WATER WELLS
...that last for generations

Government of Alberta
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# Table of Contents

## Introduction—How to Use This Workbook
- Contents
- Other Features of the Workbook

## Module 1—Understanding Groundwater
- What is Groundwater?
- Aquifers and Aquicludes
- Confined and Unconfined Aquifers
- Types of Aquifers in Alberta
- Groundwater Movement
- Groundwater Recharge
- Factors Affecting Groundwater Quality
  - Depth from Surface
  - Permeability of Sediments
  - Chemical Makeup of Sediments
  - Climatic Variations
- Geology and Groundwater Supplies in Alberta

## Module 2—Planning Your Water System
- Why Plan?
- Steps to Planning Your Water System
  - Determine Water Requirements
  - Complete an Inventory of Water Sources
- Water Source Options
  - Wells
  - Dugouts
Module 5—Monitoring Your Water Well

Water Level Measurements ................................................................. 37
  How to Measure Water Levels ........................................................... 38
  Interpreting Water Levels ................................................................. 40
Water Quality Measurements ................................................................. 44
  Bacterial Analysis ........................................................................... 44
  Chemical Analysis .......................................................................... 44
  Non-routine Testing ......................................................................... 45
  Sampling ......................................................................................... 45
  Interpreting Results ........................................................................ 45
Water Well Monitor Worksheet ............................................................... 46

Module 6—Shock Chlorination—Well Maintenance ........................................ 47

  Ideal Conditions for Iron Bacteria ..................................................... 47
  Signs of Iron and Sulfate-Reducing Bacteria ....................................... 47
    Slime Growth .............................................................................. 48
    Rotten Egg Odor ......................................................................... 48
    Increased Staining Problems ......................................................... 48
  Shock Chlorination Method ............................................................... 49
    Effectiveness of Shock Chlorination .............................................. 49
    Shock Chlorination Procedure for Drilled Wells ............................. 50
    Modified Procedure for Large Diameter Wells ............................... 53
  Calculating Water and Chlorine Requirements for Shock Chlorination Worksheet ........ 54

Module 7—Troubleshooting Water Well Problems ...................................... 55

  Causes of Well Problems ................................................................. 55
    Improper Well Design and Construction ......................................... 56
    Incomplete Well Development ....................................................... 56
    Borehole Stability Problems ......................................................... 56
    Mineral Incrustation .................................................................... 57
    Biofouling .................................................................................. 57
Potential Rural Contamination Sources .............................................................................. 65
Annulus or Casing Seal ........................................................................................................ 68
Multi-Aquifer Well Completion ......................................................................................... 68
Well Pit .............................................................................................................................. 69
Pitless Adaptor .................................................................................................................. 69
Farm Water Hydrant .......................................................................................................... 70
Poor Sewage Systems ....................................................................................................... 70
Well Contamination ......................................................................................................... 73
Contamination from an Abandoned Well ......................................................................... 73
Bridging ............................................................................................................................. 76
Cutting Off the Casing and Mounding the Clay ............................................................... 77
How to Use This Workbook

There are 12 modules in this workbook, many with worksheets for you to complete. There is a pocket on the back cover for storing your worksheets. The pocket on the front cover is for storing other well documents like your driller’s report. Extra copies of worksheets are included in the back cover pocket. Some topics will be of more interest to you than others, but we urge you to start with Module 1 “Understanding Groundwater” and then move on to topics that relate to your situation.

Three videos have been developed to be used in conjunction with the workbook. To obtain the Water Wells That Last videos, see page 93 in Module 12 “Other Resources.”

Contents

Module 1 Understanding Groundwater

Groundwater is very vulnerable to overuse and misuse. With the information in this module, you will better understand the complexities of groundwater and can use and protect the groundwater on your land so that future generations can depend on the resource. You’ll also look at factors that affect the quantity and quality of groundwater.

Module 2 Planning Your Water System

Use this module to assess whether your water source can meet your needs. You will learn how to plan a water system designed to meet your needs today and in the future. Worksheets allow you to calculate daily and annual water requirements and take a farm water supply inventory.

Module 3 Design and Construction of Water Wells

Although you need to hire a drilling contractor to design and construct your well and choose suitable materials, it is important that you know the process. You’ll look at choosing a suitable well site, design and completion.

Module 4 Water Well Drilling Agreements

This module gives an example of items that you and the drilling contractor should discuss and agree to before starting any water well drilling.
Module 5 Monitoring Your Well

An effective monitoring program will identify changes in water levels and water quality. This module outlines how to measure water levels and water quality on an ongoing basis. A water well monitoring worksheet is included.

Module 6 Shock Chlorination — Well Maintenance

This module outlines the importance of well maintenance. Shock chlorination is used to control bacteria in water wells. Uncontrolled, bacteria can cause reduced well yield, restricted water flow, staining, odors and plugging of water treatment equipment. This module outlines a procedure you can do yourself to shock chlorinate your well.

Module 7 Troubleshooting Water Well Problems

There are many causes of water well problems. This module outlines some of the more basic causes and provides a troubleshooting guide. The troubleshooting guide identifies four symptoms — reduced well yield, sediment in the water, change in water quality and spurting household taps — and explains what to check for and how to correct the problem.

Module 8 Protecting Your Well from Contamination

Once a well is contaminated, it is difficult to remove the contaminant from the well. This module aims at preventing contamination from poor construction techniques, old wells, well pits, farm water hydrants, poor sewage systems, seismic shot holes, over-application of manure, fuel tanks and pesticides.

Module 9 Plugging Abandoned Wells

Abandoned wells are a threat to groundwater quality and a safety hazard for children and animals. This module outlines nine steps to plugging a well. Some steps you can do yourself and others you may want to hire a drilling contractor to complete.

Module 10 Groundwater Management

This module outlines how the province is protecting groundwater from overuse or contamination. It also covers groundwater licensing and its objectives. Under this area, there are strategies that deal with inventory, allocation, protection and conservation.
Module 11 Contacts for More Information
This module provides a list of agencies and people who can help you with your rural water needs and problems.

Module 12 Other Resources
Use this module to access other publications and videos on water resources.

Glossary
Use the glossary to help understand various groundwater, well and well drilling terms.

Other Features of the Workbook
This illustrates an example. Study the example before you attempt the related exercise or do your own calculations.

Worksheet
This symbol tells you to complete a worksheet found at the end of the module. Working copies of the worksheets are found in the back cover pocket. Use the back pocket to store completed worksheets.

Video
This symbol tells you to refer to one of the videos in the Water Wells That Last video series.

Checklist
This symbol tells you to check off applicable items in order to identify a problem.
Understanding Groundwater

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.
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.

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.
Module 1 — Understanding Groundwater

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.

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 redissolve 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.

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.
Geology and Groundwater 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 yield of water, given the soil and rock formations found in the four geological areas. The mountains and foothills are grouped together in this chart.

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

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.

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").
Module 2 — Planning Your Water System

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.

For information on existing water well records and groundwater characteristics, contact the Alberta Environment Groundwater Information Centre at (780) 427-2770.

In some counties, you may also have access to groundwater maps and reports. Contact your local county MD office. See Module 11 "Contacts for More Information."
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.

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.

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.
Worksheet

Average Daily and Annual Water Requirements

The average daily and annual water requirement numbers can be used for estimating the amount of water used on a farm. The average daily water requirements are based on typical average outside or in-barn temperatures that occur throughout the year. These numbers, however, cannot be used for designing the water supplies and pumping capacity of a farm water system. For example, consider a beef feedlot on a hot summer day. Feeder cattle will drink approximately twice the amounts shown in the table below. For this reason, the water supply and pumping systems need to be designed to meet these peak demands.

### Household use:

| People | \( \text{_____} \times 60.0 \text{ gpd} = \text{__________ gpd} \) |

### Beef:

<table>
<thead>
<tr>
<th>Animal Size</th>
<th>No. of Animals</th>
<th>( x )</th>
<th>gpd</th>
<th>gpd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeder 550 lb.</td>
<td>( \text{_____} )</td>
<td>4.0</td>
<td>gpd =</td>
<td>gpd feeders on silage</td>
</tr>
<tr>
<td>Feeder 900 lb.</td>
<td>( \text{_____} )</td>
<td>7.0</td>
<td>gpd =</td>
<td>gpd feeders on silage</td>
</tr>
<tr>
<td>Feeder 1250 lb.</td>
<td>( \text{_____} )</td>
<td>10.0</td>
<td>gpd =</td>
<td>gpd feeders on silage</td>
</tr>
<tr>
<td>Cows with Calves 1300 lb.</td>
<td>( \text{_____} )</td>
<td>12.0</td>
<td>gpd =</td>
<td>gpd on pasture or hay</td>
</tr>
<tr>
<td>Dry Cow 1300 lb.</td>
<td>( \text{_____} )</td>
<td>10.0</td>
<td>gpd =</td>
<td>gpd on pasture or hay</td>
</tr>
<tr>
<td>Calf 250 lb.</td>
<td>( \text{_____} )</td>
<td>2.0</td>
<td>gpd =</td>
<td>gpd on pasture or hay</td>
</tr>
</tbody>
</table>

1 For peak demand on hot summer days above 25°C, multiply gpd x 2
2 For peak demand on hot summer days above 25°C, multiply gpd x 1.5

### Swine:

<table>
<thead>
<tr>
<th>Animal Size</th>
<th>No. of Animals</th>
<th>( x )</th>
<th>gpd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farrow-Finish</td>
<td>( \text{_____} )</td>
<td>20.0</td>
<td>gpd =</td>
</tr>
<tr>
<td>Farrow-Late Wean</td>
<td>( \text{_____} )</td>
<td>6.5</td>
<td>gpd =</td>
</tr>
<tr>
<td>Farrow-Early Wean</td>
<td>( \text{_____} )</td>
<td>5.5</td>
<td>gpd =</td>
</tr>
<tr>
<td>Feeder 50-250 lb.</td>
<td>( \text{_____} )</td>
<td>1.5</td>
<td>gpd =</td>
</tr>
<tr>
<td>Weaner 15-50 lb.</td>
<td>( \text{_____} )</td>
<td>0.5</td>
<td>gpd =</td>
</tr>
</tbody>
</table>

3 Includes wash water for all types of swine operations.
4 No. of animals = No. of breeding sows.

* Working copies of this worksheet are found in the pocket on the back cover.
## Module 2 — Planning Your Water System

### Dairy:

<table>
<thead>
<tr>
<th>Animal Type/Size</th>
<th>No. of Animals</th>
<th>Daily Water Requirement (gpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milking Cow</td>
<td>Holstein</td>
<td>______ x 30.0 gpd = ________ gpd</td>
</tr>
<tr>
<td>Dry Cows/Replacement Heifers</td>
<td>Holstein</td>
<td>______ x 10.0 gpd = ________ gpd</td>
</tr>
<tr>
<td>Calves</td>
<td></td>
<td>to 550 lb. ______ x 3.0 gpd = ________ gpd</td>
</tr>
</tbody>
</table>

4 Includes 3 gpd/cow for wash water

### Poultry:

<table>
<thead>
<tr>
<th>No. of Birds</th>
<th>Daily Water Requirement (gpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broilers</td>
<td>______ x .035 gpd = ________ gpd</td>
</tr>
<tr>
<td>Roasters/Pullets</td>
<td>______ x .040 gpd = ________ gpd</td>
</tr>
<tr>
<td>Layers</td>
<td>______ x .055 gpd = ________ gpd</td>
</tr>
<tr>
<td>Breeders</td>
<td>______ x .070 gpd = ________ gpd</td>
</tr>
<tr>
<td>Turkey Growers</td>
<td>______ x .130 gpd = ________ gpd</td>
</tr>
<tr>
<td>Turkey Heavies</td>
<td>______ x .160 gpd = ________ gpd</td>
</tr>
<tr>
<td>Broilers</td>
<td>______ x .035 gpd = ________ gpd</td>
</tr>
<tr>
<td>Roasters/Pullets</td>
<td>______ x .040 gpd = ________ gpd</td>
</tr>
<tr>
<td>Layers</td>
<td>______ x .055 gpd = ________ gpd</td>
</tr>
<tr>
<td>Breeders</td>
<td>______ x .070 gpd = ________ gpd</td>
</tr>
<tr>
<td>Turkey Growers</td>
<td>______ x .130 gpd = ________ gpd</td>
</tr>
<tr>
<td>Turkey Heavies</td>
<td>______ x .160 gpd = ________ gpd</td>
</tr>
</tbody>
</table>

### Sheep/Goats:

<table>
<thead>
<tr>
<th>Animals</th>
<th>Daily Water Requirement (gpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ewes/Does</td>
<td>______ x 2.0 gpd = ________ gpd</td>
</tr>
<tr>
<td>Milking Ewes/Does</td>
<td>______ x 3.0 gpd = ________ gpd</td>
</tr>
<tr>
<td>Horses, Bisons, Mules</td>
<td>______ x 10.0 gpd = ________ gpd</td>
</tr>
<tr>
<td>Elk, Donkeys</td>
<td>______ x 5.0 gpd = ________ gpd</td>
</tr>
<tr>
<td>Deer, Llamas, Alpacas</td>
<td>______ x 2.0 gpd = ________ gpd</td>
</tr>
<tr>
<td>Ostriches</td>
<td>______ x 1.0 gpd = ________ gpd</td>
</tr>
</tbody>
</table>

### Total Daily Livestock Water Requirements

Sub Total: ________ gpd

### Annual Water Requirements

Irrigation of garden and yard in the summer (assume 6 in. application)

- Area in square feet ______ x 3 gal./sq. ft. = ________ gal.
- Chemical spraying (acres) ______ x ___ gal/acre x ____ no. of applications = ________ gal.
- Greenhouse = ________ gal.
- Fire (min. 1200 gal./2 hour period) = ________ gal.
- Other uses = ________ gal.
- Total daily livestock water requirements (from above) _______ gpd x 365 days = ________ gal.

Total Annual Water Requirements: ________ gal.

* For information on water requirements for field crops, contact an irrigation specialist.

Note: These livestock and poultry water requirement numbers have been compiled with input from Alberta Agriculture and Rural Development staff. If you have questions or comments, please call an Agricultural Water Specialist at 310-FARM (3267). Also visit our website: [www.agric.gov.ab.ca](http://www.agric.gov.ab.ca) and use the calculator for determining the size of a dugout.

* Working copies of this worksheet are found in the pocket on the back cover.
**Worksheet**

## Sizing of Water Systems

<table>
<thead>
<tr>
<th>Water System Fixtures</th>
<th>Peak Use Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic cattle waterers (100 head size)</td>
<td>____ X 2 gpm = _____ gpm</td>
</tr>
<tr>
<td>Hog nipple waterer</td>
<td>____ X 1 gpm = _____ gpm</td>
</tr>
<tr>
<td>Poultry fountain</td>
<td>____ X 1 gpm = _____ gpm</td>
</tr>
<tr>
<td>Yard hydrants</td>
<td>____ X 5 gpm = _____ gpm</td>
</tr>
<tr>
<td>Household (number of households)</td>
<td>____ X 5-10 gpm = _____ gpm</td>
</tr>
<tr>
<td>Fire hydrant</td>
<td>____ X 10 gpm = _____ gpm</td>
</tr>
<tr>
<td>Other</td>
<td>____ X ____ gpm = _____ gpm</td>
</tr>
</tbody>
</table>

Note: The minimum design flow rate of the system must exceed the peak use rate of the fixture that uses the largest amount of water.

Note: If the well is not solely capable of providing enough water for your peak use demand, you will need to install a water storage facility such as a cistern. The well can be operated without overpumping, and the water storage provided by the cistern will ensure water for all your activities.

* Working copies of this worksheet are found in the pocket on the back cover.
# Worksheet

## Farm Water Supply Inventory

### A. Wells

<table>
<thead>
<tr>
<th></th>
<th>Well Purpose / Location</th>
<th>Date Constructed</th>
<th>Depth (ft.)</th>
<th>Casing Diameter (in.)</th>
<th>Well Production (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2. Unused Wells / Location

<table>
<thead>
<tr>
<th></th>
<th>Date Constructed</th>
<th>Depth (ft.)</th>
<th>Date Plugged</th>
<th>Materials Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3. Dry Holes

- How many dry holes have been drilled on and around the farmstead? ________________________
- How deep were these dry holes? ________________________

### 4. Water Quality

- What water quality problems limit the usefulness of these wells?
  - a. _____________________________________________________________________________________________________________________________
  - b. _____________________________________________________________________________________________________________________________
  - c. _____________________________________________________________________________________________________________________________

### B. Dugouts

<table>
<thead>
<tr>
<th></th>
<th>Dugout Purpose / Location</th>
<th>Date Constructed</th>
<th>Size (Length, Width, Depth)</th>
<th>Approximate Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2. Problems with these dugouts (e.g., seepage, quality, inadequate run off)

- a. _____________________________________________________________________________________________________________________________
- b. _____________________________________________________________________________________________________________________________
- c. _____________________________________________________________________________________________________________________________

### C. Other Water Sources and Their Limitations (Hauling, Springs, Rivers, etc.)

_________________________________________________________________________________________________________________________________
_________________________________________________________________________________________________________________________________

* Working copies of this worksheet are found in the pocket on the back cover.
Design and Construction of Water Wells

The initial investment for a properly designed and constructed well pays off by ensuring:

- A reliable and sustainable water supply consistent with your needs and the capability of the aquifer
- Good quality water that is free of sediment and contaminants
- Increased life expectancy of the well
- Reduced operating and maintenance costs
- Ease of monitoring well performance.

Although you need to hire a drilling contractor to design, drill and construct the well and choose the appropriate materials, it is important for you to know what is going on. You can then work with the drilling contractor to ensure you get the well design you need.

Choosing a Drilling Contractor

Choose a drilling contractor who has experience in your area. Provincial regulation requires that they have an approval to drill water wells. A list of approval holders is available through Alberta Environment.

Either you or the drilling contractor should complete a survey of existing wells in your area. It will provide important information about:

- Typical yields and water quality
- Which aquifer to tap into
- Trends in well construction methods
- Prior drilling success rates.

Surveys of existing wells are available for a nominal fee from the Groundwater Information Centre.

In some areas of Alberta, regional groundwater assessment studies are also available and may identify aquifer potential and groundwater quality. Also check with neighbors about their experiences with well performance, well maintenance and water quality changes.
Choosing a Well Site

Your choice of well site will affect the safety and performance of your well. As you examine various sites, remember to consider any future development plans for your farm or acreage such as barns, storage sheds and bulk fuel tanks. You must also consider provincial regulations that dictate well location.

