State of Iowa

1968

IOWA

PUBLIC HEALTH

BULLETIN

SANITARY STANDARDS

for

WATER WELLS

RESIDENTIAL AND OTHER SMALL INSTALLATIONS

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James F. Speers, M.D., M.P.H.

Environmental Engineering Service

Paul J. Houser, M.S., P.E., Chief

Water Supply Division

Dean W. Johnson, M.S., P.E., Director

OFFICES

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FOREWORD

Adequate quantities of drinking water are essential to life and well-being. Since water may also be the carrier of causative agents of disease, it is essential that attention be paid to the quality of available drinking water. Laboratory analyses of samples from private wells submitted to the State Hygienic Laboratory have revealed undesirable contamination in a large majority. Likewise, inspections of a large number of private wells have revealed faulty location and construction in many cases.

This bulletin sets forth sanitary standards and practical suggestions for private well construction. In many cases only minor reconstruction is required to provide adequate protection. It is hoped, therefore, that this bulletin will serve as a guide to those contemplating a new well or reconstructing an old well.

JAMES F. SPEERS, M.D., M.P.M.
Commissioner of Public Health

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INTRODUCTION

Most underground water occurring in sand or gravel deposits overlain with clay or loam is of satisfactory bacterial quality at its source. Loam, fine sand or a mixture of the two constitute excellent natural filtering media for removing objectionable bacteria, almost always found in surface waters. This is particularly true of the upper layers of soil which support abundant bacterial life. These bacteria exert a tremendous purifying effect upon surface water, by virtue of the fact that they feed upon the organic matter present in water, converting it into humus and inorganic material. These organisms thrive only in the presence of air (oxygen) and hence do not penetrate to any great depth, usually not more than three or four feet.

Clay is particularly impervious to the passage of water. Consequently, if a water-bearing vein of sand or gravel is overlain with several feet of clay, the water in such formation is likely to be of good bacterial quality. Therefore, unless the underground water has been contaminated with sewage from deep cesspools or privy vaults penetrating to or near the water bearing formation, such water is usually found to be free from objectionable bacteria.

The above does not apply to water occurring in creviced limestone or very coarse gravel. In creviced limestone, contaminated water may gain access to these formations through sinkholes or outcroppings of the rock along streams and travel a distance of a mile or more underground without undergoing any appreciable purification. Therefore, water from shattered limestone formations near the surface must always be viewed with suspicion.

In coarse gravel formations, while the situation is not as serious as in limestone, contamination will travel considerable distances without undergoing adequate purification.

Radioactive "fallout" resulting from nuclear detonations creates another possible contaminant of water supplies. This material falls from the air to the ground surface and contaminates surface waters. It will normally penetrate only a few feet into the soil. Wells, therefore, constructed and sealed so as to exclude surface and shallow ground water will also be safe from contamination by fallout.

Without proper location, construction, and protection it is possible for contaminated surface or immediate subsurface water to gain access to the well. Usually at an isolated residence it is easily possible to locate a well at a safe distance from a source of serious contamination. Therefore the most important factor is the proper construction of the well, and this bulletin deals principally with this phase of water supply development. It is realized, however, that a complete discussion to include all problems likely to arise is impossible. The State Department of Health, therefore, invites inquiry on specific problems in water supply development where additional service may be required.

The most satisfactory type of water supply for a private home is a pressure system, preferably from a public or municipal supply known to be safe and dependable. In the majority of isolated residences, however, such a supply is not available and other sources must be developed.

Shallow wells (depth less than 100 feet) are the chief source of supply for most private homes. This type of well usually furnishes a sufficient quantity of water but is the most readily contaminated and special care must be taken in the location and construction. Drilled or driven wells are preferable to dug wells whenever ground formations permit their use because it is easier to construct and maintain drilled and driven wells free from pollution. They are also generally cheaper than approved dug wells of the same depth. In the case of double tubular wells, having both casing and drop pipe, where approved types of pumps are used, pits for frost protection may be more readily avoided than with single tubular wells. Double tubular wells are therefore preferable to single tubular wells.

WELL LOCATION

Wells should be located on the highest ground practicable and on ground higher than nearby sources of pollution. If the well is located so that surface water runoff must pass over or near the well, the area immediately surrounding the well should be filled with clay or clean earth. The fill should extend at least 15 feet in all directions from the well and be graded to an elevation at least two feet above the highest known surface water elevation. A well should be located so it will be accessible for cleaning, treatment, repair, test, inspection, or such other attention as may be necessary.

Wells should be located a sufficient distance away from sources of pollution so that contamination of the well by underground water flow or seepage will be prevented. The following minimum distances should be maintained between a well constructed in accordance with the recommendations outlined in this bulletin and representative sources of pollution to provide reasonable assurance that such underground contamination will not occur. Greater distances should be provided where possible.

Cesspool (receiving raw sewage)	150 ft.
Seepage (leaching) pit, filter bed, soil absorption field, earth pit privy, or similar disposal unit	100 ft.
Septic tank, concrete vault privy, sewer of tightly jointed tile or equivalent material, or sewer-connected foundation drain	50 ft.
Sewer of cast iron with leaded or mechanical joints, independent clear water drain, or cistern	10 ft.
Cast iron sewer with leaded joints encased with 6 inches of concrete	5 ft.
Pumphouse floor drain, cast iron with leaded joints, draining to ground surface	2 ft.

Cesspools and seepage pits should not be more than 12 feet deep nor should they extend vertically within 10 feet of the ground water strata.

Farm barnyards are a common source of well contamination. Well drained barnyards and such sources of contamination as barn gutters, animal pens or stalls having concrete floors, and silos, should be located at least 50 feet away and down slope from a well. Poorly drained barnyards and accumulations of manure should be at least 100 feet away and down slope from a well.

The above distances should be considered minimum safe distances. Where coarse gravel, limestone, disintegrated rock, or other porous material that will permit a rapid flow of water is encountered above the water-bearing strata, and especially when near the ground surface, these distances do not apply. In case the water is obtained from limestone, disintegrated rock, or other porous formations which lie near the surface, too much reliance cannot be placed on increased distances and such a supply cannot be considered satisfactory unless its safe quality is demonstrated by frequent bacteriological analyses.

A well equipped with electrical powered pumping equipment will provide maximum fire protection if located some distance from the residence and other buildings and if wired separately for power. If located in a pit or room adjacent to a house basement and wired to the house electrical system, it is often useless at the time of a fire.

WELL CONSTRUCTION

In constructing a well, proper attention must be given to the depth at which safe water can be obtained and to methods of excluding surface runoff and shallow contaminated ground waters. The minimum depth for safe water will vary with different soil formations and will also depend upon the extent to which the area is developed.

In the northeastern and eastern portion of the state where limestone formations are encountered near the surface, shallow subterranean streams are apt to be contaminated at points far removed from the well site. Wells deriving water from these shallow formations are therefore likely to produce an unsatisfactory water and should be avoided if possible. Deep wells deriving water from formations below the shattered limestone formations are much more dependable if properly constructed to exclude the shallower contaminated waters.

In other sections of the state, subterranean streams are less readily contaminated by seepage from sources of pollution at or immediately below the ground surface. Hence, if proper precautions are taken in locating the well relative to sources of pollution in the immediate vicinity, a water of fairly dependable purity may be derived from shallower depths. Ordinarily the upper 10 feet of soil will be subject to intermittent contamination and in many cases the contamination will penetrate to a greater depth. Whenever possible, wells should therefore derive water from a depth below 20 feet. Under no circumstances should water be derived from a depth less than 10 feet.

In protecting a well against the entrance of surface or shallow subsurface waters, several precautions should be observed regardless of the type of well being constructed. The well top should be raised above the surrounding ground sufficiently to insure proper drainage of surface water. In all cases, the top of the well platform should be at least four inches above the surface of the ground. The top of the casing should extend above the platform to prevent water entering the well. For hand pumps, the casing should extend at least one inch above the platform into the pump base, or higher if a flanged pump setting is used as illustrated on Plate 10. For power pump installations, the casing should extend at least six inches above the platform.

Well platforms, or curbings, and manhole covers should be of impervious material, such as reinforced concrete, steel, wrought iron, or cast iron. WOOD SHOULD NEVER BE USED, EVEN FOR MANHOLE COVERS. All openings through well tops or pump platforms should be constructed with raised shoulders and overlapping covers to exclude waste water or other pollution.

Well pits present a sanitary hazard to a water supply due to the possibility of flood water gaining entrance to the well. Few well pits have watertight tops and side walls and few have concrete floors and adequate drainage. As a result, many well pits upon inspection are found to contain contaminated water, are generally damp, and in a very insanitary condition. The confined space of a well pit makes it difficult to work upon the equipment. Metal parts corrode rapidly in damp pits. Moisture is one of the worst enemies of electric motors and wiring. The need for a pit to protect a well from freezing no longer exists because of improved designs of pumps and wells, insulation of pump houses, and the manufacture of safe, cheap heating equipment. Pitless adapters are further discussed in the section "Pump Installation, Power Pumps." Well pits, or wells with the casing or curbing terminating below ground elevation, should therefore be avoided on all new well construction. Existing well pits should be eliminated whenever possible, but where not eliminated, they should be absolutely watertight, the top of the casing carefully sealed, and a drain provided terminating at the ground surface for free discharge. THE PIT DRAIN SHOULD NEVER BE CONNECTED INTO ANY OTHER SEWER OR DRAIN LINE.

Other features pertaining to the particular type of well being constructed must also be observed. These are described as follows for the various types of wells common in this state, with accompanying detailed sketches showing proper construction.

Dug and Bored Wells. (Plates 1, 2, 3, and 4.) The walls of dug and bored wells should be watertight to a depth below the ground surface of at least 10 feet and in most cases it would be desirable to extend such watertight construction to a greater depth. This may be accomplished by constructing a concrete wall or curbing at least six inches thick to the depth to be made watertight. Brick or tile walls are generally not watertight but they make convenient interior forms for pouring the concrete walls and may be left in place. Metal pipe may also be used for the interior form.

In some cases, a durable metal casing may be used, but it should be installed as described for double tubular or drilled wells. An exception to this is when light gauge metal pipe is used to form a bored well for concreting, as shown on Plate 2.

If the type of construction employed leaves an annular space or opening between the excavation and outside of the curbing or wall, the space should be filled in such a manner that surface water or shallow ground water will be prevented from running down the outside of the curbing and thence into the well or into the water-bearing strata. Such contamination of a well may be prevented by backfilling the space from the water-bearing strata to the surface or to a minimum depth of 10 feet with puddled clay, mortar, or concrete. Clean earth may be used if the other materials are not available but extreme care must be exercised in placing to assure a satisfactory seal. Gravel or sand should not be used. If concrete is used, the entire quantity should be placed at one pouring to eliminate the possibility of leaky construction joints.

The well platform should be a watertight reinforced concrete slab with a minimum thickness of four inches, and with any openings constructed with raised shoulders to exclude waste water or other contaminating material. The platform should overlap the walls or curbing by at least two inches. A sufficient amount of rich cement mortar should be used in sealing the well platform to the sidewalls to insure a watertight connection.

