A Guide for Private Domestic Well Owners

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Compiled by:

The California State Water Resources Control Board

Groundwater Ambient Monitoring and Assessment (GAMA) Program

Contents

DISCLAIMER

This document is provided for informational purposes only. Water quality problems in private domestic wells may occur even when precautions are taken. This guide can help well owners with water quality testing and interpretation and contains tips to help preserve and maintain a problem-free, clean well. For additional questions, please contact your local environmental health agency, or contact The State Water Resources Control Board (State Water Board) Division of Water Quality by email at GAMA@waterboards.ca.gov.

ACRONYMS and ABBREVIATIONS

DDW = State Water Board Division of Drinking Water

DTSC = Department of Toxic Substances Control

DWR = Department of Water Resources

EC = electrical conductivity

MCL = maximum contaminant level

mg/l = milligrams per liter

State Water Board = State Water Resources Control Board

TDS = total dissolved solids

µg/l = micrograms per liter. (A microgram is 1/1,000th of a milligram, and 1/1,000,000th of a gram.)

US EPA = United States Environmental Protection Agency

VOCs = volatile organic compounds

INTRODUCTION

What is Groundwater?

Groundwater is water that fills pore spaces between soil and rocks underground. These underground waters are known as aquifers. Most groundwater comes from rain and snow that falls to the ground and percolates downward through the soil, until it accumulates above a confining layer (see Figure 1) or aquitard (see Figure 4). The area in the ground that is filled with water is called the saturated zone, and the top of the saturated zone is called the water table. The water table can be very near or far below the ground surface, varying by region, proximity to surface water, amount of precipitation, the season, and many other factors. Groundwater is utilized by drilling a well into the aquifer and installing a pump to bring the water to the surface.

Who Uses Groundwater?

California depends heavily on groundwater to meet its water supply needs. Groundwater supplies approximately 40 percent of the state's water in an average year, with about 60 percent coming from surface water. Households outside of urban areas typically have a private domestic well, as opposed to being connected to a community public water system (water company). Private domestic wells typically tap the shallower aquifers. Public water systems also use groundwater, but since they are of higher demand, wells are typically drilled much deeper, accessing larger aquifers.

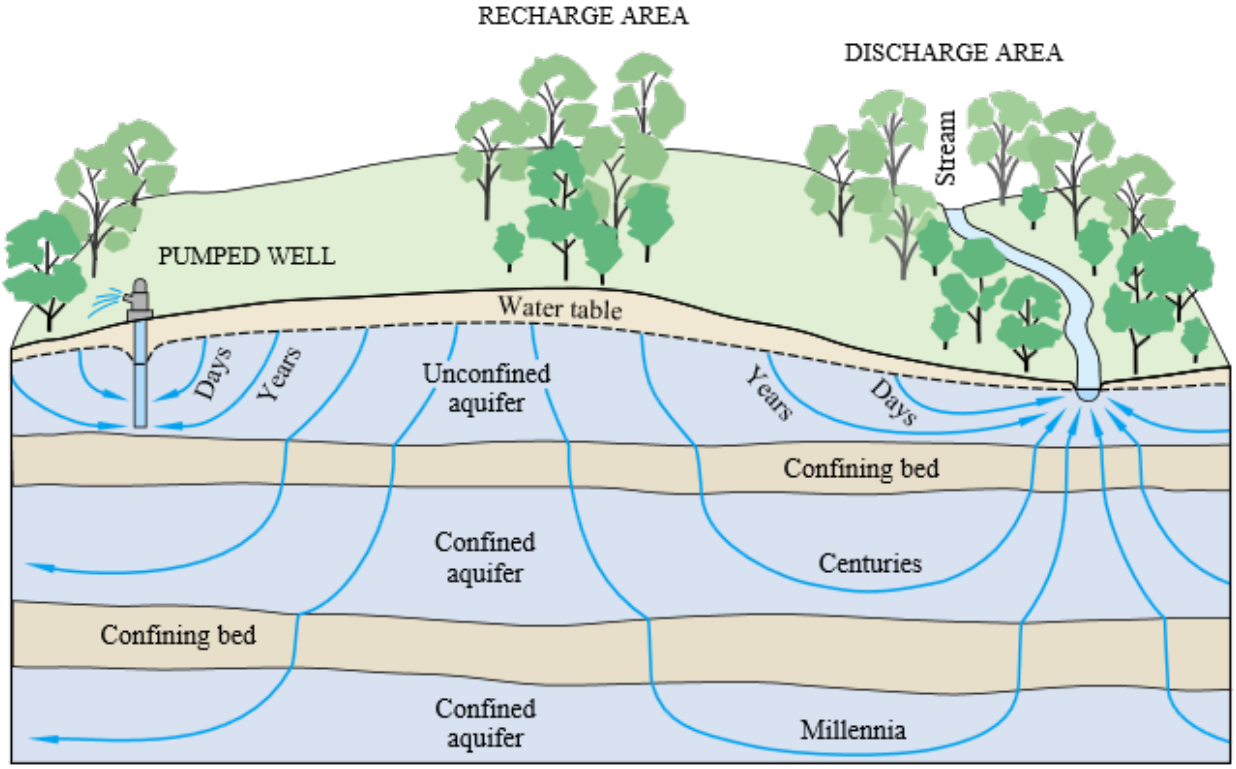


Figure 1. A typical, though simplified, groundwater system.