Most contaminants enter the well either through the top or around the outside of the casing. Sewage or other contaminants may percolate down through the upper layers of the ground surface to the aquifer. The following criteria are intended to prevent possible contamination of your well and the aquifer. It is both your and the driller’s responsibility to ensure that:

- The well is accessible for cleaning, testing, monitoring, maintenance and repair
- The ground surrounding the well is sloped away from the well to prevent any surface run off from collecting or ponding
- The well is up-slope and as far as possible from potential contamination sources such as septic systems, barnyards or surface water bodies
- The well is not housed in any building other than a bona fide pumphouse. The pumphouse must be properly vented to the outside to prevent any buildup of dangerous naturally occurring gases
- The well is not located in a well pit.
### Minimum Distance Requirements

Provincial regulations outline minimum distance requirements as follows. Equivalent imperial distances in feet are rounded up to nearest foot. The well must be:

- 10 m (33 ft.) from a watertight septic tank
- 15 m (50 ft.) from a sub-surface weeping tile effluent disposal field or evaporation mound
- 50 m (165 ft.) from sewage effluent discharge to the ground
- 100 m (329 ft.) from a sewage lagoon
- 50 m (165 ft.) from above-ground fuel storage tanks
- 3.25 m (11 ft.) from existing buildings
- 2 m (7 ft.) from overhead power lines if:
  - the line conductors are insulated or weatherproofed and the line is operated at 750 volts or less
- 6 m (20 ft.) from overhead power lines if the well:
  - does not have a pipe and sucker rod pumping system
  - has a PVC or non-conducting pipe pumping system
  - has well casing sections no greater than 7 m (23 ft.) in length
- 12 m (40 ft.) from overhead power lines for all other well constructions
- 500 m (1,641 ft.) from a sanitary landfill, modified sanitary landfill or dry waste site.

### Well Design Considerations

Well design and construction details are determined after a test hole has been completed and the geological zones have been logged. There are many components to well design the driller must take into account. Decisions will be made about:

- Well depth
- Type of well
- Casing material, size and wall thickness
- Intake design
- Formation seal
- Monitoring and preventive maintenance provisions.
Module 3 — Design and Construction of Water Wells

Well Depth

During the test hole drilling, the drilling contractor will complete a formation log. Soil and rock samples are taken at various depths and the type of geologic material is recorded. This allows the driller to identify aquifers with the best potential for water supply. Some drillers also run an electric or gamma-ray log in the test hole to further define the geology. This gives them more accurate information about aquifer location.

Generally a well is completed to the bottom of the aquifer. This allows more of the aquifer to be utilized and ensures the highest possible production from the well.

Types of Wells

There are two main types of wells, each distinguished by the diameter of the bore hole. The two types are bored wells and drilled wells.

Bored wells

A bored well is constructed when low yielding groundwater sources are found relatively close to the surface, usually under 30 m (100 ft.). Bored wells are constructed using a rotary bucket auger. They are usually completed by perforating the casing or using a sand screen with continuous slot openings (see Figure 1, Bored Well).

One advantage of bored wells is the large diameter of the casing, from 45-90 cm (18-36 in.). It provides a water storage reservoir for use during peak demand periods. A disadvantage of utilizing a shallow groundwater aquifer is that it relies on annual precipitation for recharge. Water shortages may occur following long dry periods in summer and extended freeze up during winter months.

Drilled wells

Drilled wells are smaller in diameter, usually ranging from 10-20 cm (4-8 in.), and completed to much greater depths than bored wells, up to several hundred metres. The producing aquifer is generally less susceptible to pollution from surface sources because of the depth. Also, the water supply tends to be more reliable since it is less affected by seasonal weather patterns.

There are two primary methods of drilling:
- Rotary
- Cable tool.

Rotary drilled wells are constructed using a drill bit on the end of a rotating drillstem. Drilling fluid or air is circulated down through the drillstem in the hole and back to the surface to remove cuttings. Rotary drilling rigs operate quickly and can reach depths of over 300 m (1000 ft.), with casing diameters of 10-45 cm (4-18 in.).
Cable tool drilled wells are constructed by lifting and dropping a heavy drill bit in the bore hole. The resulting loose material, mixed with water, is removed using a bailer or sand pump. This method, also called percussion drilling, reaches depths up to 300 m (1000 ft.). Well diameters can range from 10-45 cm (4-18 in.). The drilling rate is typically much slower than for a rotary rig, but when aquifers are low yielding, they may be more easily identified using this method.

There are three types of possible well completions for both drilling methods (see Figure 2, Well Completions):

- Surface casing with slotted or perforated liner
- Sand screen with continuous slot openings
- Single string slotted or perforated casing.

Materials used in the drilling and construction of water wells must be new and uncontaminated.
Casing Size and Type

Decisions about the diameter and type of well casing are made after the driller considers the following:

- Aquifer characteristics
- Hydraulic factors that influence well performance
- Drilling method
- Well depth
- Cost (in discussion with the well owner).

The casing must be large enough to house the pump and allow sufficient clearance for installation and efficient operation.

If a submersible pump is going to be used, the casing must have an inside diameter of at least 10.16 cm (4 in.), by law. It is recommended that the casing be at least one nominal size larger than the outside diameter of the pump. The more space there is between the pump and the casing, the easier it will be to service and repair the pump in the future.

There are two common materials used for casing: steel and plastic. Steel casing is the strongest but is susceptible to corrosion. Plastic casing is becoming more popular because of its resistance to corrosion.

All casing must be new and uncontaminated. Plastic casing must be made of virgin resin, not recycled material.

Intake Design

Water moves from the aquifer into the well through either a manufactured screen or mechanically slotted or perforated casing.

Screens are manufactured with regularly shaped and sized openings. They are engineered to allow the maximum amount of water in with minimal entry of formation sediments. Stainless steel screens are the most widely used because they are strong and relatively able to withstand corrosive water. Screens are manufactured with various slot sizes and shapes to match the characteristics of the aquifer.

Slotted or perforated casing or liner is made by creating openings using a cutting tool or drill. Pre-slotted plastic pipe is also available.

Slot openings and perforations are spaced further apart than screen openings. This reduces the amount of open area to allow water into the well. The openings tend to vary in size and may have rough edges depending on how they were made. This impedes the flow of water into the well and may not hold back the formation sediments.
The drilling contractor examines the cuttings from the borehole and makes a judgement whether to use a screen, or slotted or perforated casing/liner. While a screen is the more expensive alternative, it is necessary if the aquifer is composed of loose material such as fine sand, gravel or soft sandstone. A slotted or perforated casing/liner can be used when the aquifer formation is more consolidated, such as hard sandstone or fractured shale.

After a choice is made between a screen, or slotted or perforated casing/liner other decisions will be made regarding:

- Size of slot opening
- Total area of screen or perforation that is exposed to the aquifer
- Placement of the screen or perforations within the aquifer

**Slot size openings**

The slot openings must be small enough to permit easy entry of water into the well while keeping out sediment. The slot size chosen will depend on the particle size of the earth materials in the producing aquifer.

Typically a drilling contractor will select a slot size that allows 60 percent of the aquifer material to pass through during the well development phase of drilling. The remaining 40 percent, comprising the coarsest materials, will form a natural filter pack around the perforations or screen.

**Total open area of screen**

The total area of the slot openings is dependent on the length and diameter of the screen. While the length of the screen is variable, the diameter of the screen is determined by the diameter of the well casing. The yield from a well increases with an increase in screen diameter but not proportionately so. Doubling the screen diameter raises the well capacity only 20 percent.

The amount of open area of the screen or slotted or perforated casing/liner must be calculated to ensure the water from the aquifer does not enter the well too quickly. A larger amount of open area allows the water to enter the well at a slower rate, causing a lower drop in pressure in the water as it moves into the well. If the water flows too quickly, there will be problems with incrustation. As a result, the perforations get plugged and water cannot enter the well at the same rate, and the yield from the well will be reduced. The pore spaces in the aquifer immediately adjacent to the perforations may also get plugged with fine material which could result in yield reduction.

**Incrustation** is a buildup that occurs when dissolved minerals in the groundwater come out of solution and deposit on the screen or casing.

Ensure that the pumping water level in the well never goes below the top of the slot openings or perforations. This will prevent oxygen exposure to the aquifer which would enhance bacterial growth and reduce well yield.
Placement in the aquifer

The screen or perforations on the casing/liner must be placed adjacent to the aquifer. If improperly placed, the well may produce fine sediment which will plug plumbing fixtures and cause excessive wear on the pump. If the driller uses geophysical logging equipment to accurately identify the boundaries of the aquifer, the exact placement will be easier.

Annulus Seal

Sealing the well protects the well’s producing zone from contamination. The diameter of the bore hole is usually slightly larger than the casing being installed. The space between the bore hole and the casing is called the annulus of the well. It must be sealed to prevent any surface contamination from migrating downward and contaminating the water supply. It also prevents any mixing of poor quality aquifers with the producing aquifer of the well (see Figure 3, Annulus Seal).

Provincial regulations require the annulus be filled with impervious material such as cement or bentonite. To isolate the producing zone of the well, the annulus is filled from immediately above the perforated zone to the ground surface.

Well Completion

Once the well has been drilled and the equipment is in place, there are several procedures the drilling contractor must complete before the well is ready to use. The drilling contractor is responsible for:

- Well development
- Disinfecting the well
- Conducting a yield test.

Well Development

Well development is the process of removing fine sediment and drilling fluid from the area immediately surrounding the perforations. This increases the well’s ability to produce water and maximize production from the aquifer.

Jetting, surging, backwashing and overpumping are methods used to develop a well. Water or air is surged back and forth through the perforations. Any fine materials that are in the formation become dislodged and are pumped or bailed from the well. This procedure is continued until no fine particles remain and the water is clear. Coarser particles are left behind to form a natural filter pack around the screen, slot openings or perforations.
If the aquifer formation does not naturally have any relatively coarse particles to form a filter, it may be necessary to install an artificial filter pack. The pack is placed around the screen or perforations so the well can be developed. For example, this procedure is necessary when the aquifer is composed of fine sand and the individual grains are uniform in size.

It is important to match the grain size of the filter material with the size of the slot openings of the screen to attain maximum yield from the well. Typically the slot size of the screen is selected so that 85 percent of the artificial pack material remains outside of the screen.

**Yield Test**

A yield test, often called a pump test, is important because the information gathered during the test assists the drilling contractor to determine the:

- Rate at which to pump the well
- Depth at which to place the pump.

Provincial regulations outline the minimum yield test for all new wells. After drilling and developing a well, the drilling contractor must remove water from the well for at least 2 hours. If a pump is used to remove the water, then water level measurements can be recorded as the water level draws down. After 2 hours, water removal stops and the recovery of the water level is monitored and recorded. Measurements must be taken at specific time intervals for a 2 hour period or until the water level returns to 90 percent of its original level.

Once the yield test is complete, the drilling contractor will decide at what rate the aquifer can be pumped without lowering the water level below the top boundary of the aquifer, the top of the perforations or below the pump intake.

The pump that is installed in the well should have a capacity equal to, or less than, the rate at which the well can supply water for an extended period of time without lowering the level below the pump intake. That rate is considered the safe pumping rate for the well.

**Disinfecting the Well**

Provincial regulations require the drilling contractor to disinfect new wells with chlorine. The concentration is calculated on the volume of water that is in the well. The concentration must be at least 200 milligrams of chlorine per litre of water present throughout the water in the well and must be left in the well for at least 12 hours to ensure any bacteria present are destroyed. Chlorination is done after the pumping equipment is installed and before the well is put into production.
Water Well Drilling Agreements

This module outlines a checklist of items that you and your drilling contractor should discuss and agree to before starting any drilling. A clear understanding between both parties is crucial so there are no misunderstandings or false expectations. Disagreements can arise between drilling contractors and well owners after the well is drilled because they simply did not take the time to thoroughly discuss all aspects of the drilling operation ahead of time.

Water wells are far more than a deep wet hole in the ground. They are an important and significant investment for any household or farm. Well owners should take the time to ensure they understand what they are purchasing. Money spent on high quality well design and construction materials is money well invested. A low cost well may not deliver the quality, quantity or reliability you need.

A Water Well Drilling Agreement covers the topics you should discuss with your drilling contractor before any work begins. A blank copy of an example agreement is included at the back of this module and in the pocket on the back cover. Many drilling contractors have their own version of a Water Well Drilling Agreement.

Water Well Drilling Agreement Example

This agreement is designed to prevent misunderstandings between the well owner and drilling contractor. It benefits both parties and can establish costs for materials and services.

Identification

*Items 1-4 identify the parties involved in the agreement.*

1. Well owner  
   **John Q. Doe**
   
   Address  
   **Anywhere, Alberta**

2. Drilling contractor  
   **Peters Water Well Services**
   
   Address  
   **Anywhere, Alberta**

   Drilling contractor approval no. __________________________

3. Land location of well
   
   Qtr  **NE**  
   Sec  **36**  
   Twp  **17**  
   Rge  **7**  
   W of  **4**  
   Meridian
   
   Lot  ______________________  
   Block  ______________________  
   Plan  ______________________

4. Proposed starting date  
   **June 21, 1997**

   Proposed completion date  
   **June 25, 1997**
Module 4 — Water Well Drilling Agreements

Water Requirements

5. Proposed well use: Household ______ Livestock _______ Irrigation ________

The well use should be specified as being for household, livestock, irrigation or a combination. Municipal and industrial wells are usually covered by a detailed contract.

6. Desired water quality

Finding water with suitable water quality is important for all water uses. A drilling contractor can use a field testing kit to get a rough estimate of some parameters such as iron, hardness, pH and total dissolved solids, but only the tests done in a laboratory are really reliable.

The laboratories use the Guidelines for Canadian Drinking Water Quality to assess water quality. If testing shows some of the parameters are higher than these guidelines, water treatment equipment may be necessary.

7. Desired yield ______L/s (gpm) Min. acceptable yield ______L/s (gpm)

The desired yield is the flow rate of water, in gallons per minute (gpm), from an individual well. To calculate the desired yield, refer to the worksheet "Average Daily and Annual Water Requirements" in Module 2, "Planning Your Water System". Using this worksheet, calculate your daily and peak water use requirements. In some areas the desired yield is simply not available because of slow yielding aquifers. In such cases, the desired yield should be expressed as the normal yield for the area. A certain minimum yield should be established so if the well produces less than this minimum, it is not considered economically feasible to develop as a water well.

8. Groundwater supply options based on existing records

Groundwater supply options should identify potential groundwater exploration targets that have the potential to meet the owner's water requirements.

Well Construction

9. Maximum desired depth ______m (ft.)

A maximum desired depth should be established. Factors affecting this include the known depth of productive aquifers, and the water quality at the various depths. Also personal finances will be a factor.
10. Type of drilling ____________________________  

   **Rotary**

11. Diameter of hole ______________________________

   158 mm (6 1/4") and 124 mm (4 7/8"")

   The type of drilling equipment, aquifer composition, yield required and depth determine the type of well produced. Rotary drilled and cable tool drilled wells are typically 100-200 mm (4-8 in.) in diameter; bored wells range in diameter from 45-90 cm (12-36 in.). The water well drilling industry is required by law to construct wells with casings 102 mm (4 in.) or more to accommodate submersible pumps.

12. Flowing well control ____________________________

   N / A

   In cases where a flowing well is anticipated, provision must be made to equip the well with a control device that allows the flow to be shut off completely and to prevent freezing.

13. Well connection ______________________________

   **Pitless Adaptor**

   Where the connection of the pumping equipment to the well casing is made below the ground surface, a pitless adaptor is required under the Water (Ministerial) Regulation. Well pits are no longer permitted. If a jet pump is being used, a pump house that houses only the well and the pumping equipment is allowed.

14. Formation logging procedure ____________________________

   Logging the geological formations during drilling provides key information about aquifer location and quality. The information is especially important to accurately place well screens. There can be several types of formation logging.

   - **Descriptive logging** records the material encountered as drilling proceeds (lithology).
   - **Electric logging**, or E logging, verifies and supplements descriptive logging. It can only be performed in an uncased hole that is filled with drilling fluid. Basically it reveals the character of the material and relative quality of water in the formation. A limited number of drilling contractors in Alberta possess this equipment.
   - **Gamma-ray logging** can be performed in cased holes without drilling fluid and reveals the character of the material present. Very few drilling contractors in Alberta have this equipment. A combination of descriptive logging and electric or gamma-ray logging provides very accurate information about the formations through which the well is constructed.
15. Annulus or casing seal ____________

All wells must be constructed to prevent contaminated surface water from entering groundwater aquifers through the space (annulus) between the well casing and the bore hole. The annulus must be filled from immediately above the producing zone up to ground surface. The method of sealing is dependent on the type of rig the driller operates and design of the well.

16. Artificial sand pack ____________

The grain size distribution of the aquifer affects the efficiency of the screen during development. If the aquifer has a relatively uniform grain size, a well cannot be effectively developed without the installation of an artificial sand pack. This “pack” provides a natural filter which holds back the finer aquifer materials.

17. Well Development Method

Backwashing ________ Jetting ________ Surging ____________

Heavy pumping ________ Bailing ________

By regulation, the drilling contractor is responsible for ensuring a well is completed in a manner that ensures no damage will be incurred to the pumping system, plumbing or fixtures due to sediment in the water. If a newly constructed well produces sediment, it is usually because the drilling contractor did not properly develop it. Different types of well completion require different development techniques. In the rare case where a well cannot be adequately developed to produce sediment-free water, a sediment filter could be installed in the water distribution system. However, this alternative should be used only when it is evident that sufficient development of the well has been done, and the landowner is in agreement.

18. Hydrofracing ____________

Hydrofracing is a development technique used to increase well yield in bedrock aquifers. It involves pressurizing the aquifer to increase the size of the fractures and thereby increase well production. This technique is used in poorly fractured bedrock aquifers.

Material

19. Casing material ____________

Plastic Schedule 80* PVC * Steel Protector casing at Surface

Inside diameter ____________ wt. per m (ft.) ________ wall thickness ____________

See Appendix 1.
20. Well cover manufactured well cap. Distance from top of casing to ground surface \(300\) mm (12")

Minimum requirement is 20 cm (8") above ground surface or 60 cm (2") above the highest flood record unless a watertight cover is used. A vented well seal (cap) or tight-fitting or vermin-proof well cover should be specified.

The well cap should be removable for monitoring water level in the well. Alternatively, for wells with difficult to remove caps, a cap with a hole leading to a dip tube can be used for easier monitoring of the water level. A removable plug should be used to plug the hole.

21. Liner material Plastic Schedule 40 PVC

Inside diameter \(102\) mm (4") wt. per m(ft.) \(0.237\) wall thickness

See Appendix 1. Plastic PVC or ABS casing lasts indefinitely because it does not rust through like metal casing. It should be protected at the ground surface with metal casing.

22. Screen

Manufacturer ABC Screen Co.

Length

Material

Nominal diameter

Wells completed in unconsolidated aquifers, such as sand or gravel, should be screened. The length of screen required depends on the volume of water to be pumped and the ability of the aquifer to transmit water.

**Yield Testing**

23. Yield testing duration (hours) Minimum: 2 hour water removal and 2 hour recovery

The drilling contractor should conduct a yield test following completion of the well.

The purpose of the yield test is to measure the well's yield so that the most suitable pumping equipment can be selected. This also serves as a benchmark for monitoring future well performance. The test should include the following information:

a) non-pumping (static) water level
b) water removal rate in gpm (L/s)
c) depth to the pumping water level as determined over a period of time at one or more constant pumping rates (drawdown)
d) the length of time the well is pumped at each rate
e) the recovery of the water level over a 2 hour period or until 90 percent recovery of the non-pumping water level is reached.