The drop pipe opening through the well platform should be formed by a length of iron pipe sleeve of sufficient diameter to admit the pump cylinder. This pipe sleeve should always be cast into the platform (placed in top when concrete is being poured) and should extend above the platform as illustrated on Plate 10 if a hand pump is to be installed, or at least 6 inches if a power pump is to be installed as illustrated on Plate 11.

Manholes are usually unnecessary and often admit pollution to the well. If a manhole is built, the shoulder or ring should extend at least six inches above the platform. The opening should be covered by a solid, watertight lid of cast iron, steel, or reinforced concrete with overhanging vertical edges covering the exterior of the shoulder or ring at least four inches. Wood should not be used. The lid should be firmly bolted or locked in place.

Buried Slab Type of Dug Well. (Plate 5.) The buried slab type of dug well, as shown on Plate 5, was developed to overcome the main sanitary defect of most dug and bored wells—that of leaky platforms and sidewalls. This type of construction is recommended for new dug wells or reconstruction of existing dug wells. The construction as indicated should provide satisfactory surface and immediate subsurface protection for dug and bored wells.

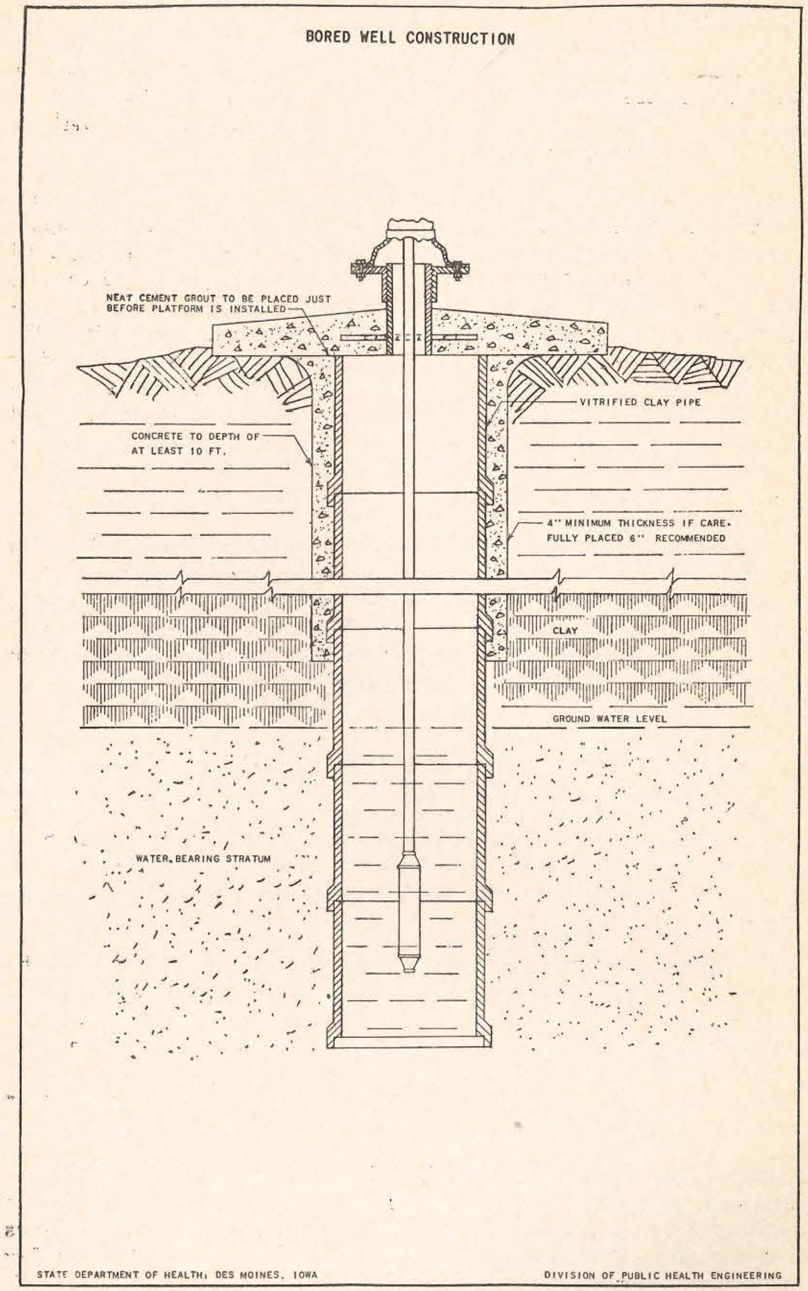


Plate 1

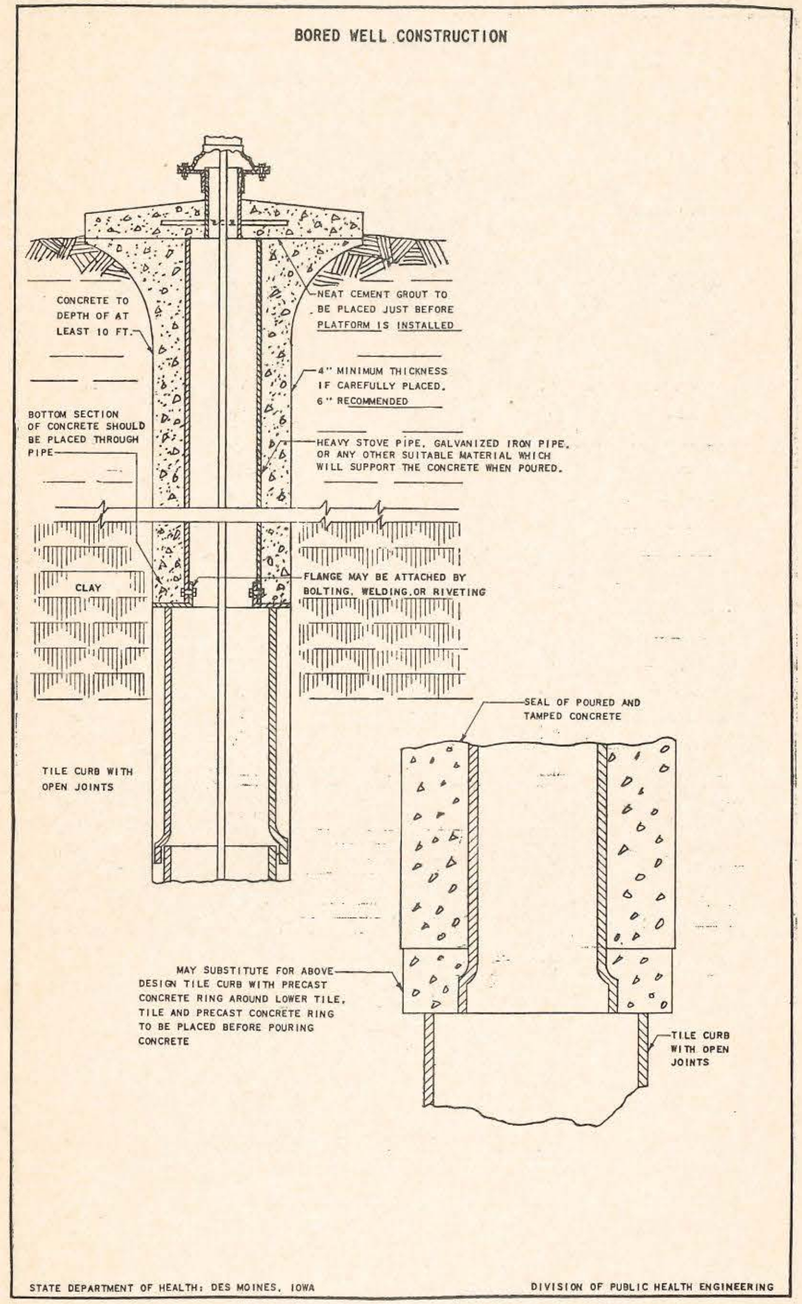


Plate 2

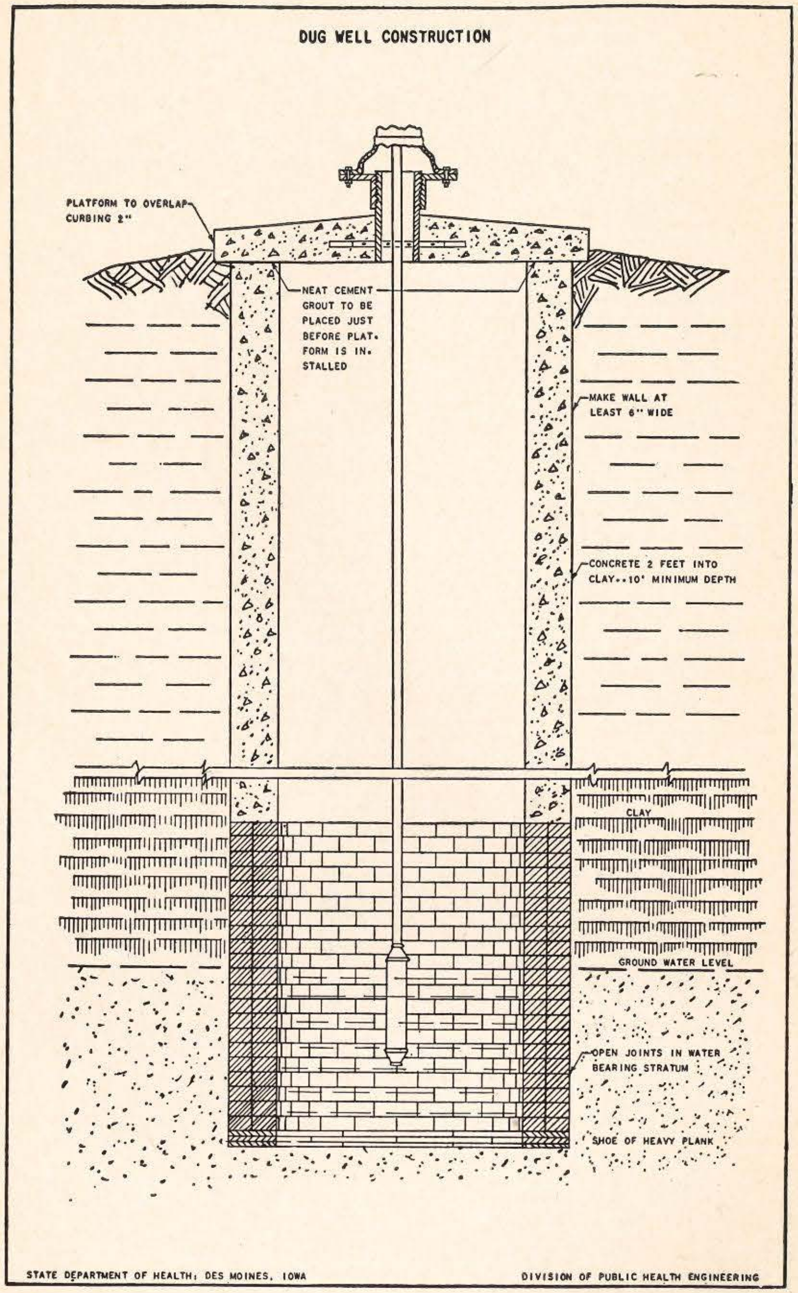


Plate 3

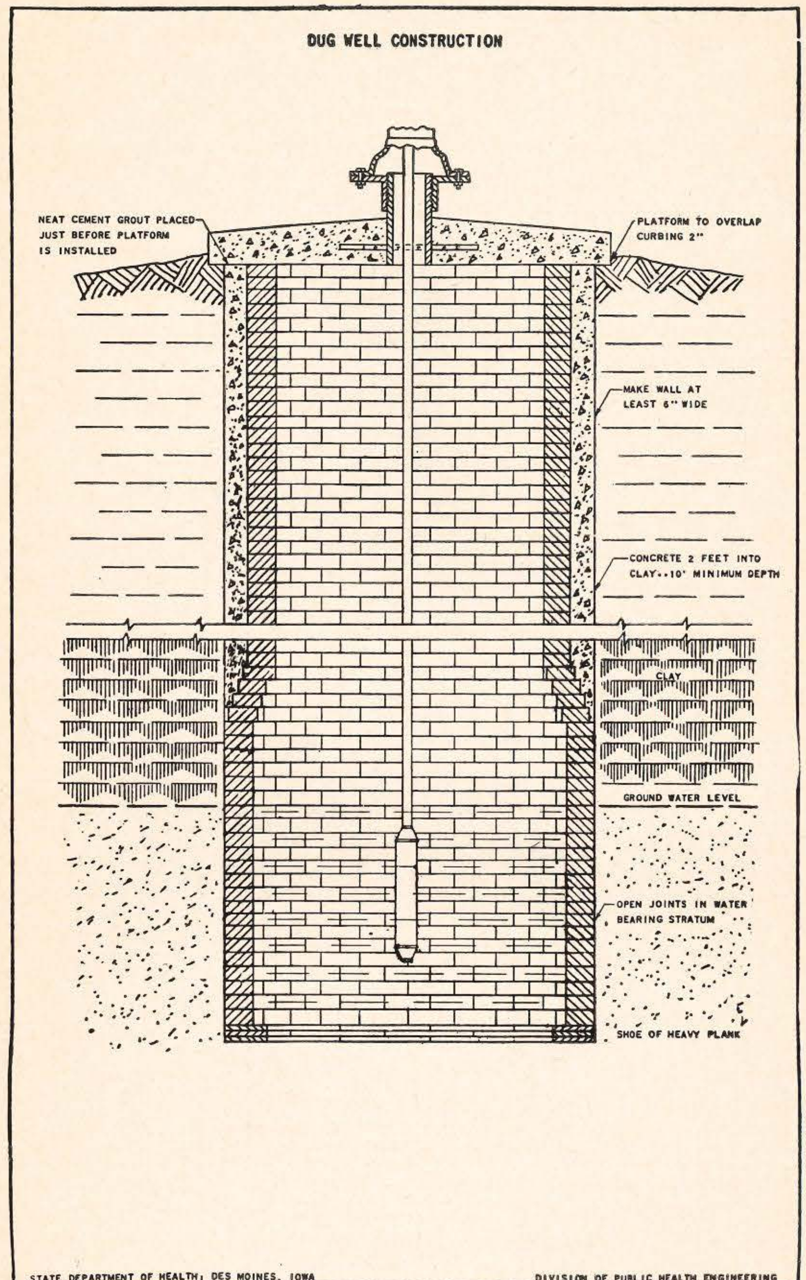
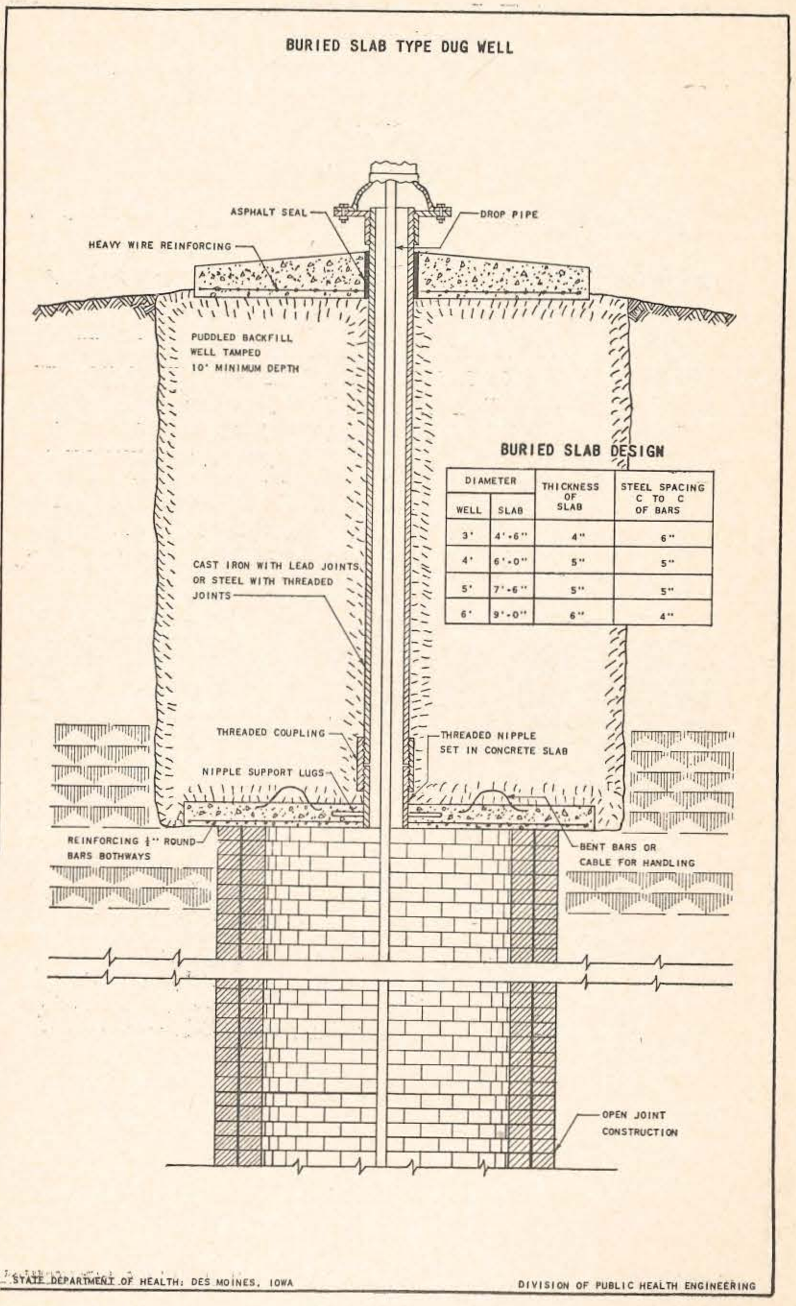


Plate 4



DIAMETER		THICKNESS OF SLAB	STEEL SPACING C TO C OF BARS
WELL	SLAB		
3'	4'-6"	4"	6"
4'	6'-0"	5"	5"
5'	7'-6"	5"	5"
6'	9'-0"	6"	4"

Plate 5

The plate includes a table indicating slabs of various diameters required for wells of different sizes. Also included are thickness of slab and reinforcing spacing required for construction. It will be noted that a minimum distance of 10 feet is indicated for the depth of backfill. This distance is not fixed and should be varied according to the formations encountered. That is, if clay or similar impervious material is available with reasonable limits below 10 feet, this backfill should be carried down and into the impervious material approximately two feet. The slab may be poured in place using form lumber over the top of the well, or the slab may be precast nearby and lowered into place.