GROUNDWATER FACTS

- California uses the most groundwater in the nation, 21% of all groundwater in the nation is used in California. 80% of that is used for irrigation.
- About 82% of Californians (33 million) depend on groundwater for some portion of their water supply (Figure 2).
- Approximately six million Californians are entirely dependent on groundwater.
- Up to two million California residents are served either by private domestic wells, or by water systems serving fewer than 15 service connections.

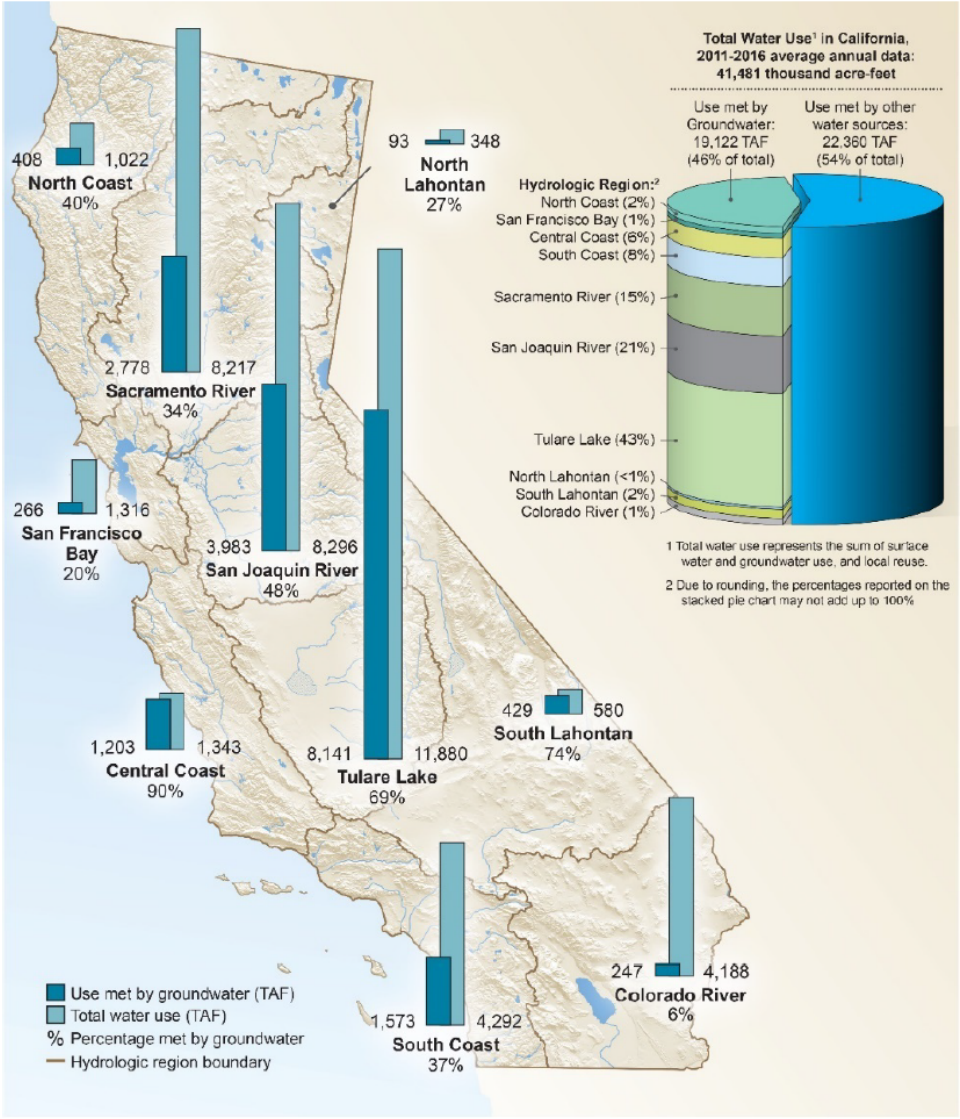


Figure 2. Total water use in California, 2011-2016 average annual data (California Groundwater Update 2020).

- In an average year, groundwater accounts for about 41% of water used. In dry years, groundwater accounts for nearly 60%.
- California has 515 groundwater basins with a usable storage capacity 8 to 12 times larger than the storage capacity of all major reservoirs.
- On average, 79% of total groundwater used in California is used for agricultural purposes, 19% for urban purposes, and 2% to manage wetlands.

- 41% of irrigation water in California is groundwater on average. This number varies during wet and dry years.
- The Tulare Lake, San Joaquin River, and Sacramento hydrologic regions account for about 75 percent of the average annual groundwater use.

GROUNDWATER BASICS

How Do We Get Groundwater?

Wells typically bring groundwater to the surface by a pump. The type of pump varies by well type. There are several types of wells: public supply wells, irrigation wells, industrial supply wells, monitoring wells, and private domestic wells (Figures 3 and 4). Artesian wells flow without pumping.

Figure 3. A typical domestic well head.

What is In Groundwater?

Groundwater quality is related to several factors including geology, climate, and land use. Many naturally occurring chemicals in groundwater come from dissolving rocks, soil, and decaying plant material. Well water can become contaminated by natural processes or by human activities. Human activities can increase the concentration of naturally occurring substances like salts, minerals, and nitrate. Poor well construction or placement close to a potential source of contamination can affect well water quality. Domestic well owners are responsible for testing their well water to ensure its quality. United States Environmental Protection Agency (US EPA) recommends annual testing of domestic wells.

