# Wisconsin State Well Drilling Sanitary Code

## RULES AND REGULATIONS

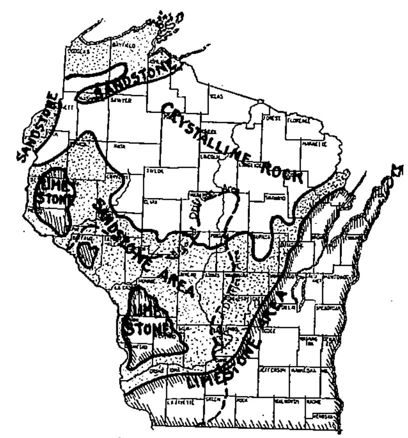
of the

## WISCONSIN STATE BOARD OF HEALTH

Governing the

**Location, Construction and Supervision of Wells Supplying Water for Human Consumption and Used in Preparation of Food Products and the Registration of Well Drillers**



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## INTRODUCTION

After years of unceasing effort, the objective sought was realized in the enactment of Chapter 434, laws of 1935 (Chapter 162, Wisconsin Statutes) relating to well drilling supervision.

Wisconsin was first among the states to provide for registration and regulation of well drilling. This function was inaugurated on January 1, 1936.

Unwise location and faulty construction of wells has cost Wisconsin dearly in the past and the chief aims of the new procedure are to insure proper location, construction and finishing of wells and proper installation of pumping equipment.

Because Wisconsin's geological picture is so varied many local problems enter into the proper location and construction of wells, and the Legislature wisely included in the well drilling law the provision that educational work be conducted in conjunction with its administration. The law affords splendid opportunity for educational work, not only on the part of well drillers, pump and water system artisans, but also of all others interested.

This code of rules and helpful information was prepared to comply with a duty imposed by the act, and adopted by the State Board of Health to meet the numerous requests from well drillers, rural dwellers, school boards, architects, engineers, manufacturers, and interested citizens for definite information relating to safe standards for drinking water wells.

In the formulation of this code a comprehensive study of existing conditions in this state was made and conferences were held with well drillers, manufacturers of well drilling and water supply equipment, and others interested as provided for by the law. Every effort was made to make this code of minimum requirements readily comprehensive and consistent with economy in installation, proper service and sanitation. It is hoped that all concerned will make a careful study of the code requirements so that the objectives sought may be realized.

These regulations are designed to safeguard the public health, to promote the best interests of our rural and urban developments, dairy and food production, our ever-growing summer resort, tourist, vacation and general outdoor recreational business.

Our aim in the supervision of well drilling is "Prevention Rather than Correction or Cure."

FRANK R. KING,
*State Domestic Sanitary Engineer,*

C. A. HARPER, M. D.,
*State Health Officer.*



An Act Relating to the Powers and Duties of the State Board of Health to Protect Public Health and Promote Public Welfare.

## CHAPTER 162

(Copied in Full From 1935 Wisconsin Statutes)

### PURE DRINKING WATER



**162.01 Pure drinking water; powers of state board of health.** (1) Establishment of Standards, Public Hearing Notice. The state board of health shall, after ten days' notice of hearing in the official state paper and such other publications as it may determine, and after a public hearing, prescribe, publish and enforce minimum reasonable standards and rules and regulations for methods to be pursued in the obtaining of pure drinking water for human consumption and the establishing of all safeguards deemed necessary in protecting the public health against the hazards of polluted sources of impure water supplies intended or used for human consumption. It shall have general supervision and control of all methods of obtaining ground water for human consumption including sanitary conditions surrounding the same, the construction or reconstruction of wells and generally to prescribe, amend, modify or repeal any rule or regulation theretofore prescribed and shall do and perform any act deemed necessary for the safeguarding of public health.

(2) Conduct of Hearing. In the conduct of any public hearing on the establishing, amending or repealing of any such standards, rules or regulations, the state health officer or any employe designated by the board may act for the board in holding such public hearing. [*1935 c. 434, 553*]

**162.02 Definitions.** For the purposes of this chapter, the following definitions are hereby established:

(1) "Board" shall mean the state board of health.

(2) "Ground Water" is defined to mean subsurface water supplied for human consumption.

(3) "Well" is defined to mean an excavation or opening into the ground made by digging, boring, drilling, driving or other methods for the purpose of obtaining ground water for human consumption.

(4) "Well drilling" is defined as the industry and procedure employed in obtaining ground water from a well by digging, boring, drilling, driving or other methods but not including the driving of points for the purpose of obtaining ground water. It shall also include all construction work and installation of well casings in said well involved therein for the protection of such well water against pollution.

(5) "Permit" is defined as the registration certificate issued by the state board of health to each person, firm or corporation duly registering and paying the annual permit fee to do well drilling as herein provided for.

(6) "Well driller" is defined to be any person, firm or corporation who has duly registered as such with the state board of health and shall have paid the annual registration fee and obtain a permit to construct wells as herein provided. *[1935 c. 434, 553]*

**162.03 Additional powers of board.** (1) Power to Enforce Act. The board may exercise such powers as are reasonably necessary to carry out and enforce the provisions of this chapter. It may, among other things:

(a) Supervisor and Assistants. Employ a competent supervisor to supervise and inspect all well drilling operations and aid in the enforcement of all laws, rules and regulations governing the well drilling industry. Said board may also employ assistants, prescribe their respective qualifications and salaries and assign their duties. Except in the adoption, amendment or repeal of rules and regulations, the state health officer may act for the board.

(b) Investigations and Experiments. Conduct investigations and experiments for the advancement of technical knowledge and ascertain and establish the cause of ground water pollution and for the casing of wells or other means of protection, and may hold public meetings and attend or be represented at such meetings within or without the state.

(c) Inspections of Premises. Enter and inspect at reasonable hours wells and equipment thereof, all water supplies for human consumption on private or public property or may order necessary corrections and repairs of construction or may order discontinuances of any well and the use of its water, if found contaminated, polluted or unfit for human consumption. It may also disseminate information relative to the construction, source and protection of such water supply.

(d) Water Analysis. Require any well driller or other person responsible for a water supply to secure an analysis of water by the state laboratory of hygiene or branch thereof or by any laboratory accredited by the board to establish the purity and fitness of such water for human consumption and for domestic purposes. A report of each such analysis shall be submitted to the board.

(e) Furnishing of Bulletins. Prepare and cause to be printed such codes, bulletins or other documents as may be necessary for the safety of the public health and the betterment of the industry, and furnish copies thereof to well drillers and to the public upon request.

(f) Recommendations Upon Request. Furnish upon request of the owner of any well, or any well driller, recommendations for obtaining a safe water supply for human consumption.

(2) Revocations or Suspension; Cause. The board may on its own motion make investigations and conduct hearings and may, on its own motion or upon complaint in writing, duly signed and verified by the complainant, and upon not less than ten days' notice to the well driller, suspend or revoke as hereinafter provided any well driller's permit if said board has reason to believe or finds that the holder of such permit has:

(a) Made a material misstatement in the application for permit or any application for a renewal thereof.

(b) Demonstrated incompetency to act as a well driller; or



(c) Has wilfully violated a second time any provision of this chapter or any rule, regulation or order prescribed by the board.

(d) Has been guilty of any action constituting fraud, or any failure to fully comply with the specifications or terms of any contract for drilling a well.

(3) Person Complained Against May Answer. A copy of the complaint with notice of the suspension of permit, if ordered by the board, shall be served on the person complained against, and his answer thereto shall be filed, in the manner and within the time provided in subsection (3) of section 136.08, and the provisions of said subsections shall govern so far as applicable.

(4) Public Hearing Before Revocation. No order revoking a permit shall be made until after a public hearing to be held before the board at the place, time and in the manner provided in section 136.09. The procedure provided in said section for notice, conduct of hearing and determination by the board shall govern so far as applicable.

(5) Application After Revocation. One year after the date of revocation or thereafter application may be made for a new permit. *[1935 c. 434, 553]*

**162.04 Well drilling; registration; fee.** (1) Annual Application and Fee. Every person, firm or corporation before engaging in the industry of well drilling in Wisconsin as herein provided shall annually before March first of each year make application to the board for registration as a well driller upon blanks prepared by the board for such purpose and shall accompany such application with the annual permit fee of ten dollars.

(2) Permit Expiration. All permits so issued shall expire on December thirty-first and shall not be transferable.

(3) Who May Engage in Well Drilling. Except as herein otherwise provided, no person, firm or corporation shall engage in the industry of well drilling for compensation in this state without having duly registered and obtained a permit therefor as herein provided. No permit shall be required of any person for driving, digging or otherwise obtaining ground water supply for his own personal use on real estate owned or leased by him, but such well and the work done thereon shall comply and be in conformity with law and the rules and regulations prescribed by the board.

(4) Water not Used for Human Consumption Exempt. The provisions of this chapter shall not apply to the construction of wells where the water is used only for stock watering and other similar domestic purposes and is not used for human consumption. *[1935 c. 434, 553]*

**162.05 Registration exceptions.** No registration or permit to engage in the well drilling industry shall be required by competent sanitary engineers or by superintendents of waterworks systems in the preparations of plans and specifications or in supervising the installation of wells and water systems for the obtaining of supplies of ground water, but all such plans and specifications shall conform to all requirements established by the board. *[1935 c. 434, 553]*

**162.06 Penalties.** Any person, firm or corporation who engages in or follows the business or occupation of, or advertises or holds himself or itself out as or acts temporarily or otherwise as a well driller without first having secured the required permit or certificate of registration or renewal thereof, or who otherwise violates any provision of this chapter, shall be deemed guilty of a misdemeanor and, upon conviction thereof, shall be punished by a fine of not less than ten dollars or more than one hundred dollars or by imprisonment in the county jail for not less than thirty days, or by both such fine and imprisonment. Each day during which a violation continues shall constitute a separate and distinct offense, and may be punished separately. [*1935 c. 434, 553*]

20.43. (21) Administration Receipts and Expenditures. All moneys received by the state board of health under sections 162.01 to 162.06. Ninety per cent of such moneys, including any unexpended balance at the end of any fiscal year, are allotted for the registration and regulation of well drillers, the inspection of wells, testing of water for pollution, and otherwise administering the provisions of said sections and the performing of such duties as may be deemed necessary to protect the public health against hazards and dangers of polluted ground water. This act shall take effect on Jan. 1, 1936.

## SUSPENSION OR REVOCATION OF PERMITS

The applicable provisions of subsection (3) of section 136.08 are as follows: A copy of the complaint, together with notice of suspension of the permit, if ordered by the board, shall forthwith be served upon the person complained against by personal service or by mailing same to his last known business address. The person so served shall file his answer thereto with the board within ten days after such service and also serve a copy of such answer on the complainant. The board shall thereupon set the matter for hearing as promptly as possible and within thirty days after the date of filing the complaint. Either party may appear at such hearing in person or by attorney or agent.

The applicable provisions of section 136.09 are: (1) No order denying or revoking a permit shall be made until after a public hearing or hearings held before the board, or before any member thereof, or before any duly authorized employe whose report the board shall have adopted. Such hearing or hearings shall be held in the county wherein the applicant for a permit or the person complained against has his place of business. In the event that said applicant or person is a nonresident, such hearing shall be held at such place as may be designated by the board.

At least ten days prior to the date of hearing, the board shall send written notice of the time and place of such hearing to the applicant for a permit or to the complainant and to the party complained against and to their respective attorneys or agents of record by mailing same to the last known address of such persons. The testimony presented and proceedings had at such hearing shall be taken in shorthand and preserved as the records of the board. The board shall as soon thereafter as possible, and within ninety days after the filing of a complaint, make its findings and determination thereon and shall send a copy thereof to each interested party.



## PURPOSE AND EXPLANATION OF THE LAW RELATING TO PURE DRINKING WATER

**The Law and Its Purpose.** Pure drinking water is essential to the public health. In recognition of this, the 1935 legislature enacted Chapter 162 which took effect on January 1, 1936, giving the state board of health broad regulatory powers as to the methods and procedures to be followed in the location, construction and safeguarding of wells, the water from which is to be used for human consumption. To this end the board prescribed minimum, uniform standards and regulations for well drilling, state wide in application. After a public hearing, of which ten days' notice was given in the official state paper these regulations have been published and have the force and effect of law. (See Part II.)

To carry out the purposes of the law, the board of health may conduct experiments, make investigations, inspect the water supply on private and public premises, require an analysis of water, order the discontinuance of any water supply found contaminated, and disseminate information in the interest of the public health.

All well drillers (defined in the law) must file application for registration annually before March 1st with the board of health on blanks furnished by the board and must secure a permit before engaging in the business of well drilling. A fee of $10 must be paid when filing the application. All permits expire on December 31st. The law does not apply to the construction of wells where the water is used for stock watering or otherwise than for human consumption.

**Revocation or Suspension of Permit.** Permits may be suspended or revoked by the board for certain causes stated in the law, but in all cases the well driller is to get a copy of the complaint against him and to have an opportunity, on at least ten days' notice, to answer the charges. No permit can be revoked without a public hearing and one year after a revocation application may be made for a new permit.

**Penalty for Violation.** Any person who engages in the business of well drilling without securing a permit or who otherwise violates any provision of the law or any rule or regulation prescribed by the state board of health is subject to a fine of from $10 to $100 or imprisonment for at least 30 days, or both, and each day during which a violation continues constitutes a separate offense.

**State Supervision.** The State well drilling supervisor will make such inspections of private and public water supplies, wells and systems, except municipal water works systems as time will permit and upon request or direction of the board as may seem necessary. All requests for state inspection should be made direct to the state board of health, Division of Well Drilling Supervision.

**Adjudication of Differences.** In case of any radical dispute or difference arising between the supervisor and the well driller in charge, the facts should be submitted to the state health officer for consideration. If the state health officer deems a hearing necessary, such hearing will be granted as will be directed by the state health officer.

**Discretionary Powers.** When for specific reasons, it may be impractical to construct a well and install pumping equipment, whether new or existing installation, so as to comply strictly with the provisions of this code, reasonable compliance may be accepted as it pertains to design, materials, construction and appliances. The supervisor employed by the state board of health may exercise discretionary power to permit such modifications as are not inconsistent with the spirit and substance hereof providing that in doing so he will not unnecessarily endanger the safety of the water supply. All such modifications must be reported in writing in such a manner prescribed by the state board of health, and filed as official record.

**Duties of Well Drilling Supervisor.** The duties of the Well Drilling Supervisor will be that of serving the best interests of our state, which will also serve the best interests of the well drilling industry; to this end the board will see to it that he is properly equipped, instructed, directed, where necessary supervised, and his investigation records properly kept. He must so contact all interested that a return trip is welcome and that his objectives will be respected by all concerned.

**Policies of the Board.** It is not the intention of the state board of health to unduly or unnecessarily disturb conditions in the well drilling industry, but rather to evolve reasonable regulations and adherence to essential sanitation requirements, elimination of objectionable material and appliances over a period of time, permitting stock changes, gradual working out of orders and contracts already entered, etc., and that all will cooperate with the board and with local officials in bringing about these desirable changes.

All must appreciate that, effective May 28, 1936, all new well installations, equipment, and repairs to existing installations, subject to regulations imposed, must reasonably comply with the provisions of regulations adopted. The interests of the general public must be conserved.

**Lack of Knowledge.** Lack of knowledge of the provisions of this code will not be accepted as an excuse for non-compliance with its requirements.

For information pertaining to the drilling and construction of wells and pumping equipment consult the provisions of this code.

It is essential that a person writing for information or requesting assistance in locating or constructing wells and private water supply systems shall give sufficient data. This can best be done by a rough pencil sketch adequately showing the situation. (See information guide, page 64 Part III)



## OTHER CODES AND REGULATIONS RELATING TO WATER SUPPLIES

Pursuant to authority given or imposed by the Wisconsin Statutes, the State Board of Health has placed in force a number of regulations having the force of law in point of uniform minimum requirements. Municipalities may make additional regulations not in conflict.

These state regulations exist under the following heads:

Wisconsin Water Works, Sewerage and Refuse Disposal Code.
Wisconsin State Plumbing Code.
Wisconsin State Well Drilling Code.
Wisconsin Lake and Stream Platting and Sanitation Code.
Regulations and Recommendations Relating to the Sanitary Care of Schools.
Wisconsin State Comfort Station Code.
Hotel and Restaurant Regulations.
Rules and Regulations Relating to Camps.
  (a) Tourist and Recreational Camps.
  (b) Industrial Camps.
  (c) Civilian Conservation Corps Camps.
Rules Governing Construction and Operation of Slaughter Houses.
Wisconsin Swimming Pool and Recreational Bathing Code.

Copies of these codes or regulations may be obtained from the State Board of Health, Madison, Wis.

## WISCONSIN STATE WELL DRILLING SANITARY CODE

### Part II

### RULES AND REGULATIONS

Rules and regulations of the Wisconsin State Board of Health, known as the Wisconsin State Well Drilling Sanitary Code, governing location, construction, and supervision of wells supplying water for human consumption and used in the preparation of food products.

The official public hearing was held on April 14, 1936. These rules and regulations were adopted by the State Board of Health on April 24, 1936, and published in the official state paper on April 28, 1936. Under the provisions of Chapter 162, Wisconsin Statutes, these rules and regulations have the force and effect of law in the form of minimum uniform standards, state wide in application.

Sketches accompanying the various rules of this code illustrating typical methods of well construction and pump installations have been adopted by the State Board of Health as an integral part of this code.

**Section 1. Basic Principles.** A well drillers' code of regulations is hereby prescribed to establish uniform standards applicable to the well drilling industry and the methods of procuring and permanently protecting an adequate supply of safe ground water fit for human consumption and for the preparation of food products by means of the construction of wells or other methods approved by the State Board of Health, in accordance with law and all rules and regulations heretofore in force and as may be herein and hereafter prescribed.

The following basic principles and definitions of terms general in scope and fundamental in character are hereby adopted by the State Board of Health as a basis for its Rules and Regulations governing the location, drilling, construction, maintenance, and supervision of wells supplying water for human consumption and used in preparation of food products.

Where a well is installed to furnish ground water, safe and fit for human consumption and for the preparation of food products, the construction of such well should be:

(a) Adequate in size and depth to furnish necessary supply of ground water.

(b) Permanent, durable and accessible in character of construction and location.

(c) Made in good and workmanlike manner, according to approved methods and standards, so as to furnish adequate protection against pollution of any character entering such well.

(d) Located in such surroundings that it can be kept in a sanitary condition without undue effort.



Nothing herein contained shall repeal, modify or abrogate any other rule or regulation promulgated by the State Board of Health in its waterworks, plumbing, sanitation and other codes now in force, unless such rule is specifically referred to herein, and the rules and regulations herein prescribed shall be supplemental to such other rules and regulations of the State Board of Health.

**Section 2. Definitions.** (a) For definitions of "Board", "Ground Water", "Well", "Well Drilling", "Permit", "Well Driller", see Chapter 162, Wisconsin Statutes.

(b) For the purpose of these rules and regulations the following additional definitions are established:

**Adequacy of Water** means sufficient quantity of water of suitable quality for the purposes for which it is intended.

**Annular Space** means space between two objects, one of which is surrounded by the other, including the space between an excavation and the wall of a pit or the curbing of a well, or between two casings.

**Approved** means approval by the State Board of Health in compliance with the respective governing laws and regulations.

**Code** means a compilation of rules and regulations governing well drilling and sources of water supply.

**Flushing** means the act of causing a rapid flow of water from a well by pumping, bailing or similar operations.

**Permanent Grade** means the permanent elevation of the surface ultimately established at the top of the well.

**Pollution** means any matter of surface origin which will render water unsafe for human consumption.

**Source of Pollution** means any place or condition which causes or allows pollution of a ground water supply, such as surface water, stagnant pools, mine shafts, polluted rivers, lakes and wells, privies, cesspools, sewage effluent disposal units, barnyards, or similar possible water supply pollution factors.

**Stuffing Box** means a receptacle in which packing may be compressed to form a water or airtight junction between a movable rod, a pipe or similar device and another pipe, container or similar receptacle.

**Terminal** means the upper or lower extremity of a well, well casing or curbing.

**Well Seal** means a device designed and used to prevent entrance of undesirable matter into a well.

**Yield** means the quantity of water, per unit of time, which may flow or be pumped continuously from a well.

**Vertical Zone of Pollution** means the depth from the surface to which pollution may penetrate.

**Vent (Breather Opening)** means an opening provided at the upper terminal of a sealed well to allow equalization of air pressure.

**Section 3. Scope of Code.** The provisions of the Wisconsin State Well Drilling Sanitary Code shall be applicable to all wells, other than for public waterworks systems, hereafter constructed or materially repaired or altered as provided by Chapter 162, of the Wisconsin Statutes of 1935.

**Section 4. Quality (Purity) of Water.** The quality of the water supply for human consumption or for the preparation of food shall meet accepted standards of purity as prescribed by the Board.

**Section 5. Analysis of Water.** For the purpose of determining the purity of water, one or more samples of water shall be forwarded for analysis to the State Laboratory of Hygiene or one of its branch or cooperative laboratories or to any laboratory accredited by the Board, by the agency performing the work, as follows:

(a) On completion of a well of new construction.
(b) On completion of pump or water system installation.
(c) On completion of material changes made in the well, the pumping equipment or the surroundings of the well.
(d) Whenever requested by the Board.

**Note:** When the pumping equipment is installed by the driller upon completion of the well, only one sample need be forwarded unless the water is found unsafe. (See Directions, Part III.)

**Section 6. Public Waterworks Systems.** (a) The design, construction and equipment of every well used or to be used as part of any public waterworks system shall be governed by the Wisconsin Waterworks, Sewerage and Refuse Disposal Code adopted pursuant to authority granted in Chapter 144 of the statutes.

(b) When a private well is to be installed in any municipality having a public waterworks system, the owner or his agent shall notify the local health officer and the superintendent of the public waterworks system, in writing, not less than one week before commencing construction.

