

THESIS

**WHEN THE WELL'S DRY, WE KNOW THE WORTH OF WATER:²
GROUNDWATER MINING IN DOUGLAS COUNTY, COLORADO**

Submitted by

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In partial fulfillment of the requirements

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² Benjamin Franklin, *Poor Richard's Almanac*, quoted in J. R. McNeill, *Something New Under the Sun: An Environmental History of the Twentieth-Century World* (New York: W. W. Norton, 2000), 149.

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY CAROL HUTTON LUCKING ENTITLED "WHEN THE WELL'S DRY WE KNOW THE WORTH OF WATER: GROUNDWATER MINING IN DOUGLAS COUNTY, COLORADO" BE ACCEPTED AS FULFILLING, IN PART, REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS.

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ABSTRACT OF THESIS

WHEN THE WELL'S DRY, WE KNOW THE WORTH OF WATER: GROUNDWATER MINING IN DOUGLAS COUNTY, COLORADO

The 1980s and 1990s saw a huge population explosion in the Denver metropolitan area. In the search for a long term water supply, the Denver Water Board proposed building a massive 1.1 million acre foot dam and reservoir on the South Platte River. Opponents of the project argued that it was unnecessary – conservation was needed before such a radical building project. Additionally, the area that would have been inundated was billed as a unique recreation spot in the state of Colorado. Supporters of the Two Forks Project felt it was necessary for the continued growth of the Front Range, and they worried that without Two Forks, the Front Range community would be forced to rely on non-renewable groundwater and purchasing water from agricultural communities on the plains.

Now, more than twenty years after William Reilly of the Environmental Protection Agency rejected the Two Forks Project, Douglas County, a large suburban community south of Denver is on the brink of a water disaster as they rely almost exclusively on water from the nonrenewable Arapahoe Aquifer. This aquifer is being drawn down at an estimated thirty feet per year. Yet because the water source is invisible, people are mining it with little understanding of the consequences. Ultimately, the residents of Douglas County will need another water source – a renewable source.

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INTRODUCTION

In October 1988, Leonard Rice Consulting Water Engineers, Inc. prepared a report confidently predicting that the Denver Basin aquifers that underlie Douglas County, Colorado would supply the county with water for “considerably longer than 400 years.”³ While county commissioners probably were delighted to hear this, they still looked elsewhere to secure a long term renewable water source for county residents. Since 1988, estimates on the life of groundwater aquifers underneath Douglas County have been gradually revised downward, with current models forecasting ten to twenty years of accessible water supply.⁴

These widely varying predictions – 400 years to 10 years – of water supply reflect trends in groundwater use and management: scientific confusion has resulted in a lack of water laws and management practices that could mitigate both environmental and human impacts of groundwater mining. In addition to the unknown quantities of groundwater in the Denver Basin aquifers, groundwater’s ability to flow unchecked and unseen beneath administrative and manmade boundaries makes governing groundwater use incredibly difficult.⁵ Groundwater’s disregard for boundaries and its subsequent extraction is similar to the rule of capture in the oil industry as well as early first come, first serve natural resource policy in the United States. In the oil industry, the first person to tap the

³Leonard Rice Consulting Water Engineers, Inc., “Douglas County Water Authority Review of Douglas County Water Advisory Board Report on Water Supply, Demand and Institutional Needs, October 1988,” Douglas County Water Advisory Board Records, Douglas County History Research Center, Douglas County Libraries, Castle Rock, Colorado, (hereafter DCHRC).

⁴Robert G. Reynolds, “Stratigraphy and Water Levels in the Arapahoe Aquifer, Douglas County Area, Denver Basin, Colorado,” *The Mountain Geologist* 41, no. 4 (October 2004): 195-210.

⁵Mark Fiege, “Weedy West: Mobile Nature, Boundaries, and Common Space in the Montana Landscape,” *Western Historical Quarterly* 35, no. 1 (Spring 2005): 22. Fiege highlights the “incompatibility of human boundaries and forms of mobile nature” including water.

deposit could pump it even if the oil lay under someone else's property. This encouraged wasteful pumping as a well owner would pump as much oil as possible before his neighbor could drill a well and pump from the same body of oil. Like oil, water's ability to move underground unchecked by humans has often led to wasteful consumption of this non-renewable resource.⁶ In addition, the value of oil led to some disreputable practices as well owners dug slant wells to facilitate extracting oil from under a neighboring property.⁷ The confusion that surrounds groundwater, both cognitively and in terms of the volume of water an aquifer can produce, has resulted in a complete lack of monitoring and conservation policies in deep aquifers. In Douglas County this cognitive dissonance between apparently abundant tap water and the depletion of the underground water body has enabled the rapid mining of a nonrenewable resource. Depletion of this groundwater could leave many residents without a source of water.

Douglas County is situated at the base of the Rocky Mountains along the Front Range between Denver and Colorado Springs. The terrain rolls away from foothills punctuated by buttes until it flattens into a vast agricultural swath on the Great Plains. The Western border of the county is the South Platte River, but Douglas County residents have very minimal access to the South Platte and its tributaries because Denver and farmers in northeastern Colorado claimed the water rights first. Plum Creek and Cherry Creek also flow through the county, but aside from Castle Rock's recent acquisition of

⁶ Martin Melosi, *Coping with Abundance: Energy and Environment in Industrial America* (Philadelphia: Temple University Press, 1985), 47-49.

⁷ Melosi, 49. The well head of a slant well is on person's property while the shaft of the well is drilled at an angle that usually terminates in an oil field under a neighboring property. This is not a legal practice, but since it is largely unseen like the oil it pumps, it can be difficult to catch. Similarly, groundwater can be pumped with a slant well although the prevalence of this practice is largely unknown.

115 acre feet of surface water from Plum Creek and a few historic water rights, most of the water flows out of the county.⁸

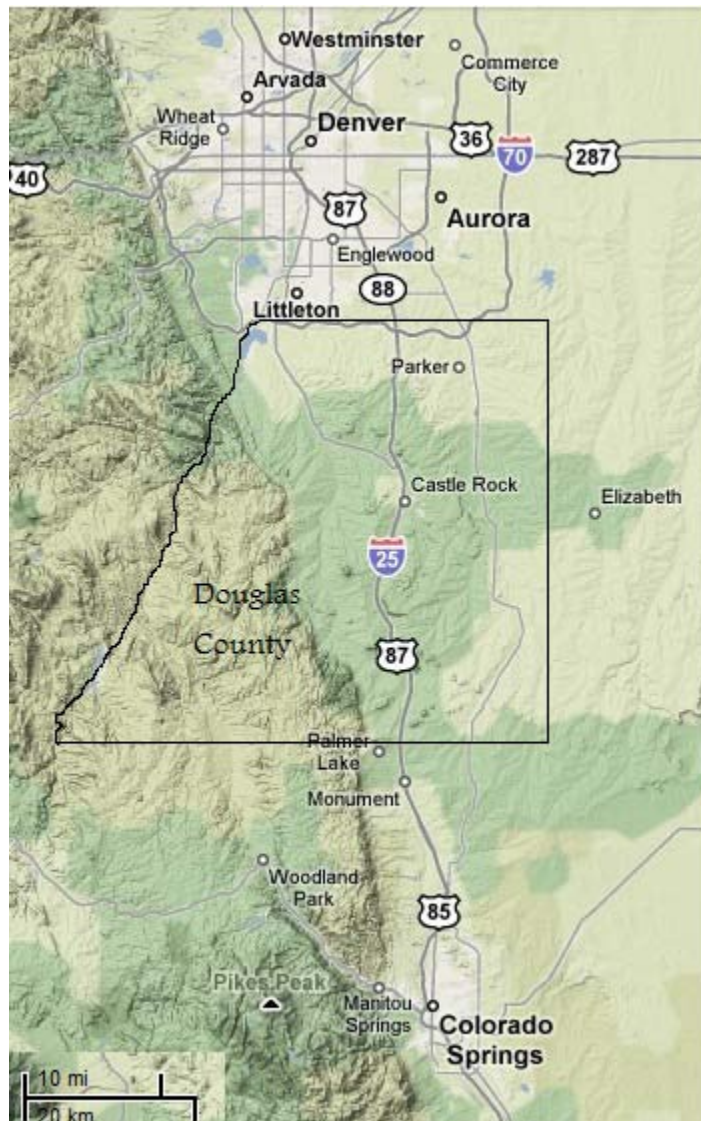


Figure 1: Map of the Colorado Front Range, including Douglas County.

With few significant rights to renewable surface water, Douglas County residents adapted by raising cattle and lambs, and irrigating relatively few acres for supplemental

⁸ *Douglas County News Press*, October 17, 1987. Castle Rock paid \$400,000 for the 115 acre-feet from Plum Creek.

feed for the livestock.⁹ The rural population grew slowly, supplementing surface water with water from shallow alluvial groundwater wells near the creek beds. Following larger national trends of rural electrification and utilizing the technology that came out of WWII, residents of Douglas County began tapping deep aquifers in the 1950s.¹⁰ Some of these aquifers are 1,000 to 2,000 feet deep, making electrification and advanced pumping technology prerequisites for access. The availability of water led to a massive population increase, doubling between 1960 and 1970 and tripling by 1980.¹¹

The entire Front Range witnessed a population explosion at this time as well, and municipalities looked for renewable sources of water for their growing populations and industries. The Denver Water Board led the charge with the Two Forks project, a dam and reservoir with 1.1 million acre-foot capacity that would provide water for much of the Denver metropolitan area. After much public input and debate, the Final Environmental Impact Statement was approved and the project went to the Environmental Protection Agency for final approval and permitting. In 1990 the EPA rejected the project.¹² Suddenly, municipalities throughout the Front Range were without a water source as Denver Water declined to be the supplier for most cities. This lack of renewable water drove people to rely increasingly on non-renewable groundwater underneath the entire Denver Basin.¹³ In addition to relying on groundwater, some cities started buying water from agriculture. The city of Parker started planning a reservoir

⁹ “Annual Reports,” Douglas County Extension Records, 1920-1998, Records of the Colorado Cooperative Extension, Colorado Agricultural Archive, Colorado State University, Fort Collins, Colorado, (hereafter CAA).

¹⁰ Douglas County Water Advisory Board Records, 1987-1995, DCHRC.

¹¹ “Annual Reports,” Douglas County Extension Records, 1969-1981, CAA.

¹² Lindsay E. Sweetser, “An Economic Comparison for Two Forks and its Alternatives” (master’s thesis, Colorado State University, 1994); Daniel F. Luecke, “Two Forks Dam and Endangered Species,” *Colorado Water* 26, no. 2 (March/April 2009): 17-19.

¹³ Raynolds, “Stratigraphy and Water Levels in the Arapahoe Aquifer, Douglas County Area, Denver Basin, Colorado,” 211.

soon after Two Forks fell through. Many neighboring cities have bought shares of space in the reservoir and are competing with each other to purchase water from farmers on the eastern plains of Colorado.¹⁴

During this water scramble, Douglas County was named the fastest growing county in the nation in 1995, exacerbating the need for water development. On the north end of the county, suburbs sprang up while the southern side saw development of 35 acre plots.¹⁵ Suddenly, the groundwater was being tapped at an incredible rate for domestic purposes as land use changed from farming and ranching to rural non-farm. By 2004, well pumping had increased to the point at which the Arapahoe Aquifer, the most frequently used in the Denver Basin for its superior water quality, was being mined an average of 30 feet per year.¹⁶ Residents, cities, and the county as a whole have largely ignored this startling rate of depletion. Residents cannot see where their water comes from and with scientists and engineers constantly revising their estimates of available water, it is difficult for groups to form a cohesive front with a clear understanding and unified message about groundwater in the county.

Western historians have long focused on water as a source of community and contention, but groundwater has been largely ignored, perhaps because it moves unseen and is difficult to visualize and understand.¹⁷ Historians like Donald Worster, Donald Pisani, and Norris Hundley examined how surface water in the West affected settlement

¹⁴ *Parker Chronicle*, "Water supply future brighter," September 19, 2008.

¹⁵ Douglas County Water Resource Authority, "About Us," www.dwater.org (accessed October 11, 2008).

¹⁶ Raynolds, "Stratigraphy and Water Levels in the Arapahoe Aquifer, Douglas County Area, Denver Basin, Colorado," 195-210.

