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TECHNICAL REPORT

Drinking Water From Private Wells and Risks to Children

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ABSTRACT

Drinking water for approximately one sixth of US households is obtained from private wells. These wells can become contaminated by pollutant chemicals or pathogenic organisms, leading to significant illness. Although the US Environmental Protection Agency and all states offer guidance for construction, maintenance, and testing of private wells, there is little regulation, and with few exceptions, well owners are responsible for their own wells. Children may also drink well water at child care or when traveling. Illness resulting from children's ingestion of contaminated water can be severe. This report reviews relevant aspects of groundwater and wells; describes the common chemical and microbiologic contaminants; gives an algorithm with recommendations for inspection, testing, and remediation for wells providing drinking water for children; reviews the definitions and uses of various bottled waters; provides current estimates of costs for well testing; and provides federal, national, state, and, where appropriate, tribal contacts for more information. *Pediatrics* 2009;123:e1123–e1137

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Key Words
water, drinking water, well, well water, private well, groundwater, nitrate, waterborne disease, fluoride, *Escherichia coli*

Abbreviations
EPA—US Environmental Protection Agency
MTBE—methyl tertiary butyl ether

BACKGROUND

Approximately 15% to 20% of households in the United States obtain their water from private wells.[1] Public drinking water systems are regulated by the US Environmental Protection Agency (EPA), with national drinking water regulations providing the legally enforceable standards. Unlike municipal water supplies and some community wells, private wells are not subject to federal regulations and are minimally regulated by states. States sometimes require that a well be dug or drilled by a certified contractor and that the water from the well be tested at least once for nitrate and coliform bacteria. After that, the owner of the well is not required to inspect the well or test the water; only New Jersey requires testing at the time of resale. The states, the Navajo Nation, and the EPA offer suggested inspection and testing schedules (Appendix).

Well water is not sterile, nor does it need to be, but it should be free of fecal contamination; such contamination is usually detected by coliform bacteria counts. In Iowa wells in the 1990s, 27% had coliforms.[2] Rigorous data are not available to compare the frequency of illness between children drinking well water versus municipal water. In a Canadian study of 235 rural households using well water, the odds of a child younger than 10 years having an episode of gastrointestinal illness, given the presence of at least 5 colony-forming units of *Escherichia coli* in the water, was 4.2 (95% confidence interval: 1.1–16.2) times higher than that for adults older than 50 years.[3] However, the risk as compared with the child drinking uncontaminated water was not studied. In a clinical trial of reverse-osmosis water filters, which should remove all infectious agents, in families drinking municipal water meeting bacteriologic standards, approximately 30% of acute gastrointestinal illnesses were prevented by the filters, with no difference according to age group. This study showed that even bacteriologically "clean" water produces some illnesses and that, because the background rate of illness was higher in the young children, the use of reverse-osmosis water filters prevented more illnesses in that age group.[4] It is likely, then, that contaminated water from a well would add to an already higher rate of such illness in children.

Well water can be a significant source of nitrate,[5] which comes from both sewage and fertilizer. In Iowa[2] and New York State,[6] approximately 2% of wells had nitrate concentrations greater than 10 mg/L, which should not be

consumed by infants. Other chemicals, such as solvents, fuel additives, and pesticides, also may contaminate private wells.

According to the Centers for Disease Control and Prevention, 28 waterborne disease outbreaks were reported in the United States in 2005–2006, the latest years for which data are published.[7] Twenty-three of the outbreaks were from drinking water, of those 8 were groundwater sources, usually private wells. Those caused illness in 458 people. The ages of the individuals were not reported. The etiology of 5 of the outbreaks is known: 1 was *Campylobacter*, 3 were norovirus, and 1 was Hepatitis A. Waterborne illness is undoubtedly underrecognized and underreported.

Although recommendations regarding wells note that infants are most susceptible to nitrate-induced methemoglobinemia,[8] recommendations regarding well water specific to families with children are not available; similarly, recommendations that address events that might expose a child to untested water, such as the birth or adoption of a child, are not available. As a general principle, children are likely to be more susceptible to waterborne illness than adults, because they drink relatively more water, develop gastroenteritis more often, and become dehydrated more quickly when they develop gastrointestinal illness. Thus, the fact that adults can consume the water without incident is not a guarantee that the child can do so. What follows is a selective compilation of information and recommendations concerning wells and well water.

GROUNDWATER AND WELLS

Groundwater is water below the topsoil and above impervious bedrock. When groundwater collects in and saturates relatively porous fractured bedrock and soil, it is said to be in an aquifer. The water table is a depth below which the soil and fractured bedrock (ie, the aquifer) is saturated with water. The water table can vary from season to season and year to year. For a well to produce water reliably, it must be deep enough so that water can be pumped from the aquifer from which it draws under virtually all weather conditions. Aquifers are recharged from above by precipitation and runoff. Wells drilled into water under sufficient pressure to come out of the ground spontaneously are called artesian wells because of their existence in the French region of Artois ("artesian," in old French, means "of Artois") (Fig 1).

Groundwater is naturally filtered on its way from the surface to the water table, so it is relatively free of particulate organic material and bacteria. It will only remain so if it is protected on its way from the aquifer to the tap.

WELL TYPES

Dug wells usually are shallow holes, 10 to 30 ft deep, lined with rock, brick, tile, or concrete, with a pump in a nearby pump house or in the dwelling. Dug wells usually are relics on older home sites. They are easy to contaminate and unreliable in most of the United States.

