NEW BRITAIN TOWNSHIP

207 Park Avenue • Chalfont, PA 18914 • Telephone: (215) 822-1391

WELL CONSTRUCTION PERMIT APPLICATION

Please Note:

Applicant To Complete All Items

A Well Construction Permit must be approved prior to any well drilling.

TOWNSHIP USE ONLY

Permit #: _____
Date: _____
Payment: _____
Check #: _____
Receipt #: _____

Identification:

1. Proposed Work At: _____ Lot#: _____
   (Streets and Street Name) (If development, give Lot #)
2. Tax Parcel Number: _____
3. Name of Applicant: _____ Email: _____
   Address: _____
   City: _____ State: _____ Zip: _____
   Phone (H): _____ Phone (W): _____
4. Name of Owner: _____
   Mailing Address: _____
   City: _____ State: _____ Zip: _____
   Phone (H): _____ Phone (W): _____
5. Name of Driller: _____
   Address: _____
   City: _____ State: _____ Zip: _____
   Phone (H): _____ Phone (W): _____

Well Information:

6. Number of Residential Lots/Units: _____
7. Non- Residential Flow Calculations: _____ gpd (Attach Supporting Analysis)
8. ☐ New Well ☐ Well Installations ☐ Residential (Occupied Single Family Home) ☐ Geo Thermal Well
   ☐ Redrilling ☐ Recasing ☐ Other _____
9. Number of Required Pump Test Wells: _____
10. Number of Required Monitoring Wells: _____

Application Checklist:

All applications must include the following items, or the application will be considered administratively incomplete and returned to the applicant.

- ☐ New Britain Township Well Construction Permit Application.
- ☐ Plot Plan or a copy of the Preliminary Plan of Subdivision and/or Land Development.
- ☐ Permit Fee according to the adopted Township Fee Schedule.
- ☐ If well withdrawal is 10,000 gdp or greater, a copy of a well application submitted to Delaware River Basin Commission.

Reviewed by New Britain Township Staff: _____ Date: _____

This is to certify that I have read New Britain Ordinance No. 2001-05-02, as amended, and that the accompanying application meets the requirements of the Ordinance to the best of my knowledge.

Signature of Applicant: _____ Signature of Owner: _____

The following notes are provided for the applicant as a guideline to assist in the well permit submission process:

- All fees shall be payable to New Britain Township. All plans, applications and forms shall be submitted directly to New Britain Township.
- Follow all well regulations per Ordinance No. 2001-05-02, as amended. See attached.
- No building permit shall be issued by the Township until the required drilling, pump testing and water quality analysis is completed to verify adequate water supply is available for the lot and water is potable.
- The well driller's certification, Domestic Well Worksheet and the Water Quality Analysis must be submitted to the township prior to issuance of a building permit.
- A plot plan of the property shall be submitted showing the location of proposed well(s) and any existing or proposed on-lot sewage disposal systems. For a pumping test well and/or monitoring well, a copy of the Preliminary Plan of Subdivision and/or Land Development shall be submitted showing the location of proposed well(s) and any existing or proposed on-lot sewage disposal systems.
- A well required for a pumping test and/or monitoring well for preparation of a Water Resource Impact Study shall comply with all requirements of the Subdivision and Land Development Ordinance, as amended. The location of the pumping test(s) and monitoring well(s) shall be approved by the Township Engineer prior to the issuance of a well permit.
- A bacterial test shall be conducted after installation of house plumbing, but within thirty (30) days of requesting issuance of an occupancy permit.

These guidelines may be amended periodically .

ORDINANCE NO. 2002-05-04

AN ORDINANCE OF NEW BRITAIN TOWNSHIP, BUCKS COUNTY, PENNSYLVANIA, REGULATING THE DRILLING OF WELLS, REQUIRING THE SUBMISSION OF APPLICATIONS FOR PERMITS, IMPOSING RESTRICTIONS ON THE CONSTRUCTION OF WELLS AND THE WITHDRAWAL OF GROUNDWATER.

WHEREAS, the Board of Supervisors of New Britain Township has determined that it is in the best interest of the Township residents to enact regulations to protect existing groundwater supplies and to enact regulations to manage groundwater resources, thereby promoting the general health, safety and welfare of the Township residents; and

WHEREAS, the Board of Supervisors has determined that it is in the best interest of the Township to enact an independent ordinance and also amendments to the New Britain Township Subdivision and Land Development Ordinance to regulate the drilling of wells and the withdrawal of groundwater;

NOW, THEREFORE, BE IT ENACTED AND ORDAINED by the Board of Supervisors of New Britain Township, as follows:

SECTION 1. **PURPOSE**

The purpose of this Ordinance is to ensure that new wells constructed in New Britain Township are able to provide a reliable, safe, and adequate supply of water to support the intended use within the capacity of available groundwater resources. Also, it is to ensure that new wells do not infringe upon the performance of existing wells. Lastly, it is to provide an opportunity to collect accurate information on the aquifers in the Township.