It is important to get a good original pump test on the well. This provides a base condition to which the condition of the well can be compared as it "ages."

See Water Well Drilling Report at the back of module as an example of what you will get from the drilling contractor.
Disinfection

24. Disinfection  Well and pumping equipment to be disinfected

The well and new pumping equipment should be disinfected for a minimum of 12 hours with at least 200 mg/L of chlorine prior to use. Use Table 1, Amount of Chlorine to Obtain a Chlorine Concentration of 1000 PPM, and the example in Step 3 on page 51 to calculate the amount of chlorine for 1000 ppm. Then divide the total litres of chlorine by 5 to get the amount required for 200 mg/L.

25. Well head finishing  Driller to remove all surplus materials and equipment on site.

Well head finishing includes the clean up of mud and aquifer debris and removal of material scraps.

Costs

26. Test holes per metre (foot) 

27. Reaming per metre (foot) 

28. Drilling/boring per metre (foot) 

29. Casing per metre (foot) 

30. Liner per metre (foot) 

31. Screen 

32. Sand pack 

33. Development 

34. Hydrofracing 

35. Labor per hour 

36. Water testing 

37. Reclamation of unused well 

38. Payment schedule 

Guarantee

39. Workmanship and materials should be guaranteed for a specific period of time.
# Appendix 1. Water Well Casing Specifications

## Materials
All well casing material must meet or exceed the specifications set for that material and purpose by the Canadian Standards Association or the American Society for Testing and Materials.

### Non-Plastic Well Casing—Required Thickness

<table>
<thead>
<tr>
<th>Type of Well Casing</th>
<th>Minimum Casing Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal well casing</td>
<td>0.188 in. (4.78 mm)</td>
</tr>
<tr>
<td>Metal liner casing</td>
<td>0.156 in. (3.96 mm)</td>
</tr>
<tr>
<td>Cement-like casing</td>
<td>*2.5 in. (6.35 cm)</td>
</tr>
<tr>
<td>* for 24 in. (60.96 cm) casing or less</td>
<td>*2.5 in. plus 1 in. for every additional foot of well diameter</td>
</tr>
<tr>
<td>Corrugated and galvanized steel casing</td>
<td>16 gauge</td>
</tr>
</tbody>
</table>

### Plastic Well Casing—Required Thickness for ABS or PVC

<table>
<thead>
<tr>
<th>Outside Pipe Diameter in. (mm)</th>
<th>Casing Schedule (SCH) Number</th>
<th>Minimum Wall Thickness in. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 (114.3) SDR 21</td>
<td></td>
<td>0.214 (5.43)</td>
</tr>
<tr>
<td>4.95 (125.7) SCH 40</td>
<td></td>
<td>0.260 (6.60)</td>
</tr>
<tr>
<td>5 Nominal (127.0) (141.2) SCH 80</td>
<td></td>
<td>0.397 (10.1)</td>
</tr>
<tr>
<td>6 (152.4) Well Casing SCH 40</td>
<td></td>
<td>0.390 (9.9)</td>
</tr>
<tr>
<td>6.625 (168.3) SCH 40</td>
<td></td>
<td>0.432 (11.0)</td>
</tr>
<tr>
<td>6.625 (168.3) SCH 80</td>
<td></td>
<td>0.280 (7.1)</td>
</tr>
<tr>
<td>8.625 (219.7) SCH 40</td>
<td></td>
<td>0.322 (8.2)</td>
</tr>
<tr>
<td>8.625 (219.7) SCH 80</td>
<td></td>
<td>0.5 (12.7)</td>
</tr>
<tr>
<td>10.75 (273.1) SCH 40</td>
<td></td>
<td>0.365 (9.2)</td>
</tr>
<tr>
<td>10.75 (273.1) SCH 80</td>
<td></td>
<td>0.593 (15.1)</td>
</tr>
</tbody>
</table>
# Water Well Drilling Report

**Module 4 — Water Well Drilling Agreements**

**Alberta Environment**

The data contained in this report is supplied by the Driller. The province disclaims responsibility for its accuracy.

## Contractor & Well Owner Information

<table>
<thead>
<tr>
<th>Company Name:</th>
<th>Licence No.:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mailing Address:</th>
<th>City or Town:</th>
<th>Postal Code:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Well Owner’s Name:</th>
<th>Well Owner has a copy of this report:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mailing Address:</th>
<th>City or Town:</th>
<th>Postal Code:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Drilling Information

<table>
<thead>
<tr>
<th>Type of Work:</th>
<th>Testhole</th>
<th>New Well</th>
<th>Reconditioned</th>
<th>Deepened</th>
<th>Packed / Drilled well</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials Used:</th>
<th>Bentonite Product</th>
<th>Other:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method of Drilling:</th>
<th>Auger</th>
<th>Boring</th>
<th>Cable tool</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Formation Log

<table>
<thead>
<tr>
<th>Depth from ground level</th>
<th>Lithology Description</th>
<th>[ ] metres</th>
<th>[ ] ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>top soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-23</td>
<td>brown clay, rocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23-77</td>
<td>gray clay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77-83</td>
<td>gray sandstone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>83-97</td>
<td>sandstone (water at 58 wt%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDS @ 1500 ppm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Well Completion

<table>
<thead>
<tr>
<th>Date Started</th>
<th>Date Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1/1997</td>
<td>1/1/1997</td>
</tr>
</tbody>
</table>

## Well Location

<table>
<thead>
<tr>
<th>Location:</th>
<th>Latitude: 49° 30' 40&quot;</th>
<th>Longitude: -114° 30' 20&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevations:</td>
<td>m (ft)</td>
<td>Elevations:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Well Yield

- **Test Date:** 7/15/1997
- **Test Time:** 9:00 AM
- **Pump:** Air
- **Borehole diameter:** 6" (15.2 cm)
- **Depth of water level:** 22.9 m (75 ft)
- **Distance from top of casing to ground level:** 11.8 m (39 ft)
- **Depth to water level:** 15.8 m (51.8 ft)
- **Rate of water removal:** 8.6 GPM
- **Non-pumping static water level:** 7.78 m (25.5 ft)

## Geophysical Log Taken

- Electric
- Gamma

## Geophysical Log Taken

- Mineralized water more than 4000 ppm TDS
- Gas

## Driller’s Name

<table>
<thead>
<tr>
<th>Field</th>
<th>Signature</th>
<th>Yr. Mo. Day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1/1/1997</td>
</tr>
</tbody>
</table>

## Contractor Certification

- If water removal was less than 2 hr duration, reason why:
  - Recommended pumping rate: 5-6 GPM
  - Recommended pump intake: 75 ft
  - Pump installed: Yes
  - Depth: 75 ft
  - Type: 100 ft
  - Any further pumpset information: Yes

(ENVIR 393)

White copy: Alberta Environment Yellow copy: Well Owner Pink copy: Contractor
Water Well Drilling Agreement Form

Identification
1. Well owner ______________________________________________________________________________________________________________________
   Address ______________________________________________________________________________________________________________________________________
2. Drilling contractor _______________________________________________________________________________________________________________
   Address ______________________________________________________________________________________________________________________________________
   Drilling contractor approval no.___________
3. Land location of well:   Qtr_______  Sec_______   Twp_______  Rge_______  W of_____Meridian       Lot_______  Block_______  Plan_______
4. Proposed starting date _______________________________________________________________________________________________________ _____
   Proposed completion date _________________________________________________________________________________________________________

Water Requirements
5. Proposed well use:  Household______________  Livestock_____________  Irrigation______________
6. Desired water quality   On-site tests:
   total dissolved solids_______________________parts/million    iron________________________________parts/million
   hardness__________________________________parts/million  pH________________________________parts/million
7. Desired yield_____________L/s (gpm)    Min. acceptable yield_____________L/s (gpm)
8. Groundwater supply options based on existing records _______________________________________________________________________________

Well Construction
9. Maximum desired depth_______________ m (ft.)
10. Type of drilling ______________________________________________________________________________________
11. Diameter of hole ______________________________________________________________________________________
12. Flowing well control ______________________________________________________________________________________
13. Well connection ______________________________________________________________________________________
14. Formation logging procedure ______________________________________________________________________________________
15. Annulus or casing seal ______________________________________________________________________________________
### Module 4 — Water Well Drilling Agreements

16. Artificial sand pack __________________________________________________________

17. Well development method: Backwashing_______ Jetting_______ Surging_______ Heavy pumping_______ Bailing_______

18. Hydrofracing _________________________________________________________________________________________

---

### Material

19. Casing material ________________________________________________________________

   Inside diameter__________ wt. per m(ft.)__________ wall thickness__________

20. Well cover ___________________________ Distance from top of casing to ground ___________________________________

21. Liner material ____________________________________________________________

   Inside diameter__________ wt. per m(ft.)__________ wall thickness__________

22. Screen

   Manufacturer ____________________________________________ Material _____________________________________________________________

   Length ____________________________________________ Nominal diameter ______________________

---

### Yield Testing

23. Yield testing duration (hours) ____________________________________________

---

### Disinfection

24. Disinfection ____________________________________________ 25. Well head finishing ________________________________

---

### Costs

26. Test holes per metre (foot) ____________________________________________ 32. Sand pack __________________________

27. Reaming per metre (foot) ____________________________________________ 33. Development __________________________

28. Drilling/boring per metre (foot) ________________________________________ 34. Hydrofracing __________________________

29. Casing per metre (foot) ________________________________________________ 35. Labor per hour __________________________

30. Liner per metre (foot) ________________________________________________ 36. Water testing __________________________

31. Screen ________________________________________________ 37. Reclamation of unused well __________________________

---

### Total

38. Total Costs ____________________________________________ 39. Payment schedule __________________________

---

### Guarantee

40. Guarantee ____________________________________________

---

*Working copies are included in the pocket on the back cover.*
Monitoring Your Water Well

Preserving the water source on your farm or acreage is as vital as preserving the quality of your soil.

When we think of factors that limit farm production, what come to mind are land base, finances, time and energy. What doesn’t always come to mind is how necessary water supplies are. Imagine having to reduce the size of a cattle herd or not being able to water your horses because of a lack of water. Water is key to our quality of life as well. Waiting an hour to take a bath or not having enough water to serve two bathrooms would be a change for many families.

Proper care and maintenance of your water source are key to protecting your water supply. An effective monitoring program will identify changes in water levels and water quality before they become serious problems. Just like a vehicle needs an oil change, tune up and inflated tires to run properly, your well needs to be monitored, checked and cared for. Regular, systematic inspections and treatment of problems will help a well to ”last for generations”. A drilling contractor may be required at times.

In this module you will learn several methods of monitoring your well. A worksheet where you can record your own information is included at the back.

The first step in preventative maintenance of your well is taking some simple measurements. Two measurements that you need to take on a routine basis are:

- Water level measurements
- Water quality measurements.

Water Level Measurements

Taking water level measurements on a regular basis will tell you whether water levels have changed significantly. In turn, this can help you spot the following problems:

- Pumping the well at a greater rate than the aquifer is capable of producing (depleting the aquifer)
- Plugged screen (or slotted casing) which can diminish the well’s efficiency and production rate
- Disturbance of the aquifer during the construction of sewers, drainage ditches and road cuts
- Reduced groundwater recharge due to land clearing and surface water drainage.

For more information refer to the Water Wells That Last video series Part II — Managing and Maintaining.
Take a water level reading monthly or quarterly as shown in the example below. Note in the example that readings were taken both with the pump on and the pump off. Readings taken with the pump on will alert you to any problems with the efficiency of the well (for example, a plugged screen). Readings taken with the pump off will alert you to any problems with the aquifer and the quantity of water available for pumping.

### Water Level Measurements Example

<table>
<thead>
<tr>
<th>Month</th>
<th>Water Level</th>
<th>Time</th>
<th>Pumping</th>
<th>Non-pumping</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>3.28 m</td>
<td>6:00 am</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Feb.</td>
<td>4.30 m</td>
<td>7:45 am</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>March</td>
<td>3.31 m</td>
<td>6:10 am</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>April</td>
<td>4.27 m</td>
<td>7:55 am</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>May</td>
<td>3.26 m</td>
<td>6:00 am</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

### How to Measure Water Levels

There are several devices and methods for measuring water levels:

- Dip tube
- Water well sounder
- Air line method.

### Dip Tube

A dip tube can be constructed using a minimum 18 mm (3/4 in.) plastic pipe or hose that is lowered into the well, to below the pumping water level. It should be taped to the pump line with electrical tape and have a capped bottom with two, 6 mm (1/4 in.) holes perforated on the bottom to let water in and out, allowing it to fluctuate identically to the water inside of the well. The dip tube should extend to 1.5 m (5 ft.) above the top of the pump. A measuring device, such as a weighted line or a well sounder tape, can then be lowered inside of the dip tube to measure the water level, with no threat of getting it entangled in the pumping equipment (see Figure 1, Dip Tube).
**Water Well Sounder**

A convenient method for measuring the water level is to use a water well sounder (also called a water tape). You can purchase one from various suppliers in the province. Although it is relatively expensive, it is a good investment. It’s an accurate and convenient way to take water level measurements.

**Air Line Method**

The air line method of monitoring water levels is simple and low cost. It is suitable for permanent installations so that water levels can be measured regularly. The cost of set up is about $60. This system has several components:

- A small diameter 6 mm (1/4 in.) plastic pipe permanently attached to the water pipe above the pump intake
- A pressure gauge and tire valve attached to the plastic pipe at the top of the well
- An air pump.

Lower the plastic pipe down the well until the bottom of the pipe is about 0.6 m (2 ft.) above the pump intake. If possible, tape the plastic pipe to the pump drop line. Measure the total length of the plastic pipe when you install it. Attach a pressure gauge and tire air valve to the plastic pipe at the top of the well (see Figure 2, Air Line Method).

There are two pieces of information you need to calculate the water level:

\[ L = \text{Length of plastic pipe or air line (in feet or metres)} \]

\[ H = \text{Height of water above the lower end of the air line (in feet or metres)} \]

You have the first piece of information (L) because you measured the length of the air line when it was installed. The second piece of information (H) is calculated using the air pump and the pressure gauge. Follow the steps below:

1. Pressurize the air line by pumping the air pump until all the water is forced from the line. You will know this has happened when the pressure reaches its maximum reading. Record the gauge reading.

2. If your gauge reads in lb./sq. in. (psi), multiply your reading by 2.31 to calculate H (in feet).

3. If your gauge reads in kilopascals (kPa), divide your reading by 9.8 to calculate H (in metres).

To arrive at the water level in your well, calculate the difference between L and H. See the examples on the next page.
Module 5 — Monitoring Your Water Well

**Imperial Measure Example**

L (Length of plastic pipe air line) = 100 ft.
H (height of water above lower end of air line) = Pressure gauge reading 15 psi x 2.31 = 34.7 ft. of water
H = 34.7 ft.

Water level (D) = L - H
= 100 ft. - 34.7 ft.
= 65.3 ft.

**Metric Measure Example**

L (Length of plastic pipe air line) = 30.0 m
H (height of water above lower end of air line) = Pressure gauge reading 105 kPa ÷ 9.8 = 10.7 m of water
H = 10.7 m

Water level (D) = L - H
= 30.0 m - 10.7 m
= 19.3 m

**Interpreting Water Levels**

Once you have an accurate method for measuring water levels, you need to be able to interpret two types of water levels — non-pumping (static) and pumping.

**Non-pumping Water Levels**

The non-pumping water level is recorded before the pump is turned on and the water level in the well has been allowed to fully recover. A good time to take a non-pumping reading is first thing in the morning before there has been any water use.

After you have recorded several measurements over a period of time, you can determine if the water level in the well has changed significantly. Some change will occur due to seasonal fluctuations. For example, in shallow wells, water levels are usually highest in June or July and gradually decline in late September or October.

**Deep wells of 60-90 m (200-300 ft.) do not experience seasonal fluctuations like shallow wells.**
Let’s look at some examples and how the results might be interpreted.

**Example 1**

The table below shows four non-pumping water level readings.

<table>
<thead>
<tr>
<th>Month</th>
<th>Time</th>
<th>Water Level*</th>
<th>Pumping</th>
<th>Non-pumping</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 1, 1996</td>
<td>6:00 am</td>
<td>3.28 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>April 3, 1996</td>
<td>5:45 am</td>
<td>3.27 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>August 1, 1996</td>
<td>5:30 am</td>
<td>3.30 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>December 1, 1996</td>
<td>6:10 am</td>
<td>3.29 m</td>
<td>✔️</td>
<td></td>
</tr>
</tbody>
</table>

*Distance from the top of the casing to water level.

Interpretation: It would appear that there have been no significant changes in the water level over the year so no action is required. The aquifer seems able to supply water to the well at the rate you have been pumping.

**Example 2**

You look back over your records for the past year and note the following non-pumping water level readings.

<table>
<thead>
<tr>
<th>Month</th>
<th>Time</th>
<th>Water Level</th>
<th>Pumping</th>
<th>Non-pumping</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 1, 1995</td>
<td>6:05 am</td>
<td>10.35 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>April 1, 1995</td>
<td>5:45 am</td>
<td>12.48 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>June 1, 1995</td>
<td>6:00 am</td>
<td>11.53 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>August 3, 1995</td>
<td>6:05 am</td>
<td>16.31 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>October 1, 1995</td>
<td>5:50 am</td>
<td>20.22 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>December 2, 1995</td>
<td>6:00 am</td>
<td>26.57 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>February 1, 1996</td>
<td>5:55 am</td>
<td>30.34 m</td>
<td>✔️</td>
<td></td>
</tr>
</tbody>
</table>

Interpretation: In this case, you should be concerned. The water level has dropped 20 m over the past year. To address the drop in water level, reduce the amount of water you draw from the well. You can do this by reducing the pumping rate and cutting back on the amount of water use.

Take another measurement in a month to see if the water level is recovering. If you find that the water level begins to rise again, you have been overpumping your well, producing more water from the well than the aquifer can supply. To prevent your well from going dry, you will need to pump your well at a reduced rate.

*If the non-pumping water level suddenly drops after remaining steady for many years, it may be a result of increased use from nearby wells that are completed in the same aquifer as your well.*
If the water level does not recover, you will need to:
- Further reduce water use
- Look for other possible water sources.

**Pumping Water Level**

Record the pumping water level while the pump is operating. If you take several readings over time, you will have data that can help you assess the efficiency of the well. When you take pumping water level measurements, you need to be consistent about when the measurements are taken. For example, you might take the measurement after the pump has been on for 2 hours. Being consistent allows you to compare the readings (see Figure 3, Pumping Water Level Drawdown).

**Figure 3  Pumping Water Level Drawdown**

Use a yield test (as described in Module 3 "Design and Construction of Water Wells") and qualified interpretation of the data to identify the cause of your well problem. Compare this data to the yield test done when the well was originally constructed.
A good time to take a pumping water level reading is during the day when the pump is pumping, for example, at noon. By then there has been significant water use. Taking the reading at the same time of day will give you comparable water levels, unless water use varies considerably between seasons.

Now let’s look at the significance of some pumping water level measurements.