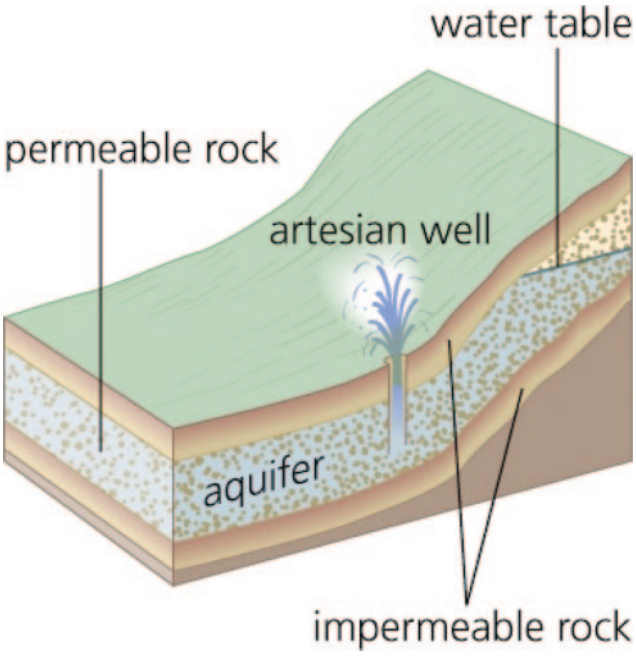

FIGURE 1
An artesian well. (Copyright © 2006 by Houghton Mifflin Harcourt Publishing Company; reproduced with permission from *The American Heritage Dictionary of the English Language*. 4th ed. Boston, MA: Houghton Mifflin Harcourt; 2006.)

For driven wells, a pipe is driven through gravel or sandy soil. These wells also tend to be shallow, usually approximately 50 ft deep; the pump is installed at the top of the well or in the dwelling. Driven wells are still relatively easy to contaminate because of their shallowness but can be rapidly and inexpensively installed if the geologic conditions are right. Dug wells and driven wells are often the water source at camps or vacation homes.

Drilled wells are 100 to 400 ft deep and reach bedrock. Most drilled wells have an electric submersible pump at the bottom.

Although the recommended minimum distances vary on the basis of the contaminant, private wells should be as far as feasible and no less than 50 ft from septic fields; they should be even further from underground fuel tanks, sheds in which fertilizers or other chemicals are stored, livestock, and cultivated fields. Thus, when siting a new well or when there is concern about contamination of an existing well, consultation with the local health department should be sought. In addition, the well should be on relatively high ground (ie, uphill from septic tanks) and covered by a well housing unit of impermeable material such as concrete. Although it is occasionally necessary to access the wellhead, security of the well housing should take precedence over convenience of access. If a homeowner is in doubt about the safety or integrity of the well, inspection by the state or county health department or a licensed well contractor should be arranged. In addition, if there is a flood or if the well housing is damaged by a vehicle, tree, etc, professional inspection is warranted.

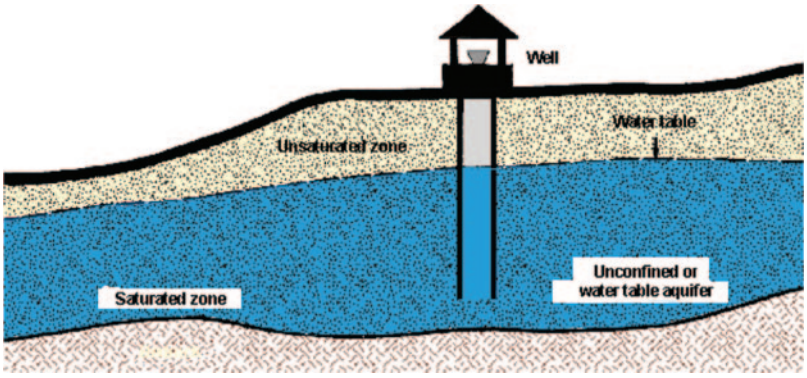

FIGURE 2
An unconfined aquifer and well (http://ecommons.library.cornell.edu/bitstream/1813/3408/2/What%20is%20Groundwater.pdf.) (Adapted from Raymond L Jr. *What Is Groundwater?* Ithaca, NY: Cornell Cooperative Extension, Cornell University; 1988:6.)

COMPOSITION OF WELL WATER

Chemicals

Nitrates

Nitrate is the most familiar and one of the most common contaminants of wells. Nitrate comes from either sewage or fertilizer. Agricultural scale application of fertilizer and permeable soil can lead to nitrate contamination of area groundwater. Nitrate is reported from the laboratory as nitrate nitrogen (NO_3-N); a level of 3 mg/L or greater indicates contamination. Water with a nitrate concentration of greater than 10 mg/L should not be used to prepare infant formula or other foods or given to a child younger than 1 year to drink.[8] The presence of nitrate requires testing for coliforms. Nitrate with no coliforms is likely from fertilizer; if possible, neighboring wells should be tested to determine if the aquifer, rather than the well, is contaminated. Nitrate with coliforms is likely from sewage (either livestock or human). Septic fields or tanks, manure fields, or settling ponds also can be sources of contamination. Examination of neighboring wells may be helpful in determining the source. The standard for nitrate is set to protect infants from methemoglobinemia. There is some evidence that long-term effects, such as gastric cancer, might result from exposure to even smaller amounts of nitrate if they help form endogenous *N*-nitroso compounds, which are potent carcinogens in many species. So far, however, the data are largely ecological and inconsistent.[9]

Volatile Organic Compounds and Pesticides

Volatile organic compounds and pesticides are problems throughout the United States. Although individual sources of these compounds are sometimes identified, such as abandoned dry cleaning shops with underground storage tanks, these compounds are very mobile and can appear without specific sources. The US Geological Survey evaluated 1255 domestic wells between 1992 and 1999, and found volatile organic compounds in 44% and pesticides in 38%.[10] Wells were more likely to be contaminated if they were shallow, were in a more urban area, or if they drew water from an aquifer with no impermeable layer between the surface and the water (see Fig 2).

Inorganic Compounds

Most state health departments and many commercial sources offer testing for inorganic compounds including calcium, sodium, fluoride, chloride, iron, manganese, magnesium, pH, hardness, and total dissolved solids. Total dissolved solids usually consist of calcium and magnesium as their bicarbonates. These bicarbonates make water "hard." Hard water is not toxic; however, the calcium and magnesium precipitate when the water is heated, and this precipitation will eventually cause electric hot water heaters, coffee pots, kettles, and any electrical device in which water is heated repeatedly to fail as the precipitate insulates the heating element. Hard water also forms scum with soaps and detergents.

