ACRES WEST

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AFFECTED BY THE FLOOD OF JUNE 2005; OR INFECTED?

An alarming rate of well contamination has been reported due to the extreme rain & flooding residents experienced earlier this summer!

"According the Health Canada's *Guidelines for Canadian Drinking Water Quality (6th Edition, 1996);* drinking water should not contain more than 10 total coliform bacteria per 100 mL of water....the maximum acceptable concentration of *E. coli* is "zero"....water containing *E. coli* is not safe to drink. Corrective action should be taken immediately. It is necessary to shock treat the well and, if possible, find and eliminate the source of contamination. If the source of contamination cannot be found and eliminated, the water should subsequently receive continuous disinfection.

Testing Well Water for Microbiological Contamination

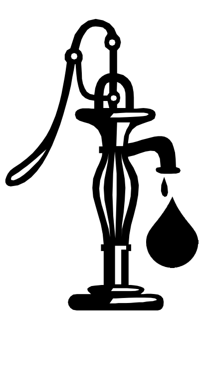
Existing wells should be tested two or three times a year. The best time to sample your well water is when the probability of contamination is greatest. This is likely to be in early spring just after the thaw, after an extended dry spell, following heavy rains or after lengthy periods of non-use.

Bacteriological testing of well water is done either by the provincial health laboratory in your area or by a certified private laboratory. They will supply you with a clean, sterile sample bottle and the necessary instructions. Samples collected in any other container will not yield meaningful results and will not be accepted by the laboratory. In all instances, samples should be refrigerated immediately and transported to the laboratory within 24 hours.

If you have experienced gastrointestinal illness and suspect that it might be associated with your well water, consult your physician and local health unit" 1) ***Health Canada www.hc-sc.gv.ca***

Additionally, Alberta Environment recommends private well owners should have a well shock chlorination performed annually. 2) ***Alberta Environment www.gov.ab.ca***

FOR MORE INFORMATION OR TO OBTAIN AN ELECTRONIC COPY OF OUR "Acreage Owner Information Guide", PLEASE CALL OUR WATER HOTLINE AT PH: 931-3733



Albertans who obtain their drinking water from alternative sources – such as personal groundwater wells and other wells, dugouts, canals, streams and lakes – are responsible for making sure their own drinking water is safe. They are responsible for having the water tested on a regular basis and for applying the appropriate treatment options based on the water quality reports.

Source: Alberta Environment

What's In Your Well? - A Guide To Well Water Treatment And Maintenance

Source: *Health Canada www.hc-sc.gv.ca*

Introduction

Typically, groundwater is naturally clean and safe for consumption. Because the overlying soil acts as a filter, groundwater is usually free of disease-causing microorganisms. However, contamination may occur following improper installation of well casings or caps, after a break in the casing or as a result of contaminated surface water entering the well. Contamination can also occur if wells are drilled in fractured bedrock without an adequate layer of protective soil and with less than the recommended minimum casing length.

In order to prevent illness, wells should be properly maintained and the water regularly tested for the presence of microbial contaminants. Well water should also be tested occasionally for possible inorganic and organic chemical contaminants.

Well Maintenance

Proper siting, location, construction and maintenance of your well will help to minimize the likelihood of contamination. The well cap should be checked regularly to ensure that it is securely in place and watertight. Joints, cracks and connections in the well casing should be sealed. Pumps and pipes should also be checked on a regular basis, and any changes in water quality should be investigated.

Surface drainage should be directed away from the well casing, and surface water should not collect near the well. The well itself should not be located downhill from any source of pollution.

Well water should be tested for bacteriological quality regularly and for chemical contamination if it is suspected. In addition to regular tests, well water should be tested immediately if there is any change in its clarity, colour, odour or taste, or if there has been a change in the surrounding land use. Through regular assessment and testing of drinking water, the microbial and chemical safety of your well water can be verified.

Testing Well Water for Microbiological Contamination

New wells should be disinfected by the well driller at the time of construction to eliminate any microbiological contamination that may have occurred during drilling. This should be done **before** collecting a sample for microbiological testing. Existing wells should be tested two or three times a year. The best time to sample your well water is when the probability of contamination is greatest. This is likely to be in early spring just after the thaw, after an extended dry spell, following heavy rains or after lengthy periods of non-use.

Depending on the province, bacteriological testing of well water is done either by the provincial health laboratory in your area or by a certified private laboratory. They will supply you with a clean, sterile sample bottle and the necessary instructions. Samples collected in any other container will not yield meaningful results and will not be accepted by the laboratory. In all instances, samples should be refrigerated immediately and transported to the laboratory within 24 hours.

If you have experienced gastrointestinal illness and suspect that it might be associated with your well water, consult your physician and local health unit.

Interpreting the Results of Testing

The microbiological quality of your water is determined by looking for the presence of bacteria indicative of faecal (sewage) contamination - namely, total coliforms and *Escherichia coli*. Total coliforms occur naturally in soil and in the gut of humans and animals. Thus, their presence in water *may* indicate faecal contamination. *E. coli* are present only in the gut of humans and animals. Their presence therefore indicates *definite* faecal (sewage) pollution.

Total Coliforms

The presence of total coliform bacteria in well water is a result of surface water infiltration or seepage from a septic system. According to Health Canada's *Guidelines for Canadian Drinking Water Quality* (Sixth Edition, 1996), drinking water should not contain more than 10 total coliform bacteria per 100 mL of water. Any water containing more than this amount should be resampled. If the repeat sample contains more than 10 total coliform bacteria per 100 mL, corrective action should be taken immediately.

Water containing fewer than 10 total coliform bacteria per 100 mL is considered marginally safe to drink. Nevertheless, the water should be resampled. If fewer than 10 total coliform bacteria per 100 mL are detected, the cause of contamination should be determined if possible and corrective action taken as appropriate.

E. coli

E. coli appear in water samples recently contaminated by faecal matter; thus, they indicate the possible presence of disease-causing bacteria, viruses or protozoa. Water containing *E. coli* is not safe to drink. Corrective action should be taken immediately.

The maximum acceptable concentration of *E. coli* is "0" per 100 mL of water.

If test results show an unacceptable level of total coliforms or *E. coli*, it is necessary to shock treat the well and, if possible, find and eliminate the source of contamination.

If the shock treatment solves the problem, repeat bacteriological testing in three to four months.