**Example 3**

In the table below, six readings were taken after the pump was on for 2 hours.

<table>
<thead>
<tr>
<th>Month</th>
<th>Time</th>
<th>Water Level</th>
<th>Pumping</th>
<th>Non-pumping</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 2, 1996</td>
<td>11:30 am</td>
<td>6.67 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>March 1, 1996</td>
<td>11:15 am</td>
<td>5.23 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>May 1, 1996</td>
<td>11:35 am</td>
<td>6.34 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>June 1, 1996</td>
<td>11:20 am</td>
<td>5.35 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>September 2, 1996</td>
<td>11:25 am</td>
<td>6.29 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>December 2, 1996</td>
<td>11:15 am</td>
<td>7.02 m</td>
<td>✔️</td>
<td></td>
</tr>
</tbody>
</table>

Interpretation: Since the levels are relatively constant, there does not seem to be a problem with the efficiency of the well and no action is required.

**Example 4**

You look back over your records and find that, although the original non-pumping water level has remained constant, the pumping water level has declined.

<table>
<thead>
<tr>
<th>Month</th>
<th>Time</th>
<th>Water Level</th>
<th>Pumping</th>
<th>Non-pumping</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 1, 1995</td>
<td>11:30 am</td>
<td>20.15 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>April 2, 1995</td>
<td>11:20 am</td>
<td>21.56 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>June 1, 1995</td>
<td>11:35 am</td>
<td>26.26 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>August 3, 1995</td>
<td>11:45 am</td>
<td>28.37 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>October 1, 1995</td>
<td>11:30 am</td>
<td>33.45 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>December 2, 1995</td>
<td>11:40 am</td>
<td>37.20 m</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>February 1, 1996</td>
<td>11:50 am</td>
<td>40.16 m</td>
<td>✔️</td>
<td></td>
</tr>
</tbody>
</table>

Interpretation: The screen (or slotted casing) may be plugged with sand, bacterial growth or mineral incrustation. When this happens, the efficiency of the well is diminished and the production rate (yield) drops.

To correct the problem, hire a drilling contractor to determine exactly what is causing the reduced efficiency of the well. The screen (or slotted casing) may need to be surged to remove sediment or in some cases may need to be replaced. You may need to shock chlorinate the well to reduce bacteria or acidize it to remove incrustation on the casing or screen.
Water Quality Measurements

Noting changes in water quality is an effective way to monitor your water well. Aquifer contamination, problems with a well’s structure, or lack of routine maintenance could each lead to a change in water quality.

Use the following checklist as a starting point to determine if a problem exists.

- Unpleasant odor or taste
- Red discoloration on plumbing fixtures and fabric
- Cloudy, dirty water
- Soap curd on dishes and fabrics
- Scale in pipes and water heater
- Salty alkali taste

Some changes in water quality are not detected by changes in taste, smell or appearance. For this reason it is important to sample and analyze your water on a routine basis.

Bacterial Analysis

Bacterial analysis determines the total coliform and faecal coliform bacteria in the water. Coliform bacteria are usually present in soil and surface water. Faecal coliform are present in animal and human waste. Both are indicator organisms for the potential presence of pathogenic (disease causing) bacteria.

A bacterial analysis does not test for iron bacteria or sulphate-reducing bacteria which are commonly found in well water. A bacterial analysis should be done annually.

Chemical Analysis

A routine chemical analysis tests for the most common chemical parameters found in water, such as iron, sodium, sulfates, nitrates and nitrites. In some cases, you may need to request testing for additional parameters when a regional health concern is identified (such as arsenic or fluoride).
Non-routine Testing

Non-routine testing is necessary when unusual situations occur. Unexplained illnesses, obvious contamination situations such as pesticide or hydrocarbon spills, or flooding are examples. Occurrences on neighboring properties may also provide reason for non-routine testing. Since specialized testing is expensive, get advice on which parameters are worth testing.

Sampling

How you collect a water sample is as important as the analysis. Proper sampling bottles and procedures are imperative and can be obtained through your health unit or private laboratory.

Important considerations are:

- Length of time well is pumped prior to sample taken
- How sample is stored
- Length of time for sample to be delivered to a laboratory.

Collect the sample as close to the well head as possible to avoid any effect the water treatment or distribution system may have on the sample. If you want to assess the effectiveness of your treatment system, you will have to take an additional sample.

Interpreting Results

Whenever an analysis is done, you will receive a written copy of the results. Keep this information in the front pocket with your other important papers. It helps to create a history of your well to use for comparison should the water quality ever change.

You can also use the analyses to help you decide whether or not any water treatment equipment is needed to improve your water quality.

Local health units are responsible for identifying whether water is fit for human consumption. The Canadian Drinking Water Quality Guidelines published by Health Canada are used to establish when the parameters exceed established maximum acceptable concentrations.
# Module 5 — Monitoring Your Water Well

## Worksheet

### Water Well Monitor

<table>
<thead>
<tr>
<th>Year</th>
<th>Well No.</th>
<th>Qtr</th>
<th>Sec</th>
<th>Twp</th>
<th>Rge</th>
<th>W of Meridian</th>
<th>Lot</th>
<th>Blk</th>
<th>Plan</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Month / Day</th>
<th>Time</th>
<th>Water Level</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pumping</td>
<td>Non-pumping</td>
</tr>
<tr>
<td>January</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>___</td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td>___</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* At the end of the year, review the chart for any water level trends.

* Working copies are included in the pocket on the back cover.
Shock Chlorination — Well Maintenance

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.

Note: All iron staining problems are not necessarily caused by iron bacteria. The iron naturally present in the water can be the cause (see Module 12 “Other Resources” for more information.)

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 gas as a by-product, resulting in a “rotten egg” or sulfur odor in the water. Others produce small amounts of sulfuric acid that 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 faecal coliform or E. coli bacteria in a water system. To be effective, shock chlorination should be done on a regular basis at least once or twice per year as part of a routine well maintenance program. Start the treatments early in the life of your well. Shock chlorination will 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 chlorinated water is siphoned down the well to displace all the water in the well and some of the water in the formation surrounding the well.

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 and water mixture to reach and disinfect the entire cased section of the well and adjacent water-bearing formation.

The procedure described on the following pages does not completely eliminate iron bacteria from the water system, but it will hold it in check. To control the iron bacteria, you will have to repeat the treatment on a regular basis, likely each spring and fall as a regular maintenance procedure.

Shock chlorination will not be effective on wells that have been seldom or never been treated. These poorly maintained wells likely require the services of an experienced water well driller who has the necessary equipment and products to effectively and safely clean and restore the well water quality and production. Sometimes these wells can be restored to near their original water quality and production capacity after the well driller uses scrubbing equipment and applies an acid treatment to remove the heavy layers of bacterial slime on the well casing prior to disinfecting with a chlorine mixture. After a thorough cleaning it may be possible to return to regular shock chlorination treatments to control bacteria buildup and its related problems.
Shock Chlorination Procedure for Drilled Wells

A modified procedure is also provided for large diameter wells.

Caution: If your well is low yielding or tends to pump any silt or sand, you must be very careful using the following procedure because overpumping may damage the well. When pumping out the chlorinated solution, monitor the water discharge for sediment.

Follow these steps to shock chlorinate your well.

**Step 1**  Store sufficient water to meet farm and family needs for 8 to 48 hours.

**Step 2**  Pump the recommended amount of water (see Table 1, Amount of Chlorine Required to Obtain a Chlorine Concentration of 200 PPM) into clean storage. A clean galvanized stock tank or pickup truck box lined with a 4 mil thick plastic sheet is suitable. The recommended amount of water to use is twice the volume of water present in the well casing. To measure how much water is in the casing, subtract the non-pumping water level from the total depth of the well. See the example below.

**Imperial Example**

The drilling record indicates the casing is 200 ft. in length and the non-pumping (“static”) water level is 100 ft. The length of casing that is holding water in it is 100 ft. (200-100). If your casing is 6 in. in diameter you need to pump 2.4 gal. of water for every foot of water in the casing, into your storage container. Since you have 100 ft. of water in the casing, you will pump 2.4 gal./ft. x 100 ft. = 240 gal. of water into storage.

Using Table 1, calculate how much water you need to pump into clean storage.

Casing diameter_________ needs_________gal./ft. x _________ ft. = _________ gal.
12% industrial sodium hypochlorite and 70% high test hypochlorite are available from:

- Water treatment suppliers
- Drilling contractor
- Swimming pool maintenance suppliers
- Dairy equipment suppliers
- Some hardware stores.

Caution: Chlorine is corrosive and can even be deadly.

If your well is located in a pit, you must make sure there is proper ventilation during the chlorination procedure. Well pits are no longer legal to construct. Use a drilling contractor who has the proper equipment and experience to do the job safely.

### Table 1 Amount of Chlorine Required to Obtain a Chlorine Concentration of 200 PPM

<table>
<thead>
<tr>
<th>Casing Diameter</th>
<th>Volume of Water Needed</th>
<th>5 1/4% Domestic Chlorine Bleach</th>
<th>12% Industrial Sodium Hypochlorite</th>
<th>70% High Test Hypochlorite</th>
</tr>
</thead>
<tbody>
<tr>
<td>(in) (mm)</td>
<td>(gal.) (L)</td>
<td>L needed per 1 ft. (30 cm) of water</td>
<td>L needed per 1 ft. (30 cm) of water</td>
<td>Dry weight² per 1 ft. (30 cm) of water</td>
</tr>
<tr>
<td>4 (100)</td>
<td>1.1 5.0</td>
<td>.019 .008</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>6 (150)</td>
<td>2.4 10.9</td>
<td>.042 .018</td>
<td>3.12</td>
<td></td>
</tr>
<tr>
<td>8 (200)</td>
<td>4.2 19.1</td>
<td>.072 .032</td>
<td>5.46</td>
<td></td>
</tr>
<tr>
<td>24 (600)</td>
<td>extra 200 gal. extra 1000 L</td>
<td>.340 .148</td>
<td>25.40</td>
<td></td>
</tr>
<tr>
<td>36 (900)</td>
<td>extra 200 gal. extra 1000 L</td>
<td>.76 .34</td>
<td>57.20</td>
<td></td>
</tr>
</tbody>
</table>

¹ Domestic chlorine bleach should not have additives or perfumes.
² Since a dry chemical is being used, it should be mixed with water to form a chlorine solution before placing it in the well.
³ See modified procedure for large diameter wells on page 53.
⁴ To reduce the chlorine concentrations to 50 ppm, divide the above chlorine amounts by 4.

**Calculating Amount of Chlorine Example**

If your casing is 6 in. and you are using 12% industrial sodium hypochlorite, you will require 0.018 L per ft. of water in the casing. If you have 100 ft. of water in the casing, you will use $0.018 \times 100 = 1.8$ L of 12% chlorine.

Using Table 1, calculate the amount of chlorine you will need for your well.

Casing diameter_______ Chlorine strength_______
L needed per 1 ft. of water_______ x _______ ft. of water in casing = _______ L of chlorine.
Figure 2  Siphoning Chlorine Solution

**Step 4** Siphon this solution into the well (see Figure 2, Siphoning Chlorine Solution).

**Step 5** Open each hydrant and faucet in the distribution system (including all appliances that use water such as dishwasher, washing machine, furnace humidifier) until the water coming out has a chlorine odor. This will ensure all the plumbing fixtures are chlorinated. Allow the hot water tank to fill completely. Consult your water treatment equipment supplier to find out if any part of your water treatment system should be bypassed, to prevent damage.

**Step 6** Leave the chlorine solution in the well and distribution system for 8 to 48 hours. The longer the contact time, the better the results.

**Step 7** Open an outside tap and allow the water to run until the chlorine odor is greatly reduced. Make sure to direct the water away from sensitive plants or landscaping.

**Step 8** Flush the chlorine solution from the hot water heater and household distribution system. The small amount of chlorine in the distribution system will not harm the septic tank.

**Step 9** Backwash and regenerate any water treatment equipment.

If you have an old well that has not been routinely chlorinated, consider hiring a drilling contractor to thoroughly clean the well prior to chlorinating. Any floating debris should be removed from the well and the casing should be scrubbed or hosed to disturb the sludge buildup.
Modified Procedure for Large Diameter Wells

Due to the large volume of water in many bored wells the above procedure can be impractical. A more practical way to shock chlorinate a bored well is to mix the recommended amount of chlorine right in the well. The chlorinated water is used to force some of the chlorine solution into the formation around the well. Follow these steps to shock chlorinate a large diameter bored well.

**Step 1**  Pump 200 gal. (1000 L) of water into a clean storage tank at the well head.

**Step 2**  Mix 4.0 L of 5 1/4% domestic chlorine bleach that does not have additives or perfumes (or 1.6 L of 12% bleach or 0.28 kg of 70% calcium hypochlorite) into the 200 gal. of stored water. This mixture will be used later in Step 5.

**Step 3**  Using Table 1 calculate the amount of chlorine you require per foot of water in the casing and add directly into the well. (Note that the 70% hypochlorite powder should be dissolved in water to form a solution before placing in the well.)

**Step 4**  Circulate chlorine added to the water in the well by hooking a garden hose up to an outside faucet and placing the other end back down the well. This circulates the chlorinated water through the pressure system and back down the well. Continue for at least 15 minutes.

**Step 5**  Siphon the 200 gal. bleach and water solution prepared in Steps 1 and 2 into the well.

**Step 6**  Complete the procedure as described in Steps 5 to 9 for drilled wells.

**Worksheet**

Use the “Calculating Water and Chlorine Requirements for Shock Chlorination” worksheet to determine how much water and chlorine you need to shock chlorinate your well. A sample worksheet is included at the back of this module. Working copies are included in the pocket on the back cover. Store the completed worksheet in the back pocket.

*Don’t mix acids with chlorine. This is dangerous.*
# Worksheet

## Calculating Water and Chlorine Requirements (200 PPM) for Shock Chlorination

Complete the following table using your own figures to determine how much water and chlorine you need to shock chlorinate your well.

<table>
<thead>
<tr>
<th>Casing Diameter</th>
<th>Volume of Water Needed</th>
<th>5 1/4% Domestic Chlorine Bleach</th>
<th>12% Industrial Sodium Hypochlorite</th>
<th>70% High Test Calcium Hypochlorite</th>
</tr>
</thead>
<tbody>
<tr>
<td>(in) (mm)</td>
<td>Imperial gal. needed per 1 ft. of water in the casing</td>
<td>L per 1 ft. (30 cm) of water</td>
<td>L per 1 ft. (30 cm) of water</td>
<td>Dry weight per 1 ft. (30 cm) of water</td>
</tr>
<tr>
<td>4 (100)</td>
<td>ft. x 1.1 gal. =</td>
<td>ft. x 0.019 L =</td>
<td>ft. x 0.008 L =</td>
<td>ft. x 1.44 g =</td>
</tr>
<tr>
<td>6 (150)</td>
<td>ft. x 2.4 gal. =</td>
<td>ft. x 0.042 L =</td>
<td>ft. x 0.018 L =</td>
<td>ft. x 3.12 g =</td>
</tr>
<tr>
<td>8 (200)</td>
<td>ft. x 4.2 gal. =</td>
<td>ft. x 0.072 L =</td>
<td>ft. x 0.032 L =</td>
<td>ft. x 5.46 g =</td>
</tr>
<tr>
<td>24 (600)³</td>
<td>extra 200 gal.</td>
<td>ft. x 0.340 L =</td>
<td>ft. x 0.148 L =</td>
<td>ft. x 25.40 g =</td>
</tr>
<tr>
<td>36 (900)³</td>
<td>extra 200 gal.</td>
<td>ft. x 0.760 L =</td>
<td>ft. x 0.34 L =</td>
<td>ft. x 57.20 g =</td>
</tr>
</tbody>
</table>

1. Domestic chlorine bleach should not have additives or perfumes.
2. Since a dry chemical is being used, it should be mixed with water to form a chlorine solution prior to placing it in the well.

* Working copies are included in the pocket on the back cover.
Troubleshooting Water Well Problems

Water well problems result from many causes including equipment failure, depletion of the aquifer, corrosive qualities of the water and improper well design and construction. Correctly identifying the cause enables you to select appropriate treatment or maintenance to fix the problem rather than abandon the well. This troubleshooting module is designed to help you recognize the symptoms of the problem, identify the cause and select the appropriate course of action. Technical assistance from drilling contractors or groundwater consultants may be valuable. See Module 11 "Contacts for More Information."

Causes of Well Problems

There are several basic causes of well problems.

- Improper well design and construction
- Incomplete well development
- Borehole stability problems
- Incrustation buildup
- Biofouling
- Corrosion
- Aquifer problems
- Overpumping.

The first two causes relate to the expertise and performance of the drilling contractor. Borehole stability problems, incrustation, corrosion and aquifer problems are related to characteristics of the aquifer. The last cause, overpumping, is caused by well users.

Exercise

List any problems or symptoms with your well.

__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
Module 7 — Troubleshooting Water Well Problems

Improper Well Design and Construction

When designing a well, the drilling contractor must match the type of well construction with the characteristics of the producing aquifer. Decisions must be made about:

- Perforated well casing/liner vs. well screen (see Figure 1, Perforated Well Liner and Well Screen)
- Slot size of well screen
- Placement of well screen or perforated liner
- Size and amount of sand pack around the well screen (if required)
- Location of the pump in the well.

If poor choices are made, you may experience problems with sediment in your water or reduced well yield. Provincial regulations require that a well must be completed to ensure no damage will be incurred to the pumping system, plumbing or fixtures due to sediment in the water. For more information on well design and construction, see Module 3 "Design and Construction of Water Wells."

Incomplete Well Development

During drilling, mud and bore hole cuttings can partially plug the aquifer. This material must be fully removed by the drilling contractor to allow water to freely enter the well. This procedure is part of well development. If the well has not been fully developed, you may experience problems with sediment in your water or low well yield.

Borehole Stability Problems

Borehole stability problems can result from damaged casing and screens, borehole wall collapse, corrosion or excessive water velocities into the well. High water velocity can cause formation particles, like sand, to flow into the well, causing eventual collapse of the borehole wall.

It is essential that the proper materials be selected and installed to avoid such problems. A combination of poor materials, improperly placed screens and a poor well seal make it uneconomical to maintain and restore such a well. Often the most cost effective solution is to drill a new well that is properly designed and constructed.
Mineral Incrustation

Mineral incrustation is a common problem in some shallow water table type aquifers where there is an abundance of dissolved minerals including calcium, magnesium and iron, as well as iron bacteria. When water is pumped from the well, changes in pressure and temperature occur. This creates ideal conditions for minerals to precipitate or settle out, causing scale formation on the casing, liner and screens.

A combination of good preventive maintenance and good management practices can minimize the effect of incrustation. Management practices that reduce water pumping rates can reduce the effects of mineral incrustation. A strategy of reduced pumping rate with longer pumping intervals helps prevent incrustation of screens and perforated liners.

