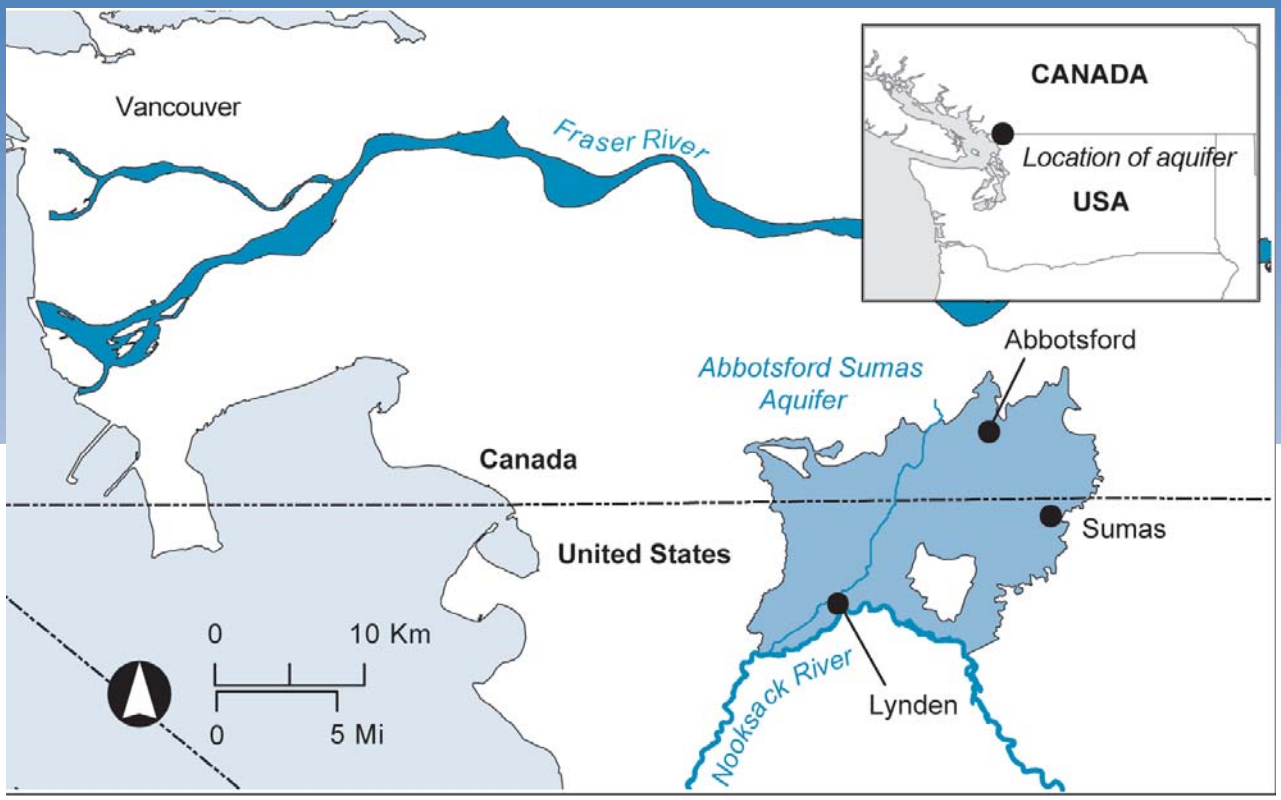


Figure 5.4 The Abbotsford-Sumas Aquifer.

using the agreements and institutions that are available to manage transboundary water resources and settle disagreements.

5.2.2.1 Abbotsford-Sumas Aquifer

The Abbotsford-Sumas aquifer underlies British Columbia, Canada, and Washington, U.S.; its water flows southward (Figure 5.4). The aquifer is unconfined and provides water for over 115,000 people (Mitchell et al., 2003; Cox and Liebscher, 1999). The current concern is the high concentration of nitrate in the aquifer from agricultural practices in both British Columbia and Washington (Washington State Dept. of Ecology, 2003; Mitchell et al., 2003). The Abbotsford-Sumas Aquifer International Task Force, a product of the 1992 Environmental Cooperation Agreement between the province and state, was created specifically to address transboundary problems concerning the aquifer. This Task Force demonstrates the presence of cooperation (A-S Task Force, n.d.) and covers the broad area of "groundwater

Sunset, Puget Sound, Washington. Photo credit: Brenda Miraglia.

Motor Vessel Grand Tower pushes the crane barges Sewell and Fisher down the Chain of Rocks Canal near Granite City, Illinois, after recovery of a barge that sank in a lock. The canal bypasses an unnavigable section of the Mississippi River. Photo credit: George Stringham, courtesy of the U.S. Army Corps of Engineers.

protection," which can be expanded to include future issues.

A recent example of small-scale cooperation surrounding the protection of the aquifer is British Columbia's proposal to reclaim a gravel pit and transform it into Aldergrove Lake Regional Park, which would use biosolids as well as biosolids-compost to revegetate the area (Van Ham, et al., 2000). The public on both sides of the border was concerned about the effects that biosolids would have on the aquifer's water quality in general and specifically for regions of the aquifer that people rely on for their drinking water (Van Ham et al., 2000). In order to allay people's fears, open meetings were held and stakeholders (elected officials, Abbotsford-Sumas Aquifer International Task Force, residents within a one-kilometer radius of the park, and local and U.S. interest groups) were informed about the project (Van Ham et al., 2000). The project, which was shown to possibly improve the aquifer's water quality, was approved and demonstrates how open cooperation from the beginning of a project can lead to success.

5.2.2.2 Missouri-Mississippi River Basin

The waters of the Milk and St. Mary Rivers in the Missouri-Mississippi River Basin are apportioned between the U.S. and Canada in Article VI of the BWT. However, due to conflicting interpretations of the BWT, specific instructions on how the waters are allocated were defined in the IJC Order of 1921 (IJC, 1921). The two countries

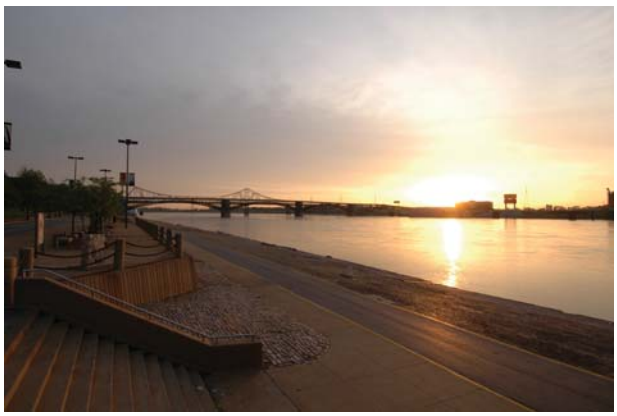
Aquatic plants in the Upper Mississippi River National Wildlife and Fish Refuge (NWFR), a 261-mile-long refuge along the Mississippi River in the states of Minnesota, Wisconsin, Iowa, and Illinois. Photo credit: U.S. Fish and Wildlife Service.

Figure 5.5 Missouri-Mississippi River Basin

also use a 1991 voluntary Letter of Intent as an administrative tool to maximize the beneficial use of the two rivers. In 2003, the Governor of Montana requested that the IJC to review the 1921 Order for the purpose of determining whether or not it is successfully meeting the intent of the BWT. In response, the IJC held public meetings in the basins and created a task force in 2004 to investigate administrative options for improving the performance of the apportionment (International St. Mary–Milk Rivers Administrative Measures Task Force, 2006).

Ship traffic on the lower Mississippi River west of New Orleans, Louisiana. Photo credit: Lieut. Commander Mark Moran, NOAA Corps, MAO/AOC, courtesy of the National Oceanic and Atmospheric Administration/Department of Commerce.

The task force prepared a report documenting its findings and gave it to the IJC (International St. Mary – Milk Rivers Administrative Measures Task Force, 2006). The IJC sees its role as a facilitator in this case, stating "…that this could be a case study of how the Commission can help facilitate dialogue and defuse tensions over issues before they erupt into full-blown disputes" (IJC, 2008). The IJC is continuing to receive updates on discussions between the two countries. This is an example of cooperation because Montana used the IJC to attempt to make a structural change in the agreement.



(Above, right) Mississippi River sunrise over the riverfront; the two bridges visible are the Eads Bridge and the Martin Luther King Bridge, which connect East St. Louis, Illlinois and St. Louis, Missouri. Photo credit: George Stringham, courtesy of the U.S. Army Corps of Engineers. Small dead crab in hypoxic (no oxygen) sediments at Mississippi River mouth, off the Louisiana coast in the Gulf of Mexico. Photo credit: N. Rabalais, OAR/National Undersea Research Program (NURP); Lousiana Univ. Marine Consortium, courtesy of the National Oceanic and Atmospheric Administration(NOAA)/ Department of Commerce.

Marina at the Old Port of Montréal, Québec. Photo credit: Krestavilis, via Wikimedia Commons.

5.2.2.3 Great Lakes and St. Lawrence River Basin

Missisquoi Bay, located in the St. Lawrence Basin, borders Vermont (U.S.) and Quebec (Canada). Vermont wanted to build a new bridge and remove part of the old bridge and causeway structure (International Missisquoi Bay Task Force, 2004). However, before taking any action the issue was referred to the IJC in 2004 by both the U.S. and Canada, which then set up a task force to assess the legality of the project under the Boundary Waters Treaty (International Missisquoi Bay Task Force, 2004). The Study Board was asked to examine issues of water flows and levels, as well as concerns regarding water quality. While the study found no consequential impacts on flows, levels or water quality associated with bridge construction or causeway removal and that more research was needed to better understand the effects of the bridge on the water quality (e.g., algal blooms and

(left) Night view of Quebec Bridge (Pont de Québec) over the St. Lawrence River, Québec City, Québec; photo credit: Martin St-Amant (S23678), via Wikimedia Commons. Ashtabula Harbor, on Lake Erie at Ashtabula, Ohio; photo credit: Ken Winters, courtesy of U.S. Army Corps of Engineers.

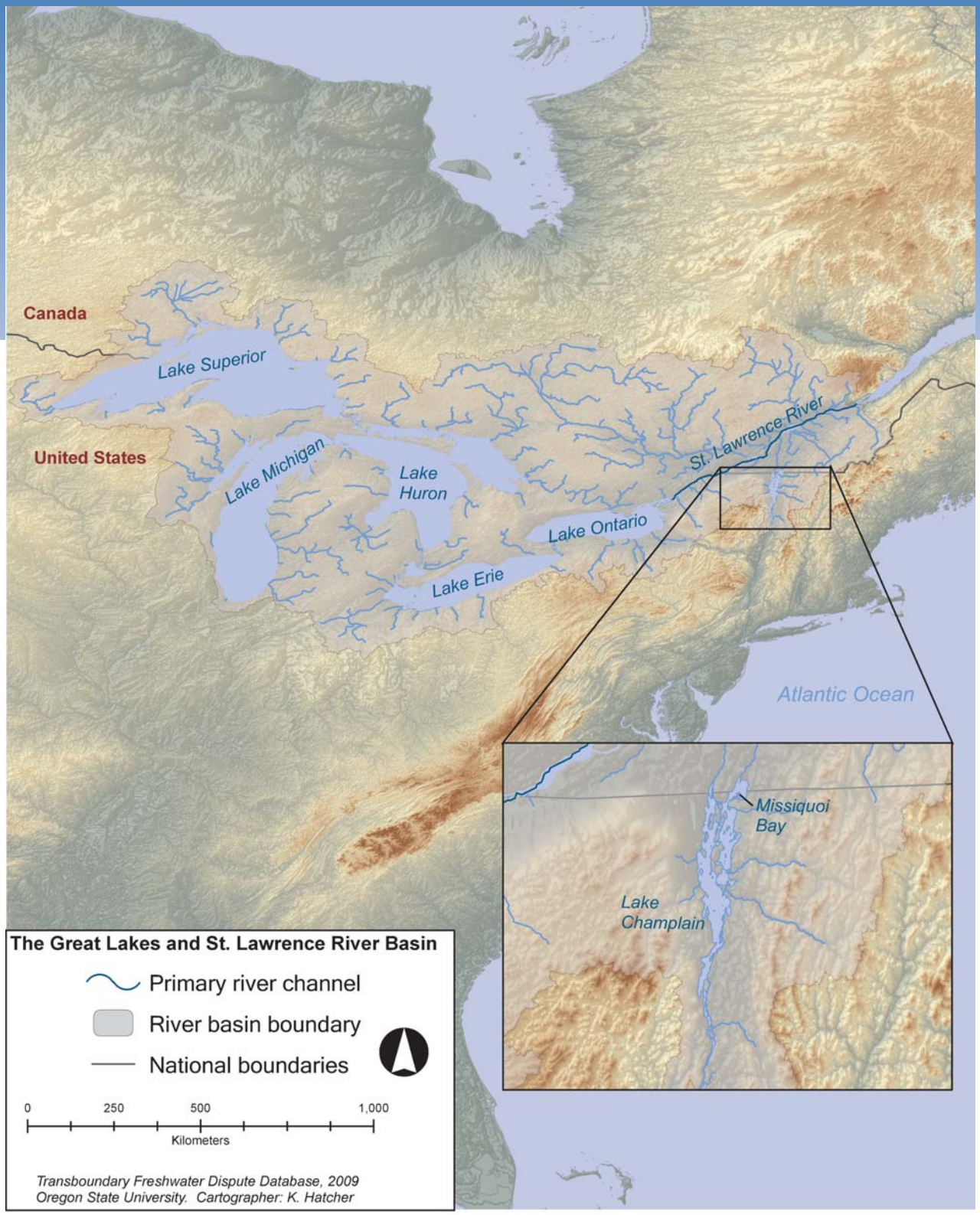


Figure 5.6 Great Lakes and St. Lawrence River Basin.

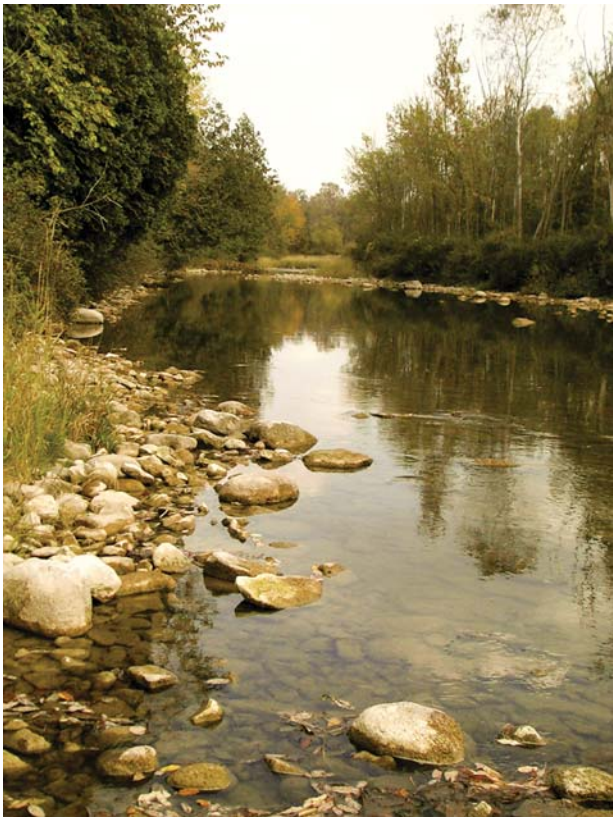
phosphorus) and ecology (e.g., turtles), the use of the IJC, the institutional entity responsible for transboundary issues, demonstrates cooperation between the two countries.

During 2009, the International Joint Commission is carrying out binational expert work assisting the two countries with specific issues about protecting Lake Champlain's water quality.

The IJC has conducted binational studies on the Great Lakes. The International Levels Reference Study (1986-1993) examined the causes of the high lake water levels in the 1980s and then expanded to include the effects of three

Racing sailboats on Lake Huron, Michigan. Photo credit: Dale Fisher, courtesy of the U.S. Army Corps of Engineers.

climate change scenarios on Lakes Superior and Ontario, the two lakes with outflow controls. It also addressed new controls on the three uncontrolled lakes (Eberhardt, 2009). The International Lake Ontario–St. Lawrence River Study (www.losl.org), a five-year study completed in 2006, used various climate change scenarios to develop management options for Lake Ontario (Eberhardt, 2009). The International Upper Great Lakes Study (www.iugls.org) , another five-year study to be completed in 2012, is assessing the roles climate change and variability may have in producing the currently observed declining upper Great Lakes levels. The study will also consider how such hydrologic changes can be incorporated into the development of a new Lake Superior management plan (Eberhardt, 2009).



Saugeen River, Ontario. Photo credit: Bethanylauren, via Wikimedia Commons.

5.2.2.4 Rio Grande/Río Bravo del Norte Basin

The Mesilla and Hueco Bolsons are transboundary aquifers that span the U.S. states of New Mexico and Texas, and the Mexican state of Chihuahua. The growing cities of El Paso, Texas and Juarez, Chihuahua, located adjacent to each other along the U.S.- Mexico border, use water from these aquifers and from the hydrologically connected Rio Grande/Rio Bravo. While the sharing of Rio Grande waters is addressed in the 1906 Convention and 1944

Rio Grande/Río Bravo del Norte between Ciudad Juárez, Chihuahua, and El Paso,Texas. Photo credit: iose, via Wikimedia Commons.

Treaty between the U.S. and Mexico, there has been no agreement about the sharing of the underlying transboundary aquifers.

Extensive pumping of the aquifers has led to a decline in the water table on both sides of the border. Initially, El Paso relied on surface water from the Rio Grande but has started using more groundwater. Juarez relies primarily on groundwater. The City of El Paso implemented a 40-year water plan in 2000 to help ensure future supplies. Juarez, on the other hand, does not have a formal plan to deal with increasing demand.

Agricultural water use of the Rio Grande/Rio Bravo has degraded surface water and groundwater quality by increasing salinity. The saline waters seep into the ground, recharging both aquifers and increasing groundwater salinity. Conversely, saline water from the shallow aquifer recharges the Rio Grande via irrigation drains (Walton and Olmacher, 2003). Due to these water quality and potential water quantity issues, a bill (S.B. 214, 2005) was passed by the U.S. Senate that will appropriate money to study the transboundary aquifers. This study may help prevent conflict and lead toward future water sharing agreements. The precursor to this bill was a joint effort by the U.S. and Mexico to create a groundwater database for the El Paso/Juarez area, titled "Transboundary Aquifers and Binational Groundwater Database." In 1998, studies completed on both sides of the border were brought into this database by the IBWC to help understand existing data gaps and make recommendations for future studies (IBWC, 1998). This study is an example of cooperation of both countries via the IBWC. By understanding the physical properties of the aquifers, there may be some attempt to minimize future conflict on both sides of the border since both cities will continue to grow and rely on the same source of water.

5.2.2.5 Colorado River Basin

The border cities of Nogales, Arizona (U.S.) and Nogales, Sonora (Mexico) along the Santa Cruz River in the Colorado River Basin were the subject

Frog in tributary of Bright Angel Creek, Grand Canyon National Park, Arizona. Photo credit: Keith Davis.

Silver Bridge over the Colorado River; Black Bridge in the distance. The Silver Bridge supports the transcanyon waterline, which brings water from Roaring Springs to the pumping station at Indian Gardens and supplies water for Grand Canyon National Park. Photo credit: Terrence E. Davis.

of a study completed by the Binational Technical Committee, headed by the Border Environment Cooperation Commission (BECC). This group, comprised of local, state, and federal water agencies, developed a plan to mitigate wastewater runoff originating in Mexico and flowing into the U.S. (BECC, 2004). The purpose of this project is to fix existing leaky wastewater pipes on the Mexican side, which will in turn improve water quality in the Nogales Wash that flows into the U.S.

The project, jointly funded by the U.S. EPA and the Mexican Government (BECC, 2004), serves as an example of cooperation between both countries in response to deteriorating water quality on both sides of the border, as well as public health issues that arose due to the presence of untreated wastewater. This area was also the subject of the first binational groundwater quality monitoring project between the two countries and set the stage for fixing the wastewater leaks in Nogales, Sonora (Castaneda, 1998).

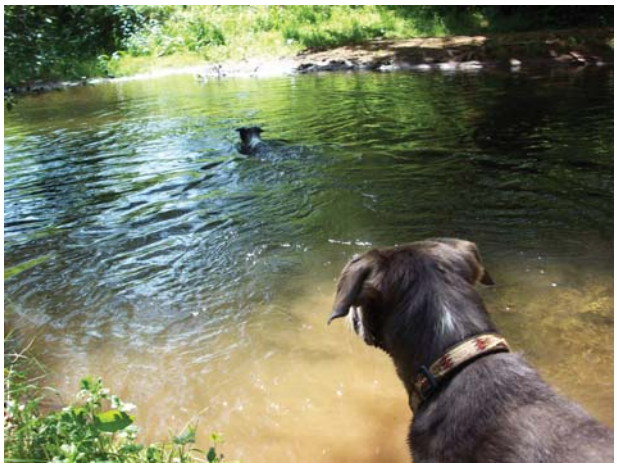
Crossing creek in campground, Colorado basin, Utah. Photo credit: Brenda Miraglia.

