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Groundwater Quality around Dilkon Chapter, Navajo Nation

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Introduction

More than 30% of Navajo Nation residents lack access to running water.[17] In the Dilkon Chapter this number is as high as 41%.[18] To access water, many residents haul water as far as 50 miles round trip from both regulated and unregulated water sources.[17] Testing of nine wells, one (1) regulated and eight (8) unregulated, in the Dilkon Chapter showed that there were concentrations of uranium, arsenic, and total dissolved solids (TDS) over the recommended levels for a variety of water uses. The purpose of this paper is to provide groundwater consumers around Dilkon Chapter on the Navajo Nation (**Figure 1**) with information about unregulated groundwater sources, water quality regulation, common water contaminants, and general information about well design and upkeep.

What is groundwater?

Groundwater is water that is located below the surface of the Earth in loose rock and cracks. It is an important resource in locations where surface water is not readily available for use, such as in large areas of Arizona and the Navajo Nation. For many Navajo water users, groundwater is necessary for maintaining livestock, irrigation, and domestic activities. Navajo groundwater consumers should be aware of how groundwater is accessed, how it is regulated, factors impacting water quality, and important water quality parameters in Arizona and the Navajo Nation.

How do we access groundwater?

Groundwater can be brought to the surface using human-made wells, which are dug, driven, or bored holes. The three most common well types installed in the Navajo Nation are spring boxes, open wells, and closed wells,[1] shown in **Figure 2**. Closed wells and spring boxes are most common for newer installations; however, open wells are present in some locations.

Figure 1. Dilkon Chapter Location, adapted from the Southwest Indigenous Women's coalition (www.swiwc.org)

Spring Boxes - Built around natural springs, where the water table meets the surface allowing water to freely run out of the ground onto the surface without pumping. They allow for the collection and storage of water. They include covers and concrete aprons that protect stored water from direct runoff that may contain organic and inorganic contaminants, including animal feces.[2]

Open Wells – Dug, driven, or bored holes allow for continued access to water tables located beneath ground level. Open wells do not have a well cap and may or may not have a pump. The open design allows for water to be accessed using buckets or other water-carrying tools. They are generally shallow, tens of feet deep as compared to closed wells which can be hundreds to thousands of feet deep.[3] One key feature of this installation type is the well casing. If there is a pump, additional key features include a well screen at the bottom of the well to prevent the uptake of sediment into the pump and delivered water, a submersible pump, and a pressure tank outside of the well to prevent the pump from cycling, extending the life of the pump.[4]

Closed Wells – Similar to open wells but have both a pump and wellhead seal. The wellhead seal and steel casing around the upper portion of the well protect the well from contamination, such as runoff from a rain event that may contain animal feces.[4]

The water quality and maintenance requirements vary by well type. For example, due to their proximity to the surface and lack of cover spring boxes and open wells are more susceptible to contaminants in runoff[2]. The wellhead seal found on closed wells is intended to protect the water from contamination.[4] If possible, all wells should be covered to protect them from contamination.

How is groundwater quality monitored?

Chemical water quality or Tó Niltólí (in Navajo) describes the concentration or amount of salts and other constituents in water. We use units like parts per million (ppm) and parts per billion (ppb) to describe the concentrations or amounts of a constituent in the water. Modern methodologies are able to detect contaminants in miniscule (ppb) concentrations. The unit ppb is equal to one drop of water in a 10,000-gallon swimming pool or 1 raindrop in 50 275-gallon IBC totes or water buffalos, as shown in **Figure 3**. Even at these low concentrations, contaminated water can have serious impacts on human health. For example, arsenic concentrations of 50-700 ppb can increase the risk of bladder cancer by 80% and lung cancer by 110%.[21]

Monitoring water quality is necessary to ensure the health of consumers. In recognition of this, there are a number of water quality regulations on a national and state level. In addition to outlining water qualities that are specific to the intended use of the water, these regulations also identify the responsible party for monitoring and maintaining water quality.