Biofouling

Installing and pumping a well increases the level of oxygen and nutrients in the well and in the surrounding aquifer. Bacteria, such as iron bacteria, may thrive under these conditions. They can form a gel-like slime or biofilm that captures chemicals, minerals and other particles such as sand, clays and silts. Minerals, such as iron, oxidize and get trapped in the biofilm. “Biofouling” occurs where biofilm accumulations are sufficient to reduce water flow. This can mean reduced well yield and water quality.

Corrosion

Chemical substances found in water can eat away or corrode metal well casings. To avoid corrosion, the drilling contractor must choose a casing material that is suitable for the water supply. For example, drilling contractors usually select plastic casing liners and stainless steel well screens for corrosive water. Sulfate-reducing bacteria can also cause corrosion. Shock chlorination can keep these bacteria in check.

Aquifer Problems

While most well problems are related to the construction, development or operation of the well, the formation can also be a source of problems.
Reduced aquifer yield can be caused by lack of recharge. For example, the amount of water withdrawn can exceed the recharge from rain and snow melt. This is referred to as "mining the aquifer." Sometimes the decline in water level is seasonal. Typically water levels are higher in spring and lower in the fall. Extended dry periods can also impact water levels, especially in shallow water table type aquifers.

Checking the water level in your well is an important maintenance procedure. You will be able to identify water level trends and identify well problems or aquifer depletion before the problem becomes serious.

**Overpumping**

A well is overpumped if water is withdrawn at a faster rate than the well was designed for or the aquifer is able to produce. Overpumping is the most common well problem that leads to premature well failure. Overpumping not only depletes the groundwater aquifer (or source), but it rapidly increases the rate of corrosion, incrustation and biofouling related problems. Overpumping also increases the rate of sediment particles moving toward the well, causing plugging of the perforated area where water flows into the well. It can also cause the aquifer to settle and compact which further restricts water flow to the well.

Now go back to the exercise at the start of this module. Try to identify possible causes for each problem you identified.
Troubleshooting Guide

There are four common symptoms associated with most water well problems:

- Reduced well yield
- Sediment in the water
- Change in water quality
- Dissolved gas in the water.

The guide on the next four pages refers to these four symptoms. To use the guide, find the section that identifies the symptom you are experiencing. Look down the left hand column for possible causes of the problem. Beside each cause is listed some indicators you can check for and ways to correct the problem.

Be aware that in many cases the well problem can be the result of a combination of causes and therefore correction may be a combination of actions as well.
### Symptom #1 — Reduced Well Yield

<table>
<thead>
<tr>
<th>Possible causes:</th>
<th>What to check for:</th>
<th>How to correct:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump and/or water system</td>
<td>Low pump production in spite of normal water level in well. Leak in system; worn pump impeller.</td>
<td>Have a licensed drilling contractor/pump specialist or plumber check the pump and water system.</td>
</tr>
<tr>
<td>Aquifer depletion</td>
<td>Compare current non-pumping static water level with the level at the time of well construction. A lower level confirms aquifer depletion. Contact prov. gov’t groundwater agency to see if water levels are declining.</td>
<td>Reduce the water use. Install cistern to meet peak water requirements. Drill a deeper well or one that taps into another aquifer.</td>
</tr>
<tr>
<td>Biofilm buildup in well casing, well screen</td>
<td>Slime buildup on household plumbing fixtures and livestock waterers. Inspect pump and use down-hole camera to check for slime buildup.</td>
<td>Shock chlorinate the well and water system as required—usually once or twice a year. See Module 6 &quot;Shock Chlorination—Well Maintenance.&quot;</td>
</tr>
<tr>
<td>Neighboring well interference.</td>
<td>Check for significant drop in water levels in nearby wells. Contact prov. gov’t groundwater agency to determine if groundwater use in the area has increased.</td>
<td>Identify other nearby wells located in the same aquifer. Reduce pumping rates as required.</td>
</tr>
<tr>
<td>Mineral scale (incrustation) buildup on</td>
<td>Scale formation on plumbing fixtures and livestock waterers. Inspect pump. Use down-hole video camera to check for mineral buildup. Calculate the Ryznar Stability Index to determine the water's incrusting potential.</td>
<td>Once the type of mineral scale has been identified, the well should be cleaned by a licensed water well treatment specialist. Treatment could include both physical agitation and chemical/acid treatment.</td>
</tr>
<tr>
<td>perforated well casing, well or pump screen.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sediment plugging on outside of perforated</td>
<td>Sediment in water, followed by sudden decline in yield.</td>
<td>Have a licensed drilling contractor redevelop the well.</td>
</tr>
<tr>
<td>casing or screen.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collapse of well casing or borehole due to</td>
<td>Compare current depth of well with original records. A collapsed well will show a shallower depth than the original well.</td>
<td>Recondition the well. If repair is not economical, plug the well and redrill. See Module 9 &quot;Plugging Abandoned Wells&quot; for more information on plugging a well.</td>
</tr>
</tbody>
</table>
## Module 7 — Troubleshooting Water Well Problems

### Symptom #2 — Sediment in Water

<table>
<thead>
<tr>
<th>Possible causes:</th>
<th>What to check for:</th>
<th>How to correct:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improper well design or construction.</td>
<td>Sediment appears in water shortly after well completion. Remove pump and use down-hole video camera to inspect well casing and screen.</td>
<td>Have a licensed drilling contractor repair the construction problem.</td>
</tr>
<tr>
<td>Insufficient well development after construction.</td>
<td>Sediment appears shortly after well completion. Well production may improve with pumping.</td>
<td>A licensed drilling contractor should redevelop the well.</td>
</tr>
<tr>
<td>Continuous over pumping of well.</td>
<td>Sediment appears in water shortly after well completion.</td>
<td>Compare current discharge rate of well with the driller’s recommended rate. If the current flow rate is higher, install a flow restrictor on pump. If required, install a cistern to meet peak water requirements.</td>
</tr>
<tr>
<td>Corrosion of well casing, liner or screen causing holes.</td>
<td>Sudden appearance of sediment in water when there was no previous problem. Often coupled with a change in water quality. Calculate the Ryznar Stability Index to determine the water’s corrosion potential.</td>
<td>Consult a licensed drilling contractor. Depending on the well construction, repair or replace well. Alternate construction materials may be required.</td>
</tr>
<tr>
<td>Failure of the annulus or casing seal.</td>
<td>Sudden appearance of sediment, coupled with a change in water quality.</td>
<td>Consult a licensed drilling contractor. It may be possible to re-establish the seal. Test water quality regularly and investigate when quality changes occur.</td>
</tr>
</tbody>
</table>
## Symptom #3 — Change in Water Quality

<table>
<thead>
<tr>
<th>Possible causes:</th>
<th>What to check for:</th>
<th>How to correct:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion of well casing, liner or screen, causing holes. Holes can allow water of undesirable quality to enter the well.</td>
<td>Change in water quality, often coupled with sudden appearance of sediment in water. Calculate the Ryznar Stability Index to determine the water's corrosion potential.</td>
<td>Consult with a licensed drilling contractor about possible repair. Alternate construction materials may be required.</td>
</tr>
<tr>
<td>Failure of the annulus or casing seal.</td>
<td>Change in water quality and possible appearance of sediment.</td>
<td>Consult with a licensed drilling contractor about possible repair.</td>
</tr>
<tr>
<td>Iron bacteria or sulfate-reducing bacteria (biofouling).</td>
<td>Change in water quality such as color, odor (e.g., rotten egg) or taste. Check inside of toilet tank for slime buildup and inspect pump.²</td>
<td>Shock chlorinate the well. For more information on shock chlorination, see Module 6 &quot;Shock Chlorination—Well Maintenance.&quot;¹</td>
</tr>
<tr>
<td>Contamination from man-made sources.</td>
<td>Changes in water quality as indicated by color, odor or taste. Compare results from regular water analyses for changes.³</td>
<td>Identify and remove contamination source. Have water analyzed through local health unit to ensure it is safe to drink.</td>
</tr>
<tr>
<td>Limited Aquifer Extent/Reduced Aquifer Recharge</td>
<td>Increase in constituents such as hardness, iron, manganese and sulfate. Compare results from original water analyses for changes. Taste and color changes in the water may also occur.</td>
<td>For surficial aquifers, trapping snow or impounding surface water can enhance aquifer recharge and improve water quality.</td>
</tr>
</tbody>
</table>
# Symptom #4 — Dissolved Gas in the Water

<table>
<thead>
<tr>
<th>Possible causes:</th>
<th>What to check for:</th>
<th>How to correct:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved gases in well water including:</td>
<td>Spurting household water taps.</td>
<td>For low concentrations of gas:</td>
</tr>
<tr>
<td>- carbon dioxide</td>
<td>Milky color to the water which lasts only a few seconds.</td>
<td>• Install an air volume release valve on the pressure tank, if the tank does not have an air bladder. Also ensure the tank is properly vented outside of building.</td>
</tr>
<tr>
<td>- methane</td>
<td>Cautions:</td>
<td>• Spray water from the well into a sealed storage tank that is properly vented to the outside.</td>
</tr>
<tr>
<td></td>
<td>1. Carbon dioxide is an asphyxiant</td>
<td>For higher concentrations of gas:</td>
</tr>
<tr>
<td></td>
<td>2. Methane can be flammable and explosive.</td>
<td>• Determine the depth that the gas is entering the well.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• If possible, lower the pump intake to below where the gas is entering. A licensed drilling contractor could install a plastic gas sleeve over the pump intake so the gas will be forced out of the water as it enters the intake. The gas will accumulate at the top of the well, so properly vent the well head so the gas is directed to the outside.</td>
</tr>
<tr>
<td>Malfunctioning pump or over pumping the well.</td>
<td>Refer to Troubleshooting Guide for your particular pumping system.</td>
<td>Have a licensed drilling contractor/pump specialist or plumber check the pump and pressure system equipment for malfunction. Make sure that any new pumping equipment is sized correctly to meet the production capability of the well. Reduce well pumping rate if necessary and install cistern to meet peak water requirements if required.</td>
</tr>
<tr>
<td></td>
<td>Compare the rate at which you are pumping the well with the rate recommended by the driller.</td>
<td></td>
</tr>
</tbody>
</table>
1. Shock chlorination is effective as a regular maintenance technique to kill bacteria and limit its ability to create biofilm. However, shock chlorination is not effective at penetrating biofilm. If biofilm buildup is suspected, the introduction of appropriate chemicals and physical agitation is required to remove the biological plugging material. Studies conducted as part of the Sustainable Water Well Initiative have shown that preventative maintenance should be applied before a biofouled well has lost about 20 percent of its original specific capacity and well rehabilitation should be conducted before the specific capacity has declined 40 percent. Also, once the specific capacity of a biofouled well has declined 60-80 percent from its original specific capacity, it becomes increasingly difficult to restore the well’s original specific capacity (City of North Battleford Well Treatment Evaluation report: http://www.agr.gc.ca/pfra/water/uab/nb00rpt.pdf; Town of Qu’Appelle Well Treatment Project: http://www.agr.gc.ca/pfra/water/swwi/qawell5.pdf).

2. The presence and aggressiveness of nuisance bacteria, such as iron-related (IRB), sulfate-reducing bacteria (SRB) and heterotrophic bacteria (HAB), can be determined by the use of Biological Activity Reaction Tests (BARTs). These bacteria are naturally present in most groundwater environments and can result in biofouling of the water well and associated infrastructure. Studies conducted as part of the Sustainable Water Well Initiative (SWWI) have shown that about 70 percent of wells in any given area may contain highly aggressive levels of these nuisance bacteria (Rural Municipality of Mount Hope #279 Water Well Inventory and Microbiological Assessment: http://www.agr.gc.ca/pfra/water/swwi/rmmh279.pdf; Biofouling and Water Wells in the M.D. of Kneehill, Alberta: http://www.agr.gc.ca/pfra/water/knee_e.htm; Microbiological Activity and the Deterioration of Water Well Environments on the Canadian Prairies: http://www.agr.gc.ca/pfra/water/swwi/iah2000t.pdf). Another SWWI study indicated that wells with high levels of nutrients, such as dissolved organic carbon (DOC) and nitrates, in the source water are at a greater risk of biofouling than wells with low levels of nutrients (Sustaining Water Well Infrastructure in an Agricultural Setting – Rural Municipality of Mount Hope: http://www.agr.gc.ca/pfra/water/swwi/MountHope.pdf). The factors that cause or accelerate water well biofouling are not well understood and additional research is still required in this area. Well capture zone studies are recommended to investigate the factors that may contribute to biofouling.

3. In many cases, variations in water quality will not result in observable changes in odor, taste or color. For instance, in situations where nitrate levels are increasing, there may be no apparent change in the odor, taste or color of the water. In addition, an increase in nitrate levels may also signal the presence of coliform bacteria or other pathogenic bacteria. A SWWI field study indicates that wells with high levels of nitrates often have high levels of coliforms (Sustaining Water Well Infrastructure in an Agricultural Setting – Rural Municipality of Mount Hope: http://www.agr.gc.ca/pfra/water/swwi/MountHope.pdf). New technologies are available that permit rapid onsite testing of coliform bacteria. A SWWI study, conducted in partnership with Saskatchewan Health, evaluated a new and innovative technology that can be used to determine the presence of coliforms and E. coli in drinking water (Evaluation of the Aquasure Pro 3000 Single Test Precision Portable Incubator Technology: http://www.agr.gc.ca/pfra/water/swwi/aqua3000.pdf)
Protecting Your Well From Contamination

Probably the most important asset on your property is your water well. Unfortunately it is often misunderstood and taken for granted. This lack of understanding increases the risk of contamination to the groundwater. Contamination can be a health risk to both people and livestock. Groundwater is an important resource that needs to be protected.

Contamination of groundwater is hard to detect in early stages. By the time the problem is obvious, there is little that can be done to remove the contaminant from the system. It can take a very long time for contaminants to be flushed out, often decades or longer. Prevention of pollution is the only effective approach.

Often the biggest contamination threats are things in your own backyard. The following are examples of potential problems and some ways to prevent them.

Poor Well Construction

- The fastest way to contaminate groundwater is through a well. A well provides a direct path for contamination to travel from the surface to the aquifer.

- A proper well casing or formation seal effectively prevents surface water or contaminated groundwater from seeping along the outside of the casing and entering your well (see Figure 1, Annulus or Casing Seal).

- Multi-aquifer well completion allows mixing of water from several aquifers which may have significantly different water qualities (see Figure 2, Multi-Aquifer Well Completion).

Prevention: The best defense is to hire a drilling contractor. All water well drilling contractors must obtain an approval that authorizes them to drill water wells in the province. To obtain this approval, they must have a certified journeymen water well driller to operate each drilling rig. Standards for drilling, construction and reclamation of wells are outlined in the Water (Ministerial) Regulation of the Water Act. Be prepared to pay for quality work and materials.
Old Wells

- Old wells that are poorly constructed or have rusted steel casing can lead to contamination of an aquifer. Nearby wells, completed in that aquifer, may eventually become contaminated.

**Prevention:** Old unused wells must be properly plugged. See Module 9 “Plugging Abandoned Wells.”
Well Pits

- Well pits provide a place for contaminated surface water or shallow groundwater to collect. When this water sits in the pit, it can contaminate the aquifer by seeping around the outside of the well casing or flowing into the well. This type of construction also makes it very susceptible to contamination by small animals and insects (see Figure 3, Well Pit). For this reason well pits are no longer allowed.

- Well pits can also be a deadly safety hazard. With changes in atmospheric pressure, air from within the well casing can displace "normal" air in the well pit. Well gases or low oxygen content resulted in human deaths, even recently. People entering the well pit can be asphyxiated.

- Methane gas buildup can cause explosions.

Prevention: If an old well pit exists, do not enter it alone and without ventilating it aggressively beforehand. Have well pits removed by an experienced drilling contractor.

Provincial regulation now prohibits the construction of well pits.

Prevention: Pitless adaptors provide a safe, sanitary and frost-free connection from the pumping system to the water well (see Figure 4, Pitless Adaptor). For more information, see the publication Pitless Adaptors, listed in Module 12 "Other Resources."

Figure 3 Well Pit

Figure 4 Pitless Adaptor
Farm Water Hydrants Installed in a Well or Well Pit

- Hydrants are designed to prevent freezing by draining water back down the well whenever they are shut off. This means that the contents of the stand pipe and hose will syphon back into the well. If the hose is directly connected to the water in a tank, this water will also be syphoned down the well (see Figure 5, Farm Water Hydrant). The contents of stock tanks, sprayers, etc. are definite contaminants.

- Shallow groundwater can be contaminated by poorly designed, installed or operating sewage systems (see Figure 6, Poor Sewage Systems). Cesspools constructed over the years have been specifically identified as a greater risk.

**Prevention:**
- Always maintain an air gap between the end of a hose and the water surface.
- Always disconnect hoses from the hydrants when not in use.

**Prevention:**
- Don’t locate hydrants in a well casing or well pits (no longer permitted).

Poor Sewage Systems

**Prevention:**
- The construction of cesspools is no longer permitted.

**Prevention:**
- Properly design, locate and install sewage systems. (See Module 3 "Design and Construction of Water Wells" for minimum distance requirements.)
  (See Module 11 "Contacts for More Information," Alberta Human Resources and Employment, for requirements.)

Seismic Shot Holes

- Improperly plugged shot holes can be a direct path for contamination to groundwater. Shot holes are typically 15-18 m (50-60 ft.) deep and are plugged by installing a plastic plug (with identification) into the hole, at a depth of not less than 1 m (3 ft.) below ground level, followed with bentonite pellets and firmly tamped borehole cuttings placed progressively upwards to the ground surface.

**Prevention:**
- Negotiate, beforehand, a more effective method of plugging shot holes with the seismic company by suggesting they install the plastic plug closer to the bottom of each hole and fill from the plug to ground surface with only bentonite pellets.
Over-Application or Improper Storage of Manure or Fertilizer

- Manure or fertilizer that is applied to land at a greater rate than growing crops can utilize the nutrients can result in nitrates leaching into groundwater. Fertilizer that is applied to lawns or gardens at excessive rates may also contribute.

**Prevention:** Balance the nutrient requirements of your crops with the nutrient content of the manure or fertilizer. Conduct regular soil and manure tests and maintain accurate records of application.

- Storage of manure concentrates nutrients in one location which can increase risk of contamination.

**Prevention:** Manure storage facilities should be designed and constructed correctly (see Module 12 "Other Resources").

**Fuel Storage Tanks**

- Leaking fuel can contaminate your water supply with hydrocarbons by penetrating water distribution lines or seeping directly into your aquifer.

**Prevention:** Monitor your fuel tanks for leakage. Practice proper refueling procedures to avoid spills. Be prepared to clean up spills. Lay out and construct a proper refueling area (see Module 12 "Other Resources").

_Fuel tanks must be located at least 50 m (164 ft.) from water wells. Buried fuel tanks are a major environmental liability and should be avoided._
Pesticide Contamination

- The most common reason pesticide contamination of wells occurs is poor pesticide handling in the area around the well.
- The highest contamination risk involving field application is when the following factors all come together:
  - persistent pesticides
  - high water table
  - highly permeable soils
  - high pesticide application rate.

**Prevention:** Never fill sprayer tanks near a well. Always use a nurse tank to haul clean water to the field for pesticide mixing.
Store pesticides properly, away from the well.