¹⁷ Donald J. Pisani, *Water, Land, and Law in the West: The Limits of Public Policy, 1850-1920* (Lawrence: University of Kansas Press, 1996); Kevin Marsh, e-mail to Mark Fiege, March 7, 2008, author's possession; Nicolai Kryloff, "Western Waters: New Mexico's Big Ditch and Groundwater in Colorado's South Platte Valley" (master's thesis, Colorado State University, 2008).

patterns and power relationships. It is appropriate that the first historians of water in the West looked at early water use. The first farmers and prospectors fought over surface water rights in the West. In those early years, underground aquifers lay largely untapped as the deep water table made hand dug wells impractical, concentrating early settlement near streams and rivers. As the population increased, surface water was no longer sufficient for supplying the needs of agriculture, industry, and municipal uses, and water users turned to groundwater.¹⁸

As water users have turned to groundwater, so, increasingly, have historians. In spite of the difficulties surrounding groundwater, John Opie, a pioneering environmental historian, wrote one of the few histories of groundwater, *Ogallala: Water for a Dry Land*. Opie interviewed farmers on the High Plains about their use of groundwater and their awareness of the nonrenewable nature of the resource. While most acknowledged that they will be facing a water crisis in the near future, none offered or saw solutions on the horizon. By looking at the history of land use on the High Plains and relating it to water use, Opie tried to present feasible solutions to help mediate the crisis that looms over the bread basket of America.¹⁹ In *Land of the Underground Rain*, Donald Green took a similar approach as he examined how farmers on the High Plains of Texas treated a nonrenewable resource, groundwater, like a renewable resource, rain. According to Green, High Plainsmen created the myth of the “inexhaustible supply” of groundwater making them indifferent to the ideals of water conservation. These ideas of an inexhaustible water supply have compounded with the natural aridity of the area to create a water crisis that can only be mitigated by water conservation and, most likely, water

¹⁸ John Opie, *Ogallala: Water for a Dry Land*, 2nd ed. (Lincoln: University of Nebraska Press, 2000), 55-70.

¹⁹ *Ibid.*, 320-344.

from elsewhere.²⁰ Doing so will require a change in the way people think about and use groundwater.

Arthur McEvoy's model of ecology, production and cognition as interacting variables provides a useful framework for understanding the changing relationship between people and groundwater in Douglas County. Ecology is the system that links living things to each other and to their environment; production is the technologies and forms of social organizations by which people transform natural things into food, materials, and wealth; and cognition is the ideas that influence human behavior. All three, McEvoy says, are continually and simultaneously interacting and influencing one another. Ecology establishes the networks of living things in which humans live and in which they must intervene; production is limited by ecological conditions, but also simultaneously shapes them; ideas matter insofar as they seem to explain ecological and production conditions, and in turn are shaped by people's ecological circumstances and production processes. To describe one necessarily requires a description of the other two – and all in relation to one another.²¹

Unlike McEvoy's example of a fishery, deep groundwater is a non-renewable resource.²² Other non-renewable resources like minerals are mined to exhaustion, and then the operation moves elsewhere to continue the extractive process. The groundwater underneath the Denver Basin is being mined, and will probably be mined to exhaustion, but when it is gone people will not simply pick up their homes and move them to another

²⁰ Donald Green, *Land of the Underground Rain: Irrigation of the Texas High Plains, 1910-1970* (Austin: University of Texas Press, 1973).

²¹ Arthur F. McEvoy, "Toward an Interactive Theory of Nature and Culture: Ecology, Production, and Cognition in the California Fishing Industry," *Environmental Review* 11 (Winter 1987): 289-305.

²² Groundwater is non-renewable on a human time scale. While the aquifers may refill in the approximately 10,000 years, it will be rather late for the residents of Douglas County.

location with available groundwater. Most residents will have to look elsewhere for water, and the sudden dearth where there was once an apparent abundance will result in major changes in water use, how people think about water, and the ecology of the landscape.

Even in the late 1800s, people understood that there was usable water stored far below the surface. Many conceptualized underground bodies of water as roaring subsurface rivers.²³ Individuals tapped into the groundwater with wells and relied on the natural pressure of the aquifer to bring deep water to the surface. They operated under the assumption that there would always be more water available for use, and they used it freely and at times, wastefully. Since the 1800s, pumping has changed groundwater conditions, and in places across the United States, wells are going dry. For farmers on the Great Plains, dry wells necessitate a change in production, forcing them to leave fields fallow.²⁴ For homeowners on the western edge of Douglas County, dry wells impose more conservative water use as people are forced to bring in water from elsewhere for daily use. As McEvoy posited, the change in the ecology of the resource, resulted in transformations in use of the resource and the ways people think about that resource.

At present, groundwater is treated as a public resource, making it subject to the “Tragedy of the Commons.” People realize that they can use more of the resource and reap the benefits . . . for a time. Much like the law of prior appropriation that governs the West, groundwater users assume that if they do not use the water, their neighbors will take it. Thus, there is no advantage for an individual to conserve water. McEvoy argues

²³ Opie, 3.

²⁴ Ibid., 27.

that a Tragedy of the Commons model is over-simplified for effectively describing resource use. The Tragedy of the Commons only looks at a resource from an economic perspective; it assumes that economic gain is the only thing that motivates people and that people have unlimited access to the resource. For most resources, use is limited by social sanctions, or, in the case of groundwater, it is limited by landownership: a person must own land over the aquifer to drill a well and access the water.²⁵

Historically, the residents of Douglas County had little access to water.²⁶ As an alternative to water-intensive irrigated agriculture, most people raised livestock. With an understanding of water as a scarce and precious resource they adapted their mode of production to fit within this framework. Of course, the livestock industry brought ecological changes to the county, but in terms of water, the ecology was balanced by a reliance on surface water or shallow renewable groundwater. In the 1980s people realized the potential stored in the deep aquifers, and residential development sprang up throughout the county as land and homeowners realized they could tap the aquifer for just the trivial price of a well permit fee. The mindset of an unlimited water supply led to massive growth as developers bought out ranches and subdivided them into thirty-five acre plots. Now much of the livestock is gone from Douglas County as people build their homes and live on the premise of unlimited water.²⁷

Many historians, McEvoy included, are quick to point out that most common pool natural resources are governed by social customs.²⁸ In small communities, social

²⁵ McEvoy, 292-297.

²⁶ Technology did not enable access to the deep groundwater aquifers until the 1950s, and it was not used heavily in Douglas County until the 1980s.

²⁷ "Annual Reports," Douglas County Extension Records, 1969-1991, CAA.

²⁸ Karl Jacoby, *Crimes against Nature: Squatters, Poachers, Thieves, and the Hidden History of American Conservation* (Berkeley: University of California, 2001).

sanctions usually work to protect a resource like a hunting ground from unsustainable use. However, social sanctions are difficult to apply in the case of Douglas County and groundwater use. Because groundwater use is not metered, measured or recorded in any way, neighbors could only guess at the amount of water their neighbors used, perhaps by looking at landscaping choices. Additionally, in a large suburban community like Douglas County, most people have social networks that extend well beyond their neighborhoods, making potential social sanctions less significant for individuals. The benefit of having a sustainable water supply could only be reaped if all individuals in the system agreed to a use schedule that penalized misuse of the resource.²⁹

However, the depletion of groundwater resources could have a very negative impact as people are forced to search for water from other sources. In Douglas County, twenty percent of the residents obtain their water from private wells and another sixty percent rely on municipal wells drilled into the nonrenewable groundwater.³⁰ When these wells run dry in the next ten to twenty years, the residents will be forced to look elsewhere for water or abandon their homes. As many people on the Front Range know, finding water is no easy task. The era of major water projects is over as funding has dried up and people are increasingly concerned about the environmental impacts, highlighted by the veto of the Two Forks project. Adoption of a conservation ethos could give the Arapaho Aquifer a few more years, but ultimately another source of water must be found. The emptied aquifer may offer part of the solution in itself. The aquifer presents an ideal storage facility for water, decreasing the impact on the surface ecosystem and reducing water loss from evaporation. Nevertheless, the water to fill the

²⁹ David Freeman, *Local Organizations for Social Development: Concepts and Cases for Irrigation Organization* (Boulder: Westview Press, 1989).

³⁰ *Douglas County News Press*, October 7, 11, 1995.

aquifer must come from somewhere. Ultimately, environmental concerns must be balanced with the needs of the population. A renewable source of water is necessary – whether it comes by drying up agriculture on the eastern plains of Colorado, a large dam project like Two Forks, or another transmountain diversion.

CHAPTER 1: COLORADO AND WATER

Residents of Douglas County are certainly not the first inhabitants of the American West to worry about the source of their water. Coloradoans have a rich history of diverting and appropriating water in different ways. The Ancestral Puebloans of Mesa Verde built small reservoirs to capture the scarce water that fell across the southwest and dug ditches to bring water to their crops. Even with a highly developed water infrastructure, archaeologists hypothesize that their cultural collapse may have been a result of prolonged drought or over-allocation of limited desert resources.³¹

While Native Americans used water in Colorado for thousands of years, the first water right recognized by the state of Colorado is the 1852 People's Ditch in the San Luis Valley. This ditch was built for irrigation by Hispanic settlers, each of whom received shares of water in return for building and maintaining the ditch. The acequia system that was and is still used to maintain the ditch encouraged responsible community management of a common pool resource. A well-run acequia requires members to invest labor in the water delivery ditches and head gates before they receive a share of the water.

Alternatively, early miners in Colorado established an entirely different system. Miners often staked claims far from streams but needed water to wash the ore. Thus, miners diverted the water they needed from streams and established rights to the water through a "first in time, first in right" system. Unlike the common riparian system used

³¹ Karla A. Brown, ed., "Citizen's Guide to Colorado's Water Heritage," Colorado Foundation for Water Education, 2004, <http://cfwe.org/CitGuides/CG-Heritage.pdf> (accessed November 2, 2008). For more information on the Ancestral Puebloans and their water structures see Kenneth Wright's *The Water Mysteries of Mesa Verde* (Boulder, Colorado: Johnson Books, 2006).

on the East Coast and Midwest of the United States, early Coloradoans determined that owning property next to a stream or river did not necessarily give a person the right to use that water. Similarly, individuals who owned land that did not abut a stream were not excluded from access rights to the stream.³² This set a precedent for a new type of water allocation that soon became enshrined in Colorado water law. Gradually, legal rulings on water rights created a series of water laws known as the Colorado Doctrine. Included in these unique laws is the principle that water is a public trust and a water right is a usufructuary right; an individual or organization cannot own the water, rather they own the right to divert and use that water for a beneficial purpose. Owners of water rights can also build diversion structures across the lands of others to deliver their water, and they can use streams and aquifers to store or transport water.³³

All of these water rights are administered under the principle of prior appropriation. Prior appropriation states that the first person to put the water to beneficial use has the right to use that water. It creates a system of senior and junior water users. Senior water users must get their full appropriation of water before a junior user gets any. Thus, in times of drought, senior water users may have their full quota of water while junior users get no water. This is a stark contrast to a riparian system or the acequia system common to Hispanic communities throughout the Southwest. Under these two systems, all users cut back their water use in times of scarcity or drought to ensure that all

³² David H. Getches, *Water Law in a Nutshell* 3rd ed. (St. Paul, Minnesota: West Publishing, 1997): 74-77.

³³ Gregory Hobbs Jr., "Citizen's Guide to Colorado Water Law," 2nd ed., Colorado Foundation for Water Education, 2004, <http://cfwe.org/CitGuides/CG-Law2004.pdf> (accessed November 13, 2008). For a more in depth analysis of Colorado water law and water history see Gregory Hobbs Jr., "Colorado and Western Water Law: A Continuing Alchemy," *The Water Report* 36 (February 2007); Gregory Hobbs Jr., "Colorado's 1969 Adjudication and Administration Act: Settling In," *University of Denver Water Law Review* (Fall 1999); Gregory Hobbs Jr., "Colorado Water Law: An Historical Overview," *University of Denver Water Law Review* (Fall 1997); Gregory Hobbs Jr., "The Role of Climate in Shaping Western Water Institutions," *University of Denver Water Law Review* (Fall 2003).

have at least a portion of the available water.³⁴ Defining beneficial use is another key aspect of the Colorado Doctrine. It is defined by the state and has changed over the years; originally it encompassed agriculture, mining, industry and municipal uses, but it has been expanded to include recreation and habitat maintenance among others. People are only allowed to take the water that they can put to a beneficial use. Water rights also can be lost. If a person does not put water to beneficial use, he can lose the water right after a number of years.³⁵

While regulations on Colorado's surface water were well-established before Colorado became a state, groundwater went unregulated for years, largely because it is difficult to conceptualize, hard to access, and scientists are still working to understand groundwater's connection to surface water. Groundwater has many different legal distinctions, but the two primary ones are tributary, or alluvial, groundwater and nontributary groundwater. Tributary groundwater is directly connected to the surface water and is drawn down and replenished on a seasonal basis. This alluvial groundwater is usually found around river and stream beds. Drawing from an alluvial aquifer can immediately and directly impact the level of a river as water from the river percolates through the loose gravel to fill in the empty pore spaces created by pumping the groundwater. In addition to creating problems of water distribution and questions of water rights, these alluvial aquifers can intensify local water problems, including salinization and the spread of pollutants.³⁶ Once farmers along the South Platte River claimed the surface water rights, late-comers to the valley snapped up the rights to the

³⁴ Brown, 14-18.