Other aspects of this project, known as the "Acuaferico Project," will eventually bring more water to those on the Sonoran side by increasing groundwater pumping (Walker and Pavlakovich-Kochi, 2003). However, some people in Arizona express concern that growing water use on the Sonoran side will lower water tables on the Arizona side, leading to increased pumping costs (Walker and Pavlakovich-Kochi, 2003). The direction of water flow in the transboundary aquifer is from south to north, with those in Sonora having the ability to use water first before it flows across the international border. This places those in Nogales, Arizona, vulnerable to the increasing population in Nogales, Sonora, especially since there is no agreement on the apportionment of groundwater. Despite deficits, this is an example of cooperation because a new institution was created in order to resolve the transboundary water problem of wastewater pollution between the U.S. and Mexico.

Sprint canoeing, women's C-4 team of the Boating Club de Canotage Otterburn, Quebec. Photo credit: Daniel Gauthier, via Wikimedia Commons.

5.2.2.6 Cooperation Summary

The majority of the current examples demonstrate binational cooperation among the three countries —they are voluntarily collaborating and using the institutions available to them in that region as well as creating new institutions to deal with specific problems and to work together more effectively. The IJC has conducted studies on the Great Lakes. The U.S. and Mexico have embarked on a study of transboundary aquifers. Task forces have been created for the Abbotsford-Sumas Aquifer (Fraser Basin), the Missisquoi Bay (St. Lawrence Basin) development, the Rio Bravo/Rio Grande (Rio Grande Basin), and the Santa Cruz River (Colorado River Basin) to deal with water quality issues. Furthermore, the water apportionment of the Milk and St. Mary Rivers (Missouri-Mississippi Basin) has been referred to the IJC. While the countries may not always agree, they are willing to involve an unbiased entity to help resolve the conflict, which makes these basins resilient.



(top) Rafters prepare to run a rapid, Wenatchee River, Washington; photo credit: Terrence E. Davis. Water dogs taking turns with a stick, Marys River, Oregon; photo credit: Logan Bernart.

Mississippi River bridges at New Orleans, Louisiana. Photo credit: Lieut. Commander Mark Moran, NOAA Corps, MAO/AOC, courtesy of the National Oceanic and Atmospheric Administration/Department of Commerce.

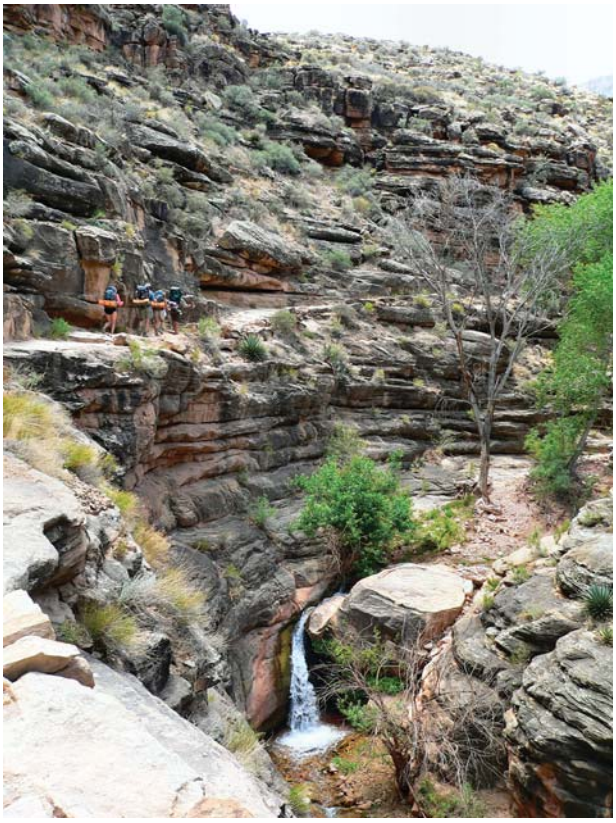
Chapter 6. Conclusion

Alyssa M. Neir, Geoffrey T. Klise, and
Michael E. Campana

The examples of conflict, cooperation, and a combination of the two that fall along the U.S.-Canada border suggest that the two countries are abiding by the agreements in place and are using the resources available to them to solve disputes or disagreements that arise. They are also collaborating to manage transboundary water resources at the watershed level, which can be seen in the creation of the International Watersheds Initiative. Although not discussed in detail in this report, much of the cooperation of the two countries is centered on the Great Lakes, which can be seen by the numerous agreements in place and the role of the IJC in managing those resources.

During 2009, the US and Canada are recognizing and celebrating the 100th anniversary of the 1909 Boundary Waters Treaty. This binational celebration recognizes that the Boundary Waters Treaty served the two countries well during the 20th century, and the Treaty and the International Joint Commission are continuing to assist the two countries well during the beginning of the 21st century.

Red Deer River, a tributary of the South Saskatchewan River, Alberta. Photo credit: Erik Lizee, via Wikimedia Commons.



(top) Aerial views of Palo Verde Irrigation District maintenance crews cleaning canals near Blythe, California. Irrigation water for the canals is pumped from the Colorado River and from deep wells. Photo credit: Andy Pernick, courtesy of the U.S. Bureau of Reclamation. Tributary of Colorado River, Arizona. Photo credit: Terrence E. Davis.

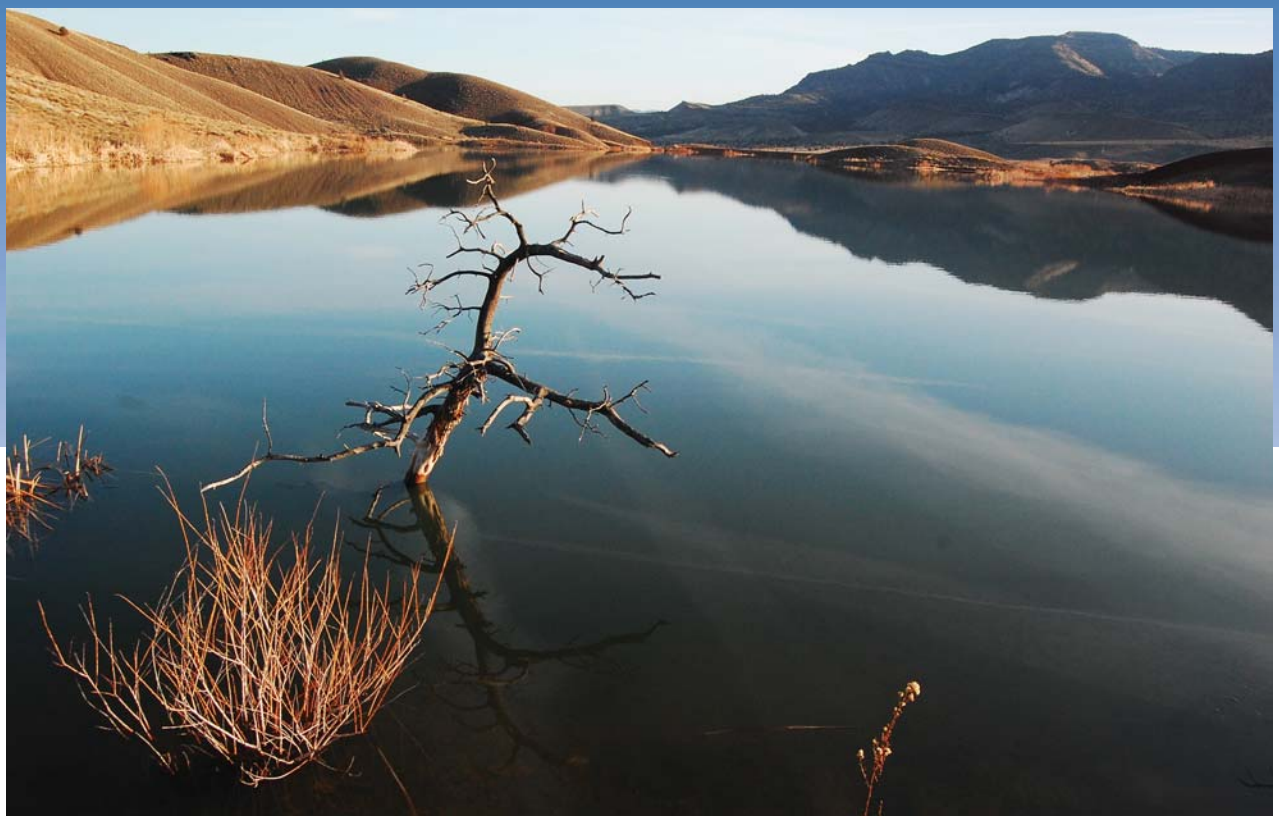
In contrast, examples of conflict and cooperation between the U.S. and Mexico show that despite having the IBWC as an intergovernmental body designated by treaty to deal with water issues, conflicts still arise. While some of these conflicts are easy to solve, such as those dealing with surface water quality, others are not as easy and deal with the eventual necessity of apportioning transboundary groundwaters. In many of these cases, the arid climate, growing population, and recent prolonged drought have made water appear even scarcer.

North America's vulnerability and resilience in the face of transboundary water conflicts is guided by the institutions that have been created to assist with water resources issues along both major borders of this continent. Each institution has specific functions due to geography and climate—the lack of or abundance of water dictates how the treaties were written and their flexibility in light of the fact that the borders themselves cross many climatic and geographic zones. The political boundaries divide many transboundary waterways and subterranean water resources.

Groundwater has been dealt with on a more local level or basin by basin through binational agreements and has been party to cooperative efforts to delineate the physical and chemical properties, as well as understand human impacts to the resource. The nature of groundwater is such that human impacts have recently been the focus of attention; the problems that have surfaced do not have a quick fix. Their solutions therefore have been undertaken through local initiatives, which have led to task forces and international exchanges of data to prevent future crises associated with the quantity and quality of the resource.

The vulnerability and resilience of these institutions in their ability to resolve bilateral disputes and promote cooperation between the countries is demonstrated in the examples of conflict and cooperation. Overall, these examples suggest that conflict is not associated with violence but rather by actions that are perceived as threats to another country's water resources. Cooperation is demonstrated by the voluntary use of the institutional entities available to each country. There are current disputes that

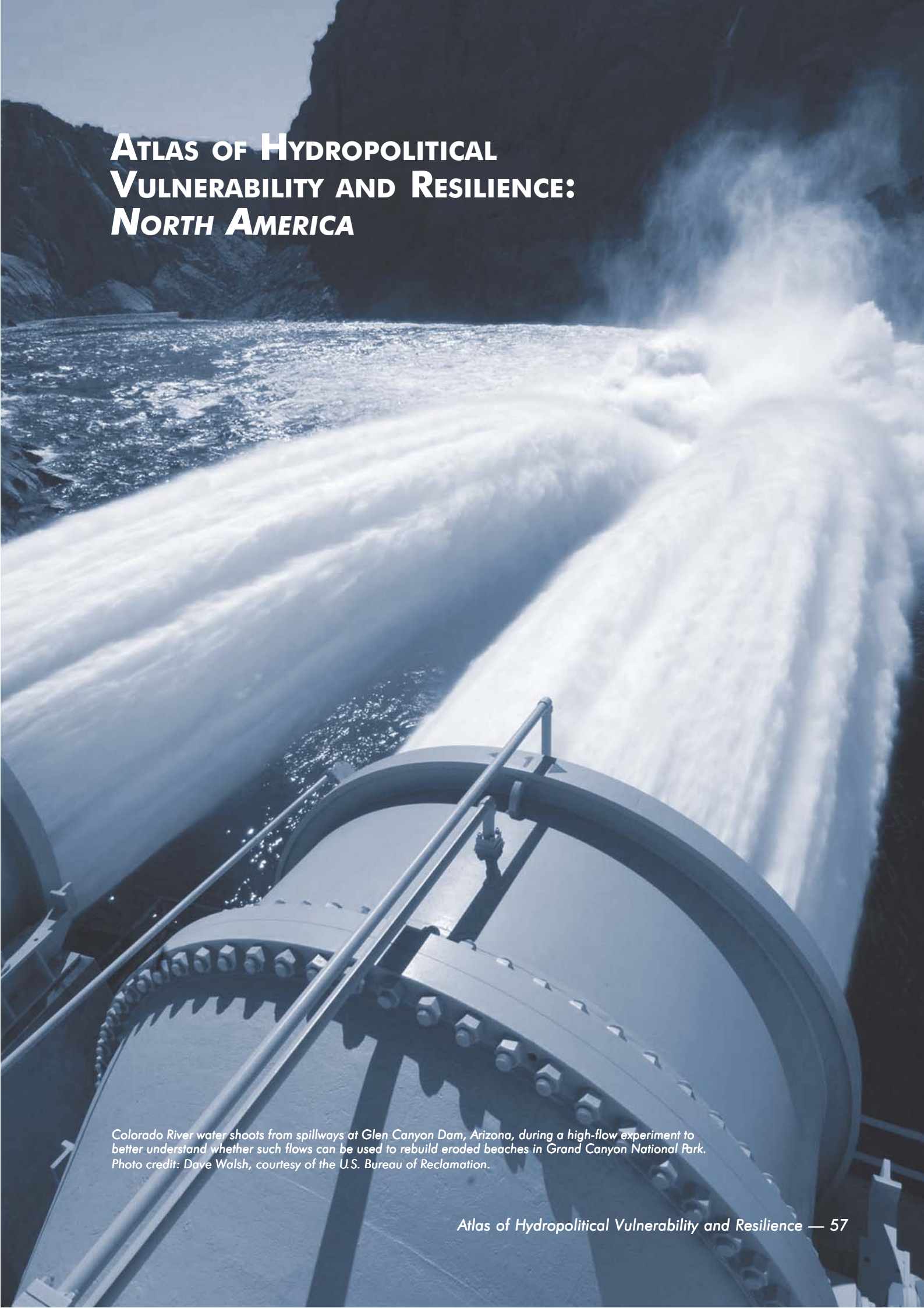
(from top) Tourist at mineral springs, Oaxaca. Photo credit: Bryan Bernart. Crowded swimming pool at a southern California hotel complex. Photo credit: Terrence E. Davis. Lake in Cascade Mountains, Oregon. Photo credit: Caryn M. Davis.



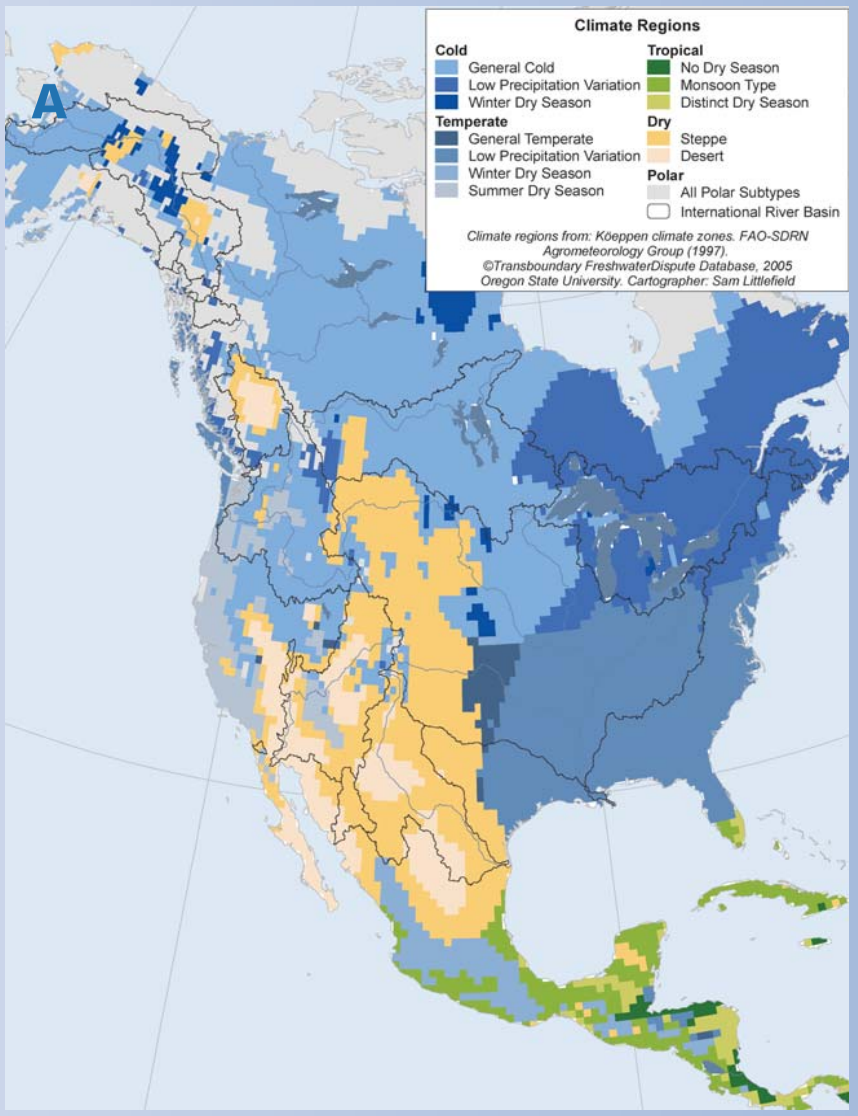
(from top) Deschutes River basin, Oregon. Photo credit: Talia Filipek. Columbia River, Washington; and child at Yocum Lake, Washington, photo credits: Kevin Davis.

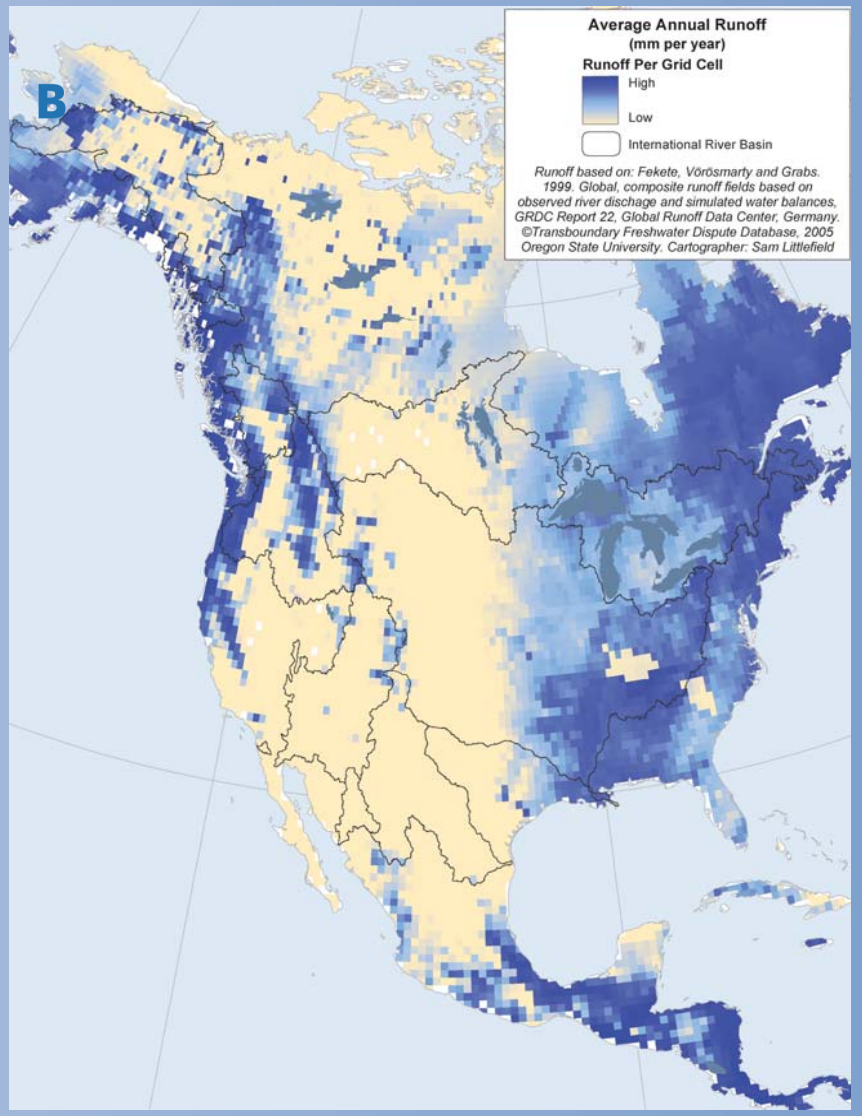
display properties of both conflict and cooperation and can lean towards one end of the spectrum; however, in terms of the vulnerability of the institutional framework by which transboundary water issues are resolved, there is great resilience in the institutions that have already survived for over a century. There are no signs of long-term vulnerability of the institutions; therefore, there is no vulnerability of the transboundary basins in North America over a long period of time. The institutions are still being used to resolve other disputes such as in the Missouri-Mississippi River Basin and the Rio Grande/Rio Bravo Basin. The resilience of these institutions in North America will be tested by the prolonged presence of drought that increases water scarcity and the specter of climate change that will alter the availability of water. Both phenomena will require flexibility to maintain resilience.