Manganese and iron can appear as rust-colored to black flecks and can stain clothing, plumbing, and fixtures. However, their levels are not usually high enough to be toxic. So-called iron and manganese bacteria can grow in such water and form black slimy colonies of microorganisms, sometimes clogging pipes and faucets.

Sodium Chloride

Sea salt is a problem near the ocean and in areas where there was formerly salt water. Most people cannot or will not drink enough salt water for it to be toxic. Domestic desalinization is neither economic nor practical except under extraordinary circumstances.

Lead

Lead is not often present in groundwater but can be leached from the brass in a submersible pump, from solder, and, in some cases, old lead pipes if the water is naturally acidic or made acidic by treatment. For example, techniques such as anion exchange remove nitrate and sulfate but leave the water acidic.

Arsenic

Arsenic occurs in specific rock formations, for example, the "slate belt" in the southeastern United States. Its presence in well water is sometimes predictable from geologic data. Arsenic has been reported to be a common well contaminant in Maine,[11] parts of North Carolina,[12] Alaska, and parts of the western United States. Arsenic is extremely toxic and is known to cause bladder, skin, and

lung cancers in humans[13]; however, there have been no reports of acute or subacute arsenic poisoning from well water in the United States. A substantial fraction of the population of Bangladesh must drink from arsenic-contaminated wells, with resulting intoxication.[14]

Radon

Radon is a naturally occurring radioactive gas. Radon, similar to uranium, emits α particles containing 2 protons and 2 neutrons. α particles are strongly ionizing but do not penetrate far into tissue or other substances. Miners exposed to radon in underground mines develop excess lung cancer.[13] Some radon exposure from water occurs by ingestion, although showering, bathing, cleaning, and spraying water are likely to produce higher exposures. Radon in well water commonly exceeds the concentrations allowed in municipal water but does not correlate well with indoor air measurements.[15]

Fluoride

Fluoride is the lightest halogen on the periodic table. It occurs naturally in water in a few parts of the United States. Fluoride is an accepted preventive for dental caries; if a child's drinking water contains none, fluoride supplements are recommended. The American Academy of Pediatrics recommends no fluoride supplementation before 6 months of age; from 6 months to 3 years of age, children require fluoride supplementation if the water has <0.3 ppm (3 μg/L) fluoride. Supplementation from 3 to 16 years of age is recommended for children in areas where drinking water fluoride concentrations are <0.6 ppm.[16] Fluorosis, a condition that results from excess fluoride intake, produces tooth discoloration in children. The discoloration can range from mild white specks to brown streaks with pitting. According to the American Academy of Pediatric Dentistry,[17] fluorosis is most commonly caused by giving fluoride supplements to a child who already has adequate fluoride in drinking water or by the child's ingestion of fluoridated toothpaste rather than from excess fluoride in well water. However, because caries prevention is achieved at drinking water concentrations of 1 ppm and the risk of dental fluorosis increases with concentration,[18] children younger than 9 years should not drink water with a fluoride concentration of >2 ppm.[1] Determining fluoride concentration in well water should be performed as part of the initial evaluation of the well.

Uranium

Uranium in groundwater, although mostly found in the Western mountains in the United States, can also be found in areas that have granite outcrops, the result of granite intrusion into existing subterranean strata and subsequent weathering. There have been reports of high uranium concentrations in waters of Connecticut and South Carolina.[19,20] Those who drink uranium-containing water absorb and then excrete it; urinary concentrations as high as 25% of peak can be present 6 months after exposure has ceased.[19] Exposures likely to be encountered in drinking water have not resulted in acute toxicity. Radiation carcinogenesis, however, is currently thought to have no threshold, and the biological effects of ionizing radiation reports[21] estimated that some cancer may be attributable to background uranium exposure, including uranium in water.

TABLE 1 Most Common Pathogenic Microorganisms Found in Well Water

Bacteria	Viruses	Parasites
E coli, including O157:H7	Small round-structured viruses, including norovirus	*Giardia intestinalis*
Salmonella species	Rotavirus	*Cryptosporidium parvum*
Shigella species	Enteroviruses	*Cyclospora*
Campylobacter jejuni	Hepatitis A and E	*Microsporidia*
Yersinia enterocolitica		*Isospora*
M. avium-intracellulare		*Naegleria fowleri*

Methyl Tertiary Butyl Ether

Methyl tertiary butyl ether (MTBE) is a partially oxidized hydrocarbon fuel additive used to oxygenate gasoline. The oxygenation of gasoline during certain seasons was mandated by the Clean Air Act in 1990 (Pub L No. 101–549) to reduce carbon monoxide emissions. Motor vehicle exhausts are the primary source of ambient carbon monoxide levels, and carbon monoxide is highest during the cold-weather months. Oxygenated gasoline is designed to increase the combustion efficiency of gasoline, thereby reducing carbon monoxide emissions. The tertiary butyl group on MTBE hinders breakdown by sterically protecting the molecule; as a result, uncombusted MTBE can persist in the environment. MTBE is now found in water supplies throughout the United States. Because it has no other uses, its presence indicates contamination by gasoline; its concentrations are higher in wells near gasoline stations and particularly high near gasoline stations that sell oxygenated fuel.[22] MTBE is toxic and carcinogenic in experimental animals[23] and is now banned in most states. Ethanol will likely replace MTBE entirely for oxygenating fuel.