³⁵ Hobbs, *Citizen's Guide to Colorado Water Law* 2nd ed.

³⁶ Ralf Topper, "Aquifers of the Denver Basin, Colorado," *The Mountain Geologist* 41, no. 4 (October 2004): 145-152.

large alluvial aquifers that surround the river bed. The groundwater rights were considered junior to the surface water rights and many wells were shut down, leaving farmers without a source of water.³⁷ However, nontributary groundwater has very little interaction with surface water and is usually found fifty to hundreds of feet below the surface. Like tributary groundwater, nontributary groundwater is stored in the pore spaces in loose conglomerates or sandstones, but nontributary groundwater is usually bounded on the top and bottom by a layer of non-permeable rock like shale. Nontributary groundwater recharges very slowly from water that trickles down through pore spaces in the rock. Rates of recharge vary widely, but the Arapahoe Aquifer receives little or no recharge “from surface water and likely receives little recharge from overlying aquifers because of the extremely low permeability of the intervening shale units.”³⁸

Four deep groundwater aquifers lie below Douglas County, the Dawson, Denver, Arapahoe, and Laramie/Fox Hills, ranging from two hundred to two thousand feet below the ground surface. Similar to modern alluvial aquifers, these nontributary aquifers were formed by permeable layers of sandstone from ancient rivers that flowed through the region, but nontributary aquifers are separated and isolated by layers of less permeable mudstone and shale. “The Arapahoe Aquifer is the most important source of groundwater for the rapidly urbanizing area south and east of Denver” because of its high quality water and confined status.³⁹ A confined aquifer is under pressure, so the water naturally rises through well bores, making pumping much cheaper than in an unconfined aquifer where the water must be brought to the surface by pumping. Most nontributary aquifers are confined until they have been pumped past a certain point. Once they

³⁷ Kryloff, 69-75.

³⁸ Reynolds, 198.

³⁹ Ibid., 199.

become unconfined, meaning the natural pressure of the aquifer will not push the water to the surface, pumping usually ceases because the cost increases drastically.⁴⁰

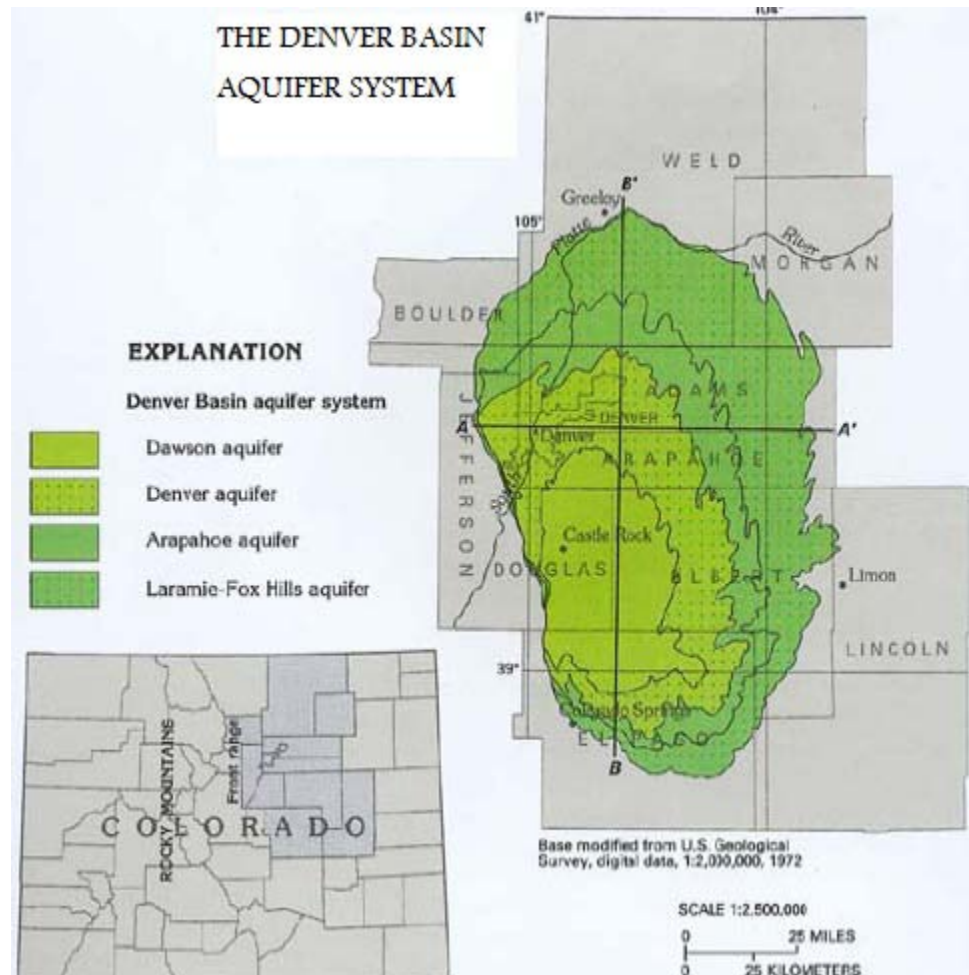


Figure 2: Map of the Denver Basin Aquifer System. Created by USGS.

The Arapahoe Aquifer lies approximately 2000 feet below the surface of the earth and is 500 to 700 feet thick. Dr. Robert Reynolds, sedimentary geologist at the Denver Museum of Nature and Science, estimates that the sediments of the Arapahoe Aquifer were deposited 68 to 66.7 million years ago. This incredibly productive aquifer with its well-connected pore spaces allowing water to flow easily can produce up to 700 gallons

⁴⁰ Ibid., 195-200.

per minute at large municipal wells.⁴¹ Similar to a Leonard Rice Water Consulting Engineers report that the aquifers of the Denver Basin held enough water for 400 years, a United States Geological Survey report found that the aquifers contained 470 million acre feet of recoverable water. Since then, that number has been revised down to 200 million acre feet and is likely to continue its decline as geologists study the aquifer system further. Additionally, geologists are not certain when the Arapahoe Aquifer will become unconfined, likely making any water left in the aquifer economically unfeasible for extraction.⁴²

In 2004, Reynolds estimated that the water level in the Arapahoe Aquifer was dropping at a rate of 30 feet per year. As its recharge is negligible, the useful life of the aquifer will soon come to an end. Once it does, the residents of Douglas County will have to look elsewhere for their water. Digging deeper to the Laramie/Fox Hills aquifer is usually cost prohibitive, and its sulfuric smell and taste give the aquifer its nickname, “end of the world aquifer,” implying that people will only drink the water if they have no other choice.⁴³ The depletion of deep groundwater aquifers is relatively new, as the depth and inaccessibility kept them from exploitation long after surface water was over-appropriated in spite of efforts to regulate it through prior appropriation.⁴⁴

The doctrine of prior appropriation had a large impact on settlement in Douglas County. Most of the water that falls in or flows through the county ends up in the South Platte River. By 1874, the settlers of Union Colony, present day Greeley, Colorado, had established their rights to the water in the South Platte, leaving little water for late-comers

⁴¹ Ibid., 200-206.

⁴² Ibid., 200.

⁴³ Ibid., 205-207.

⁴⁴ Opie, 7.

to the South Platte Basin.⁴⁵ At that time, Douglas County had few permanent settlements and little agriculture, functioning largely as a gateway to the Pikes Peak gold mining region until the 1880s.⁴⁶

By the end of the nineteenth century, the population had grown considerably and residents were looking for long-term solutions to their water shortages. To ease water demands and control flooding, the Castlewood Dam and Reservoir was built in 1890 in Castlewood Canyon in the southeast portion of the county. Using only horse and man power the reservoir behind the dam held 3,434 acre feet of water. Various ditch companies contracted to take water from the reservoir for irrigation on outlying farms. Nevertheless, this dam did not have a large impact on the modes of production in the county as the volume of water was not sufficient for large scale irrigated agriculture. The water was used as a supplement for shallow alluvial wells that were sometimes unable to draw adequate water in drier months. Perhaps the dam's largest impact on the county was when it overtopped and breached during a severe thunderstorm in August 1933. The flood coursed miles downstream, killing two people and causing over a million dollars of property damage.⁴⁷

With only Castlewood Reservoir, limited rights to surface water, and minimal access to groundwater, county residents found themselves without enough water for irrigated agriculture, leading to modes of production that differed from much of the plains of Colorado. While some tried to break the ground using single-bladed plows, many in

⁴⁵ Brown, 20-23; Kryloff, 61.

⁴⁶ Josephine Lowell Marr, *Douglas County: A Historical Journey* (Gunnison, Colorado: B & B Printers, 1983), 27-39. One of the first water diversions in Douglas County is credited to Orzo Brackett, who built a ditch in the 1860s that ran from Cherry Creek across another ranch and "over the hills" to his ranch. Brackett Ranch was known for years as the finest hay producer in the region, credited to his shrewd use of irrigation.

⁴⁷ *Ibid.*, 64-66.

the county turned to the industry that would eventually be the primary source of revenue: livestock, and especially dairy cows. In 1887, the milk wagon from Castle Rock Creamery made its rounds up and down Cherry Creek, much to the excitement of local farmers. By the early 1900s dairy farming was the most profitable commercial concern in Douglas County.⁴⁸ In addition to profitability, cattle use much less water than other forms of agriculture. For example, corn requires one liter of water per day for each plant and is usually planted at a density of 35,000 plants per acre.⁴⁹ With such consumptive demands, it is easy to imagine how much water just one field of corn uses.

For the first half of the twentieth century, Douglas County residents and their dairy cows relied on limited surface water to supplement shallow renewable groundwater that was used largely for domestic and municipal uses. Like most places in the West, early settlements in the county were located near creeks, particularly Cherry Creek, on the eastern side of the county. Even for those without access to the surface water, the soil around creeks and rivers is loose and gravelly, making for prime groundwater storage. The water table is also shallow near flowing water, allowing access to the water through hand-dug wells.⁵⁰ This groundwater was crucial to the survival of many families settling in the area. Vignettes in the local *Castle Rock Journal* displayed a consistent concern with water, in particular with well water. In 1901 a little girl asked her father, “Papa, when people can’t get well water, do they have to use sick water?”⁵¹ Puns aside, the girl’s question showed the connection people saw between well water and health. In another instance, a guest asked his hotelier if the hotel supplied good water. The

⁴⁸ Ibid., 40.

⁴⁹ Terry Podmore, “Agriculture, Irrigation, and Water” (lecture, Colorado State University, Fort Collins, Colorado, October 13, 2008).

⁵⁰ Marr, 27-44.

⁵¹ *Castle Rock Journal*, April 12, 1901.

proprietor replied, “Of course, it’s well water.”⁵² This reinforces the idea of freshness associated with well water from the county.

While the Front Range relied on renewable surface water, farmers further out on the Great Plains began developing deep groundwater. According to J. R. McNeill, an environmental historian, cheap energy and scarce surface water are the factors necessary for large scale groundwater development, making the Great Plains a prime location. Surface water was certainly scarce on the Great Plains, but until the 1940s and 1950s, energy was prohibitively expensive for most farmers.⁵³ For the average Plains farmer, irrigation equipment was the most expensive investment they could make in their land. Additionally, early equipment usually had very limited pumping capacity, making it a questionable investment. Even the most efficient windmills could only produce enough water for a few acres, and farmers had to dig small reservoirs to hold to the water so it could be evenly and consistently applied to the field. Windmills also required a considerable amount of maintenance, making them impractical for large scale irrigation on the Great Plains.⁵⁴ In the 1890s, a centrifugal pump was developed that could pump several hundred gallons per minute and did not have the bothersome valves of earlier pumps that often caused problems. The main problem with this pump was that it could not be located more than 20 feet above the water level. Some farmers tried to place the pump in a depression, but it was highly impractical for deep groundwater and was used

⁵² Ibid., October 8, 1890. For more on this connection between land and health see Conevery Bolton Valencius, *The Health of the Country: How American Settlers Understood Themselves and Their Land* (New York: Basic Books, 2002); Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Los Angeles: University of California Press, 2006).

