For more information refer to the Water Wells That Last video (Part I — Planning and Construction).

For more information see Module 1 "Understanding Groundwater" and Module 2 "Planning Your Water System".

A licensed water well contractor cannot always determine in advance the depth at which an adequate water supply will be found. Neighbouring wells offer some guidance but not a definite assurance.

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 licensed water well 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 contractor to ensure you get the well design you need.

Choosing a Licensed Water Well Contractor

Choose a licensed water well contractor who has experience in your area and knows the local geology. Provincial regulation requires that drilling companies have an approval to drill water wells and their drillers must be certified journeyman water well drillers. A list of approval holders is available through Alberta Environment and Sustainable Resource Development (AESRD). You can also contact the Alberta Water Well Drilling Association for a list of approval holders in your area. Refer to Module 11 “Contacts for More Information”.

Either you or the licensed water well 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 design and construction
- Prior drilling success rates.

The Groundwater Information Centre at Alberta Environment and Sustainable Resource Development manages the Alberta Water Well Information Database that has records of water wells in Alberta. Copies of these records can be obtained by calling (780) 427-2770 or can be viewed at www.envinfo.gov.ab.ca/GroundWater/.

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

Other things to consider when choosing a licensed water well contractor are:

- Are they approachable? Can you talk comfortably with them about the local geology, their proposed well design and construction and the pumping equipment they recommend?
- Do they have a good reputation? Ask for references and check whether previous cllients are happy with their wells.
- Are they insured?
- Are their prices competitive? The cheapest estimate may not translate into the best well. Be sure to compare cost estimates carefully.
- Will they use a written contract or agreement?
- Will they provide any guarantee on workmanship and materials?
- Will they be responsible for sizing and placement of the pump?
- Are they knowledgeable and willing to discuss the regulations that govern water well drilling in Alberta?

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 pump house. The pump house must be properly vented to the outside to prevent any build-up of dangerous naturally occurring gases and must house only the well and pumping equipment
- The well is not located in a well pit.

The installation of a leaching cesspool is no longer permitted. It is, however, highly recommended that any newly constructed water well be located at least 30 m (100 ft.) from any existing leaching cesspool. See Module 12 "Other Resources" for the requirements for Alberta Private Sewage Systems.

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 or an outdoor pit privy
- 30 m (98 ft.) from a leaching cesspool*
- 50 m (165 ft.) from sewage effluent discharge to the ground surface
- 100 m (329 ft.) from a sewage lagoon

- 30 m (98 ft.) from pesticide or fertilizer storage
- 50 m (165 ft.) from above-ground fuel storage tanks

- 30 m (98 ft.) from manure or composting materials application
- 100 m (329 ft.) from a manure storage facility or manure collection area or livestock yard
- 100 m (329 ft.) from dead animal burial or composting site

- 2 m (7 ft.) from overhead power lines if:
  - the line conductors are insulated or weatherproofed and the line is 750 volts or less
- 6 m (20 ft.) from overhead power lines if the well:
  - 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

- 3.25 m (11 ft.) from existing buildings
- 6.1 m (20 ft.) from the outer boundary of any road or public highway
- 50 m (165 ft.) from the outer boundary of a graveyard
- 450 m (1476 ft.) from any area where waste is or may be disposed of at a landfill

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:

- Type of well
- Intended use
- Well depth
- Casing material, size and wall thickness
- Intake design
- Annular seal
- Monitoring and preventive maintenance provisions.

Well Depth

During the test hole drilling, the licensed water well contractor will complete a lithologic or 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 zones with the best potential for water supply. Some drillers also run a geophysical (electric) 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

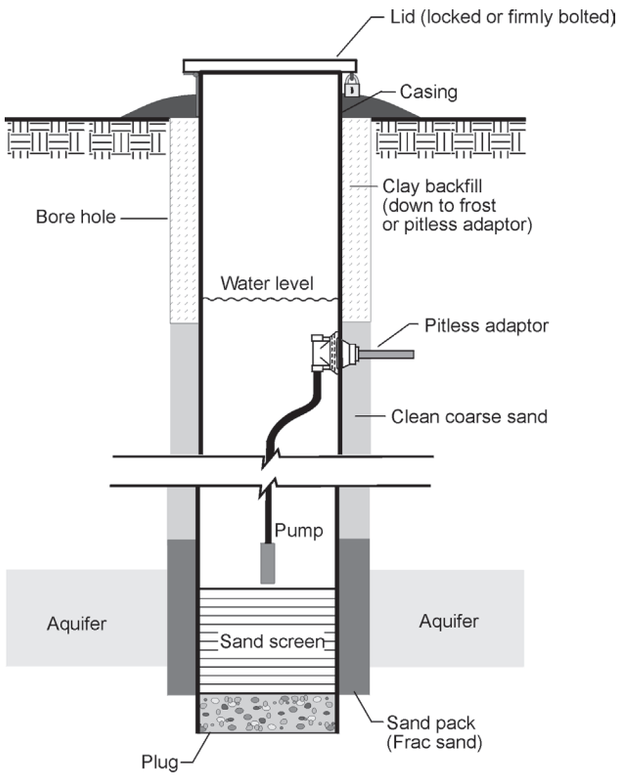
There are two main types of wells, each distinguished by the diameter of the bore hole. The two types are bored wells and drilled wells.

Bored wells

Bored wells are 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 (also called cribbing) 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 generally relies on annual precipitation for recharge. Water shortages may occur following long dry periods in summer and extended freeze up during winter months. It can also be more susceptible to contamination from surface land-use activities.

Figure 1 Bored Well



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

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.

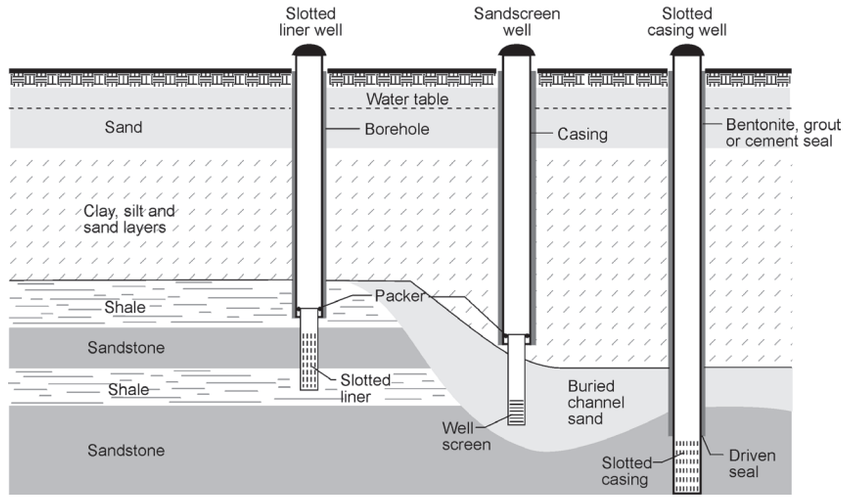
There are two primary methods of drilling:

- 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.

Figure 2 Well Completions



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.

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).

Provincial regulation provides detailed specifications for casing diameters and wall thicknesses. All casing must meet or exceed standards set by the Canadian Standards Association or the American Society of Testing and Materials (see Module 4" Water Well Drilling Agreements", Water Well Casing Specifications).

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 screen or 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 manually 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 be effective in holding back the formation sediments.

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

The licensed water well 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 openings
- 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 licensed water well 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

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

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.

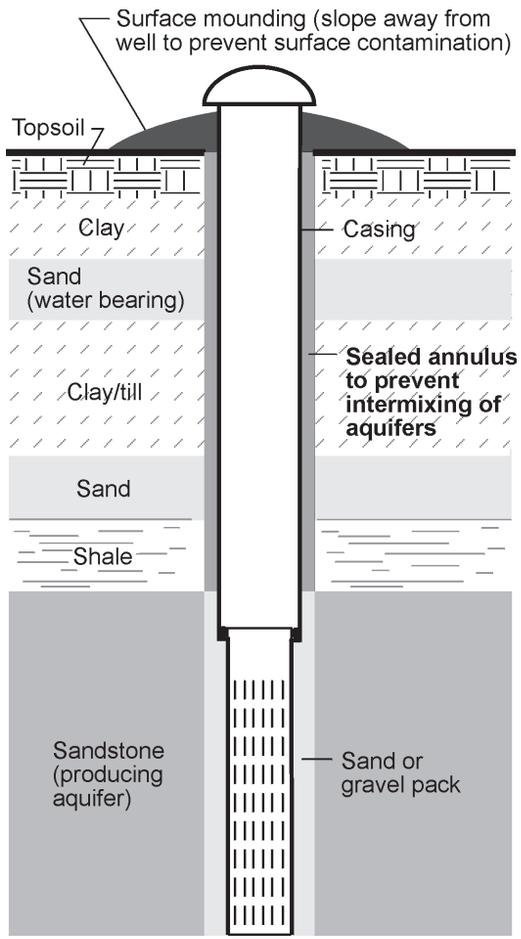
The amount of open area in the screen or slotted or perforated casing/liner will affect how quickly the water from the aquifer enters the well. A larger amount of open area allows the

water to enter the well at a slower rate, causing a lower drop in pressure as the water moves into the well. If the water flows too quickly, dissolved minerals in the water will precipitate out of solution and create an incrustation build-up in restricting the flow of groundwater into the well. The pore spaces in the aquifer immediately adjacent to the perforations may also get plugged, restricting the flow even more.

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.

Figure 3 Annular Seal



Annular Seal

Sealing the well protects the well's producing zone from contamination. The diameter of the borehole is usually slightly larger than the casing being installed. The space between the borehole and the casing is called the annulus of the well or the annular space. It must be sealed to prevent any surface contamination from migrating downward and contaminating the water supply. A properly sealed annulus also prevents any mixing of poor quality water from upper aquifers with water from the producing aquifer of the well (see Figure 3, Annular 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 should be filled from immediately above the perforated zone to the ground surface.

Well Cap

A commercially manufactured, vermin-proof well cap is the only type of cap designed to keep animals, insects and contaminants from entering your well. It comes equipped with rubber gaskets and screened vents to ensure vermin stay out and air can circulate through.

Coverings for large diameter wells must be custom made because of their larger size. Ideally they should be made of steel, or fiberglass or plastic that is stamped for potable water use.

Well Completion

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

- Developing the well
- 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.

If the aquifer formation does not naturally have any relatively coarse particles to form a filter, it may be necessary for the driller to install an artificial filter pack. This 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 pack 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 will remain outside of the screen after well development.

The yield test provides a benchmark of your well's performance. Repeating this test at a later date can be used to assess any changing conditions in well performance and indicate when maintenance is required.

Yield Test

A yield test is important because the information gathered during the test assists the driller in determining the:

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

Provincial regulations outline the requirement for a minimum yield test to be performed on all new wells. After drilling and developing a well, the licensed water well 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 during pumping. If the yield test is performed using a bailer or air compressor to remove the water, water level measurements cannot be taken during the water removal portion of the test.

After 2 hours, water removal must be stopped and the recovery of the water level then 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 driller will decide at what rate the well 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.

Your pump 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 water level below the pump intake. That pumping rate is considered the long-term, safe and sustainable pumping rate for the well.

The value of using a pump to perform the yield test is the test will be repeatable. You should periodically conduct a similar yield test to collect new data that can be compared to previous tests. If you notice a decline in well performance you can have your licensed water well contractor back to rehabilitate or repair your well. Keeping a watchful eye on your well will enable you to recognize the symptoms of declining performance before it is too late to economically repair the well.

Disinfecting the Well

Provincial regulations require the licensed water well 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 in the well and must be left in the well for at least 12 hours to ensure any bacteria present are destroyed. Disinfection is done after the pumping equipment is installed and before the well is put into production.