Perchlorate

Perchlorate is an oxidizing agent used in rocket fuels, fireworks, and airbag inflators. It also occurs naturally. Perchlorate is a well-studied steric inhibitor of the thyroid symporter, which transports iodine across the gland's membrane before hormone synthesis. It is now recognized as a water pollutant. There is evidence that perchlorate interferes with thyroid function in adult women in the United States, even at background exposures.[24]

Microorganisms

Microorganisms, including bacteria, viruses, fungi, and parasites, may contaminate the groundwater that supplies wells (Table 1). The major source of these organisms is fecal material from animals and humans. Analyzing well water at its point of use for "total coliforms" is the most common way of detecting fecal contamination of the water. Coliform bacteria may be pathogenic or nonpathogenic. Coliforms include many species of

Gram-negative bacteria found in the intestinal tract of animals and humans, in the soil, on vegetation, and in surface water runoff. Although coliforms do not reproduce in water, they can survive there for extended periods of time. Thus, assessing total coliforms in a water sample is a useful screening tool, because it does not require sophisticated technology and is inexpensive. No coliforms of any sort should be detectable in 100 mL of water. The absence of coliforms is good but not absolute evidence that significant fecal contamination is not present. The presence of coliforms does not mean that pathogens are present, but it does make fecal contamination and, thus, contamination by pathogens much more likely. Samples that contain any coliforms should be retested to determine if they are fecal coliforms; specimens that test positive should be examined for the presence of *Escherichia coli* or other pathogens.

Much of the information describing the pathogens that may be present in well water has been obtained from investigations of waterborne outbreaks. In the United States, most waterborne outbreaks are associated with noncommunity water systems, chiefly private or communal wells.[7] The microorganisms listed in Table 1 typically cause a gastrointestinal illness. However, there are notable exceptions; for example, enterovirus exposure may be asymptomatic but may also result in a febrile illness associated with sore throat, rash, myalgia, or, less commonly, aseptic meningitis syndrome. *Naegleria* species may cause a fatal meningoencephalitis. *Mycobacterium avium*-intracellulare and *Cryptosporidium* species may be found in well water, producing systemic or pulmonary disease in specific vulnerable populations. *Legionella* species and *M avium*-intracellulare are present naturally in water and do not represent fecal contamination. However, disease from *Legionella* species typically results from inhalation rather than ingestion of bacteria. Outbreaks caused by *Legionella* species typically occur in large buildings after colonization of the water-distribution system[7] and have not been identified as a result of contamination of well water.

Iron and sulfur bacteria also may be present in well water. Although these bacteria do not pose a health threat, they can cause the water to smell (like "rotten egg") and taste bad; they also increase the likelihood that plumbing equipment will become plugged or corroded.

MITIGATION

If test results confirm bacterial contamination, the well must be inspected to identify any structural defects that may have permitted the contamination. After any such defects are repaired, the well must be treated to eliminate pathogenic bacteria immediately, usually by "shock chlorination," which uses concentrations of chlorine that are 100 to 400 times the amount found in municipal water supplies. This can be done by the homeowner using household bleach, (many Web sites have instructions [www.water-research.net/shockwelldisinfection.htm]), but consultation with the health department or other experienced individuals is advisable the first time. The highly chlorinated water needs to be held within the water system pipes for 12 to 24 hours before it is completely flushed out of the system. The water should be retested in 1 to 2 weeks. If shock chlorination does not eliminate the bacteria, a continuous disinfection system or further repairs to the well are needed. A consultation with the local health department can help the well owner understand which additional treatment measures are required.

If the contamination is ongoing but under the control of the homeowner, such as from a failing septic field, that problem must be fixed before the well can be used for drinking water again. Successful, lasting decontamination of a well may require more persistent efforts. Swistock and Sharpe[25] disinfected and installed sanitary well caps on 16 wells with coliform contamination; coliforms were again present in 7 of the wells within 60 days and in all but 2 within a year. The 2 wells that did not have coliforms after 1 year had low initial coliform counts and no *E coli*. The authors suggested that contamination may occur far from the well head and may commonly be an aquifer problem. Such a problem is beyond the scope of the homeowner. If the well cannot be used, it should not be abandoned, because it would still provide access for contamination of groundwater. A certified well contractor should fill or seal the contaminated well.

Chemical contaminants are approached by investigating the possibility that the contamination from fertilizers, pesticides, or fuel from leaking tanks exists on the homeowner's or on an adjacent homeowner's property. However, remediation may be inconvenient and/or expensive. If the water supply cannot be remediated and the well is still contaminated or the chemicals in question are naturally occurring, it is possible to treat for or filter most chemicals.[26] An illustration of the relative sizes of filterable contaminants versus filter pore size is provided in Fig 3.

Carafe and faucet-mounted filters usually are designed to reduce lead, some organic materials, *Giardia* and *Cryptosporidium* cysts, and sediment. These units are intended for municipal water and would not be suitable for more heavily contaminated well water. Most other treatment measures require the service of a trained home water-treatment professional, at least for initial installation. Chemical disinfection with chlorine, ozone or hydrogen peroxide, distillation, and ultraviolet light can remove or kill many microorganisms. Chlorine is effective at killing bacteria and viruses but is less effective against *Giardia* species and not effective against *Cryptosporidium* species. Reverse-osmosis filters, usually used in conjunction with activated charcoal and mechanical filtration, can remove inorganic materials, microorganisms, and all but a few organic compounds; however, they are expensive. Treatment systems must be properly maintained to ensure safe water. Most filters, membranes, or ultraviolet lights need to be replaced at least once per year and more frequently if damaged or not working properly.