The Navajo Nation, as a sovereign nation, has adopted many of the same national regulations as the United States. The Safe Drinking Water Act (SDWA; regulated by the U.S. Environmental Protection Agency) and the Navajo Nation Safe Drinking Water Act (NNSDWA) define regulated water systems as those that meet the definition of a Public Water System (PWS). [1] These are systems that either have 15 or more service connections and/or serve more than 25 people for more than 60 days of the year. Examples

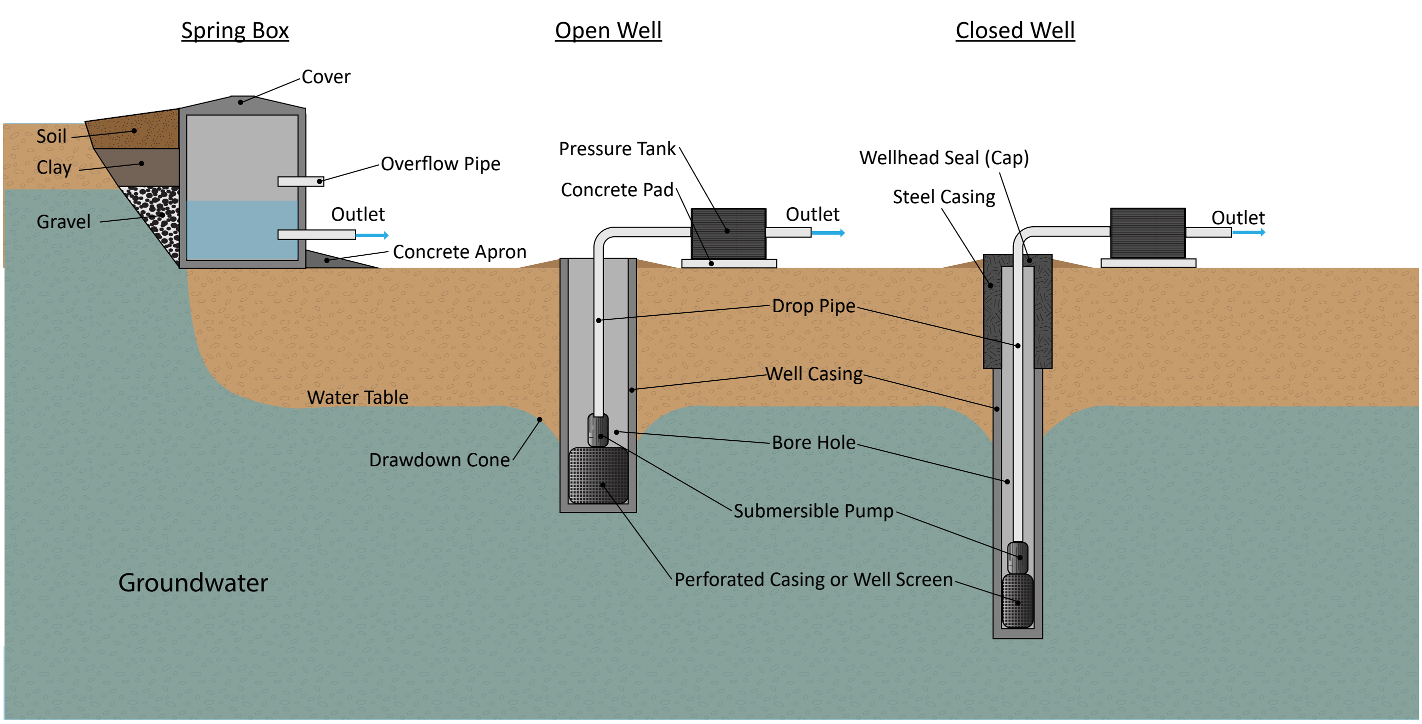

Figure 2. Open Well, Spring Box, and Closed Well Diagrams

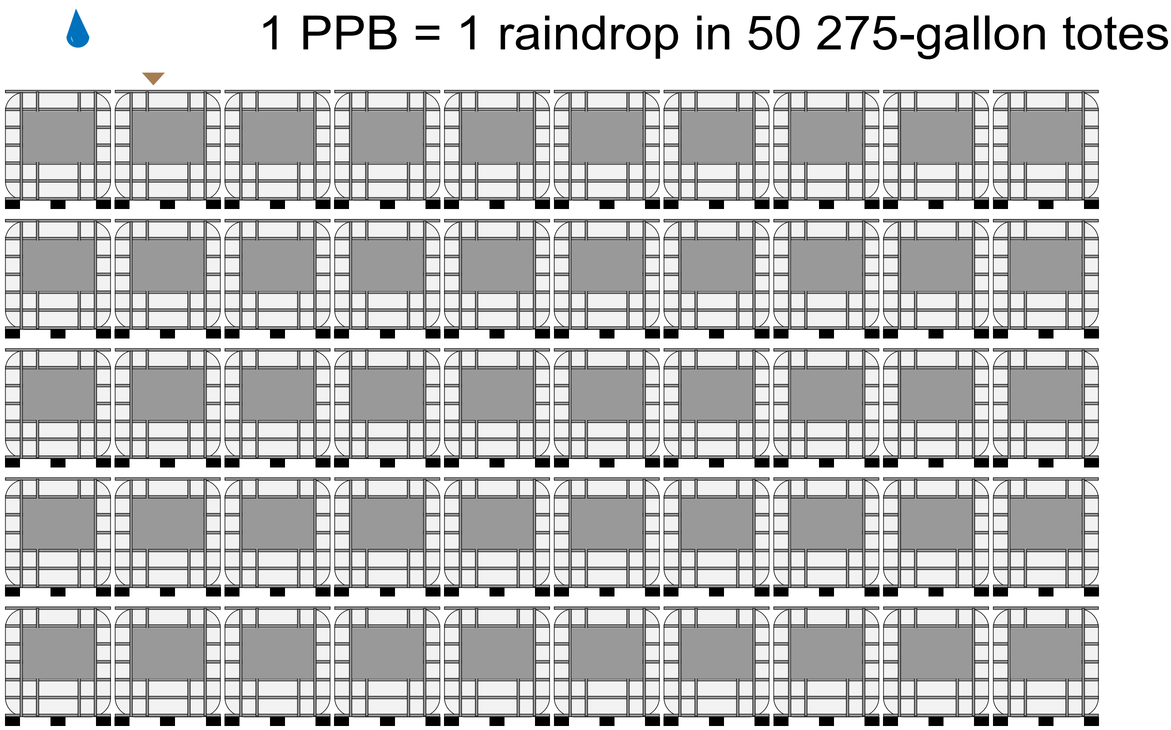

Figure 3. Parts Per Billion (PPB) Visual

of PWS include water points operated by the Bureau of Indian Affairs, Navajo Water Access Mission, or Navajo Tribal Utility Authority.[5] These water systems are subject to regulations of the NNSDWA. Depending on the water source and historical test results, water quality is evaluated monthly to quarterly for biological contamination and quarterly to every three years for inorganic constituents, such as salts and minerals, to ensure that their water quality meets drinking water regulations.[1,6]

Alternatively, if a water source does not meet the definition for a PWS then it is classified as an unregulated source. The state of Arizona and Navajo Nation do not have regulations requiring the testing of unregulated water sources. Although public health officials recommend water quality testing for unregulated sources, it is the well owners' responsibility to request and pay for testing, which may be costly. For additional information on water quality testing see Extension Publication AZ1486f, Well Water Testing and Understanding the Results from https://extension.arizona.edu/educational-materials.

How does groundwater quality inform appropriate use?