(c) Physical pipe connections, known as cross-connections, between any private and any public water supply system shall be governed by the rules and regulations of the Wisconsin Waterworks, Sewerage and Refuse Disposal Code. (See State Plumbing Code for other provisions concerning cross-connections, and also Bulletin, Cross-Connections in Plumbing and Water Supply Systems.)

**Section 7. Drilling Equipment, Ownership, Identification.** The driller's name in full, address, and permit number in legible size, shall be conspicuously posted on his well drilling rig or rigs, either by painting or its equivalent.

**Section 8. Location of Wells.** Every new well shall be located as follows:

(a) At the highest point in the premises consistent with the general layout and surroundings but in any case protected against surface wash.

(b) As far removed and in a direction opposite to the underground flow from any known or probable source of pollution, (including any existing polluted well), as the general layout of the premises and the surroundings will permit.

**Section 9. Sewers and Drains Near Wells.** No sewer or drain, located underground, shall be installed within twenty-five feet of any existing or proposed well, unless constructed of cast iron pipe with leaded joints, in which event a



minimum distance of ten feet shall be maintained. No building foundation tile or other drainage line shall be located within ten feet of any well. Location of new wells shall comply with the above minimum distances when practical. (For further particulars see Sections 56 to 59, inclusive, of State Plumbing Code.)

**Section 10. Use of Wells for Drainage Purposes.** The use of any well for disposal of sewage or other drainage, other than shallow "dry wells" installed under governing regulations, is prohibited.

**Section 11. Accessibility of Wells.** (a) When a well is located adjacent to a building, it shall be located so that the center line of the well extended vertically will clear any projection from the building by not less than two feet. (See Discussion, Part III.)

(b) Every well shall be located so that it will be reasonably accessible, with proper equipment, for cleaning, treatment, repair, test, inspection, and such other attention as may be necessary.

**Section 12. Protection During Construction.** (a) A well under construction shall be protected so that there can be no drainage of surface water into the well.

(b) All water used in constructing a well shall be from a known safe source, or sterilized by chlorination. (See Discussion, Part III.)

**Section 13. Size of Drilled Well.** (a) The bore of the drill hole shall be sufficient to permit as many reductions in diameter as may be necessary to accomplish approved sealing or grouting operations, installation of liners, screen, or other appliances.

(b) The minimum diameter of a well terminating in limestone, or sandstone overlain by limestone, shall be three and one-half inches, and the starting diameter of the drill hole shall be sufficient to permit approved sealing or grouting operations.

(c) The minimum diameter of every well terminating in sand, gravel, or other porous formations of the drift, or in alluvium, or in sandstone not overlain by limestone, shall be two inches, exclusive of a screen.

(d) The minimum diameter of a drill hole in creviced, fissured, or porous limestone shall be such that, when the casing is installed, the annular space is at no point less than two inches.

**Section 14. Casing in Various Formations.** (a) The casing of every well shall extend watertight to a point below the "vertical zone of pollution". (See Figs. 2, and 9 to 15, inc.)

(b) When groundwater is derived from limestone, the casing must extend sufficiently far into the unbroken and uncreviced limestone to be seated firmly and watertight therein. (See Figs. 7 and 9.)

(c) When the casing terminates in any sand, gravel, or other porous formation of the drift, or in alluvium, the casing shall extend watertight into the water-bearing formation. (See Figs. 7 and 11.)

(d) When the casing terminates in sandstone not overlain by unbroken or uncreviced limestone and penetrates non-caving or coarse formations, the casing or watertight liner shall enter the sandstone not less than ten feet and shall be seated firmly therein, preferably by grouting with neat cement. (See Figs. 2 and 8.)

**Section 15. Well Casing.** (a) The minimum standard of quality for casing material, when serving as the sole means of casing a well, shall be steel or wrought iron pipe having weights as specified in the following table:

| Size in Inches | Wt. Lbs. per Ft. Threads and Couplings | Pipe | | | Threads per Inch | Couplings | |
|---|---|---|---|---|---|---|---|
| | | Thickness in Inches | Diameter Inches External | Diameter Inches Internal | | Length in Inches | External Diameter Inches |
| 1 | 1.68 | .133 | 1.315 | 1.049 | 11½ | 1⅞ | 1.576 |
| 1¼ | 2.28 | .140 | 1.660 | 1.380 | 11½ | 2⅛ | 1.950 |
| 1½ | 2.73 | .145 | 1.900 | 1.610 | 11½ | 2⅜ | 2.218 |
| 2 | 3.68 | .154 | 2.375 | 2.067 | 11½ | 2⅝ | 2.760 |
| 2½ | 5.82 | .203 | 2.875 | 2.469 | 8 | 2⅞ | 3.276 |
| 3 | 7.62 | .216 | 3.500 | 3.068 | 8 | 3⅛ | 3.948 |
| 3½ | 9.20 | .226 | 4.000 | 3.548 | 8 | 3⅝ | 4.591 |
| 4 | 10.89 | .237 | 4.500 | 4.026 | 8 | 3⅝ | 5.091 |
| 4½ | 12.64 | .247 | 5.000 | 4.506 | 8 | 4⅛ | 5.591 |
| 5 | 14.81 | .258 | 5.563 | 5.047 | 8 | 4⅛ | 6.296 |
| 6 | 19.18 | .280 | 6.625 | 6.065 | 8 | 4⅛ | 7.358 |
| 8 | 25.00 | .277 | 8.625 | 8.071 | 8 | 4⅝ | 9.420 |
| 10 | 35.00 | .307 | 10.750 | 10.136 | 8 | 6⅛ | 11.721 |
| 12 | 45.00 | .330 | 12.750 | 12.090 | 8 | 6⅛ | 13.958 |
| 14 OD | 37.00 | .375 | 14.000 | 13.250 | 8 | 7⅛ | 15.446 |
| 15 OD | 61.15 | .375 | 15.000 | 14.250 | 8 | 7⅛ | 16.446 |
| 16 OD | 65.30 | .375 | 16.000 | 15.250 | 8 | 7⅛ | 17.446 |
| 17 OD | 73.20 | .393 | 17.000 | 16.214 | 8 | 7⅛ | 18.683 |
| 18 OD | 81.20 | .409 | 18.000 | 17.182 | 8 | 7⅛ | 19.921 |
| 20 OD | 90.00 | .409 | 20.000 | 19.182 | 8 | 7⅝ | 21.706 |

**Note:** The following are manufacturers' allowances:

Pipe sizes 1″ to 12″ inclusive are standard pipe sizes. Permissible variation in weight is 5% above and 5% below. Taper of threads is ¾″ diameter per foot length for all sizes.

Pipe sizes 14″ OD to 20″ OD are drive pipe sizes. Permissible variation in weight is 6½% above and 3½% below. Taper of threads is 3/16″ diameter per foot length for all sizes. Weight per foot length (for standard and drive pipe) with threads and couplings is based on a length of 20′ including one coupling.

(b) Pipe used for casing a well shall be jointed watertight. The thread may be either a standard pipe thread or approved special drive pipe thread with corresponding couplings. Joints made by a competent welder may be used.

**Note:** When made up, a screw thread joint should not have more than two exposed threads, except in the case of chamfered couplings, which are recommended. Welded joints should be made according to Standard Open Single Vee Butt Weld specifications.

(c) Every well casing shall be driven or installed so that no injury results to the pipe or the joints thereof.

(d) When used to exclude pollution from a well, pipe not conforming to the provisions of subsection (a) of this section shall be encased in a neat cement grout, or concrete, throughout the entire length. Such protection shall be applied as follows:

(1) Pipe, 12 gauge or heavier, with screw thread or welded joints, shall be encased in a neat cement grout not less than two inches thick, applied from the bottom upward.

(2) Tubing or casing, 20 to 13 gauge or heavier, not provided with threaded or welded joints, shall be encased in a neat cement grout or concrete not less than six inches thick.

(3) When necessary, centering guides shall be used. (See Figs. 9, 12, 15, and 16.)



(e) The use of wood curbing in a completed well is prohibited. (See Section 26.)

(f) Concrete well pipe, vitrified pipe, and similar forms of curbing shall be encased in a grout of neat cement or properly prepared concrete, placed in one operation, and not less than six inches in thickness. (See Section 39 for properly prepared concrete.)

(g) Every method of casing or curbing a well, other than specified in the provisions of this code, shall be referred to the Board for approval. (See also Sections 14, 16, 21, 26, and 27.)

**Section 16. Used or Reclaimed Pipe.** Except as otherwise provided in this section, no used or reclaimed pipe shall be used in the permanent construction or equipping of any well intended for supplying water for human consumption or for preparation of food products. New, undamaged pipe, withdrawn from a well of new construction, excluding test wells or borings, will not be considered reclaimed pipe.

**Section 17. Joint Lubricants.** The use of clean mineral oil, white or red lead, or equal, is permitted on the pipe threads. The coupling thread of a joint shall be thoroughly cleaned before assembling the joint.

**Section 18. Well Screens.** (a) Every newly-constructed or repaired well of three and one-half inches or less diameter, terminating in drift, shall be equipped with a screen of proper length, design and mesh.

(b) Every newly-constructed or repaired well having a screen terminal shall be developed by removing the fine material from around the screen so as to establish a natural filter of coarse material.

(c) The joint between the well screen and casing shall be made sand tight with permanent materials, in accordance with good practice.

**Section 19. Annular Space Surrounding the Casing.** (a) The annular space surrounding the well casing incidental to drilling in drift formations shall be filled with impervious material to as great a depth as practicable. (See Figs. 2, 10, and 11.)

**Note:** Suitable filler materials are puddled clay, shale, or drill cuttings of a cementing nature.

(b) The annular space surrounding the well casing established when drilling in creviced, fissured, or porous rock at or near the surface, shall be filled with durable, impervious grout material. (See Figs. 8, 9, 12 and 16.)

**Note:** Such materials are neat cement or properly prepared concrete.

(c) No platform or other permanent structure shall be built around the well casing until complete settling of the filler material is assured.

**Section 20. Frost Heaving Protection.** (a) The upper terminal of the well casing shall be encased in suitable plastic, impervious material to the maximum local depth of frost. (See Figs. 2, 8, 9 and 11.)

**Note:** Mulsified asphaltum is a suitable material.

(b) All attachments to the well casing, such as pump stands, well seals, and like appliances, shall clear the permanent grade at the well by not less than two inches. (See Figs. 18, 20, 21, 28 and 29.)

**Section 21. Caving in Drill Holes.** In general, when caving in a drill hole is sufficiently serious to interfere with proper functioning of the well or pumping equipment, a liner conforming with the provisions of Section 15 shall be installed.

**Note:** Galvanized sheet metal tubing of 20 gauge or heavier may be used without grouting, for the purpose of preventing caving in a drill hole below the "vertical zone of pollution".

**Section 22. Upper Terminal of Casing.** (a) The casing of every well shall project not less than six inches above the permanent grade at the well.

(b) It shall be the duty of the owner to inform the driller as to the permanent grade before completion of the well.

**Section 23. Alignment of Casing and Drill Hole.** So far as practical the deviation from perpendicular alignment of every well to the depth of the pump setting shall be within the following limits:

| Diameter of the Casing | Deviation, Based on Casing Diameter |
|---|---|
| 2″ to 6″ inclusive | 100% |
| 8″ to 10″ inclusive | 75% |
| 12″ and over | 50% |

**Section 24. Curbing Bored Wells.** New or reconstructed bored wells shall be cased or curbed in conformity with the provisions of Section 15. (See Fig. 11.)

**Section 25. Driven Point Wells.** Whenever practical, the well point shall be driven to a depth of at least twenty-five feet from the surface, measuring to the top of the screen of the point.

**Section 26. Dug Wells.** (a) The retaining wall of every dug well shall be substantial and watertight to a depth of at least two feet below the "vertical zone of pollution" but in no case less than twelve feet below the normal ground surface. The retaining wall shall be supported on a firm, permanent foundation wall of equal thickness extending to the bottom of the well. The retaining wall shall be constructed by one of the following methods:

(1) Concrete Wall: The concrete mixture shall conform with the provisions of Section 39. The wall shall be circular and at least six inches thick with concrete so placed as to be free from voids. Vertical and horizontal reinforcing with three-eighths inch rods on twelve inch centers shall be provided. Rods shall lap twelve inches but such lap shall not occur at construction joints. If possible the wall shall be poured in one operation but in no case shall there be a construction joint within ten feet of the surface. Construction joints shall be left rough and shall be washed and brushed with neat cement grout before pouring of concrete is continued.

(2) Metal Wall: A metal retaining wall of steel or wrought iron shall be at least three-sixteenths of an inch thick, with welded joints. The wall shall be sufficiently thick or so reinforced as to resist any external pressure to which it may be subjected.

(b) In caving soil formation the wall shall be constructed on the surface and carried down by excavating from the interior. If wood forms are used on the exterior of the wall, they shall be removed before the wall is lowered. Use of exterior wood forms below the ground surface is prohibited. Metal forms may be used if left in place.



(c) The opening between the face of the excavation and the wall due to construction work, shall be filled with clean puddled clay to as great a depth as practical.

(d) The wall shall extend at least eight inches above the permanent grade, and the ground graded up around same to within two inches of the top in such manner as to conduct all surface water away from the well.

(e) The cover of the well shall be made of substantial reinforced watertight concrete at least five inches thick and of sufficient diameter to overlap the wall or curb by at least two inches. The cover shall be poured in place and shall be free from joints. A watertight joint shall be provided between the top of the wall and the cover, using a keyway in the top of the wall if necessary. The top of the slab shall be sloped to drain away from the pump. A manhole, if installed, shall be provided with a metal curb, the top of which extends six inches above the slab and is equipped with an overlapping cover, the sides of which extend downward at least two inches. The manhole cover shall be locked or bolted in place in such manner as to be safe and to prevent entrance of water. (See Fig. 17.)

(f) No pumping equipment or appurtenances requiring access to the interior of the well for maintenance, repair or operation, except underground piping connections, shall be installed in the well.

**Section 27. Deepening Dug Wells.** (a) No well shall be continued from the bottom of an existing well, unless such dug well is constructed in accordance with the provisions of Section 26.

(b) A drilled well may be installed in an existing dug well in accordance with the following procedures:

(1) Remove all sediment and debris from bottom of dug well and sterilize any water remaining in the well or if there is no water remaining, pour in a suitable quantity of sterilizing agent in fluid form.

(2) In drift formations, drill or bore a hole not less than eight inches larger in diameter than the nominal diameter of the permanent well casing to a depth of fifteen feet from the bottom of the dug well. A temporary casing shall be installed and such casing shall extend to the surface.

(3) After the permanent well casing has been installed, a grout or concrete mixture conforming with the provisions of Section 39 shall be placed in the annular space between the permanent and temporary casings, and the temporary casing withdrawn as filling proceeds. The bottom of the dug well shall be filled with concrete to a depth of not less than two feet. Such concrete must be placed through the temporary casing, the lower terminal of which shall be kept submerged during the concrete placing operation. After sufficient time has elapsed to allow the concrete to set sufficiently, the dug portion shall be filled in accordance with the provisions of Section 33, (a) (3).

(4) The completed well must in all other respects conform with other provisions of this code applicable to drilled wells.

**Section 28. Blasting in Wells.** When blasting is done in a well, the bore of the well, the reason for blasting, the amount and kind of explosive used, the depth at which blasting was done, the depth of water in the well at the time of the blasting, and results obtained, including any change in yield, shall be reported by the driller to the Board.

**Section 29. Sterilizing, Flushing, and Testing for Yield.** (a) On completion, every well shall be sterilized, flushed, and tested for yield. Such test shall determine the quantity and stability of the yield within the limits of the quantity required.

(b) Before flushing or testing, the well shall be sterilized in the manner prescribed by the Board. (See Directions, Part III.)

(c) After sterilizing, the well shall be pumped or otherwise flushed sufficiently to remove all of the sterilizing agent.

**Note:** It is desirable that the well be flushed sufficiently to remove cuttings, mud, silt, and other objectionable substances.

**Section 30. Well Seals.** After completion of construction, every well shall be maintained under watertight seal by the owner at all times, except when necessary to remove seal for purpose of making inspection of to accomplish necessary installation, repair, or other operations. (See Figs. 18 to 23 and 25 to 29, inc.)

**Section 31. Notice to Owner.** Upon final completion of every contract for the drilling of a well, the well driller shall notify the owner of such completion, either personally, or by letter, addressed to such owner, or his agent, at the last known post-office address of such owner or agent, with postage prepaid, stating that the work of drilling said well has been completed, and that the well driller's responsibility for the protection and safety of such well has terminated. Thereafter any such well shall be protected at the risk of the owner.

**Section 32. Premises Diagram, Well Log and Report.** Within thirty days after completion of every well, the driller shall submit a report to the Board, on a form prescribed and furnished by the Board, for use in carrying out its functions as prescribed by law. Such report shall include:

(a) A diagram indicating the location of the well with reference to dwellings, barnyards, cesspools, sewage disposal units, rivers, lakes, and other possible sources of pollution.

(b) A well log covering all essential details of construction.

(c) The name and address of owner, the actual location of the premises, and such other information as is indicated on the form. (See Report form, Part III.)

**Section 33. Abandonment of Wells.** (a) When a well is permanently abandoned, the owner thereof shall protect the waterbearing formations against possible pollution in the following manner:

(1) Drilled and cased wells shall be filled with neat cement grout, concrete, or clean puddled clay.

(2) Driven well points shall be withdrawn and the hole filled as specified in paragraph (1) of this section.

(3) Dug or bored wells shall be thoroughly cleaned and then filled with clean earth after as much as possible of the curbing has been removed.

(b) When a well is to be temporarily removed from service with a view to possible future use, the owner thereof shall fill the well with clean puddled clay.

(c) A report shall be made to the Board by the owner, of every well which has been abandoned or temporarily removed from service. Such report shall



include location, diagram of premises, details of well, soil and rock formations, method of sealing, and reason for discontinuance.

**Section 34. Well Pit Structures.** (a) The dimensions for a well pit housing pumping equipment shall be determined as follows: For each square foot of area required for equipment and appurtenances, allow five square feet of free floor area, but in no case less than twenty-four square feet of total floor area. Wall thickness shall be at least six inches, floor thickness at least four inches, deck thickness at least five inches, and the width of the pit shall be not less than two-thirds of the length. The height inside shall be at least four and one-half feet, but not less than six inches higher than any equipment installed therein.

(b) The well pit and its juncture with any other structure shall be watertight.

(c) The deck and walls of any well pit structure shall, when necessary, be reinforced with iron rods.

(d) When the depth of any well pit, including any extensions of the manhole opening exceeds four and one-half feet suitable ladder facilities shall be provided.

(e) Every conduit or similar connection with the well pit shall be watertight.

**Section 35. Manhole Openings.** (a) Every well pit with equipment installed therein shall be fitted with at least one manhole opening, and same shall be so placed that the piping can be drawn through it from the well. (See Figs. 18, 20 and 21.)

(b) No manhole opening shall be less than twenty inches square or twenty inches in diameter.

(c) When there is no other means of entrance to the well pit than a single manhole, the manhole opening shall be sufficiently large to permit entrance or removal of any unit of equipment installed therein.

(d) Every manhole cover shall be so constructed that it will shed water due to rain, snow, or other possible sources of water near the well pit.

(e) When the deck of a well pit is below grade, the manhole opening shall be extended not less than six inches above the permanent grade. When projection above grade is not practical, as in the case of driveways, alleys, and the like, the manhole opening may be placed flush with the surface, but shall then be fitted with a substantial metal rim and cover of the type which can be bolted securely and watertight. (See Fig. 24.)

**Section 36. Well Pit Drainage.** (a) No well pit shall be drained by seepage, except when such pit is isolated and serves to protect a driven point well, equipped with a power head mounted above the surface, against frost and there is a sand or fine gravel stratum of five feet or greater thickness below the bottom of the pit. (See Figs. 25 and 26.)

(b) When surface drainage is available and used, the maximum depth of a well pit floor below grade shall be at an elevation equal to the elevation of the nearest dependable drainage opening plus a suitable vertical allowance to provide proper drainage pitch. (See Figs. 18 and 20.)

**Note:** A well pit floor may be placed at such height and so graded as to drain water by gravity onto the floor of a basement or other subsurface structure, provided satisfactory drainage not in conflict with this code is available.

(c) When no dependable surface drainage from the well pit can be established, dependable mechanical means shall be provided for such purpose and used when occasion demands.

Note: Either a hand or motor driven pump may be used.

(d) The water from a well pit may be drained onto the surface of the ground or into a separate seepage pit by a separate drain pipe four inches in diameter, laid at a grade, toward the outlet of not less than one-eighth inch per foot. The junction between the pit floor and the drain inlet shall be made watertight. The drain pipe and joints to a distance of ten feet from the pit shall be watertight.

Note: The outlet terminal may need to be guarded against freezing.

(e) When a sump is installed for the purpose of accumulating any water which may be present in a well pit, such sump shall be watertight.

(f) No well pit drain shall be connected directly with any sewer, house drain, or plumbing system.

(g) When a well pit is constructed in impervious soil, no porous material shall be used as a base under the well pit floor. If fill is required, same shall be clean, impervious earth, well tamped.

**Section 37. Pump Service and Connecting Pits.** Every pit constructed at the well, to protect equipment against frost, to provide access to underground connections and valves or for similar well and pump service, shall conform with the minimum specifications for well pits except that the floor space may be limited to twelve square feet.

**Section 38. Installation of Pumps.** (a) Any equipment or appurtenances, permanently installed in a well, shall be joined watertight to the well casing at the point of entrance to the well. (See Figs. 18 to 21, inc., 28 and 29.)

(b) Every well having equipment or appurtenances installed therein, properly sealed, shall be fitted with an air vent. In the case of power pumps, water systems, and the like, such vent shall be extended to a height of at least twelve inches above any possible high water level. In the case of hand pumps, such vent shall be located at least fifteen inches above the platform at the pump. The vent shall be shielded in such manner as will prevent rain or spill water from entering the opening. (See Figs. 28 and 29.)