Consumer Reports magazine periodically reviews home water-treatment devices, including the inexpensive carafe and faucet-mounted types. Although the emphasis is on treating municipal water, they also review reverse-osmosis filters. *Consumer Reports* is available in libraries and through a subscription Web site. NSF International (www.nsf.com) is a not-for-profit, nongovernmental, independent agency

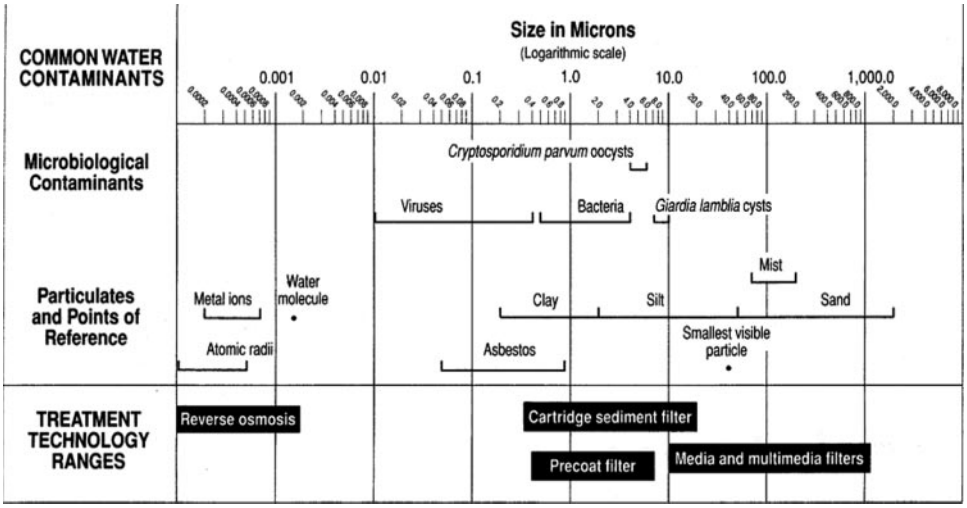

FIGURE 3
Filters and particle sizes for water contaminants.[24]

that tests and certifies consumer products, including water-treatment devices. The NSF Web site allows the consumer to pick the contaminants that are present, and the NSF will provide names of appropriate products and manufacturers. NSF certification is a voluntary program paid for by the manufacturer of the device. Some states and universities, such as Purdue University (www.purdue.edu/dp/envirosoft/groundwater/src/treat.htm#menu), provide descriptions of water-treatment devices. All sites recommend that the water first be tested and then the treatment device or devices selected to deal with the contaminants that are present.

Because there are no standards for private wells for many contaminants of concern, those seeking a specific concentration to indicate potability have little choice but to apply the same standards that municipalities do under the Safe Drinking Water Act amendments of 1996 (Pub L No. 104–182 [for the current list of drinking water contaminants, see www.epa.gov/safewater/mcl.html]). Municipalities regard water that is persistently above these federal standards as not potable. Nonetheless, well owners or home occupants are under no obligation to apply this same standard to their well water.

BOTTLED WATER

Bottled water is often labeled to describe its characteristics, source, or method of treatment. Bottled water is regulated as a packaged food by the US Food and Drug Administration under the Federal Food, Drug and Cosmetic Act (21 USC §301 et seq [1938]) if it is in interstate commerce (ie, crosses a state line). Food and Drug Administration rules for bottled water mirror EPA rules for municipal water. Thus, bottled water in interstate commerce should be free of coliform bacteria and have <1 mg/L of nitrate nitrogen.

Distilled water is boiled (killing microbes), and the steam is condensed to remove salts, metals, minerals, asbestos, particles, and some organic materials, giving it a "flat" taste. Purified water originates from any source but has been treated to be essentially pure H_2O. It must contain <10 ppm of total dissolved solids and may also be free of microbes if treated by distillation or reverse osmosis. Sterilized water originates from any source but has been treated to be free from all microbes. These waters should be sterile until opened. Other bottled waters may or may not be sterile.

Artesian water, groundwater, spring water, and well water are from underground aquifers, the waters of which may or may not be treated. It may or may not be sterile. Bottled drinking water is intended for human consumption and sealed in bottles and may contain disinfectants. Some of these are fluoridated, which should be noted on the label. Mineral water is groundwater that naturally contains ≥ 250 ppm of total dissolved solids. Carbonated water, soda water, seltzer water, sparkling water, and tonic water are considered soft drinks and are not regulated as bottled water.

CONCLUSIONS

Well water can be used safely by families, but regular testing is recommended by all relevant authorities. A recommended approach to testing is given in the accompanying policy statement[25] and outlined as a flowchart in that statement. In much of the United States, well water is hard and must be softened in order not to damage hot water heaters, kettles, and other devices, but softening per se does not remove most other contaminants or microorganisms. Whether and how water is treated should be guided by the results of testing. Testing can be expensive, and the American Academy of Pediatrics encourages states and counties to provide free or low-cost testing to families who need their water tested and cannot afford it. A list of current costs is provided in the accompanying policy statement[27]; these costs are, of course, subject to change. Inexpensive water filters can remove lead, *Cryptosporidium* species, and some volatile hydrocarbons, but these are designed more for tap water from municipal water supplies and may not be suitable for well water. Water contamination is inher-

ently local, and families with wells and pediatricians are encouraged to keep in contact with state and any local programs. A list of contacts, all of which are current as of May 2007, is provided in the Appendix. Within states, private well water programs, resources, guidance, testing groups, and regulations are found in a variety of state Departments of Health, Public Health, Environment, Natural Resources, Licensure or Water, and sometimes within multiple departments within a state. Many states also have university-based Cooperative Extension services with private well water resources. Unfortunately, website addresses change frequently. In addition to web site addresses, the Appendix includes both document titles, and, when available, authorship organization names to aid in internet searches for relevant information. Bottled water should be considered for travel or other circumstances in which an infant might need water and the source of the water is unknown, but bottled water is subject to limited regulation.