Atlas of Hydropolitical Vulnerability and Resilience: *North America*

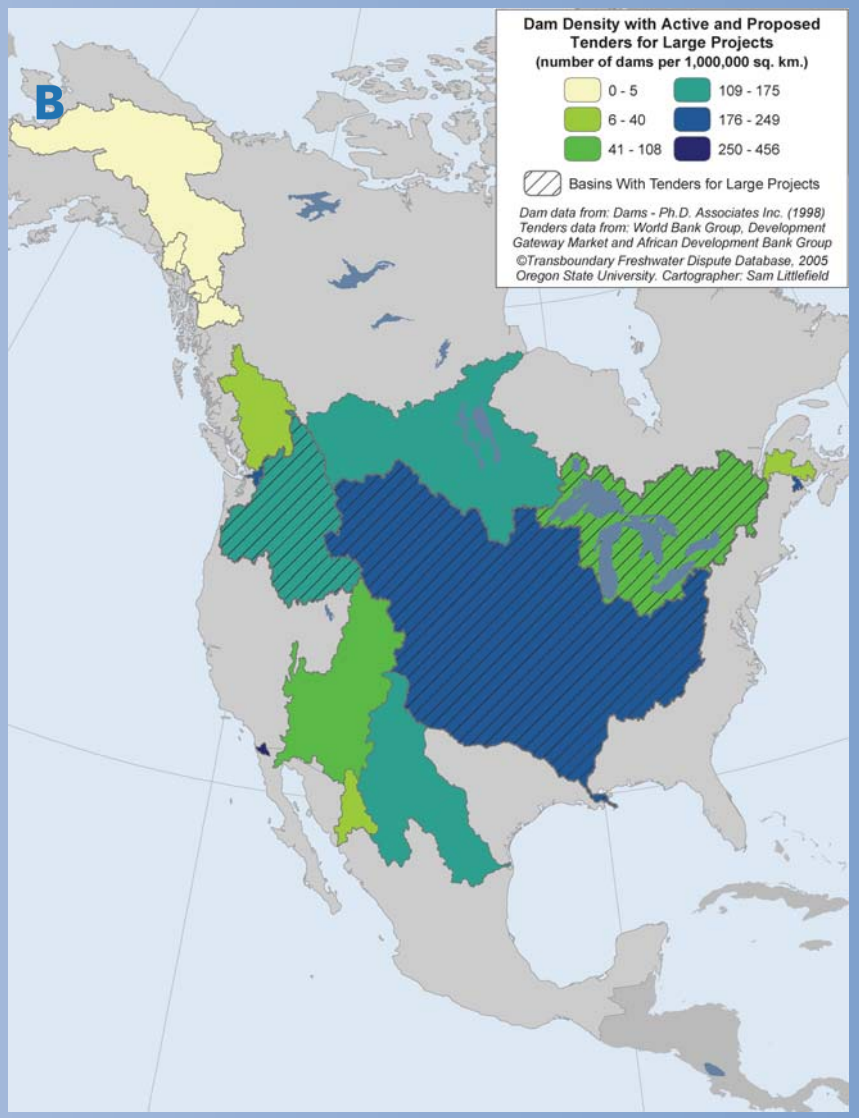


Colorado River water shoots from spillways at Glen Canyon Dam, Arizona, during a high-flow experiment to better understand whether such flows can be used to rebuild eroded beaches in Grand Canyon National Park. Photo credit: Dave Walsh, courtesy of the U.S. Bureau of Reclamation.

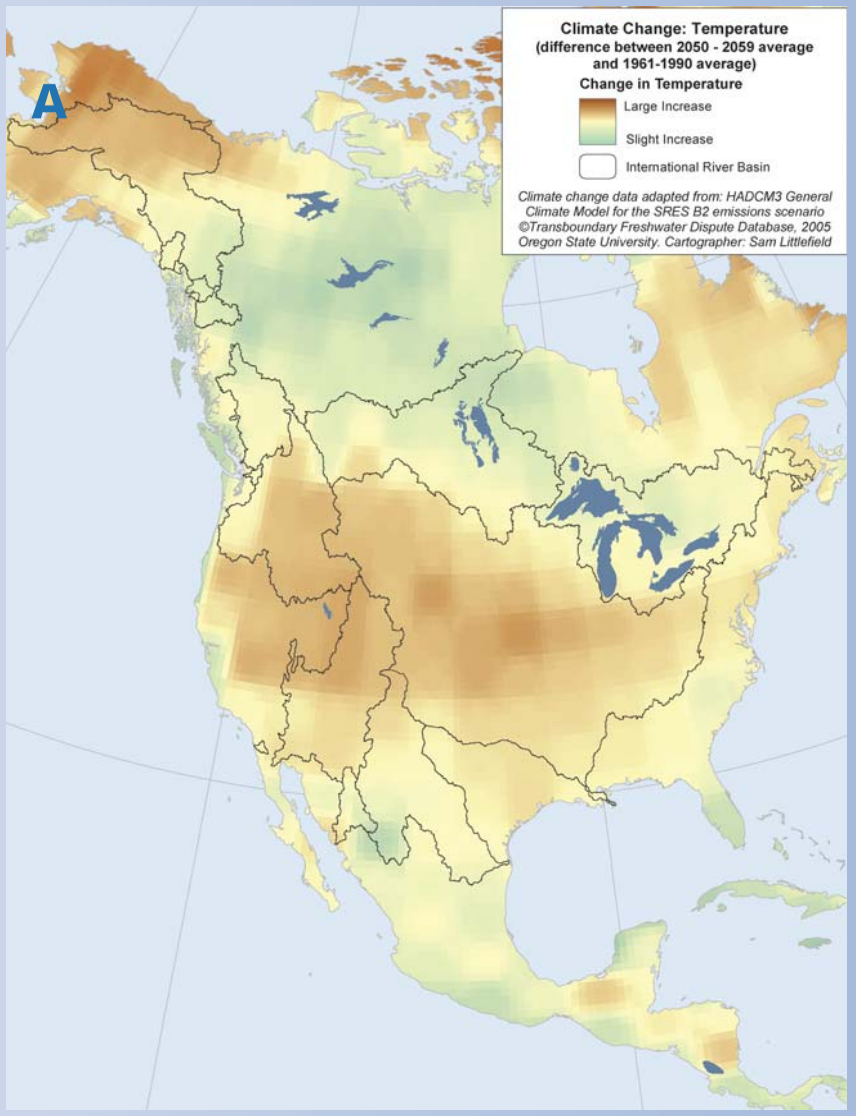


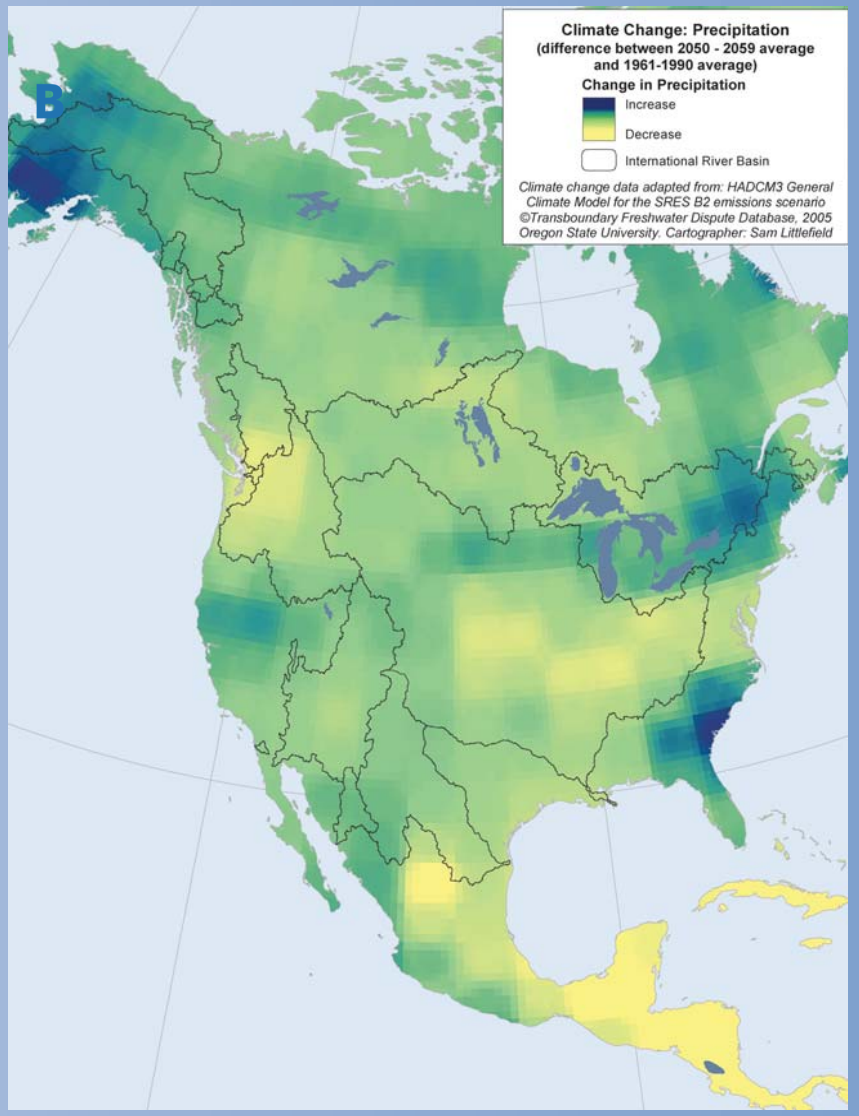


Map 1 (A) Climate Regions. *Köeppen climate zones based on a 0.5 decimal degree grid by Leemans and Cramer (1991) published by the International Institute for Applied Systems Analysis (IIASA). The Köeppen system integrates IIASA average monthly rainfall total and average monthly temperature, in most cases averaged from 1961–1990, to yield five base climate types: tropical, dry, temperate, cold, and polar. Each primary type is divided into sub-classes based mainly on the distribution of rainfall and temperature throughout the year. Not all classes may be represented at the continental level.*
(B) Average Annual Runoff. *Fekete et al. (1999) produced composite runoff fields by accessing GRDC discharge data, selecting significant global gauging stations, and geo-registering the discharge information to locations on a simulated topological network. This dataset was deemed accurate for presentation with a 0.5 decimal degree grid. Summary statistics based on the runoff dataset, such as those used for projected water stress (human indicators), may not be considered accurate for basins with an area less than approximately 25,000 km².*

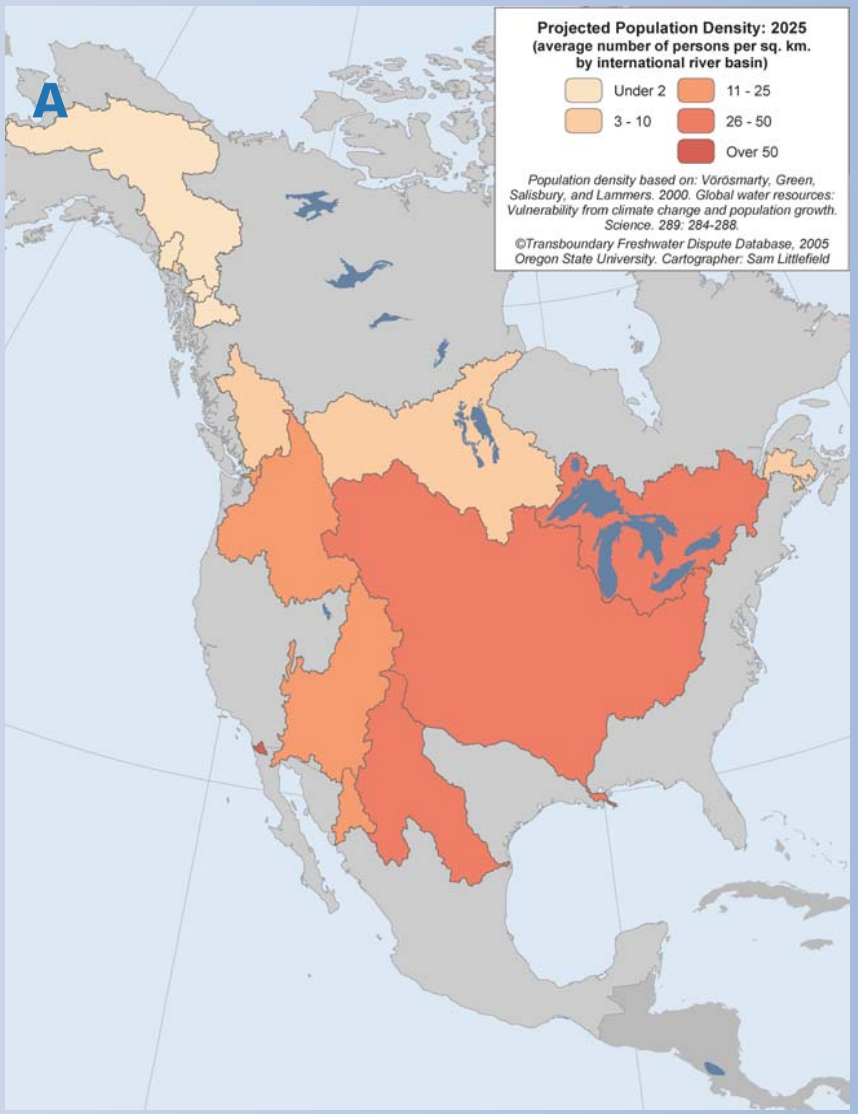


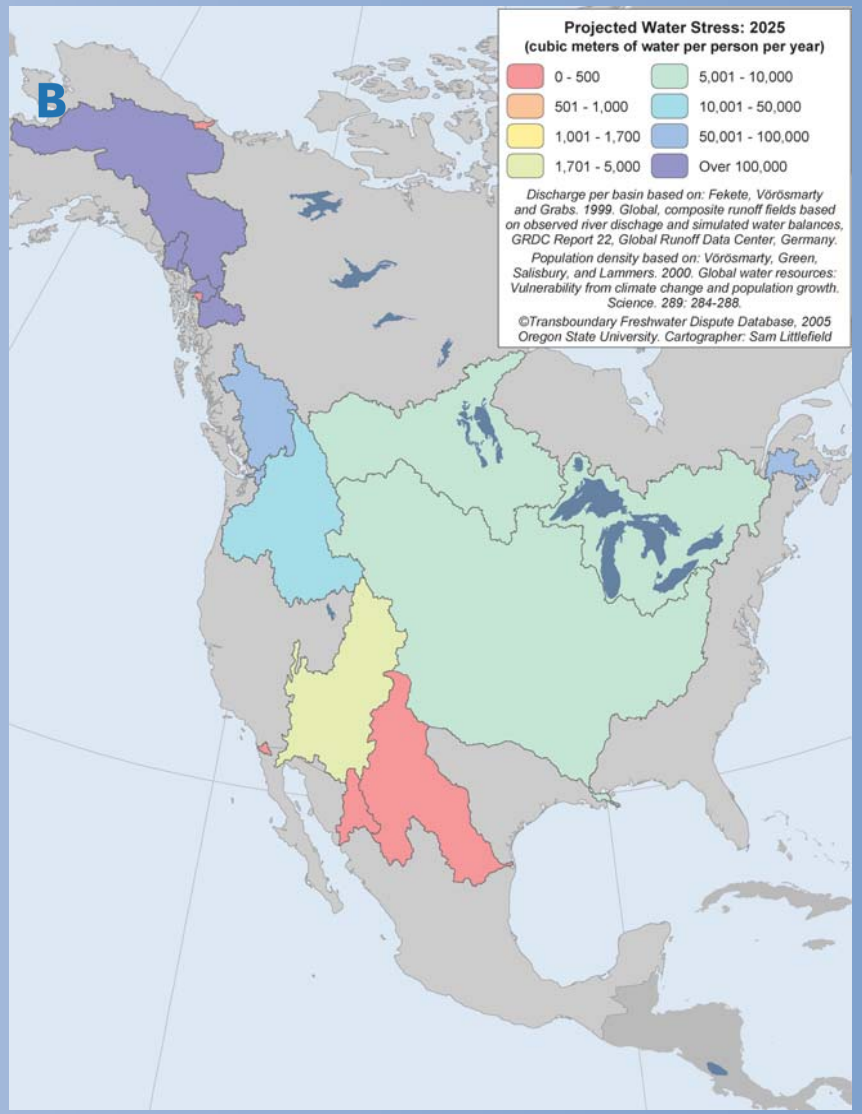
Map 2 (A) Groundwater Aquifers. *Adapted from a map developed by the World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP), August 2004. The most important groundwater basins are shown in blue. The green color symbolizes hydrogeological environments of complex structure. Unmarked regions are occupied by local and shallow aquifers in which relatively dense bedrock is exposed to the surface. Hatching has been applied in areas where "fossil" or non-renewable groundwater is stored. The boundaries of the various colored hydrogeologic regions are first order approximations using the best available information.* **(B) Dam Density with Active and Proposed Tenders for Large Infrastructure.** *Global Dams Data from: Ph.D. Associates Inc. 1998. DCW in ASCII version 3.0. 1998; Density Calculations from Fiske and Yoffee, 2001. Data on tenders is taken from the International Rivers Network "Dams In The Pipeline of Financial Institutions" database, which includes new projects in the lending pipeline from the World Bank, the Asian Development Bank, the African Development Bank and the Inter-American Development Bank, as well as links to ongoing and completed projects on the individual websites.*



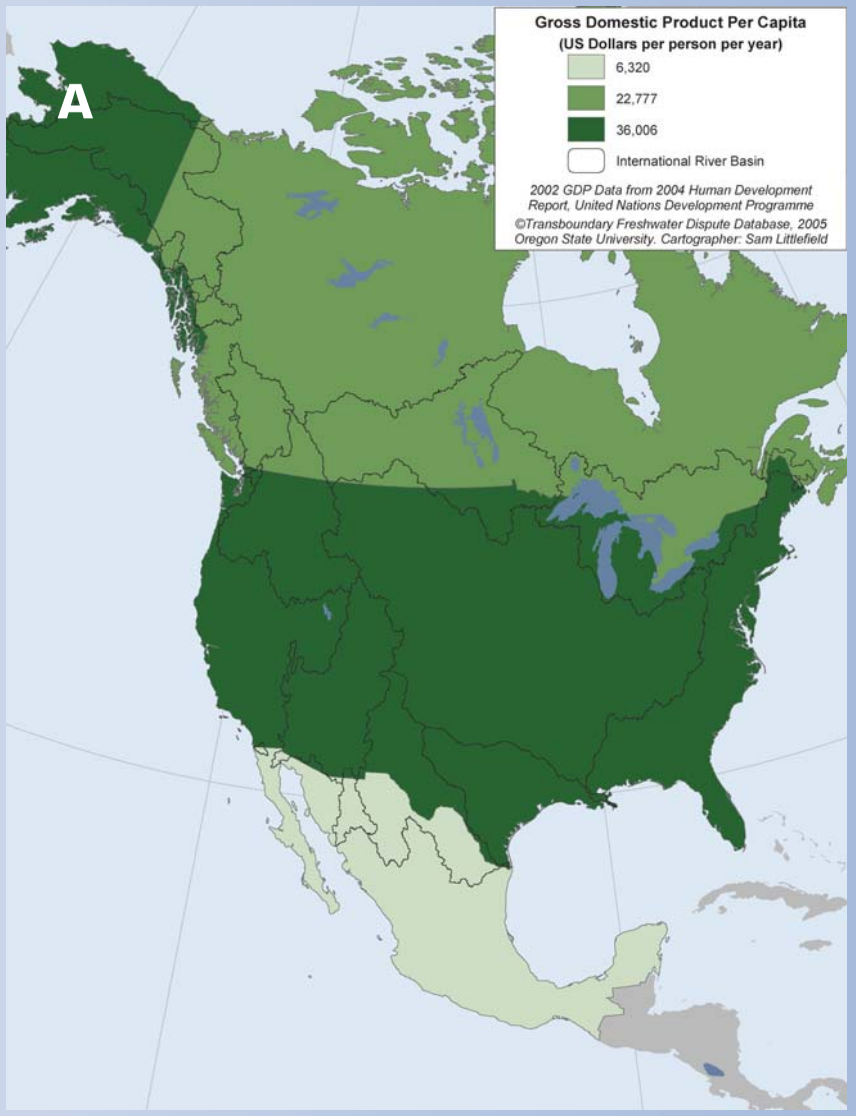


Map 3 (A) Climate Change, Temperature. (B) Climate Change, Precipitation. *Based on HADCM3 general climate model using the SRES B2 (moderate emissions, climate change, and technological advancement) emissions scenario. HADCM3 is distributed as 2.5 x 3.5 decimal degree data, which could not be properly projected in a GIS without square grid cells. Cell values were distributed to points at 2.5 x 3.5 decimal degree cell centroids, which were interpolated, using the inverse distance weighted method, at a resolution of 0.5 decimal degrees. The interpolated data used here should not be taken to exactly represent HADCM3 projections, but do provide a reasonable cartographic representation of current HADCM3 climate change predictions.*