There are many rules for using water for drinking, domestic, agricultural, and livestock. Here we apply the following definitions to identify appropriate standards for each water use type discussed in this paper: 1) Domestic water is for non-consumptive household use, such as cleaning and bathing, which should meet drinking water standards; 2) Agricultural water refers to water used to irrigate crops intended for human consumption;[7] and 3) Livestock water refers to water provided to livestock raised as a food source.[7]

Agricultural irrigation and livestock water standards are provided in the Navajo Nation Surface Water Quality Standards (NNSWQS).[7] Regulations for drinking water standards are described in the NNSDWA,[6] which closely resembles the US SDWA.[6] Through the SDWA, the US Environmental Protection Agency (EPA) created a Maximum Contaminant Level (MCL) for more than 80 contaminants. The MCL defines the maximum concentration of a contaminant in public water supplies, taking into account public health, available treatment technologies, and financial barriers. There are also additional unenforceable guidelines for drinking water known as Maximum Contaminant Level Goals (MCLG), which define concentrations with no known or anticipated adverse health impacts. Lastly, there are Secondary Drinking Water Standards (SDWS), which set levels for the aesthetics of the water such as taste, color, and odor, rather than for health. Water may have a slightly offputting taste, color, or odor but still be safe if it meets the NNSDWA regulations.[4, 19] **Table 1** shows the standards for a select group of inorganic water contaminants for the three different water uses: domestic water (should meet drinking water standards and secondary drinking water standards if feasible), agricultural irrigation, and livestock water. A more thorough list of MCLs can be found in the NNSDWA.[6] To determine if a certain water source meets the standards for use, the water quality results should be compared to the appropriate standard for the intended use.

Where Do Contaminants Come From?

Contaminants that impact water quality can be divided into three main categories:[4]

1) naturally occurring chemicals that are found in the soil, rock, and water of a region,
2) chemicals that occur in higher concentration because of human activity,
3) chemicals that are human-made.

Although there are many chemicals that occur naturally at trace or very small concentrations, human activities, such as hard rock mining and other earthwork projects, [4,8] can alter the environment in a way that may lead to higher concentrations of these chemicals in groundwater. Arsenic and uranium are examples of trace chemicals that may be impacted by human activities leading to accumulation in groundwater. They are naturally occurring in the rock layers throughout Northeastern Arizona and the Navajo Nation. However, activities such as mining and irrigation can increase the concentrations in the groundwater[8.] Another common example is nitrate, one dissolved form of the element nitrogen, which, while naturally occurring in the environment, can also be increased by agricultural practices and failing septic systems.[4]

Human-made contaminants refer to synthetic compounds that would not be found in nature such as pesticides, fuels, and plastics among others.[4,8] Manufacturing facilities, gas stations, landfills, agriculture, and mining all have the

Table 1. Water Use Standards for Select Contaminants

Parameter	Drinking Water MCL	Secondary Drinking Water Standards	Agricultural Irrigation Standard	Agricultural Livestock Standard
Arsenic (As) ppb	10	-	2,000	200
Fluoride (F^-) ppm	4	2	15	2
Nitrite (NO_2-) ppm as N	1	-	NCNS	NCNS
Nitrate (NO_3-) ppm as N	10	-	NCNS	NCNS
Uranium (U) ppb	30	-	NCNS	NCNS
Aluminum (Al) ppb	NCNS	-	20,000	NCNS
Iron (Fe) ppb	NCNS	300	NCNS	NCNS
Manganese (Mn) ppb	980	50	10,000	NCNS
Total Dissolved Solids (TDS) ppm	NCNS	500	NCNS	NCNS
Calcium (Ca^{2+}) ppm	NCNS	-	NCNS	NCNS
Lithium (Li) ppb	NCNS	-	NCNS	NCNS
Molybdenum (Mo) ppb	NCNS	-	50	NCNS
Vanadium (V) ppb	NCNS	-	1,000	100

Notes: Standards are published by the Navajo Nation EPA in the Navajo Nation Surface Water Quality Standards 2015 (NNSWQS 2015) and Navajo Nation Primary Drinking Water Regulations (NNPDWR).
NCNS – No Current Numeric Standard

potential to release human-made contaminants into the environment that can end up in the groundwater. Testing for these contaminants was not included in the testing campaign mentioned in the following section.