If the shock treatment does not alleviate the problem, it is recommended that the source of the ongoing contamination be determined and corrected, possibly with professional help. If remediation is not possible, a permanent alternative solution, such as a new well or a drinking water disinfection device, should be considered.

Water Treatment Devices for Home Use

The water quality problems described in this fact sheet may be resolved by use of a drinking water treatment unit. There are a wide variety of such devices available for home use. Health Canada works closely with NSF International to develop performance standards for water treatment devices. Consumers are encouraged to purchase products that have been certified to these standards.

Microbiological Contaminants

If elimination of the source of contamination is not possible after shock chlorine disinfection, consider the installation of a batch or continuous disinfection system or a new water supply. Some suitable devices are described in Table 2.

Table 2: Household Drinking Water Disinfection Devices

Water treatment method	Uses
Distillation	Kills all microorganisms.

Ultraviolet light	Kills all microorganisms. Use in conjunction with microfiltration to improve inactivation and remove particulate matter, including parasites.
Chlorination	Kills bacteria and viruses. Use in conjunction with microfiltration to improve inactivation and remove particulate matter, including parasites.
Ozonation	Kills harmful microorganisms. Use in conjunction with microfiltration to improve inactivation and remove particulate matter, including parasites.
Ceramic candle filtration	Removes parasites and bacteria. Use in conjunction with chlorination to kill viruses.

Chemical Contaminants

Well water should also be tested for hazardous chemicals whenever contamination is suspected. Chemical analysis of water samples can be provided by commercial testing laboratories. Some provincial health laboratories will analyse water for nitrate, which typically originates from farming activities and seepage from septic tanks. High concentrations of nitrate may cause "blue baby syndrome" (methaemoglobinaemia), a condition in which methaemoglobin cannot release oxygen to body tissues, and which mostly affects infants under three months of age. Other chemical contaminants of concern include pesticides, heavy metals and volatile organic compounds. Guidelines for Canadian Drinking Water Quality provides a list of maximum acceptable concentrations for these chemicals. If hazardous chemical contaminants are detected, you should consider the installation of a treatment device or a new water supply. Some suitable units are listed in Table 3.

Table 3: Chemical Removal Devices

Water treatment method	Uses
Activated carbon filtration*	Removes organic compounds, including pesticides.
Reverse osmosis*	Removes heavy metals and nitrates; often used in combination with activated carbon filters.
Distillation	Removes heavy metals and nitrates; often used in combination with activated carbon filters.
Ozonation	Removes organic compounds, including pesticides; often used in combination with activated carbon filters.

* Should not be used with microbiologically unsafe waters or water of unknown microbiological quality.

Hardness, Taste, Odour and Colour

Well water contains naturally occurring minerals, such as calcium, iron and sulphur. Although these minerals are not hazardous to human health, they can alter the hardness, taste, odour or colour of the water when present in excess quantities. Groundwaters may also contain natural organic materials (tannins). Table 4 describes some signs that may indicate the presence of these substances in your well water and some solutions. In order to select the best treatment method, a full testing of the suite of minerals should be conducted prior to the purchase of a device.

Table 4: Common Aesthetic Water Quality Problems and Solutions

Problem	Cause	Solutions
Hard water (scales/deposits in kettles and water heaters)	Excess calcium	Water softeners* Reverse osmosis Distillation

Rusty (red to brown) staining of fixtures and laundry and/or metallic taste	Excess iron	Chlorination-filtration Greensand filtration Aeration-filtration Distillation
Black staining of fixtures and laundry and/or metallic taste	Excess manganese	Chlorination-filtration Greensand filtration Aeration-filtration Distillation
Rotten egg smell	Hydrogen sulphide	Chlorination-filtration Greensand filtration Aeration-filtration
Water has laxative effect	Excess sulphates	Reverse osmosis Distillation
Turbidity/grittiness	Mud/silt/clay/sediment in water	Sediment filters
Organic (tea) colour	Tannins	Chlorination-filtration Ozonation-filtration

* Individuals on sodium-restricted diets should consult their physician before drinking artificially softened water. Iron and manganese can also be removed by a softener, provided the water is not too hard.

Summary of Guidelines for Chemical and Physical Parameters

Parameters with Guidelines

Guidelines for all chemical and physical parameters, including all new, revised and reaffirmed maximum acceptable concentrations (MACs), interim maximum acceptable concentrations (IMACs) and aesthetic objectives (AOs), are listed in Table 3. For more information on the drinking water guideline for any particular compound, please refer to the Supporting Documentation for the parameter of concern.

Table 3.Summary of Guidelines for Chemical and Physical Parameters

Parameter	Maximum Acceptable Concentration (mg/L)	Aesthetic Objectives (mg/L)	Reason / Comment

aldicarb	0.009		
aldrin + dieldrin	0.0007		
aluminum [1]			
antimony	0.006 [2]		
arsenic	0.025		
atrazine + metabolites	0.005		
azinphos-methyl	0.02		
barium	1.0		
bendiocarb	0.04		
benzene	0.005		
benzo[a]pyrene	0.00001		
boron	5		
bromate	0.01		
bromoxynil	0.005		
cadmium	0.005		
carbaryl	0.09		
carbofuran	0.09		
carbon tetrachloride	0.005		
chloramines (total)	3.0		
chloride		≤250	
chlorpyrifos	0.09		
chromium	0.05		
colour		≤15 TCU [4]	
copper [2]		≤1.0	
cyanazine	0.01		
cyanide	0.2		
cyanobacterial toxins (as microcystin-LR) [3]	0.0015		
diazinon	0.02		
dicamba	0.12		
dichlorobenzene, 1,2- [5]	0.20	≤0.003	
dichlorobenzene, 1,4- [5]	0.005	≤0.001	
dichloroethane, 1,2-	0.005		
dichloroethylene, 1,1-	0.014		
dichloromethane	0.05		
dichlorophenol, 2,4-	0.9	≤0.0003	
dichlorophenoxyacetic acid, 2,4- (2,4-D)	0.1		
diclofop-methyl	0.009		
dimethoate	0.02		
dinoseb	0.01		
diquat	0.07		