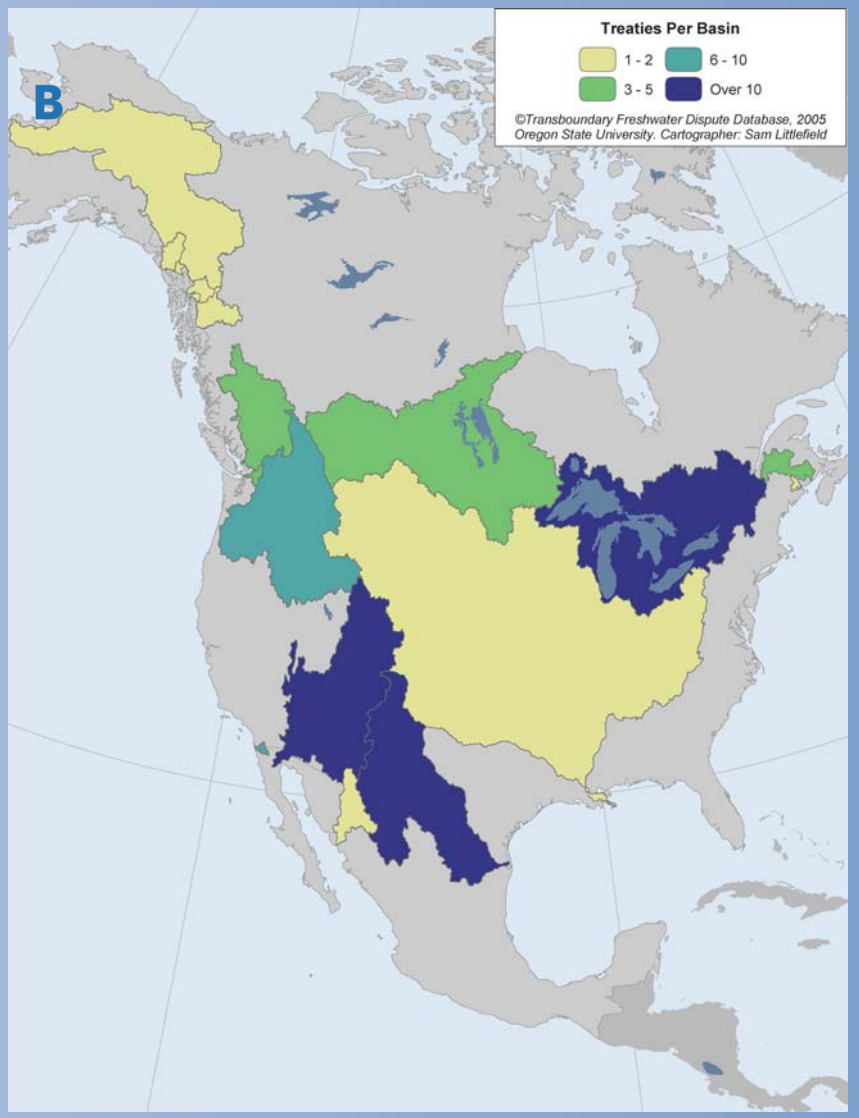




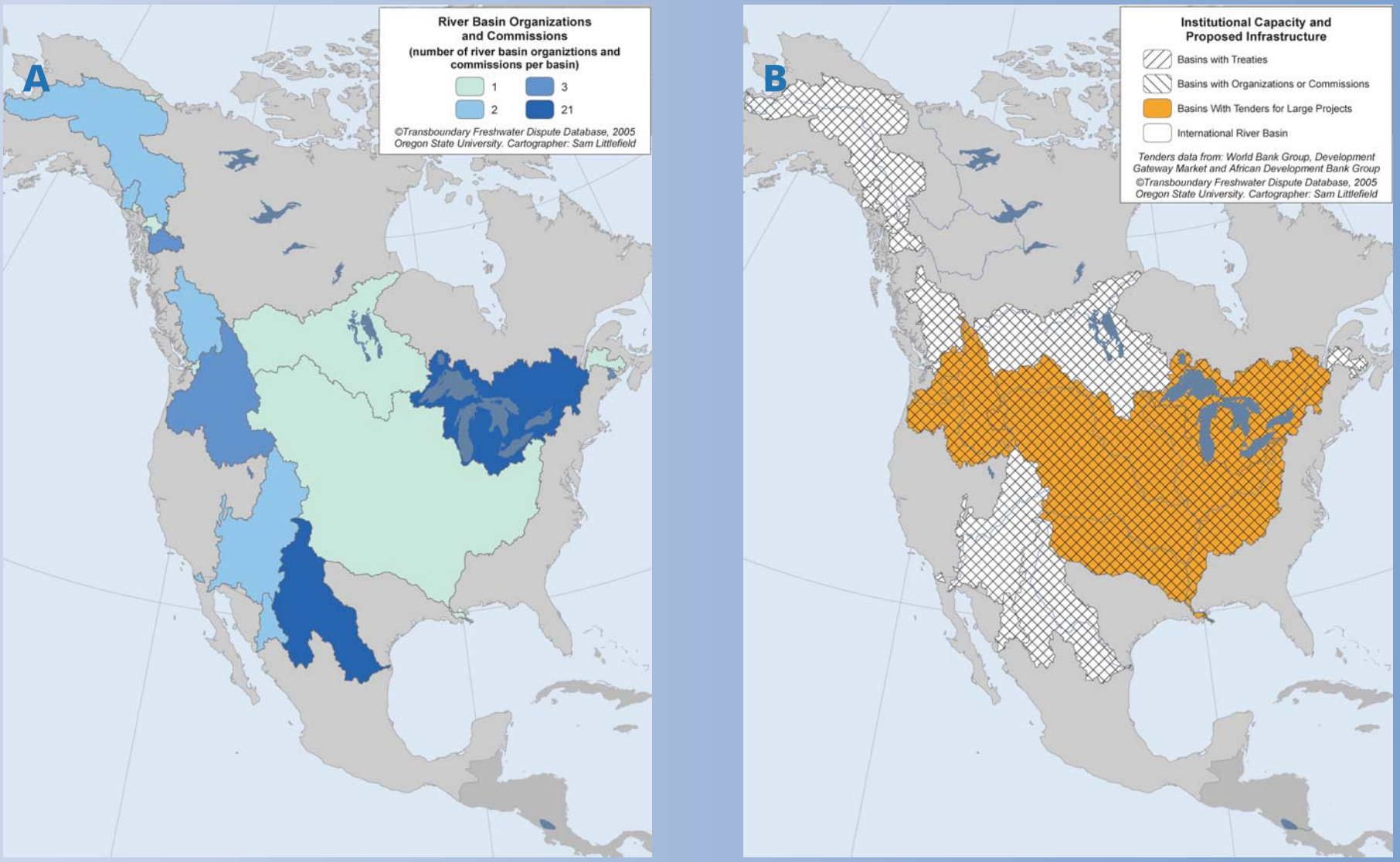
Map 4 (A) Projected Population Density: 2025. *The 2025 population dataset is published at a cell size of 0.5 decimal degrees (DD), which places a size constraint for small basin analysis. The raster was resampled at 0.01 DD to overcome the deficiency. This disregards some of the assumptions of the original 0.5 DD cell size, but affords a tentative estimate of predicted population in small basins. Because small basins maintain less area, there is less area to smooth out data errors. Therefore, some basins, especially those with a relatively small area (less than 25,000 km²), may have projected populations significantly lower or higher than they should be.* **(B) Projected Water Stress: 2025.** *Water stress is the amount of water available per capita. Water stress estimates do not account for spatial variability of water resources, nor for technological or other adaptations affecting how a given population manages water scarcity. The map's calculation of water stress is based on renewable water supply defined by discharge, and does not consider groundwater extraction. Falkenmark's (1989) definition of water stress, calculates water supply based on renewable surface and groundwater flows. According to Falkenmark, a threshold value of 1000 cubic meters per person per year indicates a general point at which water shortages begin to chronically hamper economic development and human health and well-being in moderately developed nations.*



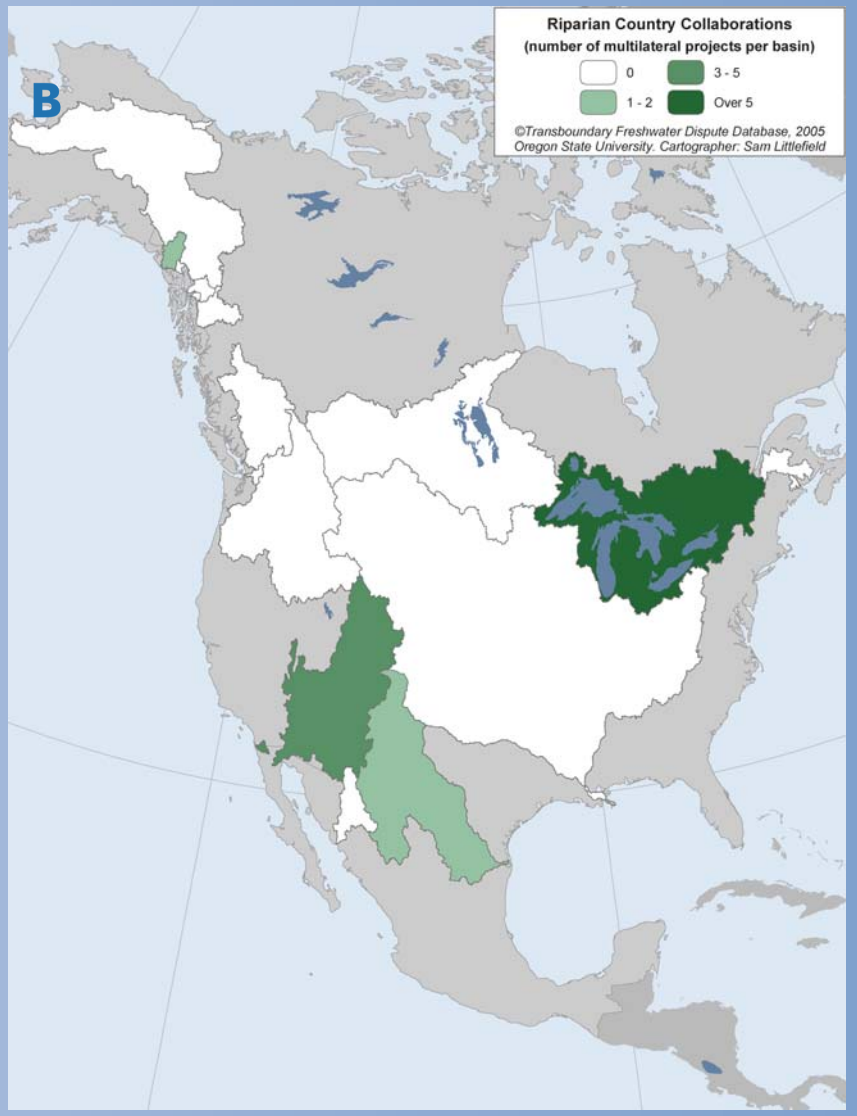
Map 5 (A) Human Development Index. *The human development index (HDI) is a composite index that measures the average achievements in a country in three basic dimensions of human development: a long and healthy life, as measured by life expectancy at birth; knowledge, as measured by the adult literacy rate and the combined gross enrolment ratio for primary, secondary and tertiary schools; and a decent standard of living, as measured by GDP per capita in purchasing power parity (PPP) US dollars. The formula to calculate the HDI, as well as specific data on the indicators, can be found at http://hdr.undp.org/reports/global/2004/.* **(B) Agricultural Water Use.** *Agricultural water use is based on a model of irrigation water requirements developed for AQUASTAT by the FAO Land and Water Development and incorporates crop, reference, and actual evapotranspiration, crop coefficient, area under irrigation as percentage of the total area under analysis, and cropping intensity. Renewable water resources available for agricultural use are defined as the sum of internal renewable water resources and incoming flow originating outside the country, taking into consideration the quantity of flows reserved to upstream and downstream countries through formal or informal agreements or treaties.*



Map 6 (A) Water Dependency Ratio. Water dependency ratio is calculated for AQUASTAT by the FAO Land and Water Development Division. It incorporates total country inflow and outflow of surface water and groundwater after accounting for flow submitted to and reserved by bilateral and multilateral treaties. (B) International Freshwater Treaties Per Basin. Number of treaties per basin is the sum of all agreements (historical, present, general) which have been signed by States governing water resources in the basin, either with one another or as part of a regional agreement, where the concern is water as a scarce or consumable resource, a quantity to be managed, or an ecosystem to be improved or maintained. Documents concerning navigation rights and tariffs, division of fishing rights, and delineation of rivers as borders or other territorial concerns are not included, unless freshwater as a resource is also mentioned in the document, or physical changes are being made that may impact the hydrology of the river system (e.g., dredging of river bed to improve navigation, straightening of a river's course.



Map 7 (A) River Basin Organizations and Commissions. *Data for map was collected over a six month period from July to December 2004, drawing from: a compilation by Johannes Akiwumi at UNEP's Division of Environmental Information and Assessment (Nairobi); and internet searches and email interviews with international waters practitioners and scholars. (See SECTION 4 Tables for sources). We define an RBO/RBC as "a bilateral or multilateral body composed of representatives of national governments acting in an official capacity, created for the purpose of dialogue and/or coordinated management of an international water body." Presence of an RBO/RBC in an international river basin does not imply that all riparian countries are parties to the institution. Zero values do not necessarily reflect an absence of an RBO/RBC.* **(B) Institutional Capacity and Proposed Infrastructure.** *Treaties and River Basin Organizations and Commissions may serve to increase the hydropolitical resilience of a basin. This may be particularly important in basins with tenders for large projects, which can alter river functions and displace local inhabitants.*



Map 8 (A) Environmental Sustainability Index. *The 2005 Environmental Sustainability Index (ESI) measures the ability of a country to protect the environment over the next several decades. The ESI is an equally weighted average of 21 indicators, grouped into categories such as environmental systems, reducers of environmental stresses, reducers of human vulnerability, societal and institutional capacity and global stewardship. These data are combined from 76 separate data sets of natural resource endowments, pollution levels, environmental management efforts, etc. The ESI is useful for comparative analysis in identifying leading countries in environmental sustainability. The full ESI report is available at http://www.yale.edu/esi.* **(B) Riparian Country Collaborations.** *These are defined as projects, programs, or partnerships with a river basin as a geographic focus, involving organizations or representatives (acting in an official or non-official capacity) from two or more countries that share the international water body. Data for the map was collected from internet searches, and compiled over a five-month period from July to December 2004. Due to the short time period in which the study took place, the number of projects represented on the map may not accurately reflect the number of collaborations actually occurring. Detailed information about each riparian country collaboration (including participating countries; principal issue area; level of collaboration; dates of collaboration; and source from which the information was gathered) is compiled in Appendix 2.*

Appendices

Top of a small waterfall on a tributary of the Santiam River, Oregon. Photo credit: Bryan Bernart.

Appendix 1. International Freshwater Agreements, River Basin Organizations, and River Basin Commissions of North America

The treaties contained in this document were compiled as part of the Transboundary Freshwater Dispute Database (TFDD) project at Oregon State University in collaboration with the Food and Agriculture Organization (FAO) of the United Nations. The documents included are treaties or other international agreements relating to international freshwater resources, where the concern is water as a scarce or consumable resource, a quantity to be managed, or an ecosystem to be improved or maintained. Treaties concerning navigation rights and tariffs, division of fishing rights, and delineation of rivers as borders or other territorial concerns are not included, unless freshwater as a resource is also mentioned in the document, or physical changes are being made to the river system that might impact the hydrology of the river system (e.g., dredging of river bed to improve navigation, straightening of river course).

For ease of reference, the treaties are first categorized by continent, and then by international basin, as delineated in the TFDD Geographical Information System. The treaties listed under each international basin either refer directly to that international basin, or a sub-basin thereof. In cases of multiple spellings or names for the same river system of an international basin, a " / " separates the names (e.g., Asi/Orontes). Where the basin represents the confluence of a set of major rivers, a " - " is used to separate the names of the different river systems (e.g., Ganges-Brahmaputra-Meghna).

It is important to note that the following database of treaties is, by its very nature, a work in constant progress, and makes no claims to completeness. Those interested in updates should follow progress on the relevant sites, such as the Transboundary Freshwater Dispute Database Project (http://www.transboundarywaters.orst.edu/).

The area of each basin and its riparian countries' territorial share was calculated using a GIS at 1km spatial resolution (Wolf et al. 1999). We recognize the limitations of the data sources and process by reporting the size of basins, not as raw data as is common with digital data, but by rounding the last significant figure in basins 1–99 km^2 and the last two significant figures in basins 100 km^2 or larger. As a result of rounding the area values, the numbers for areas within each basin do not necessarily add up to the total area for that basin. The percentage areas were calculated based on raw data, and therefore do not reflect the rounding of the areas.

Description of Terms

Commission—A bilateral or multilateral body, composed of officials appointed by national governments to participate in dialogue, discourse, and negotiations regarding the international water body for which it was created.

Date—The date usually indicates the date on which a treaty document was signed or a river basin commission was instituted. If such information was unavailable, the next choice was the date of entry into force, followed by the date of ratification. For agreements consisting of a series of letters or notes written on different dates, the latest date was used. Dates are represented in a month/day/year format.

Economic program—A bilateral or multilateral economic development project or program which aims to improve investment/trade/economic activities among countries sharing an international water body.

Environmental program—A bilateral or multilateral project or program which aims to improve/protect/conserve the quality and habitat of aquatic systems associated with an international water body.

International initiative—A bilateral or multilateral body, composed of non-official actors who serve a Track 2 function, bringing stakeholders together to dialogue and strategize about transboundary water issues. International initiatives involve stakeholders from multiple countries who are mainly functioning to enhance dialogue and improve stakeholder participation, but do not necessarily implement their own projects, as they do not have funding to do so.

Level of collaboration—Indication of level of international water collaboration form: official or non-official. Official collaboration is acknowledged by the national government while non-official collaboration has no governmental involvement.

Organization—A bilateral or multilateral body, composed of officials acting on behalf of their government (ministerial, technical or other) to conduct coordinated and/or informed management of the international water body. An organization differs from a commission in that it involves the implementation of bilateral or multilateral programs (information sharing, joint management, etc.).

Participating countries—The countries that are party to the international water collaboration form.

Principal issue—Issue area that international water collaboration form focuses on more than on other issues.

Riparian country collaborations—Projects, programs, or partnerships *with a river basin as a geographic focus*, involving organizations or representatives (acting in an official or non-official capacity) from two or more countries that share the international water body.

Signatories—Signatories to the agreement. The formal country names as delineated in the actual treaty are used if that information is readily apparent; otherwise, common country names are listed instead.

Social / health program—A bilateral or multilateral social and/or health project or program which aims to improve the social and/or health conditions of the people living in an international water body.

Treaty basin—Identifies the basin or sub-basins specifically mentioned in the document. If a document applies to all basins shared between the signatories, but no river or basin is mentioned specifically, the treaty basin is listed as "frontier or shared waters." For frontier or shared waters, a treaty is listed under all the TFDD basins shared between those signatories. A document may therefore appear listed under multiple basins.

Treaty or agreement—The full formal name of the document or best approximation thereof. The place of signature is often included as part of the agreement name. Agreement titles, regardless of the language of the source document, are listed in English. Not all titles are official.

Type of international water collaboration—Form of international water collaborations.

Alsek

Total area: 28,400 km²

Countries	Area of Basin in Country km²	%
Canada	26,500	93.5
United States	1,800	6.5

Finley Wildlife Refuge, Willamette Valley, Oregon, Columbia River basin. Photo credit: Bryan Bernart.

Treaties and Agreements

Pacific Salmon Treaty signed between Canada, the United States and representing Tribes from both nations. Adresses the harvest and management of salmon

Treaty basin: Stikine, Alsek, Taku *Date:* January 28, 1985

Signatories: Canada, United States of America

Treaty Between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Lake Michigan, Lake Erie, Niagara, St. Mary, Milk *Date:* January 11, 1909

Signatories: Great Britain, United States of America

River Basin Organizations and Commissions

Pacific Salmon Commission (PSC), set up in compliance with the 1985 Pacific Salmon Treaty

Long-term goals include achieving optimum salmon production and providing each Party benefits equivalent to the salmon production originating in its own waters.

Treaty basin: Alsek, Stikine, Taku *Date:* 1999

Signatories: Canada, United States of America

Source: http://www.oceanlaw.net/texts/psc99.htm

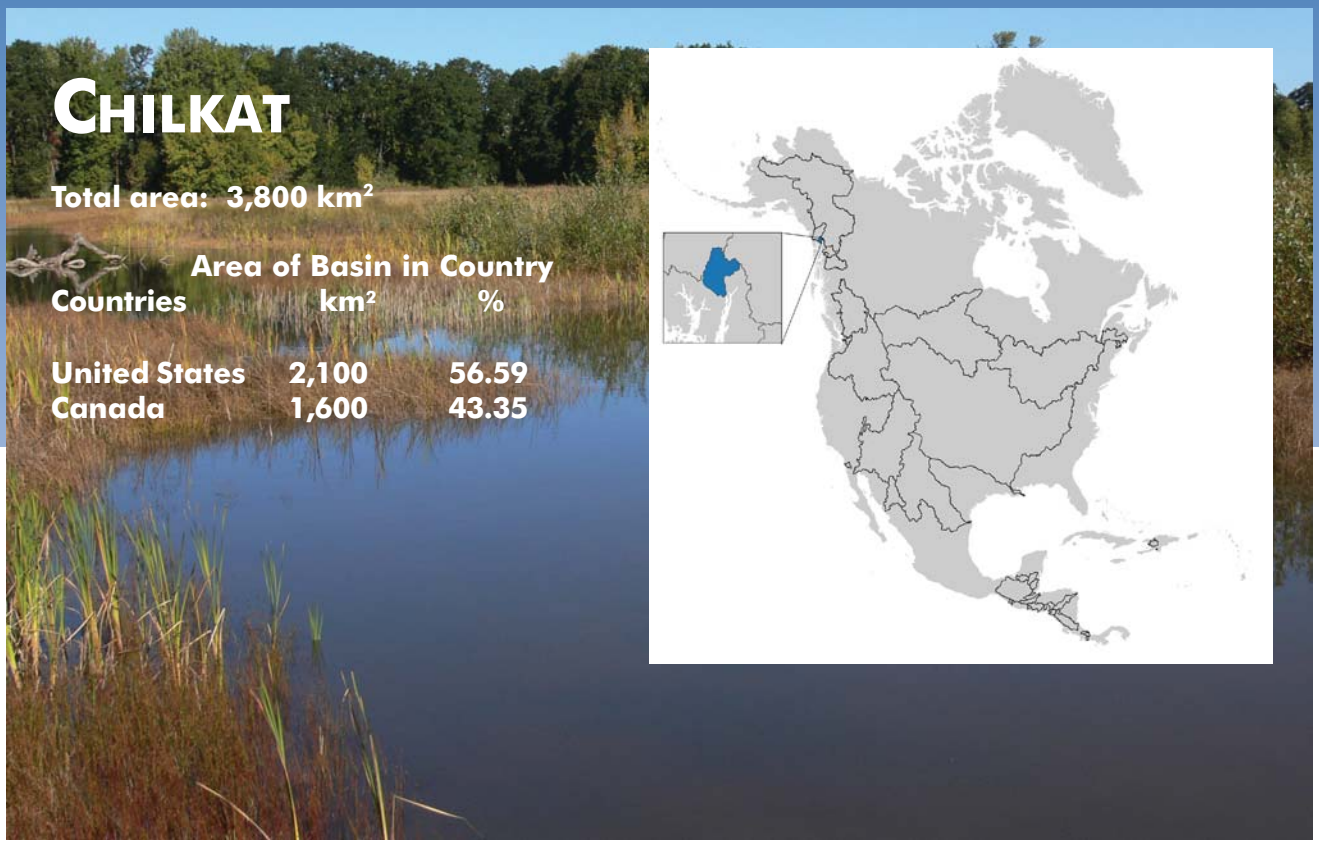
International Joint Commission (IJC)

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.

Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm



TREATIES AND AGREEMENTS

Treaty Between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Lake Michigan, Lake Erie, Niagara, St. Mary, Milk *Date:* January 11, 1909

Signatories: Great Britain, United States

RIVER BASIN ORGANIZATIONS AND COMMISSIONS

International Joint Commission (IJC)

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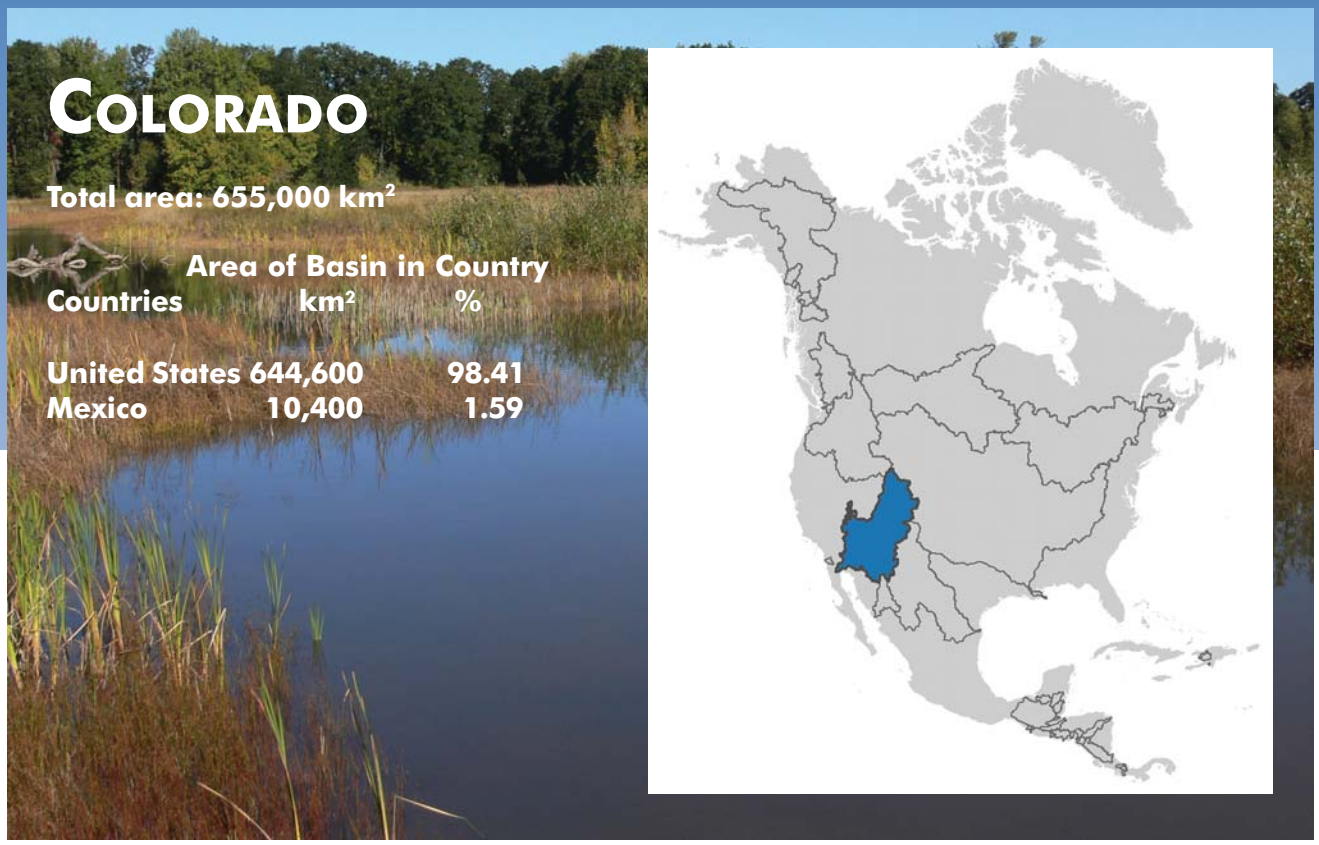
Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm



Colorado

Total area: 655,000 km²

Countries	Area of Basin in Country km²	%
United States	644,600	98.41
Mexico	10,400	1.59

Treaties and Agreements

Minute no. 291 of the International Boundary and Water Commission, U.S.A. and Mexico, concerning improvements to the conveying capacity of the international boundary segment of the Colorado River

Treaty basin: Colorado *Date:* July 16, 1994

Signatories: Mexico, United States of America

IBWC Treaty Minute 288 between United States of America and Mexico regarding long-term plan to address wastewater and water quality problems at international boundary.

Treaty basin: New, Alamo *Date:* November 1992

Signatories: Mexico, United States of America

Agreement of cooperation between the United States of America and the United Mexican States regarding pollution of the environment along the inland international boundary by discharges of hazardous substances

Treaty basin: Frontier or shared waters *Date:* July 18, 1985

Signatories: Mexico, United States of America

Agreement between the United States of America and the United Mexican States on cooperation for the protection and improvement of the environment in the border area

Treaty basin: Frontier or shared waters *Date:* August 14, 1983

Signatories: Mexico, United States of America

La Paz Agreement between Mexico and the United States of America regarding border water pollution, nuclear waste siting, and bilateral protection of the environment.

Treaty basin: Frontier or shared waters *Date:* August 14, 1983

Signatories: Mexico, United States of America

Treaty Minute 264 between United States of America and Mexico regarding sewage discharge at New River international boundary.

Treaty basin: New *Date:* August 26, 1980

Signatories: Mexico, United States of America

Recommendations for the solution to the border sanitation problems

Treaty basin: Frontier or shared waters *Date:* September 24, 1979

Signatories: Mexico, United States of America

Agreement extending Minute no. 241 of the International Boundary and Water Commission, United States and Mexico, or July 14, 1972, as extended

Treaty basin: Colorado *Date:* April 30, 1973

Signatories: United States, Mexico

Mexico-US agreement on the permanent and definitive solution to the salinity of the Colorado River Basin (International Boundary and Water Commission Minute No. 242)

Treaty basin: Colorado *Date:* August 30, 1973

Signatories: Mexico, United States

Agreement effected by Minute no. 241 of the International Boundary and Water Commission.

Treaty basin: Colorado *Date:* July 14, 1972

Signatories: United States, Mexico

Treaty to resolve pending boundary differences and maintain the Rio Grande and Colorado River as the international boundary

Treaty basin: Colorado, Rio Grande *Date:* November 23, 1970

Signatories: Mexico, United States of America

Exchange of notes constituting and agreement concerning the loan of waters of the Colorado River for irrigation of lands in the Mexicali Valley.

Treaty basin: Colorado *Date:* August 24, 1966

Signatories: United States, Mexico

Treaty Between the United States of America and Mexico Relating to the Waters of the Colorado and Tijuana Rivers, and of the Rio Grande

Treaty basin: Colorado, Rio Grande, Tijuana, Rio Bravo del Norte *Date:* November 14, 1944

Signatories: United States, Mexico

Boundary waters: Rio Grande and Rio Colorado, November 21, 1900 Extension of Convention of March 1, 1889

Treaty basin: Rio Grande, Colorado *Date:* November 21, 1900

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, Decmber 22, 1899 Extension of Convention of March 1, 1889

Treaty basin: Rio Grande, Colorado December 22, 1899

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, December 2, 1898 Extension of Convention of March 1, 1889

Treaty basin: Rio Grande, Colorado *Date:* December 2, 1898

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, October 29, 1897 Extension of Convention of March 1, 1889

Treaty basin: Rio Grande, Colorado *Date:* October 29, 1897

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, November 6, 1896 Extension of Convention of March 1, 1889

Treaty basin: Rio Grande, Colorado *Date:* November 6, 1896

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, October 1, 1895 Extension of Convention of March 1, 1889

Treaty basin: Rio Grande, Colorado *Date:* October 1, 1895

Signatories: Mexico, United States

Convention on Boundary Waters: Rio Grande and Rio Colorado

Treaty basin: Colorado, Rio Grande *Date:* March 1, 1889

Signatories: Mexico, United States

International Boundary and Water Commission: The Convention of November 12, 1884 to deal with ever-changing location of international boundary along Rio Grande and Colorado

Treaty basin: Colorado, Rio Grande *Date:* November 12, 1884

Signatories: Mexico, United States of America

Treaty of Guadalupe Hidalgo in 1848 established borders between United States of America & Mexico stipulating international border along the Rio Grande

Treaty basin: Colorado, Rio Grande *Date:* February 2, 1848

Signatories: Mexico, United States of America

River Basin Organizations and Commissions

Border Environmental Cooperation Commission (BECC)

Created under NAFTA side agreements. Group composed of local, state, and federal water agencies for mitigation of wastewater runoff originating in Mexico and flowing into the United States. BECC identifies, supports, evaluates and certifies sustainable environmental infrastructure projects through broad public participation, to improve the quality of life of the people of the U.S.-Mexico border region. Focus is on the Santa Cruz, a subbasin of the Colorado.

Treaty basin: Colorado, Rio Bravo/Rio Grande, Tijuana, Yaqui *Date:* November 1993

Signatories: United States of America and Mexico

Source: http://www.cocef.org/ingles.php

International Boundary and Water Commission (IBWC)

Has the responsibility for applying the boundary and water treaties between the United States and Mexico and settling differences that may arise out of these treaties. The IBWC is an international body composed of the United States Section and the Mexican Section

Treaty basin: Colorado, Rio Bravo/Rio Grande, Tijuana, Yaqui *Date:* 1950

Signatories: Canada, United States of America

Source: http://www.ibwc.state.gov/html/colorado_river.html

Columbia

Total area: 668,400 km²

Countries	Area of Basin in Country km²	%
United States	566,500	84.75
Canada	101,900	15.24

Treaties and Agreements

An Act to Amend the International Boundary Waters Treaty Act: Regulations prohibiting the bulk removal of boundary waters from Canadian basins for any purpose. and licensing for projects affecting the level or flow of waters to the United States side of the border

Treaty basin: Frontier or shared waters *Date:* December 19, 2002

Signatories: Canada, United States of America

Environmental Cooperation Agreement between British Columbia and the State of Washington to protect and manage groundwater resources

Treaty basin: Columbia River, Fraser River *Date:* May 7, 1992

Signatories: British Columbia, Canada, Washington State, United States of America

Exchange of notes concerning a special operating programme for the Duncan and Arrow storages on the Columbia River System

Treaty basin: Columbia, Arrow Lakes, Duncan Lake *Date:* April 1, 1968

Signatories: Canada, United States

Exchange of notes (October 4, 1965) between the government of Canada and the government of the United States of America relating to the establishment of directions to be followed by the permanent engineering board established under article XV of the ColumiaRiver Treaty in relation to its administration and procedures

Treaty basin: Columbia *Date:* October 4, 1965

Signatories: Canada, United States

Exchange of notes constituting an agreement between Canada and the United States of America authorizing the Canadian entitlement purchase agreement provided for under the treaty relating to cooperative development of the water resources of the Columbia River Basin

Treaty basin: Columbia *Date:* September 16, 1964

Signatories: Canada, United States

Exchange of notes constituting an agreement between Canada and the United States of America regarding sale of Canada's entitlement to downstream benefits under the treaty relating to co-operative development of the water resources of the Columbia River Basin

Treaty basin: Columbia *Date:* January 22, 1964
Signatories: Canada, United States

Exchange of notes constituting an agreement between Canada and the United States of America concerning the treaty relating to cooperative development of the water resources of the Columbia River Basin

Treaty basin: Columbia *Date:* January 22, 1964
Signatories: Canada, United States

Treaty relating to cooperative development of the water resources of the Columbia River Basin (with annexes)

Treaty basin: Columbia, Kootenai *Date:* January 17, 1961
Signatories: Canada, United States

Exchange of notes constituting an agreement between the United States of America and Canada relating to a study to be made by the International Joint Commission with respect to the Upper Columbia River Basin

Treaty basin: Columbia *Date:* March 03, 1944
Signatories: Canada, United States

Treaty Between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Lake Erie, Lake Michigan, Milk, Niagara, St. Mary *Date:* January 11, 1909
Signatories: Great Britain, United States of America

River Basin Organizations and Commissions

Abbotsford-Sumas Aquifer International Task Force

Product of 1992 Environmental Cooperation Agreement between British Columbia and the State of Washington to coordinate groundwater protection efforts in the region.

Treaty basin: Abbotsford-Sumas Aquifer *Date:* 1992
Signatories: British Columbia, Canada, Washington State, United States of America
Source: http://wlapwww.gov.bc.ca/wat/

IJC Board: International Columbia River Board of Control

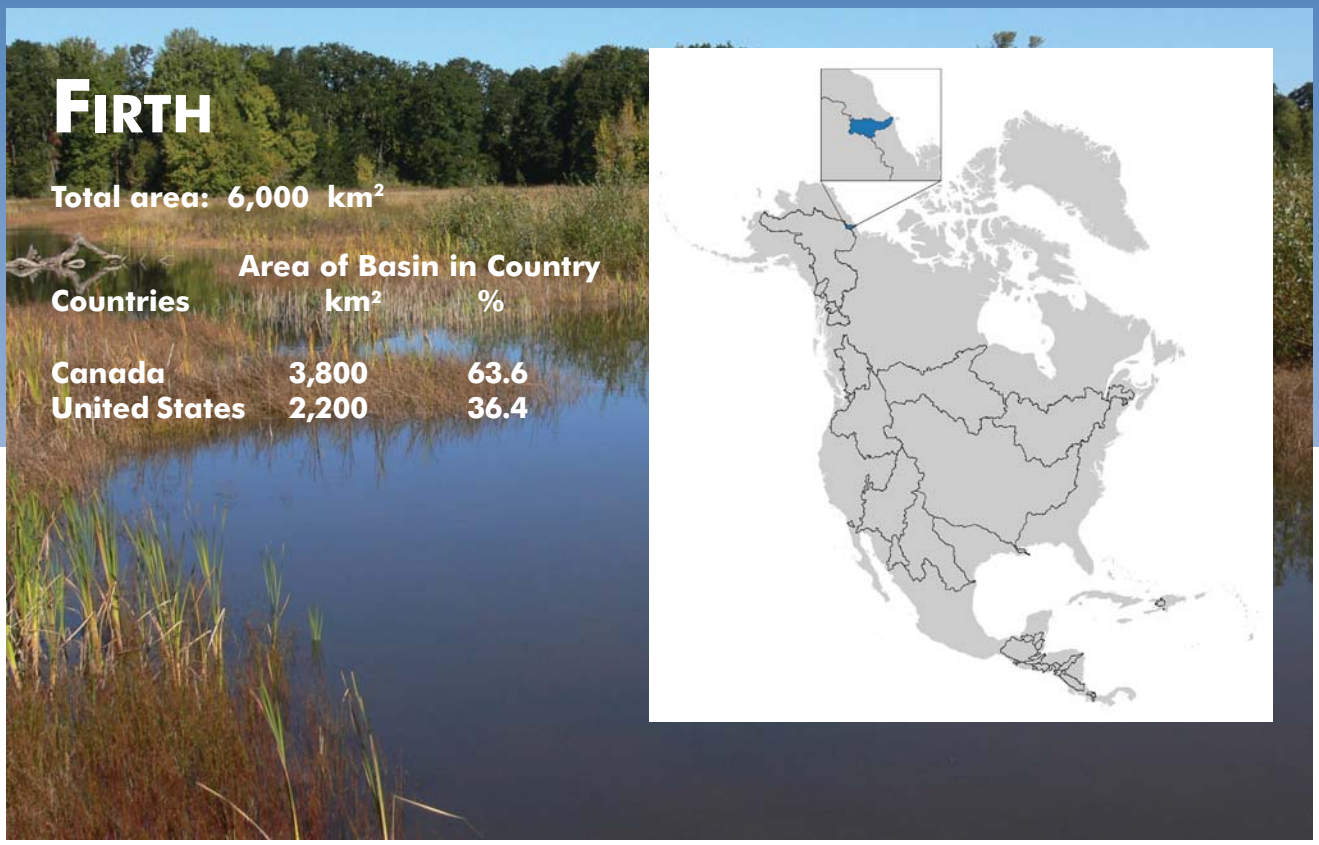
The Board keeps the Commission apprised of stream flow and water-level data on both sides of the international boundary and reports to the Commission each April. Established to ensure the implementation of the provisions of that Order and to continue to study the effect of the operation of the Grand Coulee dam and reservoir upon water levels at and above the international boundary.

Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1941
Signatories: Canada, United States of America
Source: http://www.ijc.org/conseil_board/columbia/en/columbia_home_accueil.htm

International Joint Commission (IJC)

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.

Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909
Signatories: Canada, United States of America
Source: http://www.ijc.org/en/home/main_accueil.htm



River Basin Organizations and Commissions

International Joint Commission (IJC)

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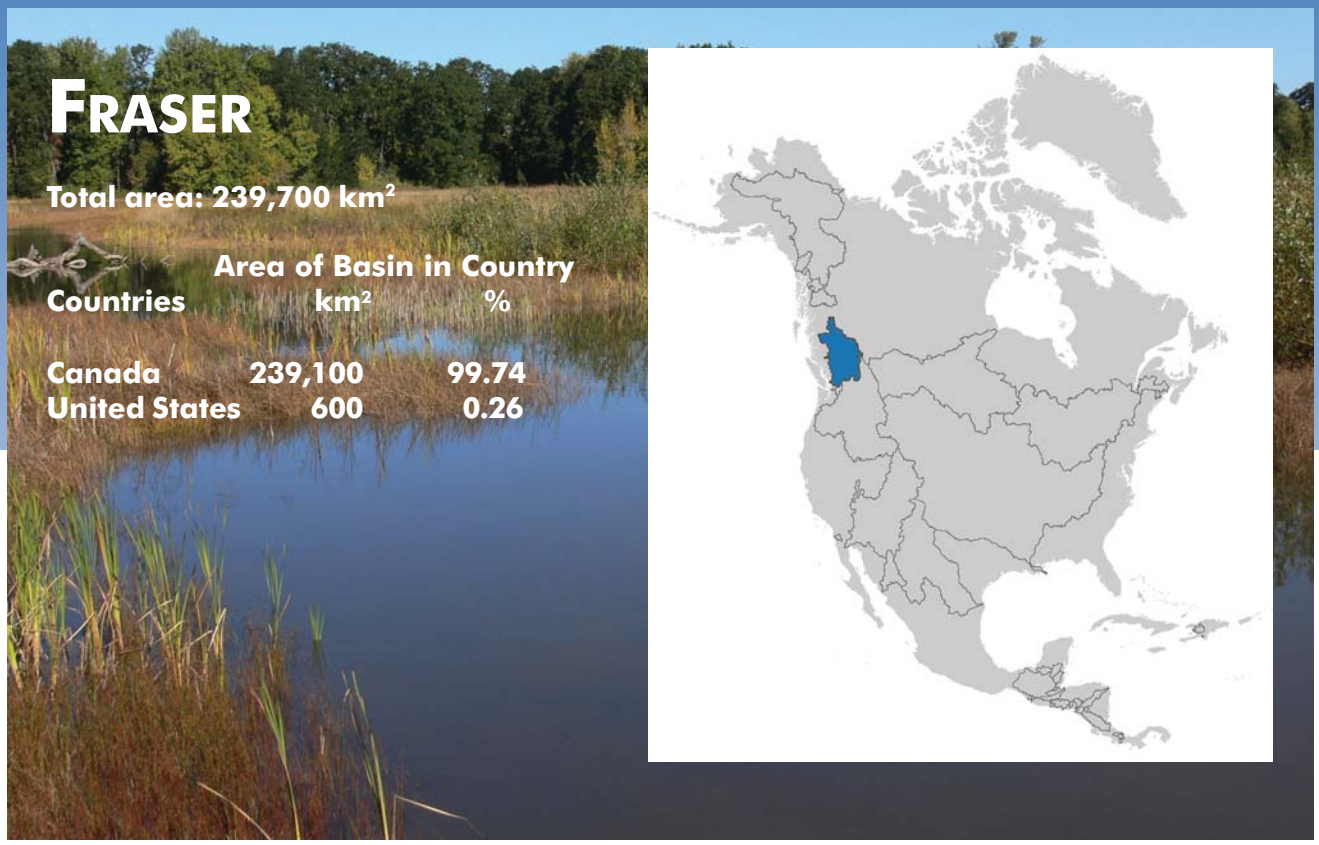
Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm



Treaties and Agreements

An Act to Amend the International Boundary Waters Treaty Act: Regulations prohibiting the bulk removal of boundary waters from Canadian basins for any purpose. and licensing for projects affecting the level or flow of waters to the United States side of the border

Treaty basins: Frontier or shared waters *Date:* December 19, 2002

Signatories: Canada, United States of America

Environmental Cooperation Agreement between British Columbia and the State of Washington to protect and manage groundwater resources

Treaty basins: Colombia River, Fraser River *Date:* May 7, 1992

Signatories: British Columbia, Canada, Washington State, United States of America

Pacific Salmon Treaty signed between Canada, the United States and representing Tribes from both nations. Addresses the harvest and management of salmon.

