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## Social memory and infrastructure governance: a century in the life of a rural drinking water system

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Supplementary material for this article is available [online](#)

### Abstract

Even in advanced economies, underperforming infrastructure is a persistent rural development challenge, with the case of non-compliant small drinking water systems (SDWSs) especially concerning because of the importance of safe drinking water to human health. While technical and financial deficits are known contributors to SDWS underperformance in rural settings, the role of local cultural and social context in water governance are less clear. The need for interoperable concepts that help explain how local contextual factors influence rural water governance and operation motivates this study. Drawing on insights from community resilience and critical infrastructure scholarship, this study draws attention to a previously overlooked dimension of local infrastructure governance: social memory. Archival research and 25 semi-structured interviews with experts and local stakeholders inform the paper's reconstruction of the 100 years history of an SDWS in rural Montana, USA and analysis of the contemporary social memory it has generated. The study finds that social memory acts as a medium through which the lived experience of infrastructure influences priorities and values about its governance, especially in the context of small towns. Three major themes in the dynamics of social memory of infrastructure are described, including longevity, aesthetic and material qualities, and articulation with economic trajectories. In addition to establishing social memory as an effective conceptualization of the generative influence of infrastructure in water governance at the local scale, the paper has implications for policy; specifically, the observation that in addition to financial and technical capacity, historical experience is a powerful driver of infrastructure governance and outcomes such as underperformance.

## 1. Introduction

As a result of decades of economic restructuring and industrial transformation, rural regions in advanced economies face profound social and economic challenges (Edelman, 2019; Goetz *et al* 2018). 'Underperforming' infrastructure ranks high on the list of rural development issues, and the case of small drinking water systems (SDWSs) is particularly vexing. The compounding effects of underinvestment and insufficient technical and financial capacity are persistent and well-known obstacles to bringing SDWSs into compliance with public health mandates (America's Water Infrastructure Act, 2020; McFarlane and Harris, 2018). In resource-dependent communities with industrial histories, legacy contamination can make safe drinking water provision especially burdensome. As a result, SDWSs are overrepresented in water quality noncompliance in many industrialized countries, including the U.S., where, at the time of writing, the

U.S. Congress is debating an infrastructure package that would include billions of dollars in ‘overdue’ water infrastructure spending (U.S. Environmental Protection Agency, 2016; U.S. Office of the Press Secretary, 2021).

While federal funds and programs are much needed, scholars of both water governance and rural development warn against assuming federal resources alone will remedy the rural infrastructure deficit. Local capacity and flexibility are critically important to the success of infrastructure development (Pipa and Ferguson, 2021). In the contemporary rural U.S., the ambivalence shown by rural local governments and their constituents toward senior government mandates and public programs adds to the imperative to ‘localize’ development programs (Cramer, 2016). For all of these reasons, the local dynamics of rural infrastructure governance constitute a pressing research imperative (National Academies of Sciences, Engineering, and Medicine (NASEM), 2021). In a recent review of SDWS research, McFarlane and Harris (2018, p 392) note that governance issues are under-researched and call for critical social science research that analyzes ‘the institutions, processes and relationships’ that contribute to SDWS underperformance.

This study draws on insights from community resilience and critical infrastructure scholarship to investigate an aspect of rural infrastructure governance that has been previously overlooked: social memory. A sprawling concept employed in numerous disciplines, social memory is broadly concerned with the role of past experience and history in the production of shared identities and knowledge (Tallentire, 2001). Community resilience theory frames social memory as a factor in the agency and functional capacities (e.g., resilience) of communities confronted with change or challenge (Colten *et al* 2012; Leap and Thompson, 2018; Wilson, 2012; Wilson *et al* 2017).

The concept of social memory articulates well with a recent focus in critical scholarship on infrastructure’s temporality (Anand *et al* 2018). A key contribution of this research is to put social memory and critical infrastructure studies in dialogue. We posit that, in rural settings with multi-generational residents and long-serving local officials, water infrastructure—as it is lived, used, and managed—generates social memory. Social memory, in turn, shapes and reflects the perceived value and consequence of past public infrastructure choices and how local actors understand and approach present-day or future infrastructure investments and maintenance. Describing and theorizing the social memory of public infrastructure management, we argue, both expands and sharpens how scholars and policy makers approach the rural infrastructure deficit.

To explore the formation of the social memory about rural infrastructures and its implications, this paper develops an in-depth case study of the rural drinking water challenge. Denton, Montana, USA, is a small town (population 250) that has struggled to comply with safe drinking water standards for over half a century. Perennial issues for rural public services—declining economic circumstances, shrinking population, environmental contamination, and limited local financial and technical capacity—are all present in the Denton case study. Approaching SDWS governance as an evolutionary process deeply entwined with local custom and context, we document and analyze the full 100 years history of Denton’s public water system. Through archival records and interviews conducted with regional experts and local informants, this paper documents the pathway of local leaders navigating the evolving drinking water policy corridor (Wilson, 2013) as they built, operated and repaired Denton’s public water system over time. We then analyze the social memory of Denton’s drinking water system through interviews with local stakeholders, seeking to understand its contours, its genesis, and its implications for SWDS decision-making.

The paper’s roadmap is as follows: first, we review and synthesize the work of others to establish a conceptual framework that links SDWS governance, critical infrastructure scholarship, social memory, and community resilience in the rural context. We then provide an overview of the case study region and a description of methods. Findings are reported in two parts—the public water system’s management history and an explication of key features of social memory of that history—followed by a synthetic discussion and conclusion.

## 2. Conceptual framework

Rural development expert Flora (2009, p 6) interprets local water provision as a fundamental to community development. ‘Management is more than the technical operation of water systems’, she writes. ‘It is the governance of the community, and how water fits into the community’s present and future’. This paper shares this orientation, adding to it a critical third dimension—the idea that rural water provision of the future is closely connected to that of the past. Thus, the paper’s conceptual framework brings the longitudinal features of infrastructure governance into frame as a factor of SDWS governance. In making a case for the influence of social memory, this literature review establishes the importance of local dynamics as factors in SDWS management. It then demonstrates how the concept social memory aligns with perspectives in critical infrastructure scholarship which emphasize the social and political agency of infrastructures and the importance of temporalities therein.

## 2.1. Drinking water governance and rural development

Public water systems represent a critical nexus between environmental resources, social well-being, and local governance capacity in rural communities (Flora, 2009). Chronic SDWS underperformance is increasingly recognized as a public health concern (Balazs and Ray, 2014; Riggs *et al* 2017). SDWS failures are not for lack of regulation; federal and state laws (e.g., the Safe Drinking Water Act in the U.S.) establish standards in water systems management to which local actors must adhere (Humphreys and Tiemann, 2021). However, rural public service provision occurs in a broader political economic context of rural decline—characterized by narrowing tax bases and limited leadership capacity (Halseth *et al* 2019). Programs that devolve governance to the local level, including the implementation of infrastructure development and maintenance, face low odds of success when local capacities are so overtaxed (NASEM, 2021). The misalignment between policy and local capacity is particularly acute in the case of SDWSs in Canada and the U.S. (Doyle *et al* 2018; McFarlane and Harris, 2018; NASEM, 2021).