What are key contaminants of concern in Northeastern Arizona and the Navajo Nation? A case study in Dilkon, Navajo Nation

The most common groundwater contaminant in Northeastern Arizona is arsenic,[20] a naturally occurring element that is tasteless and odorless. Other measured water quality parameters include uranium, a metal contaminant that is commonly found with arsenic, and high total dissolved solids (TDS), which describes the salinity of the water.

Water quality testing from nine water sources in the Dilkon, Navajo Nation showed that the most common water quality concerns are arsenic, uranium, and elevated TDS. The Dilkon Chapter House, a regulated water source, and eight unregulated wells were tested. The full water testing results for each site are available in the appendix to this document, below. These water quality results were compared to the water quality standards in **Table 1** to determine which sources meet the standard domestic, irrigation, and livestock use (**Figure 4**). Of the nine water sources tested five had concentrations of substances that exceeded the primary drinking water standards specified in the NNSDWA.

Exceedances in such drinking water standards can have negative implications for the health of people and livestock. The presence of different contaminants in water sources influences whether the source should be used for drinking, irrigation, or livestock. A discussion on the impacts of water contaminants on human health and their occurrence in Dilkon is provided below.

Arsenic

Standards: Drinking Water (10 ppb), Agricultural Irrigation (2,000 ppb), Agricultural Livestock (200 ppb)

Arsenic or Béésh Libáhí Ba'át'e' hólónígíí (Navajo) is a prevalent contaminant in the Dilkon Chapter, as it is naturally occurring in groundwater in this region.[14] Its movement in aquifers is dependent on pH, a measurement of acidity, and oxygen content of water, meaning that a change in these characteristics can either increase or reduce arsenic concentrations.[8] Five out of the nine springs tested showed levels over the NNPDWS of 10 ppb and one water source, Chandler Springs, was near the standard

