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The Law of Transboundary Aquifers, introduced to the United Nations General Assembly in December 2008, encourages nations to make multilateral arrangements for the proper management of transboundary aquifers.

This study seeks to answer the question: “What are the main challenges for successful collaboration in assessing and managing Transboundary Aquifer Systems (TAS) in North America?” The study follows an analytical assessment of four different aquifers in the area: the Santa Cruz River Aquifer, the Chateauguay River Aquifer, the Memphis Sand Aquifer, and the Snake Valley groundwater development project. Each case was analyzed to determine the sources of conflict, and the challenges that impede successful collaboration. The study found that asymmetries in institutions, values, goals, and power are common in the area, and they hinder the collaboration process. Assessment and management of TAS in North America is characterized by a lack of agreement on the conceptual models and characterization of the aquifers. This failure to collaborate on assessing the TAS is a fueled by conflicting goals, lack of incentives to cooperate, and a fear of compromise. A collaborative conceptual model can reduced the uncertainties associated with groundwater. If the aquifer States can reach an agreement on the conceptual model of the aquifer; they can manage it independently in accordance with the principles of the Law of Transboundary Aquifers.

Collaborative Assessment and Management of Transboundary Aquifers in North America

by

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I understand that my thesis will become part of the permanent collection of the Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Pablo Alvarez Tostado Delgado, Author

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1. Introduction

1.1. Research problem and context

Water fills pores, cracks and fractures underneath the earth's surface; this water is referred to as groundwater or ground water. At different levels, groundwater exists throughout the planet. Groundwater has been an important source of drinking and irrigation water for thousands of years. Humans have intensively exploited groundwater, especially over the past 60 years, with the advent of high capacity pumping technology. A technical understanding of aquifers has evolved with computer technology and numerical models that simulate groundwater flow.

Groundwater is, by nature, a complex and mysterious natural resource. Uncertainty is inherent to the understanding and interpretation of aquifers. In addition, the political boundaries that overlay aquifers further complicate the assessment process. Without understanding the conditions of the aquifer, such as quantity and recharge, it is impossible to adequately manage it.

Groundwater represents 0.5 percent of the world's water. This number by itself would make the importance of groundwater seem small. However, looking at the representation (Figure 1) of the freshwater available in the world, it is clear that groundwater is the premier source of water available for human consumption. Furthermore, groundwater is the most extracted natural resource (Shah 2008; Zekster and Everett 2008). Humans have extracted groundwater for thousands of years. Today, around fifty percent of the world's population relies on groundwater to meet its drinking water needs.

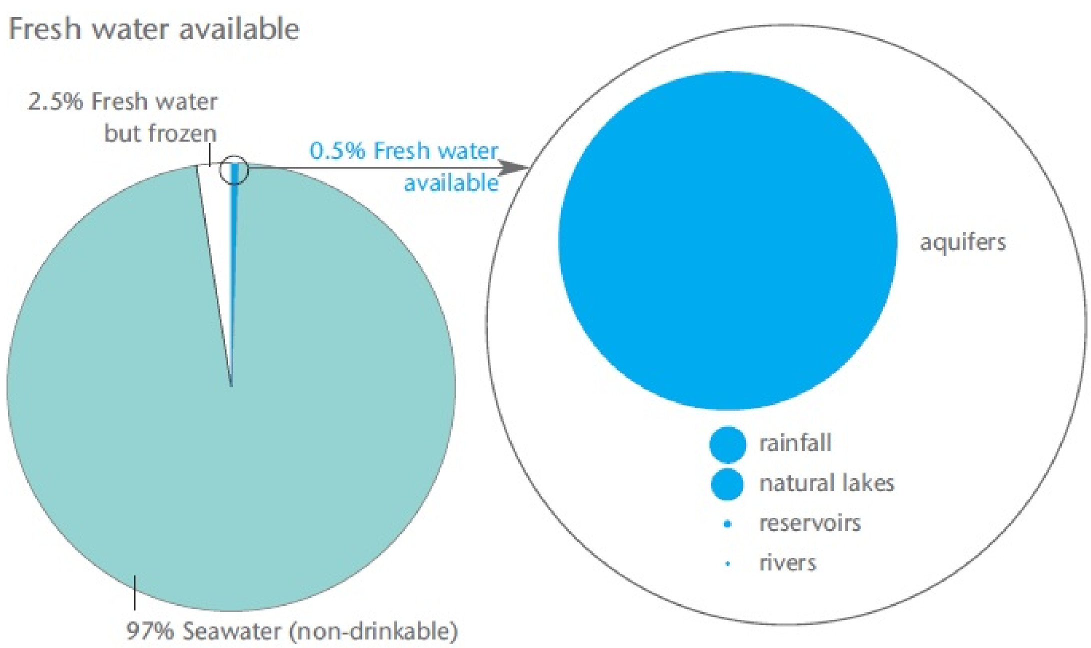

Figure 1 Freshwater of the world (Fry, Haden, and Martin 2006)

Computer models and numerical models are powerful tools that allow the analysis and understanding of aquifers. However, groundwater systems are inherently hidden and uncertainty in characterizing them remains. In order to assess the groundwater availability of the aquifer, data is required from all the aquifer, not only one side of the border.

Water is one natural resource whose management is especially susceptible to uncertainties, many of which are being exasperated by climate change. Some of these uncertainties originate from knowledge deficits in physical conditions while others relate to behavioral and social variability related to water supply and use. However, to my knowledge no quantitative analysis of how uncertainties have been translated into transboundary water treaty structures exists.

Uncertainty is inherent to groundwater; different types of uncertainty undermine the process of understanding and interpretation of aquifers. In addition, the political boundaries that overlay aquifers further complicate the assessment process. Hydrological needs are further complicated by political considerations (Jarvis 2010); the physical aspect of a Transboundary Aquifer System (TAS) makes it difficult for one country to assess the aquifer without data collection on the other side of the border. Hence, collaboration is required when assessing a TAS.

Without understanding the conditions of the aquifer, such as quantity and recharge it is impossible to adequately manage it (Giordano 2009). Assessment is the method of characterizing an aquifer, and identifying its physical properties. The hydro-geological model of the aquifer identifies the hydrological conditions. The conceptual model can be used to conduct a groundwater availability assessment. Traditional management practices are based on the concept of safe yield, the notion that a development is sustainable if it is less than the recharge. However, Sophocleous points out that the temporality of groundwater systems reaching a new equilibrium can take a long time, maybe even millions of years (Sophocleous 2012). Thus, Bredehoeft states that the change in recharge due to a development is difficult or even impossible to quantify (Bredehoeft 1997). More modern practices of sustainability have replaced safe yield, with 'sustainable yield'. The difference between the two approaches is that sustainable yield takes into consideration the negative effects and changes produced by a development (Lavigne et al. 2012).

Surface and groundwater that cross international boundaries present increased challenges to effective water management, because hydrologic needs can often be overwhelmed by political considerations. While the potential for paralyzing disputes are especially high in these types of basins, history shows that water can catalyze dialogue and cooperation, even between especially contentious entities that share subterranean resources. Moreover, as we move from thinking about rights to thinking in terms of equitably sharing “baskets” of benefits, the opportunities of cooperation become palpable (Jarvis et al. 2005).

There are at least 276 basins (UNESCO 2013), and 445 aquifers (ISARM 2012), which cross the political boundaries of two or more countries. International basins cover 45.3 percent of the land surface of the earth, affect about 40 percent of the world’s population, and account for approximately 80 percent of global river flow. There is a connection between groundwater and surface water. Managing these basins is complicated by the involvement of regional politics, in an already difficult task of understanding and managing complex natural systems.

Disparities (economic development, infrastructural capacity, political orientation, etc) between riparian nations further complicate international water resources management. The result is that development projects, treaties, and institutions are regularly perceived as ranging from inefficient to ineffective, to even causing new tensions themselves. Yet, despite these tensions inherent to the international setting, riparians have engaged in preventive diplomacy, and created “baskets of benefits” leading to positive-sum, integrative allocations of joint gains.

The United Nations adopted Resolution A/RES/63/124 in December 2011 (U.N. 2013); called the “Law of Transboundary Aquifers” the resolution encourages nations to make multilateral arrangements for the proper management of transboundary aquifers.

With multiple transboundary aquifers, North America presents a challenge for both counties and states that share the benefits and responsibilities of managing the aquifer. It is within the spirit of the United Nations resolution that this study seeks to answer the question: “What are the main challenges for successful collaboration in assessing and managing Transboundary Aquifer Systems in North America?”

In order to answer the question this study conducted an analytical assessment of four different aquifers: the Santa Cruz River Aquifer shared between Mexico and the US, the Chateauguay River Aquifer shared between the US and Canada, the Memphis Sand Aquifer shared between the States of Tennessee and Mississippi, and the Snake Valley groundwater development project shared between the States of Utah and Nevada.

1.2.TAS of North America

There are 17 international transboundary aquifers in North America (Table 1).

Table 1 International Transboundary Aquifers of North America (ISARM 2009)

North America International TAS		
1N	Abbotsford-Sumas	Canada-USA
2N	Okanagan-Osoyoos	
3N	Grand Forks	
4N	Poplar	
5N	Estevan	
6N	Northern Great Plains	
7N	Chateauguay	
8N	San Diego-Tijuana	Mexico-USA
9N	Cuenca Baja del Rio Colorado	
10N	Sonoyta-Pápagos	
11N	Nogales	
12N	Santa Cruz	
13N	San Pedro	
14N	Consejos Médanos-Bolsón de la Mesilla	
15N	Bolsón del Hueco- Valle de Juárez	
16N	Edwards-Trinity-El Burro	
17N	Cuenca Baja del Río Bravo/ Grande	

Also, TAS are not limited to the international frame; interstate aquifers are a common occurrence. In the United States there are several interstate aquifers; the aquifers of the United States are represented in Figure 2. It is common in the literature to find a distinction between international and domestic transboundary aquifers (Campana, Neir, and Klise 2007); unlike those articles I included both international and domestic aquifers in this study.

With the goal of representing a wide spectrum of conflict and cooperation situations I chose aquifers involving the three countries that form part of North America; Canada, Mexico, and the United States. To identify the challenges facing assessment and management of TAS in North America I selected four case studies; two international and two interstate aquifers. The selection of the four cases was looking to get a variety of conditions, relationships, power dynamics, goals, interests, etc. For the two interstate cases I selected aquifers from the east and west of the United States.

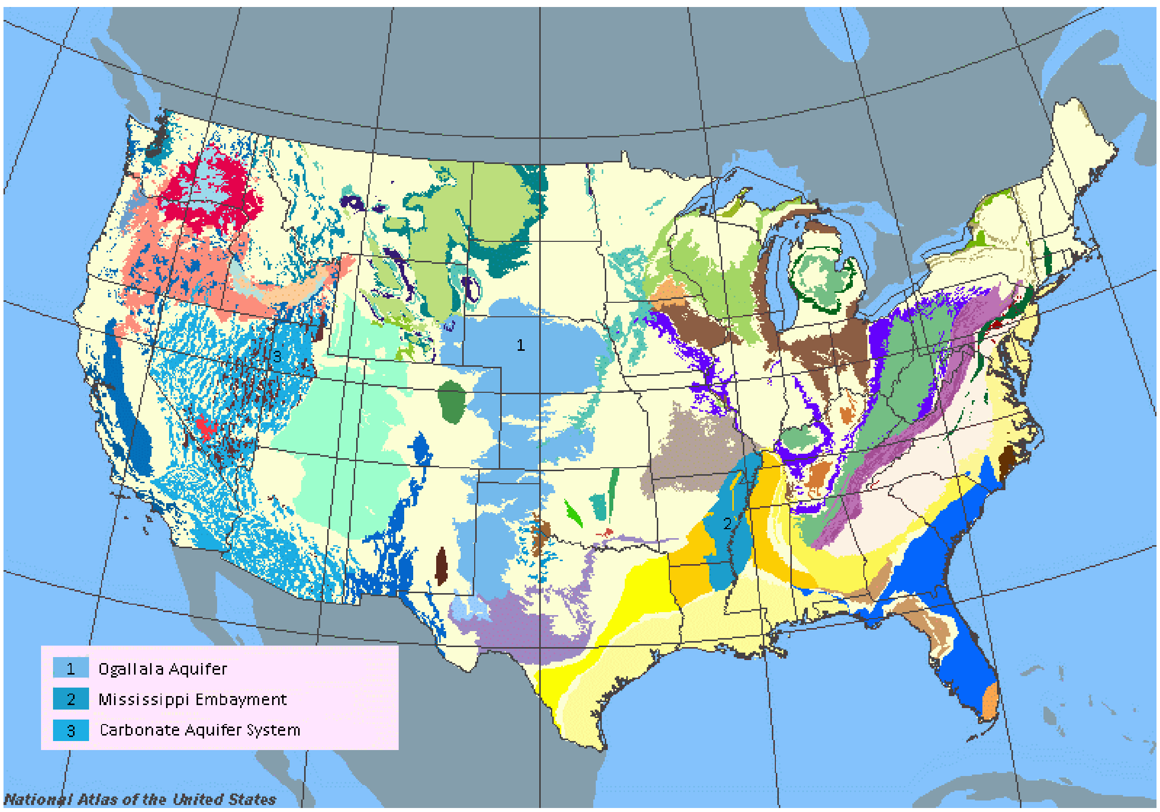

Figure 2 Aquifers of the United States (United States Department of the Interior 2013)

For the international cases I decided to analyze aquifers that have some common ground, but that involved different countries. The first case is the Santa Cruz River Aquifer; its waters are shared by the United States and Mexico. The Chateauguay River Aquifer is a TAS common to Canada and the United States.

The Santa Cruz River Aquifer and the Chateauguay River Aquifer have some aspects that make the comparison between both cases interesting. They are both situated in North America, and the United States is a co-aquifarian in both cases. Additionally, the Chateauguay River Aquifer was recently assessed in a collaboration effort by the Geological Survey of Canada and the US Geological Survey (USGS).

The Santa Cruz and San Pedro aquifers are shared by the Mexican state of Sonora and the US state of Arizona. The Transboundary Aquifer Assessment Program (TAAP) was signed in 2006, it establishes a US federal agency- university partnership collaborative effort (Megdal et al. 2010). However, Mexico and the United States have different interpretations of the conceptual model of the aquifer (Milman and Ray 2011), thus creating conflict.

The Canadian province of Quebec and the state of New York share the Chateauguay River Aquifer. The Geological Survey of Canada and the USGS conducted a hydrogeological study of the aquifer (Nastev et al. 2008). Understanding the hydrogeology is fundamental to managing and aquifer (Morin, Williams, and Nastev 2009).

The Memphis Sand Aquifer, or “Sparta” as it is known in the US state of Mississippi (“Mississippi”), spans a subterranean area beneath northwest Mississippi and the western part of the US state of Tennessee. Both state sovereigns separately own and control the valuable aquifer waters within their borders. Neither state has dominion over the other’s water resources. Mississippi and Tennessee were “apportioned” or allocated their discrete respective shares of the aquifer groundwater upon attaining statehood, a fundamental attribute of sovereignty acknowledged and respected by both states.

In the arid region of the western US, the competition for water is exemplified by the Carbonate Aquifer that underlines the US states of Utah, Nevada, Oregon, and Idaho. The Snake Valley is one of the many surface watersheds that overlie the Carbonate Aquifer, and the area has been targeted by the Southern Nevada Water Authority (SNWA) as one of the solutions to the water supply of Las Vegas. A contentious battle has been fought between these two aquifer States since the project was introduced in the late 1980s.

1.3. Conflict and Cooperation

Conflict over natural resources is a common occurrence; people have always competed for the resources they desire (Buckles and Rusnak 2005). And, competition over scarce resources that people need, want, or value leads to struggle (Coser 1956).

Collaboration is also common, and the Basins at Risk study (BAR) by Wolf et al has demonstrated that when two countries interact over transboundary water they collaborate (Wolf, Yoffe, and Giordano 2003) in more cases than not. However, not all conflict is bad and not all collaboration is good (Zeitoun and Mirumachi 2008). The outcome of some of the collaborations is not equitable, and a treaty does not resolve all the issues.

This study looks at both conflict and collaboration; by focusing on the notion of a "successful collaboration". In order to answer the research question it is important to identify what constitutes a "successful collaboration". This study focuses on collaboration of both assessment and management of TAS.

Firstly the study focused on the assessment portion of the aquifer; a successful collaboration will allow the aquifer States to generate a conceptual model that represents the aquifer as accurately as possible. The data and methods for this physical assessment of the aquifer need to be collaboration between the different parties, and they must believe that the model represents the aquifer. Collaboration over management cannot occur if the aquifer States do not have a common understanding of the TAS.

The Law of Transboundary Aquifers takes into consideration the recognition of sovereignty of countries over natural resources. However, signing countries relinquish absolute sovereignty over ground water (U.N. 2009), as they agree to make reasonable and equitable use of the aquifer (Eckstein 2011b); taking into consideration the sustainability of the resource and the long-term maximization of the benefits. Evaluating a successful collaborative managing strategy is not a simple task; this study does not look at the management strategy in specific, but at the notion that there is a management plan that takes into consideration the general principles of the Law of Transboundary Aquifers. Successfully managing an aquifer allows all aquifer States to make reasonable and equitable use of the resource with a long term view and a focus on sustainability.

Understanding that cooperation is unique to each TAS (Jagerkog and Zeitoun 2009), and that challenges and solutions in one case may be different from another, lessons from positive and negative cases can be analyzed and in some cases applied to other aquifers. This study presents the identification of the principal challenges facing assessment and management of TAS in North America.

1.4.Objectives

The goal of this study was to analyze the challenges facing assessment and management of TAS in North America. The use of four case studies provides a look at different obstacles faced in aquifers throughout the area. Looking at the literature, and pertinent information for each case the objectives of this research are as follows:

1. Assess the role of asymmetry in institutions, power, values, and goals in assessment and management of TAS in North America.
2. Identify the challenges facing collaboration in assessing and managing TAS in North America.
3. Compare collaboration efforts and identify successful practices.
4. Determine possible collaboration scenarios.

Based on the case study approach of this study the first objective is addressed case by case throughout Chapter 3. After the individual cases are analyzed a discussion of the sub-continental challenges is discussed in Chapter 4.

1.5.Significance and Justification of Research

Groundwater is the largest source of freshwater available in the world; almost 50 percent of the population relies on groundwater to meet their basic needs. Transboundary water has been the source of many studies and papers for a long time. Yet, groundwater has been ignored in transboundary water law (Lopez-Gunn and Jarvis 2009; Zeitoun and Mirumachi 2008; Bruce 2011), and most of the treaties regarding transboundary waters do not contemplate aquifers. Furthermore, the Law of Transboundary Aquifers was signed less than five years ago, Eckstein says TAS has mostly been ignored, treated as the 'neglected stepchild of international law' (Eckstein 2011b).

It is rare to find in the scientific publications papers that focus on the collaboration aspects on TAS. The inclusion of concepts like power, and values follow the spirit of the Law of Transboundary Aquifers, and the results could be very useful for the international community.

Additionally, it is common for papers to center on areas with high conflict and significant water stress. I believe contemplating both two cases where water is scarce and two where it is not presents a unique view of North America TAS.

The use of case studies provides a good way to analyze different aquifer systems in North America.

2. Methods & Materials

In order to analyze, and dissect each of the case studies a theoretical assessment framework is required. To develop a complete understanding of the conflict situation I used an analytical model that allows the analysis of different components of the conflict independently in a clear way. It is also important that the results are presented in a way that allows comparison between the case studies.

An analytical framework was used to study the problem, looking at ideological, institutional, and social construction issues. Literary review was conducted to determine current views and positions of diverse agencies. Also, a case study method was used to analyze both existing models of collaboration. In order to understand, analyze, and compare the four case studies a specific analytical framework was developed as part of this study.

The assessment framework looks at different aspects of the problems and allows for analysis and comparison of the four case studies. The assessment framework is a mix of social and conflict assessment. The social assessment allows for analysis of a particular political and social issue, like the assessment and management of TAS. The conflict assessment incorporates the study of the dynamics of conflict (Daniels and Walker 2001). The main aspects that need to be considered are: context, institutions, power, values, and goals (Figure 3).

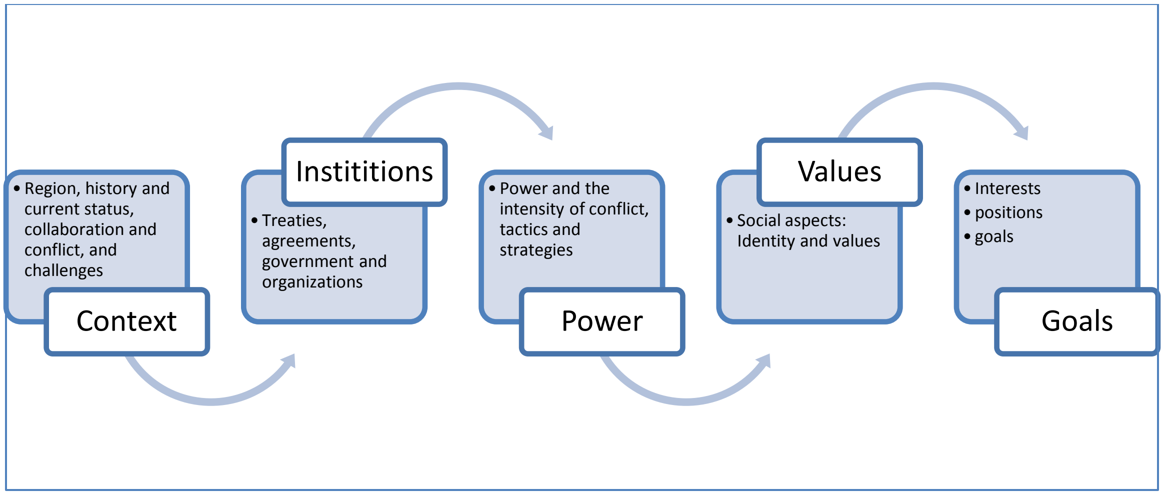

Figure 3 Conflict Assessment Framework

Assessment of the situation needs to be done in accordance to a framework that organizes the topics and foments the structured gathering of information and analysis. The model must include attention to the characteristics of the conflict, parties, goals, tactics, etc. As Carpenter and Kennedy stated a "thorough understanding" of a situation is fundamental in order to device an effective and long lasting management plan (Carpenter and Kennedy 1998). Diagnosing the causes of conflict and assessing the situation requires a broad approach that looks at multidisciplinary nature of the conflict; this allows one to develop collaborative systems (Delli Priscoli and Wolf 2009). Originally developed by Moore, the circle of conflict is a model that categorizes the causes of a conflict situation as a way of understanding the underlying issues at the bottom of the conflict (Moore and Kemp 1988). The circle of conflict is an analytical tool to understand a conflict situation according to the sources of the conflict (Moore and Delli Priscoli

1985).The elements shown by Delli Priscoli and Moore are fundamental to the analysis of a conflict situation; however, the circle of conflict is not a formal assessment tool. The circle of conflict (Figure 4) demonstrates five distinct sources of conflict; value, data, structural, relationship and interest (Moore and Delli Priscoli 1985). Multiple adaptations from the circle have been made, some have identified a sixth source: identity (Jarvis and Wolf 2010). Conflicts change over time –and– the sources of conflict are not definite.