Note: The size of vent extensions should be in proportion to the length, viz. ⅜ in. up to 2 ft., ½ in. up to 6 ft., ¾ in. when over 6 ft.

(c) In the case of deep well pumps whose power heads are mounted substantially over the well, all such power heads shall be mounted on an elevated sub-base conforming with the following:

(1) Minimum clearance between floor and sub-base—fourteen inches.

(2) Minimum annular clearance around well casing above floor—ten inches. (See Fig. 20.)

(d) In the case of suction piping entering a well underground, such piping shall enter the well as follows:

(1) When the connection between a well and a basement or other subsurface structure can be made in a straight line and without intervening joints, the suction pipe shall enter the well through a durable, watertight conduit, made of standard weight pipe. The conduit shall be joined permanently and watertight to the well casing and shall be fitted with a



watertight stuffing box connection between the conduit and suction pipe. (See Fig. 19.)

(2) When the connection cannot be made as in the preceding paragraph, (1), a pit conforming with the provisions of Section 37 shall be installed to facilitate making connections at the well. The suction pipe shall then enter the well either at the side through a stuffing box which shall be attached permanently and watertight directly to the well casing or through a short section of conduit attached to the casing, or through the upper casing terminal, in such manner that a watertight joint is made between the well casing and the piping. (See Fig. 18.)

(e) All pressure systems shall be provided with a pet cock, located between the pump and pressure tank for the purpose of drawing a sample of water for analysis.

(f) (1) When mounting a hand pump on a well cased with iron pipe, the pump head shall be mounted watertight upon a base flange which is attached rigid and watertight to the well casing. (See also Section 20 (b) and 30.) (See Figs. 28 and 29.)

(2) When mounting a hand pump on a well not cased with iron pipe, the pump head shall be mounted watertight on a concrete platform, well pit deck, frost pit deck, or similar structure. (See Figs. 17, 25, 26 and 27.)

(g) Delivery of water from a well by means of pumping equipment, either hand or power driven, utilizing moving parts in the well below a depth of ten feet, shall be through piping enclosing such moving parts. Such piping shall be distinctly separate from the casing of the well irrespective of the diameter of the well. (See Fig. 30.)

(h) All pumping equipment shall be protected from freezing by a drain in the pump pipe located below the frost line, within the well, by approved underground pipe arrangements, or by heated pump rooms.

**Section 39. Concrete and Grout Mixtures.** (a) Concrete for use in construction of wells, well pits, connecting pits, and the like shall be made of clean, hard, tough, and durable aggregates. The maximum diameter of aggregate particles shall not exceed 1/5 of the minimum width between forms. The fine aggregate, or sand, should be separated from the coarse aggregate by means of a ¼" screen and to make the ratio of coarse aggregate to fine aggregate 1½ to 1, by volume. In general, this ratio shall not exceed 2 to 1 nor be less than 1 to 2. From 30 to 70 per cent of the sand passing a ¼" screen should be retained on a No. 30 sieve. In proportioning concrete sufficient sand and coarse aggregate shall be mixed to make approximately three cubic feet of mixed aggregate. To this aggregate shall be added one sack of cement and 5½ gallons of water. If the aggregate is wet, reduce the water to five gallons per sack of cement. Thoroughly mix, adding cement and water if the mix is too dry. The consistency shall be wet enough to permit easy placement without an excess of water.

(b) Concrete grout: A mixture of cement, sand and water in the proportion of one bag of cement, (94 lbs.), an equal volume of dry sand, and five and one-half to six gallons of clean water.

(c) Neat Cement Grout: A mixture of cement and water in the proportion of one bag of cement, (94 lbs.), to five and one-half to six gallons of clean water.

Attest: C. A. HARPER, M. D.,
*State Health Officer.*

ILLUSTRATIONS

Figs. 1 to 30 supplement regulations contained in Part II and general information Part III.

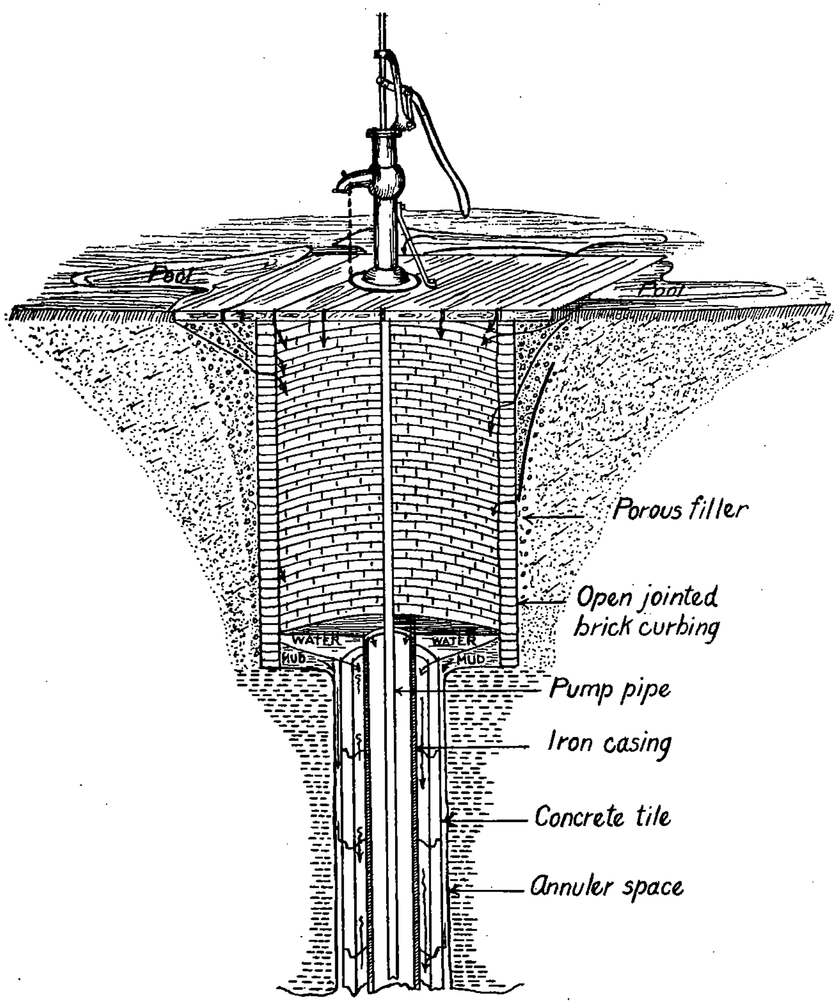



Fig. 1. Indicates improper construction of a dug well. The platform is of plain lumber and laid flush with the grade. All drippings and surface wash at the well can enter the well and carry into it any animal wastes and other pollutional matter. The arrows indicate how pollution follows various channels into the dug well and from there to the several extensions to greater depth, none of which are protected against entrance of pollution.



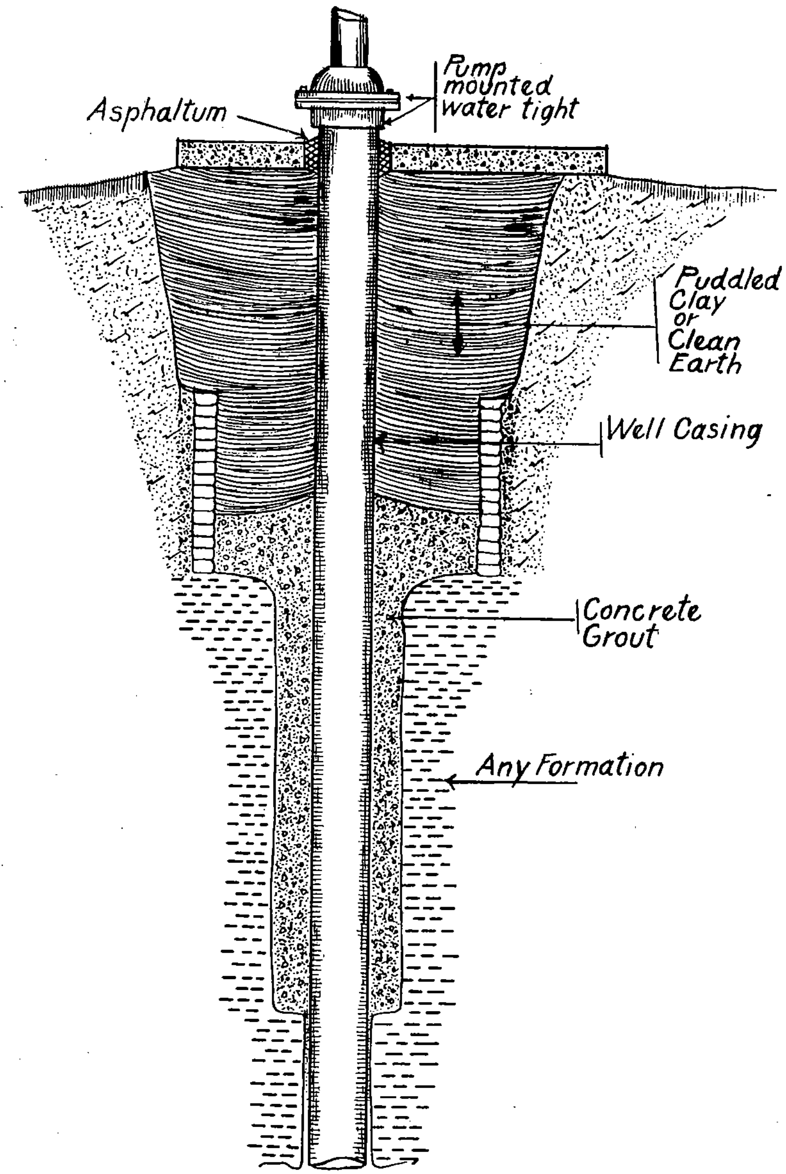



Fig. 1 (a). Illustrates the proper construction of a dug well drilled deeper. Proper precautions are taken to prevent entrance of pollution by way of the old excavation and the annular space surrounding the well casing. See Sec. 27.

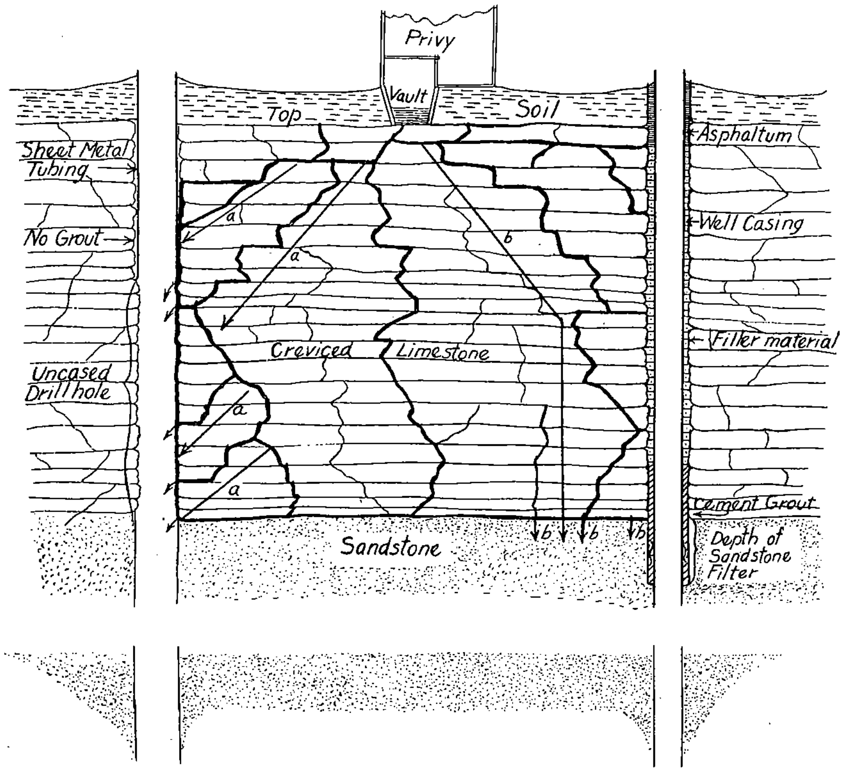



Fig. 2. Illustrates improper construction (left) and proper construction (right) of a well through creviced limestone. Arrows (a) indicate how raw sewage pollution from a source such as indicated or from any other source such as barnyards, cesspools, dry wells, septic tanks, polluted wells, mines, and other excavations can enter the well. Arrows (b) indicate the course polluted water must follow before it can enter the well. The casing is entered and grouted into the sandstone to a sufficient depth to compel the necessary filtration of the ground water through sandstone to purify the water before it enters the well. See Secs. 14 and 20.



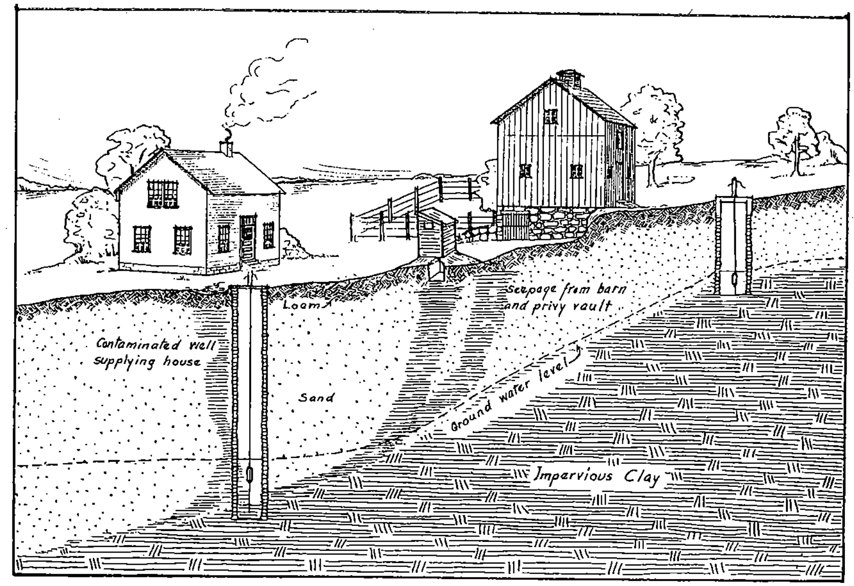



Fig. 3. Illustrates improper location of the lower well with reference to buildings and surface contour. Natural drainage, both surface and subsurface is toward, instead of away from, the well.

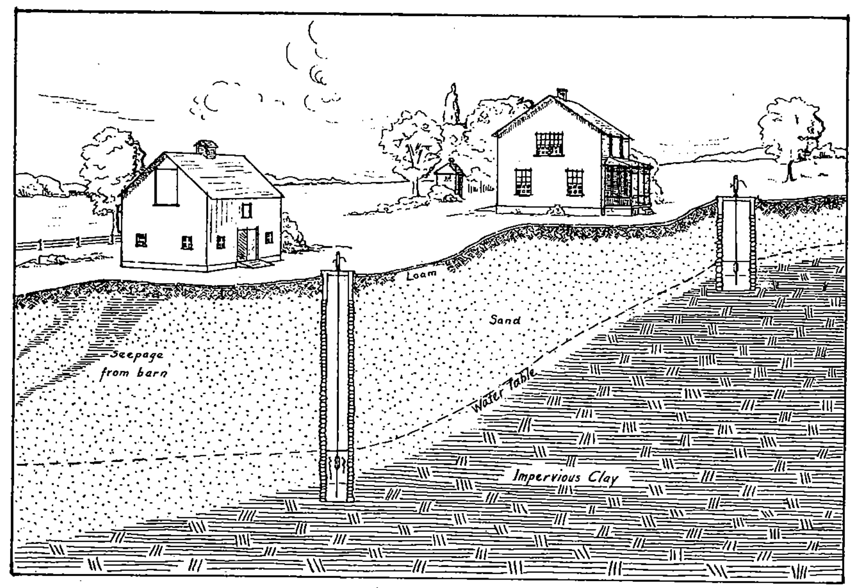



Fig. 4. Illustrates proper location of the wells with reference to buildings and surface contour. Subsurface drainage of a pollutional character is away from, instead of toward, the wells. The well tops are properly protected against surface wash.

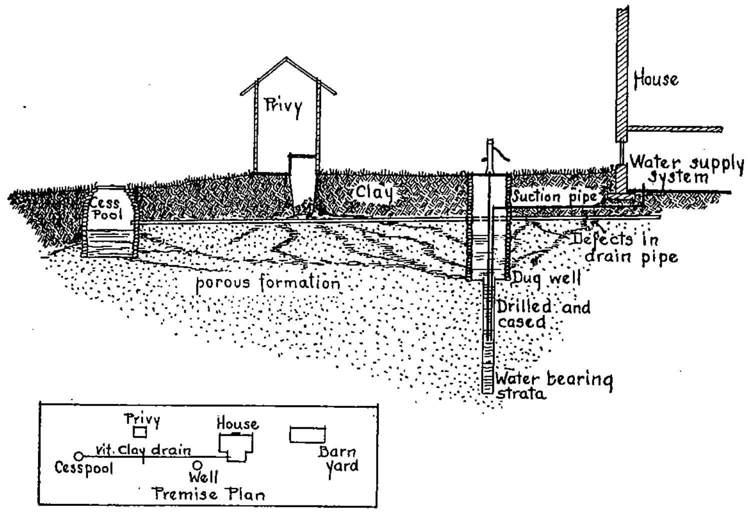



**Fig. 5.** Showing possible sources of drinking water pollution. In tracing the source of pollution in such cases the tests should be applied separately and in the following order: privy, cesspool, house drain, barnyard, or other suspected source of contamination through porous near surface formations.

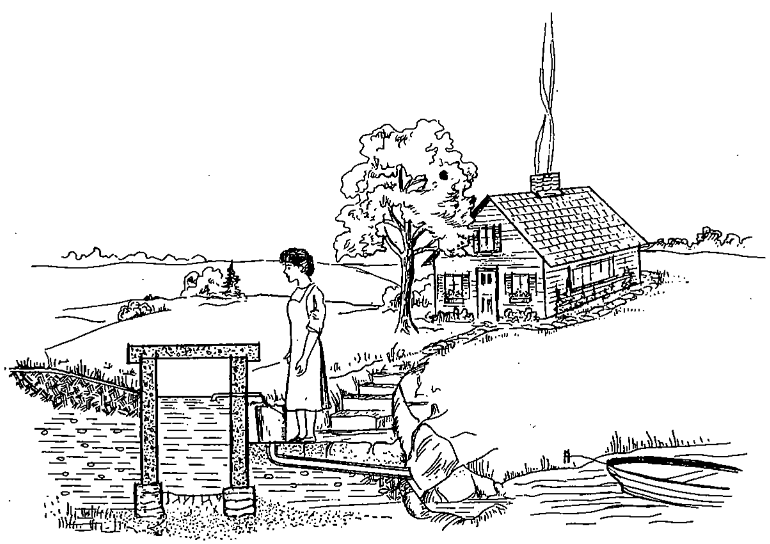


**Fig. 6.** A concrete structure will protect a spring against surface pollution. The spring cannot be protected against underground pollution, particularly when water flow is in the direction of the spring.



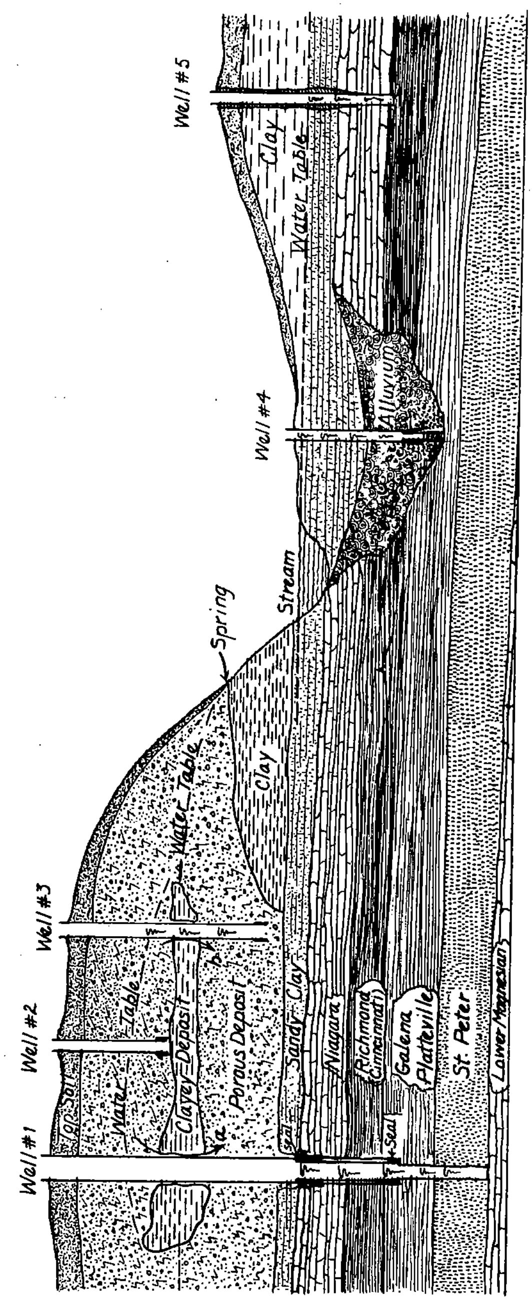



**Fig. 7.** Illustrates wells terminating in various deposits of drift or alluvium and rock formations. Wells 2 and 3 may or may not be safe, depending upon the surroundings of the wells. Well 1 can be made safe by means of seals at the points indicated, since the formations in which the casing shoe and the liner seal are situated are of a dense character. While pollution may exist in the stream it is probable that safe water can be had from Well 4 because the watertable is high. Well 5 may, however, become polluted under heavy pumping since its terminal is within the zone of pollution. If the channels indicated at arrows *a* and *b* are not automatically sealed by caving clayey material, the perched water reservoir may be eliminated entirely, thus resulting in a dry well at 2.