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APPENDIX Private Well Water Resources: Web Sites and Telephone Contacts and Federal, Tribal, National, and State Organizations

Organization	Web Site	Web Site/Document Title/ Description	Telephone No.	Telephone Contact Organization
Federal and tribal government organizations				
EPA	EPA private drinking water site: www.epa.gov/ogwdw/privatewells/index2.html EPA state water well Web sites: www.epa.gov/safewater/privatewells/whereyoulive_state.html EPA state water well analysis laboratories: www.epa.gov/safewater/labs/index.html	The EPA Office of Ground Water and Drinking Water, together with states, tribes, and its many partners, ensures safe drinking water and protects ground water. This office, along with the EPA's 10 regional drinking water programs, also oversees implementation of the national Safe Drinking Water Act	(800) 426-4791	EPA Safe Drinking Water Hotline
EPA-Region 9 Tribal Program	http://earth1.epa.gov/region09/indian/success/03/water.html	The EPA-Region 9 Tribal Program serves 147 federally recognized tribes in the American Southwest. For other tribes, EPA regional offices coordinate tribal programs within their respective regions. The Navajo Nation has its own EPA (see below)	(415) 972-3560	EPA Regional Drinking Water Office
Navajo Nation Environmental Protection Agency	www.navajopublicwater.org/index.html www.navajonationepa.org	The Navajo Nation EPA serves the Navajo Nation in the states of Arizona, New Mexico, and Utah. The Navajo Nation EPA Surface and Groundwater Protection Department is responsible for protecting the waters of the Navajo Nation and enforcing the Navajo Nation Safe Drinking Water Act	(928) 729-4320 (928) 871-7755, ext 7758	Navajo Nation Division of Natural Resources Department of Water Resources Navaho Nation EPA Public Water Systems Supervision Program
Indian Health Service	www.dehs.ihs.gov/index.cfm	The Indian Health Service is the federal health program for American Indian and Alaska Native individuals. The Indian Health Service provides information on safe water to American Indian/Alaska Native communities on reservations, many of which depend on wells (usually community wells) for drinking water	(301) 443-1247	Indian Health Service Office of Environmental Health and Engineering
US Geological Survey	www.usgs.gov/science/science.php?term=1235&type=feature	The US Geological Survey provides scientific information about regional issues, supply and management, watershed, and contaminants of well water		
Centers for Disease Control and Prevention	www.cdc.gov/ncidod/dpd/healthywater/privatewell.htm	The Centers for Disease Control and Prevention Division of Parasitic Diseases maintains this Web site with information on contaminants that can be found in water from private wells		

APPENDIX Continued

Organization	Web Site	Web Site/Document Title/ Description	Telephone No.	Telephone Contact Organization
US Department of Agriculture	www.csrees.usda.gov/qlinks/partners/state_partners.html or www.csrees.usda.gov/Extension/index.html	Department of Agriculture CSREES maintains these Web sites with links to all states' state and national (university) partners and to all states' Local Cooperative Extension System Offices. These offices have extensive information on local and regional well water issues		
US Food and Drug Administration	www.fda.gov/oca/sthealth.htm	The Food and Drug Administration maintains this Web site with links to all state health departments or agencies		
Oak Ridge National Laboratory	http://rais.ornl.gov/CRE/CRE_eco_state.html	The Oak Ridge National Laboratory maintains this Web site with listings of all state departments of environment and/or natural resources protection. Information on local contaminants in well water can be found within state departments		
National Organizations				
NSF International	www.nsf.org/consumer/drinking_water/dw_well.asp?program=WaterTre	NSF International maintains this Web site with information about private well water systems and groundwater		
National Ground Water Association	www.wellowner.org; www.ngwa.org	The National Ground Water Association maintains the Web site with resources for private water well owners. The National Ground Water Association maintains a separate Web site (www.ngwa.org) with information geared to groundwater professionals.		
State Contacts				
AL	www.aces.edu/waterquality/faq/faq_list.php3?Code=303	AL State Water Program, AL Cooperative Extension Service, US Department of Agriculture, CSREES, and Land Grant Colleges: "Applying Knowledge to Improve Water Quality"	(334) 271-7773	AL State Water Program; Extension Water Coordinator
AK	www.uaf.edu/coop-ext/water/drinking_water_and_human_health.html	AK Water Quality Program and CSREES: "Drinking Water & Human Health"	(907) 786-6300 (907) 786-6311	AK Water Quality Program Rural Drinking Water and Small Systems
AZ	www.azdeq.gov/environ/water/dw/download/privatewells.pdf	AZ Department of Environmental Quality: "Private Wells After the Fire"	(602) 771-4644 (602) 364-0720	AZ Department of Environmental Quality AZ Department of Health Services Bureau of State Laboratory Services

APPENDIX Continued

Organization	Web Site	Web Site/Document Title/ Description	Telephone No.	Telephone Contact Organization
AR	www.healthyarkansas.com/eng/index.html	AR Department of Health and Human Services, Division of Health: "Drinking Water Information for Arkansans"	(501) 661-2623	AR Department of Health and Human Services, Division of Health
CA	www.water.ca.gov/drought/wellinfo.cfm	California Department of Water Resources, Drought Preparedness: "Well Information"	(916) 653-5791	CA Department of Water Resources
	www.groundwater.water.ca.gov/technical_assistance/gw_wells/gww_domown/index.cfm	"Domestic Well Owners"	(916) 653-6192 (916) 341-5779	CA State Water Resources Control Board Groundwater Ambient Monitoring and Assessment Program
CO	www.ext.colostate.edu/PUBS/NATRES/06700.html	Colorado State University Cooperative Extension: "Private Wells for Home Use"	(303) 692-3500, ext 4	CO Department of Public Health and Environment Water Program
CT	www.drought.state.ct.us/well.htm	State of CT Drought Response: "Guidance for Private Well Users"	(860) 509-7389	CT Department of Public Health Lab Certification Program
DE	http://ag.udel.edu/dwrc/concerns.html	DE Water Resources Center, University of Delaware: "The Water Resource Problems of Delaware"	(302) 739-9950	DE Public Water Systems Supervision Program
DC	There are no private water wells in the District of Columbia. All public water is through the Washington Aqueduct. See http://washingtonaqueduct.nab.usace.army.mil	NA	NA	NA
FL	www.doh.state.fl.us/environment/water/index.html#Public	FL Department of Health Bureau of Water Programs	(904) 791-1599 (850) 245-8059 (850) 245-4240	FL Department of Environmental Protection FL Bureau of Water Programs
GA	www.engr.uga.edu/service/extension/publications/c819-9c.html	University of Georgia Cooperative Extension	(404) 656-4807	GA Department of Natural Resources, Drinking Water Permitting Program
HI	www2.ctahr.hawaii.edu/oc/freepubs/pdf/HH-9.pdf	University of Hawaii at Manoa Cooperative Extension Service: "Drinking Water Wells"	(808) 586-4258	HI Department of Health, Drinking Water Branch
ID	www.deq.state.id.us/water/prog_issues/ground_water/wells/overview.cfm	ID Department of Environmental Quality: "Ground Water Quality in Idaho: Ground Water and Private Wells"	(208) 334-2235, ext 233	ID State Health Department
IL	www.idph.state.il.us/envhealth/waterwells.htm	IL Department of Public Health: "Water Wells"	(217) 782-5830	IL Department of Public Health, Drinking Water Section
IN	www.in.gov/isdh/23258.htm www.in.gov/dnr/water/2457.htm	IN Department of Natural Resources, Division of Water: "Recommended Standards for Private Water Wells" and "Ground Water/Wells"	(317) 921-5500 (317) 308-3286	IN State Department of Health Drinking Water Compliance Officer
IA	www.iowadnr.com/water/wells/index.html	IA Department of Natural Resources, Water Supply Operations: "Iowa's Private Water Well Program"	(800) 421-4692 (319) 335-4500	University of Iowa Hygienic Labs