Other compounds, such as pesticides and volatile organic compounds (VOCs), do not occur naturally in the environment. These substances can enter groundwater through spills, irrigation, wastewater percolation fields, leaking underground fuel storage tanks, and other sources.

Wells draw water from different depths and can be affected by different pollution sources. Types of wells and possible pollution sources are illustrated in the figure below:

- A: Shallow wells capture water from shallow aquifers close to the surface. Some private domestic wells are shallow wells.
- B: Intermediate wells can tap either deep or shallow aquifers, and can include private domestic, agricultural, and industrial supply wells.
- C: Deep wells tap deep aquifers, and include public supply, agricultural, and industrial supply wells.

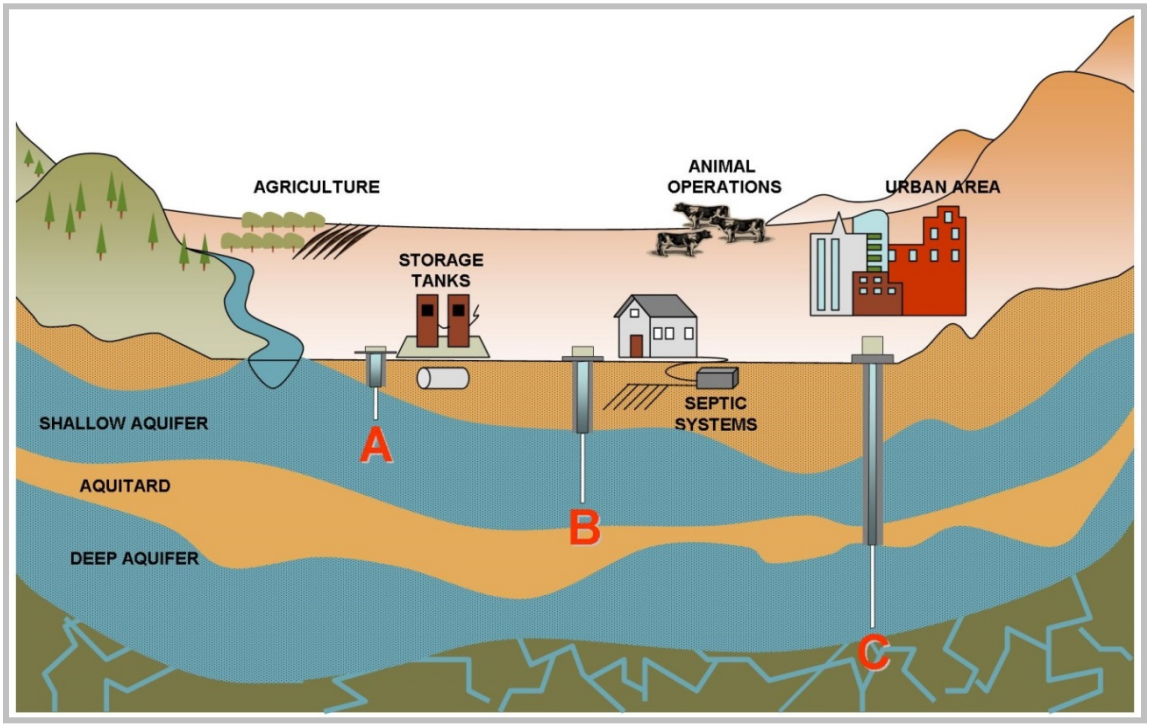


Figure 4. Possible pollution sources for groundwater wells.

PRIVATE DOMESTIC WELL USE IN CALIFORNIA

Over 95 percent of the 39 million California residents get their drinking water from a public or municipal source – these supplies are typically treated to ensure that the water is safe to drink.

However, up to 2 million California residents are served either by private domestic wells or by water systems serving fewer than 15 service connections. The State Water Board Division of Drinking Water (DDW) does not regulate the quality of water from either of these sources. Private domestic well owners are responsible for maintaining their well and are encouraged to test their well water quality.

The State Water Board recommends that you test your well at least once a year to ensure it is safe. There are water quality testing kits available for purchase at most hardware stores that can let you know if a constituent is present in your water, but they

can't give you concentration. If you have a constituent in your water that you are concerned about, you should send your samples to a laboratory to have it tested. There are many laboratories that can test water in the state, and some are more expensive than others, so it is recommended you research some labs to get quotes before selecting a lab. DDW maintains a list of certified drinking water laboratories that can provide testing in your area. If the test results show a chemical above the maximum contaminant level (MCL), it is a good idea to use an alternate drinking water source and investigate ways to fix the problem. MCLs are the highest concentration allowed in drinking water for many toxic constituents based on hazardous health effects to exposure.

Water treatment systems are an effective way to clean your water depending on the type of contaminant. Water treatment systems include mechanical filtering used to remove particles in the water; absorption filtering used to trap waterborne constituents; ion exchange used to soften hard water; and reverse osmosis used to remove constituents by forcing water through a semi-permeable membrane under pressure.

There is a possibility that your water may be too impacted to clean by filtering. Consider drilling a new well that taps a less contaminated aquifer. Boiling your water does not remove many of the commonly found chemicals.