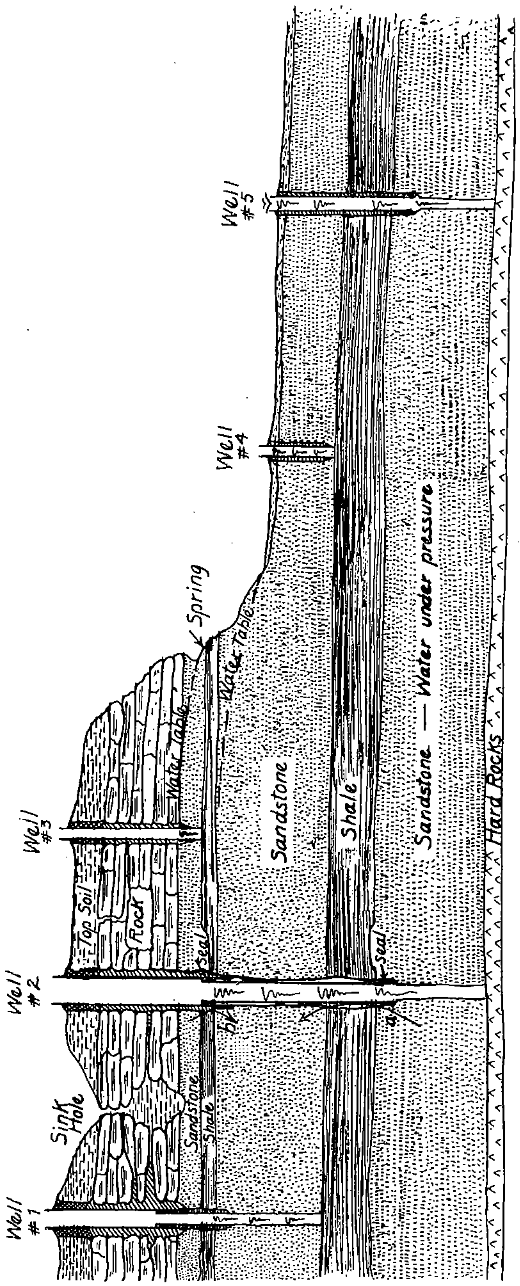
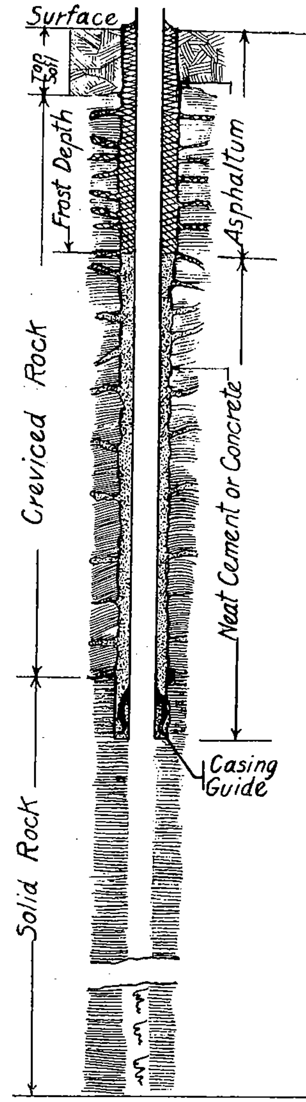



Fig. 8. Illustrates wells terminating in various formations and waterbearing horizons. Grouting, as indicated, within the vertical zone of pollution, provides protection against entrance of pollution by way of the annular space surrounding the casing. Arrow (*a*) indicates how leakage may occur from an artesian horizon with detrimental effect upon the existing pressure. Arrow (*b*) indicates how groundwater may pass from a higher to a lower horizon. Pollution is frequently carried from one horizon to another by this route.





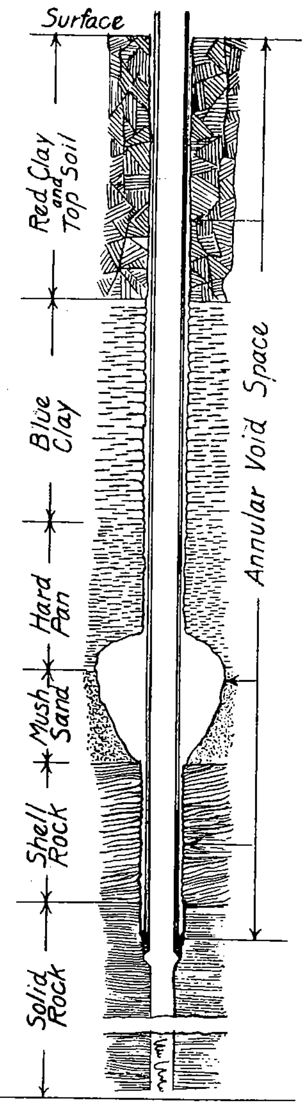
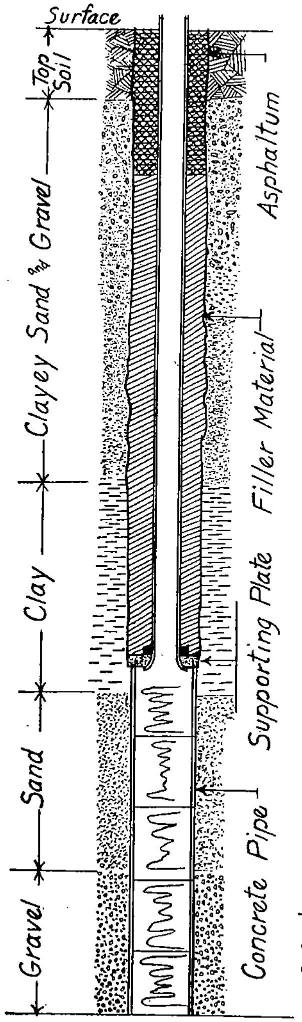




Fig. 9. Indicates proper construction of a well through creviced rock within the vertical zone of pollution. See Secs. 15, 19, 20, and 39.

Fig. 10. Illustrates the annular space which exists around the well casing, providing a channel by way of which pollution can enter the well. This space must be filled. See Secs. 15, 19, and 20.



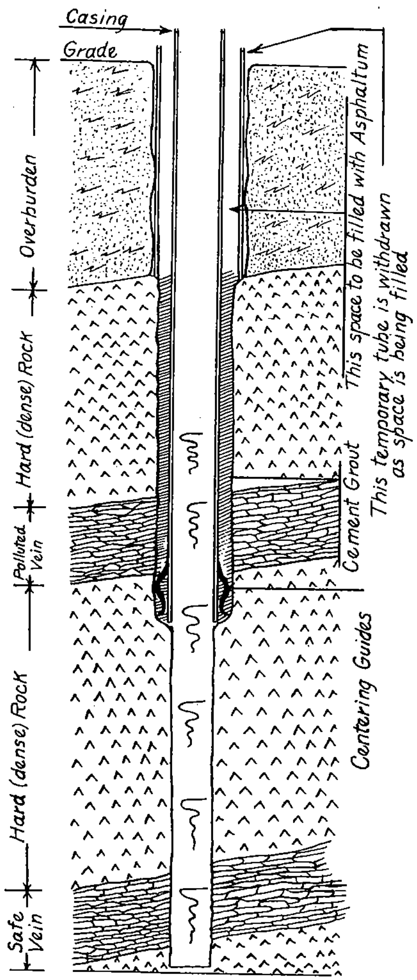
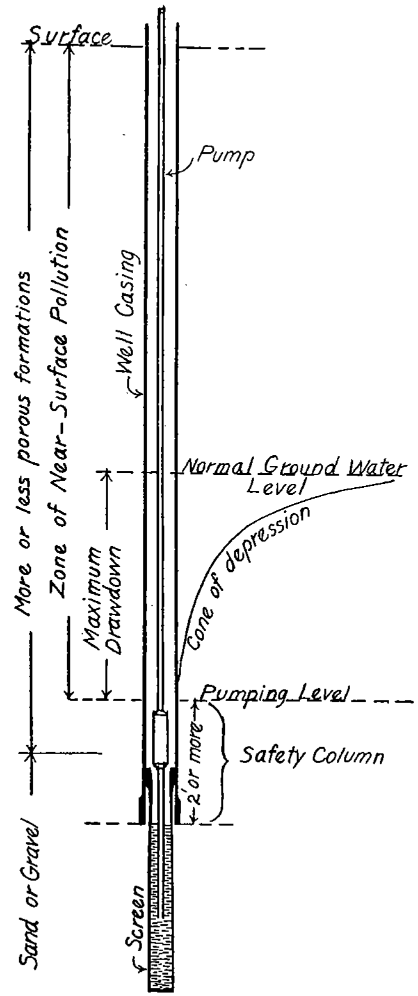
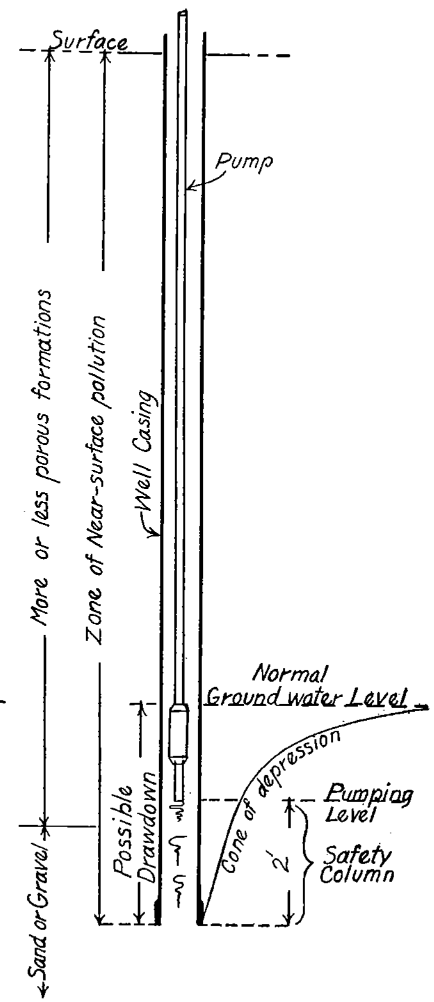




**Fig. 11.** Illustrates how a bored well may be reconstructed to provide protection against pollution. See Secs. 14a, 15, and 24.

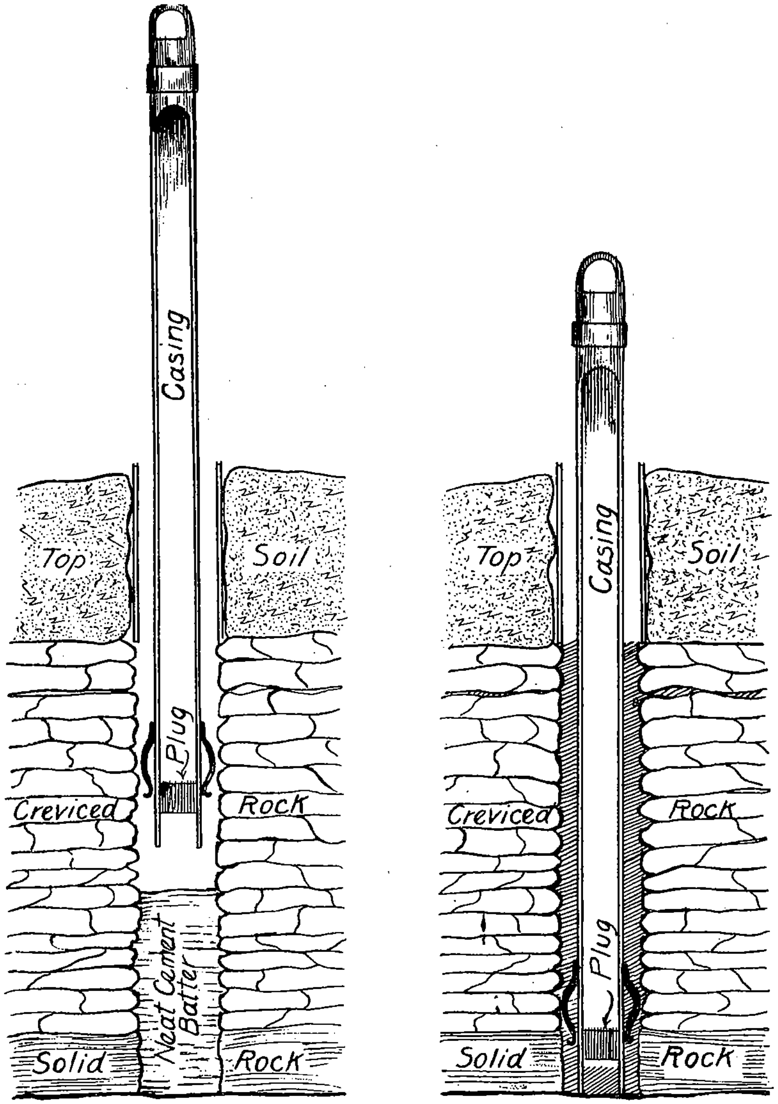
**Fig. 12.** Indicates how a polluted waterbearing horizon can be effectively "sealed off" to exclude polluted water from the well.






**Figs. 13 and 14.** Illustrate the behavior of the ground water level, at the well, when pumping. A high water level in the well, while pumping, automatically affords a certain degree of protection against entrance of pollution at the lower terminal of the well. The capacity of the pump and the depth of the piping in the well should be so adjusted that a "safety column" of water is automatically maintained in the well.




Figs. 15 and 16. Illustrate a simple method of grouting a casing in near surface rock formation of creviced character. The batter of neat cement is placed in the drill hole and the casing, arranged as shown, is forced down into the batter. This causes the batter to flow upward along the casing, thus thoroughly sealing all crevices. This method can be successfully used when the work is near the surface and the entire operation can be completed before setting of the cement begins.



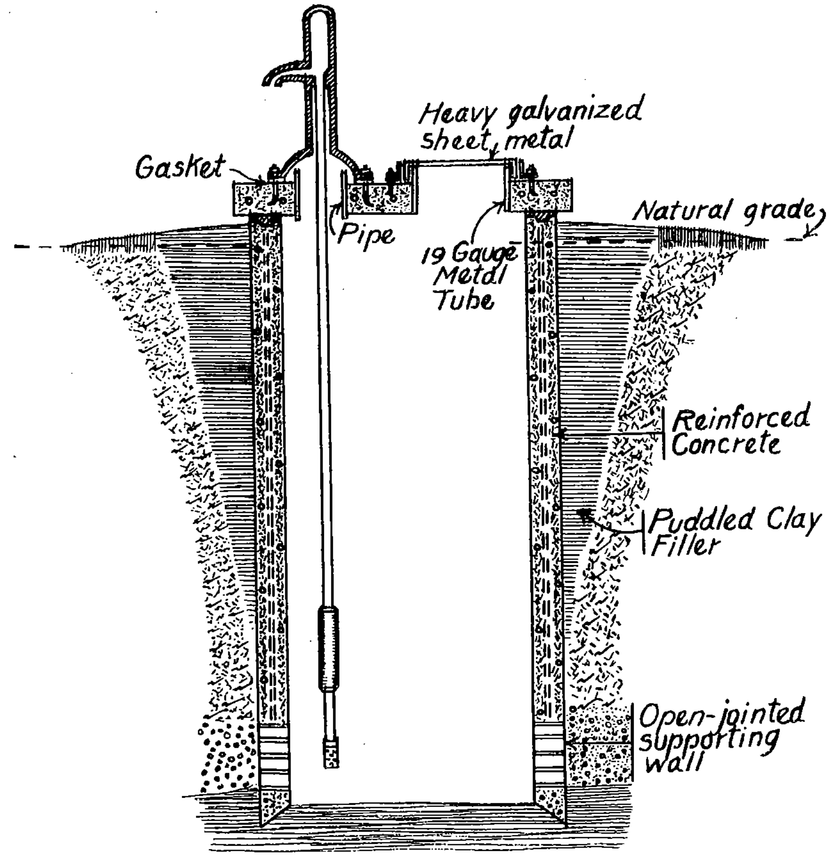
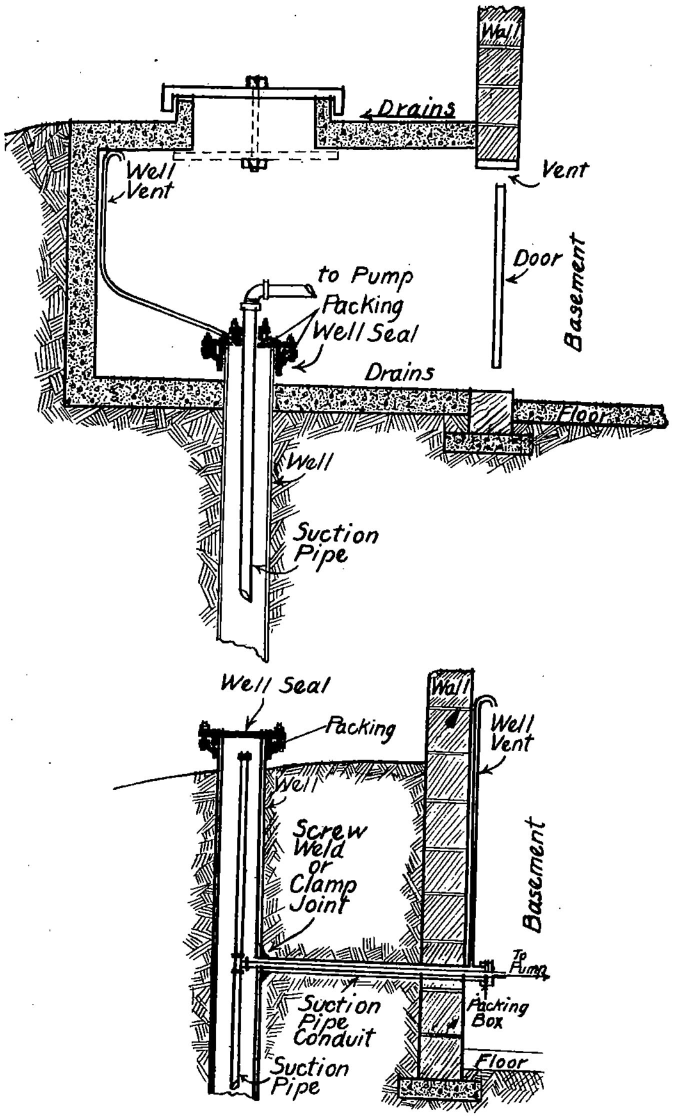
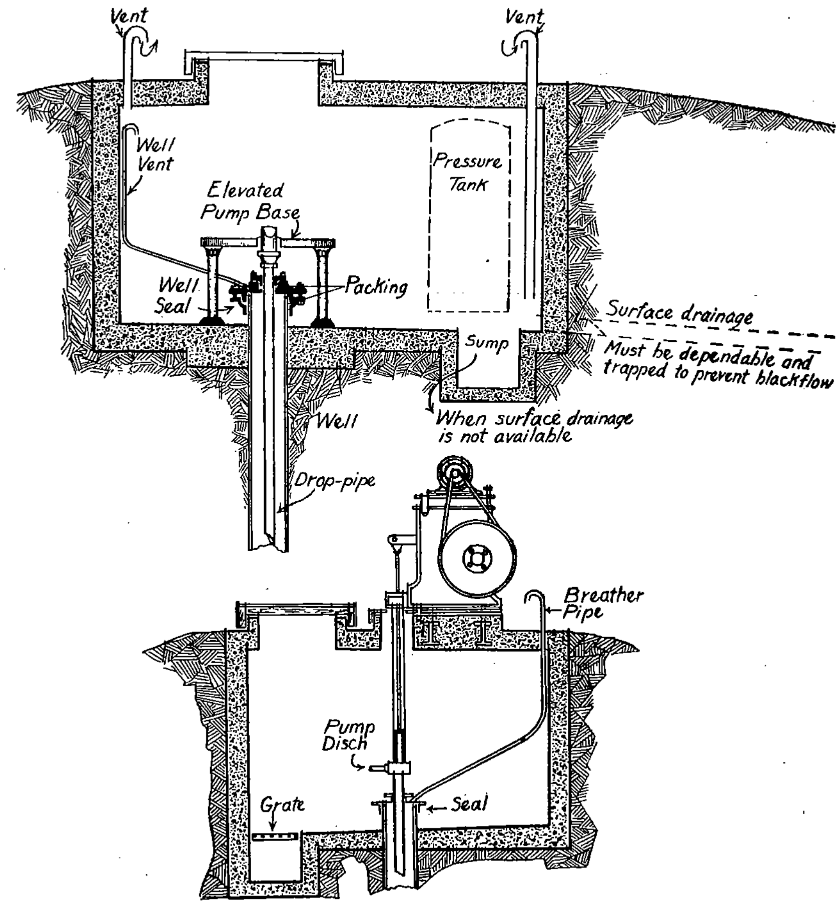



Fig. 17. Indicates the salient features of the construction of a dug well having a concrete retaining wall. Particular attention is directed to filler material in the annular space around the curbing, construction of the well top, mounting of the pump, manhole opening and cover and grading of the ground surface around the well. See Secs. 26, 38, and 39.

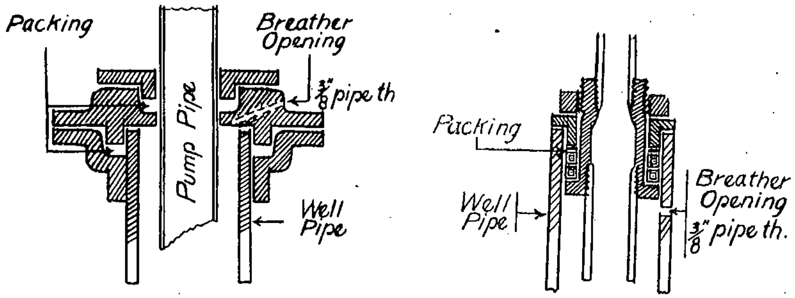



**Figs. 18 and 19.** Indicate proper methods of entering suction piping in a drilled and cased type of well. In each case, the well is properly protected against entrance of polluted water, and the well is correctly vented. See Sec. 38.