APPENDIX Continued

Organization	Web Site	Web Site/Document Title/ Description	Telephone No.	Telephone Contact Organization
KS	www.oznet.ksu.edu/library/H20QL2/MF871.PDF	Kansas State University: "Recommended Water Tests for Private Wells"	(785) 296-1639	KS Health and Environmental Lab
KY	www.water.ky.gov/dw/profi/tips/welltest.htm	KY Division of Water: "Well Testing"	(502) 564-3410	KY Department of Environmental Protection Drinking Water Management
LA	www.dhh.louisiana.gov/offices/publications.asp?ID=205&Detail=1198&Arch=2002	LA Department of Health and Hospitals Environmental Epidemiology/Toxicology:	(225) 765-5038	LA Department of Health and Hospitals Office of Public Health Safe Drinking Water Program
		"Private Water Well Testing in LA: What You Need to Know to Protect Your Water"	(504) 219-4447	Laboratory Services
ME	www.maine.gov/dhhs/eng/water/Templates/PrivateWells/privatewells.htm	ME Division of Environmental Health Drinking Water Program: "Private Well Information for Homeowners"	(207) 287-1929	ME Division of Environmental Health, Drinking Water Program
MD	http://extension.umd.edu/environment/Water/files.well.html	MD Cooperative Extension, University of Maryland: "Water Wells and their Maintenance Guidelines"	(410) 537-3729	MD Department of the Environment, Water Supply Program
MA	www.mass.gov/dep/public/publications/mapwell2.pdf and www.mass.gov/dep/water/drinking/privurb.pdf	MA Department of Environmental Protection: "A Guide	(978) 682-5237, ext 331	MA Department of Environmental Protection
		to Water Quality Testing for Private	(617) 983-6870 (978) 640-9673	Division of Epidemiology and Immunization
		Wells" and "Private Wells in Urban Areas"	(617) 292-5770	Drinking Water Program
MI	http://web1.msue.msu.edu/waterqual/docs/wq02p1.html	Michigan State University Extension: "Testing of Private Wells"	(517) 353-5459	Michigan State University, Center for Environmental Toxicology
			(517) 373-1376	MI Department of Public Health, Water Supply Division
MN	www.health.state.mn.us/divs/eh/wells	MN Department of Health: "Well Management: Protect Your Health—Test Your Private Well Water"	(800) 383-9808	MN Department of Health
MS	http://msucares.com/pubs/publications/p1868.htm	MS State University Extension Service: "Protecting Your Private Well: An Environmental Self-assessment"	(601) 576-7518 (601) 987-6893 (800) 626-7739	MS State Department of Health
MO	www.scchealth.org/docs/ph/ph_docs/phnews/jun01.html	St Charles County, MO Division of Public Health: "Private Drinking Water Supplies"	(573) 751-4090 (800) 361-4827	MO Public Drinking Water Program
MT	http://waterquality.montana.edu/docs/homeowners/qanda.shtml	MT State University Bozeman, Department of Land Resources and Environmental Sciences: "Q&A: Water Quality testing for Private Well Owners"	(406) 444-2642	MT Department of Public Health and Human Services, State Environmental Lab
	www.dphhs.mt.gov/PHSD/Lab/Environmental/environ-lab-private-well-testing.shtml	MT Department of Public Health and Human Services: "Private Well Testing Program at the State Environmental Laboratory"		

