Addressing Arizona's Failing Private Water Systems

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Introduction

The reliability and safety of large-scale private water systems such as those maintained by Homeowner Associations and Condominium Owner Associations (referred to collectively as HOAs here) face challenges that are often overlooked. These systems do not fully fall under the jurisdiction of the municipal water service provider and are considerably more complex than those found in single-family homes.

Failures of these systems can have a negative impact on the health of residents, and the systems can be very costly to properly maintain if they were designed and installed incorrectly. Loss of service, poor water pressure, possible contamination, costly leaks, and sinkholes are just a few of the issues faced by communities with private water systems. The purpose of this paper is to help owners and operators of private community water systems (CWSs) understand the factors that contribute to premature system failure, make informed decisions on maintaining the reliability of their water supply, and decide when it makes financial sense to either rehabilitate or completely replace their system.

New waterline ready to be installed at an HOA owned CWS

The 1970s and 1980s saw one of the largest development booms in the southwestern United States. The growth of the real estate industry was accompanied by a massive surge in construction of CWSs to meet the increasing water demand. According to the U.S. Census Bureau, in 1982 alone, the southwestern U.S. experienced a 60% increase in the construction of new privately owned housing units. Much of this growth has been attributed to federal legislation focused on stimulating the economy after the preceding periods of recession. The fast pace of construction during this time often resulted in poor construction practices that contributed to pipe breaks and issues with water quality today.

There are over 2 million miles of large water mains in the United States, with an estimated 6 billion gallons of treated drinking water lost every day due to breaks (ASCE, 2021a). This staggering statistic does not even account for breaks in private distribution networks, but it does underscore the magnitude of the overall problem. The reliability of a water system depends on the competency of the engineer responsible for the design as well as the contractor's or plumber's knowledge of proper installation practices. When breaks or leaks occur, understanding the role of a repairman compared to an engineer should be of utmost importance to owners of any private community water systems.

Common incorrect practice of improper materials being left in a trench before backfilling

The Unique Case of Private Community Water Systems

Challenges Faced by Owners of Private Water Systems

A water system that serves multiple units on private property should be viewed as its own entity and warrants

the same level of attention and expertise as one would find in a municipal water system. Despite the societal importance of a safe and reliable water supply, the American Society of Civil Engineers (ASCE) evaluated the nation's overall infrastructure as being in poor condition, with drinking water scoring extremely low among all infrastructure, second only to public school infrastructure (ASCE, 2021a). Private infrastructure faces the same concerns as public infrastructure, such as system age and deferred maintenance, while also contending with the effects of a lower level of oversight and regulation during both construction and operation.

These factors present a challenge to HOAs when maintaining the integrity of their water supply, as pipe breaks or other major disturbances are usually unexpected and can be costly and disruptive to residents. Since most of the infrastructure is buried below ground and largely unseen, water infrastructure is often out of sight and out of mind (EPA, 2018). When presented with the cost of replacing a multi-unit water distribution system, it may seem more cost effective to rely on quick fixes to keep everything running. The result will be that the water system becomes a patchwork of repairs, and the overall rate of degradation accelerates over time. This situation presents another unique challenge: how to find the right professional to meet the specific water needs of the community.

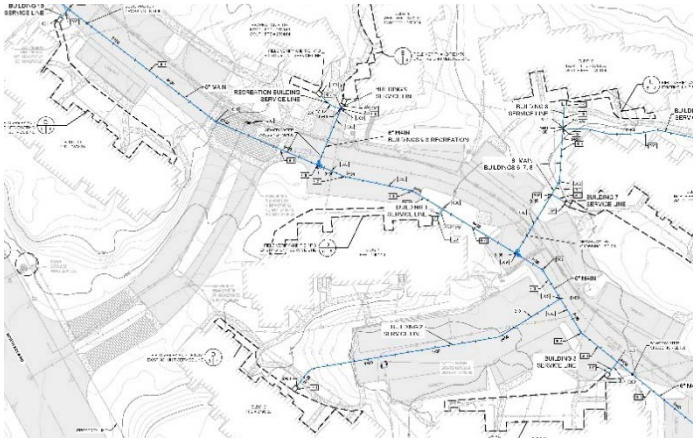
The Construction Gap

In almost all cases, conversations with owners reveal that a professional plumber has mainly been responsible for maintaining the water system for large private water networks, usually in response to an interruption of service such as a pipe break or lack of adequate pressure. As skilled as the plumber may be, they are limited by the overall state of the water system and how it was originally installed.

"Understanding and meeting the water needs of an HOA requires an experienced civil engineer, an installer with pipeline expertise, and rigorous oversight of the construction process."