Seamless metal pipe, such as cast iron, wrought iron, or steel pipe, is absolutely necessary for the pipe between the two concrete slabs. Under no condition should tile pipe of any kind be used. The pipe should be fastened securely in the buried slab as indicated in Plate 5. In the case of threaded steel-pipe, the nipple should be set in the slab. In the case of bell and spigot joints in cast iron pipe, lead joints properly poured are satisfactory. The pipe casing should extend above the platform as shown in Plate 10 for a hand pump, or at least six inches if a power pump is to be installed. A joint filled with an asphaltic or other similar flexible compound should be provided between the concrete platform and the casing to permit settlement and prevent breaking the casing or bond between the casing and the buried slab. Puddled clay is recommended for backfilling but other clean earth may be used if clay is not available. Care should be taken in placing and tamping the backfill so as to minimize settling.

Drilled Wells. (Plates 6 and 7.) A drilled well is one equipped with both a casing and a drop pipe. This type of well should be cased with a standard wrought iron or steel well casing with the sections joined together by threaded couplings or by welding except where it passes through solid rock in which there is no danger of caving or inflow of mud, silt, or sand. When the casing ends in a water-bearing sand or gravel formation and a screen or strainer is used, the joints between the screen and casing should be made tight, as illustrated in Plate 6, in order to prevent sand flowing into the casing which might cause wear on the pump or reduce the yield of the well.

The casing should be of sufficient size to allow the production of the quantity of water required. This is important because the capacity of the well will be limited by the amount of water which the casing or screen section will pass with a reasonable loss of head and also by the size of the pumping equipment which can be placed in the casing.

In all cases, steps should be taken to prevent contaminated water from upper formations passing downward along the outside of the casing and entering the well at the lower end of the casing or entering the water-bearing formation which is to be used as a source of supply. A satisfactory seal may be obtained by grouting the opening between the casing and the drill hole with cement grout or, in some instances, clean puddled