⁵³ McNeill, 151.

⁵⁴ R. Douglas Hurt, *Agricultural Technology in the Twentieth Century* (Manhattan, Kansas: Sunflower University Press, 1991), 63.

most successfully in river valleys where the water table was near the surface.⁵⁵ The other limiting factor of the early centrifugal pumps was the constraints of power-transfer technology. Steam, internal combustion, and electric motors all required near constant maintenance and many farmers simply did not have the knowledge and skills to keep the pumps and motors running.⁵⁶ At the turn of the century the increase in crop productivity from irrigation did not pay for the technology.

To make full use of the centrifugal pumps, most farmers had to wait for gasoline burning combustion engines. While they were available by 1900, most were not reliable or still too expensive for small farmers to purchase. Additionally, most farmers did not understand irrigation. Those who used it often waited and waited for rain until their crops dried up, and only then, once it was too late, would they irrigate. The agricultural crisis in the 1920s further slowed the drive to irrigate, as many farmers were having trouble making ends meet. The New Deal programs again discouraged irrigation, focusing instead on soil conservation. In fact, in 1936 the Great Plains Committee stated that, “Irrigation at best can cause only minor changes in the economic life of the Great Plains.”⁵⁷

By the end of the 1930s, farmers on the plains realized that profitable agriculture was not feasible without irrigation. Gradually, they understood the power of readily available water, not to supplement rain water, but to replace it. World War II accelerated the need for the crops of the Great Plains, and after years of hardship some farmers were able to save enough for a well, pump, and engine, sometimes selling surface water rights to get the money. Out of World War II came more efficient and dependable engines, and

⁵⁵ McNeill, 150-153; Hurt, 63.

⁵⁶ Opie, 124-142.

⁵⁷ Ibid., 131.

perhaps most importantly, these engines were readily available to the public, often salvaged from defunct Fords and Chevys.⁵⁸ Rotary drills were also advanced enough to drill large bores that could produce large volumes of water. At the same time, farmers made significant advances in irrigation techniques. Previous methods of flooding an entire field depended on the field being nearly level and could potentially result in major erosion. Furrow irrigation, where water is run down furrows along the field from a main ditch at the top of the field, proved very effective, especially where absorption rates were slow.⁵⁹

Constantly in search of new methods of irrigation, farmers started using sprinklers on land that was too hilly or too flat for furrow irrigation.⁶⁰ One of the greatest advances for Plains irrigation that worked in conjunction with the new pumps and engines was the center-pivot irrigator developed in the early 1950s by Frank Zybach, a Colorado farmer. This glorified sprinkler allowed farmers to water a huge area of land from one well.⁶¹ Center pivots enabled farmers to micromanage irrigation. No longer reliant on rains, or in some places ditches and canals, they could deliver the ideal amount of water to a field at any given time.⁶² Requiring considerably less maintenance and supervision than the furrow system with its siphon tubes, farmers were able to reduce their labor costs.⁶³

⁵⁸ Ibid., 124-139.

⁵⁹ Hurt, 67. Furrow irrigation requires a slightly sloped field so the water will flow through the furrows and water the entire field.

⁶⁰ Ibid., 68.

⁶¹ Opie, 142. Center pivot irrigators have one well at the center that draws water for the entire system. Farmers use tractors to drag the end of the irrigator around the field, similar to motion of the hands of a clock. These center-pivot irrigators create the circular patchwork pattern of fields that can be seen throughout the Great Plains. For more information on irrigation see Douglas Hurt's comprehensive treatment of irrigation in the West in *Agricultural Technology in the Twentieth Century*.

⁶² Opie, 142-144.

⁶³ Hurt, 68.

Even with new technology that enabled many different types of terrain to come under the regime of irrigated agriculture, most parts of Douglas County maintained long entrenched forms of land use. Additionally, much of the land in western Douglas County is dotted with large buttes and gullies, making large scale use of center-pivot irrigation impractical. In 1920, the county extension agent, Raymond Miller, reported that of Douglas County's 810 square miles, 585 were used for farming or ranching, and the average farm size was 830 acres. The population was primarily rural, and Miller noted that "nearly all of the crops raised within the County are marketed [through] Livestock. Thus making the principal resources of the County Dairying and General Stock Raising."⁶⁴ In 1921, Douglas County won seven first place awards at the Colorado State Fair for dry land corn. Most of this corn was grown as feed for stock. Throughout his years as the county extension agent, Miller also reported helping many farmers create contours on their land, a common technique in dry land farming to help keep the water on the land and prevent soil erosion.⁶⁵

While other farmers in the American West were using incredible amounts of water for irrigation, Douglas County farmers adapted their cropping and ranching to fit the low water availability in the county. They relied on summer rainfall to grow their crops. This adaptation was not because the farmers of Douglas County were more environmentally sensitive than farmers in other areas. They simply never had access to large quantities of water as did early farmers along rivers like the Platte and Arkansas. Irrigated agriculture was unable to develop on a large scale in Douglas County. Even when residents had the technology to gain access to the deep groundwater that could

⁶⁴"Annual Report," Douglas County Extension Records, 1921, CAA.

⁶⁵ Ibid.

sustain more intensive agricultural production, the livestock industry was already well established, and people continued thinking of the county as a livestock region.⁶⁶

While there was much development in agriculture, cities on the Great Plains and the Front Range were also growing rapidly. A succession of small companies supplied water to Denver residents, but by the turn of the century, the city needed more water storage and built the 80,000 acre-foot Cheesman Dam and Reservoir on the upper reaches of the South Platte River.⁶⁷ In 1918, Denver voters created the Denver Board of Water Commissioners (DWB) because they realized the need for a comprehensive water strategy for the city.⁶⁸ Meanwhile, most residents outside of city limits obtained their water from shallow domestic wells.

Statewide increases in population and greater understanding of groundwater and surface water interaction led to the 1965 State Ground Water Management Act to regulate well permits and establish the Ground Water Commission. As former state engineer M. C. Hinderlider noted, Colorado was one of the last states to pass groundwater laws, perhaps because of the complex interaction between surface and ground water and Colorado's extensive development of surface water resources put off the need for groundwater laws.⁶⁹ Unfortunately, a drought in 1962 and 1963 exacerbated the passage of the Ground Water Management Act as people fought viciously over what they perceived as their water rights. Engineers, legislators, and water users all agreed that some form of regulation was necessary, but they disagreed about what type of oversight and laws would be most effective. Luckily, 1965 was a wet year, temporarily

⁶⁶ Ibid., 1921-1980.

⁶⁷ Denver Water Board, "History," www.denverwater.org/aboutdw/history.html (accessed March 17, 2009).

⁶⁸ Sweetser, 12.

⁶⁹ M.C. Hinderlider, "Groundwater Problems of My State" Undated, MSS 312, Box 8, Stephen H. Hart Library, Colorado State Historical Society, Denver, Colorado, cited in Kryloff, 60.

suppressing the quarrels until the legislature was able to pass at least cursory laws to regulate groundwater.⁷⁰ This Act required a permit for any well that tapped any type of groundwater in the state. It also acknowledged that “deep groundwater is of great economic importance to overlying landowners and to local public water suppliers,” allowing for economic development centered on groundwater.⁷¹ Legislators hoped to appease surface water user by putting tributary groundwater regulations under the control of the State Engineer who monitors surface water. Of the wells that tapped the deep groundwater in Colorado, some were exempted from the system and were not monitored by the State Engineer. These wells included domestic and livestock use, observation wells, and unregistered wells dating before 1972. They are typically limited to pumping fifteen gallons per minute, but no one monitors their use. (However, if you pumped more than fifteen gallons per minute your neighbors would probably notice the lush oasis surrounding your house).⁷² By allowing for some economic development of groundwater and subjugating groundwater use to surface water, legislators hoped they had settled the question of use and ownership. Nevertheless, the 1965 Act did little to regulate nontributary groundwater use, as landowners and developers needed only a permit to drill a well and subsequent water use was not monitored.⁷³

As Colorado water laws were codified, Douglas County was on the verge of a population explosion. The report from the extension agents in 1969 verified that “the county is changing from an agricultural to a rural non-Farm area.” The population had almost doubled from its 1960 size of 4,816 residents to 8,407 residents in 1970, and it

⁷⁰ Kryloff, 60-67.

⁷¹ Hobbs, *Citizen’s Guide to Colorado Water Law* 2nd ed.

⁷² Ibid.

⁷³ Kryloff, 67.

was on the verge of an even greater population boom. By 1980 the county was home to an astounding 25,153 residents. Even though the population was booming, the size of cities like Castle Rock and Parker were not increasing at the same rate. Many of the newcomers were from the Denver area and wanted to escape the increasing suburban sprawl that surrounded the city. Land in the county was often sold in thirty-five acre parcels, allowing new residents to have a few horses on their properties and a sense of living in the country. Most of these people obtained their water from private unmonitored wells that tapped deep into the Arapahoe Aquifer.⁷⁴

⁷⁴ “Annual Reports,” Douglas County Extension Records, 1969-1989, CAA.

CHAPTER 2: TWO FORKS

The entire Front Range and Douglas County were growing at unprecedented rates during the 1970s and 1980s. People associated with local governments and those concerned about the future of development in Colorado worried about where residents of the South Metro area would get water in the coming years. Many suburbs of Denver like Aurora and Thornton looked to the Denver Water Board for their supply. Governor Richard Lamb formed a Governor's Roundtable, and together with a committee of West Slope and East Slope interests, identified the most pressing water concerns for the state as a whole. The Roundtable recognized that conservation and increased storage were needed to offset potential deficits in coming years.⁷⁵ Because of these mounting concerns, Denver Water once again looked to the South Platte for a water storage option. With the Army Corps of Engineers, it decided that the Two Forks Project, a potential water storage site that had been periodically revisited for almost 100 years, was the most feasible option. The proposed Two Forks dam site and reservoir straddles Jefferson and Douglas Counties. It projected the inundation of the town of Deckers and some twenty miles of canyon along the main stem of the South Platte River and the north fork of the South Platte River.⁷⁶

In 1986, Denver Water requested approval from the EPA for the project, slated to store 1.1 million acre-feet of water. Included in the evaluation for approval were many public meetings and forums to disseminate information to customers and those who

⁷⁵ Sweetser, 14.

⁷⁶ U.S. Army Corps of Engineers, Omaha District, "Metropolitan Denver Water Supply Final Environmental Impact Statement (EIS) Executive Summary," March 1988.

would be affected by the dam. The meetings were also a chance for the public to ask questions and express support or disapproval for the project.⁷⁷

Residents who supported the project, like former Denver water manager James Ogilvie, believed that Two Forks was vital to protect Denver water users from a drought. Ogilvie spoke at public forums and wrote letters to the editor on behalf of Water for Metro Denver, which he describes as “a broadly-based citizens’ committee which advocates leaving our children and grandchildren an inheritance of immense value – sufficient water for a high quality of life in a semi-arid region.” He also pointed out that Two Forks would provide water that would otherwise have to be sought elsewhere – like from agriculture or groundwater. For Ogilvie, drying up agriculture on the eastern plains of Colorado was not a favorable solution. Ogilvie also worried that further delays to the project would just increase cost. He asserted that “the biggest problem with the 1.1 million acre-feet Two Forks is that it wasn’t built soon enough.” Referring to the longstanding interest in Two Forks as a potential water storage site for the Denver metropolitan area, he noted that it was almost built in the 1960s, but was tabled in favor of even larger water storage projects like the Central Arizona Project.⁷⁸ As former manager of Denver Water, Ogilvie remembered his experience in running “an environmentalist opposition gauntlet not unlike the one which had been placed in the path of Two Forks.” For Ogilvie, this “blind opposition” worked only to delay a project that he viewed as necessary and inevitable. He argued that the people of Colorado were blissfully ignorant of the very real possibility of a major drought. A large drought,

⁷⁷ Sweeter, 18.