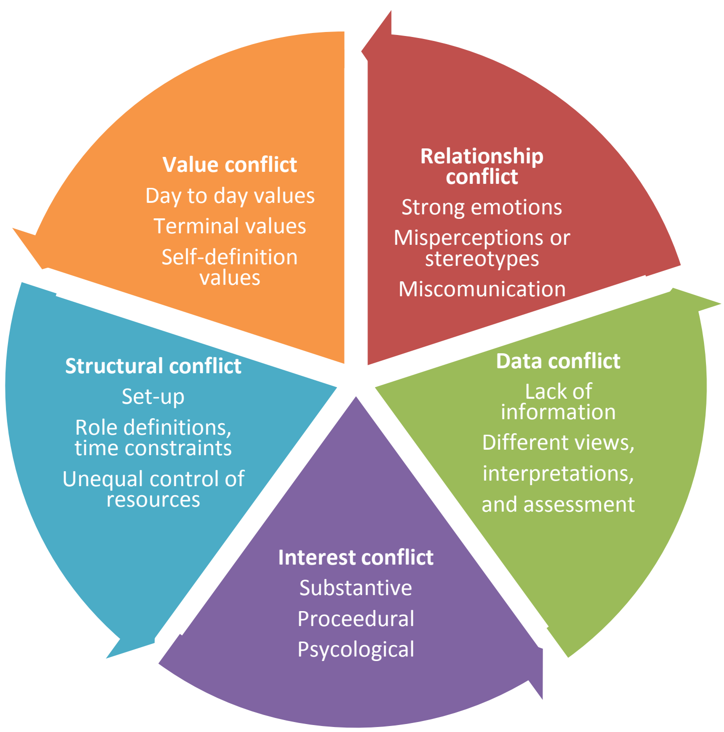

Figure 4 Circle of Conflict Adapted from (Delli Priscoli and Wolf 2009)

Interest conflicts can deal with substantive, procedural or psychological issues. These are caused by physical resources, perceptions of trust and fairness, and the specific set-up of the conflict situation. Structural conflicts relate to a specific issue, and deal with the substance of a conflict itself, whether it is a natural resource issue, like water; or economic, etc. Relationship conflicts are usually related to negative feelings, emotions, mistrust and other problems between the parties. Data conflicts are due to the lack of information, misinformation, or incompatible data between the parties.

Data plays a fundamental role of water management; more so in the case of groundwater. Assessment of aquifers provides the scientific information needed to make sound water management decisions. Uncertainty is a part of groundwater assessment, and even though numerical models and computer technology have made modeling complex systems easier, hydrology is not an exact science and, it is open to different opinions and interpretations.

Social values of water and visions can influence management practices, the notion of safe yield, and have a role in the assessment of an aquifer (Milman and Ray 2011). Groundwater assessment is especially subject to interpretation, conflicting views derived from diverse value systems can lead to the ‘dueling expert’ syndrome (Jarvis 2010; Wilson 2004; Bracken 2010), where each side defends their models, methods, and findings instead of looking critically at all the information. Data conflicts in the context of TAS are related directly to the assessment of the aquifer; it is a fundamental issue to every TAS. Furthermore, if there is collaboration in assessing the TAS, there is no data conflict. Hence, for this study, data conflicts are not analyzed as a source of conflict, but as a symptom of failed collaboration.

Regardless of the original source of conflict, the situation may develop additional sources of conflict. In the case of water, identity issues almost always are at the root of the problems (Rothman 1997). When analyzing a problem, and the boundary of a conflict is expanded to include moral and sociopolitical issues, the issue becomes a wicked problem –with diverse values for individuals and groups and– without an overriding social theory, there is no way to determine who is right or wrong (Shindler et al. 1999). A wicked problem is one to which there is no solution due to incomplete, contradictory, changing elements (Shindler et al. 1999). Wolf and Delli Priscoli state that through regional thinking and collaborative conflict resolution these kinds of problems can be successfully managed (Delli Priscoli and Wolf 2009). They elaborate that water can be a unifying element that can bring people together.

Common pool resources are characterized by having an open access nature, and it is difficult to exclude or regulate use of the resource. In addition, the utilization of the resource diminishes the availability to others. This is the case with groundwater, where anyone with the capability to drill a well can access the aquifer, without others knowing that the resource is being extracted. In his classic article Hardin calls the "tragedy of the commons" to the catastrophic management of the common pool resource (Hardin 1968), where the users lack the capability of self-regulation, and lead to the depletion of the resource. There are multiple authors who argued and presented cases that show that the 'tragedy of the commons' is not a prophecy, and does not affect every case of a common pool resource (Ostrom et al. 1999; Giordano 2009; Martin 2012) . Van Vugt

(2009)identifies four conditions for successful management of a shared resource –like groundwater: information, institutions, identity, and incentives.

2.1.Context

Understanding the basic conditions of a conflict is the first step in analyzing a situation. The context serves to paint a picture of the area, the demand for water, the physical characteristics, and the challenges that the aquifer States and the region experience. In the context I also analyzed: the history of the aquifer, the uses and concerns of both countries; and a chronological description of the resource, management practices, and the current plans for exploitation and conservation.

The initial step of the assessment allows the identification the following:

- Aquifer basics
- Location
- Climate
- Uses of groundwater
- Collaborative/conflict history
- Management plans and practices
- Triggering events

2.2.Institutions

Institutions are the norms, regulations and agencies that govern collective action. Whether they are formal or informal, they provide guidelines for behavior and use of the common resource. In the case of a TAS the institutions can be bi-national agencies, treaties, minutes, property rights, as well as other regulations and customs that regulate groundwater. Institutions are one of the most important aspects of TAS analysis.

Institutions present a way for ideologies to formalize themselves into the legal structure of society, social norms or common sense. Property is both an institution and a concept. In time the notions of concept and institution influence each other (MacPherson 1978). Property rights and the ownership of water are a basic aspect of the situation.

This step of the assessment looks at the existing institutions that regulate the common resource, as well as the independent use, assessment, and management of groundwater, such as: treaties, rules, and regulations that govern the aquifer. The analysis of the governmental agencies that manage the resource in each state is looked at independently, and a comparison between the aquifer States is used to look for symmetry and challenges.

Since water has been a source of conflict at the borders for many years, there are many existing institutions already in place that deal with transboundary issues; their effectiveness, range, and limitations need to be studied in order to understand the situation. This section seeks to identify and clarify the following aspects:

- Parties
- Treaties
- Regulations
- Agencies
- Symmetry

2.3. Power

Power is not one of the sources of conflict identified by Moore (Moore and Delli Priscoli 1985); however, it is one of the most decisive aspects of conflict. In most cases the power differential between the parties leads to advantages and control of the situation by the hegemonic party (Zeitoun and Warner 2006a). Dahl says that it is through power that a someone makes something they would not do otherwise; power is a relationship that leads to one party taking control of the situation (Dahl 2006).

There are two basic dimensions of power. The first one refers to force; the capability of mobilizing economic, military, political pressure, etc. It is the way in which the powerful can impose harm or pressure to subdue others into compliance. The second dimension is a more subtle form, by controlling the regulations and the way the relationship works, the 'rules of the game'. It can also lead to the non powerful party (or parties) agreeing with what the hegemonic party wants and they do not. These two dimensions of power also relate to the concepts of hard and soft power. Hard power is exercised through brute force methods, is a way to make others do what the hegemonic power wants them to do. On the other hand, soft power uses tactics of control and focuses in making others want what the powerful party wants (Warner, Zeitoun, and Mirumachi 2013).

Zeitoun and Warner developed a framework for analyzing power differential in transboundary water interactions (Zeitoun and Warner 2006a). The framework takes two fundamental elements: intensity of conflict, and power and joins them in their 'hydro-hegemony' framework to analyze how 'hydro-hegemony' is used to manipulate cooperation and decide water allocation.

The framework has the following elements:

- Form of hydro-hegemony: positive (leadership), negative (dominative), and flux
- Control strategy: integration, resource capture (containment)

- Interaction: shared control (cooperation), consolidated control (competition), and contested control (competition)
- Distribution of water: equitable, inequitable, (distribution uncertain)
- Conflict: no conflict, cold conflict, violent conflict
- Intensity scale from the BAR study scale from 7 to -7

The BAR intensity scale for events relating to transboundary waters has the parameters identified in Table 2 (Wolf, Yoffe, and Giordano 2003).

Table 2 Water Event BAR scale, adapted from (Wolf, Yoffe, and Giordano 2003)

Scale	Event Description
7	Voluntary unification into one nation
6	Major strategic alliance (International Freshwater/ aquifer Treaty*)
5	Military, economic or strategic support (Shared management of the aquifer*)
4	Non-military, economic, technological or industrial agreement. Legal cooperative actions(assessment of aquifer*)
3	Cultural or scientific support. Agreements to set up cooperative working groups
2	Official verbal support of goals, values, or regime (Agreement reached, not signed*)
1	Minor official exchanges, talks or policy expressions- mild verbal support
0	Neutral or non-significant acts for the inter-nation situation
-1	Mild verbal expressions displaying discord in interaction
-2	Strong official verbal expressions displaying hostility in interaction
-3	Diplomatic-economic hostile actions (lawsuit*)
-4	Political-military hostile actions
-5	Small scale military acts
-6	Extensive war acts causing deaths, dislocation or high strategic costs
-7	Formal declaration of war

Both ends of the BAR scale are not represented in any of the four case studies I selected; hence, I will only represent the values from 6 to -3 that are somehow represented in the chosen North American aquifers.

This section of the framework is used to analyze the following aspects of the interactions between aquifer States as they relate to assessment and management of the TAS:

- How power plays out
- Are the parties with equal or different levels of power?
- What kind of power differential, economic, military, legal?
- Tactics
- Hierarchy
- Hegemonic tactics
- Counter tactics

2.4. Values (Values and Identity & ideology)

The next step of the assessment framework will be to look at the social aspects of the situation. The values, identity, and ideology of the people on both sides of the border, and to identify how this affects water management.

Values are the beliefs of what is right or wrong, and what is important to both an individual and a society. Value conflicts arise from incompatible values of what is right, ethical or moral. As values are important and close to the core of a society, these conflicts are commonly very heated and personal.

Ideologies are a social phenomenon that takes experience and everyday notions to elaborate intellectual doctrines of the consciousness of social actors and the institutionalized thought –systems and discourses of a society (Therborn 1980). It refers to the dimension of the human condition with which people make sense of their lives under specific political and economic conditions. Ideologies are not individual ideas;

they are chained and linked as clusters. Thus, multiple ideological formations are present in any society.

This part of the assessment identifies the social component of the aquifer. The relationship between society and water is complex. Linton expressed the connections between humans and water as altering, and redefined the traditional hydrological cycle to reflect the human component that is attached to it; he established a relationship and called it the hydrosocial cycle (Linton 2011). Even though the original notion of the hydrosocial cycle reflects a different concept, the merger of the social and physical aspects of water is fitting. This section analyzes the following issues:

- What does water mean?
- Ownership and water rights
- Ecological implications
- Utilitarian, domain, what kind of view they have?

2.5.Goals

This section of the assessment focuses on the substance of the conflict situation; goals, interests, tactics, and positions of the aquifer States. Interests and positions frame the debate when dealing with a scarce resource. The issues that are at the core of the situation are seen through the lens of interests; the mixture of relationship, interests, values, etc make the aquifer States define a position. There are many advocates and practitioners of interest-based bargaining when dealing with natural resource issues (Delli Priscoli and Wolf 2009).

Goals play a fundamental role in a conflict situation, beyond the issues the process will evolve according to the preferred outcome of the parties. The goals determine the incentives or disincentives of parties to engage in collaboration, negotiation or avoidance. The parties may also have BATNAs, or best alternative to a negotiated agreement (Daniels and Walker 2001; Jarvis and Wolf 2010). Uncertainties in understanding groundwater create a difficulty when attempting to establish goals. In surface transboundary water the status quo usually favors the hydro-hegemon (Zeitoun and Warner 2006b). In the case of groundwater, access and control of the resource are not controlled by the hydro-hegemon. This part of the assessment looks to identify the goals of each county for the management of the resource and the outcome for the conflict. In order to define what and how they approach, I analyzed:

- Positions
- Interests
- Concerns
- Fears
- Goals
- Tactics

2.6. Analysis

The framework distinguishes the specific issues according to a particular category. The assessment of the case studies, following the framework that I developed helps identify the pertinent aspects of each case study. To better understand the issues, an analysis of the framework guided subjects, was used to identifies the challenges faced by the aquifer States in order to collaborate on assessing and managing the aquifer.

3. Results

This chapter contains the four cases looked at through the assessment framework.

3.1. Santa Cruz River Aquifer

The first case study I selected was the Santa Cruz River Aquifer. Shared by the United States and Mexico, the Santa Cruz presents an interesting case; communities in Arizona and Sonora rely on groundwater for agricultural, urban, and other water uses. The aquifer is not the subject of any treaties, and even though there has been talks and some collaboration among the aquifer Sates or they both have contrasting conceptual models of the aquifer (Milman and Ray 2011).

3.1.1. Context

The Santa Cruz and San Pedro aquifers (Figure 5) are shared by the Mexican state of Sonora and the US state of Arizona. Both the Santa Cruz and the San Pedro rivers are tributaries of the Colorado. The Santa Cruz River is a peculiar case, as it originates in the United States, goes south into Mexican territory, and then it goes back into the United States, where it merges with the Gila River, which later flows into the Colorado River. In addition, the waters of the Santa Cruz and the San Pedro rivers are not mentioned in the treaty between Mexico and the US that regulates surface transboundary waters (Kelly and Contreras 2003).

The Santa Cruz River has a mostly seasonal flow that responds to rainfall events and snowmelt. Flow from the Nogales International Wastewater Treatment Plant (NIWTP), operated by the International Boundary and Water Commission (IBWC) contributes to the base flow of the Santa Cruz River (Megdal et al. 2010). The Santa Cruz and San Pedro aquifers are adjoining transboundary aquifers, of regional relevance, but not big enough to have an impact at the national level.

The region possesses a semiarid climate, with hot summers. Rains occur mostly in the summer months (mostly July and August) (Luege Tamargo et al. 2010), when close to 50 percent of the yearly precipitation occurs. The total precipitation for the region ranges between 0.28 and 0.44m per year. Temperatures above 32˚C are common from May through September. Drought is a common occurrence in the region; last year pumping was suspended in January in the Santa Cruz and adjacent basins in order to evaluate the levels, and plan accordingly (Horcasitas 2012).

Groundwater provides drinking water for the cities in the area, as well as irrigation on both sides of the border. In Arizona the population is predominantly rural, with small developments and a population of fewer than 30,000 people. Rangeland comprises most of the area in Arizona. Agricultural land and irrigated acreage started to decrease in the mid 1970s. Contrastingly the city of Nogales Sonora has over one quarter of a million habitants (Milman and Scott 2010). The cities of Ambos Nogales rely on the Santa Cruz River Aquifer for about 50 percent of their water supply (Mumme 2000).

Figure 5 Santa Cruz River Aquifer and San Pedro Aquifer (Megdal and Scott 2011)

Rapid growth and economic development started in the 1960s, and with the signing of the North America Free Trade Agreement (NAFTA), the city of Nogales, Sonora has experienced increased growth and development with many factories opening during the past decades.

Groundwater quality is also a problem for the Santa Cruz River Aquifer. The United States Geologic Survey (USGS) found in a study of the Upper Santa Cruz Basin several samples with levels exceeding the Federal or State water-quality standards for arsenic, fluoride, nitrates, iron, and dissolved solids (Coes et al. 2002).

The Transboundary Aquifer Assessment Program (TAAP) was signed in 2006, and a federal agency- university partnership leads a collaborative effort (Megdal et al. 2010) on the United States side of the border. However, Mexico and the United States have different interpretations of the conceptual model of the aquifer (Milman and Ray 2011), thus creating conflict.

Recalling the Law of Transboundary Aquifers, the UN encourages nations to make multilateral arrangements for the proper management of transboundary aquifers. Discussions in the conferences of the International Shared Aquifer Resources Management (ISARM) program look for ways to promote cooperation. The ideas of “shared vision”, collaborative assessment and management, and “sharing the benefits” are often discussed and promoted within these conferences, between professionals, and in TAAP. However, the United States and Mexico have yet to come with a shared vision, and to maintain their own practices of water resource management.

There are significant problems facing the area of the Upper Santa Cruz River Basin (USCRB), not all of them relating directly with the Santa Cruz River Aquifer. The Nogales

Wash is one of the sources of water for the city of Nogales Sonora, and faces major contamination issues due to industrial discharge. The city has turned to the Los Alisos Aquifer in order to increase its water supply.

3.1.2. Institutions

The United States and Mexico have different ways of managing groundwater. In the U.S. the management is responsibility of the states, while in Mexico groundwater is managed by the National Water Commission (CONAGUA). In the United States groundwater management is responsibility of each state.

With a border of 3142km, almost two thirds of it lined by the Bravo River, the management of transboundary waters between the United States and Mexico has always been an important issue. In 1848 with the signing of the Treaty of Guadalupe Hidalgo following the Mexican-American War, the United States obtained ownership of Upper California, and a vast territory that encompasses Arizona, New Mexico, Utah, Nevada, and parts of Colorado and Wyoming. The treaty also defined the boundary line with Texas at the Rio Grande. Surveying and maps were commissioned after the treaty, which outlined the boundary, and demarcate the new border.

The Gadsden Purchase of 1853 gave the US a territory south of the Gila River, from the Colorado River all the way to El Paso, Texas (Figure 6). This was the last adjustment to the border between Mexico and the US. It was at this time that the Santa Cruz River and aquifer becomes a transboundary basin. The border was surveyed from El Paso to the Pacific Ocean between 1891 and 1894.

There is a long history between the US and Mexico regarding water; transboundary water between the two countries is regulated by the treaty of 1944, called “Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande”. The treaty and protocol were signed in 1944 and ratified by both countries the following year. The Rio Grande (Río Bravo) and the Colorado River were referred to in the 1848 treaty as ’for navigation only’. The 1944 treaty regulates how the waters may be used for additional purposes. The treaty allots water from the Rio Grande, the Colorado River, and the Tijuana River (USA and Mexico 1944). The treaty also specifies flood control, some water quality issues, as well as sharing of information and collaboration principles; yet, it does not address groundwater.

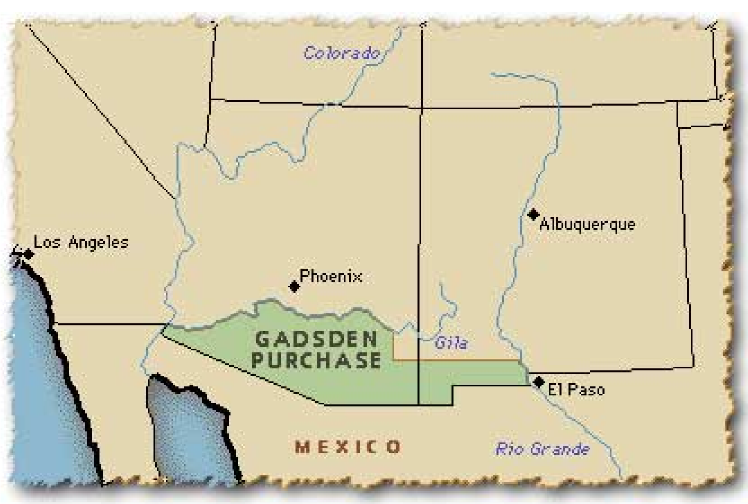

Figure 6 Gadsden Purchase (City of Mesilla 2013)

Long before the treaty was signed, the IBWC was formed. The IBWC has been helping deal with transboundary water issues for 125 years. The IBWC has two separate and independent sections, one for each country; the Mexican agency is called the Comisión Internacional de Límites y Aguas (CILA). The mission of the IBWC is to provide solutions to issues of ownership of waters, quality, flood control, sanitation, and boundary demarcation in the application of treaties in the border region (IBWC 2013). The IBWC also serves as a diplomatic liaison in additional accords or agreements in water and border issues.

Additional issues have been managed by minutes; there are eight notable minutes dealing mostly with quality issues that have been issued between 1973 and today. There was a problem with the quality of the water from the Colorado River that was being allocated to Mexico, as per the 1944 treaty; the water had high levels of salinity. This problem became apparent in 1961 and started a lengthy conflict regarding how to reduce the salinity of the water of the Colorado River that is allotted to Mexico. The solution to the problem was finally agreed upon in Minute 242 in 1973. The minute is the first official document between the countries to talk about groundwater. Even when not addressing the problem, it talks about the importance of groundwater, and the desire of both countries in working together:

> *"Pending the Conclusion by the Governments of the United States and Mexico of a comprehensive agreement on groundwater in the border areas… "and "With the objective of avoiding future problems the United States and Mexico shall consult with each other prior to undertaking any new development of either surface or groundwater resources…"*(International Boundary and Water Commission 1973, 3).

Limits to pumping groundwater in the border area of San Luis Rio Colorado was addressed in Minute 242 to reduce the groundwater flow from the United States into Mexico, and to dilute the salinity of the water allocation from the Colorado River. Nevertheless, 30 years after the signing of the Minute 242 there have not been any significant steps to address groundwater (Mumme 2000). Furthermore, Minute 242 remains the only bi-national agreement between Mexico and the US to directly addressing groundwater.

Another problem of the 1944 treaty is the lack of consideration of climate and drought affects. The allotment of water that Mexico receives from the Colorado River is always the same. The fixed quota has been a source of tension between the two countries. In the US there appears to be and agreement that Mexico should get an adjusted quantity of water in years where water is scarce (Sánchez-Rodríguez and Mumme 2010; Cooley et al. 2009; Jones 2009). In Mexico on the other hand, the 1.85 billion cubic meters per year of water that the United States must give Mexico from the Colorado River is seen as sacred.

Last year the United States and Mexico agreed on a deal that reduces the amount of water Mexico receives from the Colorado River in dry years. It gives Mexico the possibility to store water on Lake Mead (Ritter 2012). The deal was reached after an earthquake damaged irrigation canals in Mexico. The deal also allows the United States to buy water from Mexico, which will use the money to repair the concrete lining of the canal. Framing is an important issue, as there is not mention in the literature of additional allocation of water to Mexico during wet years.