The dilemmas of SDWS management and rural service provision have been well-reprised elsewhere (McFarlane and Harris, 2018; NASEM, 2021). Studies evaluating SDWS governance suggest that local capacity, regulatory compliance, and inconsistent public support are key challenges in SDWS governance, leading to chronic system underperformance. Despite the highly local nature of SDWS governance, a small number of studies go beyond managerial and financial capacity to characterize how local factors affect SDWS governance. Among water system users, aesthetic qualities such as taste, smell, and color have been shown to distort perceptions of health risk and dampen enthusiasm for interventions. Studies suggest that for their part, water managers in under-resourced contexts cope with overwhelming regulatory burdens through strategies such as delayed decision making and informal capital improvement planning (Hanrahan *et al* 2014; Kot *et al* 2015). In addition, studies of remote indigenous communities note the importance of aligning SDWS governance solutions with cultural practices and social institutions (Daley *et al* 2015; Hanrahan *et al* 2014).

Taken together, the literature addressing how and why local SDWS decisions are made in a highly challenging rural policy environment affirms the influence and heterogeneity of local factors (Halseth *et al* 2019). It also suggests ample opportunity for theory-building work. While this study relies on a single in-depth case study, it is motivated by the need for interoperable concepts. Specifically, this paper explores how infrastructure represents the embodied experience of local government decisions, how it shapes local perceptions of water quality, and how it influences local appetite for government intervention. In most SDWS governance and public service provision scholarship, the actual infrastructure is largely inert, hulking in the background of the study as an impossible cost, engineering dilemma, or health hazard. This passive conceptualization of infrastructure is in contrast to the approach of critical scholars who maintain that infrastructure has an active political, social and cultural role in society (Anand *et al* 2018; Howe *et al* 2016).

## 2.2. The agency of infrastructure

Infrastructures like drinking water systems are far from neutral technologies, according to political ecologist Farhana Sultana. Rather, they thrust government actions and decisions into the immediate everyday experiences of citizens (Sultana, 2013). Public anger in the aftermath of catastrophic water service failures, as in Flint, MI, provides striking evidence of infrastructure's direct influence on political subjectivity (Morckel and Terzano, 2019). Government inaction, too, is evident in day-to-day function of infrastructural systems, as Meehan (2014) documents in her case study of unreliable water services and public coping mechanisms in Tijuana.

The temporal dimensions of infrastructure notably contribute to its outsized role in the cultural lives of communities and societies. Carse and Kneas's (2019) review of scholarship on 'unbuilt and unfinished' infrastructure projects parses the temporal dynamics of infrastructure's cultural agency into a typology, showing that unbuilt infrastructure can act like a 'zombie' or encourage a 'suspended present', where waiting for a promised infrastructure development can feel to subjects more permanent than transitory. Thus, critical infrastructure scholars argue for conceptualizing infrastructural systems not as fixed objects, but as *processes* constantly in flux (*ibid*). Whether functional or decrepit, built infrastructure is a material collective that spans human generations (Sagarra, 2020).

Given infrastructure's long-lived character, it is not surprising that infrastructure features occasionally in memory studies, including critical scholarship focused on collective or social memories and their relationship to cultural, social, and environmental trajectories. For example, Schwenkel (2018) demonstrates that in addition to acting as catalysts of political positions, infrastructures also mediate affective, psycho-social dynamics in communities. In her example, a community in Vietnam is empowered by seeing an abandoned, dilapidated powerplant as, to them, it is symbolic of a shared prosperous past and steadfastness through violent conflict.

With its orientation toward collective historical narratives as a powerful component of the perceived agency of communities, social memory provides a useful conceptual framework to approach the social and cultural agency of infrastructure in SDWS governance and decision-making. More specifically, in this paper, we employ

an approach to social memory articulated by community resilience scholars, which focuses on social memory's role in community decision-making and response to environmental and economic change.

### 2.3. Social memory and community resilience

Resilience scholars define social memory as an essential dynamic in environmental systems (Wilson, 2012). Social memory features especially prominently in community resilience scholarship, which emphasizes that community transitions are strongly shaped by local histories (Colten *et al* 2012; Leap and Thompson, 2018; Wilson, 2010). As articulated in Wråkberg's thick description of its influence on a remote Norwegian mining region in transition, social memory is 'a group-based cognitive resource for everyday use by its holders to form opinions and make decisions that are important to their futures' (2020, p 2).

Social memory can confer resilience or deepen vulnerability. Community resilience scholars have traditionally focused on local environmental management practices as examples of the influence of social memory—both positive and negative. In an example of 'positive' social memory, nomadic herders' survival depends on social memories that catalog robust and layered information about a variety of resources that can be utilized under different environmental conditions (e.g., water or forage locations as in Fernandez-Gimenez, 2000). Similarly, collective knowledge about alternative fishing sites and ways to supplement lost income is described as 'inherent resilience' in Colten *et al*'s (2012) longitudinal comparison of coastal community responses to oil spills in Louisiana. In other cases, the persistence of historic customs and practices—for example, local religious rites believed to ward off dangers—may be a social memory that impedes the adoption of what might otherwise appear to be 'common sense' hazard mitigation (Wilson, 2012, pp 95–96).

The adaptive and non-adaptive dimensions of social memory are not necessarily mutually exclusive; resilience operates across different domains and temporal and geographic scales. Resilience in one arena or scale may create vulnerabilities in another. As Wilson writes (2015, p 243):

Social memory leading to increased vulnerability can nonetheless persist in communities and be passed on through generations if it is at least in part counter-balanced by social memory that has enabled the community (or parts thereof) to survive. It is only when encoded traditions that are beginning to tip a community over the resilience thresholds that practices linked to memories increasing vulnerability may disappear.

Striking a similar note about the multivalent operations of social memory, Wråkberg notes 'nuanced narratives', among stakeholders in the collective memory of iron mining residents that engender 'pragmatism' toward new development in the outlooks of those familiar with mining in contrast to less experienced stakeholders (2020, p 6).

Reviewing and applying decades of social memory scholarship, Wilson (2012, 2013) points to three types of collective processes that influence social memory: social learning, historical stakeholder networks, and traditional practices and customs. Social learning connotes shared knowledge and information flows within a community, making it complimentary to understanding stakeholder networks. Historical stakeholder networks are agents of social memory in that they describe how people are connected to one another. Networks, though, often contain power asymmetries, allowing individuals to not only exert influence over decisions in-the-moment, but also to emboss knowledge selectively into shared memories. Shared beliefs are encoded in traditions and customs, which include collective practices such as holidays or public meetings.

An especially powerful aspect of the concept of social memory is its recognition that every decision builds on the outcomes and features of past decisions, echoing the emphasis on temporality in critical infrastructure scholarship. However, the ongoing interactions between community decision-making (and decisions-made), their outcomes, and social memory *over time* are largely absent from scholarship on rural public service provision, including SDWS governance. In response, the following case study delves deeply into interactions between decisions about a public water system, their outcomes, and a small town's evolving social memory of water infrastructure.