⁷⁸ The Central Arizona Project was a major project funded in the 1960s by the Bureau of Reclamation. It provided water from the Colorado River to major cities in Arizona like Phoenix. For more information see the Central Arizona Project website www.cap-az.com (accessed March 30, 2009).

coupled with the expected growth of the Front Range, would leave the region in “terrible trouble.”⁷⁹

Ogilvie dismissed concerns of the environmentalists as irrelevant. He observed that “tens of millions of dollars have been spent on gnat-sized problems—if indeed they are problems at all.” As a prime example of one of these problems, Ogilvie cited the widespread concern over the endangered Pawnee montane skipper, a small rare butterfly whose main home was Cheesman Canyon, which the Two Forks project would inundate. Ogilvie was frustrated that millions were spent on research to determine if the butterfly would make its home at higher elevations, but not a dollar was spent on the potential impacts of a major drought on the Denver metro area. For Ogilvie, the solution to coming water problems on the Front Range was relatively simple. “It boils down to this,” he wrote.

“If metro Denver fails to build adequate water storage facilities now, at a future date there is a near certainty that the agricultural water of northeast Colorado will be the fallback source, either through purchase or condemnation. If that happens, the adverse economic and environmental impacts will prove to be a body blow to the entire state.”⁸⁰

Denver resident Gary Manderich, another Two Forks supporter, saw the project as key to Denver’s future development. While many people argued that Denver was done growing or should be done growing, Manderich pointed out that Denver was in the process of building an enormous new airport and convention center – both designed to bring people to the city. Manderich recognized that this growth would require water

⁷⁹ James L. Ogilvie, “Statement for the Legislative Public Forum on Current State Water Policy and the Future Needs of the State,” July 14, 1988, Denver, CO, Papers of James L. Ogilvie, Water Resources Archive, Colorado State University, Fort Collins, Colorado, (hereafter WRA).

⁸⁰ Ibid.

development, and he believed that Two Forks was the solution to this need.⁸¹ Taking a different tactic, Bob McWhinnie championed Two Forks by accusing the detractors of relying too much on their emotions. He emphasized that the decision to build the reservoir should be based on the facts in the Environmental Impact Statement, not people's emotions about the landscape.⁸²

Opponents to the project worried that building a large dam and reservoir like Two Forks was a drastic measure to solve a problem that many believed did not exist. The Environmental Caucus, an umbrella name for fifteen groups that opposed the project, was led by the Sierra Club and the Environmental Defense Fund. Recreation associations and individuals who used the area for hunting, fishing, and kayaking also opposed the project.⁸³ These groups challenged Two Forks as unnecessary and worried that it would cause irreparable environmental damage. At a public meeting held in Denver to discuss the Environmental Impact Statement, Robert Crifasi, a geologist with extensive background on Denver Basin groundwater, opposed Two Forks, suggesting that there was plenty of water available in the aquifers that underlie Denver to supply the needs of the city and outlying municipalities for years to come.⁸⁴ Denver resident Paul Geisendorfer agreed with Crifasi and asserted that the aquifers of the Denver Basin could not only be tapped for water but could also be used for water storage.⁸⁵ Many others who opposed Two Forks felt that Denver Water should invest more in conservation efforts

⁸¹ U.S. Army Corps of Engineers, Omaha District, "Transcript of Public Hearing Concerning Permits Pending for the Two Forks Dam and Reservoir and Williams Forks Gravity Collection System and the Final Denver Metropolitan Water Supply EIS," April 23, 1988, 1:00pm Denver, Colorado, 53.

⁸² *Ibid.*, 64.

⁸³ Sweetser, 22.

⁸⁴ U.S. Army Corps of Engineers, Omaha District, "Transcript of Public Hearing Concerning Permits Pending for the Two Forks Dam and Reservoir and Williams Forks Gravity Collection System and the Final Denver Metropolitan Water Supply EIS," April 15, 1988, 7:00pm Denver, Colorado, 125-127.

⁸⁵ U.S. Army Corps of Engineers, Omaha District, "Transcript of Public Hearing," April 23, 1988, 1:00pm Denver, Colorado, 127.

before building a major project.⁸⁶ Yet another individual against Two Forks, Kris Chick, felt that the legacy left for future generations was one of the most important aspects of the project. He noted that “we did not inherit this land from our parents, we are borrowing it from our children.”⁸⁷ Both supporters and opponents of the project used the powerful idea of leaving a valuable legacy for future generations to support their arguments.

As Governor Roy Romer pointed out in an open letter to the people of Colorado, “significant supplies of water currently exist for the Denver metropolitan area and that sensible plans of water conservation and the development of known interim supplies of water could add years to the region’s water supplies.” He also noted that the projected growth on the Front Range might not happen – making such a large water project superfluous. Governor Romer referred to the Two Forks project as “the Denver area’s insurance project,” implying that whatever sources of water were developed, all municipalities expected to use Two Forks as a backup in case of drought or unexpected growth. He hoped that the work done on conservation would make Two Forks entirely unnecessary, even as an insurance plan.

While Governor Romer did not support the Two Forks Project, he refused to veto it. He feared that a veto would result in each municipality panicking and rushing without coordinated planning to get rights to any water source. Romer clearly saw this type of competition as negative for water providers, users, and the state as a whole. He agreed with Ogilvie that water providers “must not put increased pressure on groundwater. And

⁸⁶ U.S. Army Corps of Engineers, Omaha District, “Transcript of Public Hearing Concerning Permits Pending for the Two Forks Dam and Reservoir and Williams Forks Gravity Collection System and the Final Denver Metropolitan Water Supply EIS,” April 14, 1988, 7:00pm Conifer, Colorado; “Transcript of Public Hearing,” April 15, 1988, 7:00pm Denver Colorado; “Transcript of Public Hearing,” April 23, 1988, 1:00pm Denver, Colorado.

⁸⁷ U.S. Army Corps of Engineers, Omaha District, “Transcript of Public Hearing,” April 23, 1988, 1:00pm Denver, Colorado, 17.

we must be very careful in taking water off farms.”⁸⁸ However, some detractors of the Two Forks project, like resident Jeff Cook, argued that agricultural conservation would allow cities to buy excess water from farmers, helping both the farmers and the cities. He believed that taking water from farms was preferable to building a large dam and reservoir.⁸⁹

To summarize, the supporters of Two Forks felt it was a necessary project for the future stability and prosperity of Denver and the entire Front Range. Two Forks would provide adequate water so the nonrenewable aquifers would not need to be tapped and agriculture on the eastern plains would still be feasible. Two Forks also could be used as a back up in case of a major drought or the failure of the Moffett Tunnel, a major supply line for the Front Range for water from the Western Slope. Conversely, the opponents felt such a large project was unnecessary and would place an unfair burden on the taxpayers. They wanted to see Denver Water implement more conservation programs. Many also believed that Cheesman Canyon, which would be inundated by the reservoir, had unique aesthetic value, and it was cited as being an important Colorado fishery. Environmentalists also worried about the impacts to wildlife, including the Pawnee montane skipper, the bighorn sheep herd in Waterton Canyon, and the impact on birds both in the canyon and those far downstream like the whooping cranes in Nebraska. In addition to the loss of wildlife and recreation areas, the town of Deckers, a small mountain town with a rich history of mining, would have been flooded.⁹⁰ Opponents of the project also worried that estimates of population growth were too high – many

⁸⁸ Roy Romer, “Statement by Governor Roy Romer to the People of Colorado Concerning Two Forks and Water Development in Metropolitan Denver.” June 10, 1988, in Papers of James L. Ogilvie, WRA.

⁸⁹ U.S. Army Corps of Engineers, Omaha District, “Transcript of Public Hearing,” April 23, 1988, 1:00pm Denver, Colorado, 123.

⁹⁰ Sweetser, 15.

believed that the Front Range population would level off. Fishing and wildlife groups wanted to see groundwater used before a major dam was built. They felt that using deep nonrenewable groundwater had less impact on the environment. Still others believed that taking water from agriculture was the solution. Interestingly, both opponents and supporters of Two Forks acknowledged that the Denver metropolitan area would need more water eventually, but they clashed over the best source of that water.

In spite of the best efforts of opponents of the project, the Environmental Impact Statement was approved and everything appeared to be on line for the Two Forks project. The head of the Army Corps of Engineers in Omaha was in the process of approving the vital Clean Water Act 404 permit when William Reilly, newly appointed head of the Environmental Protection Agency, notified the Corps of his intention to initiate a review of the permit. The Clean Water Act 404 regulated the discharge waters that would be released from the dam. Opponents had long argued that the quality of this water would negatively impact plant and animal species along the whole of the Platte River. To both supporters and detractors of the project, permit review signified President George H. W. Bush's intent to become a friend to environmentalists. It was clear that the permit review would be the demise of the Two Forks project. Champions of the project hired Lee Atwater, Bush's campaign manager and chairman of the Republican National Committee to lobby for their cause in Washington, while the opposition chose former President Gerald Ford. It is unclear if Ford or Atwater had any influence in the process, but in November 1990, the EPA denied the permit claiming that the damages caused by Two

Forks would be unacceptable and irreparable. Without the Clean Water Act 404 permit, the entire project was derailed.⁹¹

When the Two Forks Project did not come to fruition, Front Range communities were left scrambling for a new source of water. Cities and municipalities that had relied on Denver Water as their supplier were suddenly in the market for water rights, as Denver Water realized that it could no longer be responsible for supplying water to much of the Front Range. Cities like Aurora began tapping the groundwater on a massive scale, while others like Parker immediately started planning a large reservoir to supply Parker and other cities in Douglas County with a viable water storage option.

⁹¹ Luecke, 17-19.

CHAPTER 3: RUETER-HESS RESERVOIR

The town of Parker, located in the northeastern portion of Douglas County, was one of the municipalities that had to start looking for new solutions to the impending water problem when Two Forks was vetoed. In 1985, it bought very junior water rights to divert water from Cherry Creek, and it began looking for ways to store the water to put it to its maximum use. By 1991, Parker Water and Sanitation District (PWSD) determined that Castlewood Canyon would be the ideal site for the reservoir – the same site that had been previously used for water storage by Douglas County. However, since it was last used as a reservoir, Castlewood Canyon was now a state park, and in addition to inundating the protected canyon, the large reservoir would dislocate nearby historic cattle operations. This site met with so much opposition that PWSD ended up in court and lost the decision to the Colorado Division of Parks and Recreation. Frank Jaeger, manager of PWSD, looked for alternative sites and eventually decided on one on the north edge of Douglas County that abutted Interstate 25. Unlike the convenient canyon site, the new site would require considerably more excavation and massive construction for the dam. Starting in 1996, PWSD made detailed studies of the site to craft a master plan.⁹² Spurring on PWSD’s reservoir plan, Douglas County was declared the fastest growing county in the nation in 1995.⁹³ In 2000, the Army Corps of Engineers began the Environmental Impact Statement, and 2001 saw public comments on the EIS. As seen at Two Forks, supporters of the Rueter-Hess Project saw it as necessary to allow for growth

⁹² U.S. Army Corps of Engineers, Omaha District, “Final Environmental Impact Statement, Rueter-Hess Reservoir, Parker Water and Sanitation District,” 2003.

⁹³ Cheria Yost, “S.O.S. Save Our Small Town: Creating Sprawl” (master’s thesis, Colorado State University, 2002), 1-3.

and development in Parker and surrounding areas. For supporters like PWSD's Frank Jaeger, water storage was a necessary part of life on the Front Range. Opponents worried about the environmental impact of such a large project, and while some water would be from Cherry Creek, most of the water for the Rueter-Hess Reservoir would come from agriculture – effectively drying up farming operations east of Parker. Nevertheless, after the Final Environmental Impact Statement was released the project was approved in 2004. Just one year later, PWSD requested an enlargement of the original project, and it was granted in 2008. Currently, construction is slated for completion in 2010 and the reservoir will begin to fill soon after.⁹⁴

According to the Final Environmental Impact Statement from 2003, PWSD was then responsible for providing water to 9,000 taps that served approximately 25,000 people. Like much of the Front Range, significant growth was expected – PWSD planned eventually to supply almost 25,000 taps serving 85,000 people.⁹⁵ The EIS noted that PWSD's primary water sources were the non-renewable aquifers of the Denver Basin and junior surface water rights to Cherry Creek. It also acknowledged Parker's effective water conservation efforts in the late 1980s, but even so the town needed considerably more water. PWSD especially needed more flexibility with its water to adequately supply the public during times of peak demand and to store water when the demand was lower. The Rueter-Hess Reservoir accomplished both of these goals by helping reduce peak demand on the aquifers and “optimizing the re-use of Denver Basin water.” Of course, the reservoir also allowed PWSD to store a large capacity of water. Ideally, the

⁹⁴ “Rueter-Hess Reservoir.” www.rueterhess.com (accessed March 23, 2009).

⁹⁵ U.S. Army Corps of Engineers, Omaha District, “Final Environmental Impact Statement, Rueter-Hess Reservoir, Parker Water and Sanitation District,” 2003, Vol. II, 1.

