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Towards Water Sensitive Cities in the Colorado River Basin: A Comparative Historical Analysis to Inform Future Urban Water Sustainability Transitions

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Abstract: Many population centers in the American West rely on water from the Colorado River Basin, which has faced shortages in recent years that are anticipated to be exacerbated by climate change. Shortages to urban water supplies related to climate change will not be limited to cities dependent on the Colorado River. Considering this, addressing sustainable water governance is timely and critical for cities, states, and regions facing supply shortages and pollution problems. Engaging in sustainability transitions of these hydro-social systems will increase the ability of such systems to meet the water needs of urban communities. In this paper, we identify historical transitions in water governance and examine their context for three sites in the Colorado River Basin (Denver, Colorado, Las Vegas, Nevada, and Phoenix, Arizona) to provide insight for intentional transitions towards sustainable, or "water sensitive" cities. The comparative historical approach employed allows us to more fully understand differences in present-day water governance decisions between the sites, identify past catalysts for transitions, and recognize emerging patterns and opportunities that may impact current and future water governance in the Colorado River Basin and beyond.

Keywords: transitions; water; governance; historical analysis; sustainability

1. Introduction

A growing number of disciplinary and interdisciplinary scholars have concluded that transitions towards comprehensive sustainable natural resource management are necessary as human-environment systems face grand challenges such as global climate change and political and economic instability [1]. Transitions have been defined in the sustainability literature as a gradual process of societal change leading to structural differences in major social-ecological-technical systems such as water, energy, or agriculture [1,2]. Water governance is one area of natural resource management that has been the focus of attention for sustainability transitions. The history of water management in the western United States has been marked by episodes of significant conflict, but also innovative collaboration [3]. As the population in the western U.S. steadily increased over the past century, conflicts over water allocation emerged, especially in places with large population centers and competing interests between domestic, agricultural and industrial uses. This has led to calls for water governance transitions in the Colorado River Basin [4]. Identifying patterns and understanding the context of historical transitions within a system can inform future efforts to intentionally transition

a system towards sustainability. In this research, we contribute a comparative historical analysis of water governance transitions in three cities reliant on Colorado River water. We additionally examine events at the state level that influence the three cities. Our goal is to interpret the historical context to identify patterns. Such an understanding may provide insights related to (1) catalysts and unintended consequences of past events and (2) practical considerations (such as timing and stakeholders involved) [5]. This information may be relevant to scientists, managers, and policy makers who develop strategies for transitioning sites towards more sustainable, water sensitive areas.

1.1. Transitions and Transition Management

The concept of sustainability transitions has been applied in several areas of relevant literature, including transitions management [6], resilience and transformation [7] and energy policy [8,9]. While the conceptual and operational definitions of transition vary between and even within these bodies of literature, transitions in general are defined as gradual processes of societal change. For instance, in the transitions management literature, the concept is defined as "a gradual process of societal change in which society or an important subsystem of society structurally changes" [10]. Other bodies of literature have sometimes used the terms "transition" and "transformation" interchangeably, leading to confusion [11]. In this article, we employ the definition and characteristics of transitions outlined in the transition management literature, following [6]. This definition combines elements of definitions used in the transitions, resilience, and energy policy literature and is directly related to understanding systems to provide insight into transitions towards sustainable natural resource governance.

Transitions are characterized as being gradual or incremental, often spanning generations, and non-linear, occurring as multiple variables change simultaneously. The S-curve (Figure 1) is used to describe phases of a transition in the sustainability transitions literature [1], similar to the S-curve in technological adoption and diffusion of innovation theory [12] and related research. The four main phases are: predevelopment (the status quo holds, but contestations begin to appear), takeoff (system changes begin, due to social or technological innovation), breakthrough (also "acceleration"; changes become more prominent as the innovations in social, economic, ecological and other areas begin to accumulate), and stabilization (changes decrease, and a new dynamic equilibrium is established).

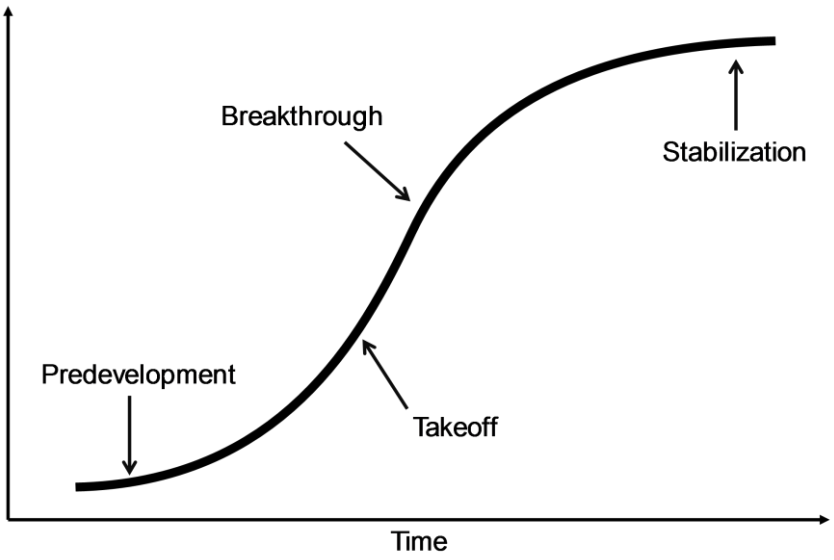

Figure 1. S-curve. See [13] for a detailed figure and discussion of features such as backlash and path dependency.

A transition can be accelerated or altered by a single event (such as a war or natural disaster), analogous to a focusing event [14,15] or policy window; a single event however is not sufficient

to initiate a transition [6]. This is because transitions are ultimately caused by multiple forces, exogenous and endogenous. Transition management thus examines how multiple variables and efforts may interact to produce different outcomes to guide or influence transitions that lead to system transformations. The implementation of the idea of transitions management for sustainability can be traced in part to the process to develop the 2001 fourth Dutch National Environmental Policy Plan (NMP4). The plan took a vanguard approach, looking 30 years into the future. Considering this, the goal of transition management is "to bring about a transition from present functional systems towards more sustainable systems" [6] (p. 4). This can be accomplished with adaptive and multilevel governance; in the resilience literature, transitions and transformations may also be assisted by adaptive and multilevel governance [16]. Recently, transitions management has been considered in the context of past long-term policy planning efforts [17]. Previous long-term efforts have been critiqued for their inflexibility, resulting in rigid planning approaches that often failed [17]. Transitions management attempts to avoid these past mistakes, by adopting a more reflexive approach, but much related research has ignored the political context and processes in which transitions are embedded. Historical analyses can help explore these political processes. With an understanding of the conceptual foundations of transitions, we turn our attention next to considering approaches for analyzing water governance with the aim of integrating these bodies of literature.

1.2. Approaches to Analyzing Sustainable Water Governance

Many cities globally have worked towards bolstering the sustainability of their water supply systems [18,19]. Given this, practitioners and scientists have considered the elements that make a city's water supply system sustainable. There are multiple approaches to analyzing the sustainability of water governance, and the transitions management literature has recently been linked to systems approaches through, for instance, the "water, people and sustainability" systems framework for analyzing water governance regimes [20] or the sustainability wheel assessment [21]. These approaches aim to provide an overarching understanding of an entire water governance system, inclusive of natural science, engineering, and social science perspectives, capable of informing change and innovation [22]. Integrating an in-depth understanding of the social, institutional, built, and hydrological components of a water governance system with a set of transparent sustainability principles provides insights into which sustainability principles (such as those related to equity or environment) are being achieved and how those that are unmet can be addressed [22].

Another systems approach to conducting sustainability assessments of water governance is the "sustainability wheel" [21], which is an analytical framework that is interdisciplinary in nature. Such approaches can account for multiple perspectives and types of knowledge inherent to water governance. A strength of systems approaches to sustainability assessments of water governance more broadly is that they focus on multiple characteristics of water governance and their interactions, such as social learning, adaptive capacity, infrastructure, or water quality or supply [21]. Although it is acknowledged that innovations in governance may promote transformational solutions for societal transitions [23], it is difficult to operationalize governance innovations. Frameworks like the sustainability wheel and comprehensive sustainability principles can aid stakeholders in identifying actionable steps to operationalize normative sustainability goals. The weaknesses of these frameworks include the practicality of collecting (or accessing) relevant data for the multiple social, ecological, and other variables.

1.3. Water Sensitive Cities

Brown et al. [24] introduced the concept of "water sensitive cities" as another conceptual framework to explore the sustainability of water systems. Water sensitive cities are defined as those cities that meet three key principals: (1) "access to a diversity of water sources" with both centralized and decentralized infrastructure; (2) "provision of ecosystem services for the built and natural environment" and (3) "socio-political capital for sustainability and water-sensitive behaviors" [25].

The water sensitive cities framework includes several stages that cities progress through including "water supply", "sewered", "drained", "waterways", "water cycle", and "water sensitive" cities. Each of these stages is associated with distinct characteristics including expanded water infrastructure, a focus on public health-related water issues, environmental regulations, the recognition of water as a limited resource and inter- and intra-generational equity. Currently, no single city that has been assessed has met all facets of the three criteria associated with the water sensitive city, but several cities globally have made substantial progress in attempting to adopt the water governance characteristics [25]. For instance, the sustainability transitions literature has informed cities' efforts to become water sensitive in Australia and Singapore. Australian cities face many of the same issues as urban areas in the Colorado River Basin, especially water shortages in the face of increasing droughts exacerbated by climate change.

Successful transitions towards water sensitive cities have often involved focusing on transformational (as opposed to incremental) improvements in one of the three principals of water sensitive cities. For instance, increased domestic use of recycled wastewater and rainwater resulted in an over 80 percent reduction in potable water usage in certain Australian cities [25]. Creating water sensitive cities ultimately requires surpassing conventional approaches to water governance and employing socio-technical resources to engage in innovative management of complex social-hydrological systems [26]. Additionally, governance in water sensitive cities is likely to differ from traditional water governance arrangements, particularly in that stakeholders need to regularly work together to manage risk and will require high levels of trust [27].

Although the water sensitive cities framework is useful for providing insights into a city's progression towards sustainable water governance, the framework has several potential weaknesses. These include that the framework may be too linear (i.e., cities do not always follow the same sequence from water supply cities towards water sensitive cities) and may also make several unconfirmed assumptions (e.g., why is a diverse portfolio of water sources necessarily always better if a city has access to a long-term water supply from a primary source?).