WELL CONSTRUCTION

Well owners obtain permits from local environmental health agencies or sustainability agencies before construction, modification, or destruction of a well takes place. The Department of Water Resources (DWR) has established well construction standards (well standards). Domestic wells must be drilled by a licensed well contractor and must meet applicable local and/or state well standards. When choosing a location for a well, make sure the area is free of potential sources of contamination (see "WATER QUALITY PROTECTION" on page 15).

The driller records geologic information at the drill site and submits a copy of this information (driller log or well completion report) to the homeowner, the local permitting agency, and to DWR. The well boring will intersect layers of sand, gravel or other porous media that produces water (aquifers). The driller may pass through upper shallow aquifers to find a deeper aquifer with better production or water quality (Figure 5). Typically, a length of plastic or steel pipe (well casing) is installed in the well boring. Portions of the well casing will have thin cuts or perforations in it (well screen) or can be open at the bottom (open hole) so water can enter the well.

To keep fine sand, silt, and clay from entering the well, the driller may surround the well screen with sand or gravel (filter pack). The driller must also install a concrete or cement seal (annular or sanitary seal) between the upper portions of the drill hole and the well casing. Local agencies or water districts generally mandate well seal depths.

The annular or sanitary seal extends to the surface. Typically, the well head will be protected with a concrete pad and the well casing will extend upward (wellhead). The casing should extend at least 1 foot above the surface and be securely capped so that nothing –including surface water – can enter the well. The concrete pad should slope away from the well. Typically, a pump is placed in or near the well to bring water to the surface.

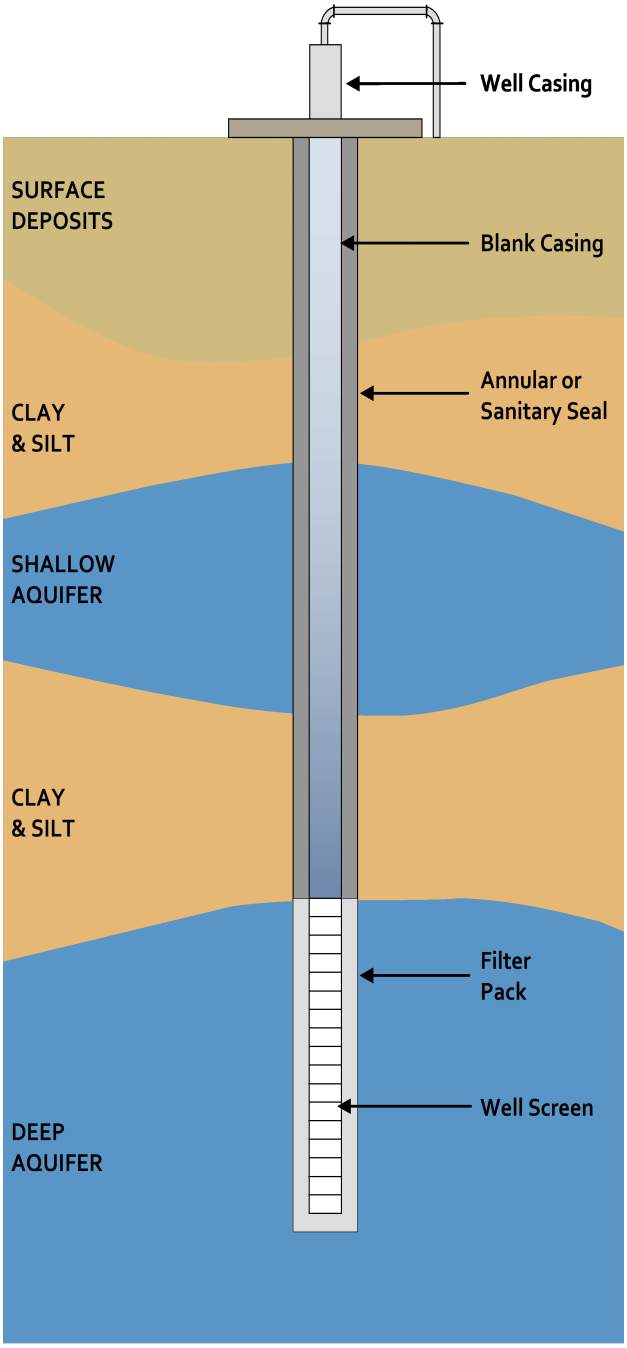


Figure 5. Typical well construction.

WATER QUALITY TESTING

How to Test a Water Well

Some hardware stores have at-home water quality testing kits available for purchase, this is a good first step in testing a water well (Figure 6). If the results of the at-home test kit indicate that there are constituents in the well water, you may send water samples to a laboratory for a more accurate water quality assessment. There are many labs to choose from and it is recommended that you get quotes from several labs for water quality analysis. DDW certifies laboratories that meet their requirements; however, it is not required that you use one of these laboratories.

What to Test

It is recommended that well owners test for total coliform bacteria, nitrate, and electrical conductivity (EC) in their well water annually (Table 1). More thorough testing should take place if you suspect contamination or notice a change in taste or appearance of your water.

Sampling Costs

Basic sampling costs can range from $100 to $400 (Table 1). Hiring an outside business to interpret the results will likely cost more. Ask the laboratory for a written estimate before sampling.

Figure 6. Individual collecting water sample from a spigot near the well head.

Interpreting Test Results

The State of California does not regulate water quality in most private domestic wells. Some private drinking water wells on farmland may be required to test for nitrate. DDW regulates the water quality in public water systems. Comparing your well's test results to public drinking water standards may be helpful.