Figs. 20 and 21. Illustrate application of "Well Seals" in connection with deep well pump installations. See Secs. 30 and 38. Construction of "Well Pit", see Secs. 34, 35, and 39. Well Pit Drainage, see Sec. 36.




Figs. 22 and 23. Illustrate types of well seals. The ideal construction of a seal is such as will permit placing or removal thereof without disturbing the pumping equipment. See Sec. 38.

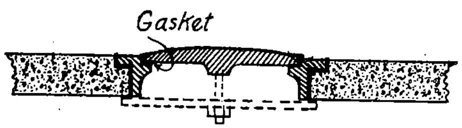
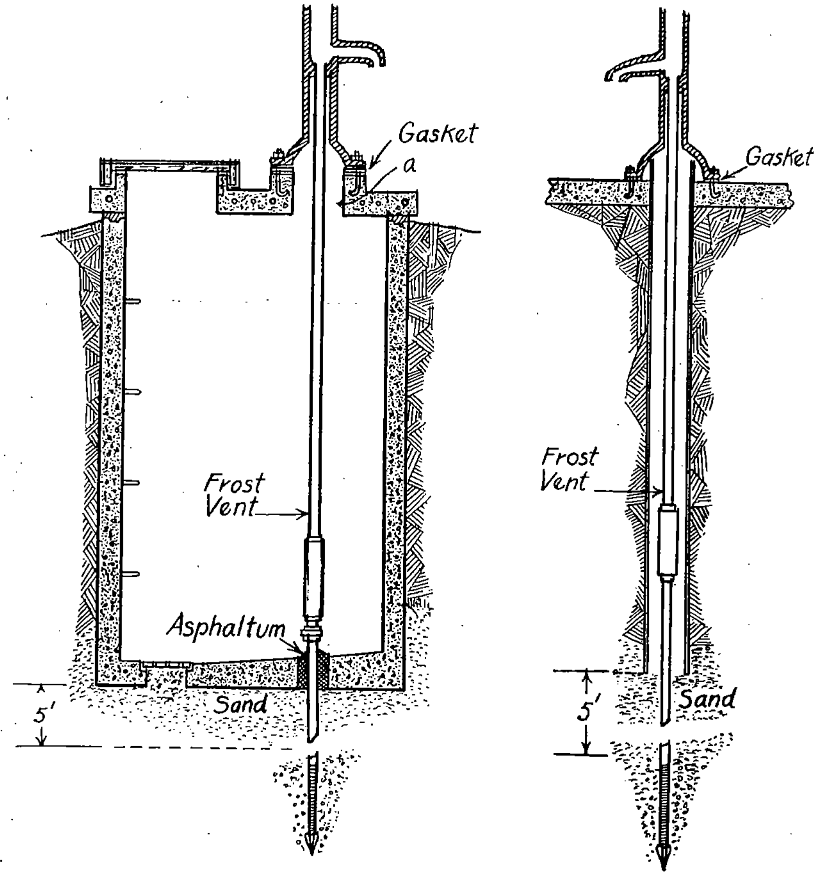



Fig. 24. Suggests the construction of a flush type manhole rim and cover. See Sec. 35.






Figs. 25 and 26. Indicate satisfactory methods of installing frost protection provisions in connection with driven point wells. The pump heads are mounted watertight. Surface water is excluded from either the pit or casing to a suitable depth. Under the conditions indicated the small amount of water issuing from the bleeder may be drained by seepage from the pit or tube with reasonable safety. See Sec. 36.

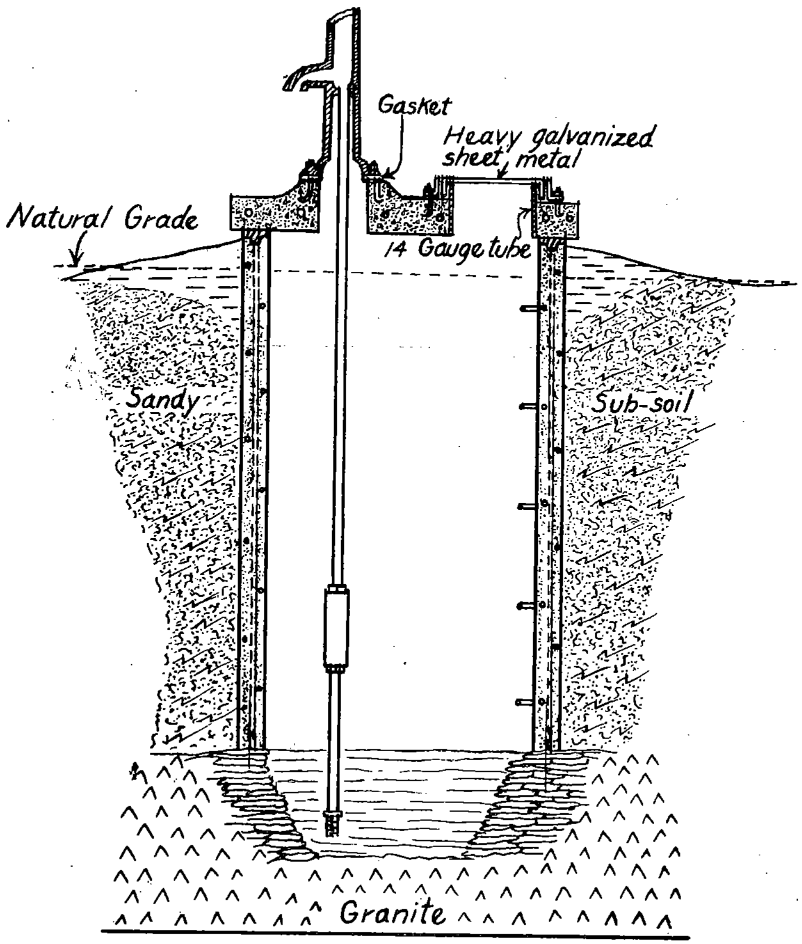
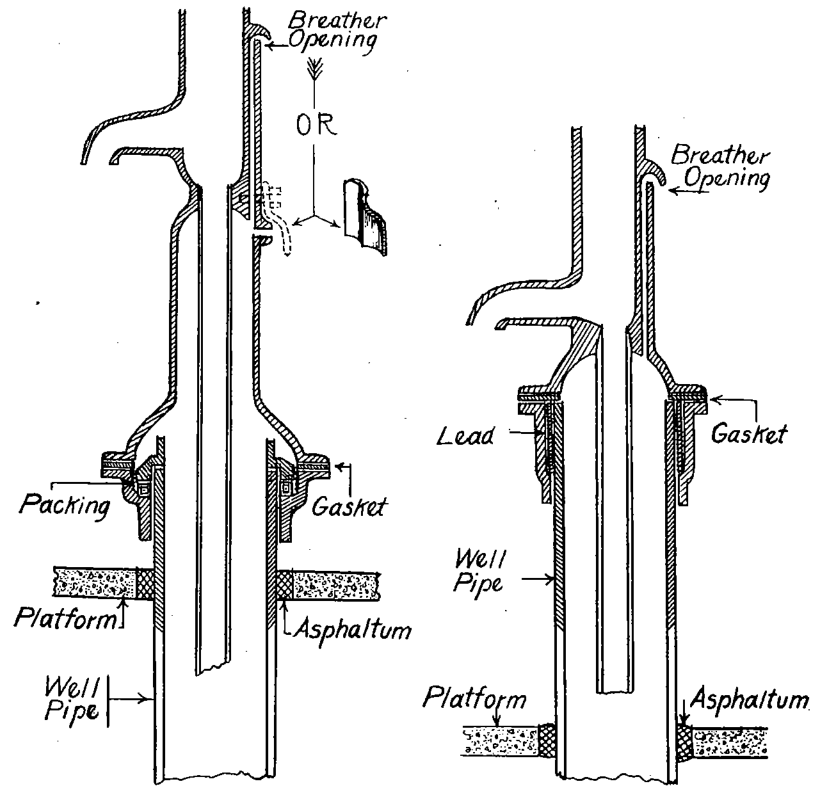



Fig. 27. Illustrates proper construction of ground water accumulator type of well in the hard rock area where frequently the only source of ground water is the accumulated water in the drift overlying the hard rock formation. The walls of the pit and also the pump mounting and manhole cover must be water-tight. All water entering the well must penetrate the entire depth of the sub-soil, thus providing as much filtration as possible. See Secs. 26, 38, and 39.






Figs. 28 and 29. Illustrate typical hand pump settings, providing positive protection against entrance of pollution at the well top. A satisfactory arrangement to permit breathing of the well is also indicated. See Secs. 20 and 38.

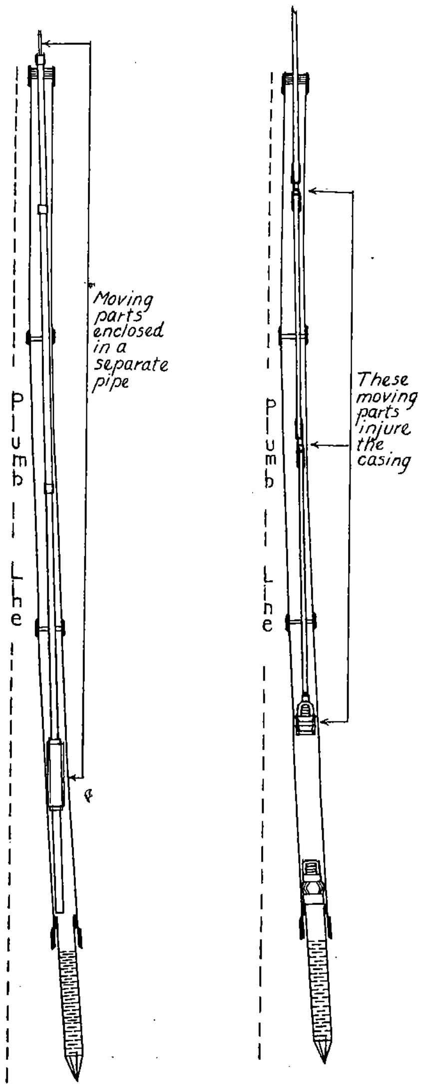



Fig. 30. The figure at the right illustrates the objection to the use of the well casing as a means of delivering water from a well. Small diameter wells are usually in very bad alignment. This results in dragging of the plunger rods on the walls of the casing, wearing them through, thus establishing an opening where pollution can enter. The figure at the left illustrates the moving parts properly encased to prevent damage to the well casing. See Sec. 38 (g).



# WELL LOG, PREMISES DIAGRAM, and REPORT

For Official Record of the Board.

(TO BE USED FOR THAT PURPOSE ONLY)

Owner Jacob Keller
(If a joint ownership give name of responsible official. Also name of each individual holding an interest. Use a separate sheet and attach hereto.)

Driller Harold Howard

Address Willard P.O. Wis.

Address Willard, Rose, Day
(City, village, township, county)

Date of Report March 15 1936

Registration No. 103

Give below the location of the property on which well is drilled.

If incorporated village or city: ........ Name ........ Lot ........ Blk. ........ Street and No.

If unincorporated hamlet ........ Name ........ County ........ Twp. ........ Highway

If Lake Shore Plat ........ Name of Plat ........ Lake ........ Lot ........ Blk. ........ Street

If Farm Day (County) Rose (Twp.) 18 (Sec.) U.S. 30 (Highway)

If School ........ County ........ Twp. ........ Sec. ........ District

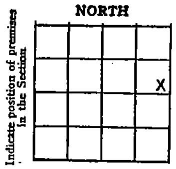
If other public building ........ Kind ........ County ........ Twp. ........ Sec.

Miscellaneous ........ Kind ........ County ........ Twp. ........ Sec.

## WELL LOG and REPORT

| Screens, Seals Grouts, etc. | Well Diagram (Each vertical line equals 1") | Kind of Casing, liner, shoe, etc. (Each horizontal line equals 5') | Formations State if dry or water bearing | Record of FINAL Pumping Test |
|---|---|---|---|---|
| | 25 | 0' to 100' Std weight | Top Soil and Red Clay 16½' | Duration of test. Hours 8hrs. |
| | 50, 75 | Driller Special Wrought steel pipe 6" | Blue Clay (Some boulders) 71½' | Pumping Rate. G. P. M. 25 |
| Lead Seal (swedged) | 100 | | Very fine sand 5' | |
| Neat Cem. Grout | 125 | Shoe 6" forged Steel-hardened | Hard dense limestone 20' Broken limestone and mudpockets 23' | Depth of pump in well. Ft. 100' |
| | 150, 175 | 95' to 140'-std wt Wrought steel pipe-4½" | Limestone Very dense 47' | Standing water-level (from surface.) Ft. 60' |
| | 200, 225 | 100' to 140' Drillhole 15-6" Dia. | Limestone (seamy) Water-bearing 47' | |
| | 250 | | Shale 5' | Water level when pumping Ft. 70' |
| | 300 | | | Water. End of test. Check: Clear ✓ Cloudy ........ Turbid ........ |
| | 350, 400 | | | Was well sterilized before test? Yes ✓ No ........ Date Feb. 28/36 |
| | 500 | | | To which Laboratory was sample sent? Madison Date Feb. 30/36 |
| | | | | Was the well sealed on completion? Yes ✓ No ........ |
| | 600 | | | How high did you leave casing above grade? 18" |
| | | | | Well was completed Feb. 30 1936 |
| | 700 | | | Well Driller: Harold Howard Signature. |

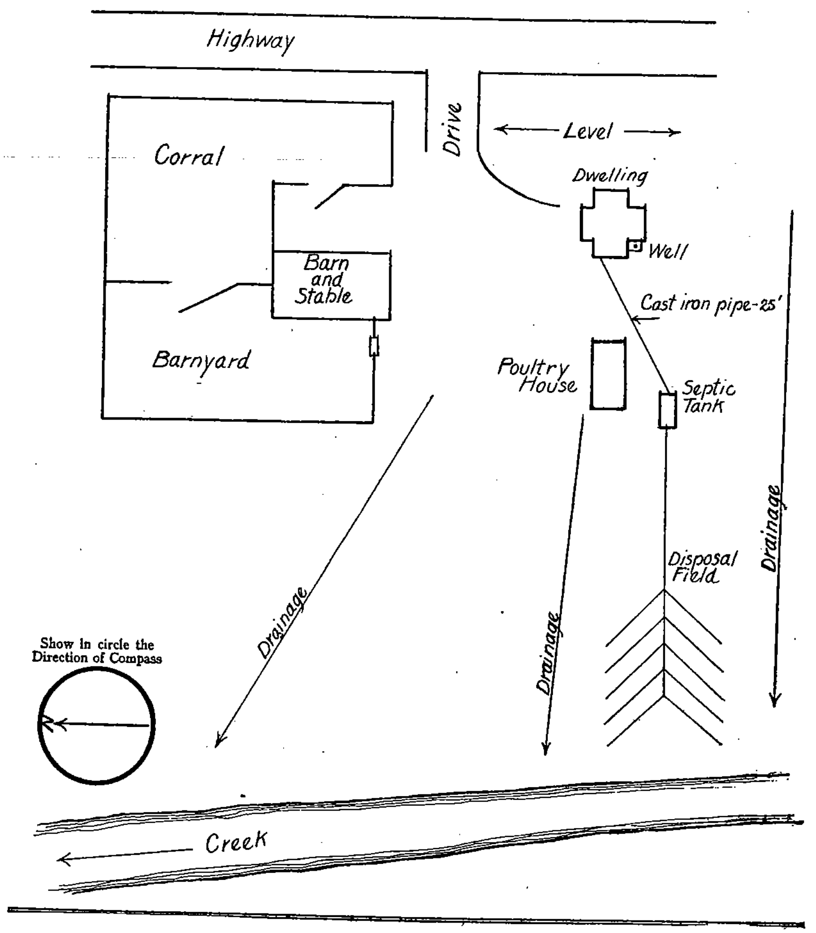
# PREMISES DIAGRAM




REMARKS:

Sec 18 T 8 R 21 (E) (W) (Each division equals 10') (If more or less indicate: ..............................)

Show in circle the Direction of Compass






## Part III

## INFORMATION

This part of the bulletin is devoted to helpful information and illustrations referred to in Part II.

### Ground Water Supplies

In obedience to the law of self-preservation, all forms of life are engaged in a constant struggle to preserve and prolong that life. The lower forms are subject to the vagaries of nature. The higher forms instinctively avoid that which threatens their existence. The highest form of life, the human being, endowed with intelligence and a free will, too often misuses these superior qualities to its own disadvantage. Witness the appalling number of casualties resulting from injudicious use of modern machines and devices, improper use of modern conveniences, unrestrained indulgence in food and drink and misguided pursuit of happiness. Waste, destruction, or despoiling of the resources provided by nature, for use in common, by man, reflect eventually and unfavorably upon mankind.

In the case of water, this is more than true. There is no substitute for water. Without water, a human being cannot survive. Moreover, water used for human consumption must be pure, (free from harmful germ life or substances). Any act, on the part of anyone, which contributes to rendering unsafe any part of the water supply drawn upon for human use is therefore an act detrimental to the common welfare.

The major percentage of water other than municipal supplies for human use in the State of Wisconsin is drawn from its ground water supplies. The groundwater supplies of Wisconsin are well distributed. Some areas have not fared as well as others, and haphazard practices in the construction of wells have rendered many previously excellent supplies unsafe. Although the attempt to regulate private water supplies may be belated, if proper methods of obtaining ground water are pursued and effective safeguards applied, existing safe supplies will be conserved and many unsafe supplies recovered and made safe.

### Influences Adverse to Safe Water

It is becoming more and more difficult to obtain safe, (pure), water in adequate quantity at reasonable cost. The more important reasons are:

1. Constant growth of population per unit of area with consequent increased demand upon available supplies.
2. The unavoidable befouling wastes incident to human and animal life increase with density of population and unless disposed of in a safe manner become a serious factor in polluting ground water supplies.
3. Improper methods of tapping ground water supplies, thereby exposing them to pollution and waste.

4. Pollution of ground water supplies by way of abandoned wells, quarries, mines, caves, prospectors' drill holes, drainage wells, ponds, etc.

5. Pollution brought about by leaching into the soil or discharging into underground formations, the contents of privies, dry wells, cesspools, house sewers, drains, septic tank effluent, etc.

6. Surface pollution which often enters the well, spring or reservoir through defective walls, well tops, pump settings, connections, manholes, etc.

### Water Borne Diseases

The bacillus of typhoid fever, is present in enormous numbers in the feces and often in the urine of persons having that disease. Moreover, many persons having suffered from typhoid continue to discharge the bacilli in the feces long after having apparently returned to normal health. Such persons are called "typhoid carriers." Other important water borne diseases which may be carried in similar manner by persons apparently healthy are paratyphoid and dysentery. Numerous water borne bacteria cause diarrhea. The germs of these diseases enter water supplies with sewage. The time and place of entrance of these germs into water supplies cannot readily be anticipated, and may occur in locations and at times least expected. Obviously the matter of water supply pollution concerns every individual citizen indirectly and certain individuals and interests directly.

### Interests and Factors Affecting Ground Water Supplies

Community interest in ground water supplies is the most important and least understood. Like the air we breathe, ground water is available for the use of all, and it should not be the privilege of any individual to contaminate any ground water supply to the detriment of his fellow citizen in the community. To understand this, it is necessary to understand the cycle of water on this earth.

### The Water Cycle

Beginning with the oceans and the smaller bodies of water, the cycle begins by evaporation of water from their surfaces and transpiration from vegetation. The vapor rises into the sky, forming clouds. The clouds drift, (driven by wind), across land and sea. Upon reaching a cool area in the sky, the vapor of the clouds is precipitated into water, which falls upon the earth in the form of rain, snow, or hail. Upon reaching the earth, part of the rain water runs off immediately over the surface into streams, and back to lakes and oceans. The remainder is absorbed by the earth and becomes ground water. This ground water in part is lost by evaporation at the surface and transpiration through vegetation. The balance eventually reappears at the surface in the form of springs or surface water or is withdrawn through wells.

### Movement of Water Underground

In general the movement of ground water is analogous to that of surface water except that the courses or channels through which the ground water moves are more involved and the velocity of flow is dependent upon the porosity of the formation through which it passes. The rate of underground flow of



water may vary from a few hundred feet per year to a mile or more per day. Some water becomes entrapped in basins which may be compared to a large cistern or reservoir filled with sand or gravel, the voids of which are occupied by water.

### Individual Property Owner's Responsibility

Since ground water may enter the ground anywhere, and having entered, may flow in any direction, it follows that the supply moving under any premises should not be considered private property and while the owner of property may use therefrom, he should not be privileged to either waste or pollute such water. Briefly stated, the purity and conservation of ground water supplies is dependent upon proper use thereof by all who draw upon such supplies.

Having cited the principle of the individual owner's responsibility to the community, we may consider how the individual owner can discharge his obligation to the community in connection with the use of ground water supplies.

Any opening, (hole or excavation), establishing a connection between the surface and ground water supplies, or between two or more ground water levels is a channel by way of which pollution can enter ground water supplies. To obtain ground water, it is necessary to have an opening to the ground water levels through which such water can be brought to the surface. Such an opening is commonly called a "well." Since wells are a necessity, it follows that their construction and use must be of a character which precludes introduction of pollution into ground water supplies.

### Regulation

It is obvious that some kind of uniform Code for Ground Water Users is a public necessity. Since the well drilling industry is most directly concerned in the processes of constructing wells which will avoid the hazards of ground water pollution, it is but logical that this industry be required to adhere to uniform minimum standards which insure the results sought.

Since certain contagious diseases originating in human wastes, (sewage), can and do reach the human body by way of the "water route", it should be clear to everyone that regulation is necessary. Fortunately, such regulation does not need to be drastic or burdensome. If the pollution of the ground water supply problem is attacked vigorously and with the whole-hearted cooperation of all concerned, the damage already done to ground water supplies can gradually be rectified and further damage prevented or controlled.