Overall, the framework is a useful starting point for examining transitions in water governance, provides normative characteristics for cities to accomplish, and can lend insight into how other cities have transitioned between sets of progressive water governance characteristics in the past. To increase the credibility of any sustainable water governance analysis, it is important to justify the normative elements and goals by clearly articulating the values associated with sustainability principles [22]. The water sensitive cities framework is inherently value laden, but allows researchers to explore transitions, associated with different values, in a more transparent way. In this article, we use the water sensitive cities framework to explore historical transitions in water governance in three western U.S. case studies in the Colorado River Basin.

1.4. Water Governance Transitions in Three Western U.S. Cases

The Colorado River is the lifeblood of the western United States. It provides drinking water to one in 10 Americans across cities including Phoenix, Denver, Las Vegas, and Los Angeles. The water irrigates more than five million acres of land to grow crops like alfalfa, cotton, and lettuce. Hydropower plants along the river provide more than four thousand megawatts of renewable electricity. The river supports ecosystems in several national wildlife refuges and national parks, including the Grand Canyon, and stimulates over $1 billion in annual tourism revenue. The river is also integral to the history, culture, religion, and economy of nearly two dozen Native American tribes [28].

The Colorado River is also the most completely allocated and heavily regulated river system in the world [29], and the region is projected to suffer increasing water supply deficits by mid-century [30]. The river is managed through a patchwork of laws, court decisions, and regulations that are collectively known as "The Law of the River" [31]. These agreements guide the allocation of water between seven U.S. states and Mexico. The foundation of it all is The Colorado River Compact of 1922, which defined the relationship between the upper basin states, Colorado, New Mexico, Utah, and Wyoming, where

90% of the water originates, and the lower basin states, Arizona, California, and Nevada, where most of the water demands have developed.

Case Study Sites and Comparative Historical Analysis

Political, economic and social efforts related to water governance in Colorado River Basin states have been punctuated by distinct policy, law, and infrastructure changes. Some of these changes characterize transitions, where elements of water governance gradually shifted across years. We identify and explore historical transitions in water governance in a cross-site study focusing on three sites in the lower basin: Denver, Colorado; Las Vegas, Nevada; and Phoenix, Arizona. We selected these locations to facilitate cross-site comparisons between places that are similar in important aspects such as receiving a substantial amount of their residential water supply from the Colorado River, but also differ on several variables that may have influenced differences in historical water governance transitions. These include belonging to the upper basin (Denver) and lower basin (Phoenix and Las Vegas), having different water governance structures, and different biophysical climatic conditions.

Given that it is not feasible to conduct "natural experiments" in cities, where key variables are held constant and variables of interest are changed while examining the response of outcome variables, this comparative case study approach [32] is useful for identifying and exploring variations in historical transitions. Comparative historical analysis is a method with a rich history in the social sciences and humanities [33]. It has provided insights into areas ranging from how revolutions occur (e.g., [34]) to how energy systems have changed over centuries (e.g., [35]). Comparative historical analysis, in contrast to methods like statistical inference, starts from the premise that the specifics and degree of variability in each case should be explored before assuming generalizations can be drawn between cases [36]. Comparative historical analyses have made substantial contributions to environmental policy, including providing the opportunity to gain a systematic understanding of the past, linking culture, society and technology, to inform future natural resource policy and governance efforts [5]. Most scholars agree that historical analyses involve empirical data in some format [5]. As the amount of existing research on the Colorado River Basin is large, we relied on existing in-depth research that incorporated both primary and secondary sources, similar to other approaches in historical energy transitions (e.g., [37]).

Our analysis is not intended to be comprehensive and include every water governance event in our case study sites, but rather is presented as an overview of events synthesized in the context of identifying historical transitions and breakthrough events. Limitations of our analysis include our narrow discussion of Native American water rights and associated transitions in the Colorado River Basin. Native American water rights in the Basin remain contested and complex, and other research has focused on these issues in-depth (e.g., [38,39]).

In the next section, we present an overview of the transitions we have identified as relevant to water governance in each of our three sites. We proceed to provide the historical context of each of these transitions, exploring water governance events in decadal periods from the 1800s to the present. This detailed timeline and context provides a relevant overview of water governance in our sites useful for water regulators, providers and distributors; scientists; and other stakeholders. Few studies of historical sociotechnical transitions have provided recommendations or insight into how individuals or organizations might act to reach defined (and inherently normative) policy goals for sustainability transitions [40]. In our discussion, we compare the overlap and identify critical differences in the findings from each site to clarify information relevant to future sustainability transition efforts in water governance towards what we believe is the goal: working towards implementing the characteristics of water sensitive cities in the western U.S. and other cities globally.

2. Decades of Transition in Arizona, Colorado, and Nevada

Since the 1800s, several identifiable transitions have occurred in water governance in Arizona, Colorado, and Nevada (Table 1). Here, we identify transition breakthrough events that influenced

the existing status quo and the catalysts that likely engendered them. We explore the context of these transitions by examining the related events in each case in each decade, starting with the 20th century to the present.

Table 1. Historical transitions across Arizona (AZ), Colorado (CO) and Nevada (NV).

Year	State(s)	Transition "Breakthrough" Events	Reasons/Catalysts	Stage in the Water Sensitive Cities Framework [24]
1902	CO, NV, AZ	Theodore Roosevelt promulgated the National Reclamation Act	Mounting political and social pressure to support western U.S. development	
1922	CO, NV, AZ	The Colorado River Compact was formulated by the seven basin states	Political entrepreneur	
1928	CO, NV, AZ	The Boulder Canyon Project Act was passed by Congress, approving construction of the (renamed) Hoover Dam	Technological innovation; political pressure to expand water supplies in the western U.S.	
1963	CO, NV, AZ	The United States Supreme Court's decree in the case Arizona v. California (1963) upheld the allocation of lower basin water to the lower basin states outlined in the 1928 Boulder Canyon Project Act	Results from previous Arizona v. California cases	
1999	CO, NV, AZ	The Secretary of the Interior issued regulations allowing interstate water banking among the lower basin states	Technological innovation in water storage; pressure from states to formalize water conservation efforts	
1932–1935	CO	Eleven Mile Canyon Dam and Moffat Water Tunnel Diversion Projects were constructed	Dust Bowl drought event and President Roosevelt's New Deal's Public Works Administration Program	In progress towards becoming a drained city
1997	CO	Denver Water issued a new Conservation Master Plan including water conservation strategies	Drought, social/ideological shift in public's views of conservation	Waterways city with rhetoric support for the water cycle city from water providers and at the city and state policy level
2006	CO	Denver Water began a new water conservation advertising campaign, entitled "Use Only What You Need"	Prolonged drought conditions	
1955	NV	Las Vegas began receiving Lake Mead water	Political and social pressure to limit reliance on declining groundwater	Drained city
1991	NV	The Southern Nevada Water Authority was established	Political and social pressure	Waterways city with regular environmental regulations
1995	NV	The first conservation plan for the Las Vegas region was developed	Pressure from citizens to consider future water supplies and sustainability	Rhetoric support for the water cycle city from citizen and environmental groups

Table 1. *Cont.*

Year	State(s)	Transition "Breakthrough" Events	Reasons/Catalysts	Stage in the Water Sensitive Cities Framework [24]
1864	AZ	The Howell Code was adopted, establishing "first in time, first in right" regarding "prior appropriation for surface water"	Political pressure to adopt formal water rights similar to established western states	Water supply city
1944	AZ	Arizona ratified the Colorado River Compact	Political pressure and fear of losing water supplies to Mexico	Drained city
1980	AZ	The Groundwater Management Act was promulgated, formally prioritizing conservation efforts prior to many western states	External political pressure; perceived threat of federal funding losses for water development projects	Drained city progressing towards waterways city with increased environmental regulation
1993	AZ	The Central Arizona Groundwater Replenishment District was established	Political pressure related to the impending implementation of assured water supply rules	Rhetoric support for the water cycle city from citizens and other stakeholders

2.1. 1800s: European Settlers Begin (Re)constructing Water Infrastructure and Searching for Water in the Southwest, Establishing "Sewered Cities"

From 300 C.E. to approximately 1450, the Hohokam, a Native American culture, lived in the Salt River Valley in the area around present-day central Arizona, with the support of an elaborate system of irrigation canals they constructed [41]. The original canal system supported up to 50,000 people. The exact reason for the disappearance of the Hohokam from the region remains unknown, but their masterful canal system served as the basis for the water system that European settlers began expanding in the southwest in the 1800s [42]. As permanent cities were established in the region, the need to provide water infrastructure and consistent water supply for industrial, agricultural, and residential purposes increased.

As European settlers continued to expand westward in the United States, the territories of Arizona, Colorado, and Nevada attracted people hoping to strike gold or secure larger land parcels. During the latter half of this century, Arizona, Colorado, and Nevada adopted legislation that influenced water governance for decades to come (Figure 2) [43]. The governments of the regions that would become the cities of Denver, Las Vegas, and Phoenix were moving towards "sewered cities." Efforts were focused on implementing sewage systems and investing in water treatment and monitoring facilities.

This period was marked by the adoption of the prior appropriation doctrine, both implicitly and explicitly. Prior appropriation doctrine was new to many settlers, as it is markedly distinct from riparian water rights and characterized a "takeoff" period, or the beginning of a system change due to policy innovations, on an S-curve. Under prior appropriation, water rights do not belong to the land and can be sold without selling the land. Despite the common misconception that prior appropriation doctrine originated in arid regions in the western United States, historians have documented that it was common in mining regions globally as far back as the Middle Ages [44]. In 1863, Arizona officially became a territory as it separated from the existing New Mexico territory. A year later, the Arizona territorial legislature adopted the Howell Code, which proved to be a critical moment in the state's water rights and governance. The policy established the "first in time, first in right" doctrine regarding "prior appropriation for surface water" in Arizona [44]. Colorado adopted prior appropriation in 1882 (Coffin v. Left Hand Ditch Co.). Nevada, except for a brief period in the 1870s–1880s, always used prior appropriation doctrine for water. Related water rights laws in Nevada were enacted beginning in the 1860s [45]. Prior appropriation doctrine continues to characterize water rights in arid regions of the western United States today.