15,000 acre-foot reservoir would reduce Parker's pumping load on Denver Basin aquifers by one half.⁹⁶

Parker's original plan for the reservoir was rather modest. Once PWSD realized that other communities within Douglas County were interested in buying the water storage in the reservoir, it applied for an enlargement of the reservoir. From its originally planned 15,000 acre-feet, the project expanded to 72,000 acre-feet. Already neighboring Castle Rock, Castle Pines North and Stonegate had purchased space within the reservoir. But the space did not get these cities water – only a place to store water. All three districts are currently negotiating with farmers in Sterling trying to buy water rights from the South Platte.⁹⁷ All of these municipalities have been trying to reduce their dependence on groundwater that they realize is quickly diminishing. As a consequence, and as predicted by supporters of the Two Forks Project, multiple municipalities are in the process of purchasing water from farmers and drying up agriculture, something that most people agree is not a desirable outcome.

According to PWSD, the Rueter-Hess Reservoir will serve many important functions for the town of Parker and the South Metro area as a whole once it is completed in 2010. In addition to being used on a daily basis by Parker residents, water managers also plan to use the water to replenish the underground aquifer, capturing storm water and water bought from agricultural users to inject into the aquifer “during non-peak demand.” While they discuss replenishing the aquifer it is unclear if they will leave the water in the ground, or if it will be extracted at a later date for consumptive use. In addition to replenishing the aquifer, PWSD claims that holding water in the reservoir year round will

⁹⁶ Ibid., 1-10.

⁹⁷ *Parker Chronicle*, “Water supply future brighter,” September 19, 2008.

reduce the pressure on the non-renewable aquifer. To help mitigate public opinion of the project, PWSD promises to have a regular newsletter updating people on the status of the project as well as the findings from ongoing environmental and scientific studies.⁹⁸

The Rueter-Hess Reservoir will help relieve water tensions in Douglas County, but there is still a chance that a large reservoir could be built at the Two Forks site to help mitigate larger water problems faced by the Front Range as a whole. In the mid-90s the section of the South Platte that runs through Cheesman Canyon – which would have been inundated by the Two Forks reservoir – was nominated for designation as a wild and scenic river. Such a designation would have put the river under federal jurisdiction and made any further development on that stretch of the river nearly impossible. As the Denver Basin aquifers are sucked out and agriculture dries up, residents of the Front Range and Colorado as whole will have to decide which consequences are most acceptable. Building a large dam certainly has environmental consequences that are very visible, as does drying up farm land. In addition to environmental issues, people will have to examine long-held cultural values and weigh the importance of recreation resources against the loss of farming communities on the plains.

⁹⁸Parker Water and Sanitation District, “Rueter-Hess Reservoir,” www.pwsd.org/rueter_hess_reservoir.php (accessed March 10, 2009).

CHAPTER 4: DOUGLAS COUNTY WATER ADVISORY BOARD

The 1980s brought greater awareness of water issues to the forefront of many Denver metropolitan area communities, and Douglas County was no exception. Many municipalities on the northern edge of the county contracted with Denver Water for water from the Two Forks Project. The County Commissioners believed the two biggest problems facing the future of water in Douglas County were a lack of knowledge about available sources and a lack of organization. To combat this, the Douglas County Water Advisory Board (DCWAB) was created in 1987 to investigate available water resources, look for potential new sources, and create a county-wide water plan. DCWAB put together a report, “Supply, Demand, and Institutional Needs of Douglas County,” originally issued in May 1988 and revised for publication in August 1989. The report noted Douglas County’s historic reliance on livestock and dry land agriculture. It found that in 1980, 6,100 acres of the 518,400 acre county were irrigated, and over 5,000 were used for pasture. The remaining 1,000 acres were used for wheat production. It estimated that in the 1990s municipal and domestic water use would catch and surpass agricultural use.

“It should be noted that existing agricultural water supplies in Douglas County are derived from the surface waters and shallow alluvial groundwaters of the Cherry and Plum Creek. Non-tributary groundwaters have not been developed for agricultural purposes because of the costs associated with developing these deep aquifers.”⁹⁹

Some DCWAB members suggested taking water from agriculture and transferring it to municipal uses but regretted that such a maneuver could end agriculture in the

⁹⁹ Douglas County Water Advisory Board, “Douglas County Water Advisory Board Report on Water Supply, Demand and Institutional Needs, October 1988,” 1-12, DCHRC.

county all together. With so little renewable water available to residents, they worried that “increasing dependency on non-tributary bedrock aquifers will impose significant economic, political, and social burdens on the County if these are not augmented or replaced by renewable sources of water.”¹⁰⁰ A similar report from 1991 estimated that eighty-two percent of Castle Rock’s water was from fifteen deep wells tapped into nonrenewable Denver Basin aquifers and the remaining water was from alluvial aquifers along Plum Creek. The DCWAB suggested that Castle Rock look into acquiring water rights from the South Platte to increase its surface water supply against the day the Denver Basin wells become unfeasible to use.¹⁰¹

In response to this report, Leonard Rice Consulting Water Engineers, Inc. (LRCWE) issued a document in 1989 that refuted the claims of the DCWAB, saying erroneous interpretation of data was to blame for the report’s rather dire predictions. This Denver firm estimated that the accessible water under Douglas County would last “considerably longer than 400 years.” It proudly trumpeted its unique understanding of water through the use of technology and computers. The company website today notes that “ground water geology and engineering was firmly established as a LRCWE expertise in 1986.”¹⁰² While the DCWAB certainly read this report, it did not trust LRCWE and the computer modeling and estimate. The Board continued to search for other sources of water for Douglas County and the impending problem that it believed would reach far beyond the realm of water into economic, social, cultural, and development issues.

¹⁰⁰ Ibid., p. 35.

¹⁰¹ Ibid., p. 37.

¹⁰² Leonard Rice Consulting Water Engineers, Inc., www.lrcwe.com (accessed November 3, 2008).

At the same time, a large California firm, Western Water Company, purchased 5,000 acres of Douglas County land to acquire the water rights. The local *Douglas County News Press* expressed its concern over the company's plans to sell the land and retain the deep groundwater rights to sell them to the highest bidder.¹⁰³ An advertisement from the Western Water Company in 1993 highlighted it as an "asset-rich play on unregulated water sales!" It estimated that their project could "return at least \$100 million over the next 24 months, providing Western Water with a better than 10-to-1 return on its original investment" and promised to provide interested investors with more detailed numbers. Meanwhile, an executive from Western Water assured the *Douglas County News Press* that the company did not intend to sell the water outside the county.¹⁰⁴

To combat this disconnect between land and water use, the DCWAB recommended a ban on exporting water from the county. Of course the already over-allocated South Platte still would be allowed to flow out of the county, but it would be illegal to sell unallocated water for a profit outside county lines. However, some members of the Board worried that such a ban would be unconstitutional and noted that "an awful lot of landowners' believe the water that they have access to is their own because they own the land." Others worried that it would "impair the free flow of water in accordance with the market economy." DCWAB ended up recommending such a ban, but nothing conclusive was ever done.¹⁰⁵

¹⁰³ *Douglas County News Press*, September 1, 1993.

¹⁰⁴ "Western Water Company," April 26, 1993, in Douglas County Water Advisory Board Records, 1987-1995, DCHRC; *Douglas County News Press*, September 1, 1993.

¹⁰⁵ *Douglas County News Press*, July 19, 1991; Douglas County Water Advisory Board Records, 1987-1995, DCHRC. The proposed ban would only apply to unallocated water, making surface water largely exempt from the ban. The ban was also not intended to apply to the natural flow of groundwater that would remove some water from the county naturally and probably without human knowledge. The ban

In 1995 the Douglas County Water Advisory Board was dissolved because of expanding growth in the county and a reorganization of staff and resources within county offices. But concern with water resources and use was still a hot topic within Douglas County. It continued to make regular newspaper appearances, as the residents looked within and outside of the county for a solution to the water problem looming on the horizon. County Commissioner and former head of the DCWAB, Jim Sullivan, suggested in 1995 that the county must be able to control all development and get people organized into water districts. At the same time, he noted that many land owners would be reluctant to organize, feeling that it was an imposition on their rights to use water.¹⁰⁶

was trying to keep companies like Western Water Company from speculating on Douglas County water and selling it for a profit to the detriment of local residents. The arguments board members used against a ban on water sales outside the county are the same ones frequently cited by individuals and corporations that support water privatization. For a detailed discussion of water privatization see Maude Barlow's *Blue Covenant: The Global Water Crisis and the Coming Battle for the Right to Water* (New York: The New Press, 2007).

¹⁰⁶ *Douglas County News Press*, October 14, 1995.

CHAPTER 5: VIRTUAL AQUIFERS: VISUALIZING THE INVISIBLE

Because scientists and water users cannot see groundwater while it is in the aquifer, they create metaphors to describe the aquifer and its behavior. Historian Mark Fiege tracked this need to visualize the invisible by examining atomic scientists. He found that they used phenomena they observed in nature to create models and visualizations of the behavior of atoms. Envisioning the movement of atoms helped men like Neils Bohr with the complex calculations that eventually led to the creation of the atomic bomb.¹⁰⁷ Even though the atomic scientists acknowledged that models helped them visualize processes they could not see, models and representations of processes invisible to humans also have the potential to distort reality. In the early twentieth century geologists were aware that there were deep underground bodies of water, but since it was inaccessible, concepts of groundwater remained very indistinct and hazy. By the mid-twentieth century, technology enabled people to extract deep groundwater from large aquifers like the Ogallala. Early farmers who used the water conceptualized the aquifer as a raging underground river. The speed of the water as it left the ground and its purity led to this idea.¹⁰⁸ Increasingly people who get their water from municipalities and private wells are becoming aware of the aquifer that lies beneath the surface. Admittedly, a rock saturated with water is an abstract concept, so geologists have used models and metaphors to help people understand their water resources.

Growing up in Colorado, I was always aware that I lived in an environment where water could be scarce. Summer lawn watering schedules and water police patrolling for

¹⁰⁷ Mark Fiege, "The Atomic Scientists, the Sense of Wonder, and the Bomb," *Environmental History* 12, no. 3 (July 2007): 578-613.

¹⁰⁸ Opie, 76.

miscreants watering their lawns on the incorrect day or in the heat of the sun enforced this idea of scarcity. In 2005, I got a job with the Denver Museum of Nature and Science working on the Denver Basin Project – a collaborative effort that used geology, paleontology, and paleobotany (the study of fossilized leaves) to understand climate change. The geologists worked on accurately mapping the geologic layers of the Denver Basin using data from well cores and surface outcrops. Geographic Information Systems (GIS) enabled three-dimensional mapping of the layers of rock. This allowed us to look at the Denver Basin from a side view, as if we were within the strata.

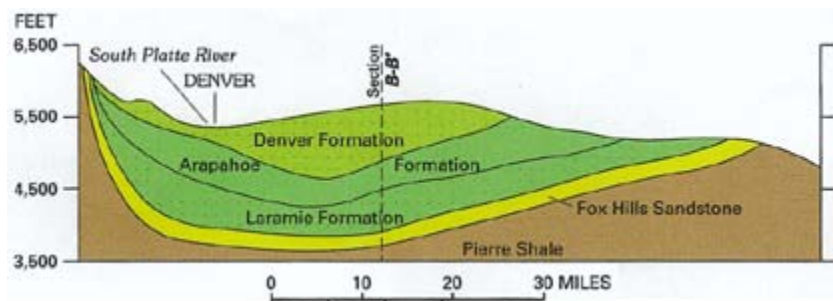


Figure 3: Two-dimensional schema of the Denver Basin strata, mapped from West to East. The water producing Arapahoe Aquifer is visible. Created by USGS.

One slow winter afternoon, the geologists invited us to a special showing in the planetarium at the museum. As we settled into the high back chairs and peered curiously at the dark ceiling, the lights went down and the familiar cubic image of the Denver Basin was projected digitally on the domed ceiling of the planetarium, creating a three-dimensional scene that engulfed my entire field of vision. Suddenly, we were flying towards the cube and we dove into the layer called the Arapahoe Aquifer. One thousand feet below the surface of the basin, we were floating in what appeared to be a subterranean lake. We zoomed through this vast underground ocean diving to avoid lenses of non-porous rock – the parts of the aquifer that don't hold water. At the controls, the geologists were laughing with raucous joy. Technology finally enabled them to

experience the world they studied in an abstract way. The lead geologist on the project, Robert Reynolds, acknowledged that the maps, “lacking a geological model and based on sparse data, are schematic in nature.”¹⁰⁹ With so little information about the nature of the aquifers, the geologists allowed their knowledge of geologic structures and their imaginations to fill in the gaps and created a three-dimensional map that helped them conceptualize and make predictions about the nature of the Denver Basin aquifers. Working with computers, they created images of aquifers based on surface contact points, information from well cores, and digital elevation models that were constantly tweaked to reflect new data or a new understanding of groundwater movement.¹¹⁰ Just as the planetarium has allowed tens of thousands of people to feel that they are flying through the solar system, it allowed us to fly through an underground body of rock.