### Construction of Wells and Causes of Pollution

The construction of safe wells is not the simple problem it is usually assumed to be. There is a vast difference between a "hole in the ground," which is a potential pollution hazard, and a "safe well", so constructed that the hazard of pollution is eliminated. Among the most common sources of pollution is the unprotected upper terminal of the well. Examples are: Casing tops terminating at or below the permanent surface grade at the well, well tops that are not watertight, casings within the "zone of pollution" that are not watertight, connections, pump settings and annular space surrounding the well casing that is not properly filled with impervious material.

### Correction of Defects

Correction of these defects in existing wells would remove 70% of the now unsafe wells in the state. Since the remedies are so obvious and inexpensive a noticeable improvement should automatically follow compliance with the prescribed regulations by all concerned.

The remaining causes of pollution are not so simple and require proper understanding and the use of proper methods and materials and frequently community-wide cooperation to eliminate.

### Well Construction Materials

Materials, (especially well casing), are subjected to severe strains in the process of drilling a well. The life of a well is usually expected to extend over a considerable period of years, and soil conditions in many localities have a decidedly deteriorating effect upon the casing. In addition, there is the ever-present hazard of defects. Therefore, the best of materials are none too good. Materials previously used, (so-called reclaimed materials), do not fit into the picture of good well construction. Whatever saving, if any, that may be had by the use of questionable materials, is more than offset by a corresponding reduction in the life of a well, not mentioning the hazard introduced thereby.

### Porous Formations

Among the wide variety of underground formations encountered there are many of very porous or creviced character. If this condition exists within the zone of pollution special attention to details of construction of the well is necessary to eliminate the pollution hazard. The most effective and least expensive procedure to meet this condition is proper "grouting operations", which are fully covered by regulations in Part II and illustrations and suggestions in Part III of the Code.

### Annular Space Surrounding Well Casing

A similar condition exists in practically all wells by virtue of the annular space surrounding the well casing or curbing. This space must in all cases be carefully filled with impervious material of some kind. If the well is drilled through clay or similar deposits, the annular space can usually be effectively sealed by filling with clean puddled clay. In suggesting puddled clay, it is assumed that the lower casing terminal is seated firmly and water-tight. Moreover, in the process of drilling the well, the driller frequently obtains a liberal supply of clean, puddled clay from the drill hole. He need only make provision for storing same until the driving of the casing has been accomplished. The material can then be fed into the annular space until filled and complete settling is assured. The cost of taking care of this important detail of well construction is therefore quite insignificant in most cases. Further suggestions and illustrations may be found on other pages of Part III as well as in the Regulations covering this subject in Part II of the code.

### Size of Well

The size of well to construct is a question which is usually decided upon a basis entirely foreign to community interest and owner responsibility. The



proper basis for determining the size of a well is the amount of water required and the type of construction necessary to insure safety of the individual supply as well as the ground water supply from which the individual supply is drawn. If the formations which must be penetrated to reach a suitable water supply are such as will require special precautions to safeguard the ground water supply, then the diameter must be sufficient to permit proper application of such safeguards. Likewise, if the amount of water required exceeds the practical possibilities of the well to deliver it, the remedy is obviously in constructing a well of sufficient size to deliver the amount of water required.

### Location and Accessibility of Wells

The importance of locating a well properly with reference to possible sources of pollution is a matter frequently overlooked by owners and drillers alike. The location of the well should be given careful consideration in planning the layout of buildings and waste disposal on the premises. Low points should be carefully avoided and underground flow of water considered. As much distance as possible should be provided between the well and any possible source of pollution. Drainage from higher elevations toward the well should be avoided. This distance cannot readily be stated in a definite number of feet since the porosity of the subsoil varies greatly and the possibility of pollution corresponds to the ability of the subsurface deposits or formations to convey pollution toward the well. In some instances a limited distance is sufficient. In others several hundred feet is insufficient.

### Pollution Due to Careless Drilling Operations

Many wells are originally polluted because of careless practices on the part of the driller. In the process of drilling a well, water for drilling purposes is used in considerable quantity. Unless such water can be obtained from a known safe source, it should be sterilized. By introducing about one and one-half ounces of chloride of lime or equal sterilizing agent into each 500 gallons of water and mixing vigorously before using. Water so treated will not cause pollution through drilling operations. Another safeguard which should be practiced by every driller is to so protect the well top during construction that surface water cannot drain into the well.

### Sterilizing and Flushing Wells

The reason for sterilizing and flushing (surging) a well on completion is to remove such pollution as may have been introduced into the well with casing and tools and from surface drainage and seepage. The sterilizing agent kills the bacteria, which may be present, and flushing clears the well of turbid water, sediment, silt, and the like. More important, however, as regards the sample of water to be submitted to the Laboratory is the removal of the sterilizing agent from the well. The reason for this is that the sterilizing agent, (chlorine), is a powerful disinfectant and the presence of even a small residual quantity of chlorine left in the well will inhibit the growth of bacteria and therefore render unreliable a bacteriological examination of the water. Thorough flushing of the well after sterilizing is therefore essential before collecting a sample. Moreover, proper flushing of the well assures a sample of water from the source rather than from the well itself. The proper procedure for sterilizing a well and drawing a sample for analysis is given elsewhere in Part III of the Code.

### Safety of Wells After Construction

It is not sufficient that wells be so constructed that the water supply is safe when the well is completed. Safety of the water supply must be maintained by continuous care of well and pumping equipment while in use and by proper abandonment procedure when no longer needed.

The one item of utmost importance is maintenance of an effective seal at the well top so that no water or other pollution can enter the well at any time. In the case of dug wells and similar existing wells, where application of more modern methods of protection are impractical, the mounting of pumps, sealing of manhole openings, and the like should be accomplished in a watertight manner. Further, the curbing of the well should be made watertight to as great a depth as possible.

### Temporary and Permanent Abandonment of Wells

When the use of a well is temporarily discontinued, it should be sealed watertight. When a well is permanently abandoned, it should be plugged and capped or filled in accordance with the provisions of Regulations in Part II of the Code.

### Conservation of Ground Water Supplies

Conservation of the ground water supply concerns every citizen of the state. Deliberate waste of ground water supplies by permitting unrestricted flow of flowing wells deprives others not as favorably located and often takes available ground water supplies completely away from them. Careless construction of wells in artesian basins frequently permits escape of ground water under pressure through openings established by drill holes from lower to higher levels to such an extent that the flow of wells in the entire artesian area is impaired or stopped. Skillful construction of wells and intimate knowledge of water-bearing horizons and impervious ground water retaining formations and community cooperation are necessary if our artesian ground water resources are to be conserved.

### Accurate Records Necessary

In order that proper and advantageous administration may be possible, a most essential part of the system of administration is a complete and accurate record of every new well constructed in the state. Similar records of reconstructed or repaired wells are essential. In the course of time, the ground water picture in the state will through such records, become clear and well-defined and the possibilities of advantageous application of the available information for the public benefit are practically unlimited. Proper forms indicating the information required are furnished in the necessary quantity to those required to make such reports. A typical report is shown on other pages of Part III of the Code.



### Permanence of Records

In order that such records may be of a permanent character and unaffected by change of ownership, subdivision of property, changes in names of locations, designation of relocation of highways, and the like, it is necessary to use permanent designations. The most satisfactory are the property descriptions given on deeds and tax receipts, either of which, or both, are usually available. Descriptions of this character are based upon original surveys of public lands and their subdivision into counties, townships, sections, quarter sections, acres, blocks, and lots. Thus, if the county, township, section, quarter section, and quarter of quarter section are given, the location of a well on any farm is definitely and permanently recorded regardless of future changes of ownership. Further subdivisions of plots are likewise recorded and available from deeds and tax receipts, thus making it possible to provide accurate descriptions of the location of wells in all cases.

### Qualifications of a Well Driller

Skill and experience in construction of wells together with a disposition to carry out every essential detail in connection therewith are essential qualifications of a good well driller. The quality of workmanship is reflected throughout the life of a well. Proper care in keeping his equipment and tools in good condition and skillful use thereof results in wells which are reasonably straight and perpendicular in alignment.

### Influence of Good Workmanship

Good workmanship eliminates unnecessary abuse of the well casing in driving and sealing and reduces the probability of injured or defective joints. The operation of pumping equipment in a well which is reasonably straight in alignment is obviously far more satisfactory and less expensive than it would be in a well of bad alignment. Moreover, the need for necessary repair, deepening, cleaning, or other operations is always present. In a well of reasonably true alignment, none of these operations present any unusual problem. If, however, such operations become necessary in a well not reasonably straight, the handicap very frequently is so serious as to require abandonment of the well and the construction of an entirely new well.

### Needless Complaints

Many unnecessary complaints and reports on polluted new wells are received by the Board of Health each year. Unless the person responsible for the construction of a well exercises proper care and follows proper sterilizing procedure upon completion of construction, there is almost certainly some pollution present in every newly-finished well. Since the Laboratory can be guided only by the results of analysis of the water, it frequently happens that a well is reported *unsafe* when in fact, if such a well had been properly sterilized and flushed, the result of analysis would have indicated a safe condition of the water.

In the case of existing wells, there is no point in taking a sample of water for analysis from a well which is obviously subject to pollution. Such wells may be safe or unsafe with only slight changes in the conditions surrounding the well and an analysis report of either safe or unsafe would express nothing more than the condition of the particular sample analyzed. To rely unconditionally upon a single report indicated water from the well to be safe, when the conditions surrounding the well are such that it is intermittently unsafe is obviously hazardous. The logical procedure is to make the construction of the well and its suroundings conform to sanitary standards and then check for safety by having a sample of water analyzed.

### Cooperation

To the Board of Health has been assigned the task of eliminating the hazards of polluted ground water supplies. The degree of success and the value of its services to the citizens of the state will depend largely upon the cooperation accorded the Board by all concerned. The Board of Health approaches its task in the hope that all concerned will cooperate in the attainment of a full realization of the end sought.



## HISTORY OF WATER BORNE DISEASES AND LABORATORY INTERPRETATION OF BACTERIOLOGICAL EXAMINATIONS OF WATER

When our forefathers landed on this continent the forest primeval was untouched by the hand of man; the soil, surface waters, streams, lakes, rivers and springs unpolluted by an environment of his creation. It is true that bands of Indians roving over the country created small filth spots but by and large the vast area of this country was virgin forest and soil, lakes and streams, where no problem in sanitation had been created. Under such circumstances water wherever found, if clear and palatable, was safe to drink. Even today in remote uninhabited spots, sufficiently far from civilization to protect from the intrusion of mankind, such virgin spots may occasionally still be encountered. The water is safe not because it is free from bacterial contamination but because of its environmental surroundings it is free from the kind of pollution which mankind creates. The bacteria in surface water in these isolated spots are contributed by all kinds of wild life, and although in the laboratory they test out to be the same kind as those which we use as evidence of dangerous pollution in areas dense with human population they do not have the same significance.

Our ancestors came here because they objected to the restrictions imposed upon their individual liberties by the ever thickening population of Europe. They wanted to hold possessions in fee simple over which the rights of no other man took priority. Accordingly many of them settled down on their own pieces of land almost always separated from their nearest neighbor by wide open spaces and as long as the individual stayed at home he was exposed only to those germs to which he was accustomed and for which he had built up body protection. He drank in the forest and on his farm and from river, creek, spring or shallow well with impunity unless some chance wanderer had happened to come into the vicinity and defiled the surroundings. Such chance pollutions seldom occurred for the country was vast, travel was difficult, and the population sparse. This no doubt accounts for the remark so aften heard by older people of our own generation and sometimes by younger members, particularly if they have lived in isolated rural communities: "My well water I know is pure because we have used it for generations and we have had no sickness." This may be true but it has become less and less true as the population of the country has thickened and isolat'on of individuals and families has become more and more difficult.

Early in the history of this country some of these settlers learned the necessity of creating communities for protection against the dangers of the forest and a pioneer life. Some of them congregated in settlements so that they might offer each other assistance from attacks against enemies. There was thus added a danger which is common to all mankind where he lives close to his neighbor, the exchange of germs. He was compelled by the closeness of contact to live with his neighbor's germs against which he had accumulated no self defense.

As the pioneer took up his homestead he was in need of a convenient water supply. This sometimes he secured by digging shallow wells. These wells, and such may occasionally be found yet, were too often located without reference to surface drainage or outhouses. Such wells and springs continued to yield an abundant supply of clear water but were apt to be contaminated with surface water. These wells did not, however, become polluted with disease producing germs until some carrier of these organisms came along to pollute the drainage area. The most common diseases spread among these settlers by such means was typhoid fever and all forms of diarrhea.

As time passed the population thickened, small communities increased in size to become cities, and farms became smaller as farmers settled closer together. Under these circumstances the communities began to see the need of public water supplies and they began to distribute water taken from rivers and lakes to whole populations. However, the individuals living on farms and in the still small communities continued to use individual supplies drawn from shallow wells and other sources often polluted by surface water. The incidence of typhoid fever and other intestinal diseases rose and now frequent outbreaks began to involve whole communities. During this period of increasing population the grade of drinking water the country over was low. This state of affairs is well illustrated by an outbreak of typhoid fever in Plymouth, Pa., a small city of some 8,000 inhabitants in 1885. In this small community within a period of a few weeks there were 1104 cases of typhoid fever and 114 deaths. The water supply of Plymouth was secured from a mountain brook, across which several small dams were built to secure storage reservoirs. On January 2, 1885, during a time when the stream was frozen, a man sick with typhoid fever came from Philadelphia. He contracted the disease from a place where three other people were sick with typhoid fever. This man was cared for in a house located about fifty feet from the brook just above one of the reservoirs. The discharges from the bowels of the sick man were not disinfected and were thrown into the deep snow on a hillside which sloped toward the stream. A sudden rise in temperature on March 26th caused the snow to melt. The resulting run-off swept the mass of typhoid dejecta into the reservoir. Within the next two to three weeks cases of typhoid fever began to appear in Plymouth. No cases could be found who had not drunk water from the city supply. However, later private wells in the city were polluted from cases and carriers incident to the epidemic and secondary cases began to occur. Similar outbreaks have occurred in Wisconsin.

Outbreaks such as these illustrate the importance of safe water.

## GERM THEORY OF DISEASE

The germ theory of disease was not recognized until the latter part of the last century. In fact it was not until 1880 that conclusive proof that bacteria caused disease was obtained, and following this discovery the proof was not accepted for many years. However, the discovery did lead to the development of an understanding of the methods by which disease germs may be transferred from one person to another, from the sick or carriers to well and susceptible people. This we know now is accomplished by passing infectious secretions both by direct and indirect contact with sick people and carriers to well, susceptible individuals. Water has been and is frequently the medium



through which this transfer occurs. The tabulation below is compiled from a recent publication of Wolman and Gorman, and shows the source of the polluted water from whence more than 92,000 cases of typhoid fever arose.

**Table I**

| Cause of the Contamination | Number of Persons Affected with Typhoid and Dysentery |
|---|---|
| A. SURFACE WATER SUPPLIES. | |
| 1. Contamination of brook or stream by pollution on the watershed | 510 |
| 2. Use of polluted river water—untreated | 525 |
| 3. Use of polluted lake water—untreated | 79 |
| 4. Contamination of spring well or infiltration gallery by pollution or watershed | 459 |
| 5. Contamination of spring well or infiltration gallery by flood waters | 523 |
| B. UNDERGROUND WATER SUPPLIES. | |
| 1. Surface pollution of shallow wells | 2,665 |
| 2. Faulty well casing or construction | 212 |
| 3. Pollution of deep well from adjacent river or lake | 0 |
| 4. Pollution of well from adjacent sewer or sewage tank | 73 |
| 5. Underground pollution of well or spring in creviced limestone | 1,378 |
| 6. Underground pollution of well or spring, source unknown | 133 |
| 7. Underground pollution of well by surface contamination through an abandoned well | 50 |
| 8. Overflow of sewer or flood water into top of well casing | 11,031 |
| C. RESERVOIRS OR CISTERN STORAGE. | |
| 1. Seepage from sewer or surface into cracked cistern or reservoir | 1,337 |
| D. WATER PURIFICATION. | |
| 1. Inadequate control of filtration and allied treatment | 47,707 |
| 2. Inadequate chlorination when only treatment | 2,367 |
| 3. Interruption of chlorination when only treatment | 626 |
| E. DISTRIBUTION SYSTEM. | |
| 1. Pollution of water mains during construction or repairs | 13 |
| 2. Leaking water and sewer in same trench | 47 |
| 3. Cross connection with polluted water supply | 8,530 |
| 4. Break in supply main in river crossing | 21 |
| F. COLLECTION OR CONDUIT SYSTEM. | |
| 1. Auxiliary intakes to polluted source | 2,369 |
| 2. Seepage of surface water or sewage into gravity conduit | 11,354 |
| G. MISCELLANEOUS. | |
| 1. Use of polluted private supply because of objectionable taste or quality of public supply | 90 |
| 2. Use of polluted water not intended for drinking | 70 |
| 3. Data insufficient for classification | 554 |
| Total Cases | 92,725 |

Soon after the establishment of the germ theory of disease and the recognition of the methods by which these germs are spread, sanitary practice became a scientific practice for either the exclusion of all surface water from drinking water supplies or the elimination of infectious matter from surface water by proper filtration and chlorination. Filtration had long been practiced but not for the purpose of removing bacteria but for the removal of mud. London in 1839 filtered river water to remove mud. In this country St. Louis in 1866 investigated a method of filtration to remove the mud from the Mississippi river water. Poughkeepsie constructed a filter in 1872 for this purpose. Beginning in 1890, filtration for the purpose of removing bacteria progressed very slowly; communities grew rapidly into cities and as the communities grew in size the typhoid death rate increased and occasional large epidemics occurred. Table II shows the death rate in Wisconsin from certain water borne diseases since 1908. It will be noticed that the death rate ranged between .3 and 14.2 per 100,000 population for typhoid. In 1910, 558 people in Wisconsin died of this disease which indicates that there were in the neighborhood of 5,000 cases in the State of Wisconsin during that year.

**Table II**

**DEATH RATE FROM DIARRHEAL DISEASES IN WISCONSIN PER 100,000 POPULATION**

| Yr. | Estimated Population | Deaths from Typhoid, Dysentery & Diarrhea & Enteritis | Death rate per 100,000 | Typhoid & Para-typhoid | Dysentery | Diarrhea under 2 years | Diarrhea over 2 years |
|---|---|---|---|---|---|---|---|
| 1908 | 2,295,300 | 2,295 | 99.9 | 322 | 128 | 1,509 | 336 |
| 1909 | 2,316,800 | 1,957 | 84.5 | 352 | 89 | 1,233 | 283 |
| 1910 | 2,333,800 | 2,559 | 109.6 | 558 | 144 | 1,503 | 354 |
| 1911 | 2,358,300 | 1,777 | 75.3 | 319 | 70 | 1,233 | 155 |
| 1912 | 2,382,700 | 1,695 | 71.1 | 310 | 40 | 1,145 | 200 |
| 1913 | 2,407,200 | 1,725 | 71.7 | 237 | 29 | 1,229 | 230 |
| 1914 | 2,431,700 | 1,309 | 53.8 | 176 | 42 | 889 | 202 |
| 1915 | 2,456,100 | 946 | 33.5 | 123 | 26 | 646 | 151 |
| 1916 | 2,480,800 | 1,337 | 53.9 | 202 | 34 | 855 | 246 |
| 1917 | 2,505,500 | 1,037 | 41.4 | 137 | 38 | 684 | 191 |
| 1918 | 2,529,500 | 1,080 | 42.7 | 102 | 42 | 716 | 220 |
| 1919 | 2,554,600 | 1,039 | 52.6 | 82 | 41 | 675 | 291 |
| 1920 | 2,631,000 | 1,007 | 38.2 | 70 | 46 | 647 | 244 |
| 1921 | 2,651,600 | 1,217 | 45.7 | 78 | 62 | 763 | 314 |
| 1922 | 2,693,200 | 765 | 28.4 | 81 | 28 | 503 | 153 |
| 1923 | 2,723,900 | 767 | 28.1 | 60 | 23 | 515 | 169 |
| 1924 | 2,754,500 | 537 | 20.6 | 29 | 13 | 410 | 115 |
| 1925 | 2,735,100 | 947 | 34.0 | 56 | 48 | 572 | 271 |
| 1926 | 2,815,600 | 692 | 24.6 | 41 | 21 | 435 | 195 |
| 1927 | 2,846,200 | 668 | 23.6 | 39 | 18 | 419 | 192 |
| 1928 | 2,876,800 | 523 | 18.2 | 24 | 20 | 351 | 128 |
| 1929 | 2,907,300 | 514 | 17.7 | 40 | 19 | 341 | 114 |
| 1930 | 2,939,000 | 517 | 17.6 | 27 | 23 | 317 | 150 |
| 1931 | 2,969,400 | 443 | 14.9 | 20 | 12 | 315 | 96 |
| 1932 | 2,999,900 | 338 | 11.3 | 21 | 13 | 205 | 99 |
| 1933 | 3,030,500 | 297 | 9.8 | 17 | 10 | 195 | 75 |
| 1934 | 3,005,600 | 370 | 12.3 | 19 | 25 | 206 | 120 |
| 1935 | 3,032,000 | 224 | 7.3 | 9 | 15 | 139 | 61 |
| Total deaths for 28 years | | 28,662 | | 3,551 | 1,119 | 18,650 | 5,355 |

| | 1908 | 1935 |
|---|---|---|
| Typhoid and Paratyphoid death rate per 100,000 | 14.2 | .3 |
| Dysentery death rate per 100,000 | 5.4 | .5 |
| Diarrhea under two years death rate per 100,000 | 63.9 | 4.6 |
| Diarrhea over two years death rate per 100,000 | 14.1 | 2.0 |

Note the gradual decline during the past 25 years.