## 3. Study region and approach

### 3.1. Study region description

The town profiled in this study, Denton, is one of several small population centers spread out along a century-old railroad system in the Judith River watershed in the state of Montana. Historically, farmers and ranchers loaded their grain and cattle onto railcars at Denton. Today, the town provides basic commercial and public services, including a library and public school. The current population is approximately 250 people, having declined steadily from a peak of just over 500 reached in the 1950s (U.S. Census Bureau, 2010).

The 7200 km<sup>2</sup> Judith River watershed sits on the western edge of the semi-arid Northern Great Plains of the United States, where rolling high plains ringed with mountains are drained by a series of tributaries to the



Missouri River. A recent study describes the area as ‘characterized by economic dependence on farming and services, relatively low economic diversity, and unchanging or declining population (numbers)’ (Jackson-Smith *et al* 2018, p 612). Key issues in the region with respect to public drinking water systems are not only the great distances between homesteads and communities and the generally limited supply of water (Hargreaves, 1993; Kraenzel, 1955), but also contamination from livestock waste and agricultural chemicals, especially nitrates.

Since groundwater monitoring began in the study area in the 1990s, the steady rise of nitrate has been striking (Schmidt and Mulder, 2010). Yet elevated nitrate levels in drinking water were recorded as early as the 1940s, suggesting the influence of local geological features, namely shallow aquifers vulnerable to contamination (Sigler *et al* 2018) and fertile soils that shed nutrients easily (Sigler *et al* 2020). Bio-geophysical complexities notwithstanding, nitrate contamination of drinking water supplies is an issue in the watershed and is linked to intensive agricultural practices of the past half-century.

Nitrate levels in drinking water are regulated by the Safe Drinking Water Act, due to well-documented public health concerns surrounding methemoglobinemia (also known as blue baby syndrome) and nitrates’ potential links to various types of cancers (Ward *et al* 2018). Denton’s public drinking water was first flagged by the state for failing safety tests in the 1940s and routinely exceeded nitrate standards from the 1970s through the 2010s. In 2020, the town completed a \$2 million upgrade necessary to achieve compliance with Safe Drinking Water Act standards, potentially bringing its long history of persistent and known contamination to a close. It is this history—a classic case of SDWS underperformance—which we document and also explore as social memory.

### 3.2. Methods

In narrating the history of Denton’s public water system, we align themes identified in Wilson (2012, 2013) with our focus on infrastructure governance—which infrastructure decisions were made, who made them, and in response to what—as a medium in which social memory evolves and adheres. Accordingly, the research approach had two objectives. The first was to document key decisions over time affecting the construction, operation, and maintenance of Denton’s public water system. The second was to characterize the contemporary social memory of the town public water system, with the hope of also identifying key historical moments that contribute to the town’s shared experience of public water. The first objective relied primarily on background policy research and consultation of local archival records, the second drew from interviews conducted with regional experts and local informants.

Archival records provided information about the history of water governance in Denton. Specifically, we collected all relevant town meeting minutes from the local courthouse and catalogued their contents to identify key decision nodes in the history of the town’s water system from 1916 to 2020. We used town meeting minutes to ascertain town council membership over time to document the historical stakeholder networks of decision-makers and identify patterns of persistence in group membership. Background research into federal, state, and local public water regulations provided the policy details necessary to document a policy corridor and its constraints/demands on local decision-making.

Interviews with key stakeholders comprised a second dataset. Semi-structured, in-person interviews were first used to collect background information from expert informants from outside the community ( $n = 9$ ). Information gathered focused on how water quality regulation and infrastructure development has occurred in the JRW region and Denton. Key informants included a state agency regulator (1), non-profit staff (1), university-based experts (2), and representatives from engineering companies engaged in local water infrastructure work around the state (5). Interviews lasted from 30 to 90 minutes and were conducted by phone (6) and in-person (3) based on the preference of the interviewee.

Sixteen semi-structured, in-person interviews with local informants occurred in winter of 2019–2020. We used a snowball recruitment strategy to develop a purposive sample of historical stakeholders in the drinking water system (Morse, 2004). Participants were selected due to their involvement in town infrastructure decision-making and operations. The group included past and present town council members (7), past and present mayors (2), past and present water system operators (2), and local residents (5).<sup>5</sup> Recruitment ended when no other interviewees could be identified. Each participant was asked about their impressions and recollections of infrastructure decision-making, dynamics within infrastructure governance networks, their experience navigating federal and state water quality regulation, the role of different stakeholders in social learning (e.g., outside expert knowledge), and their outlook on the future of the town. The interview guide was constructed with the dual intent of (1) better understanding the details of the town’s infrastructure history

<sup>5</sup> We did not request detailed demographic information, but the sample can be described as comprised of people aged 40 and older who identify with cisgender categories (2 female/14 male) and Euro-American ethnic heritage. There are no known non Euro-Americans in the town. Years of experience in water system operations and decision-making range from 5 to over 15, years of experience as water consumers commensurate with age.

and (2) exploring interactions between community resilience and water infrastructure governance (see supplemental material (<https://stacks.iop.org/ERIS/1/035004/mmedia>)). Because many of the interview questions were open-ended, participants often shared personal perspectives at some length. Interviews lasted from 60 to 120 minutes, were conducted in person, were audio recorded with permission and were subsequently transcribed.

Analysis of the interview transcripts followed an iterative, constructivist approach based on the application of grounded theory as a tool to open data up for conceptualization (Bryant and Charmaz, 2007; Coffey and Atkinson, 1996). This process evolved as a team of three analysts interacted with transcripts stored and coded in NVivo 12. We began with a theoretical coding exercise Glaser (1978, 1992, 1998) oriented toward the relationship between governance and community resilience targeted in our interview guide. However, in discussing memos made during the first round of coding, it became clear that historical perspectives and experiences strongly informed perceptions about SDWS governance. We returned to the interview transcripts to undertake open coding of representations of interviewees' perceptions and past experiences. (See supplemental material for examples of open codes.)

This new direction sent us back to the theoretical literature on the community resilience and critical infrastructure studies literatures in search of a theory that might explain the phenomena we observed—a tactic in keeping with emergent methods (see Charmaz, 2008: 161). Although we had not first set out to examine it, social memory was the concept that best captured the specific role of lived experience in water infrastructure decision-making present in our case study. A team of two paper authors then engaged in a new round of selective coding of interview data to distill analytical categories about the formation and operation of social memory.

After social memory emerged as a key concept in the interview data, the research team matched key nodes in the town's archived history to shared memories. Taken together, this approach allowed us to describe the key infrastructure decisions made, relevant policy and local drivers, and the historical stakeholder network active in those decisions, which we describe as findings in sections 4.1 and 4.2. The findings section presents themes in the local social memory, which are subsequently analyzed in section 5.

## 4. Findings: social memory of a rural public water system, 1916–2020

### 4.1. Historical stakeholders and water system governance

Decision-making power over Denton's drinking water system rests with the town council. The town council exercises authority, within the parameters of state law, to assess and collect local taxes, including water rates. It is comprised of six elected, non-partisan members and a mayor who serve staggered four-year terms. The council also makes decisions about other local issues, such as street and sidewalk maintenance. By passing resolutions to issue bonds, entering into contracting agreements, and submitting work orders, the council's decisions direct the form and operations of the community's water system—including whether and how to meet state and federal requirements for drinking water quality.