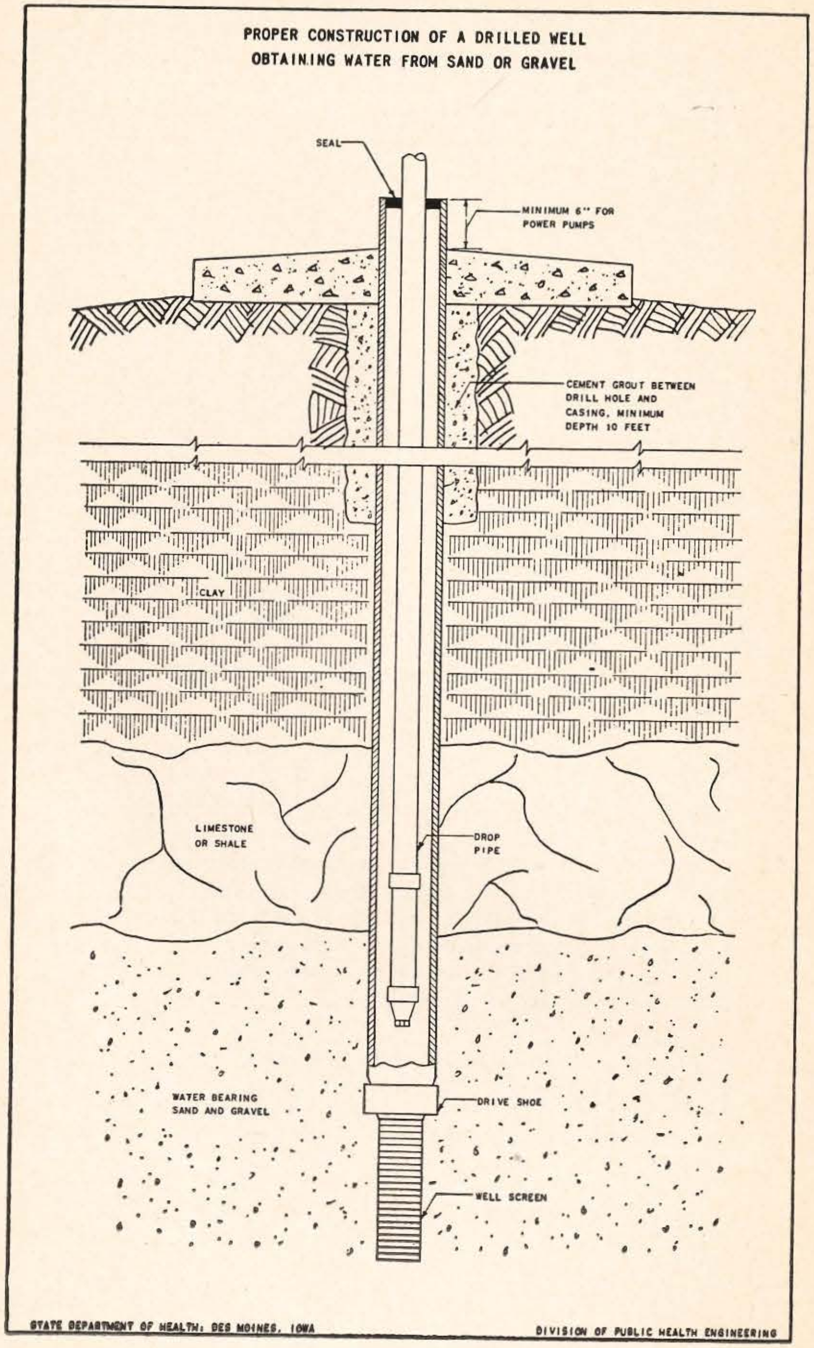


Plate 6

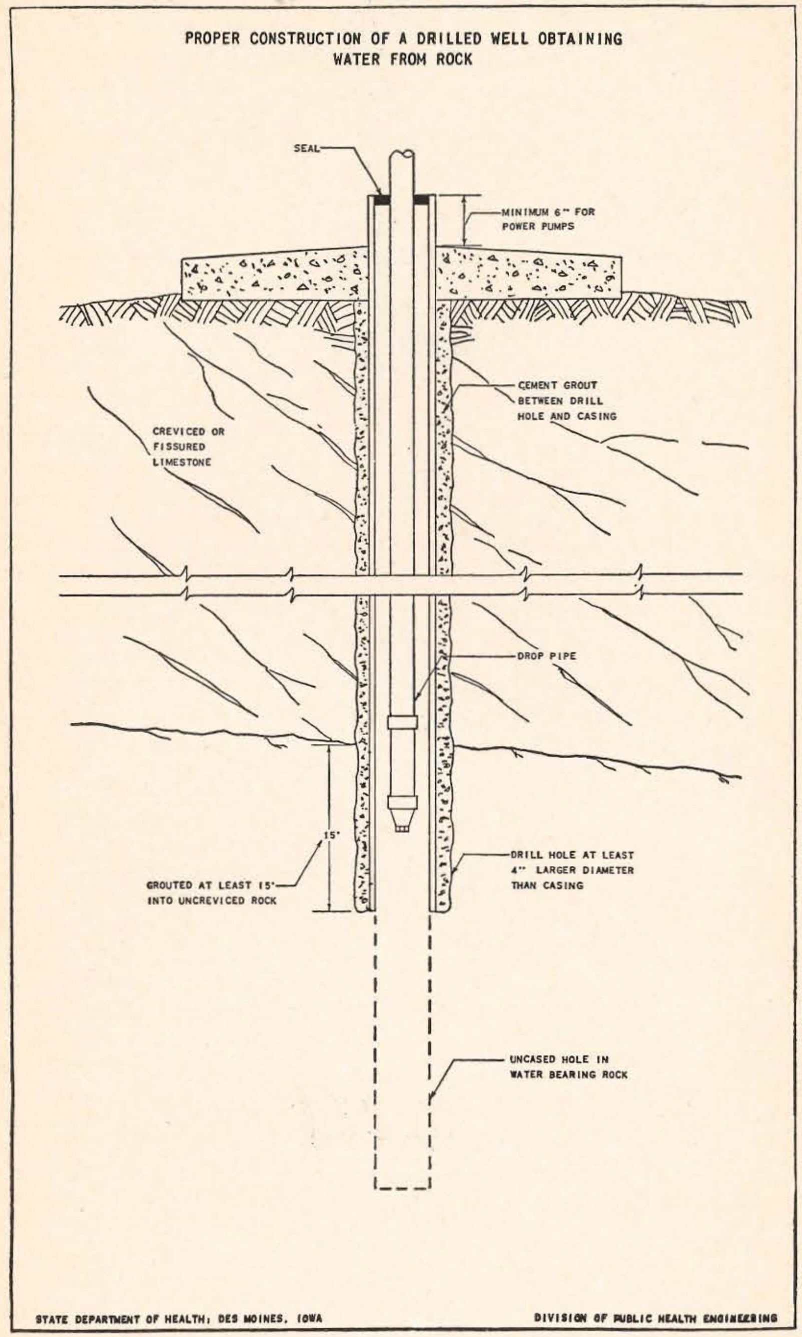


Plate 7

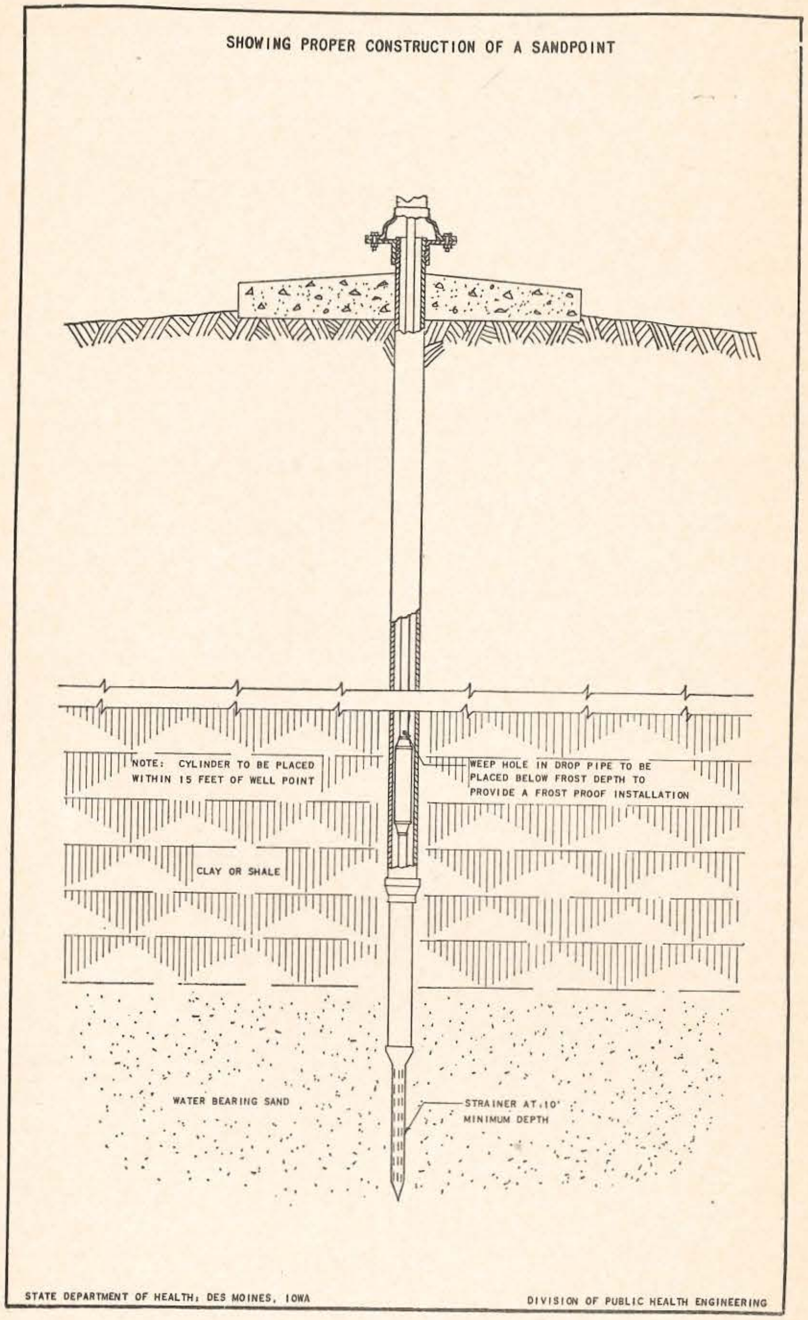


Plate 8

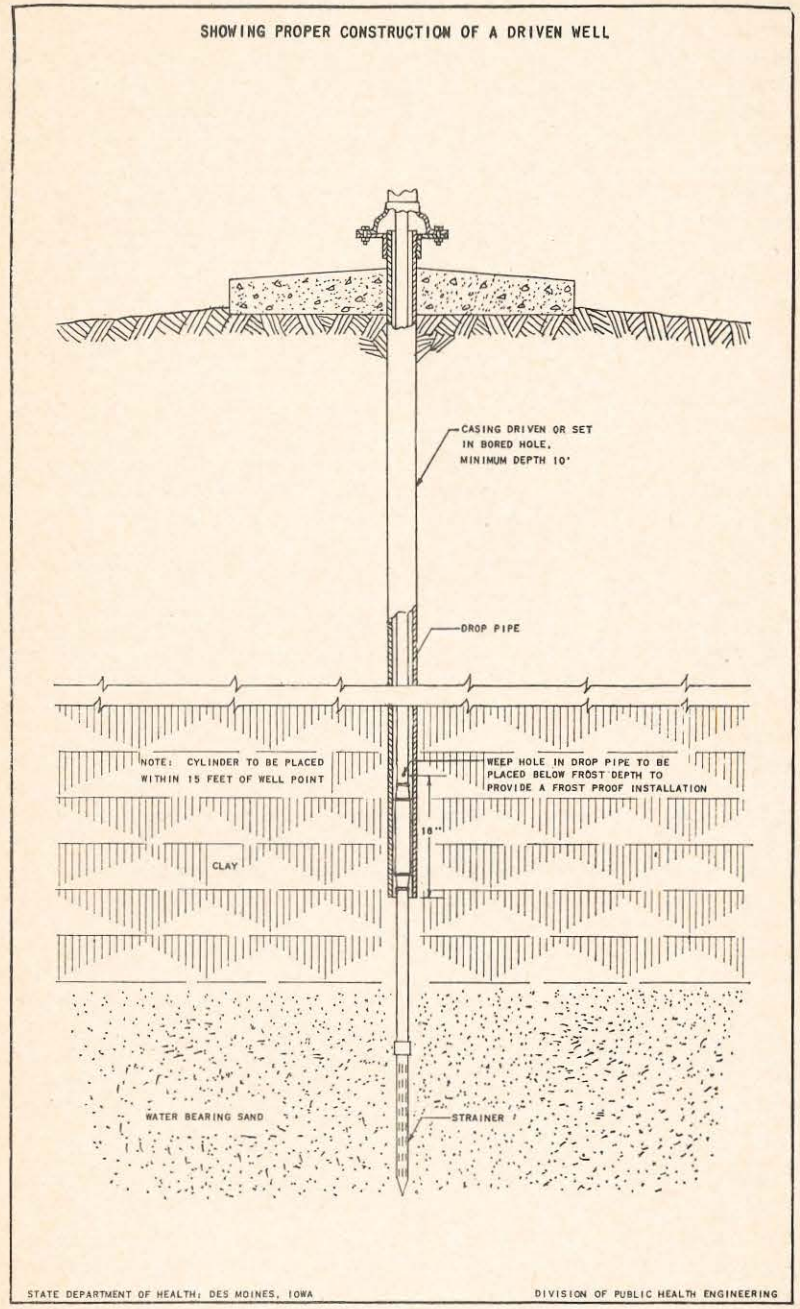


Plate 9

clay, as illustrated in Plates 6 and 7. The grouting should extend to a depth of at least 10 feet. Water should not be used as a source of supply when obtained from creviced, fractured, shattered, or otherwise channelized rock unless such rock is overlain by a mantle of soil or unconsolidated material having a depth of at least 40 feet extending at least a half mile from the well. When water is obtained from a rock formation located below creviced, fractured or shattered rock, the porous rock should be completely cased off and the casing should extend at least 15 feet into the firm rock formation. The drill hole through the creviced rock and 15 feet into the firm rock should be at least four inches larger in diameter than the casing and the opening between the casing and drill hole should be filled with cement grout. Plate 7 shows proper construction of a well where creviced, fractured, shattered or otherwise channelized rock is encountered above a safe rock water-bearing formation.

Sandpoint Wells. (Plates 8 and 9.) Sandpoint wells are used advantageously in a number of areas throughout Iowa. A satisfactory water supply may be obtained from a sandpoint well if general sanitary standards are observed, including location and construction standards previously set forth for other types of wells.

Plates 8 and 9 showing proper sandpoint construction indicate two types of sandpoints, including items of construction for sanitary protection. Ordinarily a sandpoint should never be developed as a drinking water supply at a depth less than 15 feet because of intermittent contamination of ground waters at shallower depths. Double tubular sandpoint wells, as shown on Plates 8 and 9, are preferred over single tubular wells. The joints at the top of the cylinder and screen for a driven sandpoint should be such as to permit the removal of the cylinder, as shown on Plate 8. The outside casing for the sandpoint on Plate 9 should extend into a formation that will absorb seepage from the weep hole above the cylinder. Well platforms and pump settings should conform to Plate 10 or the plates illustrating power pump installations.

ABANDONMENT OF WELLS

Wells taken out of service are a hazard not only to the water-bearing strata they penetrate but also to life and limb. Many serious cases of injury have resulted from persons falling into unprotected well holes. In addition, they provide easy access for pollution to enter the formations supplying water to other wells in the vicinity.

Wells no longer used should be filled with puddled clay or concrete throughout their entire depth. In filling dug or bored wells, as much of the curbing as possible should be removed so that surface water will not penetrate to the water-bearing formations by way of a porous lining or by following cracks and fissures in or around the lining. Trash should not be used for filling. ABANDONED WELLS SHOULD NEVER BE USED FOR DISPOSAL OF SEWAGE OR OTHER WASTES.

PUMP INSTALLATION