Table 1 on the following page provides basic information and guidance for interpreting your test results. More information about contaminants and potential health effects can be obtained by calling the US EPA's Safe Drinking Water Hotline (1-800-426-4791).

Commonly Encountered Contaminants

Drinking water, including bottled water, may contain trace amounts of some chemical constituents. Many are natural in origin, as water can dissolve naturally occurring minerals as it flows over or through the ground.

Commonly detected water contaminants include:

- Microbes - (viruses and bacteria) can come from sewage, septic systems, animal operations, and wildlife.
- Minerals - including salts, nitrate, and metals, can be naturally occurring or can result from human activities at the surface.
- Pesticides and herbicides - from agricultural, urban stormwater, and residential uses can be found in well water. Pesticides or herbicides should not be applied within 100 feet of a private domestic well.
- Organic chemicals- from industry, gasoline stations, agriculture, stormwater runoff, and septic systems have been detected in groundwater. Includes VOCs.

• Radioactive elements - typically occur naturally; however, human activities at the surface can release naturally occurring radioactive elements from sediments and bedrock.

Table 1 includes recommended tests and possible interpretations for test results. Consult a water treatment professional for a more comprehensive interpretation of your test results.

Table1. Water Quality Tests for Domestic Well Owners

Test	Recommended Frequency	Approximate Cost	If the lab report shows*:	Then you may want to consider:
Coliform Bacteria	Test for total coliform annually; fecal if total coliforms are detected.	$30 - 70	Present	First re-test another sample to verify the results. Eliminate cause, disinfect, and retest. Increase testing frequency; if recurrent problems persist, consult a water treatment professional for more advice. Some bacteria may cause serious illness or death.
Nitrate (NO3)	Annually	$25 – 60	> 45 mg/L as NO3 or > 10 mg/L as N	First re-test another sample to verify the results. Install a

				treatment system or find an alternate water supply. Consult a water treatment professional for more advice.
Electrical Conductivity (EC)	Annually	$10 – 40	> 1600 µmhos/cm or significantly different from previous result.	Test for minerals, nitrate, and/or VOCs to determine the possible cause of the high EC.
MINERALS: Aluminum (Al) Arsenic (As) Barium (Ba) Cadmium (Cd) Chromium (Cr) Fluoride (F) Iron (Fe) Lead (Pb) Manganese (Mn) Mercury (Hg) Selenium (Se) Silver (Ag)	Every 5-10 years or if significant changes occur, including EC values, taste, color, odor, or surrounding land use changes	Package $200 – 350 Individual $25 – 60 Arsenic $50 – 70 Fluoride $50 – 70 Mercury $50 – 70	Al >0.2 mg/l As > 0.01 mg/l Ba >1.0 mg/l Cd >0.005 mg/l Cr >0.05 mg/l F >2.0 mg/l Fe >0.3 mg/l Pb >0.015 mg/l Mn >0.05 mg/l Hg >0.002 mg/l Se >0.05 mg/l Ag >0.1 mg/l	Compare to previous results. Consider retesting for any high results. Install a treatment system or find an alternate water supply. The appropriate treatment system depends on your overall water chemistry and the constituents that need to be

				removed. Consult a water treatment professional for more advice.
Volatile Organic Compounds (VOCs)	See MINERALS, above	Package $150-350	Any detection	Ask lab to re-test. If confirmed, consult a water treatment professional for more advice.

* Some labs report minerals in micrograms per liter (µg/L). 1 milligram per liter (mg/L) is equal to 1,000 µg/L. > means greater than or equal to.

Tests for Specific Water Quality Problems

Some well owners may have specific issues or problems with their well water. Table 2 outlines several common problems in drinking water, and substances for which you can test. Not every problem and possible cause is a health risk. Less-frequently encountered water quality issues are not listed in Table 2; consult a water treatment professional if your particular water quality problem is not listed or for a more thorough discussion of the causes of water quality problems.

TABLE 2: Possible Causes of Common Taste, Odor, and Appearance Problems in Domestic Wells

Problem	Possible Cause
Water is orange or reddish brown	High levels of iron (Fe)
Porcelain fixtures or laundry are stained brown or black	Manganese (Mn) and/or iron (Fe) can cause staining
White spots on the dishes or white encrustation around fixtures	High levels of calcium (Ca) and magnesium (Mg) can cause hard water, which leaves spots
Water is blue	High levels of copper (Cu)
Water smells like rotten eggs	Hydrogen sulfide (H2S)
Water heater is corroding	Water can be corrosive. Very corrosive water can damage metal pipes and water heaters

Water appears cloudy, frothy, or colored	Suspended particulates, detergents, and sewage can cause water to appear cloudy, frothy, or colored
Your home's plumbing system has lead pipes, fittings, or solder joints	Corrosive water can cause lead (Pb), copper (Cu), cadmium (Cd), and zinc (Zn) to leach from lead pipes, fittings, and solder joints
Water has a turpentine odor	Methyl tertiary butyl ether (MTBE) or other organic compounds
Water has a chemical smell or taste	Volatile or semi-volatile organic compounds (VOCs) or pesticides

Residents near landfills, industry, dry cleaners, gas stations, and/or automobile repair shops may wish to consider testing for VOCs, metals, total dissolved solids (TDS), and petroleum hydrocarbons. Well owners in agricultural and livestock areas may consider testing for pesticides, nitrate, bacteria, and TDS.