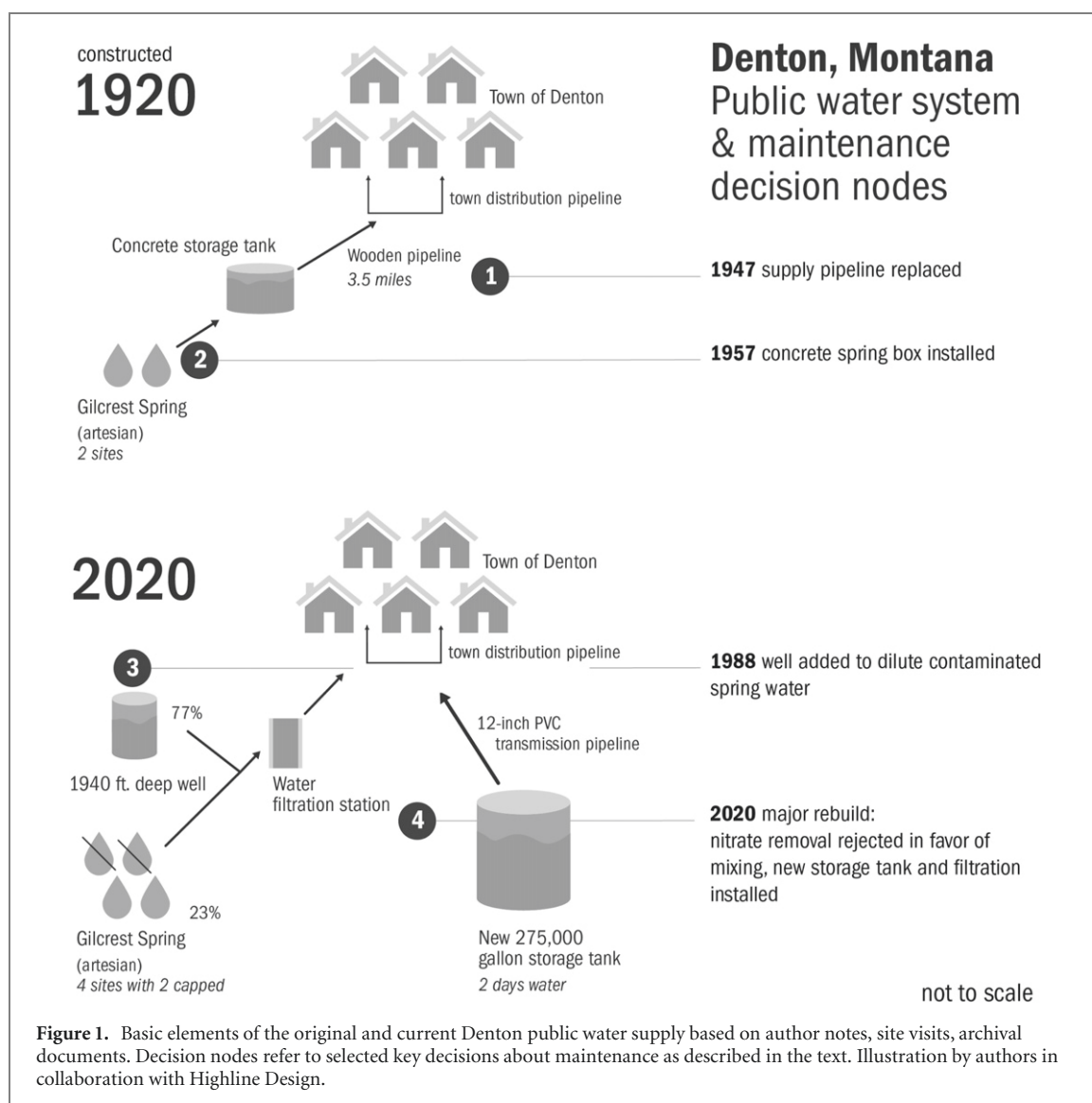
As the locus of key water system decisions and the convenor of the public dialogue accompanying them, the town council anchors the network of historical stakeholders in the town's social memory of water. Council members routinely serve two consecutive terms, while some stalwarts have served for four or more terms. The result is a group of local decision makers with a high degree of continuity and institutional memory. For example, council meetings occurring in the 1990s brought over 80 years of cumulative experience together in the room<sup>6</sup>.

Over the past century, the town council's accountability to state and national regulations regarding its drinking water system increased, adding to both the complexity and gravity of council decisions.<sup>7</sup> Since the 1970s, extensive consultation with, and input from, state and federal agencies and private engineering firms has accompanied local decision-making about the water system along with a corollary increase in costs and need for external funding. Our review of town council minutes and the interviews we conducted describe townspeople as generally willing to delegate the management of Denton's infrastructure to their elected officials. The public rarely attended town council meetings with any regularity, but historically, special meetings occasionally drew large numbers of the public—particularly when rate or tax increases were on the agenda<sup>8</sup>.

<sup>6</sup> The authors compiled town records to evaluate patterns in the length of public service by local officials.

<sup>7</sup> Administration of water quality regulations has transferred over time to different Montana agencies: Montana State Board of Health, 1901–1967; State Department of Health, 1967–1971; Department of Health and Environmental Sciences, 1971–1995; Department of Environmental Quality, 1995–present.

<sup>8</sup> While the notes from special meetings do not always indicate how many people attend, notations that do exist indicate that anywhere between 13 and 76 people attended the meetings leading up to the well project in the late 1980s.



#### 4.2. The drinking water system's evolution

The basic contours of Miracle Engineering Company's 1917 design for Denton's first public water system have endured for over a century (figure 1). Denton's drinking water is first collected and stored at the Gilcrest Spring, then piped to town through a main supply line, and finally distributed to houses, public buildings, and businesses via a network of distribution pipes. Material realities embedded in the system's original design have proven stubbornly problematic over the town's history. While the spring delivers delicious-tasting, free-flowing water, its connection to surface soil-water processes makes it vulnerable to contamination. In addition, the distance of pipes from the source to town (3.5 mi.) creates maintenance expense and headaches.

Four major decision nodes mark the Denton water system's post-construction evolution (Wilson, 2012). At each node, local decision makers wrestled with perennial concerns of infrastructure governance: how to 'right-size' a project to meet community needs and regulatory requirements and stay within budget limits. Each decision node has a remarkably similar pattern. After delaying repairs for as long as possible—generally until the point of a water supply crisis or major regulatory action—Denton's decision-makers rejected the most expensive upgrades and overhauls proposed by engineers and regulators, opting instead for the minimum level of intervention and expense. Their frugality reflects local customs and economic realities favoring pragmatism, and also some of the constraints of state grant and loan programs.<sup>9</sup> A determined commitment to keeping waters from the Gilcrest Spring in the public water supply is another important feature of this history. In this way, the decisions reflect and perpetuate a set of customs and rites of an ideologically-conservative local government: rites that are, by extension, rites of public infrastructure.