Hand Pumps. (Plate 10.) The pumping equipment for hand pumped wells should be constructed and installed in such a manner that the entrance of contaminated water or other contaminating material into the well or water chambers of the pump will be prevented. Hand pumps should be of the lift type with cylinders placed below the water level so that priming will be unnecessary. All hand pump bases should be of the solid one-piece type and should bolt to a flange secured to the well casing by thread or weld connection as illustrated in Plate 10. Hand pump bases secured to the well platform by bolts cast in the concrete have proven unsatisfactory due to difficulty in maintaining a watertight seal at the base, particularly after the pump is removed for repairs. If necessary to use such a pump, a gasket should be provided between pump base and platform to provide a watertight connection.

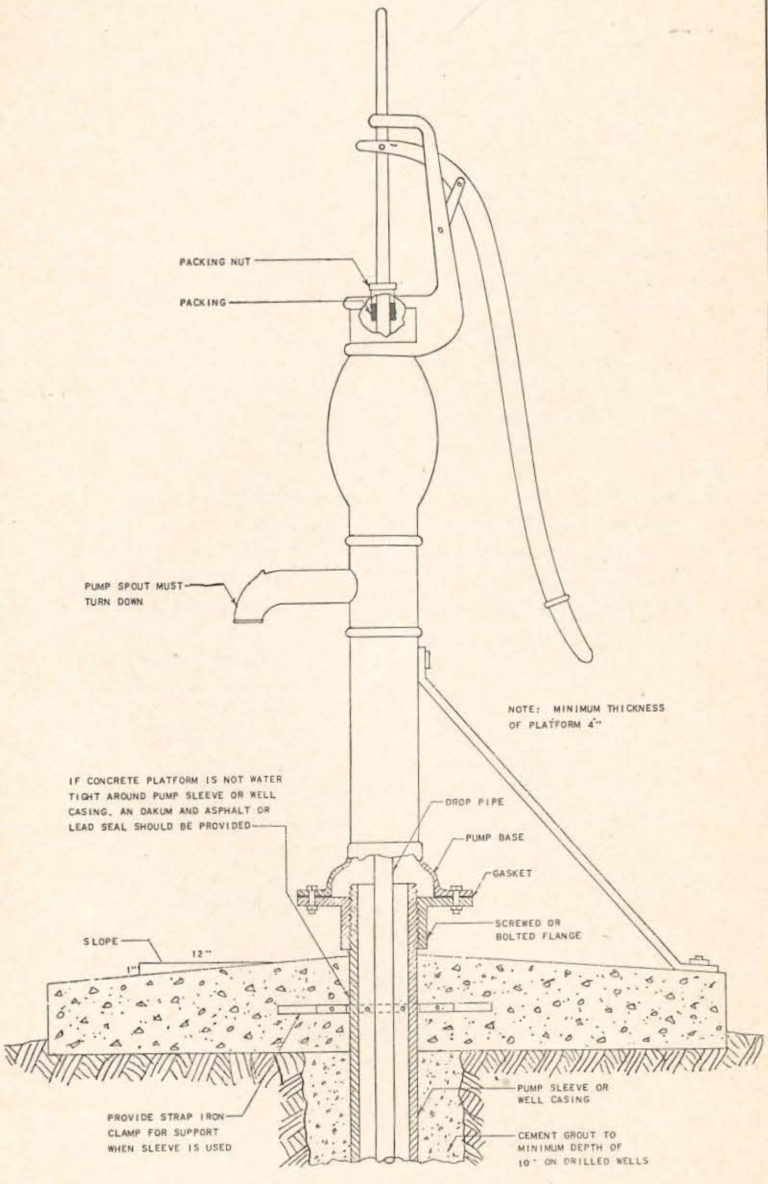
The pump head should be designed to exclude contamination by hands, bird droppings, insects, etc., of the water chamber. Force pumps are reasonably protected against such contamination by the stuffing box which surrounds the pump rod, but ordinary lift pumps with a slotted pump head are open to contamination and should not be used. Such pumps fitted with sliding, overlapping sleeves, or a hood casting over the slotted pump head top, are fairly satisfactory. Existing open pump heads may be protected to a limited extent with metal covers fastened around the pump rod. It is believed that many unsatisfactory bacterial results are caused by bird droppings gaining access to the water chamber in the pump head due to improper protection of the slot in the pump head. The pump spout should be of the closed, downward-directed type rather than of the open-type commonly used in so-called "pitcher-pumps."

Power Pumps. (Plates 11, 12, 13, and 14.) All power-driven pumps located over wells should be mounted on the well casing, a pump foundation or a pump stand, so as to provide a watertight seal at the top of the well. When the pump unit is not located over the well and the pump delivery or suction pump emerges from the top of the well, a watertight expanding or equivalent seal should be provided between the well casing and piping. Sanitary features pertaining to power pump installations are illustrated on Plate 11.

Satisfactory equipment is available as a unit which permits underground discharge pipes from the well yet bringing the permanent watertight casing above the ground surface as previously recommended. This equipment is generally called a pitless adapter. It eliminates the need for a well pit as the discharge line is completely below frost penetration. Pitless adapters can be used with above ground pumps, submersible, suction, or jet pumps. A suggested installation is shown on Plate 12.

When installing the unit, a hole is excavated to a depth below the discharge adapter and pipe. After installation, the hole is backfilled with clean earth. Such construction eliminates the opening between the drill

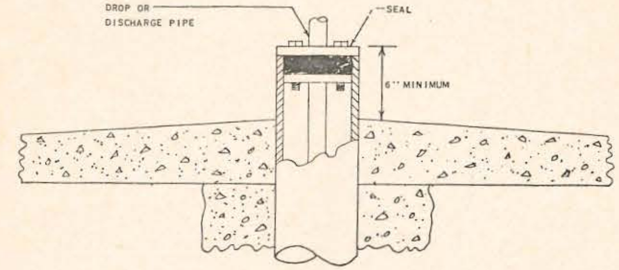
SHOWING PROPER PUMP DESIGN AND INSTALLATION



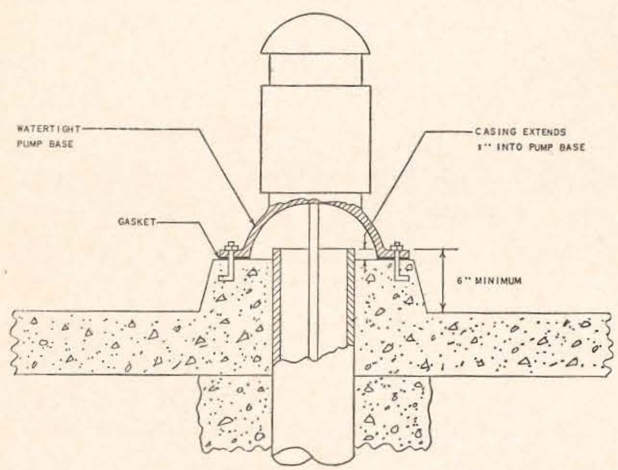
STATE DEPARTMENT OF HEALTH, DES MOINES, IOWA — DIVISION OF PUBLIC HEALTH ENGINEERING