WATER QUALITY TREATMENT

Examples of domestic well treatment systems include activated alumina filters, activated charcoal filters, air stripping, anion exchange, chlorination, reverse osmosis, ozonation, and ultraviolet radiation. The type of treatment system used will depend on the type of water quality issues you are trying to address. It is important to know what your water quality issues are before installing a treatment system. Not all water treatment systems will work for every type of contaminant. Most treatment systems also require routine maintenance and upkeep – improperly maintained systems can cause more damage than having no treatment system at all. A treatment system, installation, and maintenance can be expensive, depending on what particular water quality problem you are trying to address. Talk to a water treatment professional and verify the system you want to install will work for your situation. A list of water treatment professionals can likely be found via an internet search. Contact your county environmental health office for additional help in finding a water quality professional that can help you select and install an appropriate treatment system.

In some cases, it may be necessary to drill a new well that taps a less contaminated aquifer, or to obtain an alternative water supply. Treatment systems may not be successful in every situation.

WELL DESTRUCTION

Unused and abandoned wells can allow for contamination of aquifers used as drinking water sources. The risk of groundwater contamination increases when other wells are operating, since pumping can draw poor quality water down the abandoned well and

into the drinking water aquifer. To prevent unnecessary contamination, destroy wells that are no longer in use.

The DWR has developed standards for well destruction. Usually, an abandoned well is filled with cement or similar compounds. Local environmental health agencies are responsible for specific well destruction standards and typically require well destruction permits. A State licensed well drilling contractor must complete the destruction.

WATER QUALITY PROTECTION

Preventing groundwater contamination is the best way to keep your well water clean. Groundwater typically moves slowly, so any contamination can take decades to naturally diminish. The layer of ground between the surface and groundwater will provide some protection but is not a perfect filter. The farther away possible contamination activities are from your well, the more soil is available to filter out contaminants if an accidental spill or release occurs. Local health agencies may have legally mandated setbacks (Figure 7). The US EPA recommends that private well owners establish a “zone of protection” around their well. This zone should be considered off-limits for storing, mixing, spraying, spilling, burying, or dumping anything that might contaminate your water supply. Check with your local agencies to see if there are any specific ordinances requiring setbacks for animal enclosures, septic

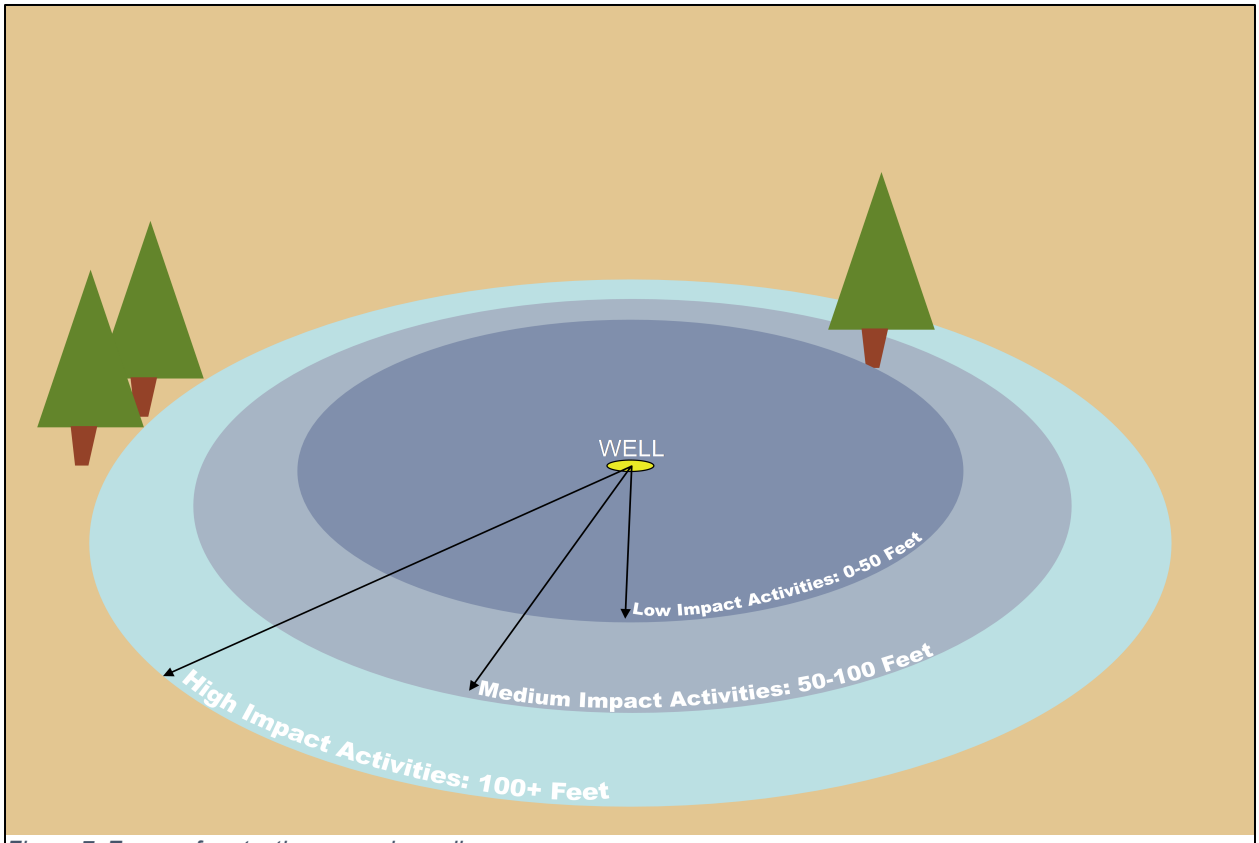


Figure 7. Zones of protection around a well.

systems, and other types of facilities. The State of California does not regulate the location of private domestic wells.

