PRAIRIE FARM REHABILITATION ADMINISTRATION SERVING THE PRAIRIE PROVINCES

Soil and Water
Conservation Service

# Wells For Farm Water Supplies

Canada

# Introduction

Wells have long been considered a desirable source of domestic water. Groundwater is usually unpolluted and is a relatively reliable water source that can be tapped from underground layers of sand, gravel or fractured rock.

To ensure that the quality and quantity of well water is adequate for present and future needs, several factors must be considered when planning and designing a well.

1. Water requirements of various fixtures and appliances.
2. Daily water requirement as related to equipment capacity.
3. Well location.
4. Types of wells.
5. Sizes and specifications of well materials.
6. Screen selection.
7. Construction methods, well development and yield testing.
8. Well disinfection and water analysis.
9. Contamination prevention.
10. Selection of a contractor.

Several tables have been included to further assist in the planning of a farm well.

1. Plumbing fixture values.
2. Daily water requirements.
3. Sand and screen size.
4. Chemical quality guidelines.

## *Sizing the Water Supply*

Wells most often supply water directly into the farm water system. The number of fixtures that must be supplied determines the capacity needed for the water system.

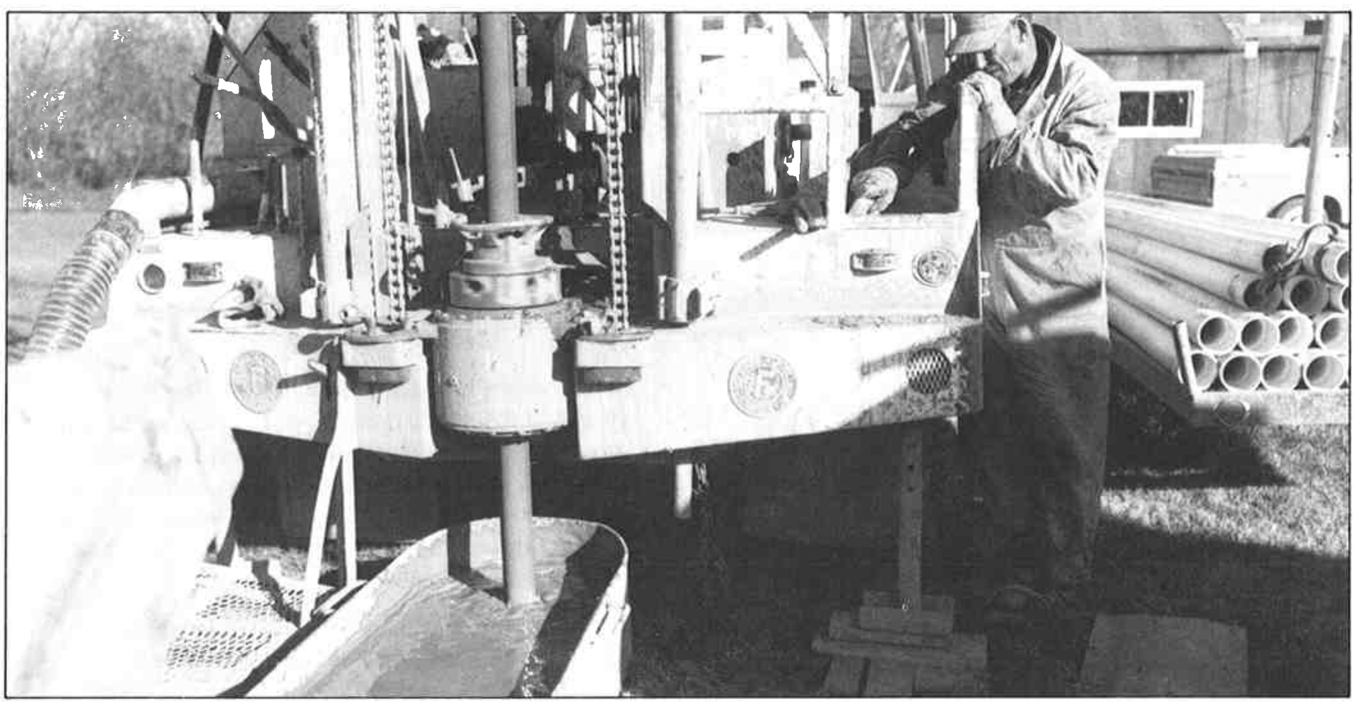
**Garden irrigation needs -** The water supply needed for irrigation is found by adding the output of all sprinkler heads that would be operated at the same time. A typical output for a small garden sprinkler with a nozzle of 4 mm (5/32 in.) would be 0.3L/s (4 gpm). Various larger nozzles and spray guns putting out up to 25 L/s (330 gpm) are often used in large garden irrigation.

**Livestock needs -** Automatic waterers are a common method of watering livestock. Most require a water supply of approximately 0.4 L/s. An adequate water supply should allow all waterers to run at once while still meeting peak residential needs.

**Residential use -** For an average home with a small family, the peak demand is considered adequately supplied if two fixtures with the largest flow demand can be operated at once. Table 1 lists values based on the flow demand of common water fixtures.

**TABLE 1**
**PLUMBING FIXTURE VALUE**

| Fixture Type | Fixture Flow Demand L/s at 240 kPa Water Pressure |
|---|---|
| Bathroom sink: | |
| 10 mm connection | 0.1 |
| Bathtub | 0.5 |
| Dishwasher: | |
| 12 mm connection | 0.3 |
| 19 mm connection (commercial) | 0.6 |
| Hose connection (wash down): | |
| 12 mm connection | 0.4 |
| 19 mm connection | 0.6 |
| Kitchen sink: | |
| 12 mm connection | 0.2 |
| 19 mm connection (commercial) | 0.4 |
| Laundry service: | |
| 12 mm connection | 0.2 |
| 19 mm connection (commercial) | 0.4 |
| Shower head (shower only) | 0.3 |
| Toilet: | |
| Tank Type | 0.2 |
| Flush Valve (commercial) | 2.2 |
| Wash sink (each set of faucets) | 0.3 |
| Washing Machine: | |
| 12 mm connection | 0.3 |



*Rotary Drilling. The mud tank is in left foreground, with plastic casing stacked behind driller.*

## *System Capacity*

It has been found that a pump to satisfactorily meet farm water requirements should have the capacity to supply one-half the average daily water requirement in a one to two hour period. Because of diversity of use, the longer period is used when calculating pump capacity only for farms with a large number of people or livestock. Average daily water consumption figures are given in Table 2.

Peak water demands are used to determine pipe size whereas the duration of peak water demands is used to determine pressure tank size. Where the peak demand is expected to be only a few minutes, pressure tank storage will be sufficient to meet this need.

When the desired pump capacity and pressure tank size are determined, a comparison with well capacity must be made. If the well capacity can be developed equal to or greater than the required pump capacity only the well pump is required. If well capacity is less than the pump requirement, then storage is needed. The well is used to supply a storage tank or cistern and the pump supplies the system from this storage.

**TABLE 2**
**DAILY WATER REQUIREMENTS**

| | |
|---|---|
| Human | 270 L (60 gal.)/day |
| Dairy Cow | 160 L (36 gal.)/day |
| Beef Cow | 70 L (15 gal.)/day |
| Horse | 70 L (15 gal.)/day |
| Hog | 20 L (4 gal.)/day |
| Sheep | 11 L (2.4 gal.)/day |
| 100 Chickens | 30 L (7 gal.)/day |

Even with a cistern, the minimum well production rate should be double the average water demand rate. At this production level, storage for about 10 average days consumption will be required to avoid shortages during periods of heavy use.

A large diameter well that produces water only slightly slower than the peak demand rate can have some storage incorporated in the well by constructing extra depth. A maximum practical storage by this method is usually two average days demand.

**EXAMPLE**

A well is required to supply water for a farm as follows:

- 5 people
- 30 beef cattle - winter only
- 2 horses
- 100 chickens
- Lawn & garden - single outlet garden hose

Peak demand is estimated as follows:

| | |
|---|---|
| Livestock waterer | 0.4 L/s (or garden hose) |
| Bathtub | 0.5 L/s |
| Dishwater | 0.3 L/s |
| Total | 1.2 L/s simultaneous demand |

Such coincidental use is assumed to last approximately 2 minutes.

Average daily consumption would be

5 people = 5 x 270 = 1,350 L
30 cattle = 30 x 70 = 2,100 L
2 horses = 2 x 70 = 140 L
100 chickens = 1 x 30 = 30 L

Total = 3,620 L daily

A pump to supply one-half this amount in one hour would deliver:

$$\frac{3620 \times \frac{1}{2}}{60 \times 60} = 0.5 \text{ L/s}$$

The delivery pump capacity will be a minimum of 0.5 L/s (7/gpm) at the **maximum** system pressure. Peak demand is greater than pump supply by 1.2 - 0.5 = 0.7 L/s. In 2 min. the pressure tank must supply 0.7 x 60 x 2 = 89 L more than the pump supplies. A 450 L (100 gal.) conventional pressure tank or a 225 L (50 gal.) precharged pressure tank would deliver this excess demand with less than 140 kPa (20 psi) pressure drop.

If a well can be developed to supply 0.5 L/s (7 gpm) the well pump can deliver to the pressure system directly. If a large-diameter well cannot deliver 0.5 L/s but can reliably deliver 4 times the average daily demand

$$= \frac{4 \times 3620}{24 \times 60 \times 60} = 0.17 \text{ L/s (2.2 gpm)},$$

then overdrilling an 800 mm diameter well by 14 m (46 ft.) and placing the well pump intake near the bottom of this depth would provide sufficient water but may not be an economical approach. A higher yielding well would require proportionately less overdrilling and may thus be economically feasible.

A well capacity as low as 0.08 L/s (1 gpm) could be satisfactory if a large cistern of approximately 40,000 L (9,000 gal.) is provided to store water for periods of higher than average consumption.

## Well Location

**Finding A Source** — Consult your local provincial agencies or district PFRA office for information on aquifers. Additional information may be gained by discussions with other well owners and local well drillers. The final step in locating groundwater is drilling small-diameter test holes. This is supplemented with an electric well logging device, used and interpreted by a specialist.

**Locating The Well** — Site considerations must include the possibility of contamination or hazard. Wells must be:
- at least 3 m (10 ft.) from any building,
- at least 8 m (25 ft.) from a septic tank,
- at least 30 m (100 ft.) from any barns, corrals or disposal field,
- at least 2 m (6 ft.) from an insulated low voltage power line,
- at least 15 m (50 ft.) from any high tension power line,
- at least 2 m (6 ft.) or more from any property line,
- at least 90 m (300 ft.) from the property line along a highway unless authority has been granted in written form,
- accessible for cleaning, inspection, test-pumping, repairing, acid treatment and chlorine treatment.

**Check guidelines and legislation in your province before locating your well.**

Low-lying areas are not recommended for wells. If a well must be constructed in such a location, the casing should be extended above ground and fill hauled in to raise the surrounding surface to prevent runoff from entering the well.

A well must not be in the basement of any building or in a pit adjoining a building or basement.

## Depths of Wells

**Shallow Wells** — Usually less than 10 m deep, shallow wells often supply the best quality water but are too often prone to failure in drought periods. The possibility of contamination of shallow aquifers is ever present, and attention to animal or chemical waste disposal is very important.

**Deep Wells** — Subsurface aquifers provide a much more secure water supply because they are less prone to drought and contamination. A deep well is preferred wherever suitable water quality is available.

## Size of Wells

**Large-Diameter Wells** — Originally the most common well was a hand-dug hole cribbed with wood or masonry. These large-diameter wells are now usually bored with a machine-driven auger and cribbed with galvanized steel or fibreglass. More costly per metre than small-diameter wells, they have a place as seepage wells when the aquifer is thin, or very fine-grained and tight, and produces water very slowly.

**Small-Diameter Wells** — Small-diameter wells are the most economical and are suitable in nearly all applications. Shallow, small-diameter wells often can be driven or jetted into place. However, small-diameter wells usually require several feet of water intake screen and thus may not be well-suited to thin aquifers. Deep wells are usually drilled with rotary or cable tool equipment.

## Construction Materials

**Casing** — Casing is required to hold the well hole open, prevent contamination of the well by surface water and stop the underground loss of water from seepage. Casing should be no smaller than 110 mm (4 3/8 in.) clear inside diameter.

Steel well casing has been used for many years but because of corrosion problems and the rising cost of replacement, more and more wells are being installed using plastic or fibreglass. Plastic well casing, rated to withstand 1.4 MPa (200 psi) internal pressure will stand up to all normal stresses except for being pulled from a deep well. For this reason, well drillers prefer steel casing where successful development of a deep well is not certain. The thickness of plain steel casing should be a minimum of 4.0 mm (0.156 in.); galvanized steel should be a minimum of 1.4 mm (18 ga.).

**Provincial requirements may permit or require some variation in casing thickness in certain locations.**

Well casings must be straight, should extend 300 mm (12 in.) or more above ground level and be fitted with a secure cap to prevent contamination. The cap for a large-diameter well should have a minimum of a 75 mm (3 in.) overlapping skirt.

**Screens** — Screens allow water to enter a well while screening out aquifer material and must be of a non-corrosive material. They are made in various slot sizes for different aquifer types and are available in plastic, fibreglass, stainless steel and bronze for both small and large-diameter wells. A screened and properly developed well will provide the maximum yield of sand-free water from a sand formation.

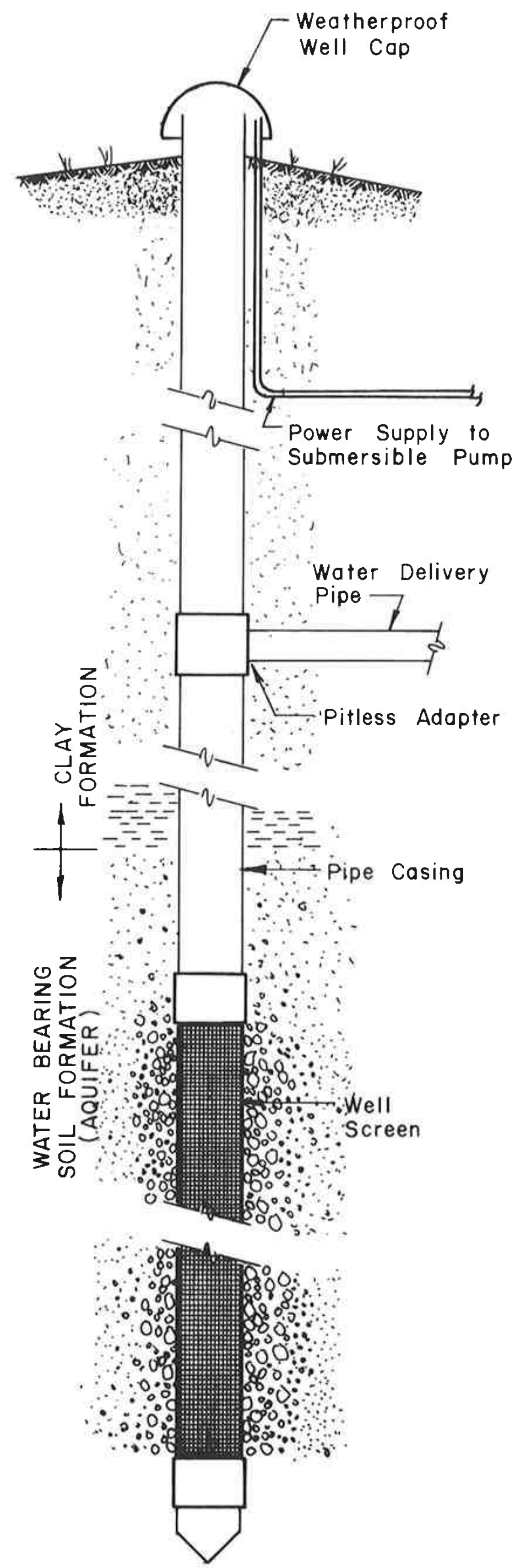
The following table relates aquifer sand sizes to suggested slot sizes for well screens.

**TABLE 3**
**SAND AND SCREEN SIZE**

| | Slot Size |
|---|---|
| **Very Fine Sand**<br>The finest aquifer material. A line of 6 to 7 grains measures about 1 mm. | 7 |
| **Fine Sand**<br>Often called sugar sand. About 4 grains measure 1 mm. | 10 |
| **Medium Sand**<br>Between 2 and 3 average grains measure about 1 mm. | 18 |
| **Medium Coarse Sand**<br>Between 1 and 2 average grains measure about 1 mm. | 25 |
| **Coarse Sand**<br>Average grain size is approximately 1 mm diameter. | 40 |
| **Coarse Sand and Fine Gravel**<br>Average grain size is approximately 2 mm diameter. | 80 |

## *Developing the Well*

Well developing is done by surging the well with high pressure jetting, alternated with air pumping to draw and evacuate the fine sand particles surrounding the screen. If low water tables are encountered, bailing or continuous pumping can be used. The removal of the fine sand leaves an envelope of coarser sand surrounding the screen. This allows water through easily and prevents the entry of abrasive and potentially clogging sand grains when the well is pumped.




TYPICAL WATER WELL

## Construction Methods

Shallow large-diameter wells can be installed with a backhoe or by hand, while deeper wells of this size are best installed with a boring rig. A boring rig uses an auger that scoops up earth, to be lifted out of the hole and emptied. These rigs are normally used to install wells from 600 mm to 900 mm in diameter.

Shallow small-diameter wells can usually be installed by jetting or driving a pointed screen into place. Although driving a well requires the screen and casing to be of sturdy metal, the more economical plastic can be used when jetting a well into place. A jetting point has a one-way valve that allows water to be jetted outward. The water jetting out of the well point allows the screen and casing to be pushed into sandy soils. A very economical casing material for shallaow wells is ABS plastic drain pipe.

Deep small-diameter wells are installed by drilling a hole with either a rotary drill or a cable tool rig. Rotary drilling uses a drilling fluid to flush drilling chips upwards from the rotating drill bit. This drilling "mud" provides the support where the hole penetrates soft or unconsolidated material. A cable tool rig forms a hole by repeatedly dropping a heavy drilling tool. This type of drilling requires driven casing for support where a well is being drilled through soft, unconsolidated materials.

To properly seal a rotary drilled or bored well, the top 3 m (10 ft.) of space between the hole and the casing should be filled with concrete or tamped clay.

## Flowing Wells

A great deal of care must be exercised when drilling wells where groundwater is under sufficient pressure to flow to the surface. The driller must follow careful procedures to control the water flow and cement in the casing. The landowner may be liable for future damages, water loss and/or cost of repairs. He must therefore ensure his well is properly constructed and of durable materials.

## Yield Testing the Well

All wells should be pump-tested to determine the yield (the continuous rate of pumping that the well can stand), and the drawdown. Drawdown is the difference between the static water level (water level before pumping) and pumping level (water level when pumping at a given rate). At a safe yield pumping rate, the pumping level in the well should remain steady.

Water level that does not recover to the original static water level after a continuous pump test is stopped, indicates the well is drilled into an isolated aquifer. These wells generally run dry within a short time.

## Well Disinfection and Water Analysis

**Disinfection** — When the pump test is completed, the well should be disinfected with a strong chlorine solution. For most farm wells, the driller should mix a solution of 25 L (6 gal.) of household bleach with 900 L (200 gal.) of water. The chlorine solution is then poured into the well and against the interior walls of the casing. The solution should be left in until the well is put into production to prevent the introduction of iron and sulphate-reducing bacteria into the well.

**Analysis** — Well water should be tested for safety for human consumption. Contact your local provincial public health agency or PFRA office to find out where an analysis can be obtained.

## Preventing Contamination

Although several aspects of contamination prevention have been mentioned throughout the brochure, several important practices should be observed.

- Shallow aquifers must be protected. Recharge areas of surficial aquifers should be identified. Care must be taken to keep these areas free of contamination from agricultural chemicals, sewage disposal or intensive livestock operations.
- Surface water should be drained away from wells in addition to ensuring proper sealing of the casing.
- The upper portion of the casing must be completely water tight. Within 3 m (10 ft) of the ground surface there should be no joints except for factory joints that are water tight and permanent.
- The well cap must be weatherproof and securely fastened.

## *Choosing a Contractor*

Well drilling is costly for both the customer and the driller. Therefore, a written agreement (Appendix A) should be drawn up before a well is drilled. The following points should also be kept in mind:

— Ensure that the driller is a properly licensed and reputable contractor.

— Agree on the costs for each item listed in the agreement.

— Agree on the casing and screen specifications.

— Agree on the quality of water which will be accepted. (Table 4).

— Agree on the acceptable capacity of the well. If the well capacity is below the required demand, storage facilities (cistern) may be required.

— Determine what warranties are provided.

— Determine if the driller carries insurance against personal injury or property damage.

For future reference, all newly constructed wells should have a completion record as shown in Appendix B.

**TABLE 4**
**CHEMICAL QUALITY GUIDELINE SUMMARY**

This table presents guidelines adopted by the Province of Saskatchewan and does not necessarily represent standards in other provinces.

| | Range of Concentrations | | | |
|---|---|---|---|---|
| **Chemical or Characteristic** | **Satisfactory** | **Poor** | **Not Recommended** | **Unsuitable** |
| *Total Dissolved solids (mg/L) | up to 1500 | 1500-3000 | 3000-4000 | over 4000 |
| Hardness (mg/L as $CaCO_3$) | up to 800 | 500-1000 | 1000-2000 | over 2000 |
| Alkalinity (mg/L as $CaCO^3$) | up to 500 | 500-1000 | 1000-1500 | over 1500 |
| Chloride (mg/L) | up to 250 | 250-500 | 500-1000 | over 1000 |
| Sodium (mg/L) | up to 300 | 300-500 | 500-1000 | over 1000 |
| Sulphate (mg/L) | up to 500 | 400-800 | 800-1200 | over 1200 |
| Nitrate (mg/L) | up to 40 | 40-100 | 100-300 | over 300 |
| Iron (mg/L) | up to 0.3 | 0.3-7.0 | 7.0-15.0 | over 15 |
| Manganese (mg/L) | up to 0.05 | 0.05-2.0 | over 2 | over 2 |
| pH (Hydrogen ion conc.) | 7.0 to 9.5 | 6-7 and 9.5-10 | 5.5-6 and 10-10.5 | less than 5.5 more than 10.5 |

*Total Dissolved Solids (TDS) is a commonly used water quality criteria and the maximum satisfactory concentration ranges from 500 mg/L to 1500 mg/L according to the various government agencies operating on the Prairies. The acceptability of high TDS depends on what minerals are present, personal taste, health considerations and, of course, what alternatives might be available.

# Appendix A

**Sample Drilling Agreement**

_______________________________ hereinafter called the "Drilling Contractor" of _______________________ and _______________________ of _______________________ hereinafter called the "Purchaser", make and enter into this agreement this ______ day of ______________ 19 _____.

This Agreement WITNESSETH:

1. That the purchaser engages and employs the Drilling Contractor, who agrees for consideration of the terms and specifications contained herein, and for the prices listed for the work, to drill and develop a well on the following property legally described as follows:

_______________________________________________

_______________________________________________

2. The following schedule of prices shall prevail:

| | | | | |
|---|---|---|---|---|
| Mobilization | $ ________ | | | |
| Test drilling only | $ ________ | per foot or $ | ________ | per meter |
| Test drilling & electric logging | $ ________ | per foot or $ | ________ | per meter |
| Drilling complete with casing | $ ________ | per foot or $ | ________ | per meter |
| Cased abandoned hole | $ ________ | per foot or $ | ________ | per meter |
| Screen and installation | $ ________ | per foot or $ | ________ | per meter |
| Drilling additives | $ ________ | | | |
| Gravel pack | $ ________ | | | |
| Well development | $ ________ | per hour x | ________ | hours |
| Pump test | $ ________ | per hour x | ________ | hours |
| Standby time | $ ________ | per hour | | |
| Disinfecting well | $ ________ | | | |
| Miscellaneous costs | $ ________ | | | |

3. The materials shall be supplied as follows:

Casing Type ________, I.D. Size ________, Wall Thickness ________, Screen Type ________, Size ________, Method of Installation ________.

4. This agreement shall be considered complete when the well will yield water of quality in the ____________ range at a rate of ________ L/min. (gpm) OR when the Purchaser requests that drilling be stopped.

5. The well shall be ________ mm (in.) inside diameter.

6. The Drilling Contractor will proceed with the drilling operations under this agreement on approximately ____________, 19 _____.

7. All charges under this contract are due and shall be paid within _____ days of completion of the work under this agreement.

8. The Drilling Contractor may, after _____ days of Purchaser's default in payment, have the right and permission to recover any materials installed by him in or on the well.

9. The Drilling Contractor shall adhere to all applicable Provincial and Federal Acts and Regulations.

10. The Drilling Contractor shall guarantee the materials and construction of the well for a period of ________ from the date of completion.

11. If the well is constructed in an area where flowing artesian conditions are known to exist, surface casing shall be installed and the flow controlled according to provincial regulations and established procedures.

_______________________________
(Date)

_______________________________ _______________________________
(Witness) (Drilling Contractor)

_______________________________ _______________________________
(Witness) (Purchaser)

# Appendix B

**Completion Record**

Casing:

Type ______________, I.D. Size ______________, Wall Thickness ______________.

Total Length ______________. Top of casing to ground level ______________.

Sandscreen:

Type ______________, I.D. Size ______________, Slot Size ______________, Length ______________

Method of installation ______________________________________________

Slotted cribbing ______________________ Type of Slot ______________________

Total depth of well ______________________________________ from top of casing.

Screened from __________ m (ft.) to __________ m (ft.) from top of casing.

Water Level:

Static Water Level __________ m (ft.); drawdown __________ m (ft.); after __________ hours;

at _______ L/min. (gpm) by air __________, bailing __________.

Recovery __________ m (ft.) after _______ hours, _______ minutes.

Pumping Equipment & Appurtenances:

Pump Make ______________, Type ______________, Model ______________

Horsepower ______________, Serial # ______________, Voltage ______________

If submersible motor, 2 wire __________, 3 wire __________, 4 wire __________

Pump Setting Depth ______________, Pipe Size(s) ______________

Type of Pipe ______________, Safety Rope Size ______________

Pitless Adapter:

Size ______________ Make ______________________________________________

# Glossary

Aquifer — A water-bearing layer of permeable rock, sand or gravel, capable of yielding water.

Casing — Material used to line the borehole of a well.

Cribbing — Large-diameter casing of wood, plastic, steel or concrete.

Flowing Well — A well that discharges water at the surface without the aid of a pump.

Jetting — A method of well-sinking where the casing is sunk into a hole washed out by a water jet. Jetting is also a method of developing wells by flushing from the inside of the screen with water jets.

Overdrilling — Drilling deeper than the water-producing aquifer to create a reservoir.

Peak Demand — The maximum momentary load placed on a water plant or pumping station.

Precharged Pressure Tank — A tank that contains pressurized air separated from the water, allowing the use of a smaller tank.

Surficial Aquifer — An aquifer that extends upward to ground level.

# Abbreviations

in. - inch
ft. - foot
m - meter
mm - millimeter
L - litre
g - gallon
L/s - litres per second
gpm - gallons per minute
kPa - kilopascals
mPa - megapascals
psi - pounds per square inch
ga - gauge

PFRA is a federal government agency, established in 1935 to deal with soil and water conservation problems in the three Prairie provinces. Before starting any on-farm water project, contact your local PFRA office for technical advice and financial assistance. PFRA policy statements and applications are available from your local district office.

# PFRA Office Locations

**ALBERTA**

Hanna
Lethbridge
Medicine Hat
Peace River
Red Deer
Vegreville
Westlock

**SASKATCHEWAN**

Gravelbourg
Maple Creek
Melfort
Melville
Moose Jaw
North Battleford
Rosetown
Shaunavon
Swift Current
Watrous
Weyburn

**MANITOBA**

Brandon
Dauphin
Morden

06/85

Agriculture
Canada

Prairie Farm Rehabilitation Administration

Administration du Rétablissement Agricole des Prairies

Disponible en français

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