Treaty basins: Fraser River, Yukon River *Date:* January 28, 1985

Signatories: Canada, United States of America

Treaty between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basins: Lake Erie, Lake Michigan, Milk, Niagara, St. Mary *Date:* January 11, 1909

Signatories: Great Britain, United States of America

River Basin Organizations and Commissions

Abbotsford-Sumas Aquifer International Task Force

Product of 1992 Environmental Cooperation Agreement between British Columbia and the State of Washington to coordinate groundwater protection efforts in the region.

Treaty basins: Abbotsford-Sumas Aquifer

Date: 1992

Signatories: British Columbia, Canada, Washington State, United States of America

Source: http://wlapwww.gov.bc.ca/wat/

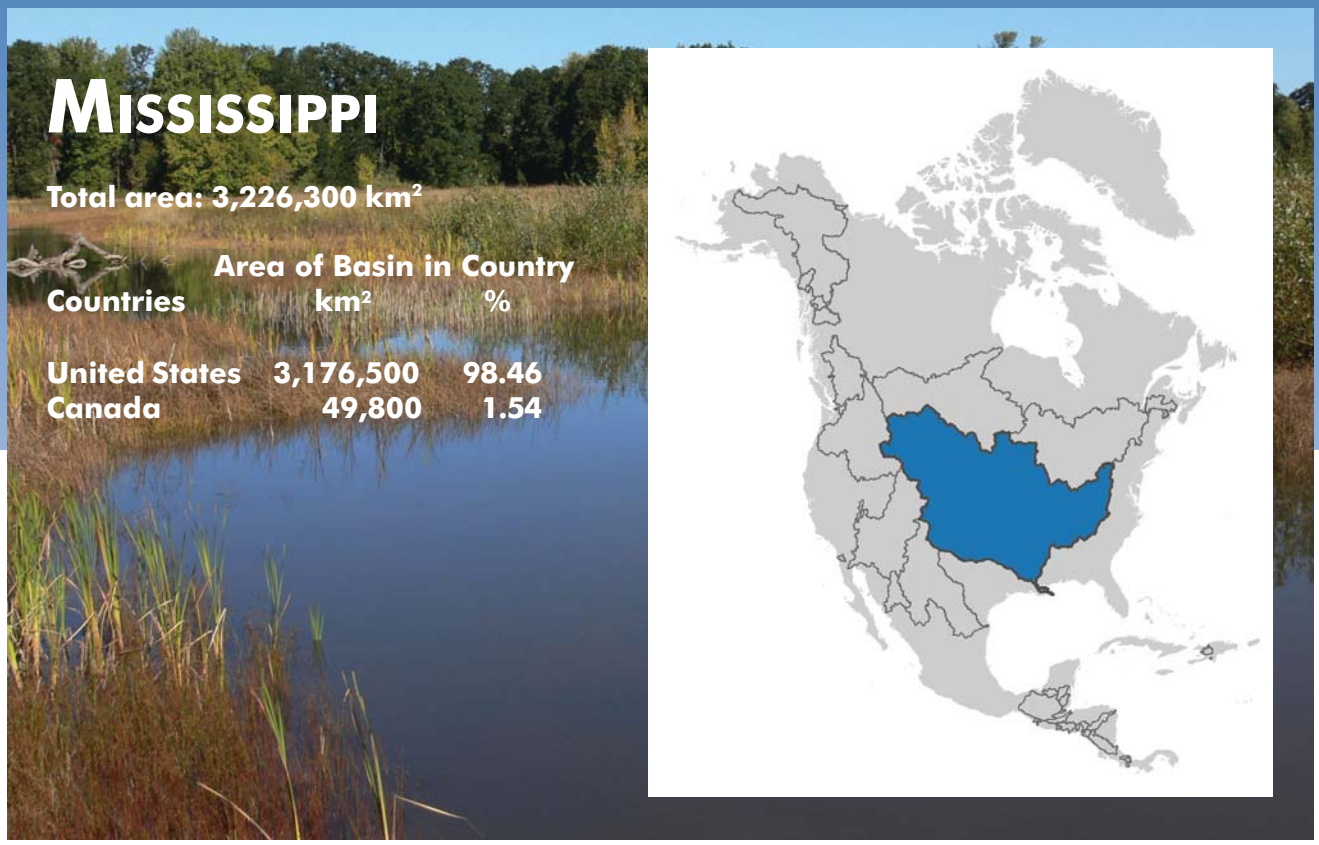
International Joint Commission (IJC)

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.

Treaty basins: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm



Mississippi

Total area: 3,226,300 km²

Countries	Area of Basin in Country km²	%
United States	3,176,500	98.46
Canada	49,800	1.54

Treaties and Agreements

Agreement between the government of Canada and the government of the United States of America for water supply and flood control in the Souris River Basin

Treaty basin: Souris *Date:* November 15, 1989

Signatories: Canada, United States of America

Treaty between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Lake Erie, Lake Michigan, Milk, Niagara, St. Mary *Date:* January 11, 1909

Signatories: Great Britain, United States of America

River Basin Organizations and Commissions

International Joint Commission (IJC)

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.

Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm

Nelson-Saskatchewan

Total area: 1,109,400 km²

Countries	Area of Basin in Country km²	%
Canada	952,000	85.81
United States	157,400	14.19

Treaties and Agreements

An Act to Amend the International Boundary Waters Treaty Act: Regulations prohibiting the bulk removal of boundary waters from Canadian basins for any purpose. and licensing for projects affecting the level or flow of waters to the United States side of the border.

Treaty basin: Frontier or shared waters — December 19, 2002

Signatories: Canada, United States of America

Exchange of notes between the government of Canada and the government of the United States of America constituting an agreement concerning the construction of a joint ring levee

Treaty basin: Red River — *Date:* August 30, 1988

Signatories: Canada, United States

Convention between Canada and the United States of America providing for emergency regulation of the level of Rainy Lake and of the level of other boundary waters in the Rainy Lake Watershed

Treaty basin: Rainy Lake — *Date:* September 15, 1938

Signatories: Canada, United States

Treaty Between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Lake Erie, Lake Michigan, Milk, Niagara, St. Mary — *Date:* January 11, 1909

Signatories: Great Britain, United States of America

River Basin Organizations and Commissions

International Joint Commission (IJC)

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Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon — *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm

Rio Bravo/ Rio Grande

Total area: 656,100 km²

Countries	Area of Basin in Country km²	%
United States	341,800	52.1
Mexico	314,300	47.9

Treaties and Agreements

International Boundary and Water Commission – minute No. 289 – observation of the quality of the waters along the United States and Mexico border

Treaty basin: Rio Grande — *Date:* November 13, 1992

Signatories: Mexico, United States

Boundary waters agreement between the United States of America and Mexico of 1987

Treaty basin: Rio Grande — *Date:* November 10, 1987

Signatories: Mexico, United States

Agreement of cooperation between the United States of America and the United Mexican States regarding pollution of the environment along the inland international boundary by discharges of hazardous substances

Treaty basin: Frontier or shared waters — *Date:* July 18, 1985

Signatories: United Mexican States, United States of America

Agreement between the United States of America and the United Mexican States on cooperation for the protection and improvement of the environment in the border area

Treaty basin: Frontier or shared waters — *Date:* August 14, 1983

Signatories: United Mexican States, United States of America

La Paz Agreement between Mexico and the United States of America regarding border water pollution, nuclear waste siting, and bilateral protection of the environment.

Treaty basin: Frontier or shared waters — *Date:* August 14, 1983

Signatories: Mexico, United States of America

Recommendations for the solution to the border sanitation problems

Treaty basin: Frontier or shared waters — *Date:* September 24, 1979

Signatories: Mexico, United States of America

International Boundary Water Commission: Minute 242; Calls for consultation between Mexico and United States if groundwater development in one country adversely affects other.

Treaty basin: Frontier or shared waters *Date:* 1973

Signatories: Mexico, United States of America

Improvement of the international flood control works of the lower Rio Grande

Treaty basin: Rio Grande *Date:* September 10, 1970

Signatories: Mexico, United States of America

Treaty to resolve pending boundary differences and maintain the Rio Grande and Colorado River as the international boundary

Treaty basin: Colorado, Rio Grande *Date:* November 23, 1970

Signatories: Mexico, United States of America

Boundary solution of the problem of the Chamizal

Treaty basin: Rio Grande *Date:* August 29, 1963

Signatories: Mexico, United States of America

Agreement to proceed with the construction of Amistad Dam on the Rio Grande to from part of the system of international storage dams provided for by the water treaty of February 3, 1944

Treaty basin: Rio Grande *Date:* October 24, 1960

Signatories: Mexico, United States

Treaty Between the United States of America and Mexico Relating to the Waters of the Colorado and Tijuana Rivers, and of the Rio Grande

Treaty basin: Colorado, Rio Grande, Tijuana *Date:* November 14, 1944

Signatories: Mexico, United States of America

Convention between the United States of America and the United Mexican States for the rectification of the Rio Grande (Rio Bravo del Norte) in the El Paso-Juarez Valley

Treaty basin: Rio Grande, Rio Bravo del Norte *Date:* February 01, 1933

Signatories: Mexico, United States

Convention between Mexico and the United States for the distribution of waters of Rio Grande

Treaty basin: Rio Grande *Date:* May 21, 1906

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, November 21, 1900 extension of convention of March 1, 1889

Treaty basin: Colorado, Rio Grande *Date:* November 21, 1900

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, Decmber 22, 1899 extension of convention of March 1, 1889

Treaty basin: Colorado, Rio Grande *Date:* December 22, 1899

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, December 2, 1898 extension of convention of March 1, 1889

Treaty basin: Colorado, Rio Grande *Date:* December 02, 1898

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, October 29, 1897 extension of convention of March 1, 1889

Treaty basin: Colorado, Rio Grande *Date:* October 29, 1897

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, November 6, 1896 extension of convention of March 1, 1889

Treaty basin: Colorado, Rio Grande *Date:* November 06, 1896

Signatories: Mexico, United States

Boundary waters: Rio Grande and Rio Colorado, October 1, 1895 extension of convention of March 1, 1889

Treaty basin: Colorado, Rio Grande *Date:* October 01, 1895

Signatories: Mexico, United States

Convention on boundary waters: Rio Grande and Rio Colorado. Formation of International Boundary Commission, Rio Grande and Rio Colorado

Treaty basin: Colorado, Rio Grande *Date:* March 01, 1889

Signatories: Mexico, United States

International Boundary and Water Commission: The Convention of November 12, 1884 to deal with ever-changing location of international boundary along Rio Grande and Colorado

Treaty basin: Colorado, Rio Grande *Date:* November 12, 1884

Signatories: Mexico, United States of America

Treaty of Guadalupe Hidalgo in 1848 established borders between United States of America & Mexico stipulating international border along the Rio Grande

Treaty basin: Colorado, Rio Grande *Date:* February 2, 1848

Signatories: Mexico, United States of America

River Basin Organizations and Commissions

Memorandum of Understanding between the City of Juarez Utilities and El Paso Water Utilities

Joint Committee formed to analyze the feasibility studies for use of Hueco Aquifer.

Treaty basin: Rio Bravo/Rio Grande *Date:* December 1999

Signatories: United States of America, Mexico

Source: Data not available

Río Grande/ Río Bravo Basin Coalition

The mission of the Río Grande/ Río Bravo Basin Coalition is to facilitate local communities in restoring and sustaining the environment, economies, and social well being of the Río Grande/ Río Bravo Basin. The Coalition is a binational organization and as such is incorporated in both the United States and in Mexico.

Treaty basin: Rio Bravo/Rio Grande *Date:* 1994

Signatories: Mexico, United States of America

Source: http://www.rioweb.org/

Border Environmental Cooperation Commission (BECC)

Created under NAFTA side agreements. Group comprised of local, state, and federal water agencies for mitigation of wastewater runoff originating in Mexico and flowing into the United States. BECC identifies, supports, evaluates and certifies sustainable environmental infrastructure projects through broad public participation, to improve the quality of life of the people of the U.S.-Mexico border region.

Treaty basin: Colorado, Rio Bravo/Rio Grande, Tijuana, Yaqui *Date:* November 1993

Signatories: United States of America, Mexico

Source: http://www.cocef.org/ingles.php

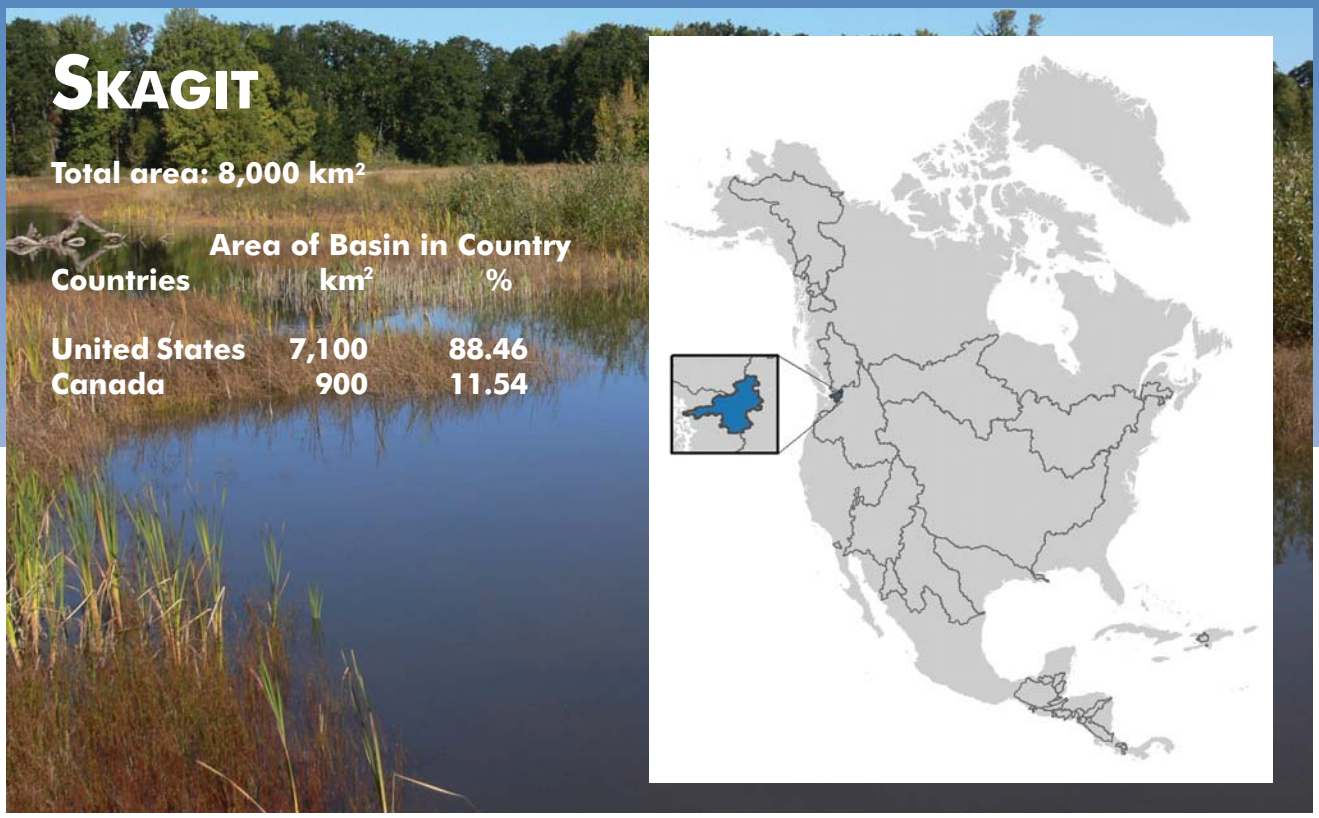
International Boundary and Water Commission (IBWC)

Has the responsibility for applying the boundary and water treaties between the United States and Mexico and settling differences that may arise out of these treaties. The IBWC is an international body composed of the United States Section and the Mexican Section

Treaty basin: Colorado, Rio Bravo/Rio Grande, Tijuana, Yaqui *Date:* 1889

Signatories: Mexico, United States of America

Source: http://www.ibwc.state.gov/



Skagit

Total area: 8,000 km²

Countries	Area of Basin in Country km²	%
United States	7,100	88.46
Canada	900	11.54

Treaties and Agreements

An Act to Amend the International Boundary Waters Treaty Act: Regulations prohibiting the bulk removal of boundary waters from Canadian basins for any purpose. and licensing for projects affecting the level or flow of waters to the United States side of the border

Treaty basin: Frontier or shared waters *Date:* December 19, 2002

Signatories: Canada, United States of America

Treaty between the United States of America and Canada relating to the Skagit River and Ross Lake, and the Seven Mile Reservoir on the Pend D'Oreille River

Treaty basin: Skagit, Pend D'Oreille *Date:* April 02, 1984

Signatories: Canada, United States

Treaty Between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Milk, Niagara, St. Mary, Lake Erie, Lake Michigan *Date:* January 11, 1909

Signatories: Canada, United States of America

River Basin Organizations and Commissions

International Joint Commission (IJC)

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Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm

St. Croix

Total area: 4,600 km²

Countries	Area of Basin in Country km²	%
United States	3,300	70.86
Canada	1,400	29.14

Treaties and Agreements

An Act to Amend the International Boundary Waters Treaty Act: Regulations prohibiting the bulk removal of boundary waters from Canadian basins for any purpose, and licensing for projects affecting the level or flow of waters to the United States side of the border.

Treaty basin: Frontier or shared waters *Date:* December 19, 2002

Signatories: Canada, United States of America

Treaty Between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Lake Erie, Lake Michigan, Milk, Niagara, St. Mary *Date:* January 11, 1909

Signatories: Great Britain, United States

River Basin Organizations and Commissions

International St. Croix River Board

The International Joint Commission combined the existing International St. Croix River Board of Control (founded in 1915) and its International Advisory Board on Pollution Control - St. Croix River and established the International St. Croix River Board. Its mandate is to assist the Commission in preventing and in resolving disputes regarding the boundary waters of the St. Croix River, to monitor the ecological health of the St. Croix River boundary waters aquatic ecosystem, and to ensure compliance with the Commission's Orders of Approval for structures in the St. Croix River.