Historically Arizona has relied heavily on groundwater, pumping at ‘unsustainable’ yields; declining water tables lead to the Arizona Department of Water Resources (ADWR) establishment of five Active Management Areas (AMA). The AMA establishes management rules for the aquifer, such as permitting, monitoring, restrictions on new irrigation and development, as well as annual use and reporting. For the Santa Cruz AMA the goal is to maintain safe-yield, and maintain the riparian areas, preventing a decrease in the water table (Arizona Department of Water Resources 2005). The AMAs face significant challenges in both monitoring and enforcing restrictions and metered pumping; the limited funding available is being reduced or in some cases eliminated all together. Managing groundwater is a complicated issue, and it took several years to see results and to stop the decline on the water table.

The United States Congress passed in 2006 the United States-Mexico Transboundary Assessment Act; the act calls on the Secretary of Interior for to establish the TAAP (U.S. House of Representatives 2005). The TAAP applies to the states of Texas, New Mexico, and Arizona, where four aquifers have been identified as priority for assessment. The aquifers of Hueco Bolson, San Pedro, Santa Cruz, and Mesilla are the four aquifers targeted by TAAP. Two of those four aquifers are shared by Arizona and Sonora, among them the Santa Cruz River Aquifer. TAAP establishes a group of collaboration between the Secretary, states, institutes, and other entities (both domestic and foreign) with the goal of characterizing, mapping and model the specific aquifers. The program is directed at both quantity and quality issues of the aquifer. The program allows funding for 10 years, and a total amount of 50 million dollars (TAAP 2011).

The portion of the TAAP that deals with the Santa Cruz and San Pedro Aquifers is called the TAAP-A/S; it is a collaborative process between the USGS, Water Resource Research Center (WRRC), University of Arizona, and the Udall Center for Public Studies. Stakeholder groups from both countries contribute in setting priorities and putting issues on the agenda.

The collaboration lead by TAAP-A/S involves the IBWC and CILA, along with the Bureau of Reclamation, the Arizona Department of Water Resources, the City of Nogales, the Friends of the Santa Cruz, the Upper San Pedro Partnership, CONAGUA, the Sonora Water Commission, the University of Sonora, the Technological Institute of Sonora, and the OOMAPAS-Nogales (Organismo Operador de Agua Potable y Alcantarillado-Nogales). The TAAP has established means of communication, and has led to data sharing and limited shared data collection; there has been progress made, but not a breakthrough that leads to the assessment of the Santa Cruz River Aquifer (Milman and Ray 2011).

Along with Canada, Mexico and the United States signed the North America Free Trade Agreement (NAFTA). Campana, Neir, and Klise (2007)argue that NAFTA could provide a way to regulate groundwater. NAFTA regulates the transfer of water in Chapter 11; the provisions treat water as having an intrinsic value, and do not look at water as a commodity with an economic value. It can be seen more as a neighborly interaction than a market regulation (Forest 2012).

NAFTA's Chapter 11 establishes the right of foreign investors to gain the same rights as domestic users once water is removed from its natural state. This has lead to claims from private businesses to governments over enforcement of policies designed to protect natural resources or public health. In 2004 a Texan group of landowners referred to Chapter 11 in claims against Mexico, claiming failure to release the allotted water from the Rio Grande (Kibel and Schutz 2007). There is a prevision in Chapter 11 that allows the government to make the necessary provisions to preserve the quality and quantity of the water source (Forest 2012).

3.1.3. Power

Historically, there has been a power imbalance between Mexico and the United States that relates directly to TAS. As outlined in previous sections, the border that divides the two countries today was forged in 1848 and modified later in 1953. In 1848 as part of the armistice of the Mexican-American War, Mexico was forced to sell more than half of its territory to the United States. In the United States, the territory associated with the Treaty of Guadalupe Hidalgo is referred to as the Mexican Cession. This is a clear example of hard power, with military and financial tactics involved. Meanwhile in the Gadsden Purchase of 1853, which is the latest modification to the border line between the two countries, the United States again displayed its economic power. The United Sates wanted the land south of the Gila River, to build a railroad to the Pacific Ocean.

Through the Gadsden Purchase the United States acquired about 76,800 km^2 for 10 million dollars. This amount is significantly more (almost thirteen times the dollars per square kilometer) than the 15 million dollars they paid Mexico for 1.4 million km^2 five years earlier.

The relationship between the two North American neighbors has been one of closeness from afar. There has been cooperation over many important issues, and a strong commercial partnership. The United States has always looked for ways to influence Mexican politics, sometimes through direct diplomatic intervention, sometimes through soft power tactics. In the early days of the Mexican revolution (1911) it is said that Porfirio Diaz (Mexican president for almost 30 years) said "Poor Mexico, so far from God, so close to the United States"; the quote reflects the sentiment of wariness that in many Mexicans to this day lives on. There is also a counter view that sees the United States as a strong country an example and a powerful ally.

Even though the era of the Mexican-American war is long gone, and the relationships between the two countries are cordial, the relationship between the two neighbors is not one between equals. There is a significant power difference in the Santa Cruz. The United States is one of the most powerful nations in the world, a military, economic and political giant. On the other side Mexico is a developing nation with a good overall standing in the world economy, but with much more limited economic development. Mexico is the 14th economy in the world based on its Gross Domestic Product (GDP), but it occupies the 62nd place in GDP per capita. On the other hand the United States occupies the 1st place in GDP. And, even though they also have a disparity in GDP per capita, where they drop to the 9th spot, they are still a powerful and economically developed nation.

In the case of the Santa Cruz River Aquifer, power tactics can be seen in the lack of action by CONAGUA. The Santa Cruz River Aquifer provides about 30 percent of the water for Nogales Arizona (Prichard et al. 2004). The hydro-hegemony framework was used to analyze the power aspects of the Santa Cruz Aquifer (Table 3).

Table 3 Hydro-Hegemony assessment of the Santa Cruz River Aquifer

*Bi-national collaboration does not include groundwater

<table>
<tr><th>Form of hydro-hegemony</th><th>Main Water Control Strategy</th><th>Form of Interaction</th><th>Potential Distribution of Water</th><th>Form of Conflict</th><th>BAR</th><th>Events</th></tr>
<tr><td rowspan="10">Mixed, leadership and soft power tactics</td><td rowspan="6">Independent extraction, no control strategy</td><td rowspan="6">Independent control (some cooperation)</td><td rowspan="10">No distribution</td><td rowspan="10">Stable with potential for conflict</td><td>6</td><td>1944 Treaty*</td></tr>
<tr><td>5</td><td></td></tr>
<tr><td>4</td><td>1973 Minute 242*, 1994 NAFTA*</td></tr>
<tr><td>3</td><td>2006- TAAP</td></tr>
<tr><td>2</td><td></td></tr>
<tr><td>1</td><td></td></tr>
<tr><td rowspan="4">Resource capture, containment</td><td rowspan="4">Consolidated Control (competition)</td><td>0</td><td></td></tr>
<tr><td>-1</td><td></td></tr>
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<tr><td>-3</td><td></td></tr>
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The assessments of the TAS commissioned by CONAGUA show availability of water for development, more than 30,283 cubic meter per day (Luege Tamargo et al. 2010). Yet, in the 1990s they developed the Acuaférico project to bring water from the neighboring Los Alisos Aquifer; Los Alisos Aquifer is not a TAS. The Acuaférico was developed with funding from the North America Development Bank (NADB); a grant from the Mexican government was needed to complete the development of the project (Fernandez and Carson 2002).

3.1.4. Values

In Mexico the richness of the land (natural resources) belongs to the people; this notion is part of the identity of every Mexican (Cámara de Diputados del H. Congreso de la Union 1917). Mexico was the first country to recognize social values, such as property and water rights at the constitutional level (Romero Reséndiz 2000). The exploitation of natural resources had been conducted with foreign capital in Mexico from the birth of the country and up to following years of the revolution. The Mexican constitution of 1917, in its Article 27, gave the legal framework to revise the concessions made to foreign countries and companies. A transition to national ownership followed, with a climax in 1938 with oil expropriation. Several modifications to Article 27 have been made, including a fundamental change in 1993 to facilitate the signing of NAFTA; however the notion of national ownership has not changed in the minds of the Mexican people.

In Arizona, water rights are associated with property rights. Arizona follows the prior appropriation doctrine for water allocation. The prior appropriation doctrine takes into consideration the seniority of the water use. The first user to appropriate water and put it into a beneficial use has the right and priority over other users. If there is water available additional claims can be made; nonetheless, in case of scarcity the older (senior) water right holder has priority over the water. The right to use water is associated with the ownership of the land. In Arizona groundwater is seen as the common property of the landowners (right holders). In Mexico they are the common property of the people. On the United States there is a value and sense of ownership of water, it is seen as a personal right (my water, not our water).

In the management of water in the United States and Mexico people are a priority; the riparian vegetation is non essential. This is the shared view for people on both sides of the border. But, while it is view shared by some in the United States, it is a general sentiment on the Mexican side. Natural resources are seen in Mexico as the only thing that people have. The leader of the Confederación Nacional de Campesinos (CNC), Mexico's main agricultures association, Francisco Porras Medrano calls water "our only heritage" (OOSKAnews 2012). There is a disconnection between the people of Mexico and its government, a lack of trust that the government will act in the best interest of the people.

The values of the Mexican people and the fear of compromise of their authorities with international and domestic interests is represented in popular culture. Singer Oscar Chavez writes in his song "Se Vende Mi Pais" (my country is (being) sold): "Its mountains and its rivers are sold… the only thing I had that it was mine…it's sold to the foreign and to the gringo". The reference to foreign and in particular US interests reflects a widely accepted notion among sectors of the Mexican population.

3.1.5. Goals

Water management objectives and waters use in the Santa Cruz River Basin are independent and distinct between the United States and Mexico. A compilation of visions and goals (Table 4) illustrates the commonalities, as well as highlights the differences.

Table 4 Vision and Goals in the Santa Cruz River Aquifer adapted from (Milman 2009)

	Visions	**Goals**
Arizona	General well-being of residents	Maintain Health, economy and services
	Economic growth and urbanization	Subdivide, develop and sell land
	Preserve way of life/ historic ranching lifestyle	Continue agricultural practices
	Preserve the character of the community	Maintain open space and aesthetic of the community
	Maintain aesthetic environment and protect ecosystems	Protect riparian ecosystems
Sonora	General well-being of residents	Extend and improve quality of existing water supply
	Economic growth and development	Maintain the growth with the area, with development of basic services

The need for the existing and the growing population on the Mexican side of the border put a huge amount of pressure on the OOMPAS-Nogales, the Sonora Water Commission, and CONAGUA to provide potable water. Water service is intermittent through most of Nogales Arizona, and there is a large number of people who lack water service altogether; upgrades in the water supply would provide improved way of living to a population in need (Fernandez and Carson 2002). A limited water supply with a ban on the Santa Cruz River Aquifer, and an aging a leaking infrastructure are a burden too heavy to overcome. Before the Acuaféico project, the losses in the Nogales water distribution system were estimated as high as 50 percent (Milman 2009). The challenges faced in Sonora are to provide water to the population, to keep up the water supply to the factories, and to promote economic growth.

This is one aspect in where people and government in Mexico agree, the interest and goals for the region are simple, and are mostly consensual. In addition to water quantity, quality is also a source of concern for Mexico. The Nogales Wash, which provides about 23 percent of the water supply to Nogales, does not meet water standards, with pollution from industrial discharge.

On the Arizona side of the border things are a bit more complicated; there are different interests, and a wide array of considerations. There are a number of distinct voices that agree on the social benefit of water, as well as economic development. However, other interests like sustainability, conservation, riparian conservation are part of the conversation as well.

3.1.6. Analysis

The history between the United States and Mexico, as it pertains to transboundary water has been a mix of completion and collaboration. In took almost all of the nineteenth century to set, define, map and mark the borders as they changed with the separation of Texas, the Treaty of Guadalupe, and the Gadsden Purchase. Once the survey and marking of the border was concluded additional boundary issues were dealt originally in a regional way. Little has been done to address groundwater issues between the countries. Forty years after Minute 242, there is still no agreement on transboundary aquifers.

The relationship between Mexico and the United States is characterized by asymmetries. The assessment of the conflict over the Santa Cruz River Aquifer shows asymmetries of institutions, power, values, and goals (Table 5). Every aspect analyzed in this study reflects differences between the countries that difficult successful collaboration in assessing and managing the Santa Cruz River Aquifer.

The institutional asymmetry is an important factor that creates barriers to cooperation, and taxes efforts of collaboration. The centralized control of water in Mexico by CONAGUA creates difficulties when dealing with state organizations in Arizona. These institutional asymmetries make cooperation harder, bureaucracy makes sharing information, data, and even money a daunting task. However, with time and effort the differences in the institutional structure of the aquifer States can be overcome (Megdal et al. 2010; Scott et al. 2008). The TAAP has brought together agencies and institutions from both countries; provided a forum for communication (Megdal et al. 2010; Luege Tamargo et al. 2010)and has helped breach the challenges of the institutional asymmetry.

Another aspect that undermines successful collaboration is the asymmetry of power. The United States have a hegemonic position in the relation with Mexico. The use of political and financial pressure is not uncommon in management practices in the area of Ambos Nogales. Mexico has not lifted a ban on development of the Santa Cruz River

Aquifer, despite having the scientific report that shows the availability of water (Luege Tamargo et al. 2010).

Table 5 Case Assessment- Santa Cruz Aquifer

At a Glance	The Santa Cruz River Aquifer is a highly exploited aquifer; both Arizona and Sonora rely mostly on groundwater. There are conflicting views of the conceptual model of the aquifer and of aquifer use - each country has its own hydrological model; disagreement of the physical conditions and availability of water. Even though there is an open dialogue and there has been cooperation on some scientific information there is still no agreement on a collaborative assessment or management of the aquifer.			
Collaboration:	**Assessment**	NO	**Management**	NO
	Symmetry		**Importance**	
Institutions	Asymmetric		Med	
Power	Asymmetric		Med	
Values	Asymmetric		High	
Goals	Uneven interests, unclear goals		High	
Challenges	Overcoming the asymmetry in values and power Conflicting goals Lack of incentives to collaborate on management BATNAs Reluctance to compromise			

Additionally, all the water that is treated at the NIWTP is released into the US side of the Santa Cruz River, where it flows to the Gila River. Mexico wants some of the water to store underground and recharge the aquifer. Sometimes the hydro-hegemon denies the existence of conflict (Zeitoun and Warner 2006b), in the Santa Cruz River Aquifer both countries do; the discourse between the agencies is of cooperation. Yet, the interpretation of the aquifer from both countries is contradictory (Milman and Ray 2011).

The asymmetry of values between the two countries is a very important aspect, and does not receive as much attention. It is common for all the social aspects to be analyzed together with the interests of each country. However, values and identity are not a part of the agenda in the Santa Cruz River Aquifer (University of Arizona 2013). The asymmetry of goals is another important factor in the Santa Cruz River Aquifer, the clarity and understanding of the interests of each country is somewhat clear. The Mexican side has interests that are consistent from the local, state, and Federal Level (Milman and Scott 2010). In the United Sates, there are many different interests, and vary according to specific groups (Milman 2009).

The uncertainties on the Santa Cruz River Aquifer impede hydro-geological characterization of the aquifer; the lack of understanding of the benefits and risks of cooperation or lack thereof undermine the process as well (Milman and Ray 2011). The human aspect associated with the assessment of the aquifer can be more important than the scientific facts (Drieschova, Fischhendler, and Giordano 2011).

3.2. Chateauguay River Aquifer

The Chateauguay River Aquifer is a case where collaboration between the two aquifer States led to a joint assessment of the aquifer. Residents of both aquifer States rely on groundwater, yet the aquifer is not intensively exploited and there is the possibility for further development. There is not a shared management strategy for the aquifer, but the successful collaboration in assessing the aquifer makes the Chateauguay a case worth studying.

3.2.1. Context

The Canadian province of Quebec and the US state of New York share the Chateauguay River Aquifer (Figure 7). The watershed originates in the mountains in New York, where the Chateauguay Lake lies at an elevation of 399 m above sea level. Lake Chateauguay is located about 32 kilometers south of the US- Canada border, the river of the same name flows north into Canada, where it meanders until it drains into St. Lawrence River at St Louis Lake.

The Chateauguay River Watershed has a total surface of 2543 km^2. Most of the aquifer, 57 percent is in Canada and the remainder is in the US. The Chateauguay River Basin is home to a population of about 215,000 thousand people, most of whom rely on the Chateauguay River Basin for their water supply (Taylor et al. 2013). On the Canadian side groundwater is the only source of water for about 65 percent of the population. Meanwhile US rural communities in the area depend almost entirely on the aquifer. There are over 20,000 wells on the Canadian side of the aquifer. The Chateauguay has a shallow Cambro-Ordovician sedimentary rocks (sandstone, dolomite, limestone, and shale) aquifer, yet, despite abundance of groundwater, recent drought conditions and overexploitation on certain areas has led to water shortages, and created potential for conflict (Nastev et al. 2012).

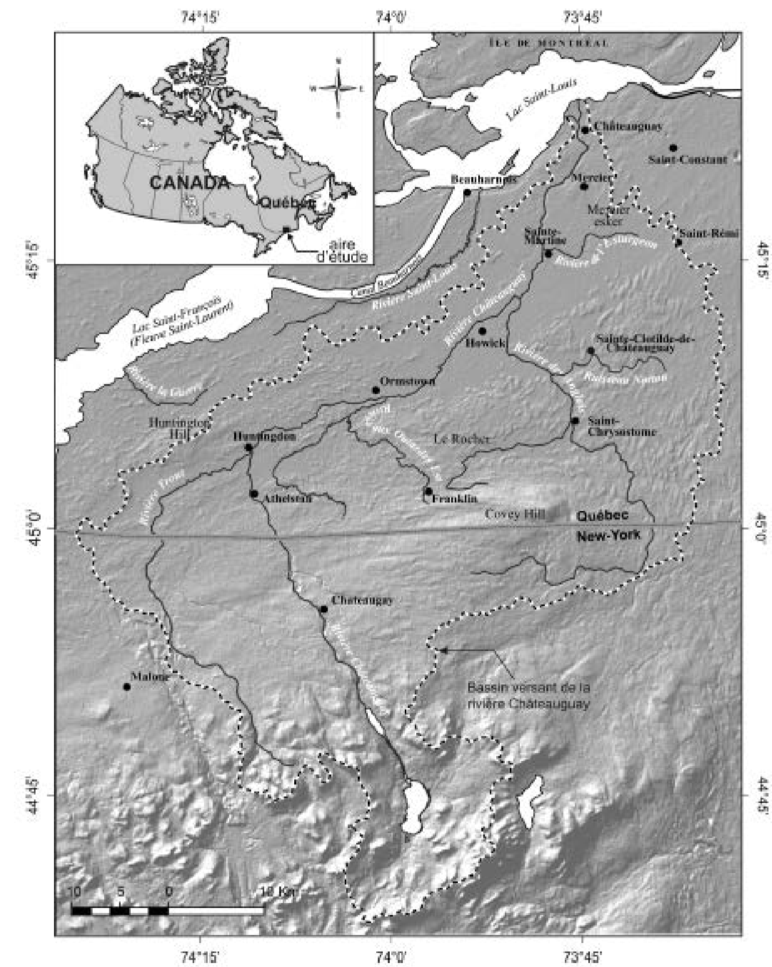

Figure 7 Chateauguay River Aquifer (Nastev et al. 2012)

These problems led the Geological Survey of Canada and the Quebec Ministry of Environment (MENVQ) to promote an assessment of the Chateauguay River Aquifer. The climate in the Chateauguay River Basin is semi-humid; precipitation on the Chateauguay river basin is around 1 m per year, water years in the US run October to September (U.S.G.S. 2009); part of the precipitation, around 0.23m, falls as snow during the winter. The basin experiences hot humid summers with a mean temperature of

22˚C; temperatures of -2˚C and above are not rare. The winters in the Chateauguay River Basin are cold with a mean temperature of -10˚C (Sulis et al. 2012).

Pollution from fertilizers and industrial activity created quality concerns in the 1970s, leading to the closure of wells that used to supply municipalities with water in the northern part of the basin. Throughout the aquifer there are areas of concern for contamination, and groundwater development from the entire aquifer yields elevated hardness levels (Taylor et al. 2013).

The Geological Survey of Canada and the USGS conducted a hydrogeological study of the Chateauguay River Aquifer (Nastev et al. 2008). Understanding the hydrogeology is fundamental to managing an aquifer (Morin, Williams, and Nastev 2009). The current withdrawal of 34 Mm^3/yr the aquifer is estimated to be within the sustainable level, with a potential increase of 14 Mm^3/yr (41 percent) before the drawdown of 2.2m (estimated sustainable drawdown limit) is reached (Lavigne et al. 2012).

3.2.2. Institutions

Canada has a parliamentary system, where the executive branch is derived from the legislative power (parliament). In the US the executive and legislative branches of government are independent. Canada has a highly decentralized approach to water management. It is the only country in the Organization for Economic Co-operation and Development (OECD) that does not have a mandatory federal standard for drinking water. Only four provinces meet the voluntary standards. Nearly one in every four

Canadians depends on groundwater as their only source of drinking water (Bakker and Cook). The existing fragmented management structure is not robust enough to manage large issues, like transboundary water. Water resources and supply are responsibility of the provinces and municipalities. However, the Canadian constitution states that the management of international waters is the responsibility of the state. As most of the issues regarding water are managed at the local level, a fragmented approach persists throughout the country. There is also the problem of lack of coordination between municipalities, i.e. the overlapping and duplication of efforts (Bakker and Cook 2011).

In New York water appropriation follows the riparian doctrine. Groundwater not regulated on comprehensive basis; only the Great Lakes Basin and the Long Island regions have strict regulations for groundwater pumping.

The International Joint Commission (IJC)has been in place for more than 100 years, since the 1909 Boundary Water Treaties was signed (Bakker and Cook 2011). The IJC is charged with preventing and resolving conflict as it pertains to transboundary water and environmental issues. The framework that regulates the IJC's work is focused on six main principles: consultation and consensus building; providing a forum for public participation; engagement of local governments; joint fact-finding; objectivity and independence; and flexibility (International Joint Commission 2000).

Collaboration efforts from multiple agencies in both countries led to the Chateauguay River Hydrogeological (CRH), a study that was conducted between 2003 and 2007 (Nastev and Lamontagne 2012). The project was led by the Geological Survey of Canada, the Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Natural Resources Canada, the Chateauguay Watershed Management Agency, and the U.S. Geological Survey. There were many other agencies and individuals involved in the study as well, providing assistance, expertise, and funding. The results were analyzed by multiple parties during the five year period, with results posted for review on the Natural Resource Canada's website.

Like in the case of the Santa Cruz River Aquifer with the US and Mexico, the US and Canada have also signed NAFTA. There is an extensive history of conflict over bulk transfer of water; in the 1960s a report showed that the city of Detroit, Michigan was pumping 212 billion liters of water from Canada (90m north of the border). The conflict of the Detroit water transfer was settled in 2008, where an exemption from Ontario's Ministry of the Environment allowed Detroit to continue the extraction of groundwater (Bureau of Reclamation 2012). In 2010, the Canadian Minister of Foreign Affairs amended the International Boundary Waters Treaty Act (IBWTA) in order to protect the transboundary waters of Canada, waterways that flow across the border to and from the US. The IBWTA offers protection from bulk removal outside of Canada, the same protection had already been established to lakes (Parliament of Canada 2013). The Chateauguay River is listed in the IBWTA; the act does not specifically talk about aquifers, but it protects all waters under federal jurisdiction.