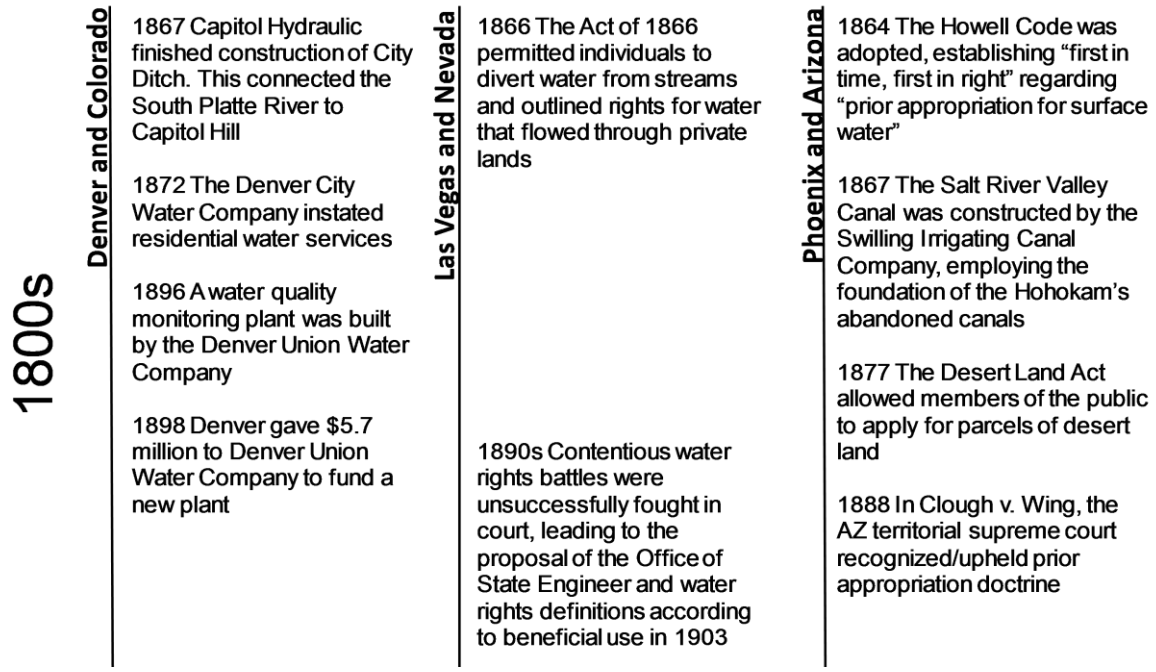

Figure 2. Timeline of significant events in the 1800s.

2.2. Early 1900s: The National Reclamation Act is a Breakthrough in Water Policy and Governance

As the United States' population continued to increase, the federal government realized that water infrastructure expansions and upgrades were becoming progressively vital. The promulgation of the National Reclamation Act by Theodore Roosevelt in 1902 was a breakthrough event in water governance in the western United States (Figure 3) and provided the means to fund major water infrastructure improvements and additions throughout the country [46]. The Act was key to continued western United States' industrial and residential development and established that " . . . beneficial use shall be the basis, the measure, and the limit of the right" ([47], p. 76). The act recognized that the arid southwestern United States needed irrigation networks to provide water to its growing population. The U.S. Reclamation Service (now known as the Bureau of Reclamation) was created to manage the resulting funds from the sale of public lands that the Act determined could be used for water infrastructure and development projects. The Act's promulgation represented the accumulation of years of prior concerns with the existing state of funds available to expand water development in the western United States. Without the National Reclamation Act, it would have been extremely difficult to fund major water infrastructure projects, such as the Hoover Dam, that support present populations in Denver, Las Vegas, and Phoenix.

Shortly after the passage of the National Reclamation Act, ranchers and farmers from the metropolitan Phoenix area formed the Salt River Valley Water Users' Association (SRVWUA) [48]. The SRVWUA became the first combined water and power reclamation project in 1903. Water developments in early 20th century Denver were primarily marked by infrastructure expansions, including the construction of several reservoirs (Marston, Platte Canyon, Antero and Cheesman) [49]. These efforts were significant, with Cheesman Dam and Reservoir being the tallest in the world at the time of construction, and represented efforts to shift these regions towards "drained cities" with expanded urban delivery and drainage infrastructure.

In 1905, formal water governance efforts in Las Vegas were nascent. The San Pedro, Los Angeles and Salt Lake City Railroad, which would later become the Union Pacific Railroad, established the Las Vegas Land and Water Company (LVL&W) [50,51]. The Las Vegas Land and Water Company provided

water to residents, farmers and businesses via wells and underground springs (the Las Vegas Springs). Other infrastructure and water sources were not added until later in the 20th century.

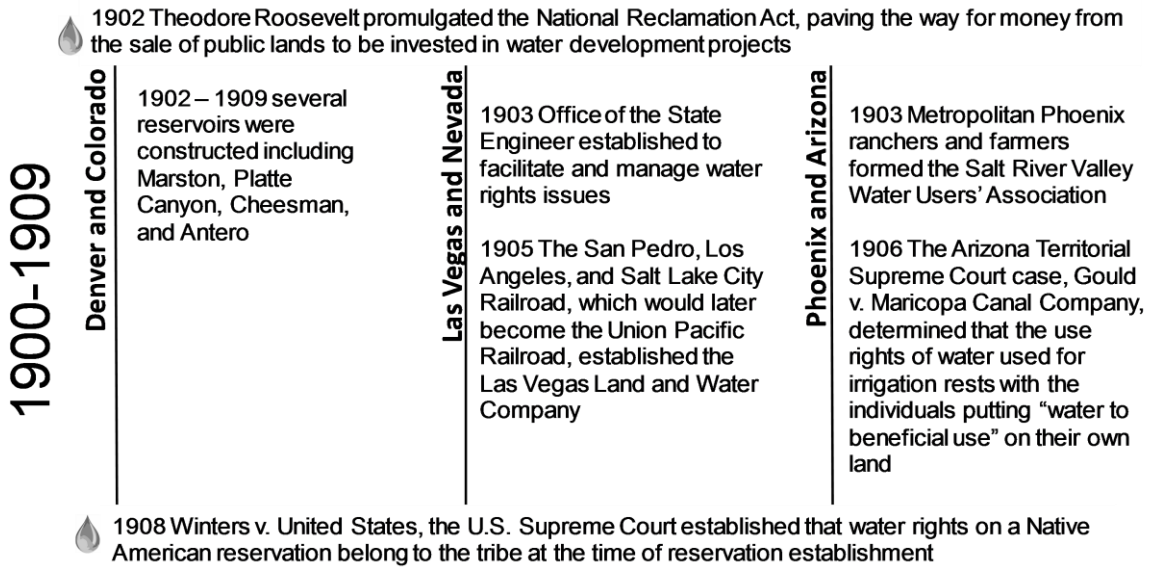

Figure 3. Timeline of significant events in the early 1900s.

2.3. 1910s: Colorado River Basin States Face Water Supply Pressures, Building Momentum in Predevelopment and Takeoff Prior to the Colorado River Compact

With the recent National Reclamation Act, new water infrastructure was invested in, and battles over who would control residential water supplies continued in Denver. The predevelopment stage associated with the future Colorado River Compact took shape in this decade as policymakers and stakeholders began to question the present and future equitable allocation of Colorado River water. By 1910, Arizona was preparing to become a state, and the constitution was adopted by delegates as a preamble to statehood in 1912; the constitution reaffirmed prior appropriation doctrine and beneficial use of water. Phoenix completed infrastructure expansions critical to its continued growth including the Theodore Roosevelt Dam northeast of Phoenix by the Bureau of Reclamation in 1911 (currently managed by the Salt River Project) [52]. Colorado water companies disputed water resources, and several improvements were made to Denver's water supply during this decade, including the addition of chlorine in 1911. In 1918, Denver purchased the Denver Union Water Company and rechristened it Denver Water; Denver Water continues to manage most of Denver's water supply today [49].

Denver's concern with public health issues related to water embodied characteristics of the "sewered city," prior to the city adopting all of the characteristics of a "water supply" city (Figure 4). Infrastructure including dams and pipes would continue to be completed as the city simultaneously focused on reducing issues like water-borne illnesses (such as cholera). Nevada's state legislature revised state water law in 1913, and the basic statutory principles have endured to the present. The principles recognized groundwater and made early references to conserving Nevada's groundwater [45]. This decade also saw the formation of the League of the Southwest, whose membership was comprised of the seven states that would later sign the Colorado River Compact. These social changes, including the formation of the League, were part of takeoff events, precursors to the coming breakthrough of the Colorado River Compact. The League was formed to promote economic development throughout the southwest, which eventually included lobbying for the creation of an agreement among the states regarding Colorado River water allocation [44].

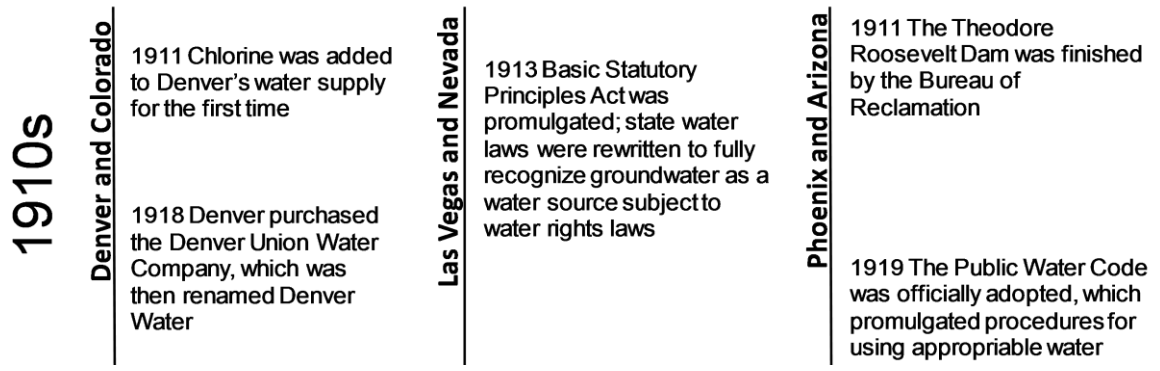

Figure 4. Timeline of significant events in the 1910s.

2.4. 1920s: The Colorado River Compact as a Breakthrough Event in Water Policy

The 1920s saw the passage of two policies that would dramatically shift the course of water allocation and use in states relying on Colorado River water, representing breakthrough events in western United States' water policy. In 1922, the Colorado River Compact was created by the seven Colorado River Basin states. It was called "the most ambitious illustration of interstate agreements" [53]. The compact established upper and lower basin boundaries and allocated 7.5 million acre feet (MAF) per year to each basin. Arizona abstained from ratifying the compact at the time partially because it was unhappy with the treatment of its Salt and Gila tributary rivers. Near the end of the decade, Congress passed the Boulder Canyon Project Act in 1928, approving the (renamed) Hoover Dam with the stipulation that the Colorado River Compact must be ratified. As the Act also provided a means to pass the compact without Arizona's approval, it was ratified, and California, Arizona, and Nevada were allocated a portion of the Colorado River's lower basin 7.5 MAF annual allotment (4.4, 2.8 and 0.3 MFA respectively). With the compact ratified, the Secretary of the Interior became the authority for lower basin Colorado River water use [44].