Treaty basin: St. Croix *Date:* 1915 (2000)

Signatories: Canada, United States of America

Source: http://www.ijc.org/conseil_board/st_croix_river/en/stcroix_home_accueil.htm

International Joint Commission (IJC)

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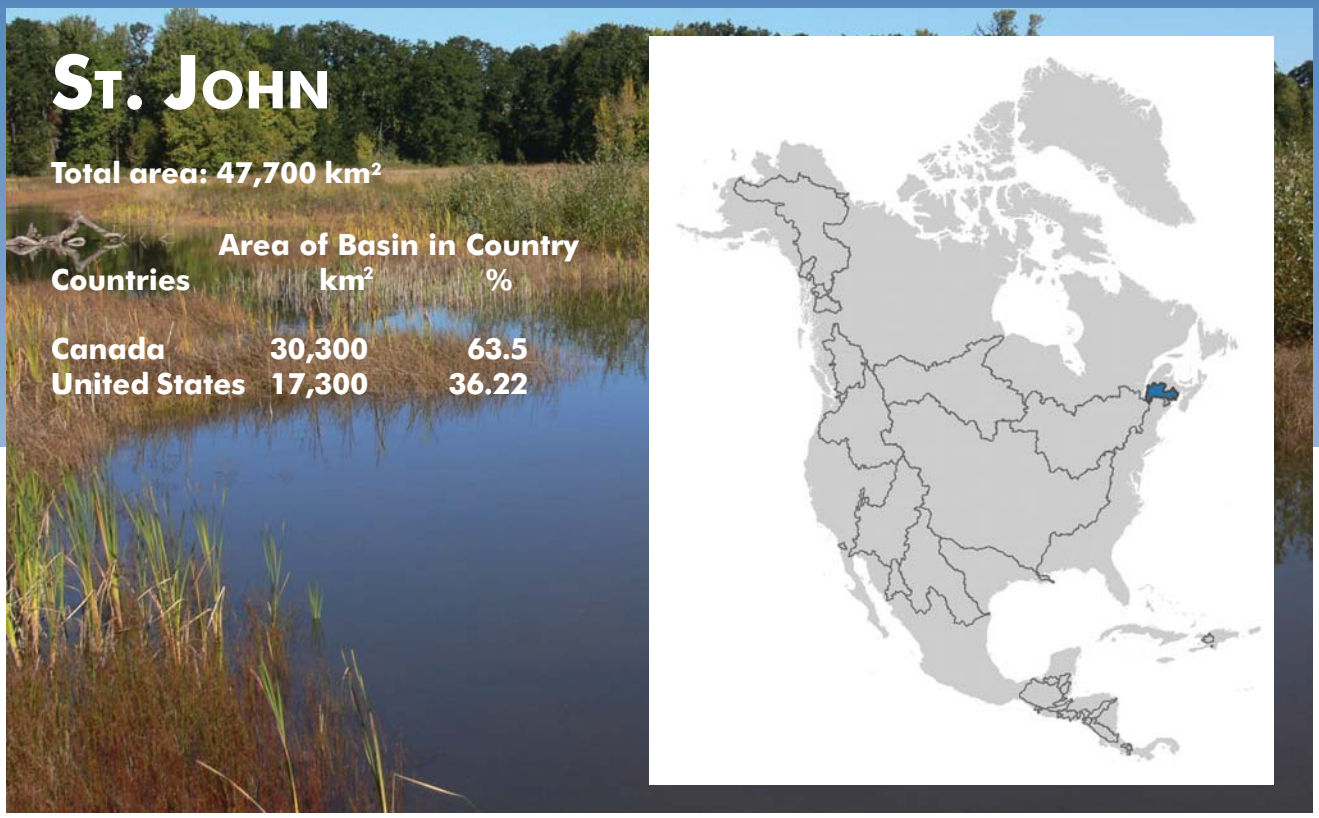
Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm



St. John

Total area: 47,700 km²

Countries	Area of Basin in Country km²	%
Canada	30,300	63.5
United States	17,300	36.22

Treaties and Agreements

An Act to Amend the International Boundary Waters Treaty Act: Regulations prohibiting the bulk removal of boundary waters from Canadian basins for any purpose. and licensing for projects affecting the level or flow of waters to the United States side of the border

Treaty basin: Frontier or shared waters

Signatories: Canada, United States of America

Exchange of notes between the government of Canada and the government of the United States of America constituting an agreement regarding the continued preservation and enhancement of the water quality in the international section of the Saint John River

Treaty basin: St. John *Date:* February 22, 1984

Signatories: Canada, United States of America

Agreement relating to the establishment of a Canada-United States committee on water quality in the St. John River and its tributary rivers and streams which cross the Canada-United States boundary, with annex

Treaty basin: St. John *Date:* September 21, 1972

Signatories: Canada, United States of America

Treaty Between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Lake Erie, Lake Michigan, Milk, Niagara, St. Mary *Date:* January 11, 1909

Signatories: Great Britain, United States of America

River Basin Organizations and Commissions

International Joint Commission (IJC)

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.

Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm

St. Lawrence

Total area: 1,055,200 km²

Countries	Area of Basin in Country km²	%
Canada	559,000	52.98
United States	496,100	47.02

Treaties and Agreements

An Act to Amend the International Boundary Waters Treaty Act: Regulations prohibiting the bulk removal of boundary waters from Canadian basins for any purpose. and licensing for projects affecting the level or flow of waters to the United States side of the border

Treaty basin: Frontier or shared waters *Date:* December 19, 2002

Signatories: Canada, United States of America

Protocol amending the 1978 agreement between the United States of American and Canada on Great Lakes water quality, as amended on 16.10.1983

Treaty basin: Great Lakes *Date:* November 18, 1987

Signatories: Canada, United States

Supplementary agreement amending the agreement between Canada and the United States of America on Great Lakes water quality, 1978

Treaty basin: Great Lakes *Date:* October 16, 1983

Signatories: Canada, United States

Exchange of notes between the government of Canada and the government of the United States of America constituting an agreement with respect of article I of the convention between Canada and the United States of America to regulate the level of the Lake of the Woods

Treaty basin: Lake of the Woods *Date:* June 19, 1979

Signatories: Canada, United States

1978 agreement between the United States and Canada on Great Lakes water quality

Treaty basin: Great Lakes *Date:* November 22, 1978

Signatories: Canada, United States

Agreement constituting appendix I, relating to gross reductions in inputs of phosphorus to Lakes Superior and Huron to the Great Lakes water quality agreement of 1972

Treaty basin: Lakes Superior and Huron *Date:* November 21, 1973

Signatories: Canada, United States

Agreement on Great Lakes water quality with annexes and attachments, signed at Ottawa

Treaty basin: Great Lakes *Date:* April 15, 1972

Signatories: Canada, United States

Exchange of notes constituting an agreement between the United States of America and Canada for the construction of a temporary cofferdam at Niagara

Treaty basin: Niagara *Date:* March 21, 1969

Signatories: Canada, United States

Exchange of notes constituting an agreement between the United States of America and Canada for the temporary diversion for power purposes of the water normally flowing over the American Falls at Niagara

Treaty basin: Niagara *Date:* March 21, 1969

Signatories: Canada, United States

Exchange of notes constituting an agreement relating to navigation improvements of the Great Lakes connecting channels of the Saint Lawrence Seaway

Treaty basin: Detroit, Great Lakes, St. Clair, St. Mary *Date:* April 9, 1957

Signatories: Canada, United States

Exchange of notes constituting an agreement between the United States of America and Canada modifying and supplementing the agreement of 30 June 1852 relating to the St. Lawrence Seaway Project

Treaty basin: St. Lawrence *Date:* August 17, 1954

Signatories: Canada, United States

Exchange of notes constituting an agreement between the United States and Canada relating to the establishment of the St. Lawrence River joint board of engineers

Treaty basin: St. Lawrence *Date:* November 12, 1953

Signatories: Canada, United States

Exchange of notes constituting an agreement between the United States of America and Canada relating to the St. Lawrence Seaway Project, Washington

Treaty basin: St. Lawrence *Date:* June 30, 1952

Signatories: Canada, United States

Treaty between the United States of America and Canada relating to the uses of the waters of the Niagara River

Treaty basin: Niagara *Date:* February 27, 1950

Signatories: Canada, United States

Treaty between Canada and the United States of America concerning the diversion of the Niagara River, with agreement between Canada and Ontario and protocol of exchange

Treaty basin: Niagara *Date:* February 27, 1950

Signatories: Canada, United States

Exchange of notes (August 31 and September 7, 1944) between Canada and the United States extending the agreement for the temporary raising of the level of Lake St. Francis of November 10, 1941

Treaty basin: Lake St. Francis *Date:* September 7, 1944

Signatories: Canada, United States

Exchange of notes constituting an agreement extending…agreement [re. raising level of Lake St. Francis, Nov. 11, 1941], Washington 5 and 9 October 1942

Treaty basin: Lake St. Francis *Date:* October 9, 1942

Signatories: Canada, United States

Exchange of notes between the government of the United States and the government of Canada constituting an arrangement concerning temporary diversion for power purposes of additional waters of the Niagara River above the falls

Treaty basin: Niagara *Date:* May 20, 1941

Signatories: Canada, United States

Exchange of notes between the governments of the United States of America and of Canada constituting an agreement relating to the temporary raising of the level of Lake St. Francis during lower water periods, Washington

Treaty basin: Lake St. Francis *Date:* November 10, 1941

Signatories: Canada, United States

Exchange of notes constituting an agreement between the government of the United States and the government of Canada relating to additional temporary diversion for power purposes of waters of the Niagara River above Niagara Falls

Treaty basin: Niagara *Date:* November 27, 1941

Signatories: Canada, United States

Exchange of notes between the government of the United States of America and the government of Canada constituting an agreement regarding the development of certain portions of the Great Lakes-St. Lawrence Basin project

Treaty basin: St. Lawrence *Date:* November 7, 1940

Signatories: Canada, United States

Regulation of flow of water from Lake Memphremagog

Treaty basin: Lake Memphremagog *Date:* November 6, 1935

Signatories: Canada, United States

Agreement between the United States of America and Canada to regulate the level of Lake of the Woods and accompanying protocol

Treaty basin: Great Lakes, Lake of the Woods, Rainy River *Date:* February 24, 1925

Signatories: Great Britain (Canada), United States

Treaty Between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Great Lakes, Columbia, Niagara *Date:* January 11, 1909

Signatories: Great Britain, United States

River Basin Organizations and Commissions

International Missisquoi Bay Task Force

Established by the IJC to investigate water quality and flow impacts possible transboundary implications of the Alburg-Swanton Bridge, which crosses the waters connecting Missisquoi Bay with the rest of Lake Champlain in the State of Vermont. Missisquoi is a subbasin of the St. Lawrence.

Treaty basin: Missiquoi *Date:* 2004

Signatories: Canada and the United States of America

Source: http://www.ijc.org/conseil_board/missisquoi_bay/en/missbay_home_accueil.htm

Lake Huron Binational Partnership (LHBP)

In 2002 the federal, state and provincial agencies that manage binational environmental activities under the 1987 Great Lakes Water Quality Agreement formally endorsed the formation of a Lake Huron Binational Partnership in order to prioritize and coordinate environmental activities in the Lake Huron basin. The federal and state/provincial environment agencies and the state/provincial natural resource agencies form the core of the Partnership by providing leadership and coordination. Lake Huron is a subbasin of the St. Lawrence.

Treaty basin: Lake Huron *Date:* 2002

Signatories: Canada, United States of America

Source: http://cfpub.binational.net/huron/intro-e.cfm

Great Lakes Information Network (GLIN)

The GLIN is a partnership that provides one place online for people to find information relating to the binational Great Lakes-St. Lawrence region of North America. GLIN offers data and information about the region's environment, economy, tourism, education and more. GLIN development and maintenance services are provided by the Great Lakes Commission.

Treaty basin: St. Lawrence *Date:* 1993

Signatories: Canada, United States of America

Source: http://www.great-lakes.net/

Integrated Atmospheric Deposition Network (IADN)

Established by the United States and Canada for conducting air and precipitation monitoring in the Great Lakes Basin.

Treaty basin: St. Lawrence *Date:* 1990

Signatories: Canada, United States of America

Source: http://www.msc-smc.ec.gc.ca/iadn/Overview/index_e.html

Great Lakes Science Advisory Board

Provides scientific advice to the International Joint Commission and the Great Lakes Water Quality Board and is responsible for developing recommendations on all matters related to research and the development of scientific knowledge pertinent to Great Lakes water quality.

Treaty basin: St. Lawrence *Date:* 1978

Signatories: Canada, United States of America

Source: http://www.ijc.org/conseil_board/science_greatlakes/en/glsab_home_accueil.htm

Great Lakes Water Quality Board

The principal advisor to the IJC with regard to all functions, powers and responsibilities regarding water quality.

Treaty basin: St. Lawrence *Date:* 1978

Signatories: Canada, United States of America

Source: http://www.ijc.org/conseil_board/water_greatlakes/en/glwqb_mandate_mandat.htm

International Joint Commission (IJC)

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.

Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm

Great Lakes Commission

The Great Lakes Commission is a binational public agency dedicated to the use, management and protection of the water, land and other natural resources of the Great Lakes-St. Lawrence system.

Treaty basin: St. Lawrence *Date:* 1955

Signatories: Canada, United States of America

Source: http://www.glc.org

IJC Board: International St. Lawrence River Board of Control

Main duty: to ensure that outflows from Lake Ontario meet the requirements of the Commission's order. The Board also develops regulation plans and conducts special studies as requested by the Commission. Outflows are set by the Board under the regulation plan. The St. Lawrence River and Lake Ontario are both subbasins of the St. Lawrence.

Treaty basin: St. Lawrence River, Lake Ontario *Date:* 1952

Signatories: Canada, United States of America

Source: http://www.islrbc.org/new-Version/engmain.html

IJC Board: International Niagara Board of Control

The Board's main duties are to oversee water levels regulation in the Chippawa-Grass Island Pool and installation of the Lake Erie-Niagara River Ice Boom. Lake Erie and Niagara are subbasins of the St. Lawrence. The Board also collaborates with the International Niagara Committee, a body created by the 1950 Niagara Treaty to determine the amount of water available for the Falls and power generation.

Treaty basin: Lake Erie, Niagara *Date:* 1950

Signatories: Canada, United States of America

Source: http://www.ijc.org/conseil_board/niagara/en/niagara_home_accueil.htm

International Niagara Committee

Niagara is a subbasin of the St. Lawrence. This body was created by the 1950 Niagara Treaty to determine the amount of water available for the Falls and power generation.

Treaty basin: Niagara *Date:* 1950

Signatories: Canada, United States of America

Source: http://www.lre.usace.army.mil/Storage/HH/IJC/Niagra/niagara.pdf

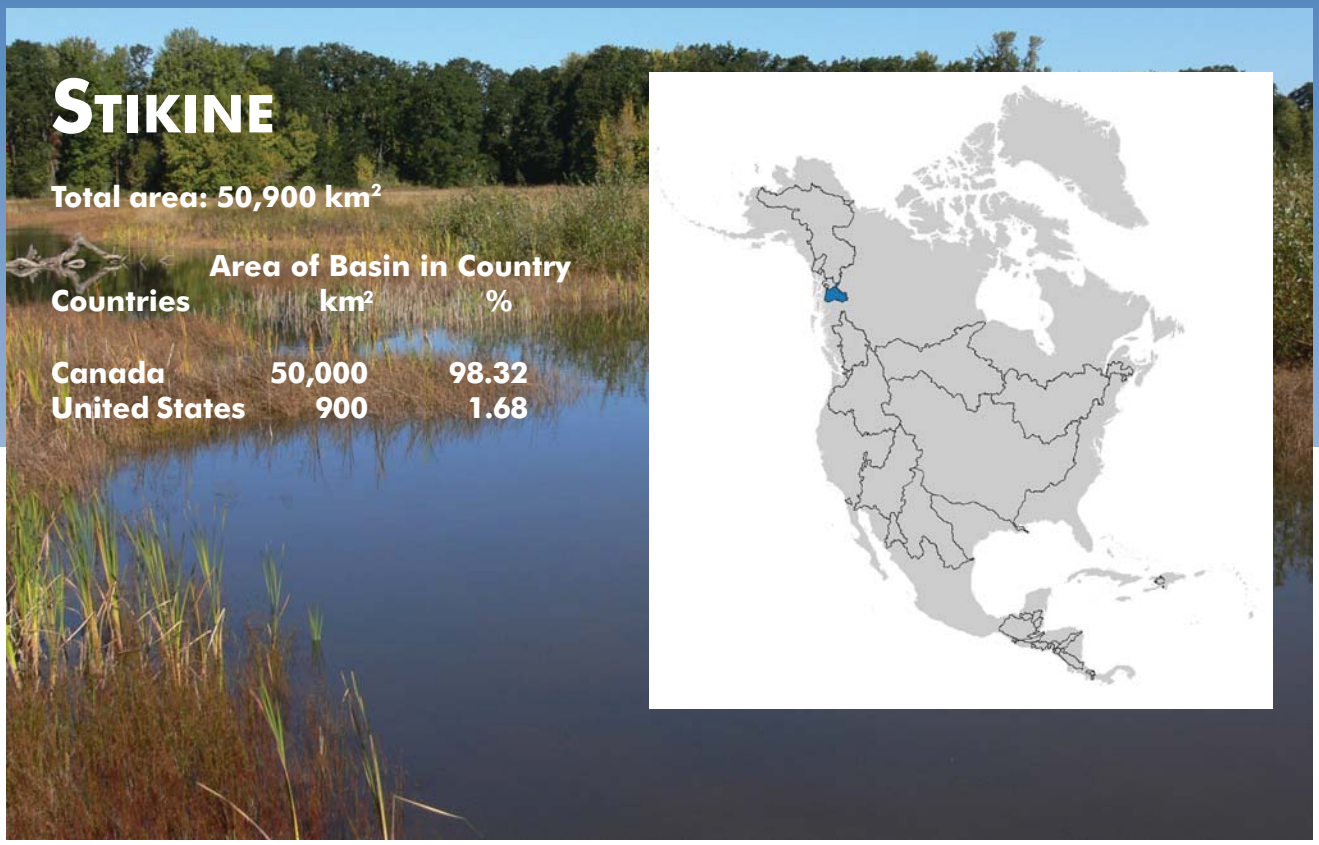
IJC Board: International Lake Superior Board of Control

The Board's duties include setting Lake Superior (a subbasin of St. Lawrence) outflows, and overseeing the operation of the various control works.

Treaty basin: Lake Superior *Date:* 1914

Signatories: Canada, United States of America

Source: http://www.ijc.org/conseil_board/superior_lake/en/superior_mandate_mandat.htm



Stikine

Total area: 50,900 km²

Countries	Area of Basin in Country km²	%
Canada	50,000	98.32
United States	900	1.68

Treaties and Agreements

Pacific Salmon Treaty signed between Canada, the United States and representing Tribes from both nations. Adresses the harvest and management of salmon.

Treaty basin: Stikine, Alsek, Taku *Date:* January 28, 1985

Signatories: Canada, United States of America

Treaty Between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Milk, Niagara, St. Mary, Lake Erie, Lake Michigan *Date:* January 11, 1909

Signatories: Great Britain, United States

River Basin Organizations and Commissions

Pacific Salmon Commission (PSC), set up in compliance with the 1985 Pacific Salmon Treaty

Long-term goals include achieving optimum salmon production and providing each Party benefits equivalent to the salmon production originating in its own waters.

Treaty basin: Alsek, Stikine, Taku *Date:* 1999

Signatories: Canada, United States of America

Source: http://www.oceanlaw.net/texts/psc99.htm

International Joint Commission (IJC)

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.

Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm

The Transboundary Watershed Alliance (TWA)

Formed to assist its 22 member organizations to maintain and replenish the diversity and abundance of fish and wildlife species and their habitat in the transboundary watersheds of Canada and Southeast Alaska, from the Unuk watershed in the South to the Alsek watershed in the north, and to encourage the adoption of long-term conservation based planning.

Treaty basin: Stikine *Date:* Data not available

Signatories: Canada, United States of America

Source: http://www.riverswithoutborders.org/index.htm

Taku

Total area: 18,100 km²

Countries	Area of Basin in Country km²	%
Canada	16,300	90.09
United States	1,700	9.13

Treaties and Agreements

Pacific Salmon Treaty signed between Canada, the United States and representing Tribes from both nations. Adresses the harvest and management of salmon.

Treaty basin: Stikine, Alsek, Taku *Date:* January 28, 1985

Signatories: Canada, United States of America

River Basin Organizations and Commissions

Pacific Salmon Commission (PSC), set up in compliance with the 1985 Pacific Salmon Treaty

Long-term goals include achieving optimum salmon production and providing each Party benefits equivalent to the salmon production originating in its own waters.

Treaty basin: Alsek, Stikine, Taku *Date:* 1999

Signatories: Canada, United States of America

Source: http://www.oceanlaw.net/texts/psc99.htm

International Joint Commission (IJC)

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.

Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm

TIJUANA

Total area: 4,400 km²

Countries	Area of Basin in Country km²	%
Mexico	3,100	70.57
United States	1,300	29.43

TREATIES AND AGREEMENTS

Distribution of construction, operation and maintenance costs for the international wastewater treatment plant constructed under the agreements in Commission Minute NO. 283 for the solution of the border sanitation problem at San Diego, California/Tijuana

Treaty basin: Tijuana — *Date:* April 16, 1997

Signatories: Mexico, United States of America

Recommendations for construction of works parallel to the City of Tijuana, B.C. Wastewater Pumping and Disposal System and rehabilitation of the San Antonio de los Buenos Treatment Plant

Treaty basin: Tijuana — *Date:* December 2, 1997

Signatories: Mexico, United States of America

Boundary waters: San Diego, California/Tijuana, Baja California. Minute No. 283 of the International Boundary and Water Commission, United States of America and Mexico.

Treaty basin: Rio el Alamar — *Date:* July 2, 1990

Signatories: Mexico, United States

Recommendations for the first stage treatment and disposal facilities for the solution of the border sanitation problem at San Diego, California-Tijuana, Baja California

Treaty basin: Tijuana — *Date:* April 30, 1985

Signatories: Mexico, United States of America

Agreement of cooperation between the United States of America and the United Mexican States regarding pollution of the environment along the inland international boundary by discharges of hazardous substances

Treaty basin: Frontier or shared waters — *Date:* July 18, 1985

Signatories: United Mexican States, United States of America

Agreement between the United States of America and the United Mexican States on cooperation for the protection and improvement of the environment in the border area

Treaty basin: Frontier or shared waters *Date:* August 14, 1983

Signatories: United Mexican States, United States of America

Treaty Between the United States of America and Mexico Relating to the Waters of the Colorado and Tijuana Rivers, and of the Rio Grande

Treaty basin: Colorado, Rio Grande, Tijuana Date: November 14, 1944

Signatories: Mexico, United States of America

River Basin Organizations and Commissions

Border Environmental Cooperation Commission (BECC)

Created under NAFTA side agreements. Group comprised of local, state, and federal water agencies for mitigation of wastewater runoff originating in Mexico and flowing into the United States. BECC identifies, supports, evaluates and certifies sustainable environmental infrastructure projects through broad public participation, to improve the quality of life of the people of the U.S.-Mexico border region.

Treaty basin: Colorado, Rio Bravo/Rio Grande, Tijuana, Yaqui *Date:* November 1993

Signatories: United States of America and Mexico

Source: http://www.cocef.org/ingles.php

International Boundary and Water Commission (IBWC)

Has the responsibility for applying the boundary and water treaties between the United States and Mexico and settling differences that may arise out of these treaties.