Although the planetarium enables a feeling of flying through an aquifer, it is a highly impractical proposition. The geologists who map aquifers know that the aquifers are composed of loose rock whose pore spaces are filled with water. Humans will probably not ever be able to interact with an underground aquifer in situ. The closest they will ever get to an aquifer are the cylindrical samples of rock that are pulled up from well cores and represent just tiny sections of the aquifer. Yet, it was still a great moment to experience the simulation of being in an aquifer.

For most scientists, non-renewable aquifers like the Arapahoe represent a problem to be studied and solved. Sedimentary geologists and hydrologists are among the first to admit that even they are not quite sure what will happen as the water is drawn down. The

¹⁰⁹ Reynolds, “Stratigraphy and Water Levels in the Arapahoe Aquifer, Douglas County Area, Denver Basin, Colorado,” 200.

¹¹⁰ Robert G. Reynolds, Kirk R. Johnson, Beth Ellis, Marieke Dechesne, and Ian M. Miller, “Earth History Along Colorado’s Front Range: Salvaging Geologic Data in the Suburbs and Sharing it with the Citizens,” *Geological Society of America Today* 17, no. 12 (Dec 2007): 4-10.

pressure that currently pushes the water to the surface and allows it to be pumped so cheaply will certainly decrease, but no one is sure how much it will decrease. It could make pumping prohibitively expensive, even if there is still water available. There is also a risk of subsidence. Without the water that previously filled in the pore spaces of the rock, there is nothing to hold the rock in its current configuration. The Arapahoe Aquifer is very deep, and subsidence in the aquifer is unlikely to result in subsidence at the ground level, but it could disrupt pumping wells and limit further access to the aquifer.

In 2004, *Mountain Geologist*, a publication for geologists of the Rocky Mountains, devoted an entire issue to the Denver Basin's bedrock aquifers. In the preface to this edition, Dr. Robert Reynolds noted that "The [Rocky Mountain Association of Geologists] community is especially qualified to take a proactive role in helping to interpret and convey these complex aquifer issues to the public." Throughout the issue, geologists described the aquifer using scientific language; their audience was other geologists. In the opening paper, Ralf Topper described the Denver Basin as "a structural sedimentary basin." Topper depicted the aquifers within the basin as an "asymmetrical bowl shape" in cross section and "kidney shape[d]." He illustrated the prolific Arapahoe Aquifer as "an interbedded sequence of conglomerate, sandstone, siltstone, and shale." In this paper, he gave background information on the aquifers to establish a fuller context to the following papers. For Topper, the aquifers of the Denver Basin represented a "tremendous and controversial groundwater reservoir."¹¹¹ In terms of available water, the aquifers form one of the larger confined aquifer basins in the United States. It is controversial because people are mining the groundwater at an unsustainable rate. The impacts of this massive aquifer use are largely unknown, and in

¹¹¹ Topper, 145.

the future, water will have to be imported into the Denver Basin from elsewhere. These issues are intimately tied up with questions of growth and water use – both controversial issues in themselves. Topper’s use of the word reservoir implies that the aquifers are simply storage basins. Reservoirs, however, are typically built by humans for use by humans. In Colorado, reservoirs are generally filled with spring snow melt and slowly drawn down throughout the spring and summer to meet agricultural, municipal, and domestic needs. The amount of water that enters and leaves a reservoir is heavily regulated. By describing aquifers as reservoirs, Topper implies that their main use is water storage for people. It also entails a level of human control over the aquifer.

While people have a modicum of control over aquifers, they do not necessarily control how much goes into aquifers. In some places, like the San Luis Valley in southern Colorado, scientists have experimented with injecting surface water into aquifers for storage. However, this does not work everywhere because of varying porosity levels in aquifers and the need for an outside source of water. Geologists still struggle to fully understand the workings of an aquifer as the opening story illustrates. With the future of water from aquifers limited at best, scientists take their knowledge to the public arena and work with engineers and lawmakers to find solutions to the coming water crisis. They may clash on when the aquifers will run out, but as with any non-renewable resource, all agree that eventually a renewable source of water must be found for the residents of Douglas County.

While many people in the water business view aquifers as a source of water with a very limited lifespan, public perceptions of aquifers have been distinctly different. Most people, if they think about aquifers at all, have thought of them as underground

reservoirs. A reservoir is simply a place to store water, but in the dry West reservoirs are used for much more than water storage. Some ninety percent of Colorado's natural lakes lie above 8,000 feet. Most of the population lives well below this altitude. The Colorado Front Range also lacks large rivers; the two largest rivers, the South Platte and the Arkansas, are heavily augmented by water from the Western Slope. This general scarcity of surface water makes the reservoirs even more important. They often form the center of the most popular state parks. Used for fishing, sailing, swimming, and numerous other recreation opportunities, the reservoirs provide Coloradoans and other residents of the West with large bodies of water that otherwise would be unavailable. While the original use of the reservoirs is to store water for municipal, agricultural, and industrial uses, recreation is an increasingly important issue. However, aquifers cannot be used for recreational purposes, forcing them into a different framework.

People can see when reservoirs are drawn down – the tree line recedes from the water's edge, the boat launch ramps become very long – sometimes not even reaching the water, and the sandy appealing beaches are replaced by muddy trash-strewn plains. On the other hand, no one can see the impacts of drawdown on a deep bedrock aquifer.¹¹² While aquifers and reservoirs are distinctly different, a close analysis of Jackson Lake reservoir on the Snake River in Idaho revealed that people do not have complete control of either resource. Ideally, water managers and users believed that they could remove any water that was put in the reservoir. In reality, evapotranspiration, seepage, and senior calls on the water rights force people to create compromises between all water users to

¹¹² In some areas like Florida, aquifer depletion has resulted in ground subsidence or large sink holes because the rock is not strong enough to support the overlying ground without water to fill in the pore spaces. This has not happened in the Denver Basin because the aquifers are very deep and there are significant bodies of rock between the aquifers and the surface.

account for the water that they could not control.¹¹³ While water managers have become very adept at estimating water losses from reservoirs, estimating available groundwater is much more difficult. Because people are unable to see and interact with aquifers, scientists and writers use metaphors and analogies to help people imagine what an aquifer is like and to create estimates of water yield. Rather than describing aquifers as bodies of loose rock with pore space in the middle, most scientists and citizens resort to more colorful descriptions of aquifers and how they work.

In 2004, the *Rocky Mountain News* ran a four part series addressing the problems of water in Douglas County, and it used rich metaphors throughout to help people conceptualize aquifers. The series began with Keith Lehmann's nearly dry well on the northwest edge of Douglas County. When he built his home, he dug his well "into the vast and seemingly inexhaustible Denver Basin, an aquifer that experts said held enough water to fill Lake Erie." In 2004, that well only yielded enough water for fifteen minutes of sprinkling his flowers; his wife hauled the laundry into a Laundromat because she could not waste water on spin cycles. The Lehmanns' water shortage was just a forerunner for the rest of basin that is mining the aquifer at twenty to thirty feet per year. As cities scramble for solutions, scientists try to educate people about the water source from which they are drawing.¹¹⁴

Part of the confusion about how much water is available – or not – stems from terms that scientists themselves have used. At various times, the Arapahoe Aquifer was estimated to have 100 to 500 years of water left. Of course this depends on the number

¹¹³ Mark Fiege, *Irrigated Eden, The Making of an Agricultural Landscape in the American West* (Seattle: University of Washington Press, 1999): 81-116.

¹¹⁴ *Rocky Mountain News*, November 22, 2004.

of people drawing off the water, but Raynolds describes this estimate as “paper water.”¹¹⁵ Certainly, there might be enough water in the Denver Basin to last that long, but the problem is getting access to it. At a certain point, the cost of extraction will become prohibitively expensive, leaving the water inaccessible. Additionally, each of the four main aquifers is interleaved with shale lenses, creating mini-aquifers that could further prohibit the movement of water through the aquifer and the extraction of it.¹¹⁶ This idea of paper water is similar to William Cronon’s depiction of the grain futures market in *Nature’s Metropolis*. People traded pieces of paper in an aggressive market that often bore no direct connection to grain – they speculated that the futures would become real grain. The grain futures market existed separately from the actual grain, and people who paid high prices for a grain note sometimes found that it could not be redeemed in real grain – it was just a piece of paper. They depended on nature, on favorable conditions for grain, to realize a profit. While there are no water futures, many people have invested money in homes and property anticipating that water will be available. However, geologists’ varying predictions of the quantity of water in the Arapahoe Aquifer may be irrelevant if people cannot access that water, just as promised grain futures were worthless if there was no rain to nurture the grain.¹¹⁷

Water in the Arapahoe Aquifer is currently very cheap to withdraw because it is a confined or artesian aquifer, meaning the natural pressure within the aquifer pushes the water to the surface. According to the *Rocky Mountain News*,

“hydrologists liken the aquifer to a champagne bottle. Once the cork is popped, or a well is drilled, the fizz pushes water close to the surface.

¹¹⁵ Ibid.

¹¹⁶ Raynolds, “Stratigraphy and Water Levels in the Arapahoe Aquifer, Douglas County Area, Denver Basin, Colorado,” 201.

¹¹⁷ William Cronon, *Nature’s Metropolis: Chicago and the Great West* (New York: W. W. Norton, 1991).

Douglas County has been using water pushed toward the surface by this so-called fizz for decades, too. But just as a champagne bottle left open too long goes flat, hundreds of new wells drilled in the last 30 years have bled off the fizz. Once it's gone, wells begin to draw from the champagne itself."

The way champagne comes spilling out of a bottle indicates just how easy it is to pump the water, but it also gives the impression of a very lavish extravagant lifestyle. Reynolds argues that the residents "are living a lifestyle that is not sustainable." Like the fizz of the champagne, the water is the not the only thing that will disappear – the lifestyle supported by that water will go as well. The *Rocky Mountain News* goes on to report that not even the experts agree on what will happen once multiple wells have tapped out the artesian pressure. Some argue that the water level will stabilize, while others argue that it will slowly drop, and the direst predictions estimate that the water level will continue plummeting rapidly.¹¹⁸

For Keith Lehmann, the frequently cited bathtub analogy is all too applicable. He lives on the western edge of the basin, and the *Rocky Mountain News* explains that "Like a curved bathtub, these western edges drain before the middle does." The use of a bathtub in this context implies that the aquifer is under human control. A bathtub can be drained and filled at will by humans. CH2M Hill hydrologist Courtney Hemenway used this analogy in a newspaper article explaining Highlands Ranch's plans to store water in the emptied aquifer below the development. According to Hemenway, the bathtub would be filled in the winter months by treated surface water. When water demands rise in the

¹¹⁸ *Rocky Mountain News*, November 22, 2004.

summer with swimming pools and sprinklers, the water would be slowly drained from the tub.¹¹⁹

Another frequently cited metaphor for the Denver Basin is four sequentially stacked bowls with the smallest on top. These evenly divided bowls are neatly composed of porous sandstone and are separated by thick layers of clay. But as scientists have discovered, and the *Rocky Mountain News* acknowledges, the reality is much more complex. The layers are uneven and there are many shale lenses that lie within the aquifers. These irregularities make it very difficult to predict the yield of any given well. The *Rocky Mountain News* diagrams the idealized concept of the aquifers and a representation of the reality with a picture of stacked bowls and another of what look like stacked bumpy pancakes.¹²⁰

Yet the most repeated description of an aquifer is an underground or natural reservoir. An article about Highlands Ranch's water storage plan titled "Reservoirs go underground," opened "You can't sail or waterski on it, but water banked deep in underground reservoirs will be the cheapest, most efficient water supply for one thirsty community."¹²¹ Sailing and waterskiing as primary functions of a reservoir displays the dominance of recreational ideals associated with reservoirs. Many Coloradoans, and indeed Westerners, forget that the main purpose of the reservoirs they enjoy on hot desert days is to store water for municipal, domestic, agricultural, and industrial uses. Recreation is quite impractical on these underground reservoirs as they are composed of rocks and they lie approximately 1000 feet under the surface of the earth.