The CRH study provides a sound understanding of the aquifer that will lead to sound water management practices, with an emphasis on sustainability, preservation, and quality.

3.2.3. Power

The US and Canada share the longest non-militarized border in the world. The relationship between the two countries is a cordial one, with economic ties, trade, and cooperation in water resource issues. Nonetheless, the relationship and cooperation is not free of conflict, as structural, financial, and power asymmetries complicate shared assessment and management. When conflict arises over a transboundary water issue it is seen in Canada as a national issue, while in the US it is often seen as a regional situation. The hydro-hegemony framework for the Chateauguay River Aquifer is represented in Table 6.

Table 6 Hydro-Hegemony assessment of the Chateauguay River Aquifer

Form of hydro-hegemony	Main Water Control Strategy	Form of Interaction	Potential Distribution of Water	Form of Conflict	BAR	Events
None	Integration	Independent control (cooperation)	Equitable	No conflict	6	
					5	
					4	2003 CRH
					3	
					2	
					1	
	Resource capture, containment	Consolidated Control (competition)	Inequitable	Cold conflict	0	
					-1	
					-2	
					-3	

The US and Canada have strong economies, and possess GDP per capita that rank among the top in the world. Information from the World Bank lists Canada's GDP per capita as $52,219, while the US rates close behind with $49,965 (The World Bank 2013); the difference in GDP per capita between the two countries is less than 5 percent . Allan and Mirumachi (2010)sustain that economically developed and industrialized countries, in particular those with similar GDP per capita, can negotiate as equals. Mature and developed economies can compensate other power asymmetries as well, and can enter negotiations where there is no hydro-hegemon.

3.2.4. Values

A survey by Ipsos-Reid conducted in 2010 reveals that the most important natural resource for Canadians is water; water rated above oil and gas among those interviewed (Bruce 2011). This does not imply a unified vision throughout Canada, but rather shows that in a country where water is abundant, people do not take it for granted; the importance that Canadians place on water has been called hydro-nationalism (Forest 2012). Protecting the ownership of the water, and preventing the transfer of water is a priority of Canada.

Basic values are comparable in Canada and the US. The IJC looks to promote solutions within the shared principles and values of the two nations, which the IJC says have been outlined in the Boundary Waters Treaty (International Joint Commission 2000). Basic principles of equality, no interference, pollution, and the right to be heard are identified in the text of the Boundary Waters Treaty, but neither the words ‘values’ or ‘specific values' are mentioned in the text of the agreement.

Social interactions are commonplace, the perceptions and notions of people in border areas are influenced by the close or distant relationship with the neighboring country. “Canada–US borderlands have become places invested with meaning and identity; they have emerged and have been transformed from distinct places separated by a boundary to places where people also co-exist and cooperate across the border”(Forest, 2012, 15).

Lake Champlain is a transboundary lake adjacent to the Chateauguay River Aquifer, just 48 kilometers east of Lake Chateauguay. The IJC operates the Lake Champlain Basin Program, which encourages agreements between New York, Vermont, and Quebec. The Lake Champlain Basin program creates agreements through nonbinding renewable agreements; the use of such agreements bridges differences and institutional asymmetry (Stickney 2008). In a region where a nonbinding agreements can effectively resolve issues amongst riparian neighbors, there does not appear to be a real a conflict over values or identity.

3.2.5. Goals

The general narrative of the IJC centers on the notion of shared interests, identifying the common issues in order to prevent and resolve disputes. There are many interests that are important to both countries, such as maintaining groundwater quality and quantity, joint fact finding, and community involvement and participation. Sustainability is one of the principal concerns in the area, with increased groundwater use the potential for conflict has increased (Lavigne et al. 2012).

Canada is interested in a groundwater management strategy that adheres to four basic principles (Bruce 2011): protection of quality, protection of quantity, and maximization of groundwater's social benefits, and ecosystem viability. However, just like the US, Canada is one of the highest consumers of water per capita in the world (Flaherty, Pacheco-Vega, and Isaac-Renton 2011); the desire to balance and manage the resource is faced against the allocation to meet current and future social benefits.

Local interests reflect differences in the views of multiple stakeholder groups, but there are no significant differences in the overall views held in both nations. In the Chateauguay River Basin there are riparian and upstream conflicts of interests; there is also concern about water quality. However, most of the issues are local issues, without a fundamental national difference between the aquifer States.

3.2.6. Analysis

The US and Canada have a long history of cooperation on issues of transboundary water; the countries have potential for effective cooperation in addressing TAS (Flaherty, Pacheco-Vega, and Isaac-Renton 2011). The assessment of the Chateauguay River Aquifer case highlights some differences and coincidences between the two aquifer States (Table 7).

Table 7 Case Assessment- Chateauguay River Aquifer

At a Glance	The Chateauguay River Aquifer is the primary source of water for irrigators and inhabitants of the basin in New York and Quebec. The aquifer is being used on a sustainable way; however, uneven use and the small thickness of the aquifer have led to localized scarcity and pollution problems.			
Collaboration:	**Assessment**	YES	**Management**	NO
	Symmetry		**Importance**	
Institutions	Symmetric		Med	
Power	Symmetric (GDP per capita)		Med	
Values	Partially symmetric		Low	
Goals	Symmetric		Low	
Challenges	Collaboration on management			

The institutional assessment reveals two similar systems. In the US groundwater management is responsibility of the state. Canada uses a decentralized approach to water management; the provinces/territories are responsible for the management and supply of water, but they 'delegate' to the local level, who they has the same responsibilities (Bakker and Cook 2011). The Canadian Federal government is responsible for overseeing transboundary water issues.

Just like the case of the Santa Cruz River Aquifer, there exists a treaty between the US and Canada that ignores groundwater (Campana, Neir, and Klise 2007). The IJC serves as a liaison between the countries on transboundary water issues, but groundwater is not within their responsibilities (International Joint Commission 2000). There is asymmetry at the institutional level between the US and Canada; however, the two countries were able to navigate them and agree on the need for the CRH.

The US is the most powerful nation in the world; as it would be with any other nation there exists difference between the two aquifer States as it relates to population, economic strength, and power. The asymmetry of power makes Canadians preference to deal with importance issues with the aid of multilateral institutions, like NAFTA (Bakker 2012). The economic difference of the two countries has been diminished over the years, the Canadian economy has been stable and their currency has gained almost a parity with the US currency; a 35 percent change over the last ten years. The economic similarity between the two countries' GDP per capita is an indicator that they can engage in negotiations as equals (Allan and Mirumachi 2010).

As it would be expected, different countries have different value systems; however, there are no significant differences in the values between Canadians and Americans. The social aspects of the relationship do not impede or impact the negotiations between the two aquifer States. The shared values and importance on water are more important than their differences (International Joint Commission 2000).

The US and Canada share the goal of managing the Chateauguay River Aquifer in a sustainable manner; the aquifer States want to understand the best way to deal with the localized problems of groundwater availability of groundwater and pollution in the Chateauguay River Aquifer.

There are differences between the US and Canada as it pertains to water management. However, there are many factors that facilitated the CRH. The collaboration is only an assessment of the aquifer, there is no water allotment or any management decision associated with the CRH. There are no significant asymmetries in the institutional, power, values or goals between the US and Canada.

3.3. Memphis Sand Aquifer

The Memphis Sand Aquifer is located along the Mississippi River, in an area that has plenty of rain; a place where water is not scarce and over allocated. However, even in this type of geographic setting, conflict over water has faced Mississippi and the the City of Memphis, Tennessee in a battle over the groundwater of the Memphis Sand Aquifer. Institutions are stronger on the domestic front than the international front. However, the US Supreme Court has never ruled on a case regarding transboundary (interstate) groundwater much less a case involving a US state versus a municipality; in fact, only a handful of interstate surface water cases have been settled at the highest court in the US.

3.3.1. Context

The region of the tri-state junction of US states of Tennessee, Mississippi, and Arkansas has abundant water. The Mississippi River, the third longest river in North America flows through the area. In addition the surface water of the Mississippi, the area also has a plentiful source of groundwater in the Mississippi Embayment (Figure 8). The Memphis Sand Aquifer or Sparta is an extensive aquifer that crosses multiple state lines; nine states have claim to its waters: Texas, Tennessee, Arkansas, Mississippi, Louisiana, Kentucky, Missouri, Illinois and Alabama (McKee and Hays 2002).

Figure 8 Mississippi Embayment (McKee and Hays 2002)

The Memphis Sand Aquifer is a shallow unconfined aquifer on its edges and a deep confined aquifer in the central area, with depths of up to 340 m. Besides having high availability, the aquifer also possesses high water quality. There are multiple formations and aquifers at different depths in the Mississippi Embayment; a cross section of the region shows the multiple aquifers of the Mississippi Embayment (Figure 9). The Memphis Sand Aquifer is represented in this section as the middle Claiborne aquifer. The middle Claiborne aquifer comprises the Sparta Sand and the Memphis Sand aquifers (U.S.G.S. 2009), and represents what in this paper is called the Memphis Sand Aquifer.

The Memphis Sand Aquifer is mostly confined by layers of marine shelf deposits of clay, mud, shale, and marl (U.S.G.S. 2009).

Memphis and its surrounding area possess a mild climate, with a mean temperature of 17˚C. The temperature rarely goes below 21˚C during the summer. The winters are cold, with low temperatures below the freezing level for about one month of the year. The area gets an average of 1.22 m of rain every year (Brahana and Broshears 2001). Precipitation falls throughout the year with almost every month receiving at least 0.08m of water.

The city of Memphis, Tennessee, located in Shelby County, relies on groundwater from the Memphis Sand Aquifer. Memphis is the biggest city in the world relying entirely on groundwater (Cameron 2009). The Memphis Light, Gas and Water (MLGW) utility company pumps groundwater from the "subterranean treasure" of over 378 billion cubic meters of groundwater stored in the Memphis Sand Aquifer. The utility company pumps 757,000 cubic meter per day from the aquifer (Cameron 2009). The city has a series of pumps near the Mississippi-Tennessee border (about 4 kilometers), all within Tennessee.

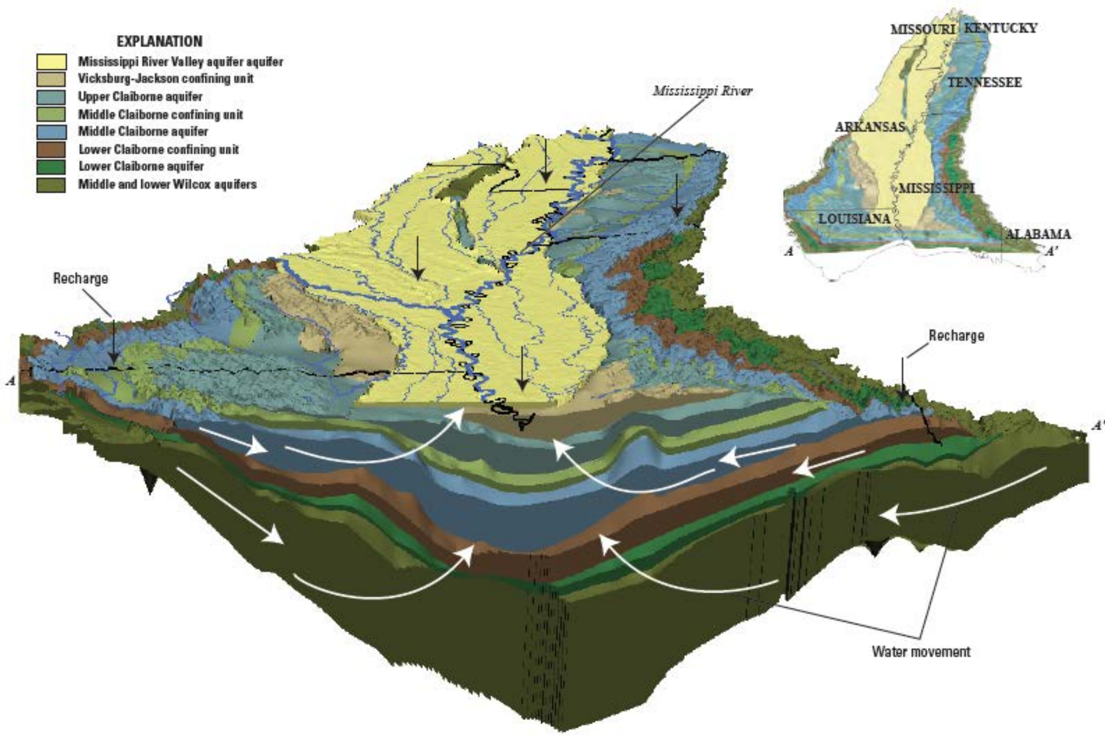

Figure 9 Cross-sectional view of the Mississippi Embayment (Clark, Hart, and Gurdak 2011)

Despite abundant rain and surface water, the quality, ease of access and somewhat predominant geographic accessibility make groundwater a highly valued and used commodity. The water is used in municipal systems like Memphis, yet irrigation is the predominant use of groundwater in the area (Figure 10).

Decreasing groundwater levels in DeSoto County, Mississippi, have been reported. This is associated with the pumping operation of the MLGW going on since the 1960s. Landowners in Mississippi complained about the pumping by the Memphis utility, and said the use was damaging their ability to access the aquifer.

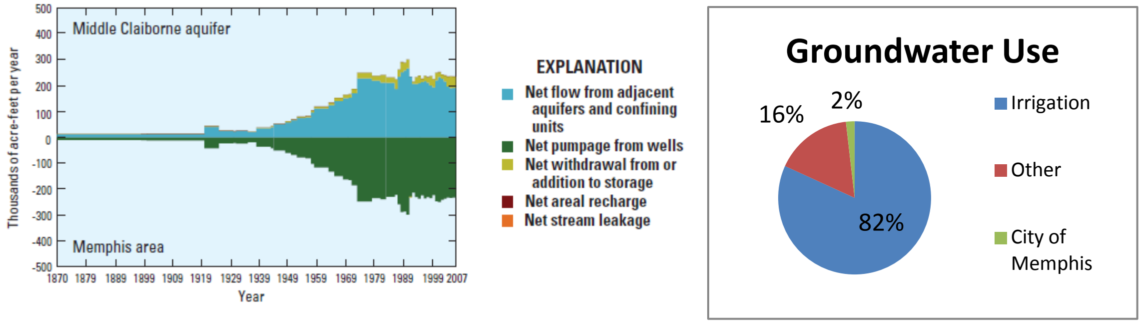

Figure 10 Yearly water pumped from the Memphis area on the Memphis Sand Aquifer (left) (Clark, Hart, and Gurdak 2011) **Groundwater use in the Memphis Sand Aquifer (right)**

In the mid 1990s the Mississippi Department of Environmental Quality (MDEQ), concerned with decreasing water levels, the cone of depression, and the flow of the groundwater wanted to conduct a joint analysis of the aquifer, along with the MLGW. In the letter, Jamie Crawford, Chief of the MDEQ ground water planning branch states that the largest user of Mississippi water is the city of Memphis, Tennessee. Not surprisingly, the MLGW declined to participate (Cameron 2009).

The precipitating event for this conflict is curiously a report done for the environmental Policy Office of Tennessee's Department of Environment and Conservation (Mynatt et al. 2008). The report states that MLGW could be held liable if they were pumping quantities that impair the rights of users in another state (Mississippi) (Feldman and Elmendorf 2000). Furthermore the report states that:

"the outcome might be unfavorable to MLGW and Memphis water users because there is another source, the Mississippi River, and MLGW's current use of the aquifer is not legal or equitable under the laws of either state, nor, probably, under the federal

common law used by the Court in making an apportionment" (Feldman and Elmendorf 2000, 57).

Cameron (2009) argues that the pumping by Memphis has altered the flow of groundwater in the aquifer, and has created the cones of depression (Figure 11).

In June 2005, Jim Hood, the state's Attorney General and the State of Mississippi filed a lawsuit against the City of Memphis and MLGW. The lawsuit mentions Mississippi, Tennessee and Arkansas as the only three US states to share the aquifer. In the suit, Mississippi seeks future and past damages for the wrongful appropriation of groundwater by the city of Memphis (United States Court of Appeals for the Fifth Circuit 2009).

Mississippi based the claim on the water within its borders as a fundamental attribute of statehood (Cameron 2009); it is the same claim that Memphis and the MLGW make, stating that the pumping is within the Tennessee. According to Mississippi, the pumping operation of the MLGW changed the predevelopment of the aquifer, and created a flow of water that moves from Mississippi into Tennessee, and then gets pumped and delivered to the Memphis.

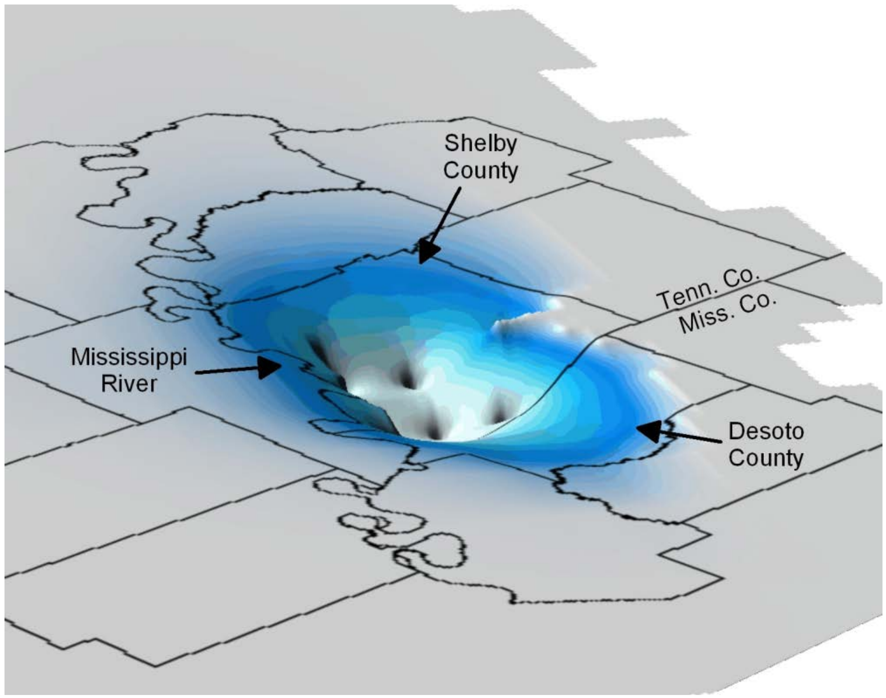

Figure 11 Cones of depression due to MLGW pumping stations in the Memphis Sand Aquifer (Cameron 2009)

3.3.2. Institutions

Mississippi and Tennessee follow the riparian method of water rights; however, they address ownership of groundwater in different ways. The riparian doctrine allows landowners adjacent to water to withdraw and use water. The pure riparian doctrine gives right to the flow of the stream; however, this is not a practical way to manage water, and riparian systems usually allow for "reasonable use" of water (Grigg 2008). Even though the connection between surface and groundwater has long been ignored, the riparian doctrine has been extended to include groundwater allocation. In Tennessee the landowner is the owner of the water, and can access it within the reasonable use principle. Meanwhile, in Mississippi the state is the owner of the resource; there are also reasonable use principles and they also have beneficial use (National Conference of State Legislatures 2013). In the case of the Memphis Sand Aquifer, there is no interstate compact that governs the use of the Memphis Sand Aquifer, and thus no appointment of waters has been established.

In the US, interstate waters can be allocated by two methods: equitable appointment; or an interstate compact. The judicial system has the capability of determine allocation due to equitable use. An interstate compact is an agreement by the states on the use and allotment of water (Hall and Cavataro 2013; Leshy 2008).

The lawsuit between a city and a state is another interesting fact of this case. Mississippi named Memphis and the MLGW in their claim, but did not include Tennessee. Memphis filed a motion to dismiss the claims due to the absence of Tennessee, which they claimed was an indispensable party. After a first motioned by Memphis was rejected, a second motion before the bench trial started in 2008 was granted. Judge Glen H Davidson noted that the aquifer is an interstate body of water, thus, the sovereign interest of the state of Tennessee is involved, and so should be the State of Tennessee (Cameron 2009).

Mississippi appealed the ruling, and argued that equitable appointment of the aquifer is not required, since the ownership of groundwater was granted to the state as a 'self-evident attribute of statehood'. The court explained that in order to determine if Memphis had misappropriated water belonging to Mississippi it would need to know what water belonged to each state (United States Court of Appeals for the Fifth Circuit

2009). The court rejected the lawsuit, stating it had no jurisdiction over the waters of two states.

The claim from Mississippi is based on the water flow of groundwater in the aquifer, had been altered from a predevelopment to a post-development state. Since the pumping of water by MLGW had caused the water to flow from Mississippi into Tennessee, the amount of water that they estimated had been forced into Tennessee was theirs, and thus they should be compensated.

Mississippi appealed the decision with the Fifth Circuit Court of Appeals in New Orleans (Camapana 2013) and the decision was affirmed. The appeals court reiterated the two points made by Judge Davis: Tennessee must be named in the lawsuit and allocation of waters is needed in order to determine ownership and misappropriation (Tauer 2011). Mississippi argued that even if Tennessee needed to be included in the lawsuit it would not limit the court's jurisdiction over the case; when the appeal was dismissed Mississippi presented the case to the Supreme Court. In January 2010, the Supreme Court denied to hear the case, dismissing it without comment or prejudice, which would allow Mississippi to file the case again at a later time (Charlier 2010).

3.3.3. Power

It seems difficult to assess the power differential between two states, or between a state and a city. Power asymmetry is prevalent in every river basin (Allan and Mirumachi 2010). Memphis is the biggest city in the area; with a population of over 1.3 million in the metropolitan area. It is by far the largest metropolis in the area (Figure 12). In any case of urban vs. agricultural use, there is an imbalance of power. Cities have economic power on their side, with the utilitarian view of the “greatest good for the greater number” plays in favor of the city dwellers. The conflict in the Memphis Sand Aquifer escaladed quickly, and many believe without warning, as Arkansas, Tennessee and Mississippi were engaged in conversations regarding the aquifer before Mississippi withdrew and filed the lawsuit (Campana, Neir, and Klise 2007).