Treaty basin: Colorado, Rio Bravo/Rio Grande, Tijuana, Yaqui *Date:* 1889

Signatories: Mexico, United States of America

Source: http://www.ibwc.state.gov/

Whiting

Total area: 2,600 km²

Countries	Area of Basin in Country km²	%
Canada	2,000	80.06
United States	500	19.94

Treaties and Agreements

Treaty between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Milk, Niagara, St. Mary, Lake Erie, Lake Michigan *Date:* January 11, 1909

Signatories: Great Britain, United States of America

River Basin Organizations and Commissions

International Joint Commission (IJC)

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.

Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm

The Transboundary Watershed Alliance (TWA)

Formed to assist its 22 member organizations to maintain and replenish the diversity and abundance of fish and wildlife species and their habitat in the transboundary watersheds of Canada and Southeast Alaska, from the Unuk watershed in the South to the Alsek watershed in the north, and to encourage the adoption of long-term conservation based planning to ensure the survival of these magnificent river systems.

Treaty basin: Whiting *Date:* Data not available

Signatories: Canada, United States of America

Source: http://www.riverswithoutborders.org/index.htm

Yaqui

Total area: 74,700 km²

Countries	Area of Basin in Country km²	%
Mexico	70,100	93.87
United States	4,600	6.13

Treaties and Agreements

Agreement of cooperation between the United States of America and the United Mexican States regarding pollution of the environment along the inland international boundary by discharges of hazardous substances

Treaty basin: Frontier or shared waters July 18, 1985

Signatories: United Mexican States, United States of America

La Paz Agreement between Mexico and the United States of America regarding border water pollution, nuclear waste siting, and bilateral protection of the environment.

Treaty basin: Frontier or shared waters *Date:* August 14, 1983

Signatories: United Mexican States, United States of America

River Basin Organizations and Commissions

Border Environmental Cooperation Commission (BECC)

Created under NAFTA side agreements. Group composed of local, state, and federal water agencies for mitigation of wastewater runoff originating in Mexico and flowing into the United States. Jointly funded By U.S. EPA and Mexican Government in response to deteriorating water quality through binational groundwater monitoring projects.

Treaty basin: Colorado, Rio Bravo/Rio Grande, Tijuana, Yaqui *Date:* November 1993

Signatories: United States of America, Mexico

Source: http://www.cocef.org/ingles.php

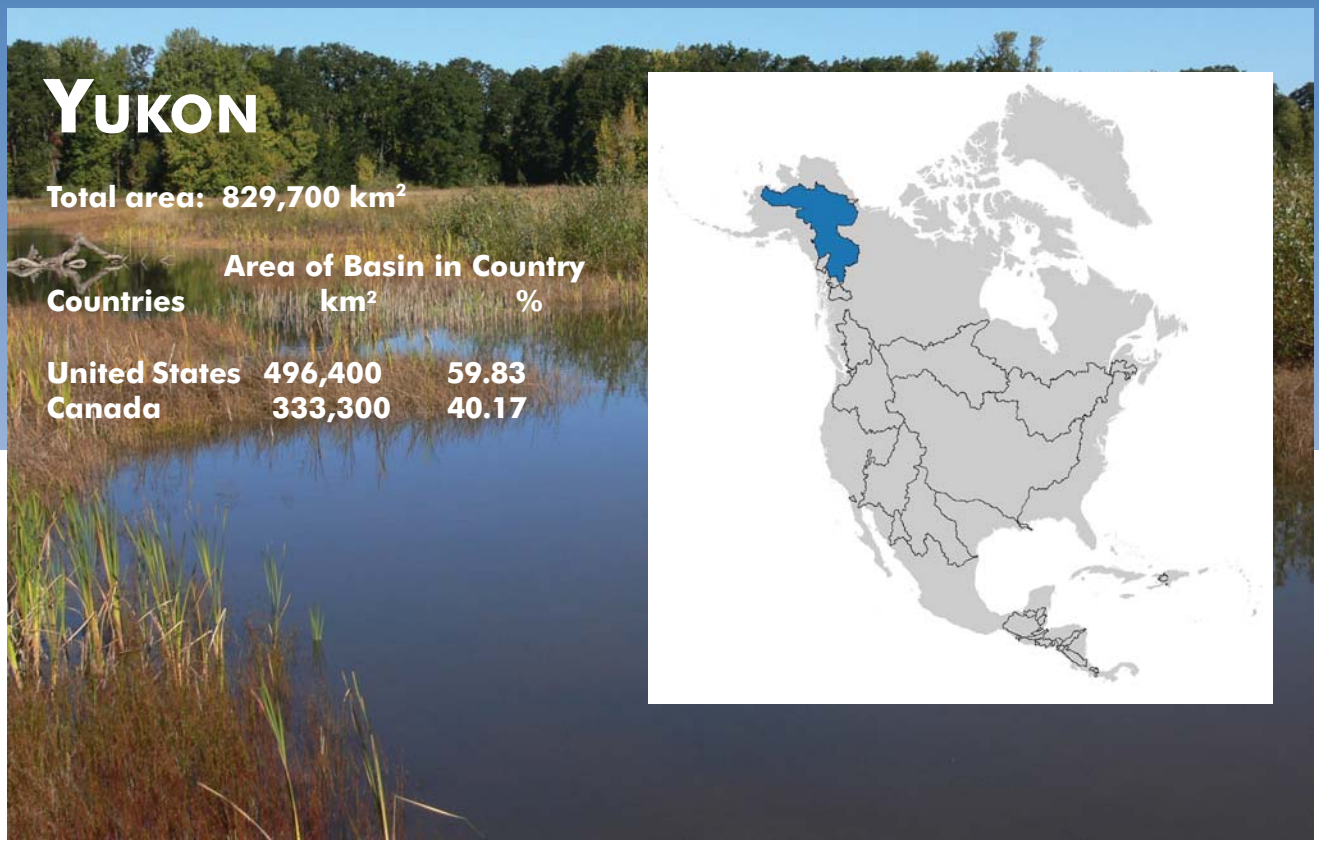
International Boundary and Water Commission (IBWC)

Has the responsibility for applying the boundary and water treaties between the United States and Mexico and settling differences that may arise out of these treaties. The IBWC is an international body composed of the United States Section and the Mexican Section.

Treaty basin: Colorado, Rio Bravo / Rio Grande, Tijuana, Yaqui *Date:* 1889

Signatories: Mexico, United States of America

Source: http://www.ibwc.state.gov/



Yukon

Total area: 829,700 km²

Countries	Area of Basin in Country km²	%
United States	496,400	59.83
Canada	333,300	40.17

Treaties and Agreements

Treaty Between Great Britain and the United States relating to boundary waters and boundary questions

Treaty basin: Milk, Niagara, St. Mary, Lake Erie, Lake Michigan *Date:* January 11, 1909

Signatories: Great Britain, United States of America

River Basin Organizations and Commissions

The Transboundary Watershed Alliance (TWA)

Formed to assist its 22 member organizations to maintain and replenish the diversity and abundance of fish and wildlife species and their habitat in the transboundary watersheds of Canada and Southeast Alaska, from the Unuk watershed in the South to the Alsek watershed in the north, and to encourage the adoption of long-term conservation based planning.

Treaty basin: Yukon *Date:* 1999

Signatories: Canada, United States of America

Source: http://www.riverswithoutborders.org/index.htm

International Joint Commission (IJC)

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.

Treaty basin: Alsek, Chilkat, Columbia, Firth, Fraser, Mississippi, Nelson-Saskatchewan, Skagit, St. Croix, St. John, St. Lawrence, Stikine, Taku, Whiting, Yukon *Date:* 1909

Signatories: Canada, United States of America

Source: http://www.ijc.org/en/home/main_accueil.htm

Appendix 2. Riparian Country Collaborations

Alsek

The Transboundary Watershed Alliance (TWA)

Formed to assist its 22 member organizations to maintain and replenish the diversity and abundance of fish and wildlife species and their habitat in the transboundary watersheds of Canada and Southeast Alaska, from the Unuk watershed in the South to the Alsek watershed in the north, and to encourage the adoption of long-term conservation based planning to ensure the survival of these magnificent river systems. SPECA assists the participating countries to strengthen their cooperation. SPECA addresses, amongst others, transport and border crossing and water management.

Participating countries: Canada, United States of America

Date: Data not available

Level/Type of Collaboration: Non-official/Environmental program

Principal Issue: Water quality

Source: http://www.riverswithoutborders.org/index.htm

Colorado

The Bellagio Draft Treaty

Developed by multidisciplinary international group of specialists to provide a blueprint for international treaties cooperating around the protection and use of transboundary aquifers.

Participating countries: Mexico, United States of America

Level/Type of Collaboration: Non-official/International initiative

Principal Issue: Joint management, other: research and education

Date: 1989

Source: http://uttoncenter.unm.edu/bellagio_treaty.html

EPA project: Border 2012

This is a 10-year, binational, results-oriented environmental program for the U.S.-Mexico border region. The Border 2012 Program is the latest multi-year, binational planning effort to be implemented under the La Paz Agreement and succeeds Border XXI, a five-year program that ended in 2000.

Participating countries: Mexico, United States of America

Level/Type of Collaboration: Official/Social-health program and environmental program

Principal Issue: Joint management, water quality

Date: 2002-2012

Source: http://www.epa.gov/usmexicoborder/index.htm

Aquaferico Project: Conducted by the Binational Technical Committee, headed by the Border Environmental Cooperation Commission (BECC)

Jointly funded By U.S. EPA and Mexican Government in response to deteriorating water quality through binational groundwater monitoring projects.

Participating countries: Mexico, United States of America

Level/Type of Collaboration: Official/Social-health program and environmental program

Principal Issue: Joint management, water quality

Date: 1996

Source: http://www.aliciapatterson.org/APF1901/Davidson/Davidson.html

UNESCO's International Hydrological Programme (IHP) / Green Cross International project: PC—> CP: case study of the Columbia River Basin

Addresses the challenge of sharing water resources. Primary objective: to foster co-operation between stakeholders in the management of shared water resources and mitigate the risk that potential conflicts turn into real ones.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Non-official/International initiative, social/health program

Principal Issue: Joint management, other: research and education

Date: 2001-2003

Source: http://www.unesco.org/water/wwap/pccp/index.shtml

Rio Grande/Rio Bravo del Norte

Transboundary Aquifers and Binational Groundwater Database

Groundwater database for El Paso/Ciuidad Juarez area with information from both sides filling data gaps to assist future studies. Brought into database by the IBWC.

Participating countries: Mexico, United States of America

Level/Type of Collaboration: Non-official/International Initiative

Principal Issue: Other: research and education

Date: 1998

Source: http://www.ibwc.state.gov/html/body_binational_waters.htm

St. Lawrence

Council of Great Lakes Research Managers

The purpose of the Council is to enhance the ability of the Commission to provide effective leadership, guidance, support and evaluation of Great Lakes research as it applies to the provisions of the Great Lakes Water Quality Agreement of 1978. Membership consists of individuals managing federal, state and provincial research programs and representatives from academic institutions and private industry.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Non-official/International initiative

Principal Issue: Joint management, other: research and education

Date: 1984

Source: http://www.ijc.org/conseil_board/research_greatlakes/en/cglrm_home_accueil.htm

Great Lakes Natural Resource Centre

The Great Lakes Field Office in Ann Arbor, Michigan, unites people throughout the Great Lakes region, the United States and Canada to protect the world's greatest freshwater seas, the surrounding ecosystem, and the benefits they provide to people and wildlife.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Non-official/International initiative

Principal Issue: Joint management, other: research and education

Date: Data not available

Source: http://www.nwf.org/resourceLibrary/index.cfm?officeID=F7439239-65BF-0A01-01BD9365CEBF53C0

Council of Great Lake Industries

This council is a non-profit organization representing the common interests of U.S. and Canadian industrial organizations from the manufacturing, utilities, transportation, communications, financial services and trade

sectors that have investments in the Great Lakes Basin. The Council works to ensure that industry is a substantive partner in the Great Lakes region's public policy development process.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Non-official/International initiative

Principal Issue: Joint management, other: research and education

Date: Data not available

Source: http://www.cgli.org/

Great Lakes Sport Fishing Council

Representing a major interest in the resources of the Great Lakes states Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and the Province of Ontario. The Great Lakes Sport Fishing Council is a confederation of organizations and individuals who share a concern for the present and future of sport fishing, our natural and stocked resources and the ecosystem.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Non-official/International initiative

Principal Issue: Other: research and education

Date: 1972

Source: http://www.great-lakes.org/

Great Lakes Research Consortium

An organization of seventeen colleges and universities in New York, with nine affiliate campuses in Ontario, dedicated to collaborative research and education on the Great lakes. Mission: to improve the understanding of the Great Lakes ecosystem, including the physical , biological, and chemical processes that shape it, as well as the social and political forces that affect human impact on the lakes and their associated economic resources.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Non-official/International initiative

Principal Issue: Joint management, other: research and education

Date: Data not available

Source: http://www.esf.edu/glrc/default.htm

Great Lakes United

Great Lakes United is an international coalition dedicated to preserving and restoring the Great Lakes-St. Lawrence River ecosystem. Great Lakes United is made up of member organizations representing environmentalists, conservationists, hunters and anglers, labour unions, community groups, and citizens of the United States, Canada, and First Nations and Tribes. Great Lakes United develops and promotes effective policy initiatives, carries out education programs, and promotes citizen action and grassroots leadership to assure: (a) Clean water and clean air for all (b) Better safeguards to protect the health of people and wildlife and (c) A conservation ethic that will leave a healthy Great Lakes.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Non-official/International initiative

Principal Issue: Joint management, other: research and education

Date: 1982

Source: http://www.glu.org/

The Council of Great Lake Governors

Mission: To encourage and facilitate environmentally responsible economic growth. This is accomplished by establishing a cooperative effort between the public and private sectors among the eight Great Lakes states and with the Canadian provinces of Ontario and Quebec.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Non-official/International initiative

Principal Issue: Joint Management, economic development

Date: 1983

Source: http://www.cglg.org/

Binational.net

A collaboration between the United States Environmental Protection Agency (USEPA) and Environment Canada (EC), to provide a single window on joint Great Lakes programs. This initiative is underway, with postings of several binational programs and reports.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Non-official/International initiative

Principal Issue: Joint management, other: research and education

Date: Data not available

Source: http://cfpub.binational.net/

US EPA and Environment Canada project: The Great Lakes Binational Toxics Strategy

The purpose of this binational strategy (the Strategy) is to set forth a collaborative process by which EC and the USEPA, in consultation with other federal departments and agencies, Great Lakes states, the Province of Ontario, Tribes, and First Nations, will work in cooperation with their public and private partners toward the goal of virtual elimination of persistent toxic substances resulting from human activity, particularly those which bio accumulate, from the Great Lakes Basin, so as to protect and ensure the health and integrity of the Great Lakes ecosystem.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Official/Environmental program

Principal Issue: Water quality

Date: 1997-2006

Source: http://www.epa.gov/glnpo/p2/bns.html

State of the Lakes Ecosystem Conference (SOLEC)

The State of the Lakes Ecosystem Conferences (SOLEC) are hosted by the U.S. Environmental Protection Agency and Environment Canada on behalf of the two countries. These conferences are held every two years in response to a reporting requirement of the binational Great Lakes Water Quality Agreement (GLWQA). The purpose of the Agreement is "to restore and maintain the physical, chemical and biological integrity of the Great Lakes Basin."

Participating countries: Canada, United States of America

Level/Type of Collaboration: Official/Environmental program

Principal Issue: Water quality

Date: 1994

Source: http://cfpub.binational.net/solec/intro_e.cfm

Great Lakes Radio Consortium

The Great Lakes Radio Consortium is a news service committed to revealing the relationship between the natural world and the everyday lives of people in the Great Lakes region. This is accomplished by thoughtful and provocative explorations of the environment in a way that reaches the widest possible audience.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Non-official/Environmental program

Principal Issue: Other: research and education

Date: 1993

Source: http://www.glrc.org/

St. Lawrence - subbasin Lake Erie

Lakewide Management Plan (LaMP) for Lake Erie

Coordinated by federal, state and provincial government agencies in the two countries. In 1987 the governments of Canada and the United States made a commitment, as part of the Great Lakes Water Quality Agreement (GLWQA), to develop a Lakewide Management Plan for the Great Lakes. The LaMP unites a network of stakeholders in actions to restore and protect the Lake Erie ecosystem.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Official/Environmental program

Principal Issue: Joint management, water quality

Date: 1987

Source: http://cfpub.binational.net/erie/intro-e.cfm

St. Lawrence - subbasin Lake Ontario

The Lakewide Management Plan (LaMP) for Lake Ontario

In 1987 the governments of Canada and the United States made a commitment, as part of the Great Lakes Water Quality Agreement (GLWQA), to develop a Lakewide Management Plan for the Great Lakes. The LaMP is coordinated by four agencies: Environment Canada, United States Environmental Protection Agency, the New York State Department of Environmental Conservation and the Ontario Ministry of the Environment. The LaMP unites a network of stakeholders which includes other government agencies, in actions to restore and protect the Lake Ontario ecosystem.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Official/Environmental program

Principal Issue: Joint management, water quality

Date: 1987

Source: http://cfpub.binational.net/ontario/intro-e.cfm

St. Lawrence - subbasin Lake Superior

Lakewide Management Plan (LaMP) for Lake Superior

Coordinated by federal, state and provincial government agencies in the two countries. In 1987 the governments of Canada and the United States made a commitment, as part of the Great Lakes Water Quality Agreement (GLWQA), to develop a Lakewide Management Plan for the Great Lakes. The LaMP unites a network of stakeholders in actions to restore and protect the Lake Erie ecosystem.

Participating countries: Canada, United States of America

Level/Type of Collaboration: Official/Environmental program

Principal Issue: Joint management, water quality

Date: 1987

Source: http://www.epa.gov/glnpo/lakesuperior/lamp2000/

Tijuana

EPA project: Border 2012

This is a 10-year, binational, results-oriented environmental program for the U.S.-Mexico border region. The Border 2012 Program is the latest multi-year, binational planning effort to be implemented under the La Paz Agreement and succeeds Border XXI, a five-year program that ended in 2000.

Participating countries: Mexico, United States of America

Level/Type of Collaboration: Official/Social-health program and environmental program

Principal Issue: Joint management, water quality

Date: 2002-2012

Source: http://www.epa.gov/usmexicoborder/index.htm

SCERP project: Cultural Ecology and the Indigenous Landscape of the Tijuana River Watershed

This project seeks to document traditional knowledge and management of the environment within the larger context of ethno historic and prehistoric patterns of environmental management in the TRW, and to transfer this information into forms that will make it useful for participating tribal communities, institutions serving these communities and binational planning efforts.

Participating countries: Mexico, United States of America

Level/Type of Collaboration: Non-official/International initiative, social / health program

Principal Issue: Other: research and education

Date: Start: 2004; ongoing

Source: http://www.scerp.org/scerp/projs/04rpts/NR-04-4.htm

Institute for Regional Studies of the California's project: The Binational Tijuana River Watershed

This project is a series of related subprojects, some of which have been ongoing for a number of years, while others are in the beginning phases. The long-term purpose of the project is to support efforts to develop a binational watershed management plan

Participating countries: Mexico, United States of America

Level/Type of Collaboration: Non-official/Environmental program

Principal Issue: Other: research and education

Date: Start: 1996; ongoing.

Source: http://www-rohan.sdsu.edu/~irsc/research.htm

Appendix 3. Tenders for Large Projects

Columbia

Black Rock Dam

If constructed, it would siphon millions of gallons from the Columbia River and pipe it into a downward-sloping valley between Yakima and the Tri-Cities, potentially staving off a Yakima Basin water crisis. Water would flood the bunchgrass and balsamroot until a new, 10-mile reservoir was formed. The whole thing would be caged by a mile-long, 595-foot-high dam.

Country: United States of America
Sector: Flood control, water supply
Cost in millions (USD): $1.8 billion
Status: Early study phase (by BLM)
Sponsors: BLM
Source: http://www.waterconserve.info/articles/reader.asp?linkid=28158

Mississippi

Olmsted Dam

The Olmsted Locks and Dam on the Ohio River will replace the deteriorating Locks and Dam 52 and 53 on the stretch of commercial navigation in the inland waterways.

Country: United States of America
Sector: Navigation
Cost in millions (USD): US $564 Million
Status: Completion 2012
Sponsors: U.S. Army Corps of Engineers
Source: http://www.house.gov/shimkus/prolmsteddamproject.htm

Eastmain-1

A main dam across the Eastmain River, 14 km east of the powerhouse, will be constructed, along with thirty-three dikes to close off the reservoir. At its maximum level, the reservoir will encompass an area of about 603 km^2; its annual drawdown will be limited to approximately 9 m. The maximum and minimum reservoir levels will be 283 m and 274 m, respectively.

Country: United States of America
Sector: Energy/hydropower generation
Cost in millions (USD): Data not available
Status: Under construction.
Sponsors: U.S. Army Corps of EngineersHydro Quebec
Source: http://www.hydroquebec.com/eastmain1/en/index.html

St. Lawrence

Mercier Generating Station

Construction of a surface hydroelectric generating station immediately downstream from Mercier dam on the Gatineau River. With a capacity of 50.5 MW, Mercier generating station will generate 282 GWh per year. Mercier dam, built in 1926-1927, will also undergo an overall rehabilitation.

Country: Canada
Sector: Energy/hydropower generation
Cost in millions (USD): $140
Status: Completion: Spring 2006.
Sponsors: U.S. Army Corps of EngineersHydro QuebecData not available
Source: http://www.hydroquebec.com/projects/index.html

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Water skier, Columbia River basin, Oregon. Photo credit: Heidi Powell.