In Phoenix, from 1925–1927, the Salt River Project constructed several new dams to expand its hydroelectric power generation and water distribution in the metropolitan area [52] (Figure 5). In contrast, Denver experienced a drought in the early to mid-1920s and subsequently implemented irrigation restrictions in the surrounding region [54]. With these restrictions and others, Denver began to recognize the need for environmental regulation of and the limits of water supplies. This incremental shift in perspective from local stakeholders contained elements of a "waterways" and "water cycle" city. This is an example of a non-linear transition where a city simultaneously embodies characteristics associated with different stages in the water sensitive cities framework before fully realizing these later stages, such as having characteristics of a "water cycle city" prior to a "waterways city." Additionally, although Nevada was also allocated Colorado River water under the compact, Nevada's largest metropolitan area, Las Vegas, left this surface water largely untouched until decades later [55]. In Nevada, this reservation of Colorado River water did not yet represent a recognition to the limits of water supplies, but was instead a reflection of the state's ongoing use of groundwater supplies.

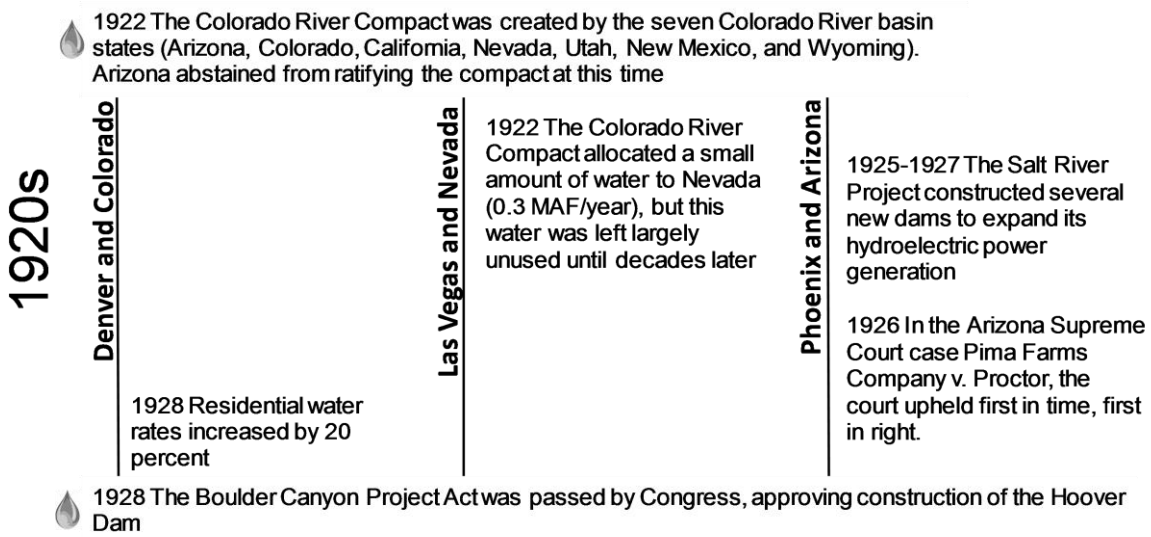

Figure 5. Timeline of significant events in the 1920s.

2.5. 1930s: Cities Expand Water Infrastructure, Striving to Become "Drained Cities" during the Dust Bowl

The 1930s brought the worst drought in U.S. history, the Dust Bowl. Despite the severe drought conditions that plagued much of the Midwestern and western U.S., water expansion projects continued in some states, as larger cities sought to improve drainage and storage designs to become "drained cities" responsible for providing safe, limitless water to their constituents (Figure 6). In Denver, Eleven Mile Canyon Dam was constructed in 1932. In 1935, as part of President Roosevelt's New Deal's Public Works Administration Program, the Moffat Water Tunnel Diversion Project in Denver commenced, and water delivery occurred one year later [49]. Amid apprehension surrounding diminishing groundwater supplies in Arizona, a group was appointed to study groundwater supplies and characteristics in 1938. This group catalyzed the appropriation of funds to the U.S. Geological Survey for the purposes of monitoring Arizona groundwater [56]. In 1935, the Hoover Dam was completed on the border of Arizona and Nevada, with the reservoir created named Lake Mead. Lake Mead would later provide most of Las Vegas's residential water supply.

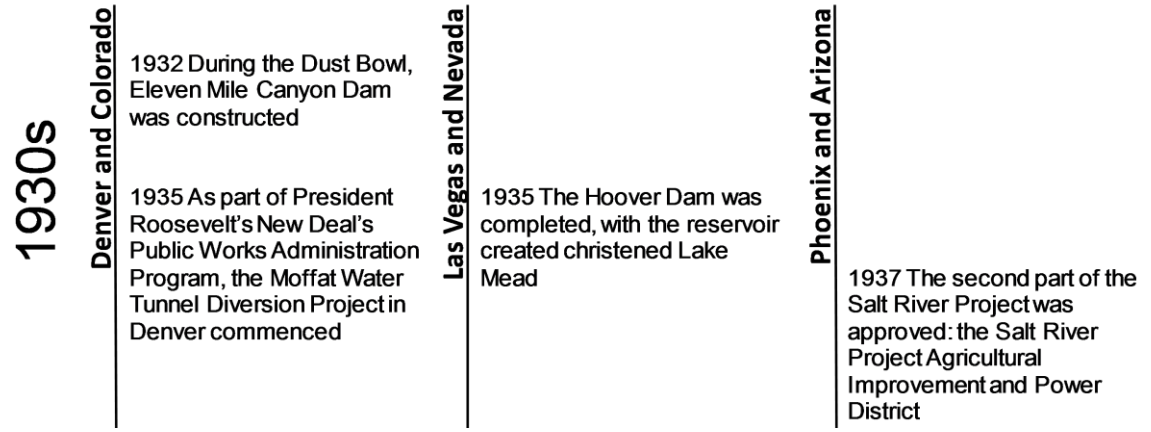

Figure 6. Timeline of significant events in the 1930s.

2.6. 1940s: The Central Arizona Project Enters Predevelopment, and Arizona Approves the Colorado River Compact

The 1922 Colorado River Compact ignored Mexico, but Mexico continued contesting this exclusion. In 1944, these efforts produced the Mexican Water Treaty, which officially allocated 1.5 MAF of Colorado River water to Mexico annually [44]. Arizona belatedly ratified the Colorado River Compact this same year, largely due to concerns related to the fate of Arizona's share of the water with the signing of the Mexican Water Treaty and the state's desire to seek approval for a reclamation project to divert water to central and southern Arizona, the Central Arizona Project [44].

The project's eventual completion represents a transition in water governance facilitated by a policy breakthrough. The reclamation project was intended to contest existing access to Colorado River water and maximize Arizona's use of its allocation by diverting water to central and southern Arizona, including metropolitan Phoenix. With securing the project's approval in mind, Arizona adopted their first Groundwater Code in 1945, requiring all wells to be registered. However, the Bureau of Reclamation declared the code insufficient to protect groundwater supplies. The Bureau warned Arizona that the Central Arizona Project would not be approved without stricter groundwater regulations, beginning a decades' long struggle between the Arizona legislature's desire to maintain lax status quo regulations and the Bureau's insistence that groundwater supplies be sustainably managed [56].

Due to increasing demand, Basic Management Incorporated in Las Vegas began employing the water from the Colorado River Compact in Lake Mead for industrial tasks in 1942 (Figure 7). Las Vegas residents continued to receive water from groundwater supplies, which began to show signs of overuse, prompting nascent contestations (predevelopment) regarding the wisdom of sustained groundwater use. The Nevada state legislature soon established the Las Vegas Valley Water District (in 1947) to begin to shift water usage in Las Vegas and Clark County away from groundwater supplies and towards the state's Colorado River allocation [57].

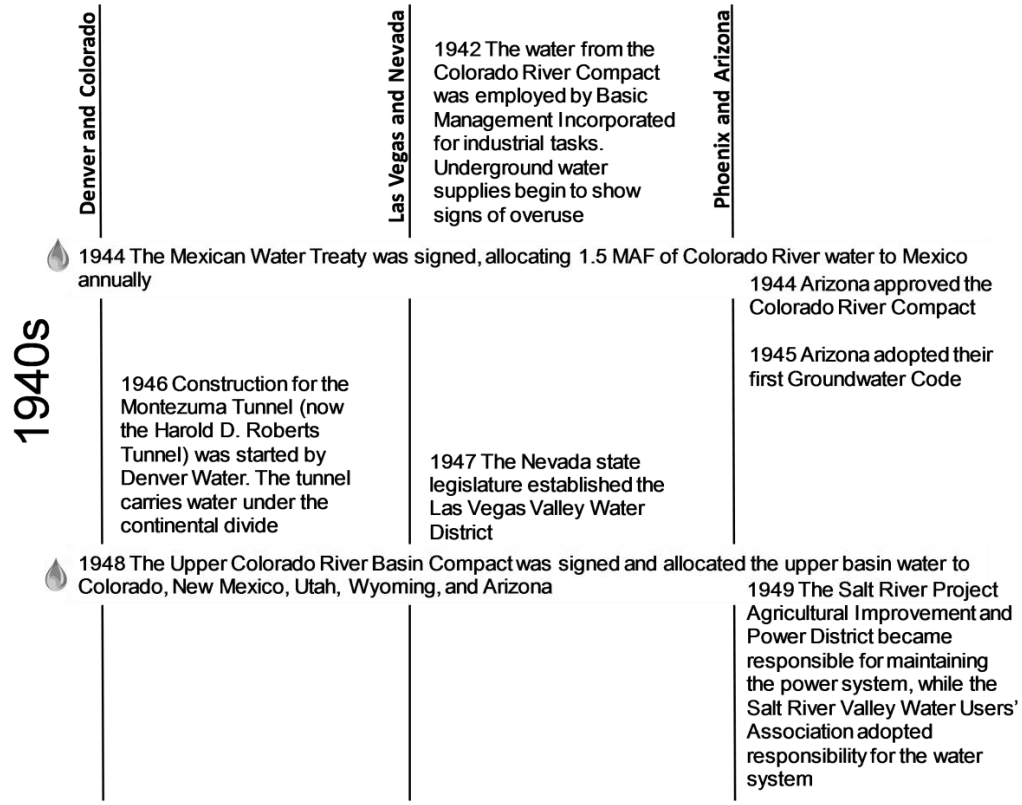

Figure 7. Timeline of significant events in the 1940s.