- Properly rinse and dispose of empty pesticide containers.

Contamination During Maintenance

- Wells can easily become contaminated with bacteria when pumps, piping and equipment are laid on the ground prior to placement into the well or during maintenance procedures.
- Pumps, piping and equipment should be thoroughly disinfected and the well shock chlorinated.

Common sense and a better understanding of groundwater and wells are the keys to preventing contamination problems. Use these preventative techniques to ensure that the wells on your farm provide a safe water supply for years to come.
Module 9 — Plugging Abandoned Wells

For more information refer to the Water Wells That Last video series Part II — Managing and Maintaining.

Figure 1 Well Contamination

Wells that are no longer being used should be plugged. They are a serious public safety and environmental hazard.

Plugging Abandoned Wells

When a well is no longer being used or maintained for future use, it is considered abandoned. Abandoned wells pose a serious threat to the preservation of groundwater quality. They are also a serious safety hazard for children and animals.

There are approximately 59,000 farmsteads in Alberta and most of these have at least one well. In addition there are a great number of non-farming rural residents that rely on water wells. The exact number of abandoned wells in Alberta is unknown but is estimated to be in the tens of thousands. Plugging an abandoned well prevents:

- Downward movement of water in the well or well annulus
- Surface contamination from reaching aquifers
- Intermixing of water between aquifers of different water quality
- Serious accidents from happening.

Unfortunately, groundwater contamination and its effects are usually not recognized until groundwater quality is seriously affected and nearby wells have been contaminated. Surface contaminants can enter a well several ways:

- Directly through the surface opening if the cap is loose, cracked or missing
- Through unsealed spaces along the outside of the casing (see Figure 1, Well Contamination).

When the steel casing of an abandoned well starts to corrode, holes will develop. When this takes place, surface contaminants or poor quality water from shallow aquifers may migrate into the deeper aquifers of nearby operating wells (see Figure 2, Contamination From an Abandoned Well).

Figure 2  Contamination From an Abandoned Well
Who is Responsible?

In Alberta, responsibility for plugging a water well is defined by legislation. The well owner is responsible for plugging the well when:

- The well is no longer being used as a water supply
- The well is in a poor state of repair and the pumping equipment has been removed or cannot be repaired or replaced
- The well produces water that is unsuitable for drinking.

The drilling contractor is legally responsible for immediately plugging a well when it is not completed due to construction problems or inadequate yield. Before you sign a contract with a driller, ask questions about what materials are going to be used to plug the well and associated costs.

It is generally best to hire a drilling contractor to complete the plugging of your well. This person has the expertise and equipment to do a proper job. Unless you use the right plugging materials and have them properly placed in the well, you will end up with a poorly sealed well that will continue to allow contaminants to enter into the groundwater. When a replacement well is drilled, your old well should be immediately plugged.

Process of Plugging a Well

There are several steps to take before actually plugging the well. Some steps you will be able to do yourself and others you may want to consult with, or hire, a drilling contractor to complete.

Preparation

To know exactly how much plugging material is needed, measure the total depth and diameter of the well, plus the non-pumping water level (the depth to the standing water in the well). If possible, compare these measurements to the information on the drilling report from when the well was originally constructed. The only time you should even consider plugging a well yourself is when the well is open to its original depth.

Ideally the casing should be removed from the well before the plugging process begins. Often only the liner casing is removed and the surface casing is left intact because it is more difficult to remove and it could separate down hole. The older the well, the more difficult it will be to successfully remove the casing. If the casing is left in place, it should be perforated, particularly if there is evidence of water movement in the annulus of the well. Any casing left in place must be cut off 0.5 m (20 in.) below ground surface after the well is plugged.

For information on how to take a non-pumping water level measurement, see Module 5 "Monitoring Your Water Well."
Materials

Materials that are used to plug a well must be uncontaminated and impervious. They must prevent any movement of water. See the chart below for acceptable and unacceptable materials.

<table>
<thead>
<tr>
<th>Acceptable Materials</th>
<th>Unacceptable Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>• grout - neat cement (cement mixed with water)</td>
<td>sand</td>
</tr>
<tr>
<td>- sand cement (cement, sand and water)</td>
<td>gravel</td>
</tr>
<tr>
<td>• concrete (cement, sand and aggregate mixed with water)</td>
<td>drilling mud or fluid</td>
</tr>
<tr>
<td>• manufactured high yield bentonite products</td>
<td></td>
</tr>
<tr>
<td>• clean, uncontaminated clay (for large diameter wells)</td>
<td></td>
</tr>
</tbody>
</table>

Cement grout and concrete may shrink after setting so may not create as good a seal as bentonite.

Sand and gravel are not acceptable materials. They are not impervious materials because water can easily move through them.

High yield bentonite is a special type of clay that swells when wet to provide a very effective impervious seal. It comes in a powder that when mixed with water produces a slurry that can be pumped into the well. It is also manufactured in pellet or granular form that is designed to pour into the well. This type of bentonite when mixed with water will actually swell to about eight times its original size and will form a water-tight plug.

It is important to understand that bentonite cannot be used as a plugging material in some situations. When the chloride level in the well water is greater than 4000 mg/L, or the calcium level is greater than 700 mg/L, bentonite will not swell properly, so then it is best to use a cement grout.

Large diameter or bored wells pose special problems because of their size and volume of material required to fill them. A lower cost alternative for the plugging material is clean, uncontaminated clay that can be shovelled into the well until it is filled. This must be done carefully, however, to ensure the clay reaches the bottom of the well and seals off all empty space. The cribbing must be cut off below ground surface and the well topped up with high yield bentonite to make a water-tight seal.
Method

Aside from choosing the appropriate plugging material, the method of placing material into the well is most critical. Regulation requires that the plugging material must be introduced from the bottom of the well and placed progressively upward to ground surface.

If the plugging material is cement grout, concrete or bentonite slurry, special equipment is needed. The material must be placed into the well through a tremie pipe that is usually about 3 in. in diameter. At all times this pipe must be kept below the surface of the plugging material to prevent it from diluting or separating. It is recommended that you hire a drilling contractor when a slurry is chosen as the plugging material because the drilling contractor will have the proper equipment and experience to do the job correctly.

When bentonite pellets are chosen for the plugging material, they can be poured into the well from the ground surface. These pellets have a weight material added to help them sink to the bottom of the hole. They are also coated to prevent immediate swelling on contact with water. When poured slowly, they should reach the bottom of the well before swelling. If you are not careful, however, these pellets will bridge off down hole and the well will be only partially plugged (see Figure 3, Bridging).

Before you pour in the pellets, you can determine how many feet of well casing can be filled with the size of pellets you have chosen. As the well is being filled, measure the depth to the top of the plugging material quite frequently. Then you will know if the plug is rising faster than expected indicating a bridge has formed. If this happens, be sure to break it up before adding more material to the well.
Steps to Plugging a Well

**Step 1** Remove all pumping equipment from the well. Thoroughly flush out the well using a bailer or air compressor.

**Step 2** Measure the total depth of the well, the diameter and the non-pumping water level. If possible, compare these figures with the information on the original drilling report. Confirm whether the well is open to its original depth.

**Step 3** Use these figures to decide which plugging material is appropriate and how much you will need. A drilling contractor can help you decide. Whether or not the casing can be successfully pulled out will also determine which material to use and what method is appropriate for placing it into the well. If the casing cannot be removed, choose a slurry that can be pumped under pressure into the well so that any space around the outside of the casing will also get filled in.

**Step 4** Disinfect the well. Add enough chlorine to bring the water standing in the well to a chlorine concentration of 200 mg/L. For every 450 L (100 gal.) of water in the well, add 2 L (.4 gal.) of household bleach (5.25% chlorine). See Module 6 “Shock Chlorination—Well Maintenance” to calculate how much water is in your well. Leave this chlorine in your well.

**Step 5** If possible, remove the well casing.

**Step 6** Place the plugging material into the well. It must be introduced at the bottom of the well and placed progressively upwards to ground surface. The only exception to this rule is when the plugging material being used is a bentonite pellet that has been designed and manufactured for pouring into the well from the ground surface.

**Step 7** If the casing was not already removed, dig around it and cut it off a minimum of 0.5 m (20 in.) below the ground surface (see Figure 4, Cutting Off the Casing and Mounding the Clay).

**Step 8** Backfill and mound this portion of the hole with material appropriate for intended use of the land (i.e., clay) (see Figure 4, Cutting Off the Casing and Mounding the Clay).

**Step 9** Use the worksheet at the end of this module to record the details of your well plugging. Include the well owner name, location, total depth, casing diameter, type and amount of plugging material used, date and method of placing material into the well. Send a copy of this record to: Alberta Environment Groundwater Information Centre 11th Floor, Oxbridge Place 9820-106 Street Edmonton, Alberta T5K 2J6

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By regulation, a well must be filled full length with impervious material. That material must be introduced into the well at the bottom and be placed progressively upward to ground surface.
Special Problems

Flowing wells present special problems for plugging. It is highly recommended that you use the services of a drilling contractor. Before a flowing well can be plugged, the flow must be controlled. Several methods can be used.

- Reduce the flow by pouring high specific gravity fluids such as drilling mud or cement into the well.
- If there is a nearby well that is tapped into the same aquifer as the flowing well being plugged, pump it to create a drawdown in the well being plugged.
- Where practical, extend the well casing high enough above the ground surface to stop the flow.

Worksheet

For future reference, use the "Record of Well Plugging" worksheet to record the date of plugging, materials and procedures used. Also mark or map the location of this plugged well for future reference. A sample copy is included at the back of this module. Working copies are included in the pocket on the back cover. Keep the worksheet in the back pocket.
Worksheet

Record of Well Plugging

Original landowner’s name: ___________________________________________________________  Date of plugging: ____________________________

Legal land location of well:  Qtr ___________  Sec _________  Twp _________  Rge _________  W of ____  Meridian
Lot ___________  Blk _________  Plan ___________________________

Location reference points on the farm (i.e., distance from buildings): ____________________________________________________________

Current well depth: ________________  Original well depth: ________________________  Well diameter: ________________________

Was well casing removed before plugging? _____________________________________________________________________________

Water characteristics: (attach any analysis done)

Reason for plugging the well: _______________________________________________________________________________________
___________________________________________________________________________________________________________________________________
___________________________________________________________________________________________________________________________________
___________________________________________________________________________________________________________________________________

Type and quantity of plugging material used: _____________________________________________________________________________
___________________________________________________________________________________________________________________________________
___________________________________________________________________________________________________________________________________

How was material placed into the well? ________________________________________________________________________________

Who completed the procedure? _______________________________________________________________________________________

Mail a copy of this worksheet to Alberta Environment, Groundwater Information Centre.
Include a copy of the original drilling report if possible.

* Working copies are included in the pocket on the back cover.
Groundwater Management

Water is one of Alberta’s most important natural resources. It is one of the building blocks for balanced economic development in the province.

Both surface water and groundwater are found in relative abundance in many areas of Alberta. By careful use and protection of these resources, we can count on a secure supply of water for future generations. Two primary pieces of legislation provide a framework for water management and protection.

The ownership of all surface and groundwater is vested in the province. The Water Act provides a system for licensing both surface water and groundwater diversions and use. Approvals are required for drilling and constructing water wells by drilling contractors and for the exploration of groundwater.

The Environmental Protection and Enhancement Act provides control and prevention of the release of substances that will cause an adverse effect on water resources. It also requires proper reclamation or remediation of contaminated groundwater sites and environmental impact assessments to determine the effects that any major development will have on our water resources.

Groundwater supplies in Alberta are currently managed through:

- Inventory
- Allocation and licensing
- Protection and conservation.

In designing legislation and policies, surface water and groundwater are taken to be two forms of the same resource.
Inventory

Alberta Environment maintains a comprehensive inventory of groundwater resources at the Groundwater Information Centre. The primary purpose of the centre is to collect, store and disseminate water well information and hydrogeological reports. Their data includes the following information.

<table>
<thead>
<tr>
<th>Hydrogeological Information</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water well drillers’ reports</td>
<td>Well owner’s name</td>
</tr>
<tr>
<td>Geophysical logs</td>
<td>Legal land location</td>
</tr>
<tr>
<td>Lithology</td>
<td>Driller</td>
</tr>
<tr>
<td>Water well chemistry</td>
<td>Drilling dates</td>
</tr>
<tr>
<td>Pumping test data</td>
<td>Well construction details</td>
</tr>
<tr>
<td>Groundwater exploration and evaluation reports</td>
<td>Intended use of water</td>
</tr>
<tr>
<td>Observation well monitoring data</td>
<td>Anticipated water requirement</td>
</tr>
</tbody>
</table>

All this information is available to the public. It is useful to collect information about water sources and wells in your area before you begin new well construction.

Alberta Environment also maintains a provincial observation well network of over 340 wells ranging in depth from 5-400 m (16-1312 ft.). Data on water quality and water level fluctuations are gathered continuously from these wells.

A series of regional groundwater reports is being produced for counties and municipal districts in Alberta. These reports provide an overview of groundwater resources and characteristics. Shallow and deep aquifers are identified along with potential yield and water quality. These reports can be viewed at county offices (where available) on the PFRA website (www.agr.ca/pfra/water/groundw.htm) or purchased on CD ROM from the Alberta Geological Survey. See Module 11 “Contacts for More Information.”

* The map on page 86 is shaded to show the counties in Alberta that currently have groundwater assessments done.
Allocation and Licensing

The right to divert and use surface water and groundwater may be obtained through a licence issued to the user. The terms and conditions of the licence are intended to protect the source of water supply, the rights of the licensee and the rights of other water users.

Under the Water Act, the priority on the licence (the date) determines priority of use. A user who was licensed first has prior right to the water source before those licensed at a later date. These rights are valid as long as the specified use continues. It can be cancelled for:

- Not exercising the right to use the water (non-use)
- Non-performance of a condition of a licence.

During emergency situations, the government has the power to suspend a water licence and redesignate the water for other uses.

Licensing is not required when water is used for household purposes. The legislation clearly defines "household purposes" as the use of a maximum of 1,250 m³ of water per year per household (750 gallons per day (gpd)), for the purposes of human consumption, sanitation, fire prevention and watering animals, gardens, lawns and trees. A "household" is further defined as one or more individuals living in a single, private and detached dwelling place.

Legislation further provides that water for household purposes has priority over all other water uses, and has no priority in relation to other household users. This means that during times of shortage, household users are entitled to their statutory right before other users of water and all household users have equal priority.

In the Water Act, a new category of rights is defined as the "traditional agricultural user" that applies to water historically used for watering livestock and pesticide application to crops. Users were given opportunity, up until December 31, 2001, to register up to 6,250 m³ of water per year (3,767 gpd). The registration protects the user’s right to use water by assigning the registration a priority number “grandfathered” back to the date when the water was first put to use. Registration was voluntary; however, if the user decided not to register, they could continue to use the water, but such use would not be protected.

Registration does not guarantee that a producing aquifer will always be capable of supplying the amount of water that you are using. In addition, water required in excess of the registered amount, or for any other agricultural purpose, does require formal licensing.
Obtaining a Licence

For licensable projects, you will need to make application under the Water Act for a licence to use groundwater. You will be required to provide information about your project, such as:

- Location of your well(s), whether existing or newly drilled
- Anticipated depth interval that water will be used from
- Total quantity of water needed
- Time frame for water use (year round or seasonal).

This information will be reviewed to determine whether or not you will be required to give public notice of your project. If the project is large, public notice will be necessary. This gives local water users an opportunity to voice any concerns.

If there are no concerns and you have provided enough information to prove that your project can operate without causing any negative impact on any local users or the aquifer, a licence may be issued.

However if there was opposition to your public notice, or if it is felt that additional information is needed to support your application, you will be issued an approval with specific conditions that must be met. A survey of existing water users is generally required, as is a pumping test to determine water availability and the potential impact your project will have on existing water users.

A licence may be issued after all the required information is received, all concerns are addressed and after a review of your file satisfies the department that your well is capable of providing adequate water for your project without causing:

- Unreasonable interference with other water users
- Adverse effect on the aquifer or the environment.

Your licence may include conditions requiring you to submit monitoring data including water level fluctuations, quantities of water used and water quality. It may also include investigating any complaints from nearby water users and monitoring of other water wells.

The licence will have an expiry date based on the nature of the project or the applicant’s estimation of how long the project will be in existence.
Protection and Conservation

Protecting groundwater resources against overuse, mining and pollution is an integral part of any water management strategy.

Both the Water Act and the Environmental Protection and Enhancement Act provide protection for our water resources. For example, all water well drilling contractors must obtain an approval that authorizes them to drill water wells in the province. The approval is issued only if the company has certified journeyman water well drillers available to operate each one of their drilling machines. The standards for the drilling, construction and reclamation of wells is outlined in the Water (Ministerial) Regulation of the Water Act and it applies to all water wells, whether they are installed for temporary water supply or for long-term use.

While regulations and legislation go a long to way to protect our water sources, it is the users who have the greatest impact on the safety of the water supply. We can no longer take for granted an unending supply of good quality water. Water must be managed, protected and conserved for future use.

See Module 9 "Plugging Abandoned Wells" for details on how to properly plug a well.
Contacts For More Information

The purpose of this module is to provide Albertans with a list of agencies and people who can help them with their rural water needs and problems. This is a topical list and each number (1 to 11) represents a separate topic. To use the reference simply skim through the topics until you find the appropriate agency or person who can help you with your specific request.

1. Information on farm water systems, water treatment, water quality, on-farm water management and programs
website: www.agric.gov.ab.ca

Alberta Agriculture and Food
Agricultural Water Specialist 310-FARM (3276)

2. Information on provincial groundwater supplies or specific water well records
website: environment.alberta.ca/

Alberta Environment
Groundwater Information Centre
11th Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
T5K 2J6
Phone: (780) 427-2770
Fax: (780) 427-1214
Email: gwinfogov.ab.ca

Microfiche and computer files of well drillers’ reports, water analysis and groundwater related reports are available. Over 500,000 records are on file.
Module 11 — Contacts For More Information

3. Information on surface water and groundwater supplies, including water wells.

Agri-Environment Services Branch (AESB), Agriculture and Agri Food Canada

District offices:

Peace River
Green Valley Centre
9910 - 102nd Street
P.O. Box 7047
Peace River, Alberta T8S 1S7
Telephone: (780) 624-3386
Fax: (780) 624-8123

Westlock
#204, 10619 - 100 Avenue
Westlock, Alberta T7P 2J4
Telephone: (780) 349-3963
Fax: (780) 349-6186

Vegreville
Suite 101 Professional Building
4902 - 50th Street, Box 1079
Vegreville, Alberta T9C 1S2
Telephone: (780) 632-2919
Fax: (780) 632-2150

Dawson Creek
#104, 1508 - 102nd Avenue
Dawson Creek, British Columbia V1G 2E2
Telephone: (250) 782-3116
Fax: (250) 782-8156

Hanna
2nd Floor 302 Centre Street
P.O. Box 428
Hanna, Alberta T0J 1P0
Telephone: (403) 854-4448
Fax: (403) 854-4989

Lethbridge
704 - 4th Avenue South
Lethbridge, Alberta T1J 0N8
Telephone: (403) 327-4340
Fax: (403) 382-3198

Medicine Hat
#210, 1865 Dunsmore Road S.E.
Medicine Hat, Alberta T1A 1Z8
Telephone: (403) 526-2429
Fax: (403) 526-0358

Red Deer
#201, 4805 - 48 Avenue
Red Deer, Alberta T4N 3T2
Telephone: (403) 340-4290
Fax: (403) 341-7071

The grey area on the map shows the area where Groundwater Reports have been completed at the time of printing.