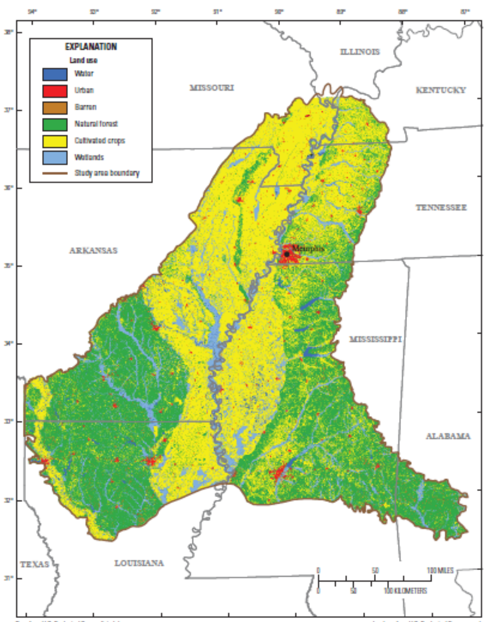

Figure 12 Land use in the Mississippi Embayment (Clark, Hart, and Gurdak 2011)

When two states fight over water there is one factor that can level the ‘playing field’: the Supreme Court. Even though the court did not listen to the Mississippi v. Memphis case, both parties can make their legal arguments with faith in the system. The supreme court can decide a case of an aquifer, as it is legally no different than a river or a lake

(United States Court of Appeals for the Fifth Circuit 2009). The analysis of the Memphis Sand Aquifer using the hydro-hegemony framework is represented in Table 8.

Table 8 Hydro-Hegemony assessment of the Memphis Sand Aquifer

Form of hydro-hegemony	**Main Water Control Strategy**	**Form of Interaction**	**Potential Distribution of Water**	**Form of Conflict**	**BAR**	**Events**
Positive/ Leadership	Integration	Independent control (cooperation)	Equitable	No conflict	6	
					5	
					4	
					3	
					2	
					1	
	Resource capture, containment	Independent Control (competition)	Inequitable	Conflict	0	
					-1	
					-2	
					-3	2005-2010 Lawsuit

3.3.4. Values

Mississippi and Tennessee are both states that form part of what is called the 'bible belt'. The region is known for its adherence to a religious faith, with conservative social values. Memphis has sometimes been referred to as the Protestant Vatican, since the middle of the nineteenth century (Hoskins and University 2009). The population of any state has a mix of values, norms, and identity. However, Birkby once speculated that "It may well be that the population of the State of Tennessee is too homogeneous-socially, religiously and economically…" (Birkby 1966, 11).

DeSoto County has been part of the urban growth of Memphis, multiple cities, like Southaven, Hernando, and Horn Lake, have become bedroom communities. It is hard to distinguish a difference in values between the city and its suburbs. It is also difficult to infer the same values to a city or a state as a whole, but there is no reason to assume that there are significant differences either.

The fact that this is a conflict between a state and a city alludes to a different view and ideas of water management. In contrast to what may be inferred from the lawsuit, the state of Mississippi is the largest user of groundwater in the Mississippi Embayment. Over 80 percent of the water pumped from the Mississippi Embayment is used for irrigation (Clark, Hart, and Gurdak 2011). There are identity based issues in the case of the Memphis Sand Aquifer; the use of the groundwater faces rural and urban users of the resource.

The Memphis Sand Aquifer is the most intensively exploited aquifer within the Mississippi Embayment. Within the Memphis area the majority of the pumping is done by MLGW. The yearly totals (Figure 10) oscillate from year to year, but the 757,000 cubic meters per day pumped by Memphis constitute between 67 and 84 percent of the total water pumped.

The notions of water in the area of the Mississippi River Basin are strong as it relates to the river. Political ideology has led to a focus on transportation along the Mississippi. The use of groundwater is fairly new, with developments starting in the late nineteenth century; a steady increase of groundwater use started in the 1940s. The states along the Mississippi river basin have plenty of water, but are aware of the benefits of groundwater. The quality of the water on the Memphis Sand Aquifer, acquired through many years of natural filtration is a source of pride for the residents of Memphis; city officials say many industries rely on the high quality water. According to Dr. Brian Waldron, Professor of Civil Engineering at the University of Memphis the quality of the groundwater of the Memphis Sand Aquifer is so high, that people want to pump the water of the Memphis Sand Aquifer, load a tanker and take it to China (Waldron, personal communication).

3.3.5. Goals

Mississippi claims it filed the lawsuit to protect the resource for the people of the state; Feldman and Elmendorf (2000) suggested that this could be grounds for litigation against the city of Memphis. Memphis wants to keep their pumping operations and to continue to supply the city with the quality water from the Memphis Sand Aquifer. The financial aspect of the conflict is something that cannot be overlooked or denied. Aside from protecting its water, Mississippi was looking for compensation for the water that MLGW and Memphis have pumped over the years, worth over one billion dollars. In addition to the damages ($980 million to $1.3 billion dollars) covered in the lawsuit, MLGW would require investing several million dollars to treat water from the Mississippi river. The estimated amount of money is based on a calculation of the fair market value of water; using MLGW’s customers’ willingness to pay and the actual retail rates.

Both states believe they have ownership of their water, but look at it with different approaches. Mississippi wants the border to serve as a marker of their resource, and wants compensation for the migrating groundwater. On the other hand, Memphis states that all the water they have pumped is within the limits of Tennessee, their wells are vertical and do not reach into Mississippi (Tauer 2011; Cameron 2009; Charlier 2010).

Memphis, interested in the continued operation of the development, has little incentive to cooperate. Memphis and MLGW's BATNA (Best Alternative to a Negotiated Agreement) is to maintain the status quo; this alternative is not dependent on the court's ruling. Mississippi on the other hand decided that their BATNA was to resort to a lawsuit and seek a legal resolution to the dispute.

3.3.6. Analysis

The analysis of the Memphis Sand Aquifer shows that the dynamics of the conflict are more important than the sources in the assessment and management of the TAS. There are institutional differences between the states (Table 9). Mississippi and Tennessee follow the riparian doctrine of water allocation; yet, the ownership of the water is different on either side of the state line. Nevertheless, the asymmetry of ownership of water does not impact the conflict; Mississippi could still protect the water for its residents if ownership of the water belonged to the landowners (Feldman and Elmendorf 2000).

The analysis of the power does not yield significant differences between the two states. Mississippi has a per capita real GDP of $28,944 (2012), the lowest in the US (U.S. Department of Commerce 2013); Tennessee's per capita GDP is nearly 30 percent higher. The economic difference highlights some economic and social issues between the states. However, there is no indication that the economic difference has any impact in the interaction between the aquifer States.

The way the lawsuit was set up without contemplating Tennessee, and with no previous allotment of groundwater for the aquifer prevented the discussion of the issues. The question of whether Memphis took Mississippi's water was not answered.

Table 9 Case Assessment- Memphis Sand Aquifer

At a Glance	The Memphis Sand Aquifer is extensively used by irrigators in Arkansas, Mississippi, and Tennessee; it is also the sole source of water of Memphis. The pumping operations of MLGW have created cones of depression affecting users in neighboring DeSoto County, Mississippi. Mississippi claims the extraction by Memphis has altered the flow of groundwater, and removed water that belongs to Mississippi. A lawsuit filed by Mississippi against Memphis and MLGW has been dismissed.			
Collaboration:	**Assessment**	YES[1]	**Management**	NO
	Symmetry		**Importance**	
Institutions	Low asymmetry		Med	
Power	Symmetric		Low	
Values	Symmetric		Low	
Goals	Asymmetric		High	
Challenges	Lack of incentives to collaborate BATNAs			

1 There is agreement on the actual conditions of the aquifer; the predevelopment conditions of the aquifer have not been analyzed in detail.

The conflict over the water of the Memphis Sand Aquifer is about management. The assessment of the aquifer, which could have been a fundamental aspect of the situation, was put aside as the conflict was revolving around procedural issues. The hydrological models of the aquifer says that groundwater flows from Mississippi into Tennessee (Cameron 2009; Parks and Carmichael 1990); this fact was never disputed by the parties. Nonetheless, the question of the pre-development conditions is a question still open for debate (Campana 2013). A recent analytical study by Waldron and Larsen (2013) looked to answer that question, they concluded that the amount of water that groundwater flows from Mississippi into Tennessee were higher before development. The issues, values, power and institutions for the most part of this situation did not take part of the lawsuit; therefore, they were not an important part of the conflict. Unless the procedural issues can be resolved Mississippi cannot argue their case. This leaves Memphis and the MLGW removed from liability and with no interest or immediate benefit to engage in negotiations with Mississippi. This does not mean that conflict of interests over the groundwater of the Memphis Sand Aquifer is not an important part of the situation. The competition over the resource and the principle of ownership of the water are the source of this conflict and they must be addressed if the states engage in negotiations over the allotment and management of the TAS.

3.4. Snake Valley Groundwater Development

The Carbonate Aquifer in the Great Basin of the southwestern is located in an arid area with little precipitation. Snake Valley is an intermontane basin that is dissected by the boundary between the states of Utah and Nevada. The SNWA that serves as the principal purveyor of municipal water in the Las Vegas, Nevada area has proposed developing groundwater stored in the Carbonate Aquifer in Snake Valley, as well as adjacent valleys, since the late 1980s. The Snake Valley groundwater development project is an interesting case that deals with interstate and transboundary issues as well as water transfer. The SNWA has applied for water permits on the aquifer, and plans to develop several deep aquifers in eastern Nevada and transfer the water to Las Vegas via a pipeline of 490 kilometers and an estimated cost of $3.22 billion; expressed in 2007 dollars (Bureau of Land Management 2012). In addition, the case of the Snake Valley wellfield and pipeline project is an example of failed collaboration and agreement between two states.

3.4.1. Context

The Snake Valley stretches from North to South along 216 kilometers of the border between Utah and Nevada. The arid region of the valley with some green vegetation areas around the edges is brown and completely dry in the middle (Dubuc 2007). Most of the land in the Snake Valley is publicly owned and managed by the Bureau of Land Management (BLM).

The Snake Valley is one of many valleys that overlie part of a group of regionally extensive carbonate aquifers that covers most of Nevada as well as significant parts of Utah, Oregon, and Idaho. The Basin and Range region is comprised of multiple, individual alluvial basins formed in volcanic and carbonate rocks. The area of the Basin and Range aquifers is the most arid in the US; with potential evapotranspiration losses that surpass precipitation in most of the region. Snake Valley (Figure 13), like most on the eastern part Nevada is underlain fractured and complexly deformed carbonate rock (U.S.G.S. 2009).

Like most of Nevada, the Snake Valley is a desert with arid climate; characterized by high temperatures, scarce precipitation, low humidity, little cloud cover, and with a high night and day temperature differential. With an average precipitation of that ranges from 0.13 to 0.5m, low precipitation near Callao and the higher average on the higher elevations of the Deep Creek Range.

Almost all of the water pumped from the Snake Valley is used for irrigation. For the Utah portion of the aquifer irrigation accounted for 99 percent of the total water use in 2010 (Burden 2012). The area is scarce in population; Baker at the heart of the Valley is home to fewer than 100 people. Most of the water use in the valley comes from pumping the unconfined aquifer that lies on top of the of the deeper carbonate aquifers (Dubuc 2007).

The city of Las Vegas, Nevada is the economic motor that keeps the state going and growing. The city has been growing at a high rate, more than doubling its population in the past 20 years; currently almost six hundred thousand people live in Las Vegas, and almost 2 million people inhabit the metropolitan area of Las Vegas. The city relies mostly on water from the Colorado River, which supplies almost 90 percent of the water to southern Nevada (SNWA 2013). The city takes advantage of "return-flow credits" that allows additional water from the Colorado River on a one-to-one bases, for every cubic meter of treated wastewater they return to the river (Dubuc 2007).

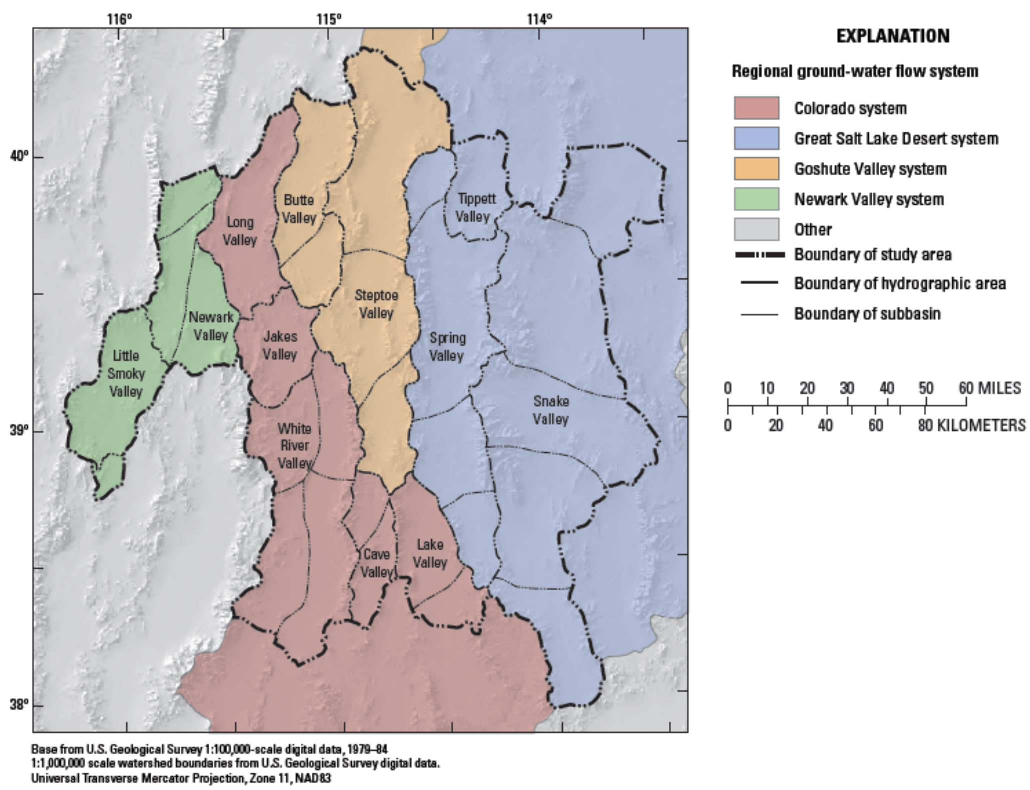

Figure 13 Location of the intermontane valleys and regional water flow systems near Snake Valley (U.S.G.S. 2009)

The Southern Nevada Water Authority (SNWA) is responsible for providing water for the growing desert city; the city is expected to add 1 million habitants by 2028. Facing drought conditions that have seen Lake Mead (the main reservoir for the area) levels drop more than 33 m since 2000, the SNWA has promoted conservation through water efficiency and restrictions. They have also implemented a water banking program, storing water in the Las Vegas Valley Aquifer in wet years (SNWA 2013).

The SNWA, looking for additional ways to provide water to the Las Vegas metropolitan area, is planning to develop groundwater in eastern Nevada, and convey the pumped water south to Las Vegas. In 1989 the Las Vegas Valley Water District (folded into the SNWA) filed 146 applications for water permits with the Nevada State Engineer (Dubuc 2007). The plan (Figure 14) calls for development of SNWA's existing water rights in Spring Valley, Cave Valley, Dry Lake Valley, and Delmar Valley (Southern Nevada Water Authority 2012). Additionally, the SNWA plans to obtain permits for water rights in Lincoln County; including the Snake Valley groundwater development project (456 kilometers north of Las Vegas).

The US Congress drafted the Lincoln County Conservation, Recreation, and Development Act of 2004. The Lincoln County Conservation Act requires that Utah and Nevada draft an agreement to in order to allow any diversion of water ("Utah/ Nevada Snake Valley Agreement"). The SNWA has applied for the permit with Lincoln County for 159,000 cubic meter per day of groundwater, which is one sixth of the water the SNWA gets from the Colorado River (Southern Nevada Water Authority 2012).

The framing of the project has changed over time. Originally viewed as a source for additional water, the SNWA now call the groundwater development a back-up plan if the Colorado River experiences continued drought and the level of Lake Mead continues to decrease (Jenkins 2009). Nevada, receives just a small portion of the waters of the Colorado River (Figure 15).

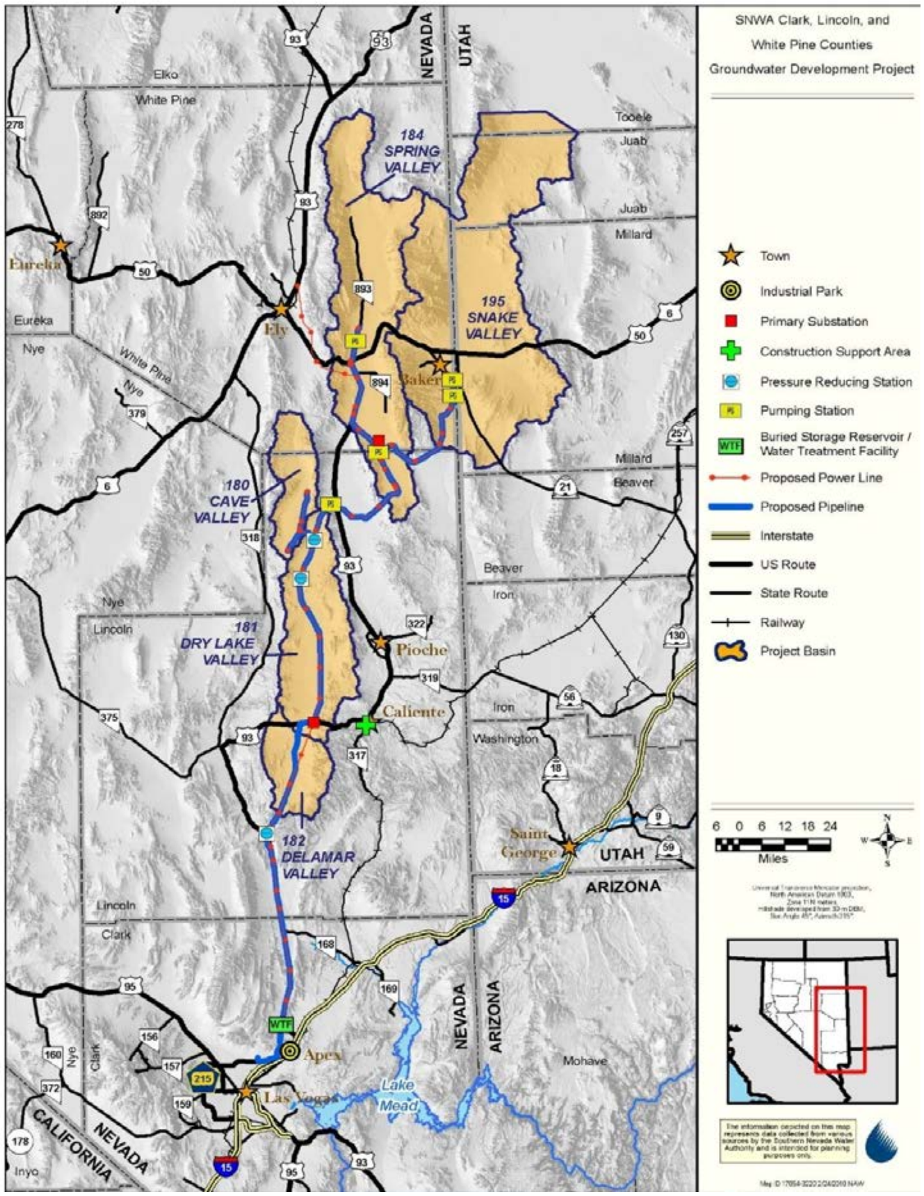

Figure 14 SNWA Proposed Groundwater Development in Eastern Nevada (SNWA 2013)

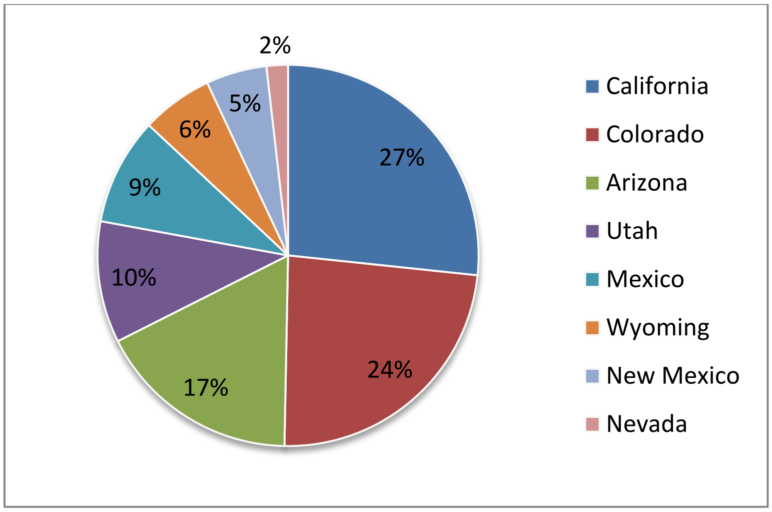

Figure 15 Colorado River Water Allocation

3.4.2. Institutions

The states of Nevada and Utah, like most of the western United Sates, follow the prior appropriation doctrine for water right allocation. SNWA's Groundwater Development Plan needs to be approved on two different levels. The overall plan for the project needs to be approved; the process requires state and federal approval. Additionally, the groundwater of the TAS underlain by the Snake Valley has to be allotted. The Snake Valley Groundwater Development project has to go through the approval of both the Groundwater Development Plan, and the interstate agreement on the TAS. The state approval goes the Office of the State Engineer; applications are reviewed for availability of water, and existing water rights. The Nevada's State Engineer has approved the project for both the Spring Valley and the Snake Valley.

On the federal level, the approval of the Ground Water Development Plan is led by the BLM. The BLM follows the mandates of the National Environmental Policy Act (NEPA) and the Federal Land Policy and Management Act (FLPMA). NEPA protocol instructs the BLM to determine if the federal actions (approval of the project) significantly affect the quality of the human environment (U.S. Congress 1969). The BLM conducted an Environmental Impact Statement in order to determine the impacts of the project. Under FLPMA the BLM needs to approve the rights of way for the pipeline in a way that minimizes esthetic, scenic, and environmental damage (Dubuc 2007). The BLM approved the "right of way" late in 2012. However, based on the failure of Utah and Nevada to reach an agreement the Snake Valley groundwater development, was not included in the review (Swearinger 2013).

Following the cooperation requirement from the Lincoln County Conservation Act the states of Utah and Nevada worked for four years (behind closed doors) on a deal to allocate water of the TAS underlying the Snake Valley. The Utah Department of Natural Resources, the Nevada Department of Conservation and Natural Resources, and the SNWA reached an agreement in 2009. The states agree that there is an available supply of 162.8 million cubic meter per year, and it distributes the whole amount on three categories: allocated (existing rights), unallocated (unallocated rights, requires monitoring for approvals of 1.23 million cubic meter per year or more), and reserved (Table 10). The total allocation of water is split down the middle with 50 percent of the water (81.4 million cubic meter per year) to each state (Utah Department of Natural Resources and Nevada Department of Conservation and Natural Resources 2009). A timeline of important events is represented in Figure 16.