diuron	0.15		
ethylbenzene		≤0.0024	
fluoride [6]	1.5		
glyphosate	0.28		
iron		≤0.3	
lead [2]	0.010		
malathion	0.19		
manganese		≤0.05	
mercury	0.001		
methoxychlor	0.9		
metolachlor	0.05		
metribuzin	0.08		
monochlorobenzene	0.08	≤0.03	
nitrate [7]	45		
nitrilotriacetic acid (NTA)	0.4		
odour		Inoffensive	
paraquat (as dichloride)	0.01 [8]		
parathion	0.05		
pentachlorophenol	0.06	≤0.030	
pH		6.5-8.5 [9]	
phorate	0.002		
picloram	0.19		
selenium	0.01		
simazine	0.01		
sodium [10]		≤200	
sulphate [11]		≤500	
sulphide (as H_2S)		≤0.05	
taste		Inoffensive	
temperature		≤15°C	
terbufos	0.001		
tetrachloroethylene	0.03		
tetrachlorophenol, 2,3,4,6-	0.1	≤0.001	
toluene		≤0.024	
total dissolved solids (TDS)		≤500	
trichloroethylene	0.05		
trichlorophenol, 2,4,6-	0.005	≤0.002	
trifluralin	0.045		
trihalomethanes (total) [12]	0.1		
turbidity	1 NTU[13]	≤5 NTU [13,14]	

uranium	0.02		
vinyl chloride	0.002		
xylenes (total)		≤0.3	
zinc [2]		≤5.0	

Notes:

1. A health-based guideline for aluminum in drinking water has not been established. However, water treatment plants using aluminum-based coagulants should optimize their operations to reduce residual aluminum levels in treated water to the lowest extent possible as a precautionary measure. *Operational guidance values* of less than 100 µg/L total aluminum for conventional treatment plants and less than 200 µg/L total aluminum for other types of treatment systems are recommended. Any attempt to minimize aluminum residuals must not compromise the effectiveness of disinfection processes or interfere with the removal of disinfection by-product precursors.

2. Because first-drawn water may contain higher concentrations of metals than are found in running water after flushing, faucets should be thoroughly flushed before water is taken for consumption or analysis.

3. The guideline is considered protective of human health against exposure to other microcystins (total microcystins) that may also be present.

4. TCU = true colour unit.

5. In cases where total dichlorobenzenes are measured and concentrations exceed the most stringent value (0.005 mg/L), the concentrations of the individual isomers should be established.

6. It is recommended, however, that the concentration of fluoride be adjusted to 0.8–1.0 mg/L, which is the optimum range for the control of dental caries.

7. Equivalent to 10 mg/L as nitrate–nitrogen. Where nitrate and nitrite are determined separately, levels of nitrite should not exceed 3.2 mg/L.

8. Equivalent to 0.007 mg/L for paraquat ion.

9. No units.

10. It is recommended that sodium be included in routine monitoring programmes, as levels may be of interest to authorities who wish to prescribe sodium-restricted diets for their patients.

11. There may be a laxative effect in some individuals when sulphate levels exceed 500 mg/L.

12. The IMAC for trihalomethanes is expressed as a running annual average. It is based on the risk associated with chloroform, the trihalomethane most often present and in greatest concentration in drinking water. The guideline is designated as interim until such time as the risks from other disinfection by-products are ascertained. The preferred method of controlling disinfection by-products is precursor removal; however, any method of control employed must not compromise the effectiveness of water disinfection.

13. NTU = nephelometric turbidity unit.

14. At the point of consumption.

Parameters without Guidelines

Since 1978, some chemical and physical parameters have been identified as not requiring a numerical guideline. Table 4 lists these parameters.

The reasons for parameters having no numerical guideline include the following:

currently available data indicate no health risk or aesthetic problem (e.g., calcium);

data indicate the compound, which may be harmful, is not registered for use in Canada (e.g., 2,4,5-TP) or is not likely to occur in drinking water at levels that present a health risk (e.g., silver); or

the parameter is composed of several compounds for which individual guidelines may be required (e.g., pesticides [total]).

Table 4. Summary List of Parameters without Guidelines

Parameter	Parameter
ammonia	mirex
asbestos	phenols
calcium	phthalic acid esters (PAE)
chlordane (total isomers)	polycyclic aromatic hydrocarbons (PAH) [2]
dichlorodiphenyltrichloroethane (DDT) + metabolites	radon
endrin	resin acids
formaldehyde	silver
gasoline	tannin
hardness [1]	temephos
heptachlor + heptachlor epoxide	total organic carbon
lignin	toxaphene
lindane	triallate
magnesium	trichlorophenoxyacetic acid, 2,4,5- (2,4,5-T)
methyl-parathion	trichlorophenoxypropionic acid, 2,4,5- (2,4,5-TP)

Notes:

1. Public acceptance of hardness varies considerably. Generally, hardness levels between 80 and 100 mg/L (as $CaCO_3$) are considered acceptable; levels greater than 200 mg/L are considered poor but can be tolerated; those in excess of 500 mg/L are normally considered unacceptable. Where water is softened by sodium ion exchange, it is recommended that a separate, unsoftened supply be retained for culinary and drinking purposes.

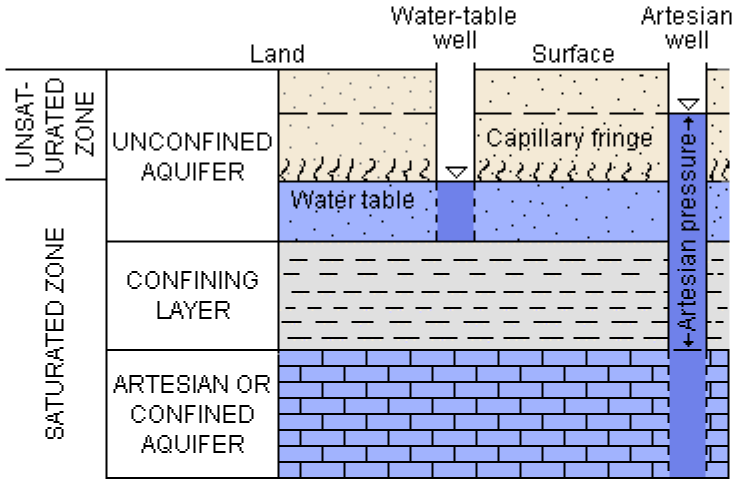
2. Other than benzo[a]pyrene.