<sup>9</sup> Denton residents have generally relied on the issuance of local bonds to fund capital investments in their drinking water systems, using rates to repay those bonds and manage basic costs of operations. However, state and federal funds—grants as well as loans—were also necessary to support projects in the 1980s and 2010s.



The pattern of frugal choices made reluctantly and only when absolutely necessary surfaces in early town records. The town's first major maintenance project constitutes the first decision node (see figure 1). When the Town Council authorized a \$68 427 (\$1.7 million in 2020 dollars) bond to build a new supply pipeline in 1947, the wooden water main had been leaking for decades, and had been discussed at numerous council meetings (Town of Denton, 1920, 1937, 1946). A concrete spring box completed in 1957 to mitigate the risk of contamination from surface land use activities followed fourteen years after the State Board of Health recommended it (node 2).

The pattern of delayed and reluctant investment repeats in decisions made during the modern era of environmental regulation. In 1982, the Montana Department of Health and Environmental Sciences repeated a request they had made several years earlier<sup>10</sup>: that community officials correct the nitrate issue in the public water system (Town of Denton, n.d.). In 1984, the state filed a civil suit against the town for violations of the maximum levels of inorganic contaminants allowed in public drinking water (Town of Denton, 1984)—thirty years after first notifying the council of excess nitrates in its drinking water. The lawsuit triggered a round of planning, engineering and funding proposals.<sup>11</sup> The final upgrades in 1988 (node 3) presented a creative and interesting choice: rather than abandon Gilcrest Spring and dig a new well as engineers initially proposed, the Town of Denton would *keep consuming its contaminated spring water*, using a new well to dilute the spring water to safe levels (Town of Denton, 1985).

The process of blending well and surface water to remediate unsafe levels of nitrate proved less than optimal. While low enough in nitrates to enable blending, the new well water's high levels of 'nuisance chemicals' (naturally-occurring iron and manganese) made town water difficult to live with due to corrosive and chemical (staining) effects. These minerals do not pose concerns for drinking water safety and they are not regulated by the Safe Drinking Water Act as nitrates are, but they make the well water considerably less tasty. In response, the local water operator managed the mix of well and spring water with the goal of using only what was needed to achieve acceptable nitrate levels. This adaptive approach may explain why the town struggled to stay in compliance with the Safe Drinking Water Act. The Montana Department of Environmental Quality required increased water testing (at times daily testing) due to routine nitrate violations for much of the 2000s (Town of Denton, 2007, 2008, 2009). The town continued to purchase bottled water for its most vulnerable citizens: expectant mothers and families with infants at home.

There were other problems as well. Almost as soon as a metering system went into place in the late 1990s (a requirement of the 1988 funding package that was reluctantly and slowly implemented) discrepancies between water plant output and household water usage became apparent, indicating possible leakage in the supply lines. Next, a legal determination by the state in 2011 characterized Denton's source water from Gilcrest Spring as 'Ground Water Under the Direct Influence of Surface Water', creating additional requirements for treatment and security due to the risk of contamination from bacteria such as *Giardia* and *Cryptosporidium*—triggering a new round of expert consultancies and project engineering discussions about system upgrades (Town of Denton, 2011a, 2011b).<sup>12</sup> On a frigid New Year's Day in 2016 the well pump failed due to corrosion from nuisance chemicals, leaving the town reliant on spring water with dangerously high levels of nitrates and forcing the council to deliver bottled water to all residents for a week (Town of Denton, 2016).

By the mid-2010s, the council was well into a lengthy consultation process with engineering firms to determine a course of action. A new storage tank would meet legal requirements for treatment of the spring water for potential bacterial contamination. Supply and leakage concerns would be addressed with an upgrade to the system's pipeline components. When it came to water quality (both aesthetic and environmental) the town rejected a proposal to add nitrate removal technology due to its expense, meaning Denton chose to retain the mode of mixing of Gilcrest Spring water with well water to dilute nitrates (node 4). The decision did not incorporate findings from a source water protection planning effort that identified land use contributions to the town's water quality concerns (interviews 2 and 17). In 2016 a declaration of emergency again provided a strategy (recommended by the State) to improve Denton's prospects in competitive grant processes. This allowed town leaders to stitch together a package of fiscal resources to purchase significant technical upgrades that promise long-run drinking water compliance. In 2020, the construction of \$2 million in upgrades marked a milestone in a century-long history of local public water supply governance.

<sup>10</sup> Minutes noted: 'in the late 1970s, the Montana Department of Health advised the Town of Denton their water supply exceeded the Federal Drinking Water Standard for nitrate content (10 mg liter) Annual testing since then has shown a nitrate peak of 26.2 mg l<sup>-1</sup> and an average content of 14.8 mg l<sup>-1</sup>'. (Town of Denton, n.d.).

<sup>11</sup> At this time, the expense of the projects added another element in the decision trajectory—the complexities of state and federal funding cycles. For example, the town's initial application for a Community Development Block Grant (CDBG) for total system improvements was denied. The re-ranked grant application allowed only for improvements to the worst parts of the current system (Town of Denton, 1987).

<sup>12</sup> Note that the state first noted concerns about bio-contaminants in 1943.

### 4.3. Denton's public water system in social memory

As many town leaders and residents have now lived through multiple phases of drinking water (non) compliance, we turn toward an investigation of how these historical events are remembered and interpreted in local social memory. Our interviews revealed a shared narrative in which the small town was getting along just fine prior to water quality enforcement that began in the 1970s and led to major system upgrades in 1988 and 2020. During the town's early years, while rural families in the region hauled water, Denton's community water system made the town a green oasis compared to its semi-arid environs. The introduction of water quality regulation is a major turning point in the town's social memory of infrastructure in that (according to the remembered experiences of our informants) the regulation addressed problems that did not exist, it failed to address the actual problems facing the town, and it introduced new problems along the way. We identify four defining themes in Denton's social memory of public water infrastructure, discussed in detail below.

#### 4.3.1. *'You can just turn on a tap it's always there': the benefits and costs of a public water system*

People we interviewed often organized their thinking around the costs and benefits of local water infrastructure. Complaints about water bills exist in tension with personal histories of growing up without running water. At the same time, all stakeholders expressed a need for 'reasonable' water system costs.

**4.3.1.1. Town water as luxury** For those residents who had lived, or whose families had ranched, in the surrounding countryside, memories of hauling water reinforce the value of so-called 'town water'. As one interviewee related, 'Well the only experience I had is I grew up 25 miles north of Denton in the summer time and we had to haul our water because we did not have water supply. So, when you haul water you appreciate water way more than, 'turn on the tap and here it is' (interviewee 10). Another version of this sentiment was expressed with the observation that 'a lot of people in the community outside of here, either haul water [or] have a cistern, nobody has water. So, people in town better be darned glad no matter what they got to pay for it!' (interviewee 15).