2.7. 1950s: Residential Water Services Expand in "Drained Cities"

Continuing its efforts to regulate groundwater to gain support for the Central Arizona Project, Arizona established a second groundwater study commission in 1951 to respond to federal criticism of the existing groundwater code (Figure 8). However, the legislature ultimately refused to adopt any of the commission's recommendations, and the Groundwater Code remained unchanged [56]. Phoenix, Denver and Las Vegas all expanded residential water services and infrastructure during the 1950s, and Las Vegas residents began receiving Lake Mead water, preserving more of Nevada's groundwater [57]. Infrastructure expansions, including efforts related to water storage, drainage and delivery, firmly identified these cities as "drained cities."

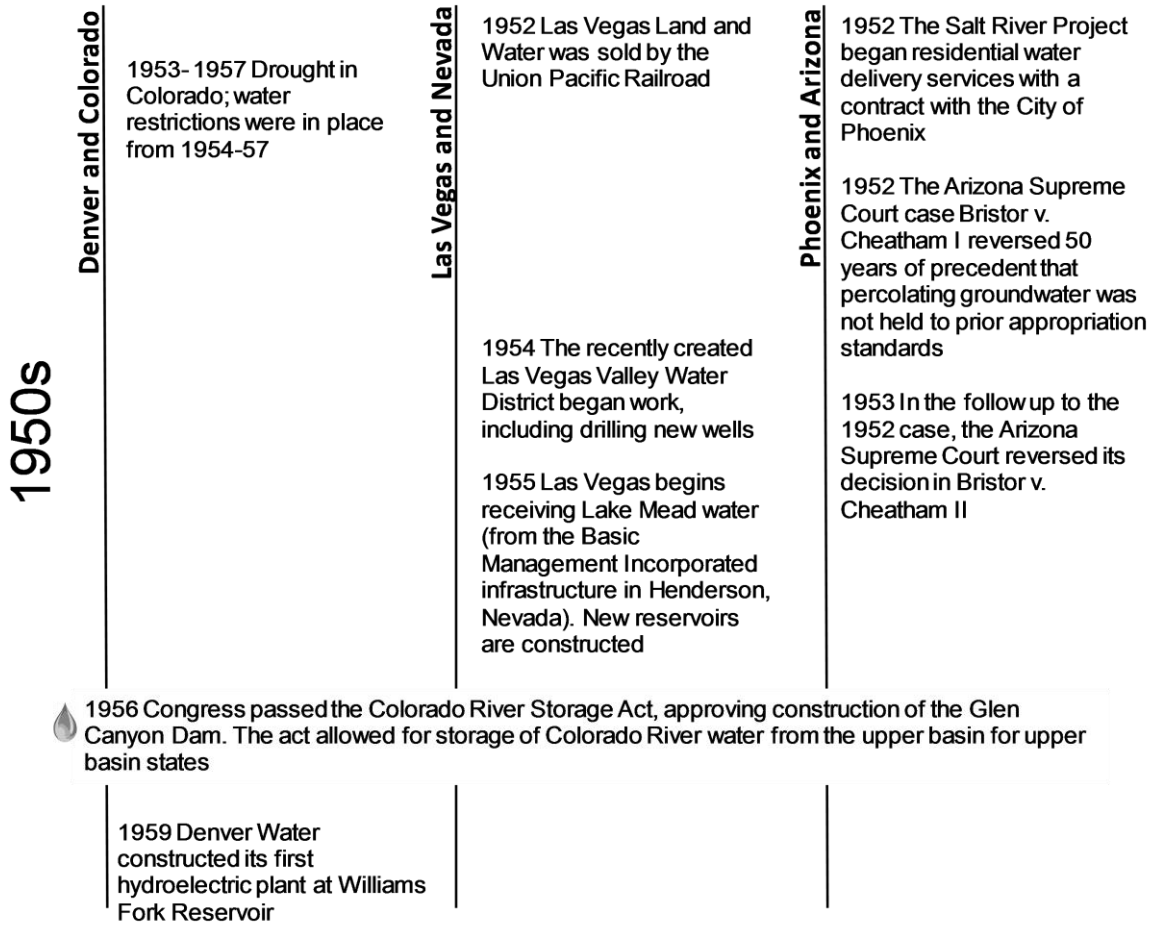

Figure 8. Timeline of significant events in the 1950s.

2.8. 1960s: Arizona v. California and Central Arizona Project Approval Breakthroughs

Arizona v. California is a set of U.S. Supreme Court cases, but the 1963 case was a breakthrough in western U.S. water governance in that it decided the contentious issue of the Colorado River's tributary waters. The rulings also directly impacted the amount of water Nevada received, as well as influencing the future of the Colorado River Compact for all involved states. The rulings upheld the allocation of Colorado River water to the lower basin states outlined in the 1928 Boulder Canyon Project Act. The court also ruled that the water allocated to the three lower basin states only included the Colorado River's main stream (excluding the tributaries residing in each state) [58]. This ruling was in Arizona's favor, as it left the state rights over its significant tributaries, the Gila and Salt Rivers. It has since been argued that this ruling, and its focus on the main Colorado River, has contributed to unsustainable water use as the new status quo in the water constrained lower basin [59].

The Colorado River Basin Project Act was passed by Congress in 1968, approving the construction of the Central Arizona Project (Figure 9). The act included the caveat that during water shortages, California has rights to its full annual 4.4 MAF before any water is allocated to the Central Arizona Project [60]. However, the passage of this act was not the final condition for Central Arizona Project construction; this progress represented part of the takeoff stage, as the act still required federal funding, and contentions between Arizona and the Bureau of Reclamation would continue.

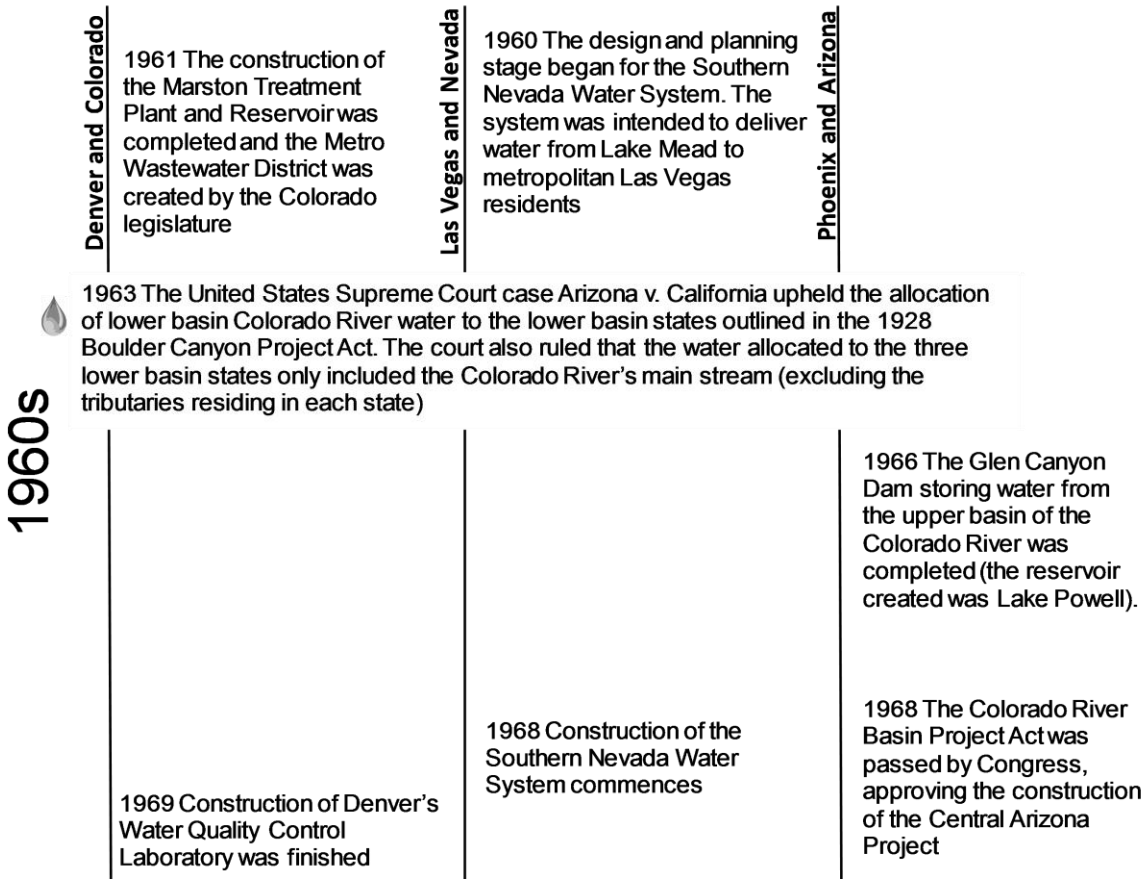

Figure 9. Timeline of significant events in the 1960s.

2.9. 1970s: Large Infrastructure Projects Encounter Federal and Local Pushback amid Environmental Concerns, with Cities Gaining Rhetorical Support for Becoming "Waterways Cities"

Construction of the Central Arizona Project Canal began at Lake Havasu City in 1973, but the project was not operational for another decade. Groundwater regulations in the state remained unresolved. In 1977, revisions to the 1948 Groundwater Code were issued because of collaboration between agricultural, municipal, and mining parties. However, in 1979, after internal discussions with Arizona's Governor Babbitt, Secretary of the Interior Cecil Andrus catalyzed the imminent 1980 breakthrough as he cautioned Arizona for a final time that the Central Arizona Project would not be funded if the state refused to pass a stricter groundwater code [56].

As water infrastructure expanded through the mountains in Colorado, tensions between environmentalists and developers increased in the 1970s. In 1974, the Foothills water treatment complex was proposed by Denver Water. The proposed plant involved escalated trans-mountain water diversion, which environmentalists opposed. After years of negotiation, the 1979 Foothills Agreement stipulated the establishment of a Citizens Advisory Committee for citizens impacted by water facility development that would advise the Board of Public Concerns on this and other water-related issues [49].

With Nevada's largest population center in Las Vegas, the success of the city's shift from reliance on its groundwater supplies to surface water from the Colorado River allotment in Lake Mead was important (Figure 10). In 1971, the Southern Nevada Water System was largely completed and initiated water delivery to Las Vegas residents. As the state became more conscientious of its water usage and supplies, citizens also fought for water conservation via different avenues. In 1978, the Las Vegas Springs received National Historic Place status, the result of citizens' efforts to protect it from ongoing development in the area [61]. These tensions between environmentalists and water developers represented emerging support for the idea that water was a social amenity worthy of protection from pollutants and other environmental concerns. The actions of environmentalists in Denver and Las Vegas initiated the adoption of characteristics of "waterways cities", joining Phoenix residents' earlier calls for environmental concerns related to groundwater use and river restoration.