Table 10 Water Distribution from the Agreement for Management of the Snake Valley Groundwater System

Allocated	Utah	67.8 million cubic meter per year
	Nevada	14.8 million cubic meter per year
Unallocated	Utah	6.17 million cubic meter per year
	Nevada	44.4 million cubic meter per year
Reserve	Utah	7.4 million cubic meter per year
	Nevada	22.2 million cubic meter per year

The agreement between the states of Utah and Nevada calls for the approval of the applications by the SNWA. Additionally it talks about mechanisms and protocols to follow in case of a grievance against the SNWA regarding negative effects by the proposed development.

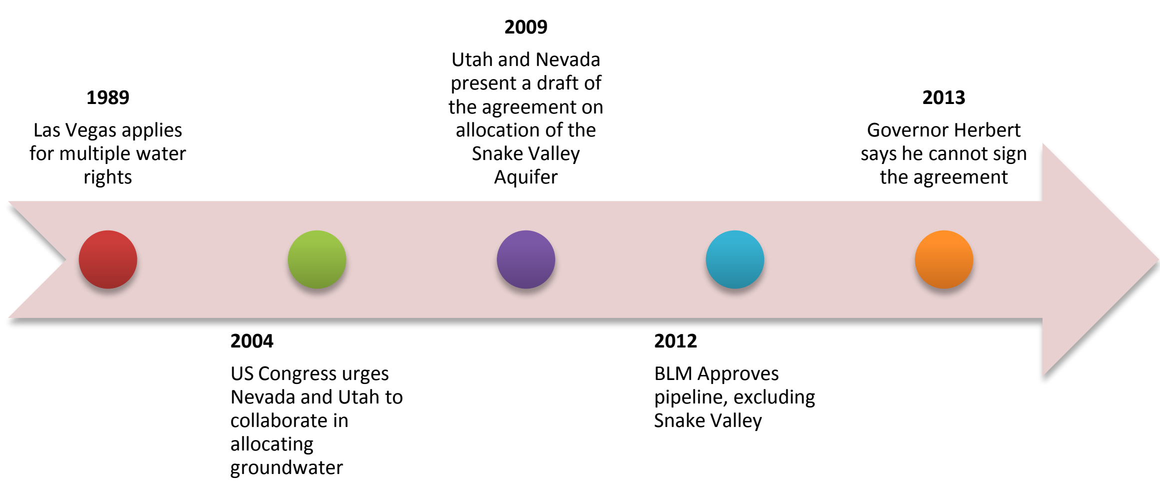

Figure 16 Timeline of the events regarding Nevada's proposed development of the Snake Valley Groundwater Development

Lastly it talks about additional scientific studies (hydrological, biological, etc.), to be carried out by September 2019, until then Nevada agrees to put the permits on hold

(Utah Department of Natural Resources and Nevada Department of Conservation and Natural Resources 2009).

Following the agreement, a draft was published and both states opened a time for public commenting. Following the public input the agreement needs to be signed by Utah, Nevada, and the SNWA. However, the agreement was never signed by Utah; after supporting the agreement, in March 2013 Governor Gary Herbert said he could not sign the agreement in good conscience (Fahys 2013; Hall and Cavataro 2013).

3.4.3. Power

The states of Utah and Nevada have a similar GDP per capita; the average Nevadan makes 13 percent more than the average Utahan. This is not a significant amount that would indicate a huge economical difference in the negotiations between the two states. However, the scale of the project and the importance to Nevada cannot be compared to the relevance to Utah.

The State Engineer needs to make the decision on the environmental soundness of the project. The State Engineer is supposed to make an independent judgment on the project based on merit. However, the political pressure by the Nevada has been documented; the head of the SNWA, Mulroy stated that the engineer could be removed from office if the plan was not approved (Dubuc 2007). Pressure was applied before to Tim Durbin, hydrologist from the USGS, he testified to the State Engineer that he was pressured by the SNWA to “disown his own work” (Jenkins 2009).

The Lincoln County Conservation Act was drafted in order to facilitate SNWA's Groundwater Development Plan; the act calls for the selling of federal property, the establishment of a utility corridor, and transfers lands between the U. S. Fish and Wildlife Service and BLM.

The act says that the states "shall" reach an agreement on the diversion of water; it was the congressional delegates from Utah that promoted the incorporation of this provision. However, the following sentence of says:

"The agreement shall allow for the maximum sustainable beneficial use of the water resources and protect existing water rights."(U.S. Congress 2004).

This statement calls for the negotiations to come up with an allotment of all the water available in a 'sustainable' way; it does not call for a division of water, it gives the instruction to use the maximum amount of water.

The has not been a case in the US history where a city has stopped growth due to the lack of water, and Las Vegas does not seem to be the first; when it comes to acquiring water cost is the issue, and Money is not a factor for Las Vegas (Rothman and Hancock 2003). The economic power of Las Vegas allows all the counties in Nevada allows provides revenue every county in the state; Las Vegas' economy represents 99 percent of the states income (Dubuc 2007).

The Hydro-hegemony analysis for the Snake River Valley is complicated, the events range from cooperation in reaching an agreement in 2009 to hostile talk and threat of lawsuits following the refusal of Gov. Herbert to sign the Utah/Nevada Groundwater

Appointment and Protection Agreement. The collaboration process between the two states produced an agreement on allocating the water of the Snake Valley groundwater development.

The need for additional sources of water for the population of almost 2 million people and the area that represents almost all the economic input to the state are not trivial. Las Vegas has a securitized vision of water, the city and the SNWA have an hegemonic role in the conflict, and have resorted to multiple power tactics get the approval of the Groundwater Development Plan, such as lobbing, political and financial pressure. Table 11 shows the Hydro-Hegemony analysis of the Snake Valley.

Table 11 Hydro-Hegemony Snake Valley Groundwater Development

Form of hydro-hegemony	**Main Water Control Strategy**	**Form of Interaction**	**Potential Distribution of Water**	**Form of Conflict**	**BAR**	**Events**
		*Independent control (future problem, no current)	*Equitable (low use, proposed equitable use)	No conflict	6	
					5	
					4	
					3	Agreement
					2	
					1	
Dominative (local level)	None at the moment			Conflict	0	
					-1	
					-2	Refusal to sign
					-3	

3.4.4. Values

There are no big differences for the people who live along the Snake Valley groundwater development project; people on both states have similar lifestyles.

Opponents of the project compare the water grab or squeeze by SNWA to the Owens Valley case in California. In the beginning of the 20th century the Los Angeles Water District secretly began secretly buying water rights and way in order to pipe the Owens River, and divert it into the San Fernando Valley. In the case of the Owens Valley there was environmental devastation following the drying of streams and the lake; Los Angeles was forced to irrigate the dry Lake to alleviate the sand storms that had become a common occurrence. The SNWA argue that today's environmental laws would prevent a tragedy such as the one at Owens Lake.

There are groups in Utah that support the governor's decision not to sign the agreement. However, there is also opposition. Utah legislators and The Utah Water Development Commission condemn the action of Gov. Herbert and sent him a letter urging him to reconsider (Fahys 2013). The SNWA released a letter stating their disappointment on the unilateral withdrawal from the agreement, and are considering their options.

Ownership of water, Utahans complain that the SNWA wants to intercept water that is going into Utah (O'Donoghue 2012).

For the Native American tribes that live on the valley water is sacred:

> "If they take our sacred water the springs will dry up, the land will dry up and the animals will suffer. It will affect our medicines, our traditional foods and our ceremonial places" (Sogobi and Bob 2013, 1)

The Goshute Indian Reservation is located in the Snake Valley, within the states of Nevada and Utah. The Goshute are a Shoshone people both in culture and language.

The Goshutes oppose the development of groundwater, and want to protect their water rights, that go back to the Treaty of Ruby Valley Land Boundry.

Regardless of the differences between the residents of the Spring and Snake Valleys and the ones in Southern Nevada the SNWA believes there are no significant differences, Mulroy says the Groundwater Development Plan is “Nevadans taking care of Nevadans” (Swearinger 2013).

3.4.5. Goals

The goals and interests are again split not along the state line; instead the division is apparent on a north and south way. On the north, the residents of the Spring and Snake Valleys are interested in maintaining their way of life; they are concerned about their water supply and livelihood. They care about the consequences of the pumping operation, a declining water table, and the drying of springs and seeps. The residents fear that large scale pumping of the project will have catastrophic effects on the livelihood of rural residents and on the environment (Brean 2012; Dubuc 2007).

On the south side Las Vegas is interesting in sustaining its growth and economic development. Additionally they are wary about the challenges of climate change and drought in the Colorado River Basin. The SNWA, concern about the decrease of water in the Colorado River, has implemented strong conservation measures, like promoting the removal of lawns with a monetary incentive. The Groundwater Development Plan gives Las Vegas a safety net in case the Colorado River “goes south” (Brean 2012).

The cost of water, SNWA has already spent hundreds of millions of dollars acquiring land and water rights (Swearinger 2013); the project that is estimated at 3 billion dollars (plus an estimated 12 billion more due to financing and inflation). The head of the SNWA, Mulroy says the Las Vegas will not be able to afford not to build it (Brean 2012). There will be significant harmful effects of the large scale pumping proposed by the Groundwater Development Plan (Bredehoeft 2011). The Environmental Impact Statement recognizes the harm that will be done by the project, some of the impacts outlined are: drop of 3 to 61m of the water table, subsidence of up to 1.5m across 1344 square kilometers, and nearly 35,000 tons of wind-blown dust every year (Bureau of Land Management 2012). The Great Basins National Park, which occupies the southeast part of the Snake Valley, would be greatly impacted by the groundwater development. Gov. Huntsman was in office when the negotiations between the Utah and Nevada took place; he had vowed to stand with Utahans when it came to make a decision. However, he left office in 2009 in order to become the US Ambassador in China. Gov Herbert was elected to finish Huntsman's term; he was supportive of the Utah-Nevada agreement on water allocation. In at least two his office said that he would sign the act (Fahys 2013). Gov. Herbert says the majority of the local residents of the Snake Valley do not approve of the agreement.

There are people who believe that Utahans deserve most of the water from the aquifer, since they have historic use on their side; others believe the water allocation may be too high, and that the aquifer cannot yield that much water (Fahys 2013). Gov Herbert's term in office will not end until 2017, if he maintains his position the political fight for the agreement will not only continue, but may become also a litigation issue, as Mulroy has made threats of suing Utah.

3.4.6. Analysis

The assessment of the Snake Valley groundwater development project (Table 12) shows both symmetry and asymmetry in most of the case. The multiple hydrologic models of the aquifer have a similar characterization of the aquifer; although, there are differences in the sustainable size of the development (Utah Department of Natural Resources and Nevada Department of Conservation and Natural Resources 2009). Despite the differences, Utah and Nevada were able to reach an agreement on allocation of the waters of the TAS, even though the agreement was not signed.

On the institutional level there are no differences between the two states; both follow the doctrine of prior appropriation (National Conference of State Legislatures 2013) with allocation of water tights is studied by the State Engineer. When the negotiations started there was one particular aspect of asymmetry, as the SNWA participated in the process. The SNWA had applied for water permits in Nevada; and since the water right applications are affected by the agreement, the SNWA was allowed to participate (Zimmerman 2010).

The participation of the SNWA allowed the parties to work on the Snake Valley Environmental Monitoring and Managing Agreement; this agreement signed only by the

SNWA and Utah (SNWA and Utah Department of Natural Resources 2009). It also highlights the power of the SNWA. The SNWA has publicly displayed their political power with public threats (Dubuc 2007; Jenkins 2009).

Table 12 Case Assessment- Snake Valley groundwater development project

At a Glance	The Snake Valley underlays a deep basal aquifer shared by Utah and Nevada. The local population relies on the top unconfined aquifer and not on the TAS. The SNWA wants to develop the aquifer, and transfer 480 kilometers south, to Las Vegas. In 2009 an agreement was reached between Utah and Nevada; Utah's Governor refused to sign the agreement. The BLM approved SNWA Groundwater Development Plan, but excluded the Snake Valley groundwater development project.			
Collaboration:	**Assessment**	YES	**Management**	Agreed, not signed
	Symmetry		**Importance**	
Institutions	Mostly Symmetric		Medium	
Power	Symmetric state, asymmetric local		High	
Values	Symmetric state, asymmetric local		Medium	
Goals	Symmetric state, asymmetric local		High	
Challenges	Reluctance on compromise Conflicting goals			

The political power struggle started in the US Congress, when Senator Harry Reid (democrat) of Nevada arranged for the transfer of land between federal agencies as part of the Lincoln Conservation Act. the In addition to the political power of the SNWA the economic power is likely to move the project forward (Rothman and Hancock 2003; Swearinger 2013). The financial might of Las Vegas moves Nevada along; it is difficult to see anybody in the state level to stand up against the SNWA (Dubuc 2007). At the interstate level, the refusal by Gov. Herbert to sign the deal has slowed down the approval of the Groundwater Development Plan, but the fight will continue (Fahys 2013). The state of Utah is under control of Gov. Hervert (republican).

The asymmetry of values and interests between Las Vegas and the Snake Valley residents can be analyzed together. The differences have been documented during the assessment of the TAS; there is little in common between the interests of the SNWA and the inhabitants of the valley. The EIS from the BLM clearly states the significant effects that the development could have on the area (Bureau of Land Management 2012); yet this asymmetry in values, goals, and interests have not been an obstacle for the project (Brean 2012).

The fight against SNWA's Groundwater Development Plan has now moved to the judicial system; there have been claims filed against the approval of the project by the Nevada's State Engineer. The transboundary water fight over the Snake Valley groundwater development project is still on the political arena. The Snake Valley groundwater development project added a complication to the development plan and vice versa. The BLM has already approved the Spring Valley portion of the project; the lack of agreement between Utah and Nevada prevented the approval of Snake Valley.

The negotiations between Utah and Nevada provided an agreement between the two states on the allocation and management of the TAS (Bureau of Land Management 2013). The interstate compact would have allowed equitable allotment of water between the two states (Hall and Cavataro 2013; Zimmerman 2010). The use of the Snake Valley transboundary issues in a political way is undermining the shared assessment and management of the aquifer; whether the BLM should have authorized the project or not should be a separate issue.

4. Discussion

This study was conducted in order to answer the question: What are the main challenges for successful collaboration in assessing and managing Transboundary Aquifer Systems in North America? In order to answer the question the theoretical framework described in Chapter 2 was used to analyze four different TAS: the Santa Cruz River Aquifer, the Chateauguay River Aquifer, the Memphis Sand Aquifer, and the Snake Valley groundwater development project.

Throughout the analysis of the four aquifers there were both recurring problems and problems specific to each case. In none of the cases there is a successful collaboration assessment of the aquifer (consensus hydrological model) and a management plan that aligns with the objectives of the Law of Transboundary Aquifers. One of the common aspects of the four cases is collaboration. In all four cases there have been conversations, negotiations, or agreements in assessing and/or managing the aquifer. However, in only one of the four cases there was successful cooperation that led with results and met the definition of successful assessment. In the cases of the Chateauguay River Aquifer, the collaboration produced the CRH, developed by collaboration of agencies on both sides of the border.

Meanwhile in the two cases of interstate aquifers, where there USGS is in charge of conducting the hydrological studies, there is still uncertainty about the models, quantities and missing predevelopment information. Problems of data and interpretation of hydrological models often leads to the problem of “dueling experts”. Dueling experts are a common occurrence in interstate and transboundary aquifers, with each side’s expert defending their model and methods that contradict one another. In the case of the Memphis Sand Aquifer there has been no debate about the validity of the existing hydrologic models. The pumping operation by the MLGW has created cones of depression, and the flow of the groundwater is in a northward direction, from Mississippi into Tennessee. However, there is an issue on how conditions have changed from predevelopment conditions. The study conducted by Waldron and Larsen is the first study of the predevelopment conditions, they dispute the claim that Memphis has taken Mississippi’s water (Waldron and Larsen 2013).

In the case of the Snake Valley groundwater development project the Agreement for Management of the Snake Valley Groundwater System started by agreeing on the physical characteristics of the aquifer, and the availability of water for development. Nevertheless, until with Gov. Herbert refusal to sign the agreement, even if the hydrology of the aquifer is not in question at the moment there is also no agreement. The assessment of the aquifer was not an issue, however, and the allocation of the aquifer’s waters was done in an equitable way. The problem in this case is the management of the aquifer, the transfer of water to a faraway place. There are significant asymmetries of interests and power in the Snake Valley, but not among the inhabitants of the valley. It seems that the faith of the Snake Valley groundwater development project will be decided in the legal and political arenas.

In the Santa Cruz River Aquifer the conversations and collaboration between the aquifer States has lead to some commitment on data sharing and studies; yet, the Mexico and the US maintain to this day their independent and conflicting interpretation of the TAS. With transboundary aquifers conflict in North America is still on the data stage.

The shared management of the transboundary aquifers in this study is further along. In the Chateauguay River Aquifer, the collaboration consisted solely in the assessment of the aquifer; the study included a look at the sustainable management of the TAS, but the management remains independent.

For the Santa Cruz River Aquifer, the collaboration has always focused on assessment and management of the TAS. The cooperation is aimed at a two step process with the intention of working on assessment and management of the aquifer. I believe that overreaching is a problem with this vision of the collaboration process. After 40 years of the signing of Minute 242, focusing on the assessment of the aquifer seems like the right thing to do. The challenges of the TAS are rooted on deep asymmetry at every level of the relationship and situation of the Santa Cruz River Aquifer.

The hidden nature and the common pool characteristics of groundwater make it difficult to manage. These difficulties are magnified when the groundwater is part of a TAS. The lack of understanding of the resource, the uncertainties in assessing aquifers, and the historical disregard of groundwater from the international law further exacerbate the lack of collaboration.

In order for the aquifer States to engage in cooperation over TAS they need to believe that the decisions and compromises they reach will have a positive outcome for their state. There has to be a change in the status quo in their favor. The concepts of "positive-sum" and "basket of benefits" present a way to increase the gains from collaboration beyond the resource itself (Jarvis et al. 2005). A process that creates additional gains or minimizes risks and hazards incentivizes cooperation. Flood control and hydro-electrical power generation are two commonly used examples of gains from surface water management that go beyond the consumptive use of water (Delli Priscoli and Wolf 2009).

Applying the notion of shared benefits and "expanding the pie" can provide incentives for collaboration. Two ideas that expand the value of groundwater are Aquifer Storage and Recovery (ASR) and unitization (Jarvis 2011). One of the differences between surface and ground water, is that groundwater is fitted with storage capability. In ASR water is pumped into an aquifer, where it can be stored and later retrieved at a later time. In addition to storage, the use of ASR provides a way to deal with the hidden nature of groundwater (Puri and Struckmeier 2010). Unitization of aquifers uses a market approach to groundwater management that helps reduce inefficiencies of the system (Jarvis 2011).

Uncertainty, is everywhere in groundwater, the old adage of "out of sight, out of mind" is often referenced by transboundary scholars (UNESCO 2009; Hardberger 2004; Puri and Arnold 2002; Eckstein 2011a). The "hidden" nature of the resource makes it easy for countries and agencies to de-prioritize groundwater management. The separation of groundwater and surface water in legal and managing issues is not exclusive to transboundary waters, it is a prevailing practice referred to as Hydroschizophrenia (Jarvis et al. 2005) . Uncertainties associated with the physical properties of groundwater (like storage and recharge) (Bredehoeft 1997; Gleeson et al. 2012), incommensurability between management goals and objectives, and the changes in climatic conditions (Milman 2009) undermine collaboration efforts.

If the BATNAs are similar of better than the possible outcome collaboration on assessing and managing the aquifer do not make sense. In the case of the Memphis Sand Aquifer, it is clear that Memphis has no incentive to collaborate. Since the dismissal of the case is a victory for Memphis and the MLGW, their BATNA outweighs any possible benefits of cooperation.

The uncertainties associated with groundwater, the impacts of management practices, and the misinterpretation of climatic challenges allows countries to misinterpret their BANTA. With appropriate information the consequences of both action and inaction will be adjusted, and the states may be more inclined to participate.

Through the assessment and analysis of the cases in Chapter 3 the challenges for each TAS were identified and the role of asymmetries was discussed. The comparison of the four study cases, as represented through the assessment framework are represented in Table 13.

Table 13 Assessment of the four study cases

Case Study	Santa Cruz	Chateauguay	Memphis Sand	Snake Valley
Parties	Mexico/ US	Canada/ US	Mississippi/Memphis	Utah/Nevada
Collaborative Assessment	NO	YES	YES[1]	NO[2]
Collaborative Management	NO	NO	NO	NO[3]
Institutions	Asymmetric	Symmetric	Symmetric[4]	Symmetric
Power	Asymmetric	Symmetric	Symmetric	Asymmetric[5]
Values	Asymmetric	Symmetric	Symmetric	Asymmetric[5]
Goals	Asymmetric	Symmetric	Asymmetric	Asymmetric[5]
Use	Asymmetric Urban/ Rural	Symmetric Rural/ Rural	Asymmetric Rural/ Urban	Asymmetric Rural/Urban

1 There is agreement on the actual conditions of the aquifer; the predevelopment conditions of the aquifer have not been analyzed in detail.

2 In the agreement between Nevada and Utah, the Basin and Range Carbonate Aquifer System Study (BARCASS) (USGS 2007) was agreed upon by both states. However, with additional negotiations this could change.

3 The agreement between Utah and Nevada (Utah Department of Natural Resources and Nevada Department of Conservation and Natural Resources 2009)was not signed.

4 The ownership of the groundwater is the one difference in an otherwise symmetrical institutional analysis.

5 There is symmetry among states, asymmetry in the local versus statewide aspects.

The assessment and management of TAS in North America present distinctive challenges. The first step to effectively manage an aquifer is getting to know the resource. Sound management decisions can be made by each aquifer if the natural resource is understood, and its characteristics are known. Minimizing uncertainties in the assessment of the aquifer should be the primary objective of TAS collaboration. The success of the cooperation between the aquifer States is determined by their ability to conduct joint scientific findings, as the best science is agreed upon (Jarvis and Wolf

2010). The development of a common conceptual model of the aquifer will not eliminate the uncertainties associated with assessing a TAS, but it will make them smaller. Collaboration does not have be achieved in one step, in the case of the Guarani Aquifer progressive agreements and compromises have allowed for an agreement that embodies the spirit of the Law of Transboundary Aquifers (Norman, Feller, and Villarreal 2012).

The main challenges of assessing and managing TAS in North America Identified in Chapter 3 are:

- Overcoming the asymmetry in values and power
- Conflicting goals
- Lack of incentives to collaborate on management
- BATNA
- Reluctance to compromise

4.1.Institutions

The assessment of the institutions of the four cases reveled asymmetry in the case of the Santa Cruz River Aquifer. The difference in the centralized approach to groundwater management in Mexico contrasts to the state management in the US. The US and Canada have similar decentralized structures of groundwater management with federal involvement in transboundary groundwater regulations, but state and provinces in control of aquifers.