Interviewee 13 added detail to this narrative in his/her explanation of the hard work involved in doing laundry without town water: 'We had a 500-gallon tank and we would have to haul water about every three weeks. Take a bath on Saturday if you really need one bad. Mom washed the clothes by hand with a wringer and she would fill it up with hot water and soap'. The scarcity of water and the difficulties in moving and using water on the ranch led him/her to add, 'we did not waste water'. In later years, he/she moved to the town outskirts and petitioned the town to let him/her hook into the public water system. Since he lived slightly outside the town limits, he had to pay to connect to town water.

[T]wo years ago this last fall I decided I am going to ask the town because they would let some other people hook on over the years after they put the well in ... And it was terribly expensive, it was close to \$50 000 by the time I got all in there and hooked up, a good \$40 000 just to get it to the place...

Although that price was high, having access to the town's water infrastructure made it worth the cost, she/he said. 'Now I do not have to worry about the quality. I do not have to worry about the electricity going out, my pump going out or something. I have got good water, as good as the town ... it is the best move'. In a bittersweet acknowledgment of the relative ease of connecting to town water compared to the challenges of supplying the ranch with fresh, potable water, interviewee 13 stated, 'I just wish that my folks could have done that rather than have to haul water all the years they were out there'.

**4.3.1.2. Avoiding an uprising: perspectives on the cost of water** These perspectives came to bear when the town council walked the fine line between raising water costs to remediate the water situation and answering the concerns of town residents. As one council member answered when asked about residents' responses to an increase in water rates: 'they were not really overjoyed about it (laughs)!' (interviewee 1). There were logics at hand that proved effective in responding to gripes about water rates, including a comparison with other living costs. Interviewee 3 noted: 'we actually had people [say] well I am going to move out of town [if my water bill is raised] ... And of course, we always made the argument ... well, how big is your [satellite TV] package? And then people just shut up!' Another effective rebuttal was to compare the convenience of town water to the challenges of hauling water. Describing how one local 'pretty much shut a lot of people up' at a public meeting, an interviewee described how:

[This person] got up and said, 'you guys do not know how good you have it. ... [W]here he lives out in the country, he ... has to haul his water out there. And you can just turn on a tap it is always there. You never have to start a vehicle in the winter to get ... your water, being hooked up and having it at your tap and anytime you want it is such a luxury. You cannot put a price on it'. (Interviewee 3)

A focal point of the social memory of Denton's water infrastructure involves the introduction of metering in the 1990s, a requirement for public funding of the 1988 system upgrade. Residents had previously paid a fixed rate for the first 10 000 gallons of water used, and more when their use exceeded the base. With metering,

they paid for each gallon. While their total water bills may not have changed much, for many in-town users the change equated to a lost right to water. Recalling public response when meters went in, one former official said ‘when we changed it to where you had to pay for every gallon that created the biggest uproar of anything in the whole project. ‘People were like, “charge us whatever but do not take our 10 000 gallons away”’ (interviewee 14). When interviewee 1 referenced a time when there was a base level of water, ‘and if you go over that you would pay extra’, she/he indicated that base levels were enough for most families. If residents wanted or needed more water, they could always choose to pay for more, specifically ‘people with big fancy lawns that liked to keep them green’. Interviewee 1 saw the base level of water as a town right and residents could choose to pay for more, if they wished.

Well-watered lawns also stand out in residents’ memories. Many remembered Denton’s green lawns with pride and longed for the days when their neighbors kept up their yards. Denton stood out from the surrounding arid countryside as a green oasis. Interviewee 12 remarked, ‘Well we have people that moved to this town because when they (drove) through here, ... it was always green here. Because we have tons of water. It was unmetered’. Her/his comment on the unmetered water demonstrates a node in the social memory of community water that recalls residents weighing the cost of watering their lawns against a lower water bill. When the cheaper option won out, in this narrative, Denton’s curb appeal suffered. Interviewee 15 explained:

There is people that do not water their lawns because it is too expensive. But it looks awful in the summertime. And I know if you cannot afford it, you cannot afford it. You got to have your medicine or something, that is fine ... When you come to Denton it was just green everywhere. But that is one thing, and it is because of the price of water.

By juxtaposing a choice to keep a green lawn with the choice to purchase essentials like medicine, interviewee 15 indirectly narrates the growing constraints of an aging town inhabited by a large proportion of retirees living on fixed incomes.

In addition to the controversy over water meters, many residents balked at the rising cost of the water projects. Interviewee 10 talked about how the cost of meeting water regulations, as well as the repairs and renovations to the water system, frustrated Denton residents, recalling that ‘[we] had some pretty heated debates with the public over, especially the money end of it, because most of the people were not excited about the increase we were talking about’. She/he observed the difficulty townspeople had accepting the costs: ‘a lot of people ... did not understand why do we have to do that. [They said], “that is just silly, let us not do that.”’ Describing the council’s reply, she/he said, ‘well, you are required to do it, you are going to do it, that is all there is to it. We have regulated to the point where we have to do it. And there is not any “no let us not do that deal”. Because it is going to happen’. In response, she/he observed, ‘we had to take a run at it in little short spurts. Because if we would have dumped three times the water price on them in one sitting, I think we would have had an uprising’.

#### 4.3.2. ‘There has never been a blue baby’: nitrate regulation as unnecessary

When serious enforcement of nitrate standards touched down in Denton in the early 1980s, the town had already known of nitrates in their water supply for thirty years. Then and now, state regulators warn of blue baby syndrome and other public health risks from high nitrate loads in drinking water (Ward *et al* 2018). But the warnings from outsiders contradict the lived experience of Dentonites and their corresponding social memory. A prominent feature of the town’s collective memory is the idea that regulators have been out-of-touch because their nitrate regulations were a solution in search of a problem.

Perhaps the most prominent character in the social memory of water quality regulation is the proverbial ‘blue baby’, precisely because no such baby ever existed in Denton. As interviewee 1 put it, ‘nobody worried about the nitrates because nobody died from it. Just the government and the EPA worried about it’. Another describes how state officials narrated the problem: ‘[state officials] used to always talk about blue babies, there has never been a case to my knowledge in Denton, I have never heard of a blue baby being born in this community’ (interviewee 10).

While ‘the blue baby’ is narrated as a specter by the state, in the shared memory of Denton, the blue baby is more like a boogeyman: a myth that is meant to scare them into taking action, but is actually harmless. In the words of interviewee 6:

[F]or a number of years there is been nitrate problems here. To the locals it’s not a problem but to the state standards or federal standards it is. Supposedly blue babies were the result of high nitrates or something. Well, there has never been one that I know of around here. And it’s never affected anyone to my knowledge. So, they dictated what we had to do.

Interviewee 6’s comments about the blue baby underscores its central role in local skepticism about regulating water quality. Interviewee 14 describes how skepticism about regulation born from lived experience has contributed to a ‘delaying’ tactic in compliance when she/he recalls:

We'd get the notice from the state that we had high nitrates .... You know people had lived here for 50 or 60 years, nitrates hadn't changed. There were not any blue babies. There was nobody sick. Everybody was getting along fine. And we just ignored it. We didn't do anything with it .... That's the way the council and the mayor and everybody viewed it and we just let it slide.