For the most current list of Groundwater Reports check the Alberta Geological survey website, and look under special reports: www.ags.gov.ab.ca/publications/
Module 11 — Contacts For More Information

4. Licensing the diversion and use of water wells through Alberta Environment

Alberta Environment

District Approvals Manager, Northern Region
—Edmonton
111, 4999 - 98 Avenue
Twin Atria Building
Edmonton, Alberta T6B 2X3
Telephone: (780) 427-7617
Fax: (780) 422-0528

—Peace River
Bag 900-5, Provincial Building,
Peace River, Alberta T8S 1T4
Telephone: (780) 62406167
Fax: (780) 624-6335

District Approvals Manager, Central Region—Spruce Grove
250 Diamond Avenue
Spruce Grove, Alberta T7X 4C7
Telephone: (780) 960-8600
Fax: (780) 960-8605

District Approvals Manager, Central Region—Red Deer
3rd Floor, 4920 - 51 Street
Red Deer, Alberta T4N 6K8
Telephone: (403) 340-7052
Fax: (403) 340-5022

District Approvals Manager, Southern Region—Calgary
2938 - 11 Street, NE
Calgary, Alberta T2E 7L7
Telephone: (403) 297-7602
Fax: (403) 297-2749

District Approvals Manager, Southern Region—Lethbridge
200 - 5 Ave, S Prov Bldg
Lethbridge, Alberta T1J 4L1
Telephone: (403) 382-4254
Fax: (403) 381-5337
5. Problems with well construction or water well drillers
   a) Contact water well driller first.
   b) Contact:
      Alberta Environment
      Enforcement and Monitoring
      Central Complaint Line
      1-800-222-6514

6. Complaints about seismic activity, water wells affected by seismic activity, seismic trespass, and damage
   a) Call seismic company first (if unsure of company, contact Municipal Administrator).
   b) Problems on private land contact:
      Alberta Environment
      Land and Forest Services
      Phone: (780) 427-3932

      Problems on public lands contact:
      Alberta Agriculture and Rural Development
      Public Lands Management Branch
      Phone: (780) 427-6597

      - These departments have investigators that will look into the problem and mediate complaints.
   c) If not resolved, the “Water Well Restoration or Replacement Program” is available through the Farmers’ Advocate’s office. Phone (780) 427-2433.

7. Complaints about water wells affected by oil and gas well activities (including coal bed methane)
   a) Contact oil or gas drilling company first.
   b) Contact:
      Alberta Environment
      Enforcement and Monitoring
      Central Complaint Line
      1-800-222-6514

      c) If not resolved, the “Water Well Restoration or Replacement Program” is available through the Farmers’ Advocate’s office. Phone: (780) 427-2433
8. Groundwater contamination

Contact:
Alberta Environment
Enforcement and Monitoring
Central Complaint Line
1-800-222-6514

9. Water Analysis

Water can be tested by a variety of laboratories, depending on the requirements.

a) When water is used for human consumption and human health is a concern, a routine chemical analysis and bacterial analysis can be done. Contact your local health unit. There may be a nominal fee required.

b) When water testing is for mortgage approvals and other non-health related purposes, you must use a private lab. Check your yellow pages under “Laboratories.”

10. Private sewage systems requirements

a) Alberta Employment, Immigration and Industry Communications
Phone: (780) 427-5585

b) Municipal Affairs — Safety Services
Phone: 1-866-421-6929
www.municipalaffairs.gov.ab.ca/ss_index.htm

11. Other Information Sources

a) Alberta Water Well Drilling Association
Box 130
Lougheed, Alberta
T0B 2V0
Phone: (780) 386-2335
www.awwda.com

b) Canadian Ground Water Association
Office of the Secretary Manager
1600 Bedford Highway
Suite 100 - 409
Bedford, Nova Scotia B4A 1E8
Phone: (902) 845-1885
www.cgwa.org
Other Resources

General Water-Related Information

Biannual Prairie Water News.
To obtain a subscription to Prairie Water News, write to:

Prairie Water News
c/o Saskatchewan Research Council
125-15 Innovation Blvd.
Saskatoon, Saskatchewan
S7N 2X8
website: www.prairiewaternews.ca

Planning Your Water System

The following FS716 series of fact sheets and manuals are available from the Publications Office of Alberta Agriculture and Food:

- Drought Proofing Farm Water Supplies
- Spring Development
- Small Earth Fill Dams
- Farm Water Supply Requirements
- Choosing a Water Pump
- Shallow Well Jet Pumps
- Submersible Pumps
- Pump Houses
- Pitless Adaptors
- Pressure Tanks
- Frost Free Yard Hydrants
- Automatic Livestock Waterers
- Pasture Water Systems for Livestock
- Quality Farm Dugouts (Manual)
- Hydrated Lime for Algae Control in Dugouts

To obtain a publication or video contact:
Publications Office
Alberta Agriculture and Rural Development
7000 - 113 St.
Edmonton, AB T6H 5T6
Phone toll free: 1-800-292-5697
FAX: (780) 422-8835
website: http://www.agric.gov.ab.ca/publications
Design and Construction of Water Wells
For specific water well records and general groundwater conditions, contact:
Groundwater Information Centre
11th Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6
Phone: (780) 427-2770

Water Wells That Last Video
Part I—Planning and Construction

To obtain a video, contact the Publications Office
(see previous page)
or
Alberta Government Library
Neil Crawford Provincial Centre Site
7000-113 Street
Edmonton, AB T6H 5T6
Phone toll free: 310-0000 and (780) 427-2104

Monitoring Your Water Well
From Publications Office of Alberta Agriculture and Food:
Chemical Analysis of Farm Water Supplies

Water Wells That Last Video
Part II — Managing and Maintaining

Shock Chlorination of Water Wells
From Publications Office of Alberta Agriculture and Food:
Alternatives for Iron Removal
Removing Hydrogen Sulfide Gas From Water

Water Wells That Last Video
Part III — Shock Chlorination
Troubleshooting Water Well Problems

From Publications Office of Alberta Agriculture and Food:
- Chemical Analysis of Farm Water Supplies
- Removing Hydrogen Sulfide Gas From Water
- Alternatives for Iron Removal
- Dissolved Gases in Well Water
- Water Softening
- Reverse Osmosis Water Treatment
- Small Water Filters for Taste, Odour and Sediment Removal
- Water Distillers

Protecting Your Well From Contamination

From Publications Office of Alberta Agriculture and Food:
- Pitless Adaptors
- Shock Chlorination and Control of Iron Bacteria
- Agricultural Impacts on Water Quality in Alberta—An Initial Assessment
- Groundwater Vulnerability in Alberta
- Protect Groundwater Quality—Minimize the Risk
- Coal Bed Methane (CBM) Wells and Water Well Protection
- Methane Gas in Well Water
- Water Wells That Last Video, Part II—Managing and Maintaining
- Farm Fuel Storage and Handling

From Learning Resource Distributing Center, Edmonton
Phone: (780) 427-2767
Fax: (780) 422-9750

Alberta Private Sewage Systems — Standards of Practice 1999
Glossary

abandoned well - a well that is no longer used or maintained for future use.

aquiclude - a water bearing layer or formation that cannot yield sufficient water for wells.

aquifer - a water bearing formation that yields water to wells in usable amounts.

artesian aquifer - a water bearing formation in which water is under sufficient pressure that the water level rises above the top of the aquifer.

artesian well - a water well drilled into an artesian aquifer where enough pressure exists for the water to flow to the surface without pumping. It is synonymous with a flowing artesian well.

bedrock - solid rock that usually underlies layers of loose soil material; bedrock may also be exposed to the land surface.

bored wells - a large diameter well that is constructed when low yielding groundwater sources are found usually within 30 m (100 ft.) of the ground surface. The larger diameter well casing is usually .3-.9 m (1-3 ft.) in diameter and can provide the additional water storage required during times of high water demand.

borehole - a hole drilled, bored or dug into the ground in which a well casing is placed.

casing - a metal, plastic or fiberglass pipe installed in a well borehole to maintain the well opening and contain the well pumping equipment.

cistern - a tank or reservoir used for storing water. Cisterns are sometimes used with low producing water wells to provide the necessary water required during times of high water demand.

coliform bacteria - bacteria that are used in testing water to indicate the possible presence of more harmful disease-causing pathogenic bacteria.

confined aquifer - an aquifer that lies between two relatively impermeable rock layers.

contamination - the deterioration in natural water quality caused by the introduction of foreign matter into water.
**discharge area** - an area where groundwater emerges at the ground surface either as a spring or seep, or into a surface water body because of the amount of pressure exerted on the groundwater.

**drawdown** - a measure of the amount the water level drops in a well during pumping.

**drilled wells** - small diameter wells, usually 10-20 cm (4-8 in.) in diameter, which can be completed to much greater depths than bored wells, up to several hundred meters.

**fecal coliform** - a type of coliform bacteria present in the intestinal tracts and feces of warm-blooded animals and humans.

**flowing well** - a well where the water level is above the ground level and thus it flows out on to the ground surface. The flow of these wells should be controlled so as not to deplete the aquifer or cause surface flooding concerns.

**fracture** - a general term to describe a break or crack in rock formations. Rock formations with more and larger fractures allow water to flow easily through them and supply water for wells.

**groundwater** - all water under the ground surface that is contained in the soil and bedrock.

**groundwater vulnerability** - the sensitivity of a groundwater system to human and/or natural impacts that could affect the supply and/or quality of groundwater.

**grout** - a sealing material of bentonite or cement used to create a sanitary seal in the annular space between the borehole wall and the well casing. This prevents the vertical movement of water that can contaminate a well.

**hard water** - water containing a high level of calcium, magnesium and other minerals. Hard water can result in a mineral scale buildup or incrustation on the well screen and perforated openings into the well.

**hydrologic cycle or water cycle** - the continuous circulation of water from the atmosphere to the earth and back to the atmosphere including condensation, precipitation, runoff, groundwater flow, evaporation and transpiration.

**impermeable** - material such as soil or rock that does not allow fluids such as water to flow through them.
iron bacteria - microorganisms that consume dissolved iron, either from water or from steel pipe, and produce a slimy gel-like deposit. These organisms tend to collect in water pipes and tanks during periods of low flow, and then break loose in slugs of turbid water to create staining, taste and odor problems. They can also accumulate on perforated well screens, well liners and pump screens and thus reduce water flows from a well.

leaching - a natural process by which water transports salts and other soluble materials down through the soil and eventually into groundwater.

milligrams per liter - mg/L - milligrams per liter of water is a measure that is equivalent to parts per million (ppm) or in other words one part in a million parts.

nitrate and nitrogen - plant nutrients that can cause an overabundance of bacteria when high amounts are present. Several forms occur in water, including ammonia, nitrate, nitrite or elemental nitrogen. High levels of nitrate in groundwater can result from seepage of agricultural products and by-products such as chemical fertilizers, livestock manure and piles of silage fed to livestock.

non-potable water - water that is not suitable for human consumption.

pathogen - microorganisms that can cause disease.

percolation - the movement of water through the subsurface soil layers, usually continuing downward to the groundwater or water table reservoirs.

permeable - material such as soil or rock that does allow fluids such as water to flow through them.

pH - numeric value that describes the intensity of the acid or basic (alkaline) conditions of a solution such as water. The pH scale is from 0 to 14, with the neutral point at 7.0. Values lower than 7 indicate the presence of acids and greater than 7.0 the presence of alkalis (bases). Most well water ranges in pH from 6.5 to 8.5.

plug - bentonite, cement grout or other impermeable material used to fill and seal the borehole around the casing of a water well.

pollution - undesirable change in the physical, chemical or biological characteristics of the air, water or land that can harm the health, survival or activities of human or other living organisms.
**Glossary**

**porous** - a measure of the volume of empty space in a material such as soil or rock.

**potable water** - water that is safe for human consumption.

**pumping water level** - the level at which water stands in a well when pumping is in progress.

**recharge** - refers to water flowing into and replenishing an aquifer's supply of water.

**recharge area** - an area where water flows down through the soil and/or rock and replenishes the supply of groundwater below.

**runoff** - surface water entering rivers, freshwater lakes or reservoirs.

**sand pack or filter pack** - sand that is smooth, uniform, clean and well rounded. It is sometimes called frac sand and is placed in a well borehole outside a well screen. Its purpose is to prevent material such as fine sediment from entering through the screen and into the well.

**seal** - the impermeable material, such as betonite or cement grout, that is placed in the annular space between the borehole wall and the casing of a water well to prevent the downward movement of surface water or the vertical mixing of waters from different aquifers.

**septic tank** - an underground storage container that collects wastewater from a home. The bacteria in the sewage decompose the organic wastes, and the sludge settles to the bottom of the tank. The effluent flows out of the tank into the ground through drains or is pumped on to the ground surface.

**shock chlorination** - an inexpensive and straightforward treatment used to control bacteria in water wells. The treatment involves placing a strong solution of chlorine and water down a well for approximately 8 to 48 hours to kill off the bacteria. The well is then pumped for a number of hours to flush out the bacteria and until the chlorine smell disappears. Regular shock chlorination treatments once or twice per year are usually very effective at controlling the problems associated with iron and sulfate-reducing bacteria.

**spring** - a natural flow of groundwater on to the ground's surface.

**static or non-pumping water level** - the static water level is the level at which water stands in a well when the water level is at equilibrium with atmospheric pressures. It is a measure of the depth from the ground surface or top of the well casing to the water level.
sulfate-reducing bacteria - microorganisms that break down the naturally occurring sulfate in groundwater and produce hydrogen sulfide gas. Wells affected by this bacteria will develop a rotten egg odor and a slimy deposit build-up on water pipes and plumbing fixtures. Regular shock chlorination is usually very effective at controlling sulfate-reducing bacteria in wells.

TDS - total dissolved solids - the sum of all inorganic and organic substances dissolved in water. Generally the lower the TDS level, the better the water quality.

water table - the water surface or water level below which the pore spaces in soil and rock are saturated with water.

water table aquifer - a shallow aquifer confined only by atmospheric pressure.

well development - the act of pumping and/or surging water or air in a well to remove drilling mud and granular material from within the sand pack, borehole wall and aquifer immediately adjacent to the perforated well screen or liner. The purpose is to clean the well so that pumped water will be free of sediment and also to maximize the amount of water that can be pumped from the well.

water well - any artificial excavation constructed for the purpose of exploring for or producing groundwater.

well yield - the volume of water pumped from a well in gallons per minute.

wetland - area that is regularly wet or flooded and has a water table that stands at or above the land surface for at least part of the year, such as a marsh or bog.
Worksheet

Average Daily and Annual Water Requirements

The average daily and annual water requirement numbers can be used for estimating the amount of water used on a farm. The average daily water requirements are based on typical average outside or in-barn temperatures that occur throughout the year. These numbers, however, cannot be used for designing the water supplies and pumping capacity of a farm water system. For example, consider a beef feedlot on a hot summer day. Feeder cattle will drink approximately twice the amounts shown in the table below. For this reason, the water supply and pumping systems need to be designed to meet these peak demands.

<table>
<thead>
<tr>
<th>Household use:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>People</td>
<td>_____ x 60.0 gpd</td>
<td>= ________________ gpd</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beef:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeders¹</td>
<td>550 lb. _____ x 4.0 gpd = _____________ gpd</td>
<td>feeders on silage</td>
</tr>
<tr>
<td></td>
<td>900 lb. _____ x 7.0 gpd = _____________ gpd</td>
<td>feeders on silage</td>
</tr>
<tr>
<td></td>
<td>1250 lb. _____ x 10.0 gpd = _____________ gpd</td>
<td>feeders on silage</td>
</tr>
<tr>
<td>Cows with Calves²</td>
<td>1300 lb. _____ x 12.0 gpd = _____________ gpd</td>
<td>on pasture or hay</td>
</tr>
<tr>
<td>Dry Cow²</td>
<td>1300 lb. _____ x 10.0 gpd = _____________ gpd</td>
<td>on pasture or hay</td>
</tr>
<tr>
<td>Calves²</td>
<td>250 lb. _____ x 2.0 gpd = _____________ gpd</td>
<td>on pasture or hay</td>
</tr>
</tbody>
</table>

¹ For peak demand on hot summer days above 25°C, multiply gpd x 2
² For peak demand on hot summer days above 25°C, multiply gpd x 1.5

<table>
<thead>
<tr>
<th>Swine³</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Farrow-Finish⁴</td>
<td>_____ x 20.0 gpd = _____________ gpd</td>
<td></td>
</tr>
<tr>
<td>Farrow-Late Wean⁴</td>
<td>50 lb. _____ x 6.5 gpd = _____________ gpd</td>
<td></td>
</tr>
<tr>
<td>Farrow-Early Wean⁴</td>
<td>15 lb. _____ x 5.5 gpd = _____________ gpd</td>
<td></td>
</tr>
<tr>
<td>Feeder</td>
<td>50-250 lb. _____ x 1.5 gpd = _____________ gpd</td>
<td></td>
</tr>
<tr>
<td>Weaner</td>
<td>15-50 lb. _____ x 0.5 gpd = _____________ gpd</td>
<td></td>
</tr>
</tbody>
</table>

Sub Total ______________ gpd

³ Includes wash water for all types of swine operations.
⁴ No. of animals = No. of breeding sows.