¹¹⁹ Ibid., February 6, 1994.

¹²⁰ Ibid., November 25, 2004.

¹²¹ Ibid., February 6, 1994.

The idea of banking water is another revealing metaphor. In addition to the monetary value of water, a water bank implies that people or municipalities could deposit water in the Arapahoe Aquifer, and its safety would be insured until they needed to withdraw the water. While many scientists are interested in the idea of using aquifers for water storage, there are many uncertainties as people are not entirely sure if the water will stay where it was deposited or if it will migrate. Additionally, it could be polluted by underground contaminants – or pollute the water that is already in the aquifer. Water banked underground may be safe from evaporation, but there is no guarantee that the amount deposited would be available for withdrawal.¹²²

With such complex ideas and imagery surrounding groundwater, it is no wonder that it remains largely unregulated in Colorado. Unlike earlier residents of the Great Plains who thought of groundwater as a raging river, recent metaphors for groundwater center on elements that are controlled by humans like reservoirs and bottles of champagne.¹²³ This concept of human manipulation of the aquifer allows people to use the aquifer freely, believing that they control it. Most people either ignore the impending water shortage or they believe that the problem will be solved by the time it impacts them. However, people like the Lehmanns, whose well does not yield enough water for a washing machine cycle, have changed the way they think about groundwater because their lives changed. Their well was not dry; it simply did not have the pressure to produce large quantities of water. They still had enough water for cooking and bathing. They just had to limit their outdoor watering and laundering. They expressed anger and disbelief that the aquifer with enough water to fill Lake Erie was not yielding as

¹²² Ibid., November 24, 2004.

¹²³ Opie, 76.

promised. Their personal experience with water scarcity and the sometimes mistaken predictions of scientists changed their way of life and the way they thought about the aquifer that was supposed to last for 400 years.

CHAPTER 6: SOLUTIONS?

Without a clear understanding of what groundwater really is and how much is available, people are reluctant to organize around groundwater, and this reflects the individualistic logic that pervades many human interactions with natural resources in the American West. As a form of common property, groundwater is a finite resource susceptible to a Tragedy of the Commons situation as each user follows individual logic to use as much of the supply before it disappears or becomes too expensive to extract. Garrett Hardin saw private property as the solution to this problem, believing that people will always pursue individual self-interest over the common good.¹²⁴ Yet in the case of Douglas County's groundwater, the problem is private land ownership. Like most natural resources, access is limited to a certain group. In Douglas County, a person must own land and have a well permit to freely access the groundwater. Individual landowners believe they own the water under their land and can use it however they see fit. There is very little idea that it is a commons to be shared, even though groundwater flows unregulated and unseen beneath property boundaries. Usually a commons is heavily regulated by social sanctions or a moral ecology within small communities. Each resource user patrols other users because they understand that if one person takes too much, there will not be enough for anyone. Unseen and unregulated groundwater makes traditional forms of social sanctions and community monitoring irrelevant, making aquifers prone to a tragedy of the commons situation. Sociologists David Freeman and Elinor Ostrom have formulated organizational theories to help individuals organize

¹²⁴ Garrett Hardin, "Tragedy of the Commons," *Science* 162 (December 1968): 1243-1248. For a thorough discussion of moral ecology see Karl Jacoby's *Crimes against Nature*.

around a resource in a sustainable manner. Originally developed for ditch irrigation systems, the models for middle level organizations present potential solutions for the groundwater problem in Douglas County and could help individuals conserve water for their own benefit and that of the community.¹²⁵

While residents may have tried to practice water conservation, there was no incentive to do so. For individuals on private wells, there is no monetary saving with conservation, and since the wells are unmonitored, they cannot even compare meter readings to measure the impact of conservation efforts. Sociologist Thomas Bruggink notes that an individual's conservation efforts in a groundwater aquifer might not be rewarded because any water he or she conserves could be used up by a neighbor. There is no guarantee that the water will be there when the user wants it, precipitating a use it or lose it mentality.¹²⁶ Using Freeman's and Ostroms' principles of organizing around a water resource, it is clear that people must be held accountable for the water they use.¹²⁷ Bruggink agrees that people must be held accountable and suggests four possible solutions to conservative groundwater management: legal reform, increased role of states in central management, privatization, or a lease arrangement between state governments and private firms. He argues that none of these solutions are easy or quick, and that the same solution will not work for every aquifer.¹²⁸

¹²⁵ David Freeman, *Local Organizations for Social Development*; Elinor Ostrom and Roy Gardner, "Coping with Asymmetries in the Commons: Self-Governing Irrigation Systems Can Work," *Journal of Economic Perspectives* 7 (Autumn 1993): 93-112; Elinor Ostrom, "Reformulating the Commons," *Swiss Political Science Review* 6 (2002): 29-52; Elinor Ostrom, "Coping with Tragedies of the Commons," *Annual Review of Political Science* 2 (1999): 493-535.

¹²⁶ Thomas Bruggink, "Third-Party Effects of Groundwater Law in the United States: Private Versus Common Property," *The American Journal of Economics and Sociology* 51 (1992): 1-17.

¹²⁷ Freeman, 25.

¹²⁸ Bruggink, 14.

One of the first steps toward the conservation of groundwater is simply monitoring well flows. Neighborhood organizations that police the height of rooflines and shrubbery maintenance could be responsible for reporting water consumption to a county office. Of course, meters would have to be installed and paid for, and landowners who already have well permits may be reluctant to monitor the use of something they consider theirs. But once a system is in place for monitoring water consumption, neighbors could police one another on groundwater use through social sanctions or even adding more stringent pumping limits to local covenants. Although metering water use sounds so simple, it would require changes to state and local laws and a major shift in the way people think about groundwater.

Another key point of working common pool distribution systems is involving local people and ensuring that users get what they pay for – and conversely making sure that free riders don't get anything.¹²⁹ The main problem with applying this to groundwater is that twenty percent of Douglas County's residents do not pay anything for their water beyond the minimal costs of a well permit and pumping.¹³⁰ Thus, a middle level organization would not have a service to provide to landowners – they receive water without paying a water provider. Instead of providing a service, landowners could focus on creating a policing organization that ensured fair allocation of the available groundwater.

An amorphous aquifer that may lie beneath city, county, state, and even national boundaries poses yet another problem for groundwater regulations. Groundwater's ability to flow unchecked and unnoticed beneath these administrative boundaries points

¹²⁹ Freeman, 31.

¹³⁰ *Douglas County News Press*, October 7, 1995.

to the need for a basin-wide solution to the groundwater problem that must involve conservation and monitoring. An effective organization must be small enough to respond to the needs of individuals, but it is essential that it can communicate with larger government entities and other middle level organizations. Middle level organizations could function as multiple parts of a Denver Basin solution, but the middle level organizations would have to be nearly identical so that individuals would feel the system was fair throughout the basin. Another important reason for a middle level organization to be part of a larger set of organizations or government entities is the dissemination of knowledge. Nomothetic knowledge, a generalizable scientific form of knowledge, could help many groups in their conservation efforts, while ideographic knowledge coming from individuals and specific localities could present more creative and unique solutions to problems.¹³¹

In the face of all of these obstacles to creating an effective middle level organization to monitor and conserve groundwater in Douglas County, privatization may sound like an effective solution. Bruggink, in “Privatization Versus Groundwater Central Management: Public Policy Choices to Prevent a Water Crisis in the 1990s,” thoroughly examines privatization as a potential solution to groundwater allocation problems across the nation. He cites the benefits of privatization as increased efficiency and improved allocation. If effectively implemented, that would be a major step towards water conservation. But Bruggink contends that the costs of privatization outweigh the benefits. Privatization would still require a massive overhaul of state groundwater laws, and he highlights that the variability and elusive nature of aquifers would not be

¹³¹ Troy Lepper, Lecture to Sociology 461, September 11, 2008, Colorado State University, Fort Collins, Colorado.

considered a good investment for most companies. A slow-moving pollutant could contaminate the water and destroy the investment, or some of the investment could flow right out of a jurisdiction into another county, state or country. Additionally, it would be very difficult to assign specific water rights to individuals who are currently using unmonitored groundwater. In spite of these obstacles, Bruggink argues that legal reform allowing more water marketing and more involvement on the state and local level is the solution to groundwater management.¹³² As McEvoy predicted, changing the use of the resource will require a major change, not just in how people think about the resource, but in the social structures of Douglas County.¹³³

¹³² Thomas Bruggink, "Privatization Versus Groundwater Central Management: Public Policy Choices to Prevent a Water Crisis in the 1990s," *The American Journal of Economics and Sociology* 51 (1992): 205-222.

¹³³ Freeman; Ostrom and Gardner, "Coping with Asymmetries in the Commons: Self-Governing Irrigation Systems Can Work;" Ostrom, "Reformulating the Commons;" Ostrom, "Coping with Tragedies of the Commons."

CONCLUSION

Even if residents of Douglas County do not organize in time to slow the draining of their main water resource, they will eventually need to organize, as Jim Sullivan of the Douglas County Water Advisory Board suggested. The need to import water from elsewhere will require a middle level organization that can communicate individuals' needs to the government and other water districts. It should be staffed by locals, responsible to local people, and have the power to provide or cut off water service as necessary to members based on payment or non-payment.¹³⁴ Having such systems in place and functioning would be greatly beneficial to homeowners once they do run out of water.

Douglas County residents and their leaders are making considerable progress in the search for water resources for the future. In Parker, the massive Rueter-Hess Reservoir is nearing completion and will hold water purchased from agricultural users on the Colorado Plains. Highlands Ranch is also buying water from South Platte agricultural water users and storing it in an aquifer. This drastically decreases the amount of water lost to evaporation. Castle Rock is scrambling to buy surface water rights to Plum Creek and plans to store the water in Rueter-Hess Reservoir. All of the municipalities within Douglas County realize that groundwater is a nonrenewable resource, no matter how carefully it is conserved.¹³⁵ As predicted by supporters of the Two Forks Project like James Ogilvie, the lack of available surface water forced rapidly growing towns to plumb

¹³⁴ Freeman, 25.

¹³⁵ *Douglas County News Press*, October 17, 1987. Castle Rock paid \$400,000 for the rights to 115 acre-feet annually from Plum Creek.

the depths of nonrenewable aquifers and buy water from farmers, hastening the dry up of agriculture in Colorado.

Towns and cities can provide for their municipal users, but the twenty percent of Douglas County residents who rely on private wells for their water may be greatly inconvenienced when their wells run dry.¹³⁶ For most it will not be feasible to drill any deeper. The water will have to come from somewhere else. To get that water, homeowners will have to organize; in doing so they may relinquish some of their perceived rights to ownership of the water. It will also require protracted fights with various environmental groups as residents, scientists, engineers, environmentalists, and law makers try to reach a consensus on how to provide water for a growing population at an acceptable price and with as little damage to the environment as possible. Many uncomfortable decisions will have to be made as individuals place value on certain parts of nature over others. Similarly, cultural values must be examined as farm families sell their water rights and leave the plains to weeds, dust, and ghost towns.

Underground aquifer storage presents a distinct possibility for a storage option, but scientists are still unsure of the long term impacts of injecting water underground. A renewable source of water will be necessary to fill the emptied aquifers, and it will probably be from agriculture or from another transmountain diversion. Limiting growth is another possibility, but people who currently rely on non-renewable groundwater will need more water, even if the population does not grow. Ultimately, most municipalities across the state and West will need to organize and create a central plan to ensure that all users have the necessary water while allowing for environmental and cultural sensitivities.

¹³⁶ *Douglas County News Press*, October 7, 1995.

The Arapahoe Aquifer lies 1,000 feet beneath the Front Range, stretching from Brighton in the north to Colorado Springs in the south, bounded by the mountains on west and slowly falling off into the eastern plains of Colorado. Filled with ancient water, it has bubbled up to supply individuals and cities across the area with its clear fresh water for decades. Its history can be traced through well logs, consumption patterns, surface water use, and water rights legislation, but its future is unknown. As consumption increases and water levels fall, the pore spaces in the aquifer will no longer hold water. They will be void spaces – the aquifer may collapse on itself, or if the spaces remain intact and unaltered by human intervention, the aquifer could recharge in approximately 10,000 years. Perhaps the pore spaces could be used to store water. The emptied aquifer may provide part of the water storage solution for the Front Range, but the water to refill the aquifer will need to come from elsewhere, emphasizing the need for a solution to the water problems of the state and perhaps the entire nation.

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