Most urban areas are served by a public water company, responsible for maintaining the network of pumps, storage tanks, and water mains needed to provide water to a municipality. However, their service typically ends at the water meter, and the property owner is responsible for maintaining the water system from that point. In most cases, when there is a water issue at a single-family home, a licensed plumber is the right choice for installing new waterlines or repairing leaks.

This is not the case, however, with a large-scale private community water system. It is not uncommon to see multiple sizes of pipe and connections of varying materials serving a private development. Longer distances and more complex systems downstream leave more room for water supply issues, especially because construction of private CWSs is subject to less oversight than construction of public systems. Once one considers the need for devices crucial to fire safety, backflow prevention, and water quality, the private CWS emerges as a uniquely complex system.



HOA Private Water System Redesign in Tucson, AZ

Understanding and meeting the water needs of an HOA requires an experienced civil engineer, an installer with pipeline expertise, and rigorous oversight of the construction process. Repeated pipe leaks or breaks typically are indicative of a larger problem, almost always due to a combination of poor construction practices and a lack of informed design choices. It is because of this inherent complexity that a CWS which is exhibiting poor performance or repeated failures should always be evaluated by a professional water resources engineer.

The Importance of Proper Design and Construction

Common Causes of Failure

The priority of any HOA is to ensure that the community is a safe place to live and to protect the investment of the residents. Many have regulations in place to ensure the health of residents through maintaining a certain level of standards, none more important than having reliable access to safe drinking water.

Managing multiple properties with shared utilities can be a

difficult task, and those responsible need to be aware of the factors that can cause avoidable failures. How quickly a water system degrades is not solely due to a pipe's age but also to the external forces acting on it.

Failed supply pipe due to improper use of glued joints

Typical pipe failure modes for buried water supply infrastructure (EPA, 2002) are:

- Faulty design/installation
- Manufacturing defects
- Geologic instability
- Higher operating pressures
- Hydraulic transients (water hammer)
- Change in water temperature
- Excessive external loads
- Damage from digging
- Internal/external corrosion
- Material incompatibilities

While this is by no means a complete list, these are the most common causes of failure experienced by HOA communities built during the construction boom of the early 1980s. The photo shown above was taken during an assessment of an HOA water system that was repeatedly experiencing pipe bursts. This section of pipe was recently repaired, and the failure was not due to the age of the pipe. In this case, the rigidity of using glued joints resulted in premature failure of the pipe, illustrating the importance of understanding the forces acting upon a large private system and specifying the correct installation methods.

New Materials and Procedures

Along with the construction surge, the 1970s-1980s saw a variety of new materials and procedures used in the water utility construction industry. The construction industry, in general, has consistently experienced pressures to innovate towards higher quality and efficiency to maximize profits.

Unfortunately, not all the new materials proved to be dependable for the long run. For the water utility industry, an acute example was the use of polybutylene pipe, also known as PB pipe. PB pipe provided a cheaper and easier-to-install option for builders to meet demand during the construction boom. However, PB pipe proved to be disastrous as its chemical structure reacted adversely with oxidants and disinfectants—like chlorine—which are used in public water supply. The reaction caused the pipe to become flaky and brittle, eventually leading to industry-wide pipe failures.

Over the years, the processes and standards in water utility construction have continued to improve. From their initial casting to final installation, pipelines are carefully monitored and assessed for proper quality and functionality. For underground water and sewer lines, sound quality of materials, attentive transport and storage of products, and proper installation have become vital aspects in future reliability and cost saving measures. Of these new pipe materials, Polyvinyl Chloride (PVC) and High Density Polyethylene (HDPE) have been widely adopted as the standard for new and rehabilitated private CWSs across the Southwest.

Installation of proper fittings for a PVC water main connection

Meeting Current Standards

Today, water utility companies throughout the U.S. use the standards developed by the American Water Works Association (AWWA) for PVC pipe and fittings. The AWWA's standards are an American National Standard, which serves as a guide to aid manufacturers, consumers, and the public. The AWWA created Standard C900, which provides requirements for PVC pressure pipe and fabricated fittings, 4" through 60" in diameter. Water utility companies such as Tucson Water state that all PVC used in their system must satisfy the minimum requirements set by AWWA Standard C900.

Standard C900 describes acceptable pipe dimension ratios (DR) and pressure ratings (pressure classes) to be used for drinking water applications. The DR is the relationship

between the outside diameter (D) of the pipe and the pipe's wall thickness (T) and is defined as DR = D/T. As the DR value decreases, the pipe thickness increases, and the pressure class increases. Thus, a pipe designated as DR 14 is much thicker and has a higher pressure class than DR 25. Specifying pipe by a DR ensures that a common pressure rating is consistent among all piping materials in the system.