APPENDIX Continued

Organization	Web Site	Web Site/Document Title/ Description	Telephone No.	Telephone Contact Organization
NE	www.hhs.state.ne.us/enh/recwtrprac.htm	NE Department of Health and Human Services: "Recommended Water Supply Practices"	(402) 471-2122	NE Department of Health and Human Services, Division of Labs
	www.unce.unr.edu/publications/files/ho/2006/fs0651.pdf	University of Nevada, Cooperative Extension: NV NEMO – Nonpoint Education for Municipal Officials POW: Protecting our Water: Action Guide #10: "What to do about Private Water Wells"	(775) 784-7070	University of Nevada, Cooperative Extension
NH	http://des.nh.gov/organization/divisions/water/dwgb/well_testing/index.htm	NH Department of Environmental Services, Water Division: Private Well Testing Program	(603) 271-3139 (603) 271-2952	NH Department of Environmental Services
NJ	www.state.nj.us/dep/pwta	NJ Department of Environmental Protection: "Private Well Testing Act: Buying or Selling a Home With a Private Well?"	(609) 292-3950	NJ Department of Environmental Protection
NM	www.nmenv.state.nm.us/dwb/Documents/Drought%20Fact%20Sheet.pdf	NM Department of Health: "Information for Well Owners: Safe Drinking Water During a Drought"	(877) 654-8720	NM Drinking Water Bureau
NY	www.health.state.ny.us/environmental/water/drinking/part5/append5b/index.htm	NY Department of Health Drinking Water Protection Program: "Information on Protection of Water Wells"	(518) 485-5570	NY Department of Health Drinking Water Protection Program
NC	http://h2o.enr.state.nc.us/aps/gpu/well_construction.htm	NC Department of Environmental and Natural Resources Division of Water Quality, Aquifer Protection Section: "Well Construction: Technical Assistance"	(919) 733-3221	NC Department of Environmental and Natural Resources Division of Water Quality, Aquifer Protection Section
	www.terraquestpc.com/downloads/brochures/WellAbandonment.pdf	Division of Water Quality, Groundwater Section "Well Abandonment: Know the Rules to Protect Yourself and Our Groundwater"	(919) 733-7308	NC Department of Health and Human Services, referral to county health departments
ND	www.health.state.nd.us/wq/gw/pubs/WellTestingBrochure.pdf	ND Board of Water Well Contractors: "Private Water Well Construction Requirements"	(701) 328-6140	ND Department of Health Division of Chemistry
OH	www.dnr.state.oh.us/water/pubs/fs_div/fctsht03/tabid/4083/Default.aspx	OH Department of Natural Resources Division of Water: "Water Efficiency for Private Well Owners" Sheet 92–3	(614) 265-6740	OH Department of Natural Resources Division of Water
OK	www.owrb.ok.gov/supply/wd/wd_forms.php	OK Water Resources Board: "Water Well Drilling Forms"	(405) 530-8800	OK Water Resources Board
OR	http://oregon.gov/DHS/ph/dwp/index.shtml	OR Department Human Services Drinking Water Program: "Ensuring that Oregonians have Safe Drinking Water"	(971) 673-0405	OR Department of Human Resources Drinking Water Program
	http://wellwater.oregonstate.edu/wells.php	Oregon State University: "The Oregon Well Water Program: Wells"	(541) 766-3556	Oregon State University Well Water Program

APPENDIX Continued

Organization	Web Site	Web Site/Document Title/ Description	Telephone No.	Telephone Contact Organization
PA	www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/SrceProt/well/default.htm	PA Department of Environmental Protection: "Private Water Wells in Pennsylvania"	(717) 787-8184	PA Department of Environmental Protection Bureau of Water Standards and Facility Regulation
RI	www.dem.ri.gov/programs/benviron/water/permits/privwell/index.htm	RI Department of Environmental Management Office of Water Resources: "Private Well Installation"	(401) 222-6867	RI Department of Health
SC	www.scdhec.net/water/html/dwrw.html	SC Department of Health and Environmental Control: "Residential Well Program"	(888) 761-5989 (803) 898-3376	SC Department of Health and Environmental Control Private Well Program
SD	www.state.sd.us/denr/des/drinking/privatewell.htm	SD Department of Environment and Natural Resources: "General Private Well Sampling"	(605) 773-3754	SD Department of Environment and Natural Resources Drinking Water Program
TN	www.state.tn.us/environment/dws/WWregprog.shtml#well	TN Department of Environment and Conservation Division of Water Supply: "Well Program"	(615) 532-0191	TN Department of Environmental Conservation Division of Water Supply
TX	www.license.state.tx.us/wwd/welldisinfection.pdf	TX Department of Licensing and Regulation Water Well Driller Program: "Private Well Disinfection"	(512) 463-7880 (800) 803-9202 (512) 458-7591	TX Department of Licensing and Regulation Well Water Driller/Pump Installer Program TX Department of Health
UT	http://health.utah.gov/lab/microbiology/envtech.html	UT Public Health Lab Bureau of Microbiology: "Drinking Water Bacteriology"	(801) 584-8400 (801) 584-8476 (801) 536-4200	UT Public Health Laboratory UT Division of Health
VT	http://healthvermont.gov/enviro/water/safe_water.aspx and http://healthvermont.gov/enviro/water/dug_well.aspx	VT Department of Health: "Safe Water Resource Guide" and "Dug Wells for Drinking Water"	(802) 863-7200 (800) 464-4343	VT Department of Health
VA	www.vdh.state.va.us/EnvironmentalHealth/ONSITE/regulations/PrivateWellInfo/index.htm	VA Department of Health Office of Environmental Health Services "Private Well Water Information"	(804) 864-7473	VA Department of Health
WA	www.doh.wa.gov/ehp/dw/Publications/331-349.pdf	WA Department of Health Office of Drinking Water: "Important Information for Private Well Owners"	SW: (360) 236-3030 NW: (253) 395-6750 E: (509) 456-3115	WA Department of Health Water Quality
WV	www.wvdhhr.org/phs/water/index.asp	WV Department Heath and Human Resources Office of Environmental Health Services Public Health Sanitation Division: "Individual Water Supplies: Wells, Cisterns, and Springs"	(304) 293-5785 (304) 558-6732	WV University Office of Environmental Health and Safety WV Department of Heath and Human Resources Office of Environmental Health Services Public Health Sanitation Division
WI	www.dnr.state.wi.us/org/water/dwg/wells.htm	WI Department of Natural Resources: "Drinking Water & Groundwater"	(608) 266-2621	WI Department of Natural Resources
	www.uwsp.edu/cnr/gndwater/privatewells	Groundwater Center University WI at Stevens Point: "For Private Well Users: Water Testing and Private Wells"	(715) 346-4270	Groundwater Center University WI at Stevens Point

APPENDIX Continued

Organization	Web Site	Web Site/Document Title/ Description	Telephone No.	Telephone Contact Organization
WY	http://deq.state.wy.us/wqd/groundwater/downloads/Private%20Wells/wellheadintro.asp or www.wywaterwell.org/educational.htm	WY Department of Environmental Quality: "Introduction to Wellhead Protection"	(307) 777-7431	WY Department of Health Public Health Lab Water Microbiology
	http://wdh.state.wy.us/phsd/lab/waterlab.html	WY Well Water Association or WY Department of Health Public Health Lab Water Microbiology	(307) 777-7781	WY Department of Environmental Quality Water Quality Division

CSREES indicates Cooperative State Research, Education and Extension Services; NA, not applicable.

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