AQUIFERS

SOURCE: Alberta Environment

An **Aquifer** as defined by North American Lake Management Society (NALMS):

A geologic formation, a group of formations, or a part of a formation that is water bearing. A geological formation or structure that stores or transmits water, or both, such as to wells and springs. Use of the term is usually restricted to those water-bearing structures capable of yielding water in sufficient quantity to constitute a usable supply.



Unconfined aquifers have an upper boundary defined by the water table. This means that the water level can rise or fall as the recharge (e.g. from surface precipitation and infiltration) and discharge (e.g. to lakes and rivers, or other formations) conditions change over time.

Confined aquifers are those which are bounded above and below by a low permeability confining layer, which tends to keep the water in the aquifer mostly contained. Movement is generally through the aquifer itself as opposed to up and down between layers. They tend to have relatively constant pressure heads, unless they are tapped by a well. Depending on the pressure head within the confined aquifer, the well may be artesian, meaning it can flow freely toward the surface (or even reaching the surface) without pumping required.

Aquifers in Alberta

Aquifers can be generally classified by the type of material in which they reside. Terms such as "shallow" or "deep" aquifers, though they can be useful, do not always take into account the complex geology beneath the ground surface. Bedrock aquifers can be located near or at the surface in some places, while surficial or overburden deposits can extend to great depths, sometimes in excess of hundreds of metres. Therefore, the characteristics of aquifers (chemistry, yield, etc.) can often be generalized based on the type of deposit, and not necessarily based solely on the absolute depth.

Surficial or Unconsolidated Overburden Aquifers

Overburden aquifers are mainly found in the gravels and sands of pre-glacial valleys. These valleys are the buried remnants of the river systems that existed prior to glaciers carving and remoulding the landscape. The valleys are now buried under layers of glacial till, fluvial (river) sands and silts, or lacustrine (lakes) silts and clays.

Other surficial deposits that can contain aquifers are lag deposits, or outwash of sands and gravels from glacial tills, post-glacial aeolian (wind-borne) deposits, and terraced sands and gravels. Also, elevated plateaus with pre-glacial sands and gravels that are surrounded by glacial till and clay can hold substantial quantities of readily available water. These types of aquifer containing formations are commonly found in northern Alberta.

Bedrock Aquifers

Most of the bedrock in Alberta that holds potable water is sedimentary. As mountains erode, the sediments are deposited in seas, lakes, deltas, beaches and on the land itself. As the layers build up, the immense pressures turn the sediments into sandstone, shale, siltstone and other types of sedimentary rocks. Typically sandstones are found near the foothills and shales are found in the plains and lowlands of Alberta. Sandstone is one of the more permeable forms of bedrock, and as a result, typically contains high yielding aquifers, that are suitable for our use.

UNDERSTANDING GROUNDWATER

Source: Alberta Agriculture Food and Rural Development

Groundwater is a priceless resource lying beneath most of Alberta's land surface. About 90 percent of rural Albertans rely on groundwater for a household water supply. Reliance on groundwater continues to increase in rural Alberta because of the steady increase in livestock populations and groundwater requirements for oil recovery purposes.

The vulnerability of groundwater to overuse and water quality degradation is often misunderstood. This module provides basic information about how the resource occurs below the ground surface. With this information you can use and protect groundwater so that current and future generations can depend on this valuable resource.

What is Groundwater?

Groundwater is one component of the earth's water cycle. The water cycle, called the hydrologic cycle, involves the movement of water as water vapor, rain, snow, surface water and groundwater. The earth's water is constantly circulating from the earth's surface up into the atmosphere and back down again as precipitation (see Figure 1, Hydrologic Cycle).

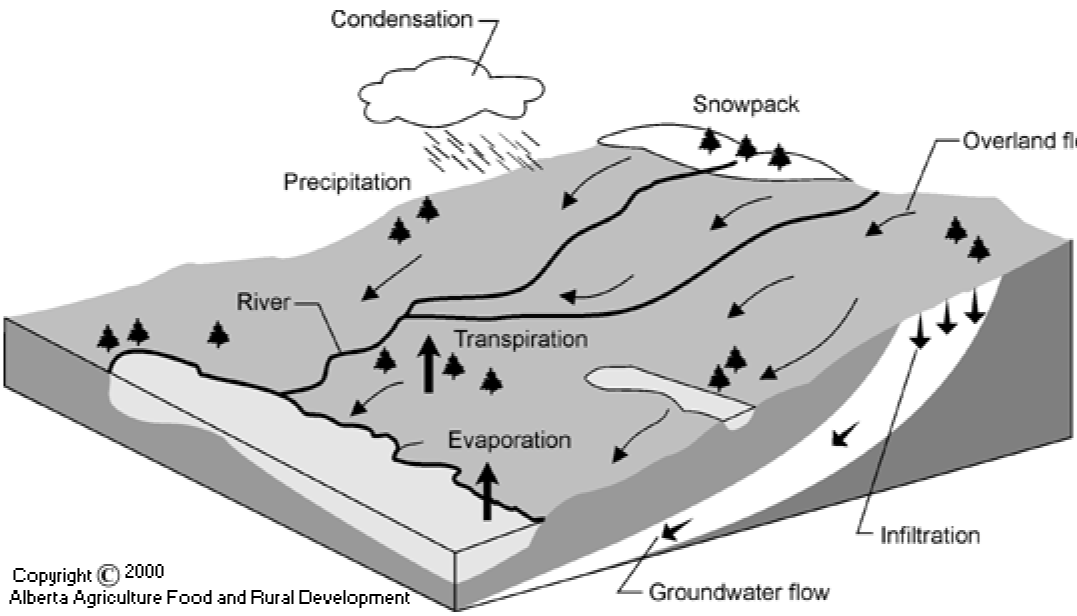


Figure 1 *Hydrologic Cycle*

Some precipitation that falls to the ground surface infiltrates the ground and becomes groundwater. Groundwater is defined as sub-surface water that fills openings and pore spaces in soil and rock layers. Below the ground surface is an unsaturated zone, which water travels through, to reach lower zones. The water table is the point at which the ground is completely saturated. Below this level the pore spaces between every grain of soil and rock crevice completely fill with water.

Aquifers and aquicludes
The layers of soil and rock below the water table are classified in two broad categories:

- Aquifers
- Aquicludes.