SECTION 2. **SEVERABILITY**

If any sentence clause, section or part of this Ordinance is for any reason found to be unconstitutional, illegal or invalid, such unconstitutionality, illegality or invalidity shall not affect or impair any of the remaining provisions, sentences, clauses, sections or parts of this Ordinance. It is hereby declared as the intent of the New Britain Township Board of Supervisors that this Ordinance would have been adopted had such unconstitutional, illegal or invalid sentence, clause, section or part thereof not been included herein.

SECTION 3. **APPLICABILITY**

A. No person, firm, corporation, or other entity within the Township shall withdraw groundwater for any purpose by use of a well except as permitted by this Ordinance.

B. No building permit for a new residential building or nonresidential building, or addition to a building which is to be served by a new well, shall be issued unless the well intended to serve the building has been drilled, tested and certified by a licensed state laboratory to be in compliance with this Ordinance.

C. This Ordinance shall apply to any and all situations where a new well is to be drilled for an existing use and where a building permit and/or occupancy permit is required by the New Britain Township Zoning Ordinance.

SECTION 4. **PERMIT PROCEDURES**

Prior to commencing the construction of a well, the owner, or agent, shall obtain a well drilling permit from New Britain Township in accordance with the following:

A. The required drilling, pump testing and water quality analysis shall be completed in compliance with the standards herein, prior to the issuance of a building permit to verify adequate water supply is available for the lot and water is potable.

B. There are two (2) phases of a well permit. Phase I consists of the permit requirements for drilling the well. Phase II consists of sampling and analysis of the water quality.

1. Phase I Drilling Requirements.

a. The following information shall be shown on a plot plan of the property and submitted with the Township's well permit application:

(1) 100-foot isolation distance for the proposed well to verify compliance with the regulations of PA Title 25 Chapter 73 Standards for Sewage Disposal Facilities.

(2) Location of all existing or proposed on-site sewage disposal systems.

(3) Location of dwelling and utility services for the lot.

b. In order to be certified for use for a single-family dwelling, a well shall have a production of not less than 6 gallons per minute as certified by a licensed well driller. If less than 6 gallons per minute

yield is established, such a well may still be certified for use if sufficient storage is provided to meet the calculated peak demand. In no case shall a well yielding less than 2 gallons per minute be certified for use by the Township.

c. Each proposed well for a single-family dwelling shall be evaluated through a two-part pump test comprised of a peak demand test and a constant rate pump test. Such pumping tests and any required storage shall be calculated in accordance with the New Jersey Geological Survey Groundwater Report Series No. 1, Two-Part Pump Test for Evaluating the Water Supply Capabilities of Domestic Wells, as prepared by Jeffrey L. Hoffman and Robert Canace for the New Jersey Geological Survey. The Domestic Well Worksheet contained in the above-referenced report shall be submitted to the Township for approval prior to issuance of any building permits.

2. Phase II Water Quality Analysis Requirements

a. Samples shall be obtained from the well at the termination of pump testing to demonstrate drinking water quality conforming to this section. Additional or specialized analysis should be discussed with the Township Engineer prior to sampling for the purposes of streamlining the permitting process; however, said discussion shall not be construed as final approval of the proposed testing.

b. All samples shall be collected, transported and analyzed in accordance with USEPA and PADEP protocol for drinking water. Sample testing shall be performed by a laboratory certified by the Commonwealth to perform drinking water analysis. Laboratory reports shall contain sufficient quality assurance and quality control data to explain any analysis and reporting conditions or deficiencies.

c. Water quality must comply with currently published USEPA National Primary and Secondary Drinking Water Standards and Health Advisories.

d. Water quality testing shall include, at a minimum, the following parameters: Total Coliform, Nitrate/Nitrite, PH, Iron, Manganese, Lead, Chloride, Hardness, Total Dissolved Solids, Surfactants (Detergents), Volatile Organic Compounds - Group 1 (VOC1) + 10 unknowns*, MTBE, Herbicides - Group 1 (H1) and Pesticides - Group 3 (P3).