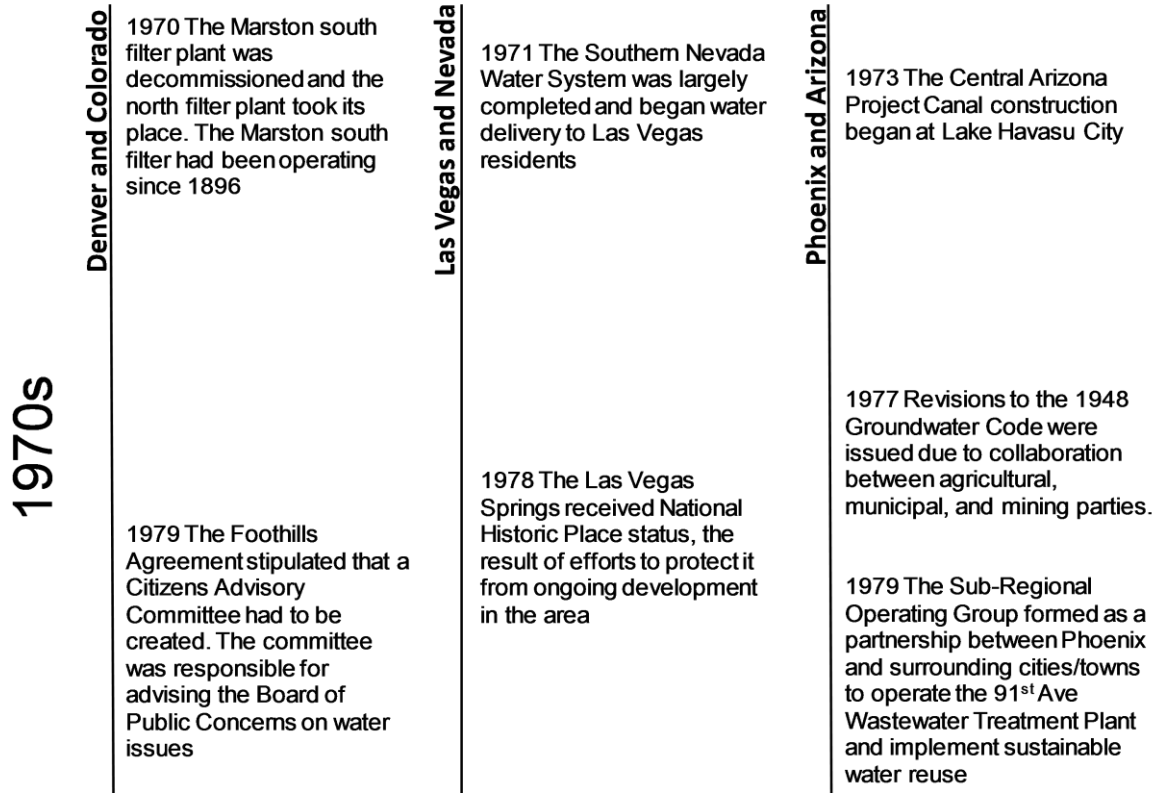

Figure 10. Timeline of significant events in the 1970s.

2.10. 1980s: Arizona Passes a Federally-Approved Groundwater Act, and New Water Conservation Efforts Challenge the Status Quo

A breakthrough in water governance in Arizona was reached with the passage of the innovative 1980 Groundwater Management Act, which established the Arizona Department of Water Resources to ensure the act was adopted as intended [62]. The act initiated mandatory conservation requirements. After its passage, Secretary of the Interior Cecil Andrus informed Arizona that the Central Arizona Project would be funded.

In Colorado, water conservation messages also became more prominent during the 1980s, beginning to challenge the status quo of limitless water supply (Figure 11). In 1981, a Denver Water employee coined the term "xeriscape," which is now commonly known in the western U.S. and elsewhere as a minimal water use landscape design [63]. Near Denver, the large Foothills water treatment plant was opened by Denver Water in 1983 after years of obstacles [49]. Amid the continued expansion of the Southern Nevada Water System, concerns for the environment also emerged. The 1988

Supreme Court case Nevada v. Morros upheld the Nevada State Engineer's decisions related to ecosystem conservation, upholding the Endangered Species Act and assuring water rights to federal agencies for wildlife and recreation [45]. These actions further strengthened the stance of Denver, Las Vegas, and Phoenix as emerging "waterways cities" concerned with the environment.

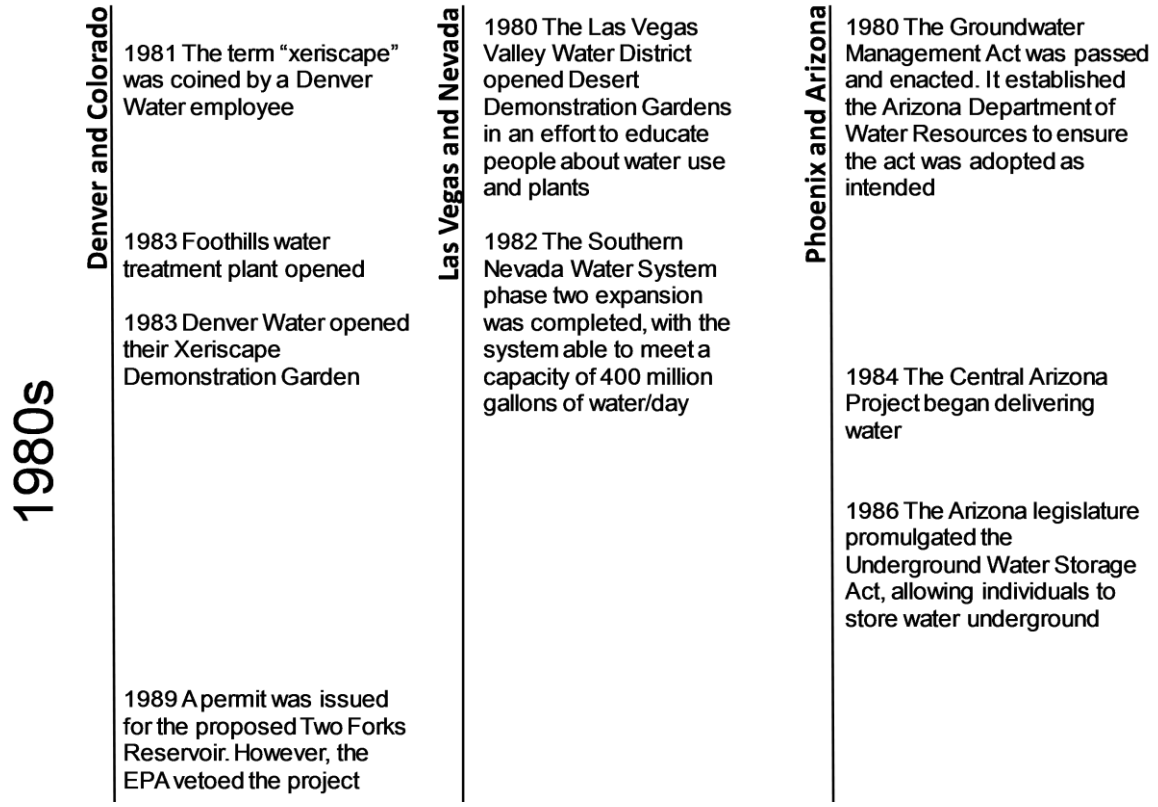

Figure 11. Timeline of significant events in the 1980s.

2.11. 1990s: Water Conservation Gains Prominence throughout the West, and the Ideas of the "Waterways City" Are Implemented with Increasing Regularity

Over the past two decades and by the 1990s, residential water suppliers in the west increased residential water conservation efforts due to pressure from environmentalists and concerns about water supply, signaling a gradual movement towards more sustainable water governance. The 1990s witnessed the introduction of several water banking programs related to the Colorado River. In 1996, the Arizona Water Banking Authority was authorized both to purchase unused Central Arizona Project water to store for shortages and to store Colorado River water at the request of Nevada or Colorado, and Phoenix and other cities in Arizona implemented and updated conservation plans [64].

In Denver, water conservation efforts became more formalized, and in 1997, Denver Water issued a new Conservation Master Plan including numerous water conservation strategies (Figure 12). Similarly, conservation efforts also became more formalized in Las Vegas; the Southern Nevada Water Authority authored five-year conservation master plans with water conservation strategies and goals. These concerns in all three cases represented nascent support for transitioning towards "water cycle" cities, which are characterized by a change in discourse recognizing the inherent limits of water and the need for conservation.

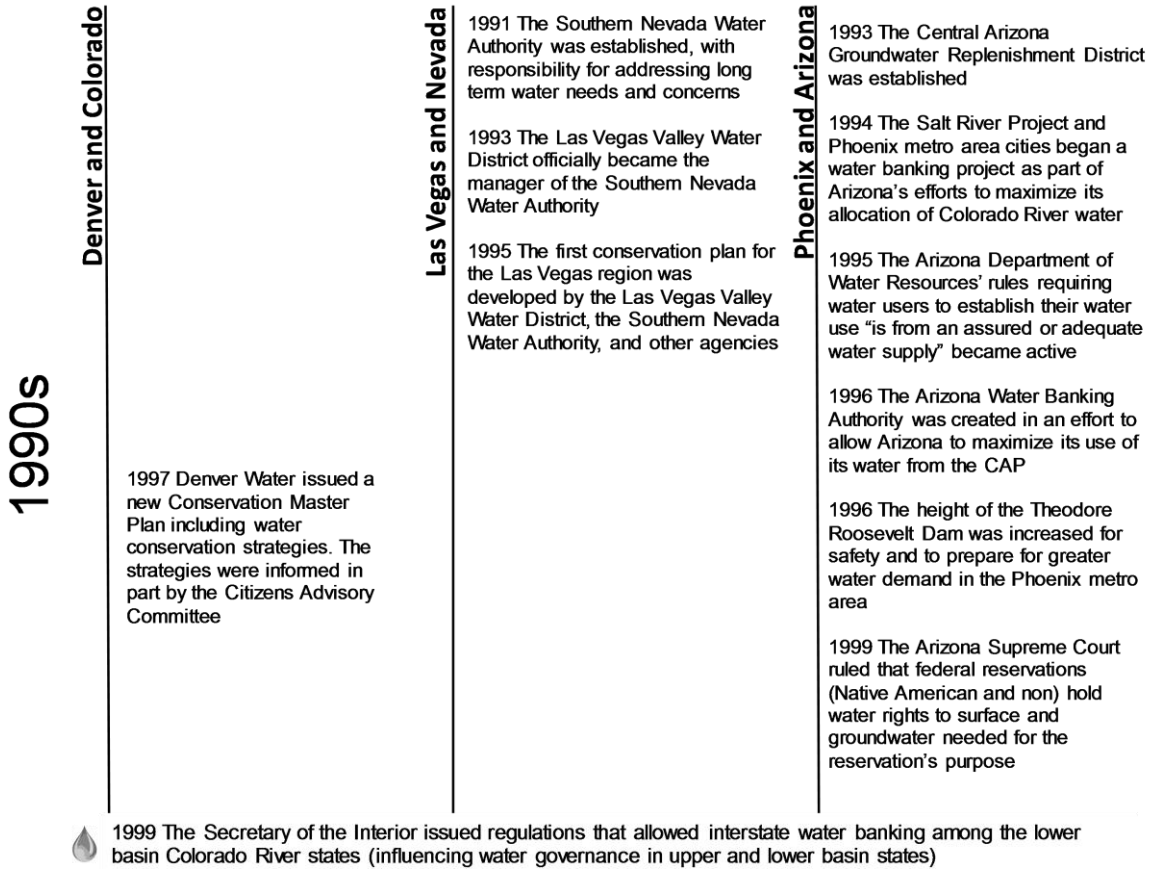

Figure 12. Timeline of significant events in the 1990s.