Plate 10

PROPER METHODS OF SEALING DRILLED WELLS



SEAL BETWEEN PUMP AND CASING



SEAL BY PUMP WITH WATERTIGHT BASE

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Plate 11

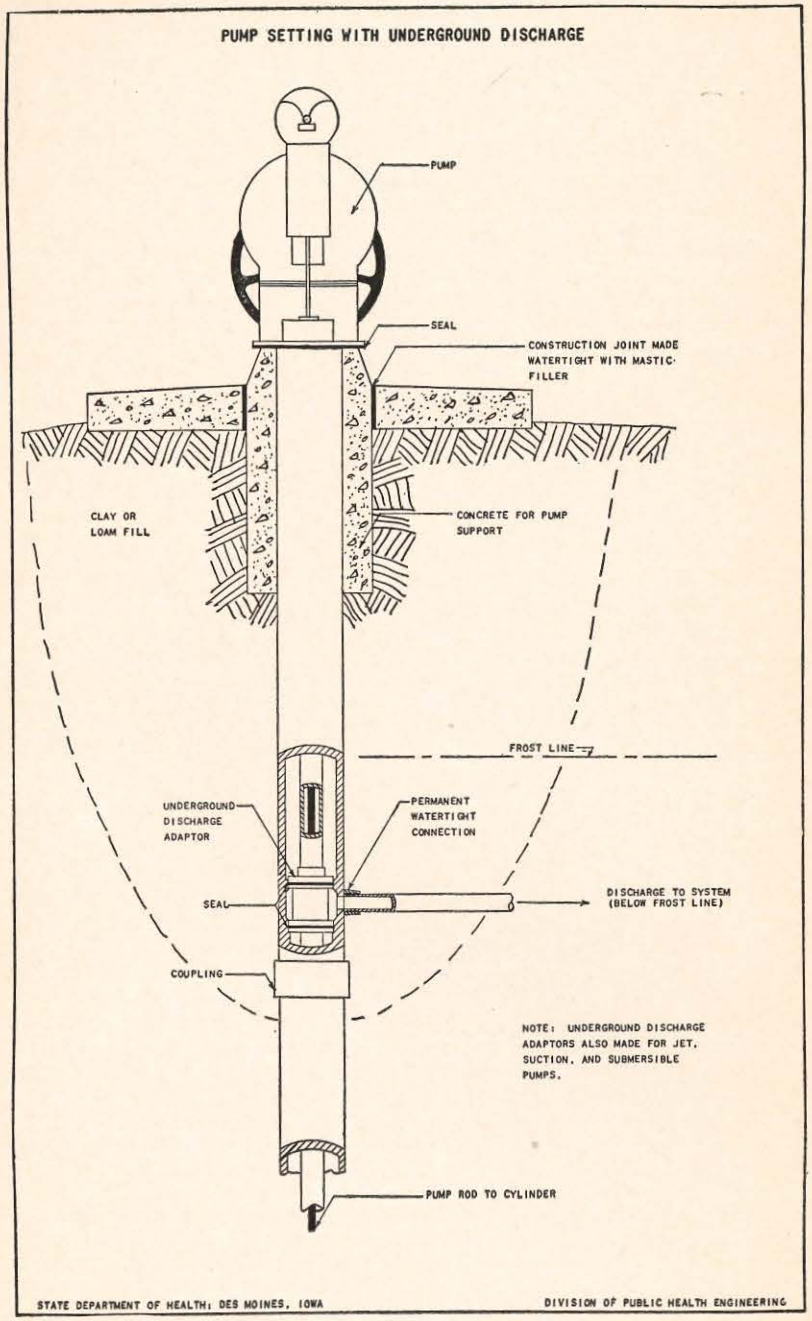

Plate 12

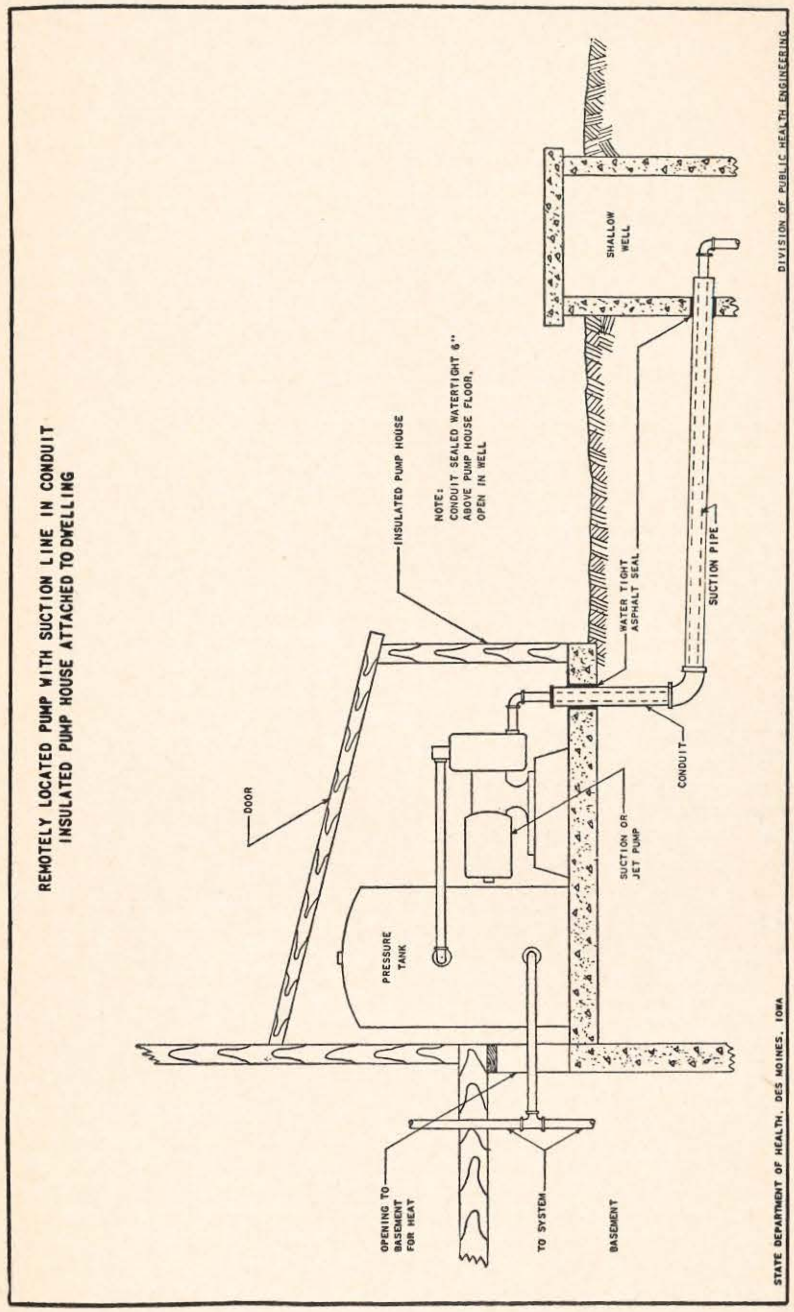

Plate 13

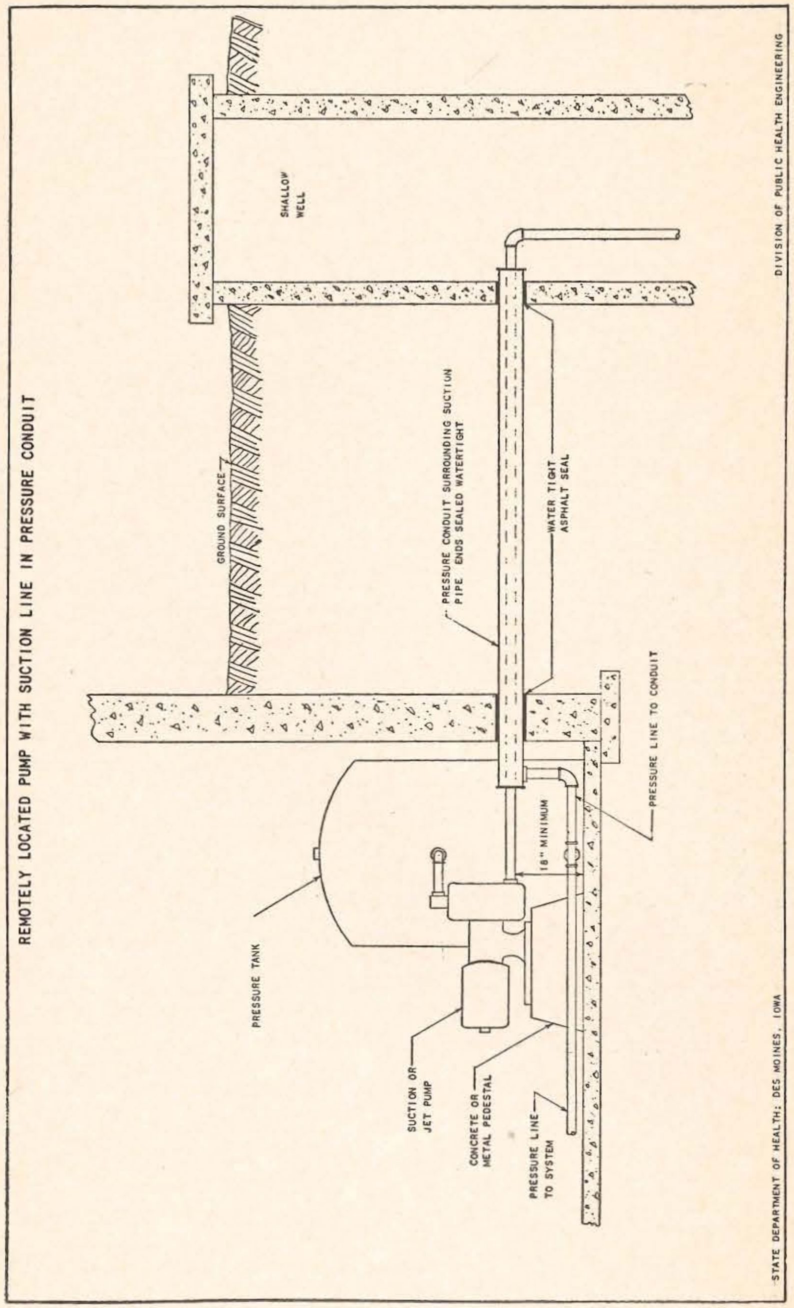

Plate 14

hole and well casing eliminating the necessity of grouting or sealing to the 10 foot depth. If a power pump is installed over the well casing and is mounted on a concrete pedestal, the pedestal should extend at least three feet below the ground to provide stability.

With all types of pumps, the extension of the pitless unit or the casing should be brought at least 12 inches above the ground surface. A watertight overlapping cover or gasketed plate must cover the top of the casing. A vent should be provided as discussed later. Any openings through the cap, such as for electrical lines, must be made watertight. It is also desirable to make a small concrete slab around the casing. The slab will prevent vegetation from growing and provide some protection from mowers and such.

The design of the pitless unit should allow for easy removal of the pump for repair. The underground discharge of the well should be permanently attached to the well casing so that it is not necessary to disturb it when pulling the pump.

It is also necessary to have a good check valve or column valve installed either close to the well in the discharge pipe or in the pump column. This obviously is to prevent the flow of water back into the well when the pump is not operating.

Thus with the use of a pitless adapter no pit type of construction need to be provided nor does a pump house have to be constructed to prevent freezing of water lines.