**POLLUTION OF DRINKING WATER**

By 1910 bacteria as the cause of disease was firmly established and the general population had accepted the idea that polluted water spreads typhoid fever and other enteric diseases; health officers and physicians had learned that about three out of every one hundred cases of typhoid fever leave the victim a life-long carrier of the typhoid germ. This high carrier incidence in the population they knew was responsible for dangerous pollution of water supplies and the cause of a high endemic rate. A serious effort was made to induce every city and village which operated a municipal water supply to secure water from deep wells properly protected from surface water or to filter and chlorinate the water if it was drawn from a river, lake or other surface reservoir. That this campaign for pure drinking water was successful in spite of the rapidly increasing population, is well demonstrated in the falling death rate due to typhoid as shown in Table II and in the following Table III showing death rates in the United States at large.

**Table III**

**DEATH RATE FROM TYPHOID AND PARATYPHOID FEVER IN UNITED STATES**

(Rate per 100,000 population)

| 1912 | 1920 | 1925 | 1930 | 1931 | 1932 | 1933 |
|---|---|---|---|---|---|---|
| 16.5 | 7.8 | 8.0 | 4.8 | 4.5 | 3.7 | 3.6 |

**FALL IN DEATH RATE**

The fall in death rate has not been uniform the country over. The decline has been more rapid in the cities than in the rural districts. The table (IV) below shows that the combined rural and urban death rate from typhoid fever since 1910 has been from two to almost three times as high as in the urban areas alone. This means that in the cities where the population has been supplied with water by the municipality the deaths from typhoid fever has rapidly reduced while in the rural areas it has declined more slowly. It seems logical to assume that this rapid reduction in the incidence of typhoid in the cities can be accounted for largely by the purification of the drinking water supply and that a similar reduction has not taken place in the rural areas because they have not abandoned the old dug wells, springs, improperly connected drilled wells, and other sources of surface water for drinking purposes. The farmer was in the past not endangered so critically as the city dweller, but with the increase in the population and with the advent of easy methods of travel his hazard has greatly increased. Every advance that promoted more frequent social relation between himself, his neighbors and the city dwellers increased his chance of contracting some water-borne disease planted in his or his neighbor's well. It is natural too that the table should show some fall in the incidence of typhoid fever in rural districts as it went down in the urban districts and it is likewise understandable that it failed to fall so fast in rural districts because of the continued use of surface water secured from shallow and improperly constructed wells.

Table IV

TYPHOID DEATH RATES IN UNITED STATES

Rate per 100,000 population

| | Rural and Urban | Cities over 100,000 |
|---|---|---|
| 1900 | 35.9 | ---- |
| 1910 | 23.5 | 20.54 |
| 1920 | 7.8 | 3.85 |
| 1922 | 7.4 | 3.26 |
| 1924 | 6.7 | 3.07 |
| 1926 | 6.5 | 2.84 |
| 1928 | 4.9 | 1.89 |
| 1930 | 4.8 | 1.61 |
| 1931 | 4.5 | 1.60 |
| 1932 | 3.7 | 1.24 |
| 1933 | 3.5 | 1.18 |
| 1934 | 3.3 | 1.17 |

## RURAL SANITATION

While the incidence of water-borne enteric disease has declined to a low figure in Wisconsin, it is still higher than it should be. Only one hundred and sixteen cases of typhoid fever with only nine deaths in 1935 in a population of over three million people is a great accomplishment for sanitation in general and water sanitation in particular but it is not good enough. This disease can be completely eradicated and the point of attack now is the rural districts. The greater part of the typhoid fever in Wisconsin last year was contracted in rural areas. In other words, it occurred among that portion of the population, the farmers and village dwellers, which still feels isolated and which is oftentimes still getting its drinking water from shallow wells or similar sources of surface water. To be sure, not all of this typhoid has come from polluted water but some of it has and some of those who have had the disease and remained carriers are sure to pollute some surface supply of drinking water if they happen in an area where sanitation is poor. The rural population has been slow to realize the importance of good sanitary surroundings to health. This backwardness is easily understandable when it is realized that the farmer as the outstanding representative of individualism remaining in this country has not always felt able to finance the improvement necessary to secure this protection. He should know that one case of typhoid fever in his family and more often if there is one there will be several, will cost him much more than a new pure supply of water well protected from surface pollution. He must also know that he no longer is the isolated individual whose premises are infrequently visited by "outsiders", possible disease germ carriers. Because he is no longer isolated, his health hazard has increased. The new state law, registering well drillers and requiring them to construct wells in such approved manner as to protect the supply of water in the well from surface water, is a forward move in rural sanitation and will be another means of still further reducing the incidence of typhoid fever and other enteric infections.

## LABORATORIES BACTERIOLOGICAL EXAMINATION OF WATER

Much of the improvement in the purity of drinking water has been brought about through the aid that comes from laboratories. It is only by bacteriological examination that the presence of pollution can be detected and it is only



by frequent and regular bacteriological examination that the efficacy of mechanical purification of surface water can be watched. In the case of deep wells, which are shown to be free from surface pollution by bacteriological examination and where the well is made tight against such pollution, frequent examination is not necessary.

It must not be inferred that the bacteriological examination of one sample from a new well, particularly if the result gives evidence of surface pollution, indicates that the water is actually polluted and unsafe to drink. Such a result always requires confirmation by the examination of a second and possibly a third properly collected sample after re-chlorination before definite evidence of actual pollution can be said to have been obtained.

This examination is extremely sensitive. The improper removal of a cap from the specimen bottle will sometimes cause the sample to show evidence of pollution. If the finger should come in contact with the mouth of the bottle or the inside of the cap, the test may show the presence of colon bacilli. In the case of new wells, contamination of the pipes by grease, by the hands of workmen and by dust particles which accumulate on the pipes may cause a test to show "bad" when the water in the well is pure, and when the well is properly constructed to protect the water from surface wash and drainage. Because of these sources of errors caution must be exercised. No well should be condemned on the result of a bacteriological examination of a single sample of water unless the inspection of the construction shows clearly that it is defective and would be likely to permit of pollution with surface water.

The bacteriological examination is planned to produce favorable conditions for the growth of colon bacilli. This organism is widespread in nature and the most common organism in the feces of man and all warm blooded animals. It can be found almost everywhere. Its mere presence then is not significant. Its importance in water analysis comes chiefly from the fact that there are only a few places in the universe where this organism should not be found. One of these places is in safe drinking water. When found in water it indicates that surface pollution has taken place. Wells can and should be so constructed and tightly sealed that no surface material can reach the water in the well. The presence of B. Coli in water which is presumed to be tightly sealed off from outside or surface environment indicates that either the seal is not tight or the water is polluted at its source. In surface water colon bacilli are part of the normal or natural bacterial flora. Their presence is neither surprising nor significant. After such a water has been treated by filtration and chlorination bacteria are dead and tests for colon bacilli should be negative. The colon bacillus is important, therefore, only when found where it should not be, and as evidence of surface pollution it is a particularly good indicator.

This explanation of the purpose of the bacteriological examination of water and its significance should emphasize the importance of the proper collection of samples and the necessity of collecting them only in containers provided from one of the laboratories. It is obvious from the preceding discussion of the colon bacillus in water that the accidental contamination of a sample can easily occur and that pure water may thus be considered to be polluted. Because of the universal presence of colon bacilli, because of the numerous opportunities for accidental contamination of samples and because of the economic importance of the test to farmers and others, it is necessary to throw around it as many precautions for the prevention of error as possible. For this purpose the State Board of Health has established the following regulations:

1. Results obtained from other than State Board of Health laboratories or laboratories approved by the Board are not recognized.

2. Samples collected in containers other than those supplied by the laboratory are not examined.

3. The bottle used for the collection of the sample must have a wide mouth and covered by a cap or stopper which protects the edge around the mouth.

4. Samples received later than 48 hours after collection are not examined.

5. New wells must be chlorinated, according to the method provided by the Board of Health, before a sample is collected for examination.

6. After the chlorine has been applied the well must be pumped long enough to get rid of all of the chlorine before the sample is collected. Samples which have a strong odor of chlorine or give a test for free chlorine when received will not be examined.

7. Small numbers of B. Coli are allowed in water considered safe to drink. In order to determine this number, five ten cubic centimeter portions are taken from each sample and placed into five different culture tubes and incubated for the demonstration of B. Coli. If more than one of these tubes shows B. Coli, the water is considered too badly polluted to be safe for drinking purposes.

The form of the laboratory report is given below.

REPORT OF WATER ANALYSIS

Source ____________________
Sent by ____________________
Address ____________________
Collected ________ Received ________ Lab. No. ________
Count at 37° ________________ Interpretation
B. Coli in 5 10 cc. portions + + + + +
Nitrogen as { Nitrites ____________ / Nitrates ____________ / Cl. as Chlorides ____________

WISCONSIN STATE LABORATORY OF HYGIENE

Laboratory of the State Board of Health

Plus signs are used to indicate the number of tubes which show evidence of pollution. If only one out of the five tubes shows it, only one plus mark will appear on the report and the interpretation put on the report is "Safe". If two or more tubes show evidence of B. Coli, two or more plus marks, as the case may be, will appear on the report and the interpretation reads "Unsafe".

The State Board of Health has laboratories located in Superior, Wausau, Rhinelander, Green Bay, Oshkosh, Sheboygan, Kenosha, Beloit and Madison. Laboratories are accessible from all parts of the state. The laboratory which is nearest to the location of the well and the one most conveniently reached should be used in every case. All laboratories, except the one in Madison and Rhinelander can be reached by addressing them as State Cooperative Laboratory, and giving the appropriate city. The one in Madison should be addressed as the state Laboratory of Hygiene and the one in Rhinelander as State Branch Laboratory.



Mailing cartons when received will contain in addition to the sterile bottle for the sample a return address label and a data blank, which is to be filled as accurately as possible with full explanation concerning the collection of the sample. Reports will be returned as promptly as possible. It must be remembered, however, that it may take as long as ninety-six hours to complete the examination after the sample reaches the laboratory and that at least twenty-four hours and sometimes forty-eight are consumed in transporting the sample and to get the report through the mails. At times, therefore, a report will not be received for as long as a week. More frequently, however, reports will be received in four or five days.

With the proper sanitary control of rural water supplies through the proper construction of wells and the control of this construction by bacteriological examination of the water in these wells, sanitation in this area should be greatly improved and the incidence of illness from gastro-intestinal diseases lowered.

We have drawn attention to the mortality statistics upon typhoid fever. Typhoid fever is however only one of a number of diseases which may be transferred through the medium of unsafe water. The decline in the prevalence of typhoid would indicate that a similar decline is occurring in other intestinal troubles, such as enteritis, and reference to the mortality statistics in the State Board of Health Biennial Reports and Tables I to IV fully substantiates it.

## DIRECTIONS FOR STERILIZING A WELL

1. Prepare a chlorine solution as follows: Take one tablespoonful of chlorinated lime from a tightly sealed container, (powder, about one inch deep in center, approximately 1 oz.). Rub up the powder with a small amount of water to make a thin paste, taking care to break up all lumps. Then stir this paste into one quart of water. Allow the mixture to stand a short period of time. Then pour off the clear liquid. The chlorine strength of the solution is about 1%. One quart of the liquid is sufficient to sterilize 1000 gallons of water. Larger quantities may be prepared in the same proportion. By placing the liquid in sealed containers, (preferably glass), it may be stored a reasonable period of time without losing its effectiveness.

2. Estimate the volume of water standing in the well. This can be determined from the following table:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dia. of well in inches | 4 | 6 | 8 | 10 | 12 | 15 | 18 | 24 |
| Gals. per foot depth | 0.6 | 1.5 | 2.6 | 4.1 | 5.9 | 9.2 | 13 2 | 23.5 |

3. For each 1000 gallons of water in the well, pour in one quart of the liquid as above prepared. No harm is done by using an overdose and it is advisable to overdose rather than risk an insufficient dose. Agitate thoroughly and allow the well to stand several hours, preferably overnight. Then flush the well thoroughly so as to remove all of the sterilizing agent. The upper part of the well can be sterilized by returning the water to the well during the first period of the flushing operation, thereby washing the wall of the well with chlorinated water. Immediately before completion of the flushing operation, the sample required for analysis should be taken. The procedure for collecting the sample is carefully outlined on the form accompanying the sample bottle supplied by the State Laboratory of Hygiene.

## WATER SUPPLY SURVEY GUIDE

To facilitate prompt and thorough consideration of well or water supply problems, correspondents are requested to supply complete and accurate information as to their problems. Please use the following as a guide.

Date ____________________________193__

*Owner of Premises*

Name ______________________P. O. Address____________________
Street and No. _____________________City ____________________
Telephone ______________________

*Tenant*

Name ______________________P. O. Address____________________
Street and No. _____________________City ____________________
Telephone ______________________

*Location of Premises Under Discussion*

County ____________Township ____________Section ____________
Quarter Section ____________City or Village__________________
State best route (by auto) to reach the premises from place named. Give directions and miles:
____________________________________________________________
____________________________________________________________
____________________________________________________________
State briefly the nature of your problem: ____________________
____________________________________________________________
____________________________________________________________
____________________________________________________________
(use separate sheet if necessary)
Source of your water supply? _________________________________
(well, spring, etc.)

If a well, state: Total depth________________feet
Dug ________feet Kind of curbing____Dia.____in. Depth____ft.
Bored ______feet Kind of curbing____Dia.____in. Depth____ft.
Drilled _____feet Kind of casing ____Dia.____in. Depth____ft.
Driven _____feet Kind of pipe ______Dia.____in. Depth____ft.

If a combination of two or more of the above explain: ___________
____________________________________________________________
____________________________________________________________
____________________________________________________________



State as accurately as you can the nature and thickness of earth and rock formations penetrated: ___________________________________
____________________________________________________________
____________________________________________________________
Who constructed the well? When? ____________________________
____________________________________________________________
Depth of water from surface? ________________feet.
Can the well be pumped dry? ____________
Is the water clear? ______Cloudy? ______Turbid? ______. Do wet or dry weather conditions affect the well? Explain_____________
____________________________________________________________
____________________________________________________________
Is the top of the well protected against entrance of surface or flood water, drippings, and the like? Explain ______________________
____________________________________________________________
____________________________________________________________
____________________________________________________________

Draw a sketch of the premises on which the well is located, showing the location of the well with reference to buildings and possible sources of pollution. Indicate the condition of the surroundings by printing descriptive words like high, low, level, slope, lake, river, swamp, forest, meadow, barnyard, cesspool, privy, sewer, etc., at their respective locations and show distance from the well on sketch. (Use separate sheet).

Give any other information you consider necessary to convey a clear picture of your problem. If the source of water supply is other than a well, explain along the same general lines to provide essential information.

____________________________________
Signature of correspondent

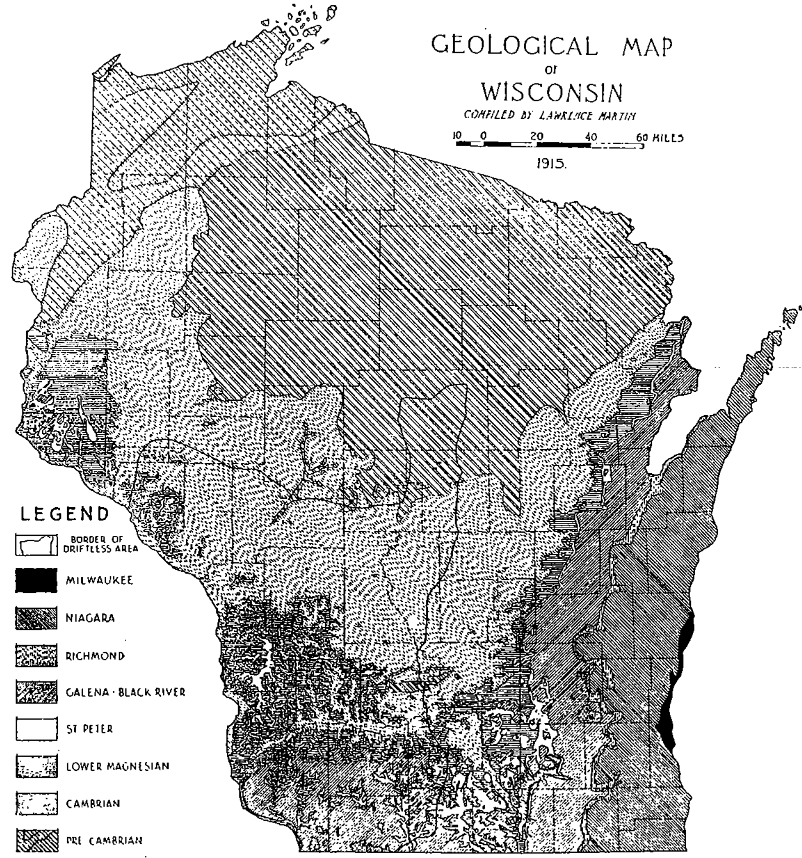
____________________________________
Address

## GEOLOGICAL COLUMN OF WISCONSIN

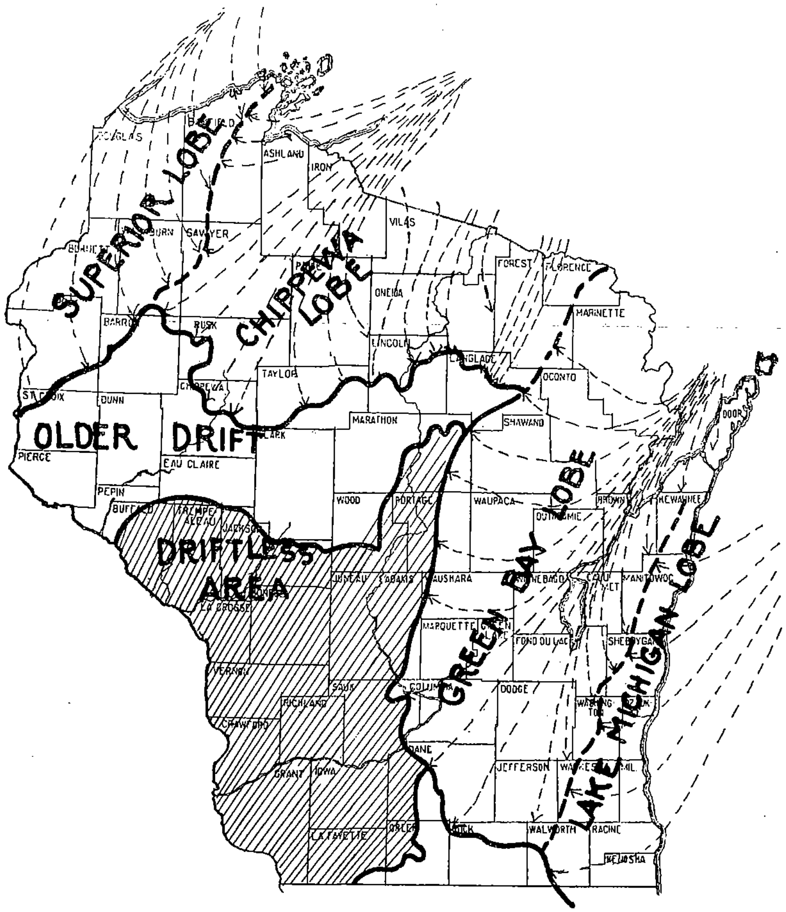
(Courtesy Wisconsin Geological Survey)

| Formation | Description | Water Supply |
|---|---|---|
| Glacial drift | Sand, gravel, clay, till (hard pan) etc. 0–600 ft. | Large yield, nearly all safe from sand and gravel where below water level; water soft in much of northern Wisconsin. |
| Mississippian | Shale 55 ft. | None |
| Devonian<br>Niagara | Dolomite and shale 75–175 ft.<br>Dolomite, almost all light gray 0–800 ft. | Small yield generally poor water. Water in openings; yield varies from large to very small; locally subject to contamination. |
| Richmond (Cincinnati of older reports) | Shale with thin layers of dolomite 180–520 ft. | Very little water; generally of poor quality. |
| Galena, and Platteville (Black River) | Dolomite and limestone 150–370 ft. | Large supplies on outcrop; locally subject to contamination; little water at depth. |
| St. Peter | Sandstone, shale at bottom 0–330 ft. | Large supplies of good quality; locally little water in parts of eastern Wisconsin. |
| Lower Magnesian (Shakopee-Oneota) | Dolomite with some thin layers of sandstone 0–280 ft. | Much water on outcrop; little at depth; locally subject to contamination. |
| Madison and Jordan | Sandstone 0–150 ft. | Good yield of safe water in western and northeastern parts of state; no water to east. |
| Trempealeau | Dolomitic siltstone (Lodi) and dolomite (St. Lawrence) 30–50 ft. | Little water; locally forms a perched water table. |
| Mazomanie-Franconia | Sandstone; shale at base in western part of state 40–190 ft. | Fair yields of safe water; shale forms perched water table with many springs. |
| Dresbach | Sandstone, white 40–80 ft. | Large yield of safe water. |
| Eau Claire | Sandstone and shale 200–300 ft. | Small to moderate yield of water; locally much iron. |
| Mt. Simon | Sandstone, in part very coarse grained, some shale layers 200—1000 ft. | Large supplies of safe wate; locally much iron. |
| Pre-Cambrian | Granite, gneiss, quartzite, etc. "Hard rocks". Locally these rocks rise as high as bottom of Black River cutting out normal succession thickness very great. | Water only in openings which vary greatly in size and yield, little chance of water more than 200 ft. from surface; locally subject to contamination. |



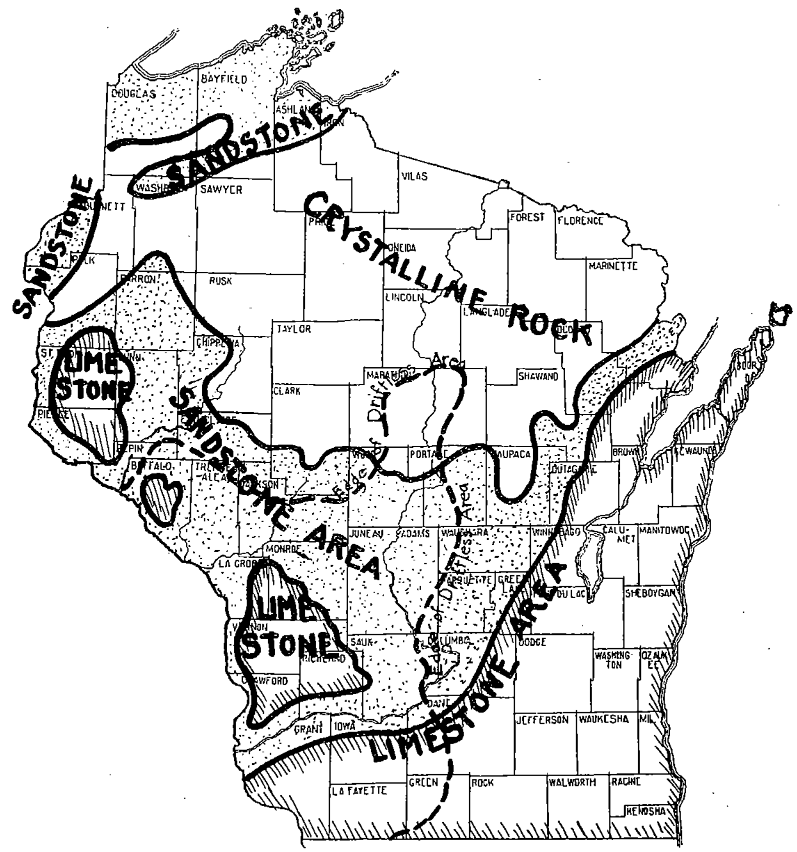



The above map shows the geological formations of Wisconsin, the character of which materially influences the mineral quality of the water supplies. The outcroppings of the various layers of rock or strata are shown, the legend giving in the general order of occurrence those strata that will be found underlying the surface rock formation indicated. Reference is made to publications of the State Geological and Natural History Survey, particularly Bulletin No. 35, for a discussion and data on waters available from these formations.