* Store the completed worksheet in the back pocket.
### Module 2 — Planning Your Water System

#### Dairy:

<table>
<thead>
<tr>
<th>Animal Type/Size</th>
<th>No. of Animals</th>
<th>Daily Water Requirement (gpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milking Cow</td>
<td>Holstein</td>
<td>30.0 gpd = ______________ gpd</td>
</tr>
<tr>
<td>Dry Cows/Replacement Heifers</td>
<td>Holstein</td>
<td>10.0 gpd = ______________ gpd</td>
</tr>
<tr>
<td>Calves to 550 lb.</td>
<td></td>
<td>3.0 gpd = ______________ gpd</td>
</tr>
</tbody>
</table>

4 Includes 3 gpd/cow for wash water

#### Poultry:

<table>
<thead>
<tr>
<th>No. of Birds</th>
<th>Daily Water Requirement (gpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broilers</td>
<td>.035 gpd = ______________ gpd</td>
</tr>
<tr>
<td>Roasters/Pullets</td>
<td>.040 gpd = ______________ gpd</td>
</tr>
<tr>
<td>Layers</td>
<td>.055 gpd = ______________ gpd</td>
</tr>
<tr>
<td>Breeders</td>
<td>.070 gpd = ______________ gpd</td>
</tr>
<tr>
<td>Turkey Growers</td>
<td>.130 gpd = ______________ gpd</td>
</tr>
<tr>
<td>Turkey Heavies</td>
<td>.160 gpd = ______________ gpd</td>
</tr>
</tbody>
</table>

#### Sheep/Goats:

<table>
<thead>
<tr>
<th>Daily Water Requirement (gpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ewes/Does</td>
</tr>
<tr>
<td>Milking Ewes/Does</td>
</tr>
</tbody>
</table>

#### Horses, Bisons, Mules

<table>
<thead>
<tr>
<th>Daily Water Requirement (gpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk, Donkeys</td>
</tr>
<tr>
<td>Deer, Llamas, Alpacas</td>
</tr>
<tr>
<td>Ostriches</td>
</tr>
</tbody>
</table>

Sub Total ______________ gpd

Total Daily Livestock Water Requirements ______________ gpd

#### Annual Water Requirements

Irrigation of garden and yard in the summer (assume 6 in. application)

<table>
<thead>
<tr>
<th>Area in square feet</th>
<th>Chemical spraying (acres)</th>
<th>Fire (min. 1200 gal./2 hour period)</th>
<th>Other uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>_______ x 3 gal./sq. ft.</td>
<td>_____ x ___ gal/acre x _____ no. of applications</td>
<td>= ________ gal.</td>
<td>= ________ gal.</td>
</tr>
<tr>
<td>Greenhouse</td>
<td></td>
<td>= ________ gal.</td>
<td></td>
</tr>
</tbody>
</table>

Total daily livestock water requirements (from above) _____ gpd x 365 days = ________ gal.

Total Annual Water Requirements ________ gal.

* For information on water requirements for field crops, contact an irrigation specialist.

Note: These livestock and poultry water requirement numbers have been compiled with input from Alberta Agriculture and Rural Development staff. If you have questions or comments, please call an Agricultural Water Specialist at 310-FARM (3267). Also visit our website: [www.agric.gov.ab.ca](http://www.agric.gov.ab.ca) and use the calculator for determining the size of a dugout.

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Module 2 — Planning Your Water System

Worksheet

Average Daily and Annual Water Requirements

The average daily and annual water requirement numbers can be used for estimating the amount of water used on a farm. The average daily water requirements are based on typical average outside or in-barn temperatures that occur throughout the year. These numbers, however, cannot be used for designing the water supplies and pumping capacity of a farm water system. For example, consider a beef feedlot on a hot summer day. Feeder cattle will drink approximately twice the amounts shown in the table below. For this reason, the water supply and pumping systems need to be designed to meet these peak demands.

### Household use:

People _______ x 60.0 gpd = _____________ gpd

### Beef:

<table>
<thead>
<tr>
<th>Animal Size</th>
<th>No. of Animals</th>
<th>gpd =</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeders 550 lb.</td>
<td>____ x 4.0</td>
<td>_______ gpd</td>
<td>feeders on silage</td>
</tr>
<tr>
<td>Feeders 900 lb.</td>
<td>____ x 7.0</td>
<td>_______ gpd</td>
<td>feeders on silage</td>
</tr>
<tr>
<td>Feeders 1250 lb.</td>
<td>____ x 10.0</td>
<td>_______ gpd</td>
<td>feeders on silage</td>
</tr>
<tr>
<td>Cows with Calves 1300 lb.</td>
<td>____ x 12.0</td>
<td>_______ gpd</td>
<td>on pasture or hay</td>
</tr>
<tr>
<td>Dry Cow 1300 lb.</td>
<td>____ x 10.0</td>
<td>_______ gpd</td>
<td>on pasture or hay</td>
</tr>
<tr>
<td>Calves 250 lb.</td>
<td>____ x 2.0</td>
<td>_______ gpd</td>
<td>on pasture or hay</td>
</tr>
</tbody>
</table>

Sub Total _______ gpd

1 For peak demand on hot summer days above 25°C, multiply gpd x 2
2 For peak demand on hot summer days above 25°C, multiply gpd x 1.5

### Swine:

<table>
<thead>
<tr>
<th>Animal Size</th>
<th>No. of Animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farrow-Finish 4</td>
<td>____ x 20.0</td>
</tr>
<tr>
<td>Farrow-Late Wean 4</td>
<td>____ x 6.5</td>
</tr>
<tr>
<td>Farrow-Early Wean 4</td>
<td>____ x 5.5</td>
</tr>
<tr>
<td>Feeder 50-250 lb.</td>
<td>____ x 1.5</td>
</tr>
<tr>
<td>Weaner 15-50 lb.</td>
<td>____ x 0.5</td>
</tr>
</tbody>
</table>

Sub Total _______ gpd

3 Includes wash water for all types of swine operations.
4 No. of animals = No. of breeding sows.

* Store the completed worksheet in the back pocket.
### Module 2 — Planning Your Water System

#### Dairy:

<table>
<thead>
<tr>
<th>Animal Type/Size</th>
<th>No. of Animals</th>
<th>Daily Water Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milking Cow</td>
<td>Holstein</td>
<td>30.0 gpd</td>
</tr>
<tr>
<td>Dry Cows/Replacement Heifers</td>
<td>Holstein</td>
<td>10.0 gpd</td>
</tr>
<tr>
<td>Calves</td>
<td>To 550 lb.</td>
<td>3.0 gpd</td>
</tr>
</tbody>
</table>

4 Includes 3 gpd/cow for wash water

### Poultry:

<table>
<thead>
<tr>
<th>Type/Size</th>
<th>No. of Birds</th>
<th>Daily Water Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broilers</td>
<td>______ x .035</td>
<td>gpd</td>
</tr>
<tr>
<td>Roasters/Pullets</td>
<td>______ x .040</td>
<td>gpd</td>
</tr>
<tr>
<td>Layers</td>
<td>______ x .055</td>
<td>gpd</td>
</tr>
<tr>
<td>Breeders</td>
<td>______ x .070</td>
<td>gpd</td>
</tr>
<tr>
<td>Turkey Growers</td>
<td>______ x .130</td>
<td>gpd</td>
</tr>
<tr>
<td>Turkey Heavies</td>
<td>______ x .160</td>
<td>gpd</td>
</tr>
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</table>

### Sheep/Goats:

<table>
<thead>
<tr>
<th>Type/Size</th>
<th>Daily Water Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ewes/Does</td>
<td>______ x 2.0 gpd</td>
</tr>
<tr>
<td>Milking Ewes/Does</td>
<td>______ x 3.0 gpd</td>
</tr>
</tbody>
</table>

### Horses, Bisons, Mules

<table>
<thead>
<tr>
<th>Type/Size</th>
<th>Daily Water Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>______ x 10.0 gpd</td>
<td></td>
</tr>
</tbody>
</table>

### Elk, Donkeys

<table>
<thead>
<tr>
<th>Type/Size</th>
<th>Daily Water Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>______ x 5.0 gpd</td>
<td></td>
</tr>
</tbody>
</table>

### Deer, Llamas, Alpacas

<table>
<thead>
<tr>
<th>Type/Size</th>
<th>Daily Water Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>______ x 2.0 gpd</td>
<td></td>
</tr>
</tbody>
</table>

### Ostriches

<table>
<thead>
<tr>
<th>Type/Size</th>
<th>Daily Water Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>______ x 1.0 gpd</td>
<td></td>
</tr>
</tbody>
</table>

### Sub Total

<table>
<thead>
<tr>
<th>Daily Water Requirement</th>
</tr>
</thead>
</table>

### Total Daily Livestock Water Requirements

#### Annual Water Requirements

<table>
<thead>
<tr>
<th>Activity</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation of garden and yard</td>
<td>Area in square feet ______ x 3 gal./sq. ft. = ______ gal.</td>
</tr>
<tr>
<td>Chemical spraying (acres)</td>
<td>______ x ______ gal/acre x ______ no. of applications = ______ gal.</td>
</tr>
<tr>
<td>Greenhouse</td>
<td>= ______ gal.</td>
</tr>
<tr>
<td>Fire (min. 1200 gal./2 hour period)</td>
<td>= ______ gal.</td>
</tr>
<tr>
<td>Other uses</td>
<td>= ______ gal.</td>
</tr>
<tr>
<td>Total daily livestock water requirements (from above)</td>
<td>______ gpd x 365 days = ______ gal.</td>
</tr>
</tbody>
</table>

### Total Annual Water Requirements

| Total Annual Water Requirements | ______ gal. |

* For information on water requirements for field crops, contact an irrigation specialist.

Note: These livestock and poultry water requirement numbers have been compiled with input from Alberta Agriculture and Rural Development staff. If you have questions or comments, please call an Agricultural Water Specialist at 310-FARM (3267). Also visit our website: [www.agric.gov.ab.ca](http://www.agric.gov.ab.ca) and use the calculator for determining the size of a dugout.

* Store the completed worksheet in the back pocket.
# Worksheet

## Sizing of Water Systems

<table>
<thead>
<tr>
<th>Water System Fixtures</th>
<th>Peak Use Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic cattle waterers (100 head size)</td>
<td>___ X 2 gpm = _____ gpm</td>
</tr>
<tr>
<td>Hog nipple waterer</td>
<td>___ X 1 gpm = _____ gpm</td>
</tr>
<tr>
<td>Poultry fountain</td>
<td>___ X 1 gpm = _____ gpm</td>
</tr>
<tr>
<td>Yard hydrants</td>
<td>___ X 5 gpm = _____ gpm</td>
</tr>
<tr>
<td>Household (number of households)</td>
<td>___ X 5-10 gpm = _____ gpm</td>
</tr>
<tr>
<td>Fire hydrant</td>
<td>___ X 10 gpm = _____ gpm</td>
</tr>
<tr>
<td>Other</td>
<td>___ X ___gpm = _____ gpm</td>
</tr>
</tbody>
</table>

Note: The minimum design flow rate of the system must exceed the peak use rate of the fixture that uses the largest amount of water.

Note: If the well is not solely capable of providing enough water for your peak use demand, you will need to install a water storage facility such as a cistern. The well can be operated without over pumping, and the water storage provided by the cistern will ensure water for all your activities.

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**Worksheet**

**Sizing of Water Systems**

<table>
<thead>
<tr>
<th>Water System Fixtures</th>
<th>Peak Use Rates</th>
<th>gpm = gallons per minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic cattle waterers (100 head size)</td>
<td>___ X 2 gpm = _____ gpm</td>
<td></td>
</tr>
<tr>
<td>Hog nipple waterer</td>
<td>___ X 1 gpm = _____ gpm</td>
<td></td>
</tr>
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<td>Fire hydrant</td>
<td>___ X 10 gpm = _____ gpm</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>___ X ___ gpm = _____ gpm</td>
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</tr>
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Note: The minimum design flow rate of the system must exceed the peak use rate of the fixture that uses the largest amount of water.

Note: If the well is not solely capable of providing enough water for your peak use demand, you will need to install a water storage facility such as a cistern. The well can be operated without over pumping, and the water storage provided by the cistern will ensure water for all your activities.

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# Farm Water Supply Inventory

## A. Wells

<table>
<thead>
<tr>
<th></th>
<th>Well Purpose / Location</th>
<th>Date</th>
<th>Depth Constructed</th>
<th>Casing Diameter (ft.)</th>
<th>Well Production (in.) (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## B. Dugouts

<table>
<thead>
<tr>
<th></th>
<th>Dugout Purpose / Location</th>
<th>Date Constructed</th>
<th>Size (Length, Width, Depth)</th>
<th>Approximate Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## C. Other Water Sources and Their Limitations (Hauling, Springs, Rivers, etc.)

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

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## Farm Water Supply Inventory

### A. Wells

<table>
<thead>
<tr>
<th></th>
<th>Well Purpose / Location</th>
<th>Date</th>
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<th>Casing Diameter (ft.)</th>
<th>Well Production (in.) (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2. Unused Wells / Location

<table>
<thead>
<tr>
<th></th>
<th>Date</th>
<th>Depth Constructed</th>
<th>Date Plugged (ft.)</th>
<th>Materials Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3. Dry Holes

- How many dry holes have been drilled on and around the farmstead? ________________________
- How deep were these dry holes? ________________________

### 4. Water Quality

- What water quality problems limit the usefulness of these wells?
  a. ______________________________________________________________________________
  b. ______________________________________________________________________________
  c. ______________________________________________________________________________

### B. Dugouts

<table>
<thead>
<tr>
<th></th>
<th>Dugout Purpose / Location</th>
<th>Date Constructed</th>
<th>Size (Length, Width, Depth)</th>
<th>Approximate Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2. Problems with these dugouts (e.g., seepage, quality, inadequate run off)

  a. ______________________________________________________________________________
  b. ______________________________________________________________________________
  c. ______________________________________________________________________________

### C. Other Water Sources and Their Limitations (Hauling, Springs, Rivers, etc.)

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

* Store the completed worksheet in the back pocket.
Water Well Drilling Agreement Form

Identification
1. Well owner _______________________________________________________________________________________________________________________
   Address _________________________________________________________________________________________________________________________

2. Drilling contractor ______________________________________________________________________________________________________________
   Address _________________________________________________________________________________________________________________________
   Drilling contractor approval no.___________

3. Land location of well:   Qtr_______  Sec_______  Twp_______  Rge_______  W of_____Meridian      Lot_______  Block_______  Plan_______
4. Proposed starting date __________________________________________________________________________________________________________
   Proposed completion date _________________________________________________________________________________________________________

Water Requirements
5. Proposed well use:  Household______________  Livestock_____________  Irrigation______________

6. Desired water quality  On-site tests:
   total dissolved solids_______________________parts/million  iron_________________________parts/million
   hardness__________________________parts/million  pH_________________________parts/million

7. Desired yield_____________L/s (gpm)    Min. acceptable yield_____________L/s (gpm)

8. Groundwater supply options based on existing records ______________________________________________________________________________

Well Construction
9. Maximum desired depth_______________ m (ft.)
10. Type of drilling ___________________________________________________________________________________________________________________

11. Diameter of hole _________________________________________________________________________________________________________________

12. Flowing well control ______________________________________________________________________________________________________________

13. Well connection __________________________________________________________________________________________________________________

14. Formation logging procedure ______________________________________________________________________________________________________

15. Annulus or casing seal ____________________________________________________________________________________________________________
16. Artificial sand pack

17. Well development method: Backwashing________ Jetting________ Surging________ Heavy pumping________ Bailing________

18. Hydrofracing

<table>
<thead>
<tr>
<th>Material</th>
<th>Inside diameter</th>
<th>wt. per m(ft.)</th>
<th>wall thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screen</td>
<td>Manufacturer</td>
<td>Material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Length</td>
<td>Nominal diameter</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Yield Testing</th>
<th>Yield testing duration (hours)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Disinfection</th>
<th>Disinfection</th>
<th>Well head finishing</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Costs</th>
<th>Test holes per metre (foot)</th>
<th>Sand pack</th>
<th>Reaming per metre (foot)</th>
<th>Development</th>
<th>Drilling/boring per metre (foot)</th>
<th>Hydrofracing</th>
<th>Casing per metre (foot)</th>
<th>Labor per hour</th>
<th>Liner per metre (foot)</th>
<th>Water testing</th>
<th>Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total</th>
<th>Total Costs</th>
<th>Payment schedule</th>
</tr>
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</table>

<table>
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<tr>
<th>Guarantee</th>
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* Store the completed worksheet in the back pocket.
# Module 5 — Monitoring Your Water Well

## Worksheet

### Water Well Monitor

<table>
<thead>
<tr>
<th>Year</th>
<th>Well No.</th>
<th>Qtr</th>
<th>Sec</th>
<th>Twp</th>
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<th>Lot</th>
<th>Blk</th>
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</table>

<table>
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<tr>
<th>Month / Day</th>
<th>Time</th>
<th>Water Level</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pumping</td>
<td>(quality, presence of sediment, yield problems)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-pumping</td>
<td></td>
</tr>
</tbody>
</table>

- January ___
- February ___
- March ___
- April ___
- May ___
- June ___
- July ___
- August ___
- September ___
- October ___
- November ___
- December ___

* At the end of the year, review the chart for any water level trends.

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# Module 5 — Monitoring Your Water Well

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**Water Well Monitor**

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* At the end of the year, review the chart for any water level trends.

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# Worksheet

## Calculating Water and Chlorine Requirements (200 PPM) for Shock Chlorination

Complete the following table using your own figures to determine how much water and chlorine you need to shock chlorinate your well.

<table>
<thead>
<tr>
<th>Casing Diameter (in)</th>
<th>Volume of Water Needed</th>
<th>5 1/4% Domestic Chlorine Bleach</th>
<th>12% Industrial Sodium Hypochlorite</th>
<th>70% High Test Calcium Hypochlorite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Imperial gal. per 1 ft. of water in the casing</td>
<td>L per 1 ft. (30 cm) of water</td>
<td>L per 1 ft. (30 cm) of water</td>
<td>Dry weight per 1 ft. (30 cm) of water</td>
</tr>
<tr>
<td>4 (100)</td>
<td>______ ft. x 1.1 gal. = ______</td>
<td>______ ft. x 0.019 L = ______</td>
<td>______ ft. x 0.008 L = ______</td>
<td>______ ft. x 1.44 g = ______</td>
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<tr>
<td>6 (150)</td>
<td>______ ft. x 2.4 gal. = ______</td>
<td>______ ft. x 0.042 L = ______</td>
<td>______ ft. x 0.018 L = ______</td>
<td>______ ft. x 3.12 g = ______</td>
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<tr>
<td>8 (200)</td>
<td>______ ft. x 4.2 gal. = ______</td>
<td>______ ft. x 0.072 L = ______</td>
<td>______ ft. x 0.032 L = ______</td>
<td>______ ft. x 5.46 g = ______</td>
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<td>24 (600)³</td>
<td>extra 200 gal.</td>
<td>______ ft. x 0.340 L = ______</td>
<td>______ ft. x 0.148 L = ______</td>
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<td>36 (900)³</td>
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1. Domestic chlorine bleach should not have additives or perfumes.
2. Since a dry chemical is being used, it should be mixed with water to form a chlorine solution prior to placing it in the well.

³ See modified procedure for large diameter wells on page 53.

* Store the completed worksheet in the back pocket.
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3. See modified procedure for large diameter wells on page 53.

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Record of Well Plugging

Original landowner's name: ____________________________ Date of plugging: ____________________________

Legal land location of well: Qtr __________ Sec ______ Twp ______ Rge ______ W of ____ Meridian
Lot __________ Blk ______ Plan ___________________________

Location reference points on the farm (i.e., distance from buildings): _____________________________________________

Current well depth: _________________ Original well depth: _________________ Well diameter: _________________

Was well casing removed before plugging? _________________________________________________________________

Water characteristics: (attach any analysis done)

Reason for plugging the well: ________________________________________________________________
______________________________________________________________
______________________________________________________________

Type and quantity of plugging material used: _____________________________________________________________
______________________________________________________________
______________________________________________________________

How was material placed into the well? _________________________________________________________________

Who completed the procedure? ________________________________________________________________

Mail a copy of this worksheet to Alberta Environment, Groundwater Information Centre.
Include a copy of the original drilling report if possible.

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