When a pump is located remote from the well, as may be done with a jet or suction type of pump, the pipe connecting the pump and well will, or may be, under negative pressure or suction when pumping. Such a suction pump should be provided special construction to prevent contamination of the water supply should the pipe ever become perforated. The suction pipe, unless greater than 10 feet in depth, should be encased in standard weight metal pipe. The protective conduit should extend at least six inches above the pump house floor as illustrated on Plate 13 and should be sealed absolutely watertight at this end. The conduit may drain back into the well. Such an encased suction pipe should be located away from sources of pollution as recommended for wells under "Well Location," except that sewers constructed of cast iron pipe with leaded or mechanical joints may be located closer. If such a sewer is within 10 feet of the suction line and the suction line must pass below the sewer, there should be no joint in either the suction pipe or protective conduit within 10 feet of the sewer.

More positive protection may be provided the suction pipe by sealing both ends of the protective conduit and applying pressure to the outer pipe as illustraed on Plate 14. Pressure may be applied to the outer conduit on a two-pipe jet installation by enclosing the pipe on the suction side of the impeller within the pipe returning water to the jet. When the suction pipe is enclosed in a pressure conduit, the line may be located within the distances to sources of contamination noted under "Well Location" but in no case within 10 feet. Sewers of cast iron pipe with leaded joints, clear water drains, and cisters may be located within 10 feet.

A watertight seal should be provided where the suction pipe or conduit pipe attaches to or enters the well. An exposed suction pipe, as in a basement room, should be at least 18 inches above the floor. Any pipe connecting a pump and a well should be buried at least five feet unless otherwise protected against freezing.

Any well vent installed should have the opening turned down, the opening should be at least 12 inches above the pump house floor, and should be screened with 20-mesh copper screen. On all water pressure systems, a water faucet or similar tap should be installed on the discharge side of the pump for collecting water samples.

PUMPHOUSE CONSTRUCTION

The safest means of protecting water system equipment from freezing is to construct an insulated pumphouse as illustrated on Plate 15. Besides being more sanitary, the pumphouse assures a dry place for the pump, motor, electrical switches and the wiring. This reduces common troubles such as rusting of equipment and dangerous electrical short circuits.

The size of the pumphouse will depend primarily upon the physical dimensions of the pump, motor and pneumatic tank. It need only be large enough to house the equipment and provide a small area for minor pump service and repair work. In most cases, however, the minimum size will be 4 ft × 5 ft., outside dimensions.

The pumphouse may or may not be equipped with a door. When the door is omitted, access for pump and equipment service is made by raising or removing the shed-type roof. For safety purposes a permanent prop should be provided to hold the roof positively open while men are working.

The pumphouse can be made of frame construction, concrete block or other common building material. To keep heat requirements to a minimum, however, the structure should be well insulated. A vapor barrier should be provided on the inside of the insulating material which can be either 4 inches of fill type or a double thickness of blanket insulation.

Supplemental heat can be provided by using one or two thermostatically-controlled heat lamps. An indicator light located so that it faces the farmstead can be used to show that lights are operating satisfactorily.

The pumphouse floor should be of watertight concrete with a mastic seal between the well casing and floor. The floor should slope to a surface drain of 1¼-inch diameter (or larger) pipe. To prevent insects from entering, this drain can be protected with a pipe cap drilled with ¼-inch holes. The structure should be anchored to the foundation with bolts so that it can be removed.

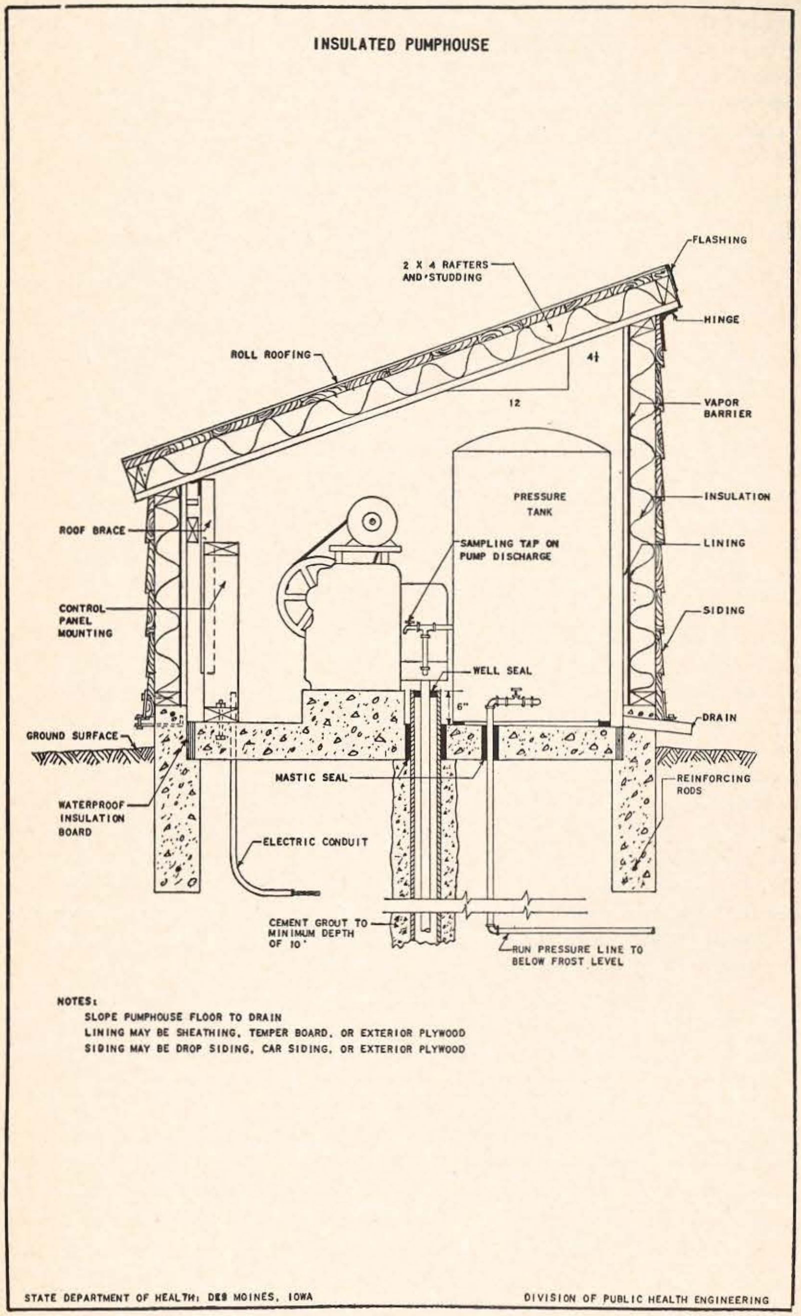

Plate 15

In most cases the pumphouse should be served with a 3-wire 230-volt service, the size of wire being determined by the electrical load and the distance between the meter pole and pumphouse. These electric service wires may be either overhead weather-proof or underground wiring of the approved type (USE or UF). However, to have a water supply for fire protection and control, it is important that this circuit be wired ahead of the main fuses at the service entrance panel.

This electrical circuit should have its individual disconnect switch, fused according to the current-carrying capacity of the wire. The neutral wire should, of course, never be fused or switched and for safety purposes, equipment should be grounded to a driven ground rod equivalent to a ¾-inch water pipe, driven into firm soil to a depth of 8 feet.

For protection against needless motor "burn-outs," thermal breaker switches or time-delay fuses should be used.

The above suggestions relative to pumphouse construction and the design illustrated on Plate 15 were provided by the Agricultural Engineering Department of Iowa State University.

HYDROPNEUMATIC TANKS

Water under pressure can be delivered through a piping system by the use of a hydropneumatic (water-air) tank. The tank is usually located at any convenient point on the pump discharge line such as a basement room or pump house. The tank can supply a quantity of water, usually 25 to 30 per cent of the tank's total capacity, by the air which is compressed in the upper portion of the tank. Careful control must be maintained over the air-water ratio in the tank if satisfactory operation is to be secured. Common practice is to maintain an air-water ratio of 40 per cent air to 60 per cent water at a cut off pressure of 40 pounds. Under presure the water will absorb small quantities of the air and it is therefore necessary to replenish it or the tank will become deficient in air or "waterlogged." Air is normaly provided by an air intake arrangement on the well pump or by an air compressor.

For the average family dwelling the 42 gallon pressure tank that is available on the market is usually adequate. For larger installations some knowledge of the maximum rate at which the water will be used for a given period of time must be known in determining the size of tank required. Knowing the maximum rate of water use in a given period of time, the size of tank required can be determined. The tank plus the pump should be able to supply the required quantity of water in this given time. For example, it may be estimated that in a mobile home park the maximum water consumption will be 8 gallons for each person in the park and that this usage will occur in a thirty minute period. If the court can accommodate approximately 100 people, the maximum water use in the thirty minute period would then be

$$8 \times 100 = 800 \text{ gallons}$$

If the well pump has a capacity of 20 gallons per minute, it will supply in the thirty minute period

$$20 \times 30 = 600 \text{ gallons.}$$

It will then be necessary for the pressure tank to supply the remainder of the required 800 gallons or

$$800 - 600 = 200 \text{ gallons.}$$

If we assume that only 25 per cent of the capacity of the pressure tank is available for water use, the tank provided must be four times this size or

$$4 \times 200 = 800 \text{ gallon capacity.}$$

In this calculation it is obviously very important that a careful estimate be made of the maximum amount of water to be used in any given period of time.

INTERCONNECTING WATER SYSTEMS

Water supplies are contaminated many times by connections installed on the distribution or plumbing system with unsafe supplies. Connecting two or more water systems together is a dangerous practice unless the waters in both systems are of the same quality and protected against contamination. Realizing the danger of such interconnections, the State Department of Health in 1930 adopted a regulation prohibiting cross-connections between public water supplies and any other water system unless the cross-connected supply meets the standard of purity required of the public supply.

The water supply pipes to stock-watering tanks, laundry tubs, and similar installations should terminate above the overflow rim of the fixture to prevent back-siphonage from the fixture should a negative pressure develop on the supply pipe. The pipes installed should be of adequate size and sufficient pressure maintained on the system at all times so reversal of flow or back-siphonage will be prevented.

A good example of a cross-connection frequently occurs in the filling of insecticide applicator tanks from a well. The hose from the well is placed inside the applicator tank. The pump stops for some reason and pressure is lost allowing the contents of the applicator tank to siphon into the well thus contaminating the well with a potentially toxic substance.

PLASTIC PIPE

Some plastic pipe may be manufactured from unsuitable materials imparting toxic substances or tastes and odors to the water. The National Sanitation Foundation tests pipe and inspects its manufacture to determine its suitability for water use. Manufacturers complying with all requirements are permitted to place an "nSf" seal at frequent intervals on the pipe. Only pipe bearing the "nSf" seal should therefore be used in a potable water supply system to protect the quality of the water being conveyed and be assured of a suitable material.

Only pressure rated pipe should be used. It should also be realized that most plastic pipe has critical temperature limitations. Plastic materials also expand and contract to a much greater degree than metal pipe materials.