Low impact activities include recreation areas, houses, outdoor furniture and play areas. Medium impact activities include garages, boats, and city sewer lines. High impact activities include chemical storage, animal enclosures, manure/compost piles, machine/auto repair, and septic systems.

Protect your well, and protect your water:

Only low-impact facilities, such as a house, outdoor play area, or outdoor furniture should be located within 50 feet of the well. Do not mix or store any material that might contaminate your water supply within 50 feet of your well. Medium and high impact activities should only occur at safe distances (Figure 8).

Figure 8. Sign depicting well head protection area.

Animal enclosures and septic systems should have a minimum setback of 100 feet from a domestic well.

Do not store or mix pesticides, fertilizers, lawn-care products, paint or paint cleaners, hazardous cleaning products, gasoline (including gasoline generators), or automotive wastes near the well.

Do not dispose of hazardous materials (including some types of household cleaners, paint and paint cleaners, automotive waste, and pesticides) to a septic system – these substances are not treated in a typical septic system and can easily migrate to groundwater. Take hazardous household chemicals to a designated collection center for disposal.

Septic systems should be located downhill (downgradient) from a domestic well, and at least 100 feet from any drinking water source.

Inspect your well at least once a year for cracks in the casing and seal, or any other types of leaks or possible paths for contamination. If issues are noted, have a State-licensed well drilling contractor repair the well.

Please see the appendix beginning on page 20 for a photographic guide to common well maintenance issues.

RESOURCE GUIDE

There are many sources of information on private domestic wells. Programs that can help answer private domestic well water quality questions are provided below.

Local Government

County environmental health agencies are typically responsible for issuing well construction/abandonment/destruction permits, septic system permits, and address other issues associated with private domestic wells. Conduct an internet search to find the specific agency in your county responsible for private domestic well oversight. Some local agencies run hazardous household waste programs. Such programs typically offer tips for use, recycling, and disposal of these products.

State Government

The State of California does not regulate the water quality in private domestic wells. However, state agencies can be helpful in dealing with water quality issues and identifying threats to water quality. The State Water Board is responsible for the adjudication of water rights and water quality protection. Visit the State Water Board website at www.waterboards.ca.gov.

Groundwater Ambient Monitoring and Assessment (GAMA) Program: The GAMA Program is the State Water Board's comprehensive groundwater quality monitoring program for California. The main goals of GAMA are to improve statewide groundwater monitoring and to increase the availability of groundwater quality information to the public.

GAMA GIS: GAMA Groundwater Information System (GIS)provides user-friendly access to groundwater quality data in California via the internet. GAMA GIS provides water quality data for raw or untreated groundwater, integrates data from multiple sources, and provides tools to analyze several datasets.

Division of Drinking Water: DDW (formerly part of the California Department of Public Health) is responsible for the regulation and monitoring of public water systems (a public water system serves 200 or more homes).

Regional Water Quality Control Boards (Regional Boards): The nine Regional Boards develop basin plans for their hydrologic areas, issue waste discharge requirements, take enforcement action against violators, and monitor water quality. Locate the Regional Board office for your area.

California Department of Water Resources: DWR provides groundwater level and water quality data.

California Department of Toxic Substances Control (DTSC): The DTSC can help answer questions about hazardous materials and waste: how to reduce household use, where to report dumping and spills, and proper disposal methods.

Federal Government

The Federal Government does not regulate water quality in private domestic wells. However, the US EPA provides helpful information to domestic well owners.

US EPA Safe Drinking Water Hotline: The Safe Drinking Water Hotline is available to help understand regulations and programs developed in response to the Safe Drinking Water Act. The hotline can be reached at (800) 426-4791. For more information, you can visit the website.

ACKNOWLEDGEMENTS

The State Water Board would like to acknowledge and thank the Santa Clara Valley Water District and the San Diego County Department of Environmental Health for use of their informational fliers in the development of this document.

APPENDIX

Photographic Guide to Common Well Maintenance Issues

Proper well maintenance can help prevent groundwater contamination. The following are examples of commonly observed well maintenance issues and suggestions on how to minimize potential contamination of your well.

Cracked Well Casing

A cracked well casing may allow surface water and contaminants into your well. One of the most common water quality issues associated with a cracked well casing is the presence of coliform bacteria. Other chemicals can also be introduced into the well through the cracked casing. Consult a water quality professional, such as a licensed well driller, to repair or replace the cracked casing.

Missing Plugs and Other Well Openings

Many wells have a small plug located at the top of the well casing. The plug may degrade over time and sometimes fall off. If the plug is missing, the well is directly open to potential contamination. The most frequently observed contaminant associated with a missing plug is coliform bacteria. Replacing a missing plug is an effective way to reduce potential contamination.