Aquifers are water bearing layers (or formations) that yield water to wells in usable amounts. Typical aquifers are made of sand, gravel or sandstone. These materials have large enough pore spaces between grains that water moves freely. Coal and shale are also suitable aquifer materials provided they are fractured (or cracked) enough to allow water to move through them easily.

Aquicludes are water bearing formations that cannot yield adequate water for wells. Examples of these are clay and unfractured shale and coal. The pore spaces between grains of these materials are so small that water moves extremely slowly.

Confined and unconfined aquifers
Unconfined aquifers are exposed directly to the atmosphere through openings in the soil. The volume of water in unconfined aquifers is mainly dependent on seasonal cycles of precipitation that refills the aquifer. A water table aquifer is an example of an unconfined aquifer (see Figure 2, Types of Aquifers).

A confined aquifer is trapped below an upper confining layer of rock, clay or shale. When a well is drilled into a confined aquifer, the water level rises above the level of the aquifer. Aquifers that are completely saturated with water and under pressure are called artesian aquifers. The artesian aquifer shown in Figure 2, Types of Aquifers, is an example of a confined aquifer. A flowing artesian well results when the pressure in the aquifer raises the water level above the ground surface.

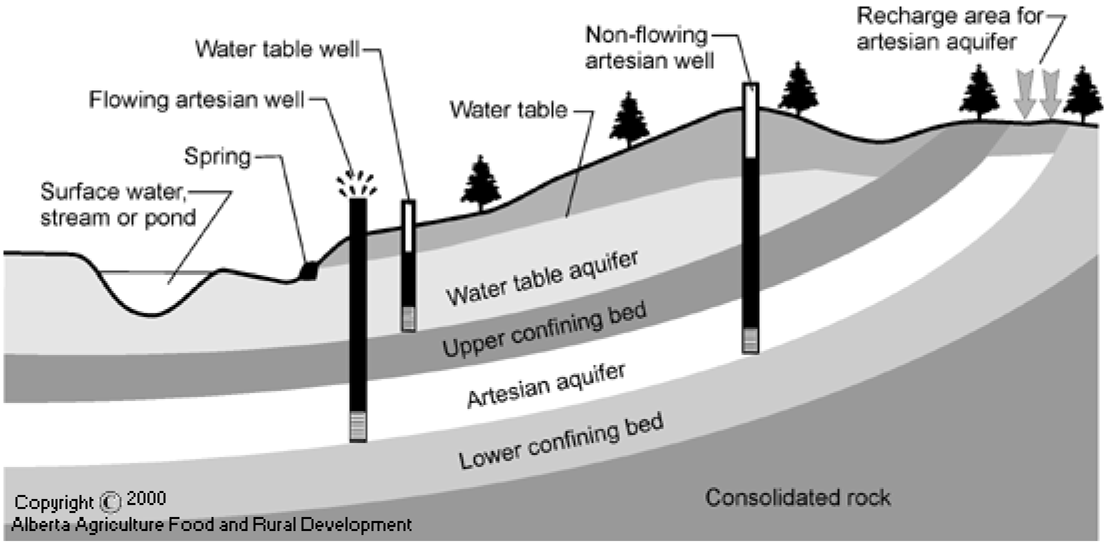


Figure 2 *Unconfined Aquifer*

Types of Aquifers in Alberta

There are two main types of aquifers in Alberta:

- Surficial
- Bedrock.

The amount of water available in each type varies depending on the geological makeup of the area.

Surficial aquifers are shallow sand and gravel aquifers that typically occur between 10-30 m (33-100 ft.). They are important sources of water for many parts of Alberta.

Buried valleys are much like our river system. In Alberta, there is a vast network of interconnected valleys located beneath the land surface. These valleys appear to have been carved into the upper portion of the underground rock formations. These buried valleys sometimes contain extensive deposits of sand and gravel. They range in depth from 15-90 m (50-300 ft.) and in width from under .4 km (1/4 mi.), to over 16 km (10 mi.).

They can offer excellent sites for high yielding wells that can produce up to 500 gallons per minute (gpm). Consequently, there has been considerable effort by hydrogeologists and well drillers over the past 10 to 20 years to identify the locations of these high yielding aquifers. It is expected that in years to come these buried valleys will become a major source of water supply for agricultural and oil recovery purposes throughout the province. If the exact locations, yield and water quality of these sources were known, community wells and pipelines could replace individual dugouts and marginal wells in areas with little other groundwater. Properly managed pipelines from wells tapping into these formations would ensure a long-term water supply.

Bedrock aquifers in Alberta are usually composed of sandstone, fractured shale and coal. These aquifers are generally sufficient for most domestic needs; however, larger livestock operations struggle to meet all of their water requirements from wells drilled into bedrock aquifers. Fractured shales and coals are generally much lower yielding than sandstone (shale and coal yield (<1 to 30 gpm; sandstone yields 1 to 500 gpm). Sandstone aquifers that yield more than 50 gpm are limited to a small portion of the province. These few high yielding aquifers are often tapped for municipal use.

Groundwater Movement

Groundwater is continually moving, often very slowly. Gravity is the major driving force and thus groundwater is always moving from areas of higher elevation to lower elevation. Notice that the water table in Figure 2, Types of Aquifers, is not level. It slopes toward the stream and thus moves in that direction. The water in the confined sandstone aquifer is also moving away from the area of higher elevation as this is where the pressure is coming from.

Knowing the direction of groundwater movement is increasingly important because of the danger of contaminating groundwater supplies. Shallow water table aquifers are especially susceptible to surface contaminants such as sewage, manure, pesticides and petroleum products when they enter the ground at higher elevations than the well. Proper well location and separation distances from potential contaminants reduce this risk.

Groundwater Recharge

Aquifers can be recharged (or refilled) directly by precipitation moving down through the soil and rock layers and into these water bearing formations. They can also be recharged by infiltration from surface water sources such as lakes, rivers, creeks and sloughs. Conversely, groundwater may discharge to surface water sources. The quantity of groundwater discharge may be a significant portion of input into the surface water source and can affect water quality accordingly.

Natural groundwater recharge is affected by human activities on the ground surface. For example, the drainage of sloughs increases the movement of water off the land surface. This reduces the water infiltration that eventually becomes groundwater. A reduction in groundwater recharge can seriously reduce the water level in nearby shallow wells.