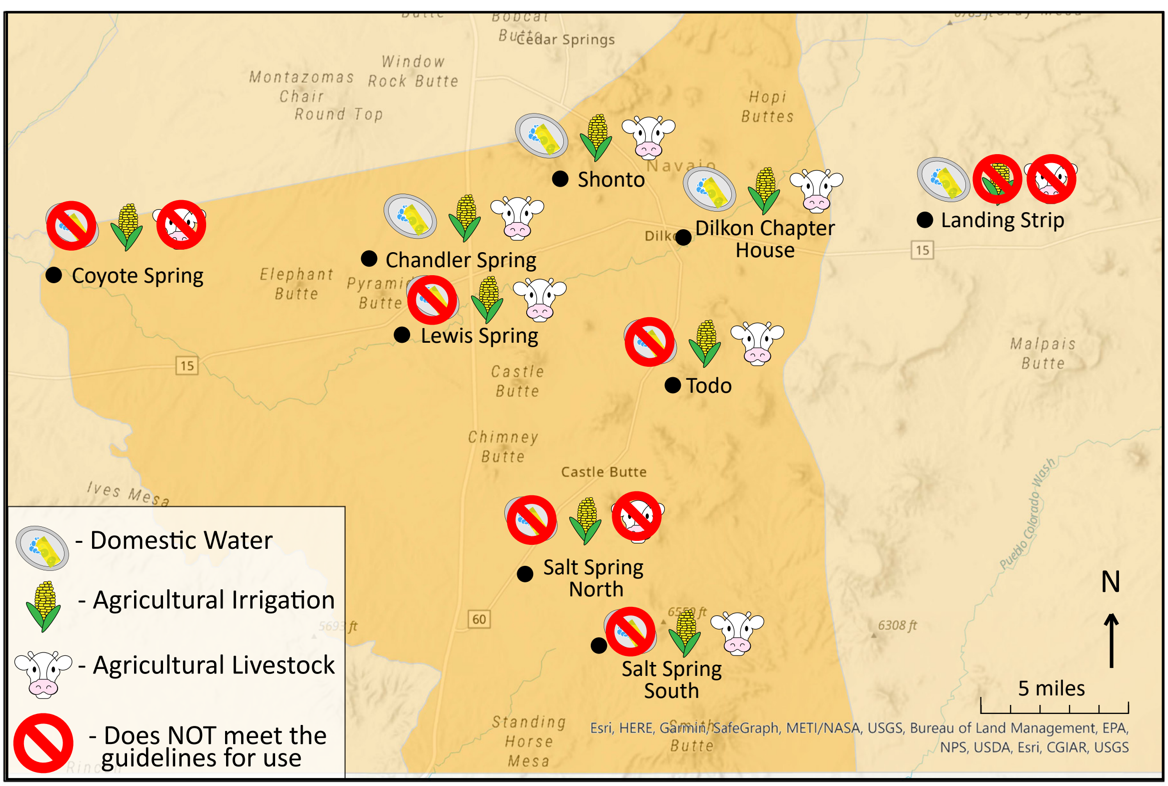

Figure 4. Dilkon Chapter Water Use by Source Map

Every water source tested met the water quality level for at least one use (domestic, irrigation, or livestock). See Figure 4 for more information.

at 8.19 ppb. All of the wells tested met both the livestock and irrigation standards for arsenic of 200 ppb and 2,000 ppb, respectively. Long-term consumption of water with elevated levels of arsenic has been associated with a range of human health impacts, ranging from nausea and diarrhea to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, or prostate.[1,8]

Uranium

Standard: Drinking Water (30 ppb), Agricultural Irrigation (NCNS), Agricultural Livestock (NCNS)

Uranium is also a prevalent contaminant in the Dilkon Chapter and is naturally occurring in groundwater in this region.[13,14] Three out of the nine water sources tested showed levels over the NNPDWS of 30 ppb. At this time, the Navajo Nation EPA does not have established standards for uranium in livestock and irrigation water. Uranium can disrupt the body from both chemical and radioactive pathways. Long-term consumption of water with elevated levels of uranium has been associated with a range of health impacts, ranging from kidney disease and reproductive issues to lung or bone cancer.[8,15]

Total Dissolved Solids

Standard: Drinking Water (NCNS), Agricultural Irrigation (NCNS), Agricultural Livestock (NCNS)

Have you ever tasted water that was salty or gritty? It may have high TDS. Total dissolved solids (TDS) is an unenforceable, secondary drinking water standard, set for taste and odor purposes. Generally, it represents the amount of salts in the water. Five out of the nine springs tested exceeded the US EPA SMCL of 500 ppm[8] and two fell in the range of 400-500 ppm. The wells in exceedance of this standard may have an unpleasant taste, however, the TDS measurement alone does not indicate detrimental health outcomes. High TDS levels may have negative impacts on crops that are not salt tolerant, such as strawberries, onions, and some bean varieties to name a few.[16]

Other Contaminants

Water quality results for other contaminants are included in the appendix to this document, below. Of these, fluoride, nitrate, molybdenum, and vanadium exceed the standards for water use at one or more locations. Three sources tested exceeded livestock standard for fluoride of 2 mg/L. High levels of fluoride can cause bone diseases in livestock, such as molting teeth and metabolic issues, issues in converting food to energy, especially in young cattle and sheep.[10] One source exceeded the irrigation standard for molybdenum of 50 ppb, which can be toxic to crops.[11] Two sources exceeded the livestock standard for vanadium of 100 ppb, which can be toxic to livestock[12]. One source exceeded the nitrate drinking water MCL of 10 ppm. High concentrations of nitrate can have severely harmful effects on infants, including blue baby syndrome.[8]

All of the wells tested are unregulated. They should not be used for drinking water.