There was one more case where the assessment revealed differences at the institutional level. The ownership of groundwater in Mississippi and Tennessee is not the same, even though both states follow the riparian doctrine of water appropriation, the ownership of groundwater is different in both states. Mississippi claimed the 'public trust' doctrine in their claim against Memphis (Campana 2013); the claim may have also been used regardless of the states ownership of the water (Feldman and Elmendorf 2000).

at the institutional level is present but not predominant in North American transboundary aquifers. There is asymmetry between Mexico and the US, and there are some symmetry issues within interstate aquifers in the US.

The dialogue established with the TAAP has helped overcome institutional asymmetries, even though they still represent challenges in sharing data, information, etc. When trying to build an agreement and look at the challenges thinking of the big picture seems like the natural thing to do. Building a shared vision for the border region requires the understanding of the problems facing the area, and knowing the availability of the resources. I think, from looking at the asymmetry of values, interests, and power between the two countries, that a commitment to a management strategy seems far away, and that assessing the aquifer would provide the countries with the necessary information to manage the aquifer.

Collaboration in transboundary aquifers is a lengthy process; the case studies reveal a timeframe of years in order to achieve some success. In order to alleviate fallout of negotiations over time it is important that the aquifer States develop institutional memory (Ganster and Lee 2012).

One of the processes of agreement on TAS assessment and management in the US and the international cases of North America is similar. In the US can be allocated through interstate compacts; compacts need to be ratified in the US Congress. The process for an international TAS agreement is similar, with an agreement between executive agencies needs to be ratified by the legislative power of the aquifer States.

In both the international and domestic context collaboration over transboundary aquifers is centered on surface water. In North America there is no provision of TAS in the treaties between the US and Canada, and the US and Mexico. In the US there are 27 interstate compacts regarding the allocation and management of interstate waters (Hall and Cavataro 2013). All of the existing interstate compacts regulate surface water. The interstate compacts have been used to groundwater assessment based on the connection to surface water.

Nonetheless, the other option for apportionment in the domestic cases, a ruling by the Supreme Court, is not available for international aquifer States. The Law of Transboundary Aquifers has no enforcement mechanism, and the international courts have limited power. However, the US Supreme Court has yet to intervene in a single case of transboundary aquifers. If the Supreme Court had taken the Mississippi v Memphis case it would have been the first time it heard a case regarding a TAS.

The agreement between Utah and Nevada regarding the allocation sought a third option for allocating and managing the TAS, a State to State agreement. The management of groundwater in the Snake Valley Groundwater Basin was a State to State agreement, not an interstate compact, negotiated with “the intention of avoiding an equitable apportionment action regarding the Snake Valley Groundwater Basin in the United

States Supreme Court" (Utah Department of Natural Resources and Nevada Department of Conservation and Natural Resources 2009, 2). If the agreement had been signed it would not need to be approved by congress, but it also might be challenged (Hall and Cavataro 2013).

Therefore, the international and domestic TAS can be analyzed almost in the same way in the institutional analysis. The most important t issue in TAS assessment and management is an agreement between the aquifer States. There are symmetry issues between the US and Mexico; there would also be asymmetry between two US states with different allocation doctrines.

The asymmetry at the institutional level presents a burden to the collaboration process, paired with asymmetries of power and values it creates a difficult hurdle in the case of the Santa Cruz River Aquifer. However, it is not the most significant issue any of the four case studies, and in general in North America.

4.2.Power

The assessment of the case studies found asymmetry in power happens in the cases of the Snake Valley groundwater development project and the Santa Cruz River Aquifer. In the Santa Cruz River Aquifer the difference in economic and political power marks the relationship between the aquifer States, and is an ever present force. The US holds a hegemonic position in its relationship with Mexico. Through the history of the relationship they have managed to use soft power techniques to set the agenda, use incentives and financial aid to get Mexico to compromise with a desirable outcome.

The 2012 negotiations over the Colorado River are an example where Mexico's need for financial resources to fix the damaged irrigation channels in Mexicali, following the 2010 earthquake, agreed to negotiate a temporary revision to the allotment of the Colorado River. This lead to Minutes 318 and 319, the US buys water from Mexico, with the money from the water sale, Mexico can fix the canal (Granados-Olivas et al. 2012). Additionally, the US agreed to store Mexico's water in Lake Mead. This is a testament to the effective cooperation between Mexico and the US in regards to transboundary surface water (International Boundary and Water Commission 2012). In the case of transboundary surface waters between Mexico and the US often the needs and desires of the two countries find a collaborative resolution. This is however not the case of transboundary groundwater.

Political power is also a very important issue to management of TAS in North America. The political power of the Senators from Nevada led to the approval of land transfers between federal agencies to facilitate SNWA's Groundwater Development Project. This kind of power struggle can have direct impact in the approval of an interstate water compact.

Power asymmetry is a source of conflict that prevents successful collaboration. There are two ways to help in a power asymmetry situation, empowering of the weaker party or 'leveling the playing field' (Jagerkog and Zeitoun 2009; Zeitoun and Warner 2006b). In the particular case of groundwater, the common pool nature of the resource allows the non hegemonic party to maintain the status quo, and avoid further compromise. It does not allow for negotiations to be conducted on equal terms, but it gives them a strategy of resistance.

In transboundary surface water the hydro-hegemon has usually the advantage in the use and management of the aquifer. Thus, maintaining the status quo is in the best interest of the hegemonic party (Zeitoun and Warner 2006a). However, in groundwater, the common pool nature of the resource allows all parties access to the water. In case of deep aquifers, where pumping is complicated and expensive, a hegemon can lower the water table to prevent the other party to accessing the aquifer. However, that is not the case of any of the four North American cases reviewed in this study.

In the case of groundwater the refusal to compromise can be a way for the non-hegemonic aquifer State to resist an unfavorable management practice, whether fairly or not. In the case of the Snake Valley, the refusal of Gov. Herbert to sign the agreement between Utah and Nevada regarding the allocation and management of the transboundary aquifer is a political move to oppose Nevada's management of the aquifer. In the mostly uncharted grounds of groundwater agreements collaboration on management of TAS is a risk that appears to be not worth taking.

National and state politics and securitization of water, asymmetry of power and at the institutional level is another important issue that prevents successful cooperation. Building shared knowledge of the TAS, addressing the challenges of demographic growth and climate change (Scott et al. 2008) are not only the challenges facing TAS assessment and management, but also part of the solution. Creating a clear understanding of the interests, goals, and objectives of each country can help reduce the uncertainties of groundwater.

4.3.Values

The analysis revels that asymmetry of values are presented in two of the study cases, both the Santa Cruz River Aquifer and the Snake Valley are highlighted by differences the values of the aquifer States. In the Santa Cruz, the asymmetry in values is a real obstacle for collaboration. In no other border live so are so many people living so close to each other and interacting so much from such dissimilar countries (Martinez 1994). The borderlands of the Mexico-US border have an identity of its own; people move through both countries living and doing business in two different languages. The values and points of views of water, environment, spirituality, and life in general are so different in Mexico and the US. The identity of the people living in the area is tied to the border. However, unlike the homogeneousness described by Forest (2012) in the Canada- US border the US-Mexico border is an heterogeneous mix of people and values. The challenges related to values for assessing and managing a TAS in North America are not limited to the Mexico-US border. The case of the Snake Valley provides a look at asymmetry in values and identity between different stakeholders related with the SNWA's Groundwater Development Project.

People participation is commonly removed from the negotiations over an international TAS. However, in the domestic level, stakeholders can participate in forums, and comment on proposed laws. And, even though governmental processes are more powerful than societal processes, societal issues and participation can influence policy (Campana, Neir, and Klise 2007).

Groundwater supports basic needs and irrigation throughout North America; the different interpretations and notions of water are strong beyond the intrinsic value of water.

Regional thinking and solutions are imperative to TAS assessment and management. In areas of similar values, concepts like border identity and the value of water can be used to engage authorities to focus on a local and regional scale to solve advance collaboration. Regional assessment led to the CRH of the Chateauguay River Aquifer (Croteau, Nastev, and Lefebvre 2010).

The challenges of bringing people together in an asymmetric value context are far more complex. The issue of values is a big challenge that is prevalent in some but not all of the TAS of North America. Thus, it is a strenuous obstacle for collaboration where asymmetry of values is at play, but not throughout North America.

4.4. Goals

In the analysis of the case studies, asymmetric goals are the most common problem. In three of the four cases there are conflicting interests and goals on the management of the aquifer. Only in the Chateauguay River Aquifer there is no conflict of interests between aquifer States.

Competition over a shared resource like groundwater is a common occurrence in North America. In the Santa Cruz River Aquifer, the goals are distinct and conflicting from inception. The asymmetry of development of each country faces them on different positions. Mexico wants to provide for a population that is lacking a reliable supply of water, while the US wants to maintain the benefits they get from the aquifer. This is not the only difference, but it is the most significant, Arizona looks to grow, take the environment into consideration and continue the development in a sustainable manner. Mexico, Sonora, and Nogales want to allow economic development and to supply water to a population that receives an intermittent delivery of the vital liquid. The goals from the Mexican side are consistent throughout the different levels of government, form local to state to federal. The municipal supply is priority in Mexico; irrigation is dependent on availability after the cities and local communities.

The conflict between Mississippi and Memphis has two conflicting interests, groundwater and money. The dispute over the groundwater is real, but the issues are not complicated. The course of action selected by Mississippi escalated a conflict that seemed suitable for collaboration. If the aquifer States (including Arkansas) decide to negotiate in the future, overcoming conflicting interests should not be an unsurpassable obstacle.

That is not the case of the Snake Valley. The asymmetry of interests over the development and water transfer to Las Vegas is not just about the allocation of water. The effects that the development could cause to the area have been identified in the EIS prepared by the BLM. The challenge of reconciling the interests of the multiple stakeholders in this asymmetric case of Las Vegas vs. rural communities is a complicated one. The negotiations between Utah and Nevada included the Snake Valley Environmental Monitoring and Management Agreement between the SNWA and Utah. It presented a way to monitor and mitigate potential environmental damages caused by the Groundwater Development Project. The inclusion of this agreement is in principle a way to address the impacts of the project. Since the agreement was not signed the failed collaboration leaves the conflicting interests unresolved.

It is common throughout the four study cases that people have a sense of ownership of the groundwater, which excludes the rights of others. The sense of ownership varies according to the particular situation of the people. The positions that people from each aquifer State have is determined by their particular use or need of the groundwater. Water stress and the fear of commitment to a long term managing solution are also challenges that hinder collaboration. With unclear goals understanding of the consequences (Milman and Ray 2011) of collaboration or failure to collaborate a separation of the assessment and management aspects of TAS can help relief the pressure on collaboration. With scarcity and water stress, the competition for groundwater intensifies, and collaboration becomes both needed and treacherous.

In Mississippi the water that is flowing to Tennessee is being illegally captured by Memphis (Charlier 2010); Memphis is pumping its water from within its boundaries (Mynatt et al. 2008).

Nevada wants to develop the water from within the state, with rights and permits that they bought and rightfully own (SNWA 2013); in Utah the historical use of groundwater gives them seniority over the aquifer, Nevada wants to use the water that flows from west to east, capturing the groundwater that would make it to Utah (Dubuc 2007).

In Sonora the water from the aquifer is theirs and they should be able to independently manage the aquifer(Romero Reséndiz 2000). In Arizona, the groundwater is being depleted by Mexico, who is using water that belongs to the US.

One of the ways to facilitate is to separate move away from positions, and focus on interests (Delli Priscoli and Wolf 2009); to move away from the notion of want, deserve or own and focus on the need.

In order to develop a sustainable agreement, it is advantageous to focus on a common interest (Jagerkog and Zeitoun 2009; Rowland 2005). The question of what can bring the two sides together to the table is there something that can unify the different parties in each of the four case studies.

The Chateauguay River Aquifer faces local issues of pollution; this is not an uncommon topic for transboundary waters between Canada and US. Even though a collaboration assessment has been conducted in this case, a focus on water quality can help the two countries reach an agreement in managing the Chateauguay River Aquifer.

The Santa Cruz River Aquifer faces scarcity and water quantity demands on both sides of the border. The development of additional sources of water can help Mexico and the US reach an agreement on assessment o the TAS. The inclusion of additional sources of water could help breach the differences between the two countries. Aquifer Storage and Recovery and desalinations are two options that could provide the area with additional sources of water, technology and financial resources can be included in the conversations of the Santa Cruz River Aquifer.

The dispute over the groundwater of the Memphis Sand Aquifer includes the issue of money. Mississippi is searching for compensation for the water that Memphis is pumping. Providing an option for Memphis to buy water from Mississippi could be a common ground in the case of this TAS. This will not answer the question of whether the pumping by the MLGW has changed the predevelopment conditions. However, it can be a way to bring them together, and perhaps managing the aquifer collaboratively.

The Great Basin National Park is located in the Snake Valley, even though the park is located only in Nevada, it is a National Park. The impacts of the development of the carbonate aquifer would impact the National Park (Bureau of Land Management 2012). This could be a unifying figure that brings Nevada and Utah to an agreement, the shared interest on preserving the Great Basin National Park could provide a way to shared management of the aquifer.

4.5.Conclusions

The assessment and management of TAS in North America is characterized by a lack of agreement on the conceptual models and characterization of the aquifers. The

Chateauguay River Aquifer is the only one, of the four cases, where the aquifer States have collaborated in a conceptual model. This failure to collaborate on assessing the TAS is a fueled by conflicting goals, lack of incentives to cooperate, and a fear of compromise.

In order to effectively manage the aquifer, the aquifer States need to collaborate in creating a conceptual model with the best available information, in a manner that satisfies the parties. Assessment and management of the aquifer are concepts that are interconnected. There cannot be effective management if there is no assessment. However, collaborative assessment and collaborative management are concepts that can go together, but they do not have to. Separating the person from the problem is one of the principles of classic negotiation. The same principle can be applied while separating assessment and management.

If the aquifer States can reach an agreement on the conditions of the aquifer, they can manage it independently according to the principles of the Law of Transboundary Aquifers. The aquifer States will maintain sovereignty over their groundwater and utilize it without causing significant harm to the other aquifer States. If the aquifer is managed independently according to the Law of Transboundary Aquifers, collaboration on managing the aquifer will both facilitated, and unnecessary.

Additionally, creating additional benefits that can be built upon the management of the aquifer, reducing uncertainty and development of an understanding of the challenges faced by the region can be incentives to move the process to collaborative management of the aquifer.

References

Allan, J. A., and Naho Mirumachi. 2010. "Why Negotiate? Asymmetric Endowments, Asymmetric Power and the Invisible Nexus of Water, Trade and Power That Brings Apparent Water Security." In *Transboundary Water Management. Principles and Practice*, edited by Anton Earle, Anders Jagerskog, and Joakim Ojendal, 261. London: Earthscan.

Arizona Department of Water Resources. 2005. "Overview of the Arizona Groundwater Management Code". Phoenix.

Bakker, Karen. 2012. "Privatizing Water , Producing Scarcity : The Yorkshire Drought of 1995 *." *Economic Geography* 76 (1): 4–27.

Bakker, Karen, and Christina Cook. 2011. "Water Governance in Canada : Innovation and Fragmentation Water Governance in Canada : Innovation and Fragmentation." *International Journal of Water Resources Development* 27:02 (January 2013): 275–289. doi:10.1080/07900627.2011.564969. Bakker, K., & Cook, C. (2011). Water Governance in Canada : Innovation and Fragmentation Water Governance in Canada : Innovation and Fragmentation. International Journal of Water Resources Development, 27:02(January 2013), 275–289. doi:10.1080/07900627.2011.564969.

Birkby, Robert H. 1966. "The Supreme Court and the Bible Belt: Tennessee Reaction to the 'Schempp' Desicion." *Midwest Journal of Political Science* 10 (3): 304–319.

Bracken, Nathan. 2010. "Exempt Well Issues in the West." *Environmental Law* 40 (141): 26.

Brahana, J. V., and R. E. Broshears. 2001. "Hydrogeology and Ground-Water Flow in the Memphis and Fort Pillow Aquifers in the Memphis Area , Tennessee". Nashville, TN.

Brean, Henry. 2012. "BLM Signs Off on Water Pipeline , but Spares Snake Valley." *Las Vegas Review Journal*, August.

Bredehoeft, John. 1997. "Safe Yield and the Water Budget Myth." *Ground Water* 35 (6): 929.

———. 2011. "REPORT ON THE HYDROGEOLGY OF PROPOSED SOUTHERN NEVADA WATER AUTHORITY GROUNDWATER DEVELOPMENT". Sausalito,CA.

Bruce, James P. 2011. "Protecting Groundwater : The Invisible but Vital Resource." *C. D. Howe Institute* 136.

Buckles, Daniel, and Gerett Rusnak. 2005. “Conflict and Collaboration in Natural Resource Management.” *International Development Research Center*. International Development Research Centre.

Burden, Carole B. 2012. “Groundwater Conditions in Utah”. Salt Lake City, Utah.

Bureau of Land Management. 2012. “Clark , Lincoln , and White Pine Counties Groundwater Development Project Final Environmental Impact Statement”. Reno, Nevada.

———. 2013. “Utah / Nevada Draft Snake Valley Agreement.” *Bureau of Land Management*. www.blm.gov/nv/st/en/prog/planning/groundwater_projects/water rights home/utah.

Bureau of Reclamation. 2012. “St . Mary River- Milk River Basin Study Draft Report.”

Camapana, Michael E. 2013. “Growing Groundwater Governance in Graceland: The Memphis Sand Aquifer.” In *American Water Resources Association Annual Conference*, 28. Portland, OR.

Cámara de Diputados del H. Congreso de la Union. 1917. *Constitución Politica de Los Estados Unidos Mexicanos*. Mexico: http://www.diputados.gob.mx/LeyesBiblio/pdf/1.pdf.

Cameron, Alan B. 2009. “Mississippi v . Memphis : A Study in Transboundary Ground Water Dispute Resolution.” In *Sea Grant Law and Policy Journal 2009 Symposium*, 48. Oxford, MS.

Campana, Michael. 2013. “Growing Groundwater Governance in Graceland: The Memphis Sand Aquifer.” In *AWRA Annual Conference*, 28. Portland, OR.

Campana, Michael, Alyssa M Neir, and Geoffrey T Klise. 2007. “Dynamics of Transboundary Groundwater Management: Lessons from North America.” In *Governance as a Trialogue: Government-Science-Society in Trannsition*, edited by Anthony R Turton, Hanlie J Hattingh, Gillian A Maree, Dirk J Roux, Marius Claassen, and Wilma F Strydom, 167–196. Berlin: Springer.

Carpenter, S.L., and W.J.D. Kennedy. 1998. “Managing Public Disputes”. San Francisco, CA: Jossey-Bass.

Charlier, Tom. 2010. “Supreme Court Shuts Off Mississippi’s Water Lawsuit Against Memphis.” *The Commercial Appeal*, January 25.

http://www.commercialappeal.com/news/2010/jan/25/supreme-court-declines-weigh-mississippis-water-la/.

City of Mesilla, NM. 2013. “Mesilla, New Mexico.” www.oldmesilla.org.

Clark, Brian R, Rheannon M. Hart, and Jason J Gurdak. 2011. “Groundwater Availability of the Mississippi Embayment”. Reston, Virginia.

Coes, Alissa, D. J. Gellenbeck, Douglas C. Towne, and Maureen C. Freark. 2002. “Ground-Water Quality in the Upper Santa Cruz Basin , Arizona , 1998”. Tucson, Arizona.

Cooley, Heather, J Christian-Smith, PH Gleick, Lucy Allen, and Michael Cohen. 2009. “Understanding and Reducing the Risks of Climate Change for Transboundary Waters.” *Environment*. Pacific Institute. http://www.pacinst.org/reports/transboundary_waters/transboundary_water_and_climate_report.pdf.

Coser, Lewis. 1956. *The Functions of Social Conflict*. Edited by The Free Press. New York.

Croteau, Anne, Miroslav Nastev, and Rene Lefebvre. 2010. “Groundwater Recharge Assessment in the Chateauguay River Watershed.” *Canadian Water Resources Journal* 35 (451).

Dahl, Robert A. 2006. *A Preface to Democratic Theory*. Expanded E. Chicago: The University of Chicago Press.

Daniels, S. E., and G. B. Walker. 2001. *Working Through Environmental Conflict*. Westport, CT: Praeger.

Delli Priscoli, Jerome, and Aaron T Wolf. 2009. *Managing and Transforming Water Conflicts*. First. New York: Cambridge University Press.

Drieschova, Alena, Itay Fischhendler, and Mark Giordano. 2011. “The Role of Uncertainties in the Design of International Water Treaties : an Historical Perspective”: 387–408. doi:10.1007/s10584-010-9896-4.

Dubuc, Rob. 2007. “Snake Valley To Las Vegas: Keep Your Pipes Out of Our Aquifer!” *JOurnal of Land, Resources , & Environmental Law* 27 (151): 44.

Eckstein, Gabriel E. 2011a. “Buried Treasure or Buried Hope ? The Status of Mexico-U . S . Transboundary Aquifers Under International Law” 13: 273–290. doi:10.1163/187197311X582395.

Eckstein, Gabriel E. 2011b. “Managing Buried Treasure Across Frontiers: The International Law of Transboundary Aquifers.” *Water International* 36 (5) (September): 573–583. doi:10.1080/02508060.2011.598642. http://www.tandfonline.com/doi/abs/10.1080/02508060.2011.598642.

Fahys, Judy. 2013. “Utah Board Wants Herbert to Reconsider Snake Valley Water Deal Rejection.” *The Salt Lake Tribune*, May 15. www.sltrib.com/sltrib/news/56311015-78/utah-herbert-agreement-nevada.html.csp.

Feldman, David Lewis, and Julia O Elmendorf. 2000. “WATER SUPPLY CHALLENGES FACING TENNESSEE : CASE STUDY ANALYSES AND THE NEED FOR LONG-TERM PLANNING”. Knoxville, Tennessee.

Fernandez, L, and R Carson. 2002. *Both Sides of the Border: Transboundary Environmental Management Issues Facing Mexico and the United States*. Springer. http://books.google.com/books?id=qXk4gJgxRZ8C.

Flaherty, Brittany, Raul Pacheco-Vega, and Judy Isaac-Renton. 2011. “Moving Forward in Canada – United States Transboundary Water Management : an Analysis of Historical and Emerging Concerns.” *Water International* 36 (7): 37–41.

Forest, Patrick. 2012. “Transferring Bulk Water Between Canada and the United States : More Than a Century of Transboundary Inter-Local Water Supplies.” *Geoforum* 43 (1): 14–24. doi:10.1016/j.geoforum.2011.07.001. http://dx.doi.org/10.1016/j.geoforum.2011.07.001.

Fry, Al, Eva Haden, and Michael Martin. 2006. *Facts and Trends Water*. World Business Council For Sustainable Development.

Ganster, Paul, and Erik Lee. 2012. “Summary of Border Institute X: Towards a Sustainable 2030.” In *T He U. S.-Mexican Border Environment. Progress and Challenges for Sustainability*, edited by Paul Ganster, 413–440. San Diego, CA: San Diego State Univestity Press.