Factors Affecting Groundwater Quality

An understanding of the factors that affect groundwater quality can help you make decisions on well depth and the best water quality for a particular application. There are several factors that affect groundwater quality:

- Depth from surface
- Permeability and chemical makeup of the sediments through which groundwater moves
- Climatic variations.

Total dissolved solids (TDS) means the quantity of dissolved material (minerals) in the water.

Depth from surface
Water is the world's greatest and most abundant solvent. It attempts to dissolve everything it comes in contact with. As a result, the longer groundwater takes to move through the sediments,

the more mineralized it becomes. Thus, shallow groundwater aquifers have a lower level of mineralization, or total dissolved solids (TDS), than deeper aquifers. Water from deeper groundwater aquifers typically has a much longer trip to its destination and thus it is usually more mineralized.

While shallow wells have lower levels of TDS, they do have higher levels of calcium, magnesium and iron than deeper wells. High levels of these minerals make the water "hard." Deeper wells have higher levels of sodium and lower levels of hardness, making the water "soft." The reason is that deeper sediments and rock formations contain higher levels of sodium and as water moves downward through the sediment and rock formation, a natural ion exchange process occurs. Calcium, magnesium and iron in the groundwater are exchanged for sodium in the sediment and rock formations. The result is groundwater with higher levels of sodium and little or no hardness. The process is identical to what occurs in an automatic water softener, except in this case, it is a natural phenomenon.

Permeability of sediments
Groundwater moves very slowly through sediments with low permeability, such as clay. This allows more time for minerals to dissolve. In contrast, sediments with high permeability, such as sand, allow groundwater to move more quickly. There is less time for minerals to dissolve and thus the groundwater usually contains lower levels of dissolved minerals.

There is also a difference in dissolved solids between groundwater in recharge zones and water in discharge zones. Recharge zones are uplands areas where precipitation readily enters the ground through permeable, sandier sediments. Generally, water in recharge zones has a low level of mineralization. Discharge areas are low areas where groundwater flow eventually makes its way back to (or near) the ground surface. Groundwater found in such areas can be extremely high in minerals such as sodium, sulfates and chlorides. Examples are saline seeps, sloughs and lakes.

Chemical makeup of sediments
Another factor affecting groundwater quality is the chemical makeup of minerals. Some chemicals are more soluble than others, making them more likely to become dissolved in the water. For example, groundwater in contact with sediments containing large concentrations of sodium, sulfate and chloride will become mineralized at a faster rate than if other chemicals were present.

A basic understanding of the factors that affect groundwater quality can help you make decisions on well depths and the best water quality for a particular application.

Climatic variations
Climatic variations such as annual rainfall and evaporation rates also play an important role in groundwater quality. In semi-arid regions discharging groundwater often evaporates as it approaches the surface. The minerals from the water are deposited in the soil, creating a salt buildup. Precipitation infiltrating through the soil can redisslove the salts, carrying them back into the groundwater. For example, in east central and southern Alberta where annual precipitation is from 25-40 cm (10-16 in.) and the evaporation rate is high, TDS are about 2500 parts per million (ppm). In areas with higher precipitation and lower evaporation rates, precipitation that reaches groundwater is less mineralized. For example, in western Alberta where annual precipitation is more than 45 cm (18 in.) groundwater in surficial deposits contains less than 800 ppm of TDS.

Geology and Goundwater Supplies in Alberta

Alberta is divided into four main geological areas: the interior plains, mountains, foothills and the crystalline shield of northeastern Alberta.

The same factors that affect water quality also affect the quantity of water available. The following table shows the high variability in potential yeild of water, given the soil and rock formations found in the four geological areas. The mountains and foothills are grouped together in this chart.

Soil and Rock Formations	Interior Plains	Mountains and Foothills	Crystalline Shield of N.E. Alberta
Shales	<1 to 20 gpm (if fractured)	<1 to 20 gpm (if fractured)	<1 gpm
Sandstones	1-500 gpm	1 to 100 gpm	<1 gpm
Siltstones	<1-5 gpm	<1-5 gpm	Not present
Coal	Dry - 30 gpm	Dry - 30 gpm	Not present
Limestones	Dry - 30,000 gpm at points of discharge (springs)	Dry - 30,000 gpm at points of discharge (springs)	Not present
Dolomites	Dry - 50 gpm northeastern plains	Dry - 15,000 gpm at points of discharge (springs)	Not present
Evaporites - Gypsum -Halite -Anhydrite	Dry	Dry	Not Present
Crystalline Rocks	Present only in extremely limited areas	Variable yield	About 5 gpm
Sand and Gravel	<1 - 500 gpm locally in some buried channels	<1 - 500 gpm	Up to 100 gpm locally
Clays	<1	<1	<1

Source: Alberta Research Council -- General Review of Geology As It Relates to Groundwater in Alberta.

Planning Your Water System

This module helps you assess whether your water source has adequate capacity to meet your needs. Water sources are covered in detail. You will also get an overview of the planning considerations and benefits of a well-designed water system.

A water system includes:

- Water sources
- Pumps
- Pressure tanks and cistern

- Distribution system including pipelines, automatic waterers, hydrants and home plumbing
- Water treatment equipment.

  If you are buying new property or building a new home where there is not a well, you should determine water quality and availability first. Where there is a well, you should have it pump tested to establish its performance. You should also have the water tested for quality.

Why Plan?

Often little thought and foresight are given to planning a farm or home water system. On the surface, a water system seems no more than an automatic pump and storage tank that delivers water under pressure to the household. There are other important aspects, such as how much water is available, the pressure, water quality and provisions for watering a garden and fire fighting. When planning your water system, consider all the uses of water in your home and business. Include such things as:

- Livestock watering
- Cleaning barn floors and equipment
- Irrigation of gardens and greenhouses
- Egg and milk production
- Fire protection.

A water system that is well planned and designed costs more initially but saves money in the end. Costly changes to correct errors are reduced and you have a convenient and reliable water supply, provided you monitor and maintain the system (see Module 5 "Monitoring Your Water Well" and Module 6 "Shock Chlorination—Well Maintenance").

Steps to Planning Your Water System

There are several steps to planning your water system:

- Determine water requirements
- Complete an inventory of water sources.