Seeing no tangible problems arise from a long history of living with nitrates in drinking water, Dentonites developed a corresponding perspective on the recent history of increased drinking water safety regulation as overbearing and unnecessary. There is a strong shared sentiment that nitrates have always been present, they always will be, and they are harmless. The expensive infrastructure improvements enforced by the federal Safe Drinking Water Act clash with this shared knowledge, and sow feelings of resignation rather than enthusiasm toward regulatory compliance.

#### 4.3.3. *'Now we do not have quite so good of water': water quality declined with regulatory compliance*

Many interviewees recall the moment in 1988 (node 3) when Denton began blending spring water with well water to reduce total nitrate loads as a pivotal change—a change when, from their perspective, the system simultaneously became more costly while delivering poorer quality water.

As described earlier, the plan to dilute nitrate-laden Gilcrest Spring water with 'clean' well water introduced new water quality issues. Interviewees regularly recalled that the aesthetic properties of Denton's water diminished drastically with the introduction of well water, which was not for all intents and purposes, especially 'clean'. After source water blending began in 1988, town water turned residents' laundry orange, ran brown from the tap, and had a poor taste. Interviewee 16 remembers this transition starkly:

Well, from the beginning when I was a kid around here, we had plenty of water. It was cold, it tasted good, it had no chemicals in it, and everything was just fine. Well then as time went on, we started ending up with nitrates in the water. So that became an issue and we eventually drilled a well out there to blend the spring water and well water to get the nitrates down .... Well then it did not taste as good .... We used to have really good water and now we do not have quite so good of water.

Long-time residents remembered clear, tasty water prior to 1988, and orange, unpleasant water flowing from their taps afterward. Another says, 'the water as far as the way it tastes and the quality it probably went downhill after [Denton started blending water sources in 1988] because we started picking up iron and stuff in the water that we did not have before' (interviewee 13).

One town leader described trying to balance the townspeople's disdain for the iron-rich water with the state's nitrate enforcement, she/he says: 'yeah, you try to blend it down to where [local residents] were not really ticked off about the iron, but so that we could also keep the nitrate levels below [the state's requirements]' (interviewee 1). The change from perceived 'good' water to 'bad' produced a mismatch between regulatory requirements and lived experience that contributes to cynicism about water quality regulation described above. The adoption of well water also introduced new maintenance problems due to its corrosive qualities.

At the same time, the 1988 project was costly, and as mentioned above, introduced new pricing structures which residents resented. Town officials were caught in a quandary between the mandate to provide suitable drinking water for their community and having inadequate resources to do so. The discussions about the value of water referenced earlier attempted to resolve this tension. At the same time, the project felt expensive, even to council members. As one put it: '[you] think just because you're [a little town of] 200 people, it doesn't have to be as expensive ... in your mind you're thinking, "well there's only this many of us how can it be THAT expensive?!"' She/he ended on an optimistic note observing, 'but it does not really matter because I think we got good water for a lot of people now' (interviewee 7).

Others contrast their interpretation of regulatory burden with their drinking water perceptions:

We have always had nitrate problems through history. I do not know, on nitrate it is kind of an odd deal for communities. The money it takes to prevent the nitrates really stresses small communities. I do not necessarily agree, they always refer to the nitrates being a real health problem and so forth but I do not see that we have ever had that kind of problem. (interviewee 10)

In summary, Dentonites we interviewed remember a historical trajectory in which compliance with drinking water regulations not only made the water worse, but also created a burden for local leaders.

#### 4.3.4. *'Waste of money but it is nice to have it': community water and Denton's future*

Most of our interviewees held a relatively neutral attitude toward the most recent upgrades to Denton's public water supply that were completed in 2020. They expressed a perspective that the project did not improve the town's prospects of surviving the real challenges facing the community: a declining population, a dearth of jobs, the inability for younger generations to afford farming, and an older population with limited incomes. Interviewees were ambivalent about the impact of the public water system improvements on the future of their town, revealing a thread about paradox in local social memory. Here, the paradox is the notion of investing in



the future when the future is itself in question. Intertwined with this paradox is a concrete concern about an impending fiscal cliff, a point in the future when residents are unable to repay the costs incurred in 2020.

Residents' concerns about the town went beyond any the water system could fix. Some lamented that Denton's heyday had passed by. Interviewee 16 referenced the multiple grocery stores, gas stations, banks, and implement dealerships that had once dotted the town's landscape. Most of these businesses have long shuttered their doors. Interviewee 5 agreed that the town's population had peaked decades, if not almost a century, earlier: 'yeah it is never been this small before except maybe in the [19]20s.' For this resident, a new water system would have limited impact, if any, on the town: 'well I think from the standpoint of a good water system they are (residents) happy about that. Probably from the standpoint that it costs them a lot they are not happy about that. As far as will it bring people to town? Probably not. Will it keep people here? Probably not (laughs)'.

Interviewee 11 bluntly assessed the future of the town without improvement in the school enrollment:

I do not think we will be here [in the coming decades]. Our school's got 32 kids K-12 next year. And the farms, instead of having 10 little farms, the same area has got one farm, there is no kids coming. And when the school closes up there will not be much going on. So, if you want to buy a house you can buy mine!

When asked to elaborate on whether or not the water improvements would benefit the town, she/he continued, 'waste of money but it is nice to have it'. Interviewee 16 shared this pragmatic viewpoint:

... [you] know it is not going to get a lot better around here. You hate to be pessimistic but you just do what you can to supply water and the basic needs. But as far as attracting industry or something to make the town bigger or something, it is probably not going to happen ... I do not see it as being a big boost or anything. It was a necessity.

Finally, interviewee 8 summed up the attitude of many regarding the impact of the water improvements on the town—the project was necessary, but a financially risky burden.

I think the water system was built too late. Should have been built 20 years ago. Now we did this and it will be good, but you will probably get down—if things do not change—you are going to wind up with so few people that they cannot afford to run it. Only it should run pretty simple, I think it should pretty well run itself. This [the old water system] has been 100 years, a little over 100. And so, [the new water system] should last again that long. If anybody is here.

In summary, key features of the social memory of Denton's public water system include the idea that Denton historically had a 'good' drinking water supply in the Gilcrest Spring, and water that was abundant, tasty, and safe. Regulations that required the addition of well water to the public water supply in the 1980s are remembered as diminishing water quality, with the effect of delegitimizing the expert characterization of agricultural runoff as a public health threat. Recent investments in the safety and efficiency of the public water supply are subsequently framed in the minds of Denton leaders as a resignation to outside pressure with dubious long-term benefits for the community.

## 5. Discussion

The history of Denton's public water system and how it is understood by local stakeholders offers a case study in social memory of water infrastructure and its implications for SDWS governance. This discussion points to three observable dynamics in the social memory of Denton's water infrastructure, linking these observations to themes in the literature reviewed in section 2. We then establish how this case study, while idiosyncratic, offers a conceptual framework and methodological approach apt for comparative thinking and theorizing.