Another means of describing pipe thickness is by schedule. PVC pipe commonly used in buildings and in landscaped areas is typically specified by a schedule rating as opposed to the DR rating defined by the C900 standard. PVC pipes are typically specified as Schedule 40 since these are commonly smaller diameter pipe (i.e., 6" and smaller).

For example, a 2" Schedule 40 pipe is the equivalent of a DR 16. Specifying pipe by schedule rating can be problematic for water systems because a 2" pipe with a Schedule 40 rating does not have the same pressure rating as a 6" pipe with a Schedule 40 rating. This mismatch of pressure ratings in a private CWS can significantly impact the longevity of the system. For instance, 6" PVC with a Schedule 40 rating isn't thick enough for use under roadways or other high-traffic areas.

Another important consideration for design of pipe systems in Arizona is temperature. Kurrus (2014) noted that PVC meeting Standard C900 is appropriate for use in warm desert climates, but the designer must consider temperature's effect on pipe pressure ratings. Subsurface temperatures in the metro Phoenix area can reach 90˚ to 100˚ Fahrenheit; at 100˚F, the rated working pressure of C900 pipe is only 62% of the rated working pressure at 72˚F (Kurrus, 2014).

To Repair or Replace?

For HOAs experiencing repeated leaks, pipe failures, and low water pressure, the question arises as to whether it's better to keep repairing the system or replace the whole thing.

Repairs generally return the CWS to working order in a short period of time, but systems needing frequent repairs face several issues:

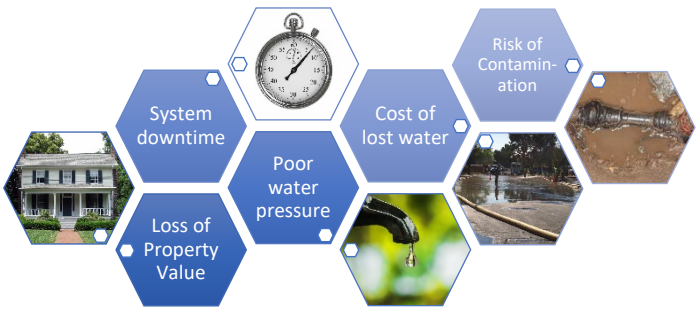
- Plumbing repairs on nights and weekends often incur costly emergency fees.
- In pipes under excessive stress due to poor bedding and backfill, repair couplings increase the strength of the pipe in the immediate location of the repair but transfer the stress to parts of the pipe on either side of the repair, leading to an increased likelihood of future breaks.
- Repair couplings and fittings decrease the efficiency of the system, resulting in decreased water pressure at each residence.
- Repairs don't address the root causes of failure in the system, which are usually inappropriate materials and poor construction.
- Residents attempting to sell their property must disclose known issues; thus, frequent water system downtime and repairs decrease property values.

Fully replacing a large private water system can feel daunting, even for the most prepared owners. HOAs strive to efficiently allocate their funds, and holding onto money for the long-term eventuality of pipe system failure can seem hard to justify.

However, robust asset management practices are increasingly becoming the standard for maintaining municipal networks of all sizes and have proven to be effective in ensuring safe and reliable water supplies (ASCE, 2021b). HOAs, especially those with utility infrastructure from the 1980s or earlier, that adopt this practice will be more prepared and better informed when (not *if*) water issues arise.

The convenience and benefits of water systems are often taken for granted in urban areas, until they break down. Owners of private CWSs will be able to maximize their funds by taking a proactive approach to management of their water supply system rather than being reactive once something goes wrong (AWWA, 2018).

When considering the question of repair or replacement, HOAs should consider not only the direct costs of repair or replacement but the indirect costs over the long term such as water cost of leaks and breaks, inconvenience to residents, and health risks from contamination that can occur when the system loses pressure (EPA, 2001). Enlisting the expertise of an experienced water engineer can help community water system owners make informed decisions and provide recommendations on the course of action that best suits the unique needs of each community.



Indirect costs of failures in CWSs

When a community decides to replace their CWS, a water engineer not only can create a robust design for a new system, but they also can supervise construction of the new system. As a representative of the owner, the field engineer (or "resident engineer") ensures that pipes and fittings are installed properly so that the new CWS should perform well for many decades. As Kurrus (2014) notes, "Proper installation of underground pipe is critical to its longevity. This is especially true of PVC pipe and other flexible pipe, because of their susceptibility to installation deficiencies and reliance on bedding and backfill as a support mechanism." Construction support from a competent engineer will protect the community's investment in the new water system.

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Chris Horstman, M.S. is a design professional with over a decade in the design build construction industry. His recent work has shifted to water resources engineering, focused on computer modeling/design of water supply systems. This background provides him the experience necessary to offer construction oversight to clients, ensuring that each project is safe and reliable for years to come.
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