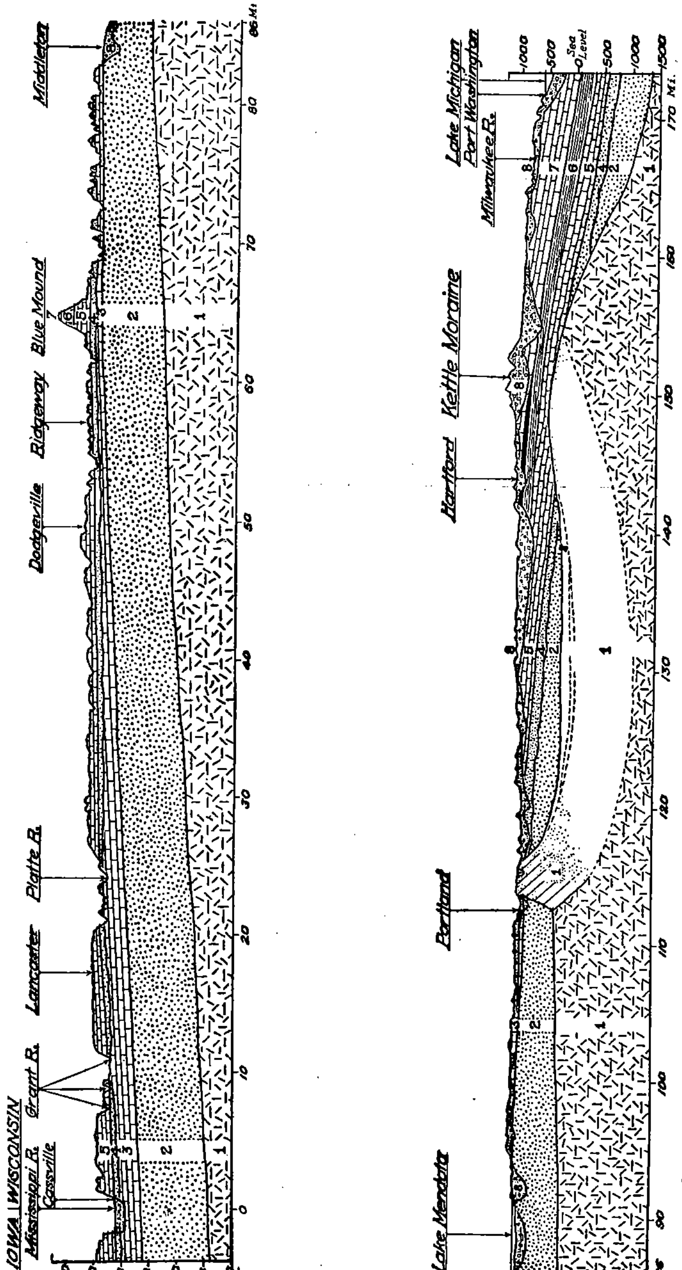



MAP SHOWING GLACIAL DRIFTS IN WISCONSIN



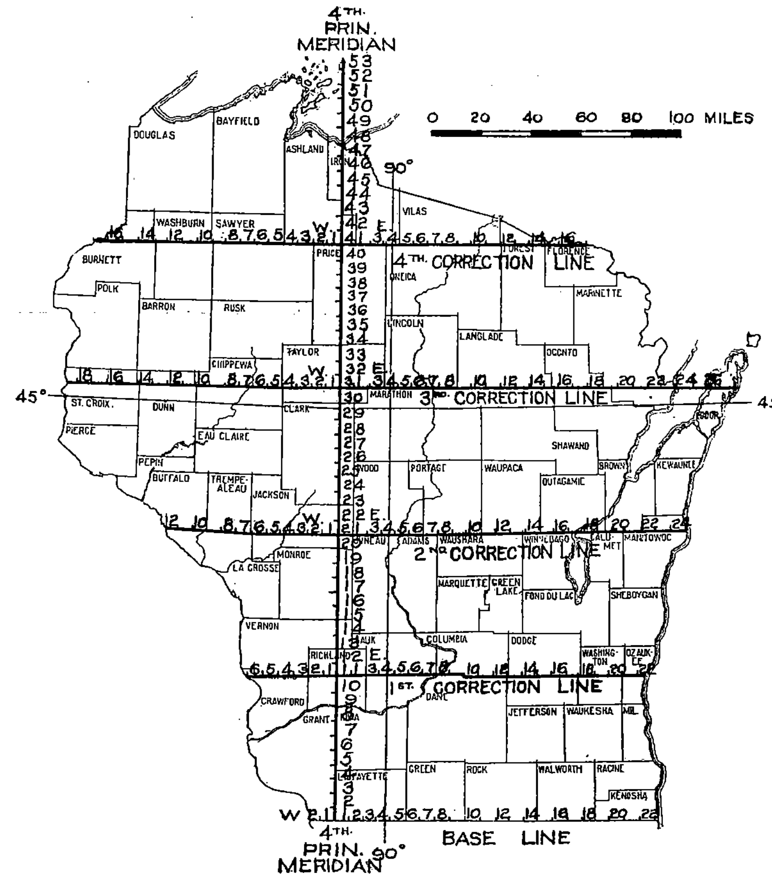



MAP SHOWING CHARACTER OF UNDERLYING ROCK IN WISCONSIN




Cross section showing beds of rock, from Grant County on the Mississippi, to Ozaukee County on Lake Michigan.
Cross section showing beds of rock, from Grant County on the Mississippi, to Ozaukee County on Lake Michigan.
1. Granite, quartzite, and other pre-Cambrian rocks. 2. Cambrian sandstone and shale. 3. Lower Magnesian limestone. 4. St. Peter sandstone. 5. Galena-Black River dolomite. 6. Richmond shale. 7. Niagara dolomite. 8. Glacial drift. (Courtesy Wis. Geological Survey.)





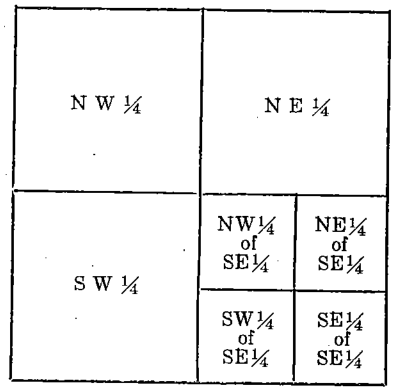

State Subdivision Base-line Map. See following page.

## State Subdivision Base Line Map

Town lines occur at intervals of 6 miles north from the base line at the 4th Principal Meridian. The first 6 miles are designated as Town 1 North (T.1.N.). The second 6 miles, T. 2 N. and continuing in this manner to T. 53 N. which is the farthest north in the state. The 4th Principal Meridian is the North/South Base Range Line. A range line occurs at intervals of approximately 6 miles from this line. The first line east is Range 1 East (R. 1 E.). The second is R. 2 E. and continuing consecutively to Range 30 East which is the farthest east in the state. Range lines west occur in like manner west from the base line from Range 1 West (R. 1 W.) to and including R. 19 W. which is the farthest west in the state.

A Township is normally six miles square and comprises 36 Sections. These are numbered as indicated. Each section is subdivided into Quarter Sections and each Quarter Section is again subdivided into quarters of the Quarter Section as shown.

| | | | | | |
|---|---|---|---|---|---|
| 6 | 5 | 4 | 3 | 2 | 1 |
| 7 | 8 | 9 | 10 | 11 | 12 |
| 18 | 17 | 16 | 15 | 14 | 13 |
| 19 | 20 | 21 | 22 | 23 | 24 |
| 30 | 29 | 28 | 27 | 26 | 25 |
| 31 | 32 | 33 | 34 | 35 | 36 |




Further details may be obtained from published county and township maps.



## USEFUL RULES AND INFORMATION

### Pump Calculations:

The driller and pump installer are frequently called upon to estimate the size of pump and motor required to provide a certain volume of water for domestic use. The following rules apply to plunger type deep well pumps, driven by single phase, repulsion start, induction run, A. C. motors. 25% of the theoretical horse power required is allowed to take care of ordinary power losses.

Example: Find the size motor required to pump 18 gal. per min. from a depth of 100 ft., against a pressure of 45 pounds per sq. in. The diameters of upper and lower cylinders are approximately equal. The sizes of the drop and discharge pipes are sufficient to make friction losses negligible.

### Rule A

When upper and lower cylinders are of equal diameter and the elevation above and below the surface is approximately equal.

Symbols: H.P. = Horsepower
G = Gallons per minute
E = Total elevation in feet

$$H.P. = \frac{G \times E}{3000}$$

Applying Rule A to the problem above:

Total elevation = (45× 2.309) + 100 = 204 ft.
Gal. per min. = 15
Then: H. P. = (15 × 204) ÷ 3000 = 1.02
A 1 H.P. motor is required.

### Rule B

When the active volume of the upper cylinder is approximately one-half that of the lower cylinder.

$$H.P. = \frac{G \times E}{2250}$$

Using the same example as before except that the active volume of the upper cylinder is one-half that of the lower cylinder.

Then: H. P. = (15 × 204) ÷ 2250 = 1.36
A 1½ H. P. motor is required.

### Rule C

When there is no upper cylinder (single action type of pump):

$$H.P. = \frac{G \times E}{1500}$$

Using the same example as before except that there is no upper cylinder,
Then: H. P. = (15 × 204) ÷ 1500 = 2.04
A 2 H. P. motor is required.

### Rule D

When the pump raises and delivers water on both the up and down strokes, (double acting).

$$H.P. = \frac{G \times E}{1500}$$

Example: Find the size of motor required for a pump equipped with a double acting cylinder delivering 30 gal. per min. to a total elevation of 250 ft. including friction losses in piping.

Then: H. P. = $(30 \times 250) \div 1500 = 5$ H. P.
A 5 H. P. motor is required.

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For gas engine drive add 50% to the H. P. calculated by above rules.

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Rules for shallow well type pumps are not necessary for the installers as the manufacturers provide power sufficient to meet the maximum conditions for which the equipment is designed.

### Estimating Pump Capacity

Many "Water Requirement Tables" have been published showing the amount of water required for certain purposes per 24 hour period. While such tables are probably very accurate, they do not take into consideration maximum sustained demands. For instance, the user may wish to draw 25 gallons of water for bathing purposes in five minutes time. The requirement would therefore be 5 gallons per minute. Expressed in terms of gallons per 24 hours the bathing water requirement would be 1+ gallons per hour. While the latter figure is as accurate as the former there is considerable difference in the information conveyed. The modern tendency in connection with private water supply systems is to store a very limited quantity of water so that the available water may be fresh. It follows that in the absence of storage, the pump capacity must be sufficient to take care of the maximum sustained demand likely to be made upon it. For purposes of illustration, let us assume the following conditions during a peak hour of the day:

Maximum water demand:

| | |
|---|---|
| Sprinkling—1 hose—per hour | 300 gal. |
| Toilet and Bath—per hour | 35 gal. |
| Kitchen—per hour | 5 gal. |
| Laundry—per hour | 10 gal. |
| Total | 350 gal. |

The requirement would be $350 \div 60 = 5.8+$ gals. per minute. The combined pump and pressure tank capacity must therefore be approximately 6 gallons per minute in order to meet the maximum sustained demand. Having provided for the maximum demand all other demands are automatically taken care of. Most water requirement problems can be handled in a similar manner and by approaching the problem from the maximum sustained demand angle the chance of error in estimating is practically eliminated.

### Water Requirements in Rural Homes

| Purposes and Conditions | Consumption per person for 24 hours in gallons |
|---|---|
| Domestic purposes, 1 pump at kitchen sink | 8 |
| Domestic purposes, 1 faucet at kitchen sink | 15 |
| Domestic purposes, running hot and cold water in kitchen, bathroom and laundry | 25 |
| Sprinkling and cooling purposes, outdoor washing, waste, leakage, etc. | 15 |
| Average daily consumption, modern house | 40 |
| Maximum daily consumption, modern home | 100 |
| Average daytime consumption (7 a.m. to 7 p.m.) | 38 |



### Water Consumption by Farm Animals

As to the requirements of stock, animals prefer a living spring or a stream of pure, cold water, and will go a long distance to obtain it. If supplied from artificial sources, fair allowances are 12 gallons per day for each horse, mule or cow, and 2 gallons per day for each sheep or hog. Heavily worked horses and mules and milch cows may consume 20 to 25 gallons per day in hot weather and with all farm animals conditions of weather, food and living may double or halve the ordinary requirements.

### Useful Rules

To convert *inches vacuum* into feet suction, multiply by 1.13.

To reduce pounds pressure to feet head, multiply by 2.3.

To reduce heads in feet to pressure in pounds, multiply by .434.

Friction of liquids in pipes increases as the square of the velocity.

Velocity: Velocity in feet per minute necessary to discharge a given volume of water in a given time is found by multiplying the number of cubic feet of water by 1.44 and dividing the product by the area of the pipe in square inches.

Doubling the diameter of a pipe increases its capacity four times.

To find the area of a pipe, square the diameter and multiply by .7854.

A cubic foot of water weighs 62½ pounds and contains 1728 cubic inches or 7½ U. S. gallons.

Approximately, every foot elevation of a column of water produces a pressure of ½ pound per square inch.

A "miner's inch" of water is approximately equal to a supply of 12 gallons per minute. In California, 9 gallons.

The gallons per minute which a pipe will deliver equals .0408 times the square of the diameter, multiplied by the velocity in feet per minute.

To find the capacity of a pipe or cylinder in gallons, multiply the square of the diameter in inches by the length in inches and by .0034.

The weight of water in any length pipe is obtained by multiplying the length in feet by the square of the diameter in inches, and by .34.

To find the discharge from any pipe in cubic feet per minute, square the diameter and multiply by the velocity in feet per minute and by .00545.

U. S. gallon of water weighs 8⅓ pounds and contains 231 cubic inches.

Imperial gallon weighs 10 pounds and contains 277 cubic inches.

To find the diameter of pipe in inches, divide the gallons per minute by the velocity in feet per minute, and multiply the square root of the quotient by 4.95.

To find the capacity of a given tank or cistern in U. S. gallons, square the diameter (in feet), and multiply by .7854, multiply by the height in feet, and by 7.48.

To find the discharge in U. S. gallons per minute from any pipe, square the diameter in inches, multiply by the velocity in feet per second and by 2.448.

The discharge from a pipe in cubic feet per second is equal to the mean velocity in feet per second multiplied by the area of cross section of pipe in square feet.

## Useful Information

On a long run of discharge piping an air chamber of ample proportion is essential to proper operation of pumping equipment. Experiments have brought out the fact that an air chamber of less than four feet length does not completely fulfill its mission.

A suction chamber should always be provided at the highest point in a suction line.

The Drop Pipe of a deep well pump should never be less than one-half the diameter of the cylinder or working barrel.

The resistance which water offers to changing its speed is called inertia and it increases very rapidly as the size of the pipe is reduced. The inertia of the water in a 1-inch pipe requires sixteen times as much force applied to the plunger rod to overcome it as when a 2-inch pipe is used to deliver the same quantity of water under the same conditions and in the same period of time.

Sharp angles or sudden bends in pipe cause increase in friction, consequently increase of power is necessary. Where change of direction is desired the same should be made by means of long easy curves or by using 45 degree ells.

Hollow, semi-floating galvanized steel rods have the advantage of buoyancy and strength. Solid steel rods for use in connection with deep well pumps are no longer considered good practice.

The size of a pressure tank should not be more than is necessary to provide a sufficient reserve to carry the system through sudden brief demands which are in excess of the capacity of the pumping unit.

To obtain maximum service from a given size pressure tank, it is absolutely necessary that the Air to Water Volume ratio is kept as nearly constant as is possible. Approximately one-third of the volume of a pressure tank should be occupied by air and two-thirds by water when the pressure in the tank is at maximum. When this condition prevails approximately one-half of the water in the tank is drawn before the pump begins to operate.

Capacity of a water system or pumping unit is a factor of limited value as a basis of comparison unless accompanied by qualifying factors such as: Size of Drop Pipe, Working Barrel, Power Head, Motor, etc. Speed at which the unit is operated. Length of stroke. Volume of water available for sudden brief demands in excess of the capacity of the pumping unit and finally, sustained capacity.

It is possible to force undersized pumping equipment to deliver capacities far beyond reasonable ratings by subjecting it to excessive speed. Such procedure is decidedly detrimental to the equipment and imposes an excessive maintenance burden upon the user.



## USEFUL TABLES

### Commercial Weight

| | | | |
|---|---|---|---|
| 16 | drams | = | 1 ounce |
| 16 | ounces | = | 1 pound |
| 2000 | pounds | = | 1 ton |

### Square Measure

| | | | |
|---|---|---|---|
| 144 | square inches | = | 1 square foot |
| 9 | square feet | = | 1 square yard |
| 30¼ | square yards | = | 1 square rod |
| 272¼ | square feet | = | 1 square rod |
| 160 | square rods | = | 1 acre |
| 640 | acres | = | 1 square mile |

### Cubic Measure

| | | | |
|---|---|---|---|
| 1728 | cubic inches | = | 1 cubic foot |
| 27 | cubic feet | = | 1 cubic yard |
| 231 | cubic inches | = | 1 gallon |
| 2150.4 | cubic inches | = | 1 bushel |

### Long Measure

| | | | |
|---|---|---|---|
| 12 | inches | = | 1 foot |
| 3 | feet | = | 1 yard |
| 16½ | feet | = | 1 rod |
| 320 | rods | = | 1 mile |

### Liquid Measure

| | | | |
|---|---|---|---|
| 4 | gills | = | 1 pint |
| 2 | pints | = | 1 quart |
| 4 | quarts | = | 1 gallon |
| 231 | cu. in. | = | 1 gallon |
| 31½ | gallons | = | 1 U. S. barrel (oil barrel approximately 51 gal.) |

### Land Measurements

7.92 inches make one link
25 links make a rod
16½ feet make 1 rod
4 rods make one chain
10 chains make 1 furlong
8 furlongs make 1 mile
320 rods make 1 mile
5,280 feet make 1 mile
10 square chains make 1 acre
160 square rods make 1 acre
43,560 square feet make 1 acre
208.7 feet on each side make a square acre, approx.
640 acres make 1 square mile or section
1 rod is 16½ feet or 5½ yards or 25 links
1 chain is 66 feet or 4 rods or 100 links
1 furlong is 660 feet or 40 rods
1 mile is 8 furlongs, 320 rods, 80 chains, or 5,280 feet
1 square rod is 272¼ square feet or 30¼ square yards
1 acre is 8 rods by 20 rods long, or any two numbers (of rods) whose product is 160
1 acre may be divided into 6-6/10 lots, size 50x125 feet. Streets are in addition
60 geographical miles make 1 degree
Gunthers chain, 22 yards or 100 links
A section is 640 acres
A township is 36 sections, each 1 square mile

## Books and Publications

Some publications containing helpful information for well drillers and installers of pumping equipment:

*Publications:*

Bulletin 35—Wisconsin Geological Survey, University, Madison, Wis.
Publications of the United States Geological Survey. Government Printing Office, Washington, D. C.
Design and Control of Concrete Mixtures, and Cementing of Water Wells. Portland Cement Association, 33 West Grand Avenue, Chicago, Ill.

*Well Drilling Journals:*

The Johnson National Driller—Minneapolis, Minn.
The Driller, South Milwaukee, Wis.

*Manufacturers and Supply Catalogs:*

Drilling and Grouting Tools and Equipment.
Pipe, Fittings, Valves, and Supplies.
Pumps, Accessories, Tanks.
Motors, Engines, Windmills.
Well Screens and Points.
Water Softeners and Filters.

*State Departments* (Regulations relating to drinking water)

State Board of Health (See Part I)
State Laboratory of Hygiene (Water Containers and Instructions)
Dairy and Food Department (Dairy Product Plants)
Conservation Commission (State Parks, Hatcheries and Forest Preserves)
State Board of Control (State Institutions)
State Department of Public Instruction (School Wells)
Local School Boards (District School Building Wells)

**Note:** These publications, trade papers, manufacturers catalogues, state department codes and regulations, water supply analysis reports, well log and premise diagram should be so filed by you that they are available when need for such information presents itself.