Well Location: Near Storage Tanks

Storage tanks for hazardous materials should be kept at least 100 feet from your well. Gasoline products, VOCs, and pesticides are the most common contaminants associated with spills or leaks from storage tanks. Keeping your fuel tanks at least 100 feet away from your well may help avoid well water contamination.

Well Location: Agricultural Areas

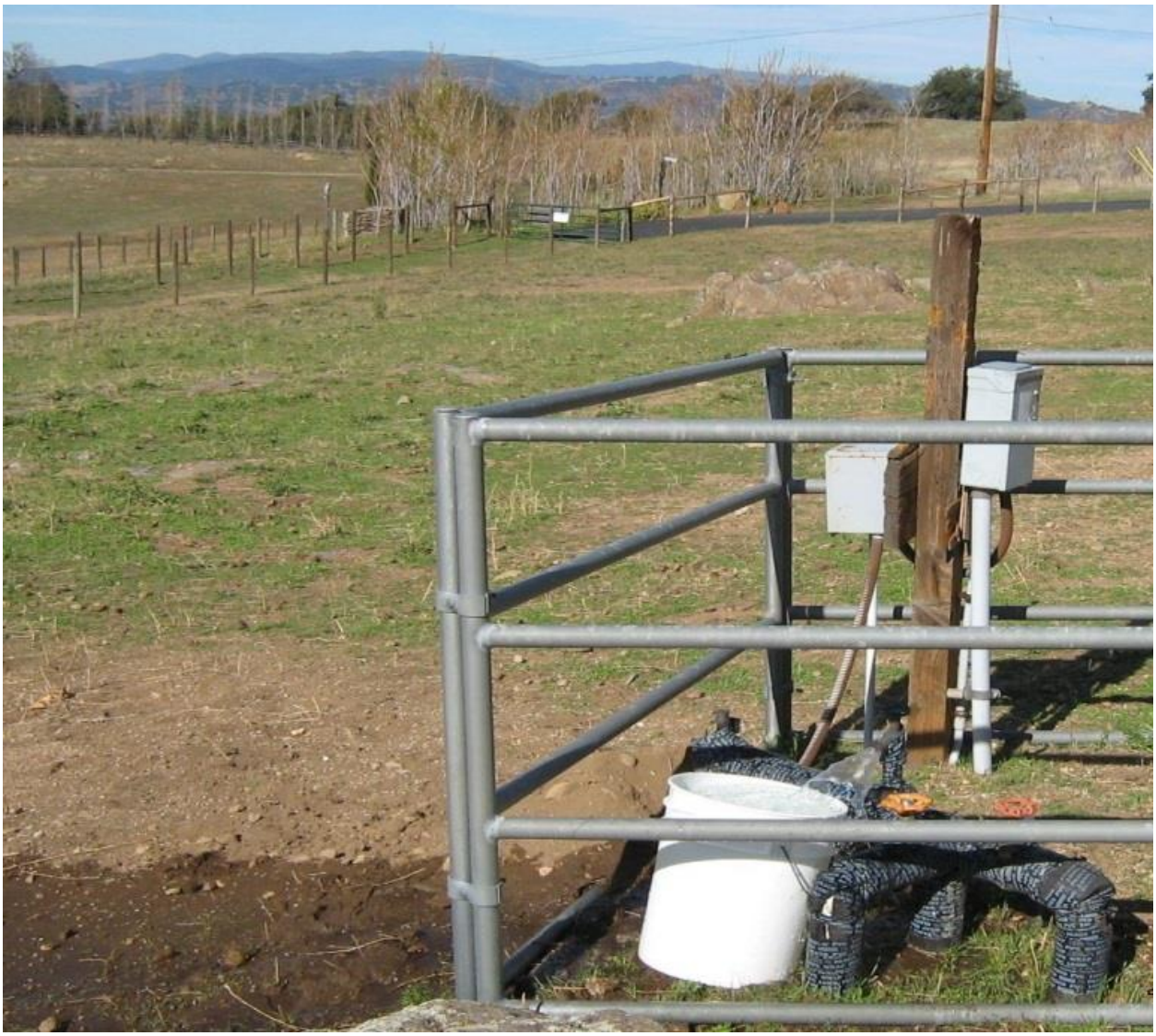
Locating a well close to agricultural areas – such as orchards or row crops – increases the likelihood of detecting nutrients (such as nitrate), salts and pesticides in your well water.

Your well should be located at least 100 feet from areas of pesticide or fertilizer application.

Well Location: Downhill (Downgradient) from a Contaminant Source

Avoid placing your well downhill from a potential contaminant source like a fuel tank or a septic system. Groundwater flow direction typically follows topography – so a leak from an uphill or upgradient contaminant source could potentially affect your well water quality.

Well Location: Animal Enclosures



Manure is a source of microbial contaminants (including coliform bacteria), nutrients (such as nitrate), and salts. Your well should be located at least 100 feet from any permanent animal enclosure.

Well Location: Storage of Hazardous Substances

Storing hazardous substances near your well increases the potential for well water contamination. Hazardous substances including paint, petroleum products (like gasoline), pesticides, herbicides, fertilizers, and solvents should be stored or mixed at least 100 feet from your well location.

Excess Vegetation Surrounding Your Well

Overgrowth of vegetation near your well may lead to root damage of the casing, creating a conduit for possible well water contamination.

Do not apply herbicides, pesticides, or other chemicals to vegetation near your well, as these chemicals may contaminate your well water.