Storage, handling, and installation procedures recommended by the manufacturer should be followed closely. Plastic pipe should only be used outside the foundation walls of a house such as from the well to the building. It should not be used in the house plumbing system or on any service line where it would be exposed to heat or hot water. It may be used for the pump drop pipe or suction pipe for relatively shallow installations.

DISINFECTION OF WELLS

A new well, a reconstructed well, or one in which the pump has been repaired is nearly always contaminated from tools, handling of the casing, surface material, etc. This contamination may contain pathogenic, or disease-producing bacteria, so disinfection of such a new or repaired well is recommended to protect the water users. Only wells properly constructed so they cannot be recontaminated should be disinfected.

Before a well is disinfected, it should be pumped thoroughly to remove all dirt and foreign material. If the well is of a bored or dug type, it may be possible to scrub the interior walls to assist in removing dirt and debris. If a dug or bored well has been grossly contaminated, it may be necessary to manually clean the well of such material as boards, dead animals, mud, etc.

A cheap and effective disinfecting agent is chlorinated lime. This material is a white powder, can be purchased in most drug and grocery stores, and usually contains 25 per cent available chlorine. There are other hypochlorite compounds available which contain a greater concentration of chlorine than chlorinated lime. When such compounds are used, the quantity should be reduced in proportion to the higher concentration of chlorine. Clorox, Hi-Lex, and other similar chlorine laundry bleaches may also be used to disinfect a well.

In disinfecting a well, it is important that a chlorine solution of sufficient strength come in contact with all contaminated surfaces long enough for complete destruction of all disease-producing bacteria. For the ordinary private well, one-half pound of chlorinated lime with 25 per cent available chlorine, or two cups of chlorine laundry bleach, is sufficient for disinfection. The chlorine powder or solution should be added to approximately 5 gallons of water and be thoroughly mixed. The 5 gallons of chlorinated water should then be poured into the top of the well—care being taken to wash down the side walls or casing and the pump drop pipe. It will generally be possible to operate the pump, pump the chlorine solution out of the well, and flush back through the opening at the top. Such recirculation of the chlorinated water will assist in disinfecting the curbing or casing and the pump drop pipe. If the well being disinfected is a deep well with a high water level, particular attention must be given to forcing the chlorine to the lower portions of the well. This may be accomplished by placing a quantity of the dry hypochlorite powder in a short section of perforated pipe capped on both ends and lowering and raising the pipe throughout the depth of water. It may also be accomplished by adding to the well a sufficient quantity of chlorinated water to displace the unchlorinated water in the well. After the well has been treated with chlorine, it should be allowed to stand at least 12 hours before being pumped. The strong chlorinated water should then be pumped to waste.

Any new or contaminated pressure system, storage tank, or water line should also be disinfected. This may be accomplished by pumping some of the highly chlorinated water from the well into the system at the same time the well is disinfected. Care should be taken to make certain that the chlorinated water is drawn into all portions of the system, including the upper portions of a pressure tank when such a tank is used. After disinfecting the well, the chlorinated water from the well should be flushed to waste through the storage and distribution system to secure more absolute disinfection of the system.

The adequacy of disinfection should be checked by subsequent bacterial examination. A sample of water should not be submitted for analysis for several days after the well and system have been disinfected and thoroughly pumped. Chlorine is likely to persist in small quantities for several days after treatment, and unless all of the chlorinated water has been pumped from the well and system, the analysis will not represent the true bacteriological character. If the bacterial examination shows contamination to still be present, the disinfection procedure should be repeated.

DISINFECTION OF WATER FOR DRINKING PURPOSES

If a water supply is known to be bacterially unsafe for drinking, but must be used, it can be made safe by one of the following methods:

1. Boiling is the safest and best method. Water that has been boiled for two minutes is safe. Boiling produces no objectionable taste or odor.

2. Disinfection with chlorine. Chlorinated lime may be purchased in most drug stores and grocery stores in one-pound cans with a strength of 25 per cent available chlorine. Add three level teaspoons of the powder to one gallon of water, stir thoroughly, and allow the lime to settle. This solution deteriorates in the presence of air and sunlight and should therefore be kept in a tightly stoppered, colored bottle in a dark place. Fresh solutions should be made up at least every week or ten days. One teaspoon of this solution is sufficient to sterilize one gallon of clear water. The solution should be thoroughly mixed with the clear water and allowed to stand at least 30 minutes before drinking. If the water

is not clear, the amount of solution should be increased to two teaspoons. A sufficient dosage to produce a perceptible chlorine taste is encouraged.

Sodium hypochlorite (chlorine laundry bleach, etc.) can be used instead of chlorinated lime. There are on the market prepared solutions of varying chlorine content and also tablets containing sodium hypochlorite. One teaspoon of a one per cent solution of chlorine is sufficient to disinfect 15 gallons of clear water. If the water is not clear, two teaspoons for each 15 gallons should be used.

When it is necessary to obtain water from a supply which is likely to be contaminated, such as a spring or well in creviced limestone rock, it may be possible to provide a supply safe for domestic use by proper continuous, mechanical chlorination. CONTINUOUS CHLORINATION SHOULD ONLY BE CONSIDERED WHEN A SAFE WATER SUPPLY BY ANY OTHER MEANS CANNOT BE SECURED. Disinfection by this method is accomplished by injecting measured doses of chlorine into the water supply line as the water is pumped. The chlorine solution is prepared from a mixture of sodium or calcium hypochlorite and water. The amount of chlorine to be applied is determined by tests for the presence of chlorine in the treated water. Such continuous chlorination requires daily inspection and care and periodic maintenance. Mechanical chlorination is not a "cure-all" for every unsafe water supply.

BACTERIOLOGICAL EXAMINATION OF WATER

Unfortunately, there is no practicable laboratory method of examining water for the presence of actual disease-producing bacteria. However, a relatively simple and reliable laboratory method of determining the presence of so-called coliform organisms is known. The normal habitat of these bacteria is in the intestinal tract of warm-blooded animals; hence, the presence of these bacteria in water indicates that the water may be contaminated with human or animal intestinal discharges. Since such discharges may at any time contain actual disease-producing bacteria, water containing these coliform organisms is considered unsafe for human consumption.

Surface water and very shallow-lying water usually contain these bacteria, and if inspection of a well reveals possibility of access of such water, bacteriological examination of the water is a useless procedure as such examination will usually reveal presence of these objectionable organisms.

Before submitting a water sample to a laboratory for bacteriological examination, a careful inspection should be made of the well and storage and distribution system. If any defect is found which would permit surface or shallow subsurface water to enter the supply, a sample should not be collected. Rather, the well and system should be provided with adequate structural protection and be disinfected before testing. Even with good well construction, there is always the possibility that shallow

water-bearing strata have become contaminated, or that a casing has become perforated.

Iron bacteria, a common biological growth in well water, does not have any adverse effect on health but does have numerous other problems associated with it. Iron bacteria will cause plugging of filters, softeners, water lines, and can cause objectionable tastes and odors. Iron bacteria should be suspected when the reddish brown precipitate in a sample bottle assumes a fluffy appearance on standing for a few hours.

Shock chlorination at levels of 50-100 ppm (pounds per million pounds) in the well, filters, and water lines is currently the only proven method of reducing iron bacteria concentrations to tolerable levels. Complete elimination of them is not likely. The procedure should be followed as outlined in the section "Disinfection of Wells" except that the amount of chlorine used should be tripled.

Continuous chlorination at a level of 1-2 ppm may retard the rate of growth of iron bacteria but probably will not completely eliminate them. It may be necessary to periodically repeat the shock chlorination procedure to control the growth of the organisms.

Bacteriological testing, procurement of containers, and charges are outlined in a following section.

CHEMICAL TESTING OF WATER

Tests can be performed for the determination of many chemicals which can be in the water. The procurement of containers and charges are outlined in a following section. The chemical determinations generally requested are nitrates, iron, hardness, and sulfates.

Nitrates are discussed in the following section, "Nitrate Cyanosis." Iron and hardness have no particular health significance. Iron if present in concentrations greater than about 0.3 ppm can cause staining of bathroom fixtures and laundry.

The soap consuming property of water is due to hardness. Calcium and magnesium are the primary chemicals causing hardness. Sulfates if present in sufficient concentrations may have a definite laxative effect. The laxative effect is commonly noted by newcomers and casual users of water high in sulfates. One evidently becomes acclimated to use of these waters in a relatively short time.

NITRATE CYANOSIS

If water containing a high concentration of nitrates is used for infant feeding, it may cause nitrate cyanosis or methemoglobinemia (blue babies). This disease reduces the ability of the blood to absorb oxygen and may be fatal unless properly treated. Humans over one year of age are not normally affected by nitrate cyanosis. Medical and epidemilogical data now available do not indicate that nitrate concentrations in drinking waters produce physiological effects in adults.

Water containing a nitrate concentration of more than 45 parts per million (ppm) is considered "UNSAFE" for infant feeding, including the preparation of formula, regardless of its bacterial quality. Boiling water will only concentrate the nitrate content, thereby increasing the possibility of cyanosis. When a water supply is found to be high in nitrates and to be used for infant feeding, the most satisfactory solution is often to secure the water from another source which has been tested and found to be satisfactory from both a bacterial and nitrate standpoint.

Expectant parents who secure their water from a source other than a municipal water supply are encouraged to have their water supply tested for bacterial and nitrate quality within the month prior to the expected date of birth. Should the nitrate content be found close to the upper limit of 45 ppm, monthly retesting of the water while it is used in preparing the baby's formula is recommended.

It is not uncommon for a water supply, which tested low in nitrates during dry seasons of the year, to show a high nitrate content after snow melt or heavy rain periods. Sudden changes in the taste of the water may indicate surface drainage which could also indicate nitrate contamination. Any defect in well construction or location which would allow surface water or shallow ground water to gain entrance to the well will greatly increase the possibility of high nitrate levels.

Nitrates are a normal constituent of most soils and rocks. Therefore nitrates in various amounts, although generally below the infant feeding recommended limit, are to be expected. A well properly located and constructed may still have a high nitrate content because of the water bearing formation. However, in most cases a high nitrate content is due to other reasons such as improper well location or construction or defects occurring through deterioration.

LABORATORY CHEMICAL AND BACTERIOLOGICAL TESTING OF WATERS

The State Hygienic Laboratory, Medical Laboratory Building, Iowa City, Iowa 52240 will perform the bacteriological determination on water samples collected only in containers which they provide. The same container may be used for chemical determinations. A container will be promptly sent upon request to the above address. The container will be in a form that can be returned readily by mail to the laboratory. Instructions for the proper collection of each sample are included with each sample container.

The water sample is of adequate size for several chemical determinations as well as the bacteriological testing procedure. The sender notes on a data card sent with the sample the determinations desired.

A fee is charged for the determinations. Although the price schedule is subject to change, the following prices apply:

1. The price for bacteriological determination is $2.00 per sample.
2. All or any of the following determinations can be performed for an additional $2.00: iron, hardness, nitrate, or pH.
3. The charge for iron bacterial determination is $2.00.
4. Other determinations are available upon special letter request and the charge is commensurate with the work involved.