Giordano, Mark. 2009. “Global Groundwater? Issues and Solutions.” *Annual Review of Environment and Resources* 34 (1) (November): 153–178. doi:10.1146/annurev.environ.030308.100251. http://www.annualreviews.org/doi/abs/10.1146/annurev.environ.030308.100251.

Gleeson, Tom, William M Alley, Diana M Allen, Marios a Sophocleous, Yangxiao Zhou, Makoto Taniguchi, and Jonathan VanderSteen. 2012. “Towards Sustainable Groundwater Use: Setting Long-Term Goals, Backcasting, and Managing

Adaptively." *Ground Water* 50 (1): 19–26. doi:10.1111/j.1745-6584.2011.00825.x. http://www.ncbi.nlm.nih.gov/pubmed/21599658.

Granados-Olivas, Alfredo, Bobby J Creel, Erika Sanchez-Flores, Javier Chavez, and John W Hawley. 2012. "Thirty Years of Groundwater Evolution— Challenges and Opportunities for Binational Planning and Sustainable Management of the Transboundary Paso Del Norte Watersheds." In *The U.S.-Mexican Border Environmental Progress and Challenges for Sustainability*, edited by Paul Ganster, 201–218. San Diego, CA: San Diego State Univestity Press.

Grigg, Neil S. 2008. *Total Water Management*. Denver, CO: American Water Works Association.

Hall, Noah D, and Benjamin L Cavataro. 2013. "Interstate Groundwater Law in the Snake Valley: Equitable Approtionment and a New Model for Transboundary Aquifer Management." *Utah Law Review* 6: 89.

Hardberger, Amy. 2004. "WHAT LIES BENEATH : DETERMINING THE NECESSITY OF INTERNATIONAL GROUNDWATER POLICY ALONG THE UNITED STATES — MEXICO BORDER AND A ROADMAP TO AN AGREEMENT." *Texas Tech Law Review* 35 (1211): 1212–1260.

Hardin, Garrett. 1968. "The Tragedy of the Commons." *Science* 162 (3859): 1243–1248.

Horcasitas, Miguel De. 2012. "Conagua y Cea Evalúan El Comportamiento de Los Acuíferos Por Situación de Sequía Severa". Hermosillo, Sonora.

Hoskins, S, and Middle Tennessee State University. 2009. *A Restless Landscape: Building Nashville History and Seventh and Drexel*. Edited by Middle Tennessee State University. ProQuest. http://books.google.com/books?id=oCxOVJZjs5oC.

IBWC. 2013. "International Boundary & Water Commission." www.ibwc.state.gov.

International Boundary and Water Commission. 1973. *Minute No 242. Permanent and Definitive Solution to the International Problem of the Salinity of the Colorado River*. USA-Mexico: http://www.ibwc.gov/Files/Minutes/Min242.pdf.

———. 2012. *Interim International Cooperative Measures in the Colorado River Basin Through 2017 and Extension of Minute 318 Cooperative Measures to Address the Continued Effects of the April 2010 Earthquake in the Mexicalli Valley, Baja California*. US- Mexico.

International Joint Commission. 2000. “The IJC and the 21st Century: Resopnse of the IJC to a Request Bye Governments of Canada and the United States for Proposals on How to Best Assist Them to Meet the Environmental Challenges of the 21st Century.” In *International Joint Commission*. Ottawa, ON.

ISARM. 2009. *ATLAS OF TRANSBOUNDARY AQUIFERS*. Edited by S. Puri and A Aureli. Unesco.

———. 2012. “Transboundary Aquifers of the World 2012.” http://www.isarm.org/publications/419#.

Jagerkog, A., and Mark Zeitoun. 2009. “Getting Transboundary Water Right : Theory and Practice for Effective Cooperation”. Stockholm.

Jarvis, Todd. 2010. “Water Wars , War of the Well , and Guerilla Well-Fare.” *Ground Water* 48 (3): 346–350.

———. 2011. “Unitization: a Lesson in Collective Action from the Oil Industry for Aquifer Governance.” *Water International* 36 (5) (September): 619–630. doi:10.1080/02508060.2011.598656. http://www.tandfonline.com/doi/abs/10.1080/02508060.2011.598656.

Jarvis, Todd, Mark Giordano, Shammy Puri, Kyoko Matsumoto, and Aaron Wolf. 2005. “International Borders, Ground Water Flow, and Hydroschizophrenia.” *Ground Water* 43 (5) (September): 764–770. doi:10.1111/j.1745-6584.2005.00069.x. http://doi.wiley.com/10.1111/j.1745-6584.2005.00069.x.

Jarvis, Todd, and Aaron Wolf. 2010. “Managing Water Negotiations and Conflicts in Concept and in Practie.” In *Transboundary Water Management. Principles and Practice*, edited by Anton Earle, Anders Jagerskog, and Joakim Ojendal, 1st ed., 125–141. Washington, DC: Earthscan.

Jenkins, Matt. 2009. “Vegas Forges Ahead on Pipeline Plan.” *High Country News*.

Jones, Patricia A. 2009. “Compliance Mechanisms of International Water Agreements Compliance Mechanisms of International Water Agreements A Case of U . S . -Mexico Boundary Waters.” *Water* (October 2011): 37–41.

Kelly, Mary E, and Salvador Contreras. 2003. “WATER USE AND WATER MANAGEMENT POLICY IN THE CHIHUAHUAN DESERT ECOREGION.” *WWF/ Chihuahua*. Kyoto: Texas Center for Policy Studies.

Kibel, Paul Stanton, and Jonathan R Schutz. 2007. “From the SelectedWorks of Paul Stanton Kibel Rio Grande Designs : Texans ’ NAFTA Water Claim Against Mexico Rio Grande Designs : Texans ’ NAFTA Water Claim Against By.” *Berkeley Journal of International Law* 25 (2).

Lavigne, Marc-andré, Miroslav Nastev, René Lefebvre, and Anne Croteau. 2012. “Regional Sustainability of the Chateauguay River Aquifers Regional Sustainability of the Chateauguay River Aquifers.” *Canadian Water Resources Journal* 35 (Winter): 37–41.

Leshy, John D. 2008. “Interstate Groundwater Resources: The Federal Role.” *West-Northwest* 14: 1475–1703.

Linton, Jaimie. 2011. “The Hydrologic Cycle and the Hydrosocial Cycle: Bridging Hydrosystems and Hydropolitics".” In *Hydrosystems & Hydropolitcs Seminar*, 1–9. Paaris: Queens University.

Lopez-Gunn, Elena, and Todd Jarvis. 2009. “Groundwater Governance and the Law of the Hidden Sea.” *Water Policy* 11 (6) (November): 742. doi:10.2166/wp.2009.021. http://www.iwaponline.com/wp/01106/wp011060742.htm.

Luege Tamargo, Jose Luis, Felipe Ignacio Arreguin Cortes, Ruben Chavez Guillen, Florencio Diaz Armenta, and Lucas Antonio Oroz Ramos. 2010. “Determinacion de La Disponibilidad de Agua En El Acuifero 2615 Rio Santa Cruz, Estado de Sonora”. Mexico City.

MacPherson, Crawford Brough. 1978. *Property, Mainstream and Critical Positions*. Toronto: University of Toronto Press.

Martin, Kevin St. 2012. “Community Resource Space.” *Fisheries (Bethesda)* 91 (1): 122–142.

Martinez, Oscar J. 1994. *Border People: Life and Society in the US Mexico Borderlands*. Tucson, Arizona: University of Arizona Press.

McKee, Paul W, and Phillip D Hays. 2002. “The Sparta Aquifer : A Sustainable Water Resource ?” Little Rock, Arkansas.

Megdal, Sharon, and Christofer Scott. 2011. “The Importance of Institutional Asymmetries to the Development of Binational Aquifer Assessment Programs: The Arizona-Sonora Experience.” *Water* 3: 949–963.

Megdal, Sharon, Roberto Sención, Christopher A Scott, Florencio Díaz, Lucas Oroz, James Callegary, and Robert G Varady. 2010. “Institutional Assessment of the Transboundary Santa Cruz and San Pedro Aquifers on the United States-Mexico Border :” In *Conference, Unesco-Iah-Unep*, 6–8.

Milman, Anita. 2009. “Bordering on Water Management: Ground and Wastewater in the United States - Mexico Transboundary Santa Cruz Basin”. University of California, Berkeley.

Milman, Anita, and Isha Ray. 2011. “Interpreting the Unknown: Uncertainty and the Management of Transboundary Groundwater.” *Water International* 36 (5) (September): 631–645. doi:10.1080/02508060.2011.599782. http://www.tandfonline.com/doi/abs/10.1080/02508060.2011.599782.

Milman, Anita, and Christopher A Scott. 2010. “Beneath the Surface : Intranational Institutions and Management of the United States - Mexico Transboundary Santa Cruz Aquifer.” *Environment and Planning C: Government and Policy* 28 (1): 528–552. doi:10.1068/c0991.

Moore, C, and Jerome Delli Priscoli. 1985. “Executive Training Course in Conflict Management.” In *USCAE*. Alexandria, Virginia.

Moore, Christopher, and Nigel Kemp. 1988. “The Mediation Process: Practical Strategies for Resolving Conflict.” *R&D Management* 18 (1): 79. doi:10.1111/j.1467-9310.1988.tb00569.x. http://dx.doi.org/10.1111/j.1467-9310.1988.tb00569.x.

Morin, R. H., J. H. Williams, and M. Nastev. 2009. “The Hydrogeologic Properties of Postdam Sandstone in the Chateauguay River Basin and Tehir Implications Regarding U.S.-Canada Transboundary Water Issues.” In *American Geophysical Union, Spring Meeting*.

Mumme, Stephen. 2000. “Minute 242 and Beyond : Challenges and Opportunities for Managing Transboundary Groundwater on The.” *Natural Resources Journal* 40: 341–378.

Mynatt, Leann, Jon E Hastings, Max Fleischer, Joel Barnes, Randy Womack, Robert Haun, and Rick Hitchcock. 2008. “State of Mississippi’s Lawsuit Against Memphis”. Environmental Law Section, Tennessee Bar Association.

Nastev, M, C Lamontagne, T Tremblay, F Hardy, M Lamothe, A Croteau, D Blanchette, et al. 2012. “Hydrogeolgy of the Transboundary Sedimentary Rock Aquifers in the

Châteauguay River Basin , Canada-United States." *Canadian Water Resources Journal* 35 (4): 483–486.

Nastev, M., R. Morin, R. Godin, and a. Rouleau. 2008. "Developing Conceptual Hydrogeological Model for Potsdam Sandstones in Southwestern Quebec, Canada." *Hydrogeology Journal* 16 (2) (January 10): 373–388. doi:10.1007/s10040-007-0267-9. http://www.springerlink.com/index/10.1007/s10040-007-0267-9.

Nastev, Miroslav, and Charles Lamontagne. 2012. "Preface to the Special Issue on the Hydrogeology of the Chateauguay River Watershed Preface to the Special Issue on the Hydrogeology of the Chateauguay River Watershed." *Canadian Water Resources Journal* 35 (Winter): 355–358.

National Conference of State Legislatures (NCSL). 2013. "National Conference of State Legislatures." http://www.ncsl.org/aboutus.aspx.

Norman, Laura M., Mark Feller, and Miguel L. Villarreal. 2012. "Developing Spatially Explicit Footprints of Plausible Land-Use Scenarios in the Santa Cruz Watershed, Arizona and Sonora." *Landscape and Urban Planning* 107 (3) (September): 225–235. doi:10.1016/j.landurbplan.2012.06.015. http://linkinghub.elsevier.com/retrieve/pii/S0169204612002101.

O'Donoghue, Amy Joii. 2012. "BLM Spares Snake Valley In Nevada Pipeline Plan." *KSL*, August 5. http://www.ksl.com/?sid=21550278.

OOSKAnews correspondent. 2012. "Mexican Farmer ' s Organization Announces ' Common Front ' Against Colorado River Agreement." *OOSKAnewx*, December 4. http://www.ooskanews.com/daily-water-briefing/mexican-farmer-s-organization-announces-common-front-against-colorado-river-agrhttp://www.ooskanews.com/daily-water-briefing/mexican-farmer-s-organization-announces-common-front-against-colorado-river-agr.

Ostrom, Elinor, Joanna Burger, Christopher B. Field, Richard B Norgaard, and David Policansky. 1999. "Revisiting the Commons: Local Lessons, Global Challenges." *Science* 284 (5412): 278–282.

Parks, W. S., and J. K. Carmichael. 1990. "GEOLOGY AND GROUND-WATER RESOURCES OF THE MEMPHIS SAND IN WESTERN TENNESSEE."

Parliament of Canada. 2013. *International Boundary Waters Treaty Act Loi Du Traité Des Eaux Limitrophes Internationales*. Ottawa, ON: Parliament of Canada. http://laws-lois.justice.gc.ca/PDF/I-17.pdf.

Prichard, Andrea, Christofer Scott, Prescott Vandervoet, and Sharon Megdal. 2004. "Drought and Urbanization." In *Arizona Hydrological Society Symposium*, 20. University of Arizona.

Puri, Shammy, and Geo Arnold. 2002. "The ISARM Programme The Miedzyzdroje Meeting : Focus on Sustainable Management" (April): 21–24.

Puri, Shammy, and WilhelmF. Struckmeier. 2010. "Aquifer Resources in a Transboundary Context: A Hidden Resource?- Enabling the Practitioner to ʼSee It and Bank It" for Good Use." In *Transboundary Water Management. Principles and Practice*, edited by Anton Earle, Anders Jagerskig, and Joakim Ojendal, 73–90. Washington, DC: Earthscan.

Ritter, Ken. 2012. "US, Mexico Sign Pact on Rules for Sharing Colorado River Water in Fight Against Drought." *The Washington Post*, November 20. www.washingtonpost.com/business/.

Romero Reséndiz, José Gilberto. 2000. "Modificaciones Al Artículo 27 Constitucional y Sus Efectos Sociales y Económicos En El México Rural ." Mexico City. http://www.atl.org.mx/coloquio/attachments/132_132_Modificaciones al art%C3%ADculo 27 constitucional y sus efectos sociales y econ%C3%B3micos en el M%C3%A9xico rural.pdf.

Rothman, H, and V Hancock. 2003. *Neon Metropolis: How Las Vegas Started the Twenty-First Century*. Routledge. http://books.google.com/books?id=K4940Wy0DikC.

Rothman, Jay. 1997. *Resolving Identity-Based Conflict in Nations, Organizations and Communities*. San Francisco, CA: Jossey-Bass.

Rowland, Marty. 2005. "A Framework for Resolving the Transboundary Water Allocation Conflict Conundrum" 43 (5): 700–705. doi:10.1111/j.1745-6584.2005.00066.x.

Sánchez-Rodríguez, Roberto, and Stephen Mumme. 2010. "Environmental Protection and Natural Resources." *UC San Diego: Center for U.S.-Mexican Studies.* http://escholarship.org/uc/item/69590158.

Scott, Christopher A, Sharon Megdal, Lucas Antonio Oroz, and Comisión Nacional. 2008. "Building Shared Vision: Assessment of Transboundary Aquifiers Along the United States - Mexico Border." In *International Conference on Water Scarcity, Global CHanges, and Groundwater: Management Responses*, 1–15.

Shah, Tushaar. 2008. *Taming the Anarchy: Groundwater Governance in South Asia*. Washington, DC: Resources for the Future Press.

Shindler, Bruce, Forest Resources, Lori A Cramer, and J Appl. 1999. "Shifting Public Values for Forest Management : Making Sense of Problems." *WJAF* 14 (1).

SNWA. 2013. "Southern Nevada Water Authority." www.snwa.com.

SNWA, and Utah Department of Natural Resources. 2009. *Snake Valley Environmento Monitoring and Management Agreement*. http://water.nv.gov/hearings/past/snake/documents/Snake_Valley_Environmental_Management_Agreement.pdf.

Sogobi, Newe, and Johnie Bob. 2013. "Running and Walking Within the 1863 Treaty of Ruby Valley Land Boundary". Austin, Nevada: Western Shoshone Nation.

Sophocleous, Marios A. 2012. "On Understanding and Predicting Groundwater" 50 (4): 528–540. doi:10.1111/j.1745-6584.2011.00876.x.

Southern Nevada Water Authority. 2012. "Southern Nevada Water Authority and White Pine Counties Groundwater Development Project Conceptual Plan of Development". Las Vegas, Nevada.

Stickney, Michaela. 2008. "Lake Champlain Basin". Waterbury, Vermont.

Sulis, M., C. Paniconi, M. Marrocu, D. Huard, and D. Chaumont. 2012. "Hydrologic Response to Multimodel Climate Output Using a Physically Based Model of Groundwater/surface Water Interactions." *Water Resources Research* 48 (12) (December 13): W12510. doi:10.1029/2012WR012304. http://www.agu.org/pubs/crossref/2012/2012WR012304.shtml.

Swearinger, Marshall. 2013. "BLM Okays Controversial Nevada Water Pipeline." *High Country News*. www.hen.org/blogs/goat/blm-okays-controversial-nevada-water-pipeline.

TAAP. 2011. "FACT SHEET : U . S . -Mexico Transboundary Aquifer Assessment Program-Arizona (TAAP-A / S) Aquifers Shared by Arizona and Sonora Outline of Program FACT SHEET : U . S . -Mexico Transboundary Aquifer Assessment Program- Arizona (TAAP-A / S) Aquifers s." *Assessment*.

Tauer, Michael D. 2011. "Evolution of the Doctrine of Equitable Apportionment-Mississippi v . Memphis." *The University of Memphis Law Review* 41 (4): 897–924.

Taylor, Publisher, Daniel Blanchette, René Lefebvre, Miroslav Nastev, Vincent Cloutier, Daniel Blanchette, René Lefebvre, Miroslav Nastev, and Vincent Cloutier. 2013. “Groundwater Quality , Geochemical Processes and Groundwater Evolution in the Chateauguay River Watershed , Quebec , Canada Groundwater Quality , Geochemical Processes and Groundwater Evolution in the Chateauguay River Watershed , Quebec , Canada” (February): 37–41.

The World Bank. 2013. “The World Bank. GDP Per Capita.” *World Bank*. http://data.worldbank.org/indicator/NY.GDP.PCAP.CD/countries?display=default.

Therborn, Goran. 1980. *The Power of Idology and Ideology of Power*. London: Verso.

U.N. 2009. *Resolution 63/124*. *Environment*. Vol. 10. United Nations, General Assembly: Official Records of the General Assembly.

———. 2013. “UNDESA.” http://www.un.org/waterforlifedecade/transboundary_waters.shtml.

U.S. Congress. 1969. *National Environmental Polici Act*.

———. 2004. *Lincoln County Conservation, Recreation and Development Act of 2004*.

U.S. Department of Commerce. 2013. “Bureau of Economic Analysis.” http://www.bea.gov/.

U.S. House of Representatives. 2005. *United States-Mexico Transboundary Aquifer Assessment Act*.

U.S.G.S. 2009. *Groundwater Atlas of the United States*. Edited by U.S. Geologic Survey and U.S. Department of the Interior. http://pubs.usgs.gov/ha/ha730/index.html.

UNESCO. 2009. “Groundwater Resources and Global Maps.” In *Atlas of Transboundary Aquifers*, edited by S. Puri and A Aureli, First, 12–30. Paris: United Nations Educational, Scientific and Cultural Organization.

———. 2013. “UN Water World Water Day 2013.” http://www.unwater.org/water-cooperation-2013/water-cooperation/facts-and-figures/.

United States Court of Appeals for the Fifth Circuit. 2009. “Hood, et Al V. City of Memphis TN, et Al.” http://www.gpo.gov/fdsys/granule/USCOURTS-ca5-08-60152/USCOURTS-ca5-08-60152-0/content-detail.html.

United States Department of the Interior. 2013. "National Atlas of the United States." *National Atlas of the United States*. http://nationalatlas.gov/.

University of Arizona. 2013. "Transboundary Aquifer Assessment Program (TAAP-A/S)." https://wrrc.arizona.edu/TAAP.

USA, and Mexico. 1944. *Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande*. USA-Mexico.

USGS. 2007. "Water Resources of the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah". Reston, Virginia. http://pubs.usgs.gov/sir/2007/5261/pdf/sir20075261.pdf.

Utah Department of Natural Resources, and Nevada Department of Conservation and Natural Resources. 2009. *Agreement for Management of the Snake Valley Groundwater System*. http://naturalresources.utah.gov/pdf/snake_valley_agree.pdf.

"Utah/ Nevada Snake Valley Agreement."

Van Vugt, Mark. 2009. "Triumph of the Commons." *New Scientist* 2772: 40–43.

Waldron, Brian, and Dan Larsen. 2013. "Did Memphis Take Mississippi's Ground Water? The $1.3 Billlion Question". Memphis, TN: The University of Memphis.

Warner, Jeroen, Mark Zeitoun, and Naho Mirumachi. 2013. "How 'Soft' Power Shapes Transboundary Water Interaction." In *GWF Discussion Paper 1323. Global Water Forum*, 6. Canberra, Australia. www.globalwaterforum.org/2013/06/03/6928.

Wilson, Elizabeth Joan. 2004. "Managing the Risks of Geologic Carbon Sequestration: A Regulatory and Legal Analysis." *Environmental Protection*. Carnegie Mellon University.

Wolf, Aaron T, Shira Yoffe, and Mark Giordano. 2003. "CONFLICT AND COOPERATION OVER INTERNATIONAL FRESHWATER RESOURCES : INDICATORS OF BASINS AT RISK 1." *American Water Resources Association* October: 1109–1126.

Zeitoun, Mark, and Naho Mirumachi. 2008. "Transboundary Water Interaction I: Reconsidering Conflict and Cooperation." *International Environmental Agreements: Politics, Law and Economics* 8 (4) (September 3): 297–316. doi:10.1007/s10784-008-9083-5. http://www.springerlink.com/index/10.1007/s10784-008-9083-5.

Zeitoun, Mark, and Jeroen Warner. 2006a. “Hydro-Hegemony – a Framework for Analysis of Trans-Boundary Water Conflicts.” *Water Policy* 8 (5) (September): 435. doi:10.2166/wp.2006.054. http://www.iwaponline.com/wp/00805/wp008050435.htm.

———. 2006b. “Hydro-Hegemony – a Framework for Analysis of Trans-Boundary Water Conflicts.” *Water Policy* 8 (5) (September): 435. doi:10.2166/wp.2006.054. http://www.iwaponline.com/wp/00805/wp008050435.htm.

Zekster, I. S., and L. G. Everett. 2008. “Groundwater Resources of the World: Transboundary Aquifer Systems (Map). e Hydrogeological Mapping and Assess-Ment Programme”. Hannover, Paris.

Zimmerman, John R. 2010. “Nevada-Utah Interstate Groundwater Negotiations.” *Natural Resources & Environment* 24 (4): 54–59.