*A Library search for Tentatively Identified Compounds (TICs). Additional analysis will be required if TICs are discovered. Group 1 (VOC1), etc. refers to PADEP categories of contaminants.

e. The applicant shall perform a survey to identify and evaluate potential sources of contamination that may impact water quality in the proposed well(s), and shall perform additional sampling and analysis as may be required to assure water quality is satisfactory for the protection of human health and the environment.

f. Additional sampling and analysis will be required to quantify any observed objectionable effects resulting from the quality of the water, including, but not limited to: odor, color, foaming, staining, scaling and sedimentation.

g. A well that does not meet the above standards will be required to meet them through adequate treatment facilities. After treatment facilities are installed, the applicant shall have the water supply tested again.

h. The following information shall be submitted to the Township with the water quality report:

(1) The report from the laboratory shall contain the name, license number and address of the laboratory.

(2) Depth and diameter of the well, including the ground elevation at the well head.

(3) Drilling method and type of casing and grouting used.

(4) Type of treatment and storage, if applicable.

i. A bacterial test shall be performed on the well after installation of the house plumbing, but within 30 days of requesting issuance of an occupancy permit for the dwelling. The guidelines set forth by the Bucks County Department of Health shall be followed for disinfecting a contaminated well.

SECTION 5. GENERAL WELL CONSTRUCTION STANDARDS

A. All well construction shall be in accordance with the construction requirements set forth by the PADEP Public Water Supply Manual, latest edition, and as contained in

this Ordinance. If there is a conflict between the requirements of the PADEP and the requirements of this Ordinance, the more restrictive shall be applicable.

B. When drilling or increasing the depth of a well, an accurate well drilling log shall be maintained. This log shall contain the following information:

a. Interval - the depth in feet below a datum level such as ground level or top of casing through which the drill is advancing.

b. Geologic Description - a description of the rock type penetrated through the particular interval. The description shall include such things as color, texture, rock type and geologic name, if known.

c. Yield - the total yield of water at the base of the interval last described.

d. General Comments - include anything that the driller finds noteworthy, i.e., water bearing zones, artesian conditions, change in pressure, loss of fluid, etc.

C. The pump shall be so located and designed as to make the use of a pump pit unnecessary. Pitless adapters shall conform to the standards set forth by the PADEP.

D. The space between the pump column and the casing of each well shall be provided with a vent which shall be protected with an elbow facing downward or mushroom type head located at least 18 inches above flood levels. All vents shall be screened to prevent the entry of insects.

E. The casing shall be temporarily capped and any open space covered until the well has been grouted and the pump installed. The cap should be either threaded onto the casing or be a friction type device which locks onto the outside of the casing.

F. The well head shall be constructed so as to assure the maximum protection of the well and to exclude entry of any contaminant. All wells shall be cased to protect against contamination. Water bearing formations that are known to be contaminated or identified as being in danger of contamination shall be sealed off with casing and grout. Sealing shall be accomplished by a method approved by the PADEP.

G. Completed wells shall be properly capped with sanitary seals to prevent the entry of contamination.

H. All wells shall be provided with a watertight, one-quarter inch thick welded steel pipe casing. Pipe shall be in accordance with AWWA Standard C200. The minimum length of casing shall be 40 feet or 10 feet into bedrock, whichever is

greater. All joints between sections of the casing shall be made by continuous welding in accordance with AWWA Standard C206. All casing shall be extended at least 18 inches above final grade or 12 inches above the basement floor. The space between the earth and outside casing shall be filled with cement grout to a distance of at least 6 feet below the ground surface.

I. Any existing well that is to be abandoned shall be properly sealed. The "Water Well Abandonment Procedures", as published in Chapter 7 of the PADEP Groundwater Monitoring Guidance Manual, February 1996 edition, as amended, shall be followed for all well abandonment.

SECTION 6. **EXEMPTION**

A. A well drilling permit is not required when an existing well is to be drilled to a greater depth and the anticipated withdrawal from the well is to remain the same. If the depth of a well is to be increased and the quantity of water withdrawn is to be increased, a permit is required and compliance with all applicable well drilling provisions of the New Britain Township Subdivision and Land Development Ordinance.

B. Either the property owner or the well driller shall notify the Township that the existing well has lost its supply and it will be modified by increasing the depth of the well, or a new well will be drilled to replace it.

C. Within two (2) weeks of the modified or replacement well being in operation, the property owner or well driller shall supply to the Township a copy of the well drilling log documenting the quantity of water to be withdrawn from the well.

SECTION 7. **REPEALER**

All ordinances or parts of ordinances which are inconsistent herewith are hereby repealed. Ordinance 2001-05-02 is hereby repealed.

SECTION 8. **EFFECTIVE DATE.**

This Ordinance shall be effective five (5) days after enactment.

ENACTED AND ORDAINED this 20th day of May A.D., 2002.

NEW BRITAIN TOWNSHIP
BOARD OF SUPERