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BAND TECHNICAL PUBLICATIONS

Water Wells and Ground Water Supplies

February 1984

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Canada

WATER WELLS AND GROUND WATER SUPPLIES

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1.0 INTRODUCTION

This document provides general guidance for individual users of ground water supplies and wells on reserves. An adequate and a safe water supply is a necessity for any residence. The supply must be constant, dependable, and free from disease carrying organisms, hazardous chemical substances and objectionable colour, odour and taste.

Ground water can provide a relatively inexpensive and constant supply of safe drinking water. It is less susceptible to contamination than surface water and for the most part has a near constant yearly temperature ranging from 8-12°C (46-54°F), unlike that of surface water which may fluctuate considerably with changes in the seasonal temperature. Most ground water requires no chemical treatment.

The construction of water wells has changed considerably since the time when they were dug with pick and shovel to depths of 3 or 4 m (10-15 ft.). Using modern drilling methods, wells may reach depths of 180 m (600 ft.) or more. Most water wells and water supply systems today are also more reliable than their predecessors. A properly constructed well will probably never go dry or be contaminated by leakage from shallow polluting sources such as septic systems or surface drainage.

Many reserves have problems in locating adequate and safe water supplies. Dug wells, drilled wells, creeks, rivers, streams, lakes, dugouts and even roadside ditches have been used.

As already mentioned, a good water supply is a necessity and it is important to spend the required time and effort on maintenance. It will be time well spent.

2.0 WELL SITE SELECTION

Care should be taken when choosing a site for a well because wells are expensive to install and many failures have been caused by poor site selection.

Important points to consider are the following:

a. Wells should be located upslope and as far away as possible from potential sources of pollution, such as septic fields, roads and contaminated surface water sources such as lakes, streams and reservoirs. Always keep sources of contamination downstream of the well.

b. It is a good idea to drill or bore wells (see 4.0) before construction begins on a house for, if a satisfactory water supply cannot be found, building plans can be changed.

c. The location of existing and planned surface and underground structures on the property, such as septic systems or basements, should be determined before a contractor is hired and drilling is begun. This information may prevent future problems resulting from poor site location.

d. A well should not be located in any area where it would be very difficult to maintain the well or remove the pump for repairs, such as in a basement, below a paved driveway, under power lines, or under the eaves of a building.

e. Contact between a pipe being removed for maintenance and overhead power lines could electrocute the person holding the pipe. Therefore some provincial construction safety acts (Ontario) do not allow equipment within 3m (10 ft.) of high voltage power lines.

3.0 TESTING AND DECONTAMINATION

3.1 Testing

Upon completion of a well, a water sample should be collected for both bacteriological and chemical analysis before the well is used for drinking purposes. In addition, samples for bacteriological examination should be collected as follows:

a. one to three weeks after the first test to confirm acceptable results,

b. following periods when the well has not been in use (in the case of seasonal residences), and

c. once or twice during the year, preferably after heavy rains.

The environmental health officer or public health nurse can collect the samples and send them to the nearest laboratory. If not, most provincial Department of Health Laboratories keep sterile bottles in metal tubes which can be used by the public. They are return addressed to the laboratory. Detailed sampling and handling instructions are included with the bottles and should be followed closely so as not to contaminate the sample.

3.2 Decontamination

When a well is contaminated, the source of the contamination must be found and removed if at all possible. When the contamination source is found and removed the well can be decontaminated by dumping 4 or 5 litres (approx. 1 gallon) of household bleach (Javex) into the well. Turn on all taps and other outlets until chlorine can be tasted in the water. Let sit for 12-24 hours and then drain all outlets until the taste has disappeared. Care should be taken to make sure that the well is not pumped dry. Another sample should now be collected for bacteriological testing to ensure that the water is safe for drinking.

* The gallons referred to in this document are imperial gallons.

To avoid interference between wells it is important to keep a planned new well as far away from other wells as site conditions permit. The type of soil may influence the distance but every attempt should be made to keep wells at least 60 m (200 ft.) apart.

If possible the well should be located where it is safe from vehicular traffic, animals and vandalism.

4.0 TYPES OF WELLS

4.1 Dug Wells

Before the development of motor-driven boring or drilling machines, digging a well was the usual method of construction. Dug wells are now seldom more than 9 m (30 ft.) deep and usually not more than .9 m (3 ft.) in diameter, and/or wide enough for the digger to work.

4.2 Bored Wells

Bored wells are usually constructed in areas where water is found in materials relatively close to the land surface. The average depth of a bored well is under 15 m (50 ft.) and very few extend to depths greater than 30 m (100 ft.). Common diameter casing sizes are 60 cm (24 in.), 75 cm (30 in.), and 90 cm (36 in.). These wells have a good storage capacity.

4.3 Drilled Wells

Drilled wells can be any depth from 3 m (10 ft.) to 180 m (600 ft.). If deep they are less likely to become contaminated or to be seriously affected by seasonal water level fluctuations. They have a small diameter, for example, 100 mm (4 in.) and 150 mm (6 in.), and have little water storage capacity.

Wells are usually drilled into an unconfined aquifer, that is a ground water source that is deep below the surface, and below an impervious layer. Some are normal pumped wells and others are artesian (flowing) wells.

4.4 Jetted Wells, Well Points, Driven Wells (Sand Points)

A jetted well is made by forcing a high speed jet of water into the ground.

A well point is a metal screen threaded to a metal riser pipe. The tip of the well screen acts as the drilling bit.

When the water table in a water-bearing sand and gravel is found within 4.5 m (15 ft.) of the surface a well point or sand point may be driven directly into the ground.

The advantages and disadvantages of the different methods of constructing a well are given below.

4.5 Advantages and Disadvantages

WELL TYPE	SUITABLE GEOLOGIC MATERIALS	ADVANTAGES	DISADVANTAGES
DUG WELLS	OVERBURDEN both low and high yielding materials (gravel, sand, silt, clay)	1) Does not require special machinery to construct. 2) Large diameter provides reservoir storage to augment low yields. 3) Can be constructed in areas of limited access.	1) Labour intensive to construct. 2) Depth is limited because of caving boulders & bedrock. 3) Well failure is common during dry periods because of usually shallow depths.
BORED WELLS	OVERBURDEN both low and high yielding materials (gravel, sand, silt, clay)	1) Efficient method of constructing large diameter wells. 2) Large diameter provides reservoir storage to augment low yields.	1) Depth is limited because of caving, boulders and bedrock.
DRILLED WELLS	OVERBURDEN AND BEDROCK moderate to high yielding materials (sand, gravel, sandstone, limestone)	1) Can reach deeper than other techniques. 2) Can penetrate bedrock.	1) Generally small diameter wells with little reservoir storage capacity.
DRIVEN OR JETTED WELLS (Sand Points)	OVERBURDEN moderate to high yielding materials (sand and gravel)	1) Simple installation; can be done by hand or machine. 2) A number of these wells can be hooked into one water supply system.	1) Small diameter provides little reservoir storage. 2) Depth is limited; depends on materials in overburden.

5.0 PROBLEMS WITH WELL WATER SUPPLIES

5.1 Equipment Failure

Most water supply equipment dealers will provide technical information pamphlets free of charge, which give "trouble shooting information" on water supply equipment. In addition, "Operating Instructions and Repair Parts List" manuals are usually included with new equipment.

These guides should be consulted when equipment failure occurs, as many of the common problems can be corrected by simple maintenance operations such as replacing a blown fuse or adjusting pressure switches.

5.2 Well Failure

5.2.1 Natural Lowering of the Water Table

Water levels in many dug or bored wells are known to fluctuate several metres due to climatic conditions. Ground water levels in these wells usually reach their maximum in April or May and then gradually decline until the latter part of September or the beginning of October. When constructing a dug or bored well, it is important that the contractor extend the well far enough below the water table to assure an adequate water supply during periods when the water level declines.

5.2.2 Artificial Interference

The water level in most wells can be lowered artificially by the pumping of a nearby high capacity well. This is known as artificial interference. When a well is pumped, the water table in the immediate area of the well is lowered. The distance that the water level is lowered is called the drawdown. The drawdown produces a decline in the water level around the well that resembles a cone and is therefore called a <u>cone of depression</u>. The size and the shape of the cone depends on the conditions of the water-bearing formation and the rate of pumping.

An example of well interference is illustrated in Figure 1: Well A, as a result of pumpage, lowered the original water table to the level illustrated. With the onset of pumpage in Well B, the deeper of the two wells, the water level has been lowered below that of the intake for Well A. This has resulted in Well A "going-dry".

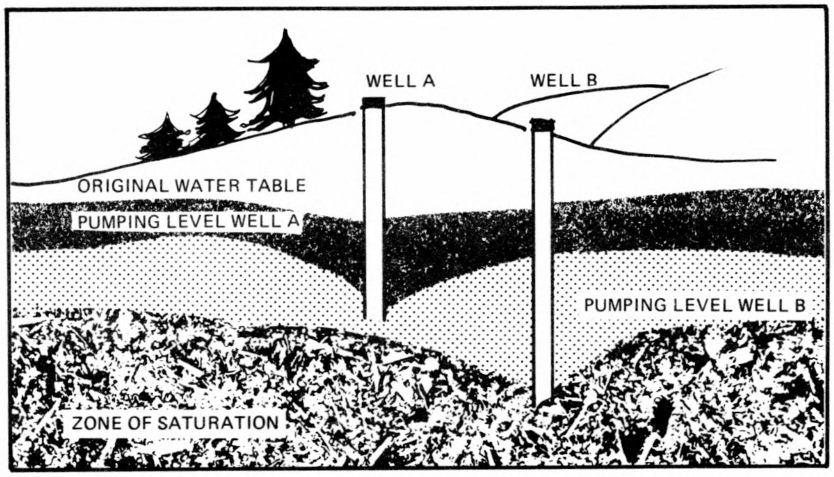

Figure 1 CONE OF DEPRESSION (WELL INTERFERENCE)

The construction of sewers, drainage ditches and road cuts occasionally causes interference with nearby shallow wells.

In situations where the water level in your well has been lowered and you suspect that this is caused by artificial interference, you should contact your District DIAND Office. The District Office can advise how to investigate the source of the interference.

5.2.3 Plugged Casings

Wells may be located in water-bearing formations containing clay, silt, or very fine-grained sand (quicksand). These materials are able to pass through the finest screen, filling the screen with particles and slowing the movement of water into the well so that the well yield is reduced. The fine-grained particles can move into the intake of a pump and cause excessive wear of the moving parts. The water pipes and pressure tank may also become plugged.

If silt or quicksand is encountered during construction, the contractor should advise the owner to deepen the well until another suitable water-bearing formation is found, or to drill in another location.

The most common cause of sand entering the well is the improper selection of slot size for the well screen. This can be avoided if a competent well contractor is selected to do the work.

5.2.4 Encrustation of Well Screens

A well screen can sometimes be plugged by deposits of magnesium or calcium carbonates, hydrated oxides or hydroxides, iron, or slime produced by iron bacteria. These deposits cause coating or encrustation, and result in a decrease in well yield.

Because the well screen is buried from sight, it often receives no attention until the well yield has been reduced appreciably.

Hydrochloric or muriatic acid is used to remove the encrustations of magnesium, calcium and iron compounds from a well screen. Sometimes the contractor pulls the screen from the well to acidize or replace it. This is a difficult procedure and it is common to just add the hydrochloric acid directly down the well casing.

You should not attempt to acidize your own well because of the danger in handling strong acid solutions.

A strong concentration of chlorine [200 mg/L (ppm)] can be used to remove iron bacteria slime-deposits from the well (see 11.0).

It is a good idea to periodically check the performance of the well. Do this by pumping the well at a set pumping rate for a certain interval of time (one hour, two hours, etc.). The difference between the levels of water in the well at the start of pumping and at the end is called the drawdown. If the drawdown has increased since the last time this performance check was taken, well may have become encrusted. It is a good idea to do a drawdown test when the well is first put into service. This test is routinely conducted by the contractor and the results are included on the well record.

5.2.5 Corrosion of Well Casing and Screens

5.2.5.1 General Remarks

Well water is often corrosive and can attack the casing and screen. Four common chemical corrosion processes are described below.

The destruction of the casing or screen by any of these processes will cause well failure.

5.2.5.2 Direct Chemical Corrosion

Direct chemical corrosion will cause the screen slots to enlarge two to ten times their original size. Fine-grained particles which were once held by the screen will then move into the well. The principal source of direct chemical corrosion in ground water is acidity. Acidity is caused by the reaction of CO_2 and/or H_2S (both caused by microbiological activity in the subsurface) and water. In addition, precipitation may be mildly acidic due to the presence in the atmosphere of acid-forming compounds. Fortunately, in many areas of Canada the high carbonate content of the overburden and bedrock acts to neutralize the acid precipitation. This is not the case in some northern areas of Canada, where ground water is often acidic.

5.2.5.3 Electrolytic Corrosion

Electrolytic corrosion can result when a screen and its connections are made of two different metals. These metals form a galvanic cell (battery). One metal forms the anode and another the cathode. A current is set up between the two metals with the anode becoming corroded and the cathode being protected.

5.2.5.4 Bacterial Corrosion

References to bacterial corrosion often give the incorrect impression that the bacteria attack metals directly. What actually happens is that the bacteria are able to change some of the dissolved materials in ground water. For example, sulphate-reducing bacteria may reduce calcium sulphate to hydrogen sulphide and sulphuric acid, both of which make water more corrosive. This speeds up the corrosion of metals, particularly iron and steel.

Little can be done about corrosion once it has happened. The corroded casing and well screen will have to be replaced. Preventive "foresight" is the best approach to this problem. For instance:

a. establish from well contractors, plumbers and neighbours whether corrosion problems are common in your area; and

b. if so, have your well contractor install casing and a screen made from stainless steel or other corrosion-resistant material.

6.0 CONTAMINATION

A contamination problem that is bacteriological, chemical or a combination of the two, can sometimes be solved by treating the water before using it or, if the source of contamination can be removed, by simply decontaminating the well.

Contamination can be caused in various ways. Some of these are:

a. leaks in underground or surface fuel-oil storage tanks, or the spilling of hazardous material near the well;

b. sources of contamination too near the well, such as barnyards, septic tank disposal fields and contaminated surface water sources;

c. a natural condition of the ground water in the area such as excessive hardness, sulphate or iron;

d. vandalism such as the dumping of dead animals or garbage down the well; and

e. not keeping the top of the well clean and sealed.

7.0 PROTECTION OF WELLS FROM SURFACE CONTAMINATION

To prevent surface water, which may be polluted, from moving into a well, a water-well contractor is required to seal the upper part of the space between the outside of the casing and the sides of most types of wells. (See Figure 2).

When a pumping system is connected to a well through the top of the casing, a commercial well seal (Figure 3) must be used to prevent surface water or foreign material from entering the well.

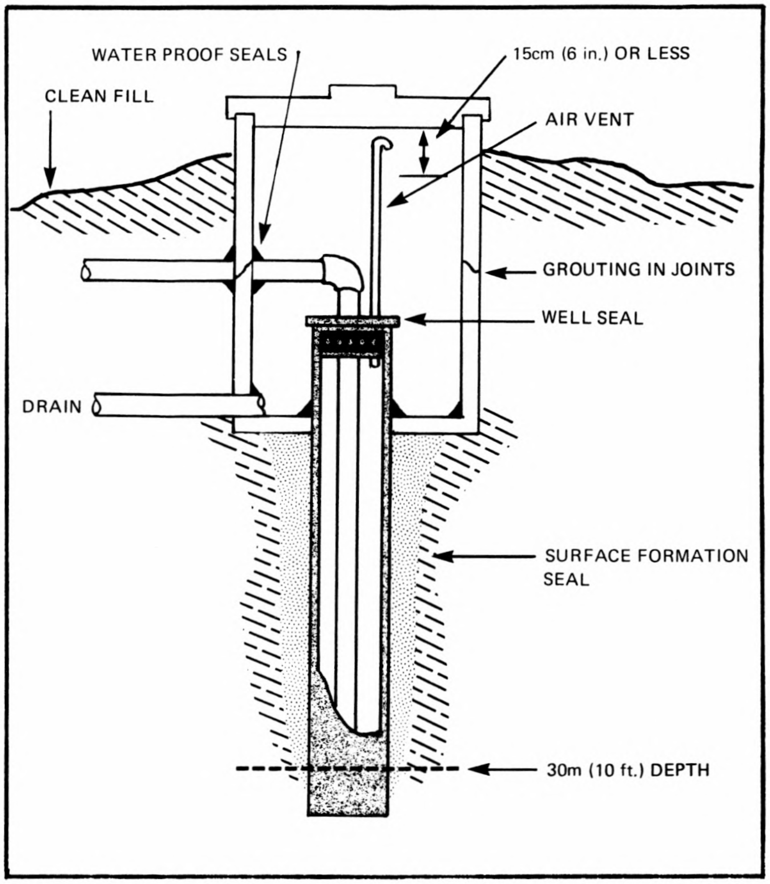

Figure 2 CASING SEAL AND WELL PIT CONSTRUCTION

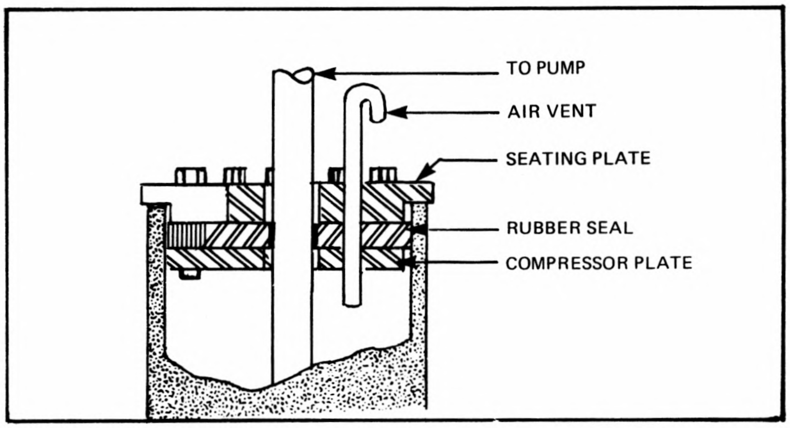

Figure 3 SEAL AND AIR VENT

8.0 WELL PUMPS

8.1 General Remarks

The basic purpose of a pump is to lift water from the well and to distribute it to where it will be used. This is accomplished by creating an increased pressure at the point at which the water is discharged and reduced pressure at the point of intake. There are three general types of pumps used for wells.

8.2 Shallow Well Pumps

Shallow well pumps can be used to a depth of about 7 m (22 ft.) and are of three general types:

- reciprocating,
- centrifugal, and
- centrifugal jet.

8.3 Deep Well Pumps

Deep well pumps are required for greater depths and are also of three general types:

- reciprocating;
- deep well jet, either double or single pipe; and
- submersible.

8.4 Hand Pumps

(See Figures 4, 5, 6 and 7 for pump illustrations)

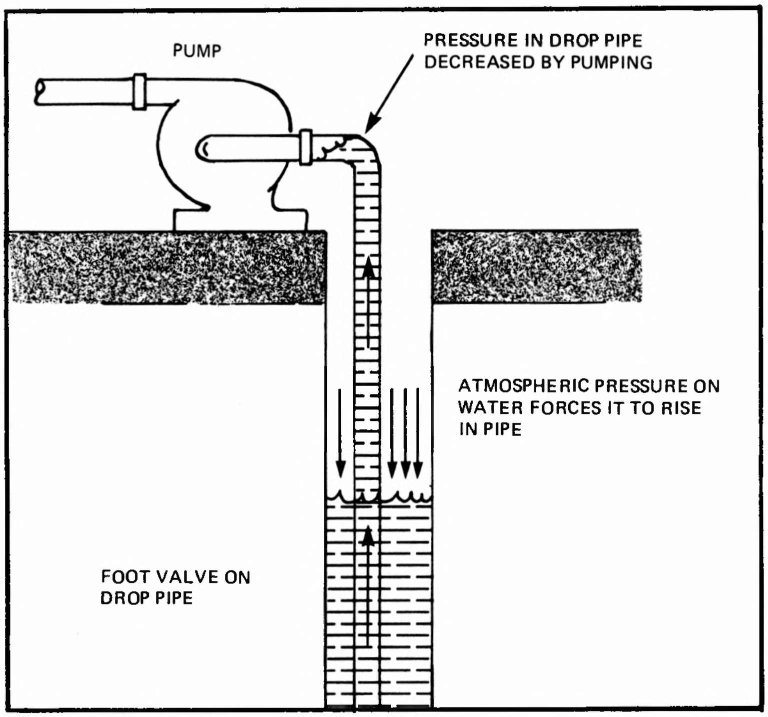

Figure 4 SHALLOW WELL PUMP – PUMP SUCTION PRINCIPLE

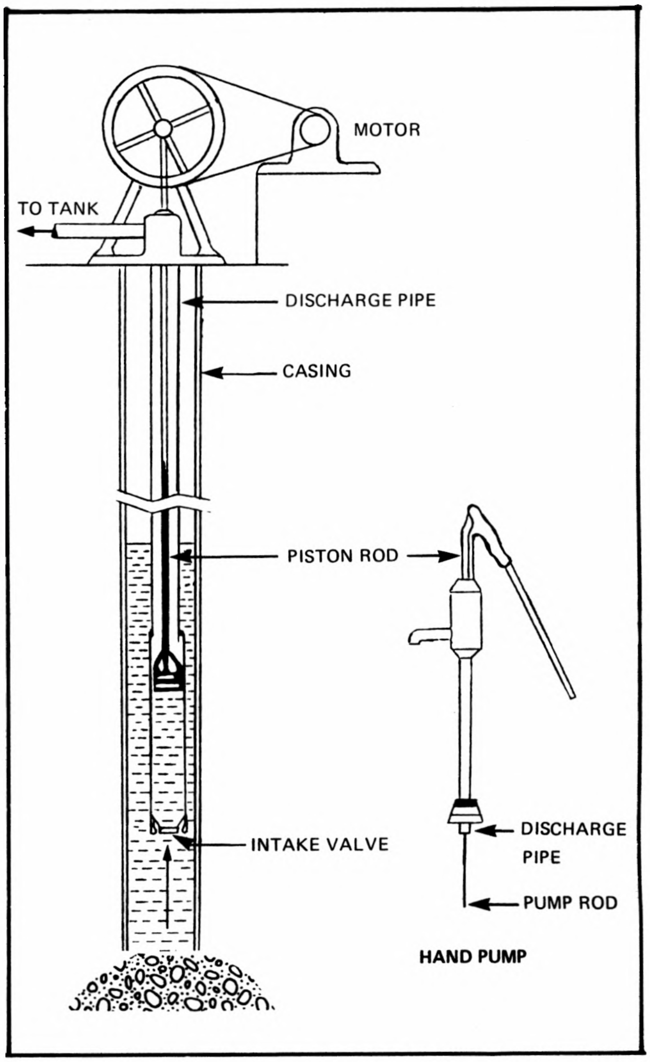

Figure 5 DEEP WELL PISTON PUMPS

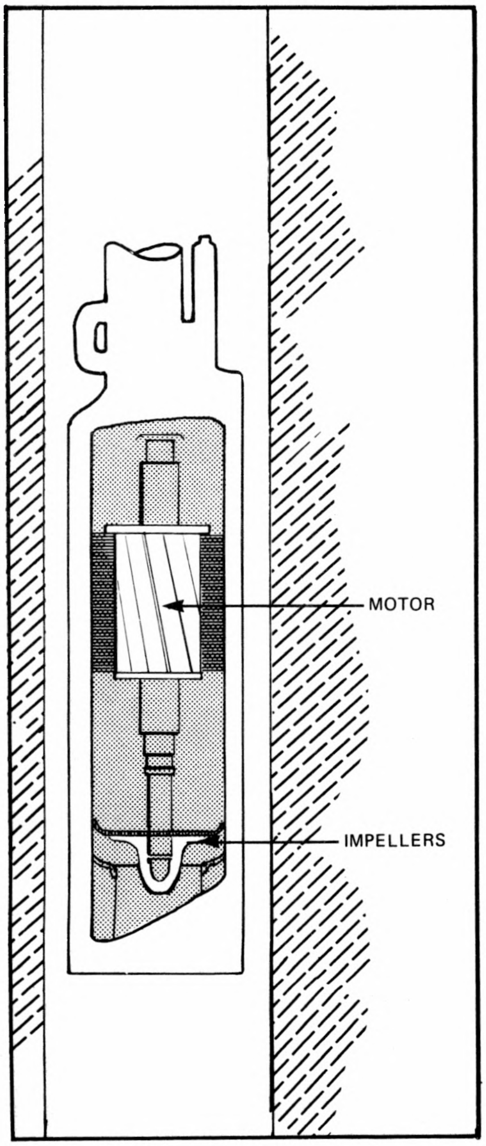

Figure 6 SUBMERSIBLE PUMP

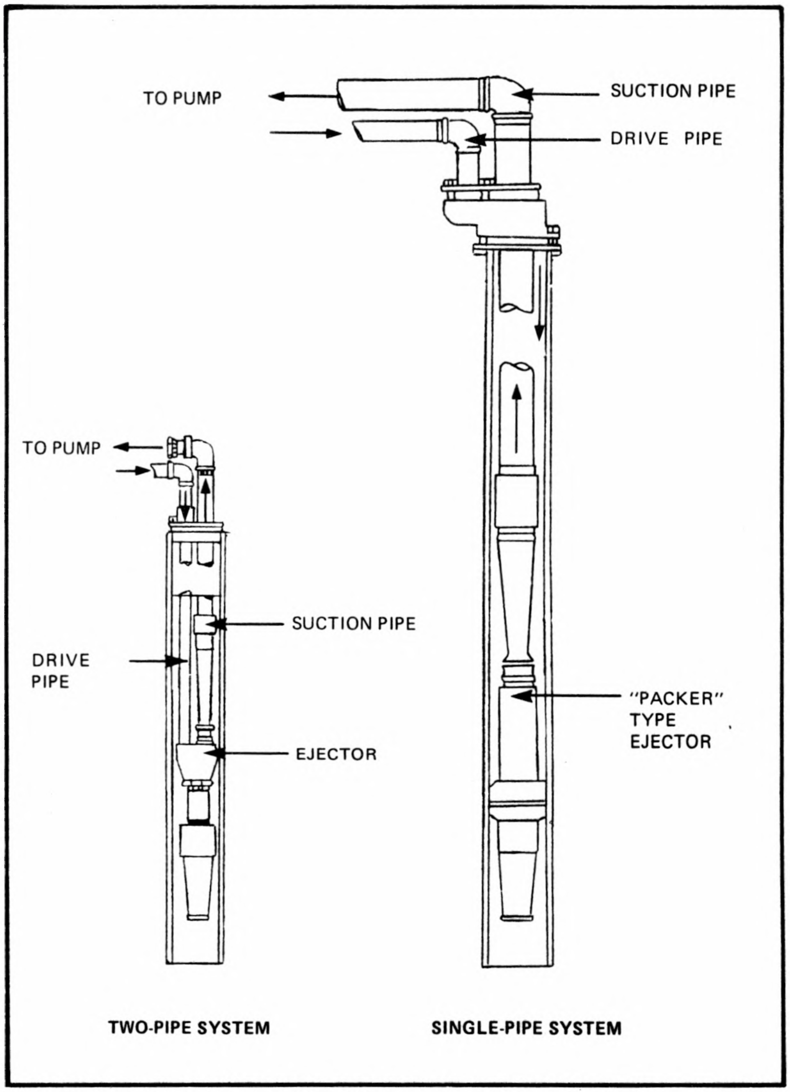

Figure 7 DEEP WELL JET PUMP SYSTEM

9.0 PITLESS ADAPTORS

Pitless adaptors are now widely used to permanently install the horizontal water discharge pipe leading away from the well. They eliminate the need for well pits and provide easy access for periodic well or pump repairs (see Figure 8).

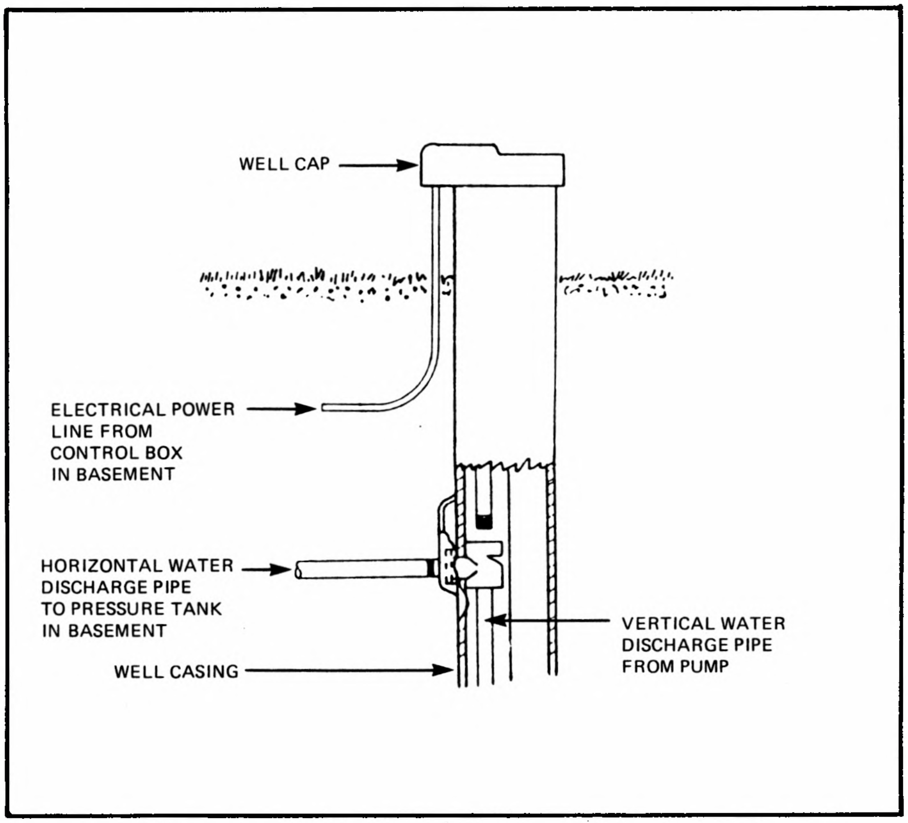

Figure 8 PITLESS ADAPTOR

10.0 WELL MAINTENANCE

10.1 General Remarks

Few owners of individual wells deny the value of proper maintenance. However, in practice, most people just let it go. "Out of sight -- out of mind" seems to be the only way to explain inadequate maintenance of water wells.

The pump usually gets attention because at least some of its working parts are in view above ground. The well itself is overlooked until the quantity of water supply to the pump is seriously affected, demanding immediate and sometimes drastic action.

The well owner must realize, however, that certain things must be done from time to time to maintain a well structure in good condition, even though it is buried from sight a hundred to several hundred metres below ground. In particular, the well screen, which is the "business end" of wells that obtain water from sand and gravel formations, needs to be remembered. The degree of attention required to keep it functioning properly varies with the quality of the water in the aquifer. When the well is pumped, the water constantly flowing through the openings and over the metal surfaces of the members comprising the well screen may plug up the openings, or eat the material away in time.

10.2 Record Keeping

It is essential to keep good records of well operation. Since one cannot see what is happening in the bottom of the well, one must depend on records of pumping rates, drawdown, total hours of operation, power used, water analysis, and other pertinent operating data to figure out what may be going on.

Good records provide, in most cases, the soundest basis for deciding just what maintenance procedures would be most likely to give the best results.

11.0 CHLORINATION PROCEDURE FOR DOMESTIC WELLS

The following procedure may be used to chlorinate the water in a well by providing a concentration of 200 parts per million of free available chlorine:

1. Measure the diameter of the well.

2. Measure the depth of the water in the well.

3. From the following table obtain the volume of water contained in the well for every 30.5 cm (foot) of length.

Inside Diameter	Litres per cm	(gallons per foot)
50.0 mm (2")	.02	0.14
100.0 mm (4")	.08	0.53
127.0 mm (5")	.13	0.86
152.0 mm (6")	.18	1.22
178.0 mm (7")	.25	1.67
203.0 mm (8")	.32	2.13
610.0 mm (24")	2.91	19.50
762.0 mm (30")	4.50	30.50
915.0 mm (36")	6.60	44.00

4. After calculating the number of litres (gallons) of water in the well, calculate the amount of chlorine containing material (that is household bleach or calcium hypochlorite) that is required, using the following quantities:

   a. 1.75 L (0.4 gal.) of javex solution, or
   b. 130 g. (0.3 lbs.) of calcium hypochlorite for every 455 L (100 gallons) of water.

5. Before disinfecting the water supply system, remove or by-pass any carbon filter in the system. A filter will tend to remove the chlorine. In addition, the water heater should be completely drained and allowed to fill with chlorinated water.

6. Thoroughly mix the chlorine solution or powder with the water in the well. The recommended method of adding the chlorine (solution, powder or tablets) to the well water, is to mix the chlorine with a volume of water larger than that in the well. This is then allowed to flow into the well displacing the well water in the formation.

   Another method is to place a measured quantity of chlorine powder or tablets into a weighted porous container. This container is then surged up and down in the well until the contents are dissolved.

7. Open all the taps in the pressure system until you can smell chlorine, and then turn the taps off. This will thoroughly chlorinate the plumbing fixtures.

8. Allow the solution to remain in the water system for at least 12 hours.

9. After the 12 hours, open all the taps until the strong smell of chlorine disappears. The amount of chlorine remaining in the water will not be harmful.

10. In about a week, send a water sample to the local health unit for a bacteriological examination. Boil or chlorinate all drinking water until the bacteriological results are returned. Two consecutive 'safe' tests will probably indicate that the treatment has been effective.

11. If tests show continuing bacteriological contamination, a second chlorination is needed. Following the second treatment, additional tests should be conducted. After repeated positive bacteriological tests, a well contractor should be contacted to surge the well and the surrounding formation with a strong chlorine solution.

12. If additional treatment is still unsatisfactory, the source of the problem should be investigated and corrected. A new well may need to be constructed away from the source of contamination.

12.0 PREVENTIVE MAINTENANCE

A new well, pump and distribution system are expensive; therefore, care should be taken to maintain existing systems in a sanitary and serviced condition. In addition, access to the well should remain unobstructed.

At regular intervals, an inspection of the well and surroundings should be undertaken to ensure that:

a. the well seal or casing cap is securely in place;

b. no openings have developed around or through the casing, due to subsidence, corrosion, or damage, through which surface water and debris can enter;

c. surface water drainage in the vicinity of the well is directly away from the well;

d. the air vent is unobstructed; and

e. no refuse, manure, petroleum, salt, or other potential contaminants are stored or disposed of in the vicinity of the well.

The pump and distribution system should be serviced as specified in the manufacturer's service manual. Exposed wiring, frayed contacts, damp or wet conditions and other hazardous situations should be corrected as they are noticed.

Dug wells should be reconstructed or repaired if they do not conform to the local Regulatory Authority well standards. This can be done by having the upper 2.4 m (8 ft.) of the well set with watertight joints and the top sealed in such a manner that surface water or other material cannot enter.

13.0 WELL ABANDONMENT

Improperly abandoned wells are a hazard to public health and physical safety. Accidents have occurred where children have fallen into large diameter abandoned wells. Abandoned wells should also be carefully sealed to prevent pollution of the ground water, to conserve aquifer yield and artesian pressure (particularly in the case of flowing wells) and to prevent poor quality ground water from moving between water bearing zones.

Employment of a well contractor familiar with abandonment procedures is usually advisable, especially in cases involving deep or flowing wells or wells in fractured bedrock.

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