Determine water requirements
The first step to planning is to determine your water requirements. Look beyond your current requirements and consider any changes you may be making in the next few years. For example, is another family moving to the farm? Are you considering diversifying to include a market garden? Use the worksheets "Daily and Annual Water Requirements" and "Sizing of Water Systems" included in the pocket on the back cover to calculate your daily, annual and peak use requirements. Sample copies are at the back of the module.

A well-planned water system should also have a backup or second water source in case of pump or water source failure. Water sources that can easily be connected using underground piping provide the flexibility required in emergencies.

Complete an inventory of water sources
The next step to planning is to complete an inventory of all existing well and surface water sources. Record production rates, storage volumes and any previous problems with water

quantity or quality for each water source. Completing an inventory will show if there is adequate water supply to meet your needs year round. Use the worksheet, "Farm Water Supply Inventory," included in the back cover pocket to list all the water sources available to you.

If you have some doubt about the adequacy of your existing water sources, take time to check all the options before choosing to drill a new well. There may be inexpensive ways of increasing well yields or water storage to meet your needs. In some situations a well can comfortably keep up to daily requirements but not peak demands. The addition of a cistern with one-half to one day storage may be all that is required.

Water Source Options Wells

Water wells are generally the first choice of Albertans wherever there is an adequate supply of good groundwater. In areas of marginal groundwater supply, livestock operations often use a combination of wells and dugouts. The better quality water from the well supplies the household and supplements the livestock's requirements.

For most household situations, wells with a production rate of less than 5 gallons per minute (gpm) for a one hour (peak use) period do not supply enough water so it is usually necessary to create additional water storage using a tank or cistern. Wells that produce at a 5-10 gpm rate usually do not require additional storage.

When a lot of demand is placed on the well at any given time, such as on a farm, it should be capable of providing a minimum of 10 gpm for at least 2 continuous hours. If the flow rate of the well falls short of this amount, a cistern is usually the best option for providing water storage, to overcome the shortage of water. For livestock operations, a well should be capable of providing all of the water requirements in an 8 to 12 hour period.

A well that produces as little as 0.5 gpm can meet average household needs for most Alberta families if the water is pumped and stored in a cistern for peak use times.

Dugouts
In areas where there is a combination of either poor groundwater supply or quality, dugouts may be used exclusively, or in combination with a well, as a water source. If you need to rely solely on a dugout for your water, size the dugout for a two to three year supply. Over this period, the dugout will be filled from runoff or an irrigation canal. When you plan the dugout, be sure to:

- Locate the dugout upstream of any livestock areas
- Fence the dugout
- Install a pumping system with a floating intake
- Aerate.

If you have a well and dugout, use the well water for household use because it is typically of better quality. Dugouts can provide a good quality water source for livestock and irrigation purposes. Check dugout water quality and be aware of risks of algae, etc.

Other Planning Considerations

No matter the water source, do the following to protect your water supply:

- Test the water quality regularly
- Treat the water if necessary

- Monitor the supply and water level
- Maintain the well and water system
- Protect the water source from contamination.

Test water quality
All farm water sources should be tested when the supply is first connected and again about every five years. Test the water more often if you notice a significant change in the water quality, if a toxic spill occurs nearby, or if a change occurs in land use or activity. A thorough chemical and bacteriological analysis of water for household use can be done through your local health unit. Water samples for agricultural purposes can be taken to private labs for testing. These labs will supply sample bottles and correct procedures for sampling.

Be sure to keep all records of water quality tests for future reference and monitoring

Treat water
Water quality tests will point out any problems that need to be corrected. The water may have a poor taste, odor or color, or be high in total dissolved solids (TDS). Iron bacteria are a common well water problem in Alberta. Treatments for these and other problems may include chlorination, special filters, water softeners or distillation.

Monitor the supply
Monitoring your water sources is an important step to ensuring a lasting water supply. It can be compared to checking the oil in a vehicle or doing soil tests. You will have advance notice of changes to the water supply and a chance to make changes before the problem is serious.

Maintain the well and water system
Regular maintenance such as shock chlorination is necessary. Well design should allow for this required maintenance.

Protect from contamination
Both dugouts and wells are susceptible to contamination from various sources. Keys to prevent contamination include proper location, proper design, plugging abandoned wells, fencing, runoff controls and grass cover around dugouts.

Are There Standards For Locating Water Wells?
Deciding where to locate a water well is the joint responsibility of the drilling contractor and the well owner. The Regulation outlines specific location requirements to ensure that new wells are accessible for cleaning, repairing, monitoring, or inspecting.

The area immediately surrounding a well must be maintained in a sanitary condition, free from ponding of any surface water and at least 3.25 metres away from any building. A well cannot be located inside a pit. There are setback distances from sources of contamination as shown in the following table:

Column 1 **Sources of Substance**	**Column 2** **Minimum Distance Required**
Watertight septic tank of sewage holding tanks	10 metres
Sub-surface weeping tile effluent disposal field or an evaporation mound	15 metres
Sewage effluent discharge to the ground surface	50 metres
Sewage lagoon	100 metres

Above round storage tanks containing petroleum substance	50 metres

Water Are The Standards For Constructing Water Wells?
The Regulation outlines standards relating to water well:

- Construction
- Disinfection
- Yield testing
- Pumping equipment installation
- Reclamation (plugging)

Some of the requirements include well owner responsibility to actively maintain wells and to properly reclaim them when they are no longer used.

Are There Minimum Specifications For The Materials Used In Drilling And Constructing Water Wells?
The Regulation sets out minimum specifications for the materials used in drilling and construction of wells, including casing wall thickness and diameter. Materials used must meet or exceed CSA or ASTM standards and must be new and uncontaminated.

Where Are The Drilling Records Kept And Is This Information Available?
The data from contractors' records are maintained in a groundwater database administered by the Groundwater Information Centre at (780)427-2770. It is available to the public for a nominal fee.
Information on the availability and quality of groundwater is very useful to have prior to drilling a new well. It can provide the drilling contractor with guidance as to the depth he will need to drill, in order to find an adequate supply of water in which to complete a well. It may help identify whether or not there are any trends in the way wells are designed and constructed in a given area. It may also help determine what the water quality is like in aquifers at different depths.

Are The Act, Regulation, And Other Information On Water Wells Available To The Public?
Copies of the ***Water Act*** and the Water (Ministerial) Regulation are available for purchase through the Queen's Printer Bookstore, at (780)427-4952.