Tó hadahadleehgóó nidaaská'ígíí t'áa'ałtso doo bee haz'áanii bik'ehgo bik'ih da'dées't'į́į' dóó baa ádahayą́ą da. Yidlą́ doo bá át'ée da (Doo yidlą́ąjígo yá'át'ééh).

Best Practices for Well Maintenance

The results above are concerning, given that the tested water exceeded levels of regulated chemicals. In many cases, these exceedances may be connected to natural phenomena, such as natural presence of arsenic and uranium in the soils of the region. However, there are general guidelines that well users can utilize to reduce the possibility of further well contamination. The guidelines provided in this section have been adapted from the Arizona Well Owner's Guide to Water Supply (2009)[4] and are intended to serve as general guidance for the typical well owner. Installation and servicing should always be performed by a professional.

- Always store hazardous materials away from the wellhead. This includes fertilizers, pesticides, fuels, oils, and paint.
- Periodically check the well opening or well cap to ensure that it is covered and that there is not any water pooling around the well.
- Always ensure that structures are built away from your well. Buildings, septic systems, and other structures should not be built in close proximity to the well. A contractor should be able to provide more information, such as the distance from the well that is safe for construction.
- Never dispose of chemicals into your septic system. Check local recommendations for chemical disposal, such as hazardous waste drop off locations.
- Ensure that there is back-flow prevention on any hose or pipe connected to your well. This will prevent your well from becoming contaminated.
- Ensure that the soil around your well is sloped in a way that water will drain away from your well.
- Always pay attention to changes in the area around your well and the well water, including the smell, taste, or color of your water. A change in any of these characteristics may indicate that the water quality has changed and testing should be performed.
- Always monitor if there is a change in the amount or type of sediment coming out of your well. If there is an increase in the volume or the grittiness, this may indicate that the well needs to be serviced.
- Always monitor if there is a slow in the flow rate. If your well starts producing less water, this could

Table 2. Recommended Water Quality Testing

Frequency	Test Method	Characteristics
Initial Testing Prior to Use	Certified Lab	Hardness, sodium, chloride, fluoride, nitrate, sulfate, radionuclides (includes uranium), iron, manganese, arsenic, mercury, lead
Annual Testing	Certified Lab	Total coliform bacteria, TDS, pH, nitrate
Monthly Visual Inspection	By Owner	Turbidity (cloudiness), color, taste, odor, health changes in consumers (gastrointestinal problems in children or guests) †

† Observed changes may indicate that testing should be completed.

indicate that either something is blocking your well screen or there has been a drop in the water table. A professional will be able to identify the issue.

- Ensure that any construction, water quality, and service documents for the well are stored in a safe place in case they need to be referenced for future repairs or water quality concerns.
- Ensure that there is a plan in place for water quality testing. A recommended testing schedule is provided in **Table 2**.

Well Maintenance and Water Quality Resources

Navajo Nation Environmental Protection Agency – Public Water Systems Supervision Program (NEPA) · (928) 871-7325 · https://navajopublicwater.navajo-nsn.gov/

- Oversee the maintenance and upkeep of drinking water services.
- Are able to assist residents in finding certified labs to perform water quality testing.

Navajo Nation Department of Water Resources (NNDWR) · (928) 729-4003 · https://nndwr.navajo-nsn.gov/

- Perform well drilling, construction of storage tanks, and maintenance of livestock, domestic, and irrigation systems.
- Provide resources and educational material related to safe water hauling.

Navajo Safe Water Project · https://navajo-safe-water-2-navajosafewater.hub.arcgis.com/

- Provides information regarding locations of safe drinking water access points and drinking water hauling practices.

University of Arizona Extension Publications · (928) 614-8403 · https://extension.arizona.edu/pubs

- Provide additional information on Arizona groundwater contaminants (AZ1503, AZ1536), troubleshooting wells (AZ1485, AZ1537), and water treatment options (AZ1498, AZ1650).

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