### 5.1. Social memory as expression of infrastructure's longevity

Critical infrastructure studies emphasize the ways that infrastructural lifecycles extend beyond those of humans, industries, and political regimes (Anand *et al* 2018; Howe *et al* 2016). Infrastructure production in the present moment, according to critical theory, is imbued with both aspirations for the future and social histories of the past (Carse and Kneas, 2019; Harvey, 2018). This case study establishes social memory as a vehicle for the persistence of infrastructure's social and political influence at the local scale. In the Denton example, the long-lived nature of the SDWS combines with the social context of small-town local government to encourage social memory formation.

Because local residents serve extended terms on town council, local government creates a natural group of historical stakeholders who are literal embodiments of institutional memory (Wilson 2012). In Denton, longevity of service means that SDWS decision-making occurs through the lens of decades of lived experience.



For example, an infrastructure upgrade from 1988 still figures prominently in the minds of Denton leadership today, who remember an abrupt change to their tap water's color and taste. Remembering their own experience and the public's reaction, local decision makers seem reluctant to make drastic changes to Denton's source water in recent years, evidenced by their choice to blend multiple water sources rather than switching entirely to a low-nitrate source. Their actions demonstrate, and our interview data supports, that the longevity of local civic leadership carries with it a legacy of collectively-held memories about the town's infrastructure past that continue to influence its infrastructure future.

In Denton's history, town council meetings served as a venue for social learning that worked to encode social memory. This is most evident in efforts to normalize and defend rate increases necessary to fund SDWS improvements. We document an important role for social memory in defending user fees—a ubiquitous enterprise of local governments. For example, when a long-time resident stands up at a public meeting to remind fellow townspeople that plumbed drinking water is a luxury through a comparison to the inconvenience of having to haul water, she/he leverages a shared memory about early settlement into validation for local government intervention. The idea that social memory serves explicitly political aims is a common theme in memory studies; however, in this example, the aims involve the very quotidian and prosaic world of the SDWS, as opposed to grand national ideologies often described by historians of social memory (Tallentire, 2001).

### 5.2. Social memory, aesthetics, and trust in regulators

Building on work in water governance that explores public attitudes and values toward drinking water, the Denton case study emphasizes the complexity of ideas about the suitability of drinking water (de França Doria, 2010; Dupont *et al* 2010; Turgeon *et al* 2004). In particular, social memory demonstrates a clear relationship between material experiences of water, system management, and public attitudes toward regulation and government intervention. An appreciable decline in water quality *after* remediation of nitrate contamination marks the social memory of Denton's SDWS governance experience and their impressions of federal water quality standards. Where the easily-recalled inconvenience of life without 'town water' serves to validate public investment, the inconveniences of 'safe water' work to undermine public faith in government management of the Denton SDWS, particularly in terms of federal mandates. This observation validates previous scholarship documenting how consumers sometimes value the aesthetic quality of drinking water more than compliance with safety mandates (Doria *et al* 2009), extending an appreciation to the role of decades-old experiences in informing present-day attitudes and values.

Similarly, the narrative surrounding blue babies in Denton's social memory reprises a classic dilemma of public health and water quality risk perception—one does not fear what cannot be seen, tasted, or smelled (de França Doria 2010). Combined with the sensory experiences of the water system's declining aesthetics in the late 1980s, the absence of a proverbial 'blue baby' in Denton's remembered history establishes a material fact which undermines the credibility of regulation. In this regard, Denton's social memory of water infrastructure may have a malign effect on community resilience in that collectively-accepted truths about local nitrate risk are at odds with science and regulation. Instead of local norms placing strong value on a healthy environment, 'rule setters' are remembered as the 'enemy' of local water quality (Flora *et al* 2016, p 184). A shared narrative has evolved which casts state and federal public safety regulation in a negative light—a perspective which may contribute to a growing sense that rural communities are underdogs that receive unfair treatment from senior governments (Cramer, 2016). In this way, Denton's social memory surrounding blue babies not only subverts the credibility of water quality standards, but also justifies an attitude of resentment toward regulation and regulators.

### 5.3. Social memory and community outlook

The social memory of public drinking water in Denton also articulates with outstanding themes in rural community change: specifically, the perils associated with devolved governance, population and economic decline, and diminished capacity to adapt to change. Witnessing the loss of main street businesses, threats of school closure, and the visible expressions of the changing economic circumstances of townspeople like less 'tidy' upkeep of front lawns creates a social memory about the town's economic trajectory that clearly interacts with ideas about SDWS governance. It is notable, for example, that many interviewees perceived the new water system to be overbuilt for community needs and poorly aligned with a trajectory of rural decline. In this way, perspectives on infrastructure are situated in a narrative about the community's economic trajectory in ways distinct from cases reporting public anger over infrastructure failure. Rather, a clear-eyed understanding of their economic context informs local leaders' pragmatism in infrastructure decision making, and, coupled with a lack of trust in regulatory mandates, informs their conservative choices in system investments. Here, social memory about economic change influences ideas about appropriate development in ways that echo what Wråkberg (2020) described about in a Norwegian mining town, suggesting that social memory is a potent

framework for understanding community outlook in resource regions in transition, including local appetites for infrastructure investment.

Finally, this Denton case history provides a template for future scholarship. Documenting and analyzing the social memory of public infrastructure depends on ‘thick’ histories built on mixed qualitative methods. Unlike the dominant approach to social memory in resilience scholarship which relies primarily on oral history and other subjective recollections, studying hard infrastructure has the unique advantage of relatively robust documentation. Time in the archives, as our compilation of Denton’s town meeting records demonstrate, yields useful material which can be organized in a ‘decision node’ structure focused on key moments in community histories (Wilson, 2012). The decision node structure, in turn, provides a starting point for organizing and understanding collective memory established through interviews or surveys.

## 6. Conclusion

This paper has established a clear presence and influence of social memory in the evolving management of an SDWS characteristic of common dilemmas in rural infrastructure development: persistent/costly remediation issues, limited financial and technical capacity, and political conservatism. Social memory is a fruitful concept for appreciating the role of infrastructure’s longevity in water governance, particularly with respect to the establishment of local values and beliefs that shape and constrain approaches to local governance of critical public infrastructure like SDWSs. Future research that operationalizes the concept of social memory in different infrastructures and economic settings can further refine understandings of its influence and relevance in understanding factors in local decision-making about infrastructure investments and operation.

Describing and theorizing the social memory of public infrastructure management, we argue, both expands and sharpens how scholars and policy makers approach the local governance side of the rural infrastructure deficit. The idea that SDWSs have a deeply engrained social memory that integrates decades of individual and collective experience challenges the idea that more or better information about contemporary water quality or more funding will lead to widespread support for safe drinking water standards and their implementation. In small towns where local government doubles as a historical stakeholder network in social memory, infrastructure decisions will track closely with local knowledge and values. While environmental standards have an indisputable role in public safety, public policy and its implementation will do well to create opportunities for infrastructure planning and funding to appreciate and honor local experience and knowledge.

## Conflict of interest

This research followed Montana State University IRB protocol # JH080917-EX.

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## Data availability statement

The data generated and/or analysed during the current study are not publicly available for legal/ethical reasons but are available from the corresponding author on reasonable request.

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