A helpful user's guide manual titled ***Water Wells That Last for Generations*** is available, free of charge, at:

- Any regional office of Alberta Environment
- Any district office of Alberta Agriculture Food and Rural Development, or through the internet site: ***agric.gov.ab.ca/water/wells/index.html***
- Any district office of Agriculture Canada (Prairie Farm Rehabilitation Administration)

Shock Chlorination - Well Maintenance

Well maintenance is essential to ensure that a well will last.

Shock chlorination is a relatively inexpensive and straightforward procedure used to control bacteria in water wells. Many types of bacteria can contaminate wells, but the most common are iron and sulfate-reducing bacteria. Although not a cause of health problems in humans, bacteria growth will coat the inside of the well casing, water piping and pumping equipment, creating problems such as:

- Reduced well yield
- Restricted water flow in distribution lines
- Staining of plumbing fixtures and laundry
- Plugging of water treatment equipment
- Rotten egg odor.

Bacteria may be introduced during drilling of a well or when pumps are removed for repair and laid on the ground. However, iron and sulfate-reducing bacteria (as well as other bacteria) can exist naturally in groundwater.
A well creates a direct path for oxygen to travel into the ground where it would not normally exist. When a well is pumped, the water flowing in will also bring in nutrients that enhance bacterial growth.

Wells can also be contaminated with harmful bacteria such as fecal coliforms. Shock chlorination is the most effective method to eliminate them.

Note: All iron staining problems are not necessarily caused by iron bacteria. The iron naturally present in the water can be the cause.

Ideal Conditions For Iron Bacteria

Water wells provide ideal conditions for iron bacteria. To thrive, iron bacteria require 0.5-4 mg/L of dissolved oxygen, as little as 0.01 mg/L dissolved iron and a temperature range of 5 to 15°C. Some iron bacteria use dissolved iron in the water as a food source.

Signs of iron and sulfate-reducing bacteria
There are a number of signs that indicate the presence of iron and sulfate-reducing bacteria. They include:

- Slime growth
- Rotten egg odor
- Increased staining.

Slime growth
The easiest way to check a well and water system for iron bacteria is to examine the inside surface of the toilet flush tank. If you see a greasy slime or growth, iron bacteria are probably present. Iron bacteria leave this slimy by-product on almost every surface the water is in contact with.

Rotten egg odor
Sulfate-reducing bacteria can cause a rotten egg odor in water. Iron bacteria aggravate the problem by creating an environment that encourages the growth of sulfate-reducing bacteria in the well. Sulfate-reducing bacteria prefer to live underneath the slime layer that the iron bacteria form. Some of these bacteria produce hydrogen sulfide as a by-product, resulting in a “rotten egg” or sulfur odor in the water. Others produce small amounts of sulfuric acid which can corrode the well casing and pumping equipment.

Increased staining problems
Iron bacteria can concentrate iron in water sources with low iron content. It can create a staining problem where one never existed before or make an iron staining problem worse as time goes by.

Use the following checklist to determine if you have an iron or sulfate-reducing bacteria problem. The first three are very specific problems related to these bacteria. The last two problems can be signs of other problems as well.

✔Checklist to Determine an Iron or Sulfate-Reducing Bacteria Problem
Greasy slime on inside surface of toilet flush tank
Increased red staining of plumbing fixtures and laundry
Sulfur odor
Reduced well yield
Restricted water flow

Shock Chlorination Method

Shock chlorination is used to control iron and sulfate-reducing bacteria and to eliminate fecal coliform bacteria in a water system. To be effective, shock chlorination must disinfect the following:

- The entire well depth
- The formation around the bottom of the well
- The pressure system
- Some water treatment equipment
- The distribution system.

To accomplish this, a large volume of super chlorinated water is siphoned down the well to displace all the water in the well and some of the water in the formation around the well.

Before you shock chlorinate, consult your water treatment equipment supplier to ensure the appropriate steps are taken to protect your treatment equipment.
Don't mix acids with chlorine. This is dangerous.

Effectiveness of shock chlorination
With shock chlorination, the entire system (from the water-bearing formation, through the well-bore and the distribution system) is exposed to water which has a concentration of chlorine strong enough to kill iron and sulfate reducing bacteria (see Figure 1, Water System). Bacteria collect in the pore spaces of the formation and on the casing or screened surface of the well. To be effective, you must use enough chlorine to disinfect the entire cased section of the well and adjacent water-bearing formation.

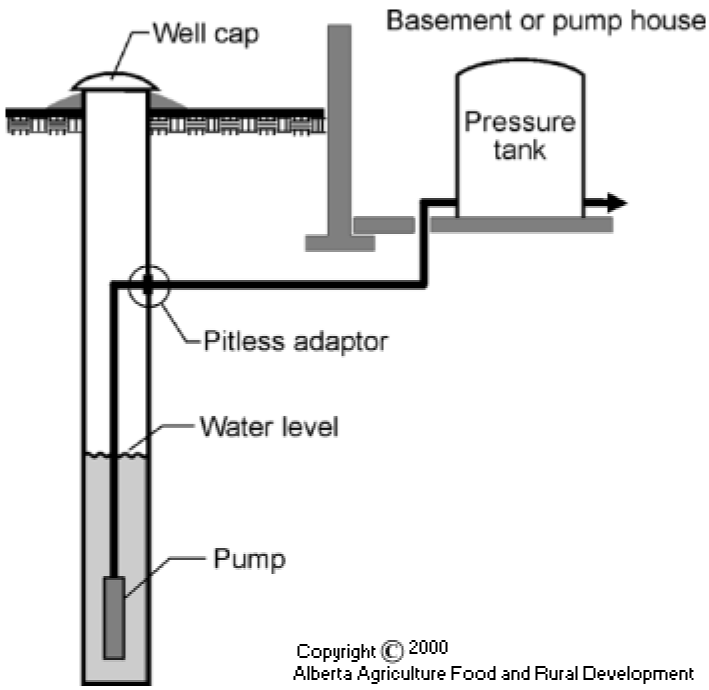


Figure 1 *Water System*

The procedure described does not completely eliminate iron bacteria from the water system, but it will hold it in check. To control the iron bacteria, you may have to repeat the procedure each spring and fall as a regular maintenance procedure. If your well has never been shock chlorinated or has not been done for some time, it may be necessary to use a stronger chlorine solution, applied two or three times, before you notice a significant improvement in the water.