2.12. Early 2000s: Water Conservation Efforts and Rhetoric Support for the Recognition of Limited Water Supplies Advance Incrementally

During the 2000s, formal water conservation and education efforts advanced in all three cases (Figure 13). In 2005, the Arizona legislature enacted the Community Water System planning and reporting requirements, necessitating that all community water systems providing water to the public create supply, conservation, and drought plans every five years and submit annual reports to the Arizona Department of Water Resources. Colorado faced additional major wildfires in 2000 in the South Platte's watershed, contributing to sediment dispersal and reservoir problems. Around 2001, the Colorado River Basin began experiencing a major drought, pushing the Southern Nevada Water Authority to produce a drought plan that was adopted in 2003. These efforts were consistent with predevelopment events in the beginning of a transition towards the characteristics of "water cycle cities".

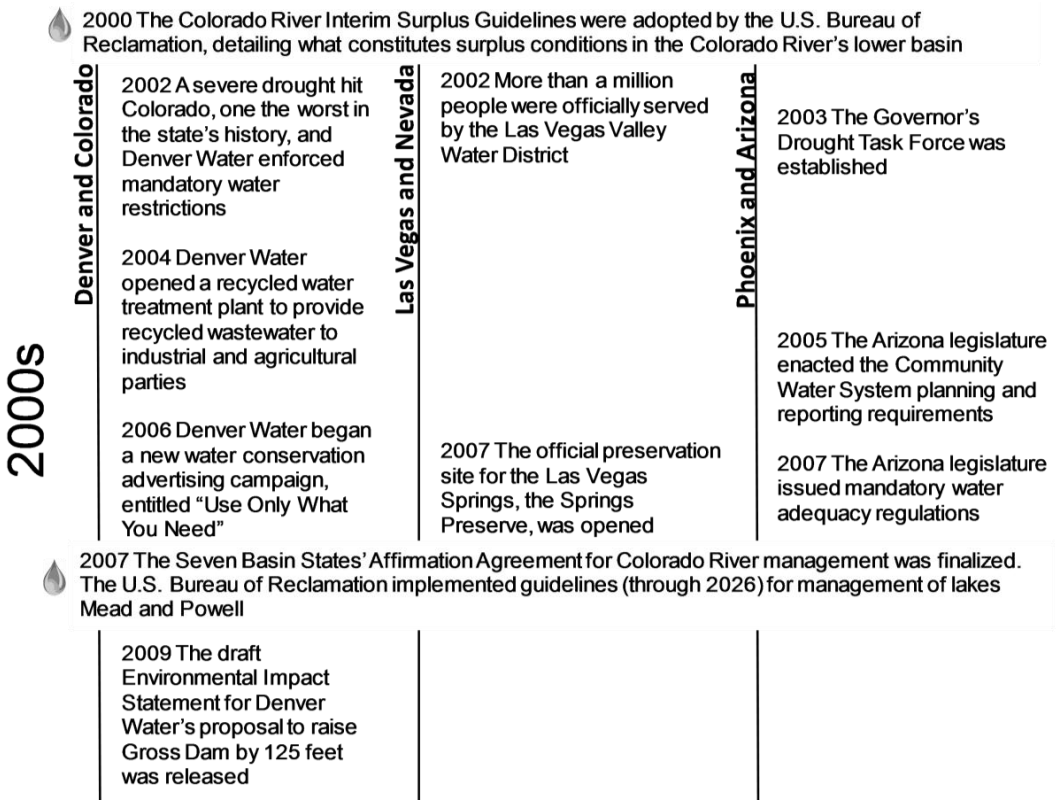

Figure 13. Timeline of significant events in the early 2000s.

2.13. 2010s: Sustainability Emerges as a New Discourse, and Ideas Associated with "Water Sensitive Cities" Are Recognized

In this decade, sustainability discourse became more widespread as major residential water providers in Arizona, Colorado, and Nevada attempted to respond to environmentalists' concerns about the sustainability of water consumption and supplies (Figure 14). Responses were also addressing scientists' projections that water supplies in the Colorado River may continue to dwindle in drought conditions and shortages may be declared [60]. Residential water suppliers in all three cities and states made efforts to produce sustainability-related assessments and materials, including conservation, sustainability, and energy efficiency reports. Related efforts are ongoing in all three cases, but the focus on sustainability in terms of environment, economy, and society from environmental groups and other stakeholders is a gradual recognition of the principles of "water sensitive cities." It has been argued that these emerging efforts are not enough to incite a transformation in water demand and usage, especially in the agricultural and industrial sectors, that may be necessary if (perhaps more accurately, when) drought conditions are declared in the Colorado River Basin [65,66].

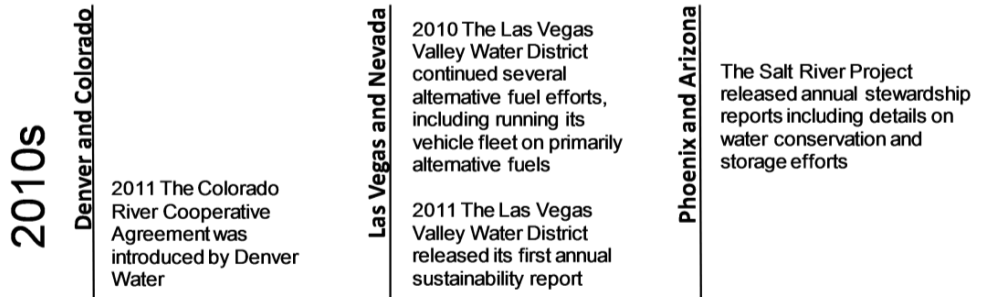

Figure 14. Timeline of significant events in the 2010s.

3. Discussion

Over the past two centuries, water governance has undergone numerous connected and overlapping transitions in the western United States. Through these cumulative transitions, urban water systems in the Colorado River Basin experienced a gradual movement towards efforts to conserve and sustainably manage water supplies in the region. Despite this, critics have argued that these states and cities are not doing enough to ensure a sustainable future water supply [67,68]. Applying concepts from the sustainability transitions literature, insights can be gained that have the potential to aid efforts to create secure water futures in these states and other locations.

Here, we discuss whether the four characteristic phases of the S-curve (predevelopment, takeoff, breakthrough, and stabilization) are present in the transitions identified for Arizona, Colorado, and Nevada. We also discuss the transitions in the context of the stages of the water sensitive cities framework. The presence or absence of S-curve and water sensitive cities' characteristics can aid researchers' and practitioners' understanding of what drives specific transitions and assist in the identification of patterns among different transitions. These insights may potentially be applied to manage intentional transitions. We limit ourselves to examining the fit of phases of the S-curve and discussing the water sensitive cities framework with breakthrough events that we identified as being relevant to all three cases in Table 1.

3.1. The National Reclamation Act Facilitates the Development of Drained Cities

Frustrations related to securing funding for major water projects increased in the late 1800s. Large investments in water projects began to be considered necessary to continue to develop the western United States, and concerns about obtaining funding were voiced to political leaders (predevelopment). In 1901, Theodore Roosevelt took office and was committed to ensuring "the sound and steady development of the West" [69] (takeoff). Political efforts before and during Roosevelt's early presidency began to accumulate and resulted in the promulgation of the National Reclamation Act in 1902 (breakthrough). After the promulgation of the act and the creation of the Bureau of Reclamation, stakeholders regularly proposed and implemented new water projects (stabilization). This investment in the widespread expansion of water infrastructure in the western U.S. helped cities adopt the characteristics of "drained cities".

3.2. The Colorado River Compact and Nascent Recognition of Limited Water Resources

For decades prior to formal efforts to distribute Colorado River water, the federal and state governments had a desire to "tame" the Colorado River and more efficiently distribute its resources between all seven U.S. states that relied on them (predevelopment). After several prior meetings that failed to produce political agreements, the seven states sent representatives to meet in New Mexico in 1922 to draft a formal agreement related to the use of the Colorado River (takeoff). On 24 November 1922, Herbert Hoover (then Secretary of Commerce) announced the committee had reached an agreement on the wording and whole of the treaty that would be known as the Colorado River Compact (breakthrough). The Colorado River Compact was nascent recognition that water was a limited resource. The western U.S. additionally experienced several droughts around this time, further contributing to changing discourse identifying water as a scarce (as opposed to unlimited) resource. Thus, several western U.S. cities, including Denver, began embodying characteristics of "water cycle" cities. In this case, the new paradigm of water as a scarce resource began to emerge before environmental regulations related to water (a characteristic of "water ways" cities) were implemented. Although the treaty was not ratified until 1928 and would not be ratified by Arizona until decades later, it was nonetheless an historic and influential agreement reached after years of concern and arguments about regulating and using Colorado River water. The project led to a large increase in agricultural and industrial productivity in the west and contributed to the region's imperialist relationship between power and water (stabilization).

3.3. Backpedaling from "Limited Water" Discourse with the Boulder Canyon Project Act

With the Colorado River Compact ratified by all but one of the basin states and funding available under the National Reclamation Act, there was a desire to construct major engineering projects on the Colorado River (predevelopment). Las Vegas began to witness Nevada's groundwater supplies diminish and sought a way to utilize their Colorado River allocation in the future, to broaden their water resources (takeoff). The Boulder Canyon Dam was proposed; it would be the largest dam in the world at the time. The dam was approved via the accumulation of multiple political efforts, overcoming environmentalists' concerns. Lake Mead was eventually used as Las Vegas' and Clark County's primary water source (stabilization). The Boulder Canyon Project Act contrasted the idea that water was a limited resource that had slowly emerged during this time resulting from droughts and the passage of the Colorado River Compact.

3.4. Further Retreat from the Characteristics of Water Cycle Cities: Arizona v. California (1963)

Arizona had opted not to ratify the 1922 Colorado River Compact in large part because Arizona and California failed to reach an agreement on key provisions of the compact, including how much water each state would receive and how each state's tributary waters would be apportioned (predevelopment). In this case, there is not a clearly identifiable "takeoff" period that involves policy or technological innovation. The 1963 case and decisions were a result of several previous Arizona v. California cases and part of a continued effort to allocate Colorado River water and resolve unclear portions of the Colorado River Compact to each state's satisfaction. In 1963, the court ruled on Arizona v. California (1963) (breakthrough). After the case's conclusion, states began adopting the rulings, and Arizona litigated internal battles related to the use of its tributaries (stabilization). With the court's decision, the status quo was cemented, and water usage in Arizona tributaries continued to be utilized unsustainably. This represented a reversion from the characteristics of "water cycle" cities, as water was again treated as an unlimited resource.

3.5. Formal Steps toward Water Cycle Cities and Increased Conservation Discourse: Interstate Water Banking

Water banking authorities were established in the lower basin states in the 1990s to work towards maximizing the use of Colorado River water (predevelopment). Water banking organizations in these states worked with the federal government to develop and promote legislation that would formalize and allow interstate water banking (takeoff). In 1999, the Secretary of the Interior promulgated an official interstate water banking agreement for the lower basin states (breakthrough). Although the 1999 "storage and interstate release agreement" developed by Arizona to allow for water banking among Arizona, California, and Nevada did not directly include Colorado, the agreement influenced broad trends in Colorado River water governance and began to promote conservation-oriented thinking among Colorado River Basin states (stabilization). The interstate water banking agreement represented a step towards water cycle cities, as the limited nature of water resources and conservation discourse became more prominent.

3.6. Patterns and Deviations in Transitions

Generally, each of the transitions in water governance follows the four phases identified in transitions literature, and some key patterns emerge. For example, we see that stabilization does not always happen or may be delayed (i.e., there may be time lags) and is difficult to observe in a complex system with multiple variables changing simultaneously. The takeoff phase can be difficult to identify as takeoff is also the result of a multitude of factors. Systems and historical approaches can help identify these factors. Critical events that threatened the status quo expansionist mindset [67] and those in positions of power often accompanied and catalyzed the takeoff phase. In the case of the Colorado River Compact, representatives met and sequestered themselves for treaty negotiations in New Mexico only after battles over water rights reached a crisis point, where development projects

were stalled after World War I. Officials in Nevada began to push for the Boulder Canyon Act when they realized the state's groundwater supplies were disappearing. Considering Arizona v. California (1963), where there is no clear takeoff period, breakthrough was similarly preceded by a messy series of court cases and decades of other legal battles related to water rights.

When examining the application of the water sensitive cities framework in Denver, Las Vegas, and Phoenix, the progression through the phases of the framework is not always linear. For instance, Denver adopted characteristics of the "water cycle" city prior to adopting those of the "water ways" city, while Las Vegas and Phoenix oscillated between the characteristics of "drained," "water ways" and "water cycle" cities. As in the cases of Phoenix and Las Vegas adopting and discarding characteristics of "water cycle" cities, cities may regress to earlier stages of the framework in the future. This may be facilitated as water infrastructure (technical and/or socio-political) decays (e.g., the case of Flint, Michigan's water system [70]). Additionally, some cities may exhibit the characteristics of multiple stages simultaneously, which may be desirable depending on existing water governance and local actors' values (e.g., cities in economically developing countries may value simultaneously strengthening public health and environmental regulations). Considering these possibilities, the water sensitive cities framework provides an incomplete picture that rests on key assumptions like any framework, but recognizing this, it is a useful tool for instigating dialogue related to and exploring (1) how water systems have developed in the past and (2) how they can move towards more sustainable water systems. The framework may be made more accurate with simple revisions, such as adding bidirectional arrows between the phases, acknowledging the often nonlinear nature of progress towards sustainable water governance.

From our analysis, understanding the circumstances surrounding takeoff in past transitions is critical to learning how to catalyze and influence the breakthrough of future transitions. Given that the breakthrough period is often preceded by a period of crisis, it is relevant to question whether breakthrough can occur without a state of political and/or social disorder. Brown et al. [71] suggests that breakthrough typically occurs because of influential questioning of the status quo by political entrepreneurs and citizen activists. If it is possible that breakthrough resulting in transformational water policy changes will continue to occur in the future because of arduous struggles against the (unsustainable) status quo, this suggests that those seeking to make transformational changes may have to be involved in the incremental process of a transition, including monitoring the political climate and being ready to propose, garner support for, and implement changes.

Considering the urgency of water governance issues in the western U.S. and other locations with similar climate and water supply stressors [72], it is relevant to consider if the speed of transitions towards sustainability can be increased compared to those of the past. Are there methods to influence the stages of a transition? This is where the transitions management literature can contribute information on the successes and failures of past efforts to intervene and influence the speed, direction, and outcome of transition efforts. Although historical transitions in water governance have marginally increased the sustainability of water governance practices in Arizona, Colorado, and Nevada, to transition to water sensitive cities and regions, managed transitions may be necessary. Transitioning a system towards sustainability fundamentally involves changes in key variables (such as those related to policy, climate or technology) and sometimes a state change of the system [73].

The transitions management literature assumes at its core that managing multi-variable, nonlinear, multi-level transitions to alternative system trajectories is possible. Transition management must involve long-term thinking and a multiscale focus on learning and innovation [74]. The initial stages of a transition management plan should also include strategizing and inventorying many possible solutions and trajectories for the future sustainable system [75]. These concepts should change with learning and collaborative development. Managing a sustainability transition relies on understanding, identifying, and taking advantage of a "policy window" or a "window of opportunity" [16]. Managing transitions concerns "the role and status of critical junctures, and the possibility of anticipating turning

points and moments when strategic nudging has the potential to change the trajectory of even complex and embedded systems" [40].

Despite the difficulty of guiding transitions in complex sociotechnical systems, managed sustainability transition efforts have been successful in the past. However, since the field is nascent, most examples are still in progress (i.e., the system is in the process of transitioning). As noted earlier, no cities globally currently meet the full criteria of a water sensitive city [24], but substantial progress has been made in transitioning the sociotechnical systems in several Australian cities, including Melbourne. Although the U.S. has critiqued the Australian example for being driven by the federal government and the costly reallocation of water (from agriculture), metropolitan Melbourne has often been identified as an international leader in urban water governance and sustainability [26]. Melbourne's partially managed transition to an "urban stormwater quality management" framework largely followed the S-curve. This included social activism challenging the water quality/management status quo, increasing knowledge and building partnerships, establishing water quality targets that defined a niche, and the stabilization of that niche through means such as securing state-wide support and funding for the water governance initiatives [26].

Arizona, Colorado and Nevada will face unique challenges in transitioning to water sensitive systems. Based on past and current water governance efforts, cities in Arizona and Nevada are likely to encounter political limitations, especially regarding state-level policy efforts. Indeed, it has been asserted that Arizona's efforts towards increasing the sustainability of its water supply are a mirage [67]. It has been argued that the 1980 Groundwater Management Act has continued to support water sustainability in appearance, but the innovative Act has been gradually weakened with legislative amendments. Specifically, the Central Arizona Groundwater Replenishment District has been critiqued for providing loopholes to key provisions of the original Act such as assured water supply requirements [76,77]. The Las Vegas metropolitan area responded to water shortages in the 1940s and 1970s by overdrafting their primary aquafer and increasing their usage of Colorado River water, respectively. Nevada has faced many of the same issues as Arizona, as the government in both states perpetuated a narrative of inexhaustible water supplies early in the twentieth century, contributing to high per capita water consumption despite actual water availability [78]. Nevada has implemented water conservation programs in the past few decades, but numerous water basins in Nevada remain over-appropriated.

Arizona, Colorado, and Nevada have devoted increasing resources for sustainable water governance over the past three decades, including analyses to explore alternative water resources, such as aquafer storage and recovery [79]. In Colorado, cities have utilized demand management strategies [80]. Colorado's formal interest in demand management supports a situation amenable to managed sustainability transitions. It has been argued that adopting adaptive water policies with use restrictions and demand management will be important to water sustainability under uncertain climate change scenarios [81–83]. With population growth and industrial/agricultural expansion predicted to continue in Arizona and Nevada [84,85], water demand management will be key to sustainability transition plans in these states [67,86], but water demand management is often contentious. In Phoenix, it was discovered that increased public engagement, social equity and attention to ecological processes are needed to strengthen water governance sustainability [22]. Sustainable water governance in the Colorado River Basin would benefit from shifting towards cooperative, integrated approaches, including increasing coordination between local, state and federal levels and among different regional water basin management projects [86].

Our analysis found that there are different factors influencing water governance outcomes in the three cases, but questions about the influence of specific policies, rules, norms, and different actors need further exploration. Future work will utilize institutional analysis (with the institutional analysis and development framework) to systematically understand the actors involved and the conditions under which collaborative efforts have succeeded and failed in the past.

4. Conclusions

Water governance in the western United States has a contentious history distinct from water governance in the rest of the country. This is due in large part to the reduced water availability in the west, and under climate change scenarios, the Colorado River is projected to experience reduced streamflow [87,88]. Over 33 million individuals and significant portions of the agricultural and industrial sectors in Arizona, Colorado, and Nevada currently rely on Colorado River water. Given this, it is imperative that policymakers and stakeholders engage in efforts to increase the sustainability of its governance. Our historical timeline and identification of transitions in water governance advance our understanding of how and when transitions occur, providing insight to researchers, policymakers, and others looking to implement managed transitions towards sustainable water governance in the Colorado River Basin. Our results highlighted that meaningful changes in water governance in Arizona, Colorado, and Nevada have often taken decades of arguments and struggle between federal and state policymakers, agriculture, industry, and environmentalists. Recent efforts in all three cases to promote water conservation, particularly residential water conservation, have resulted in varying levels of success in increasing water systems' sustainability, but perhaps represent an opportunity to encourage stakeholders to work together to design and implement a governance plan for a transition towards water sensitive cities that will empower these regions to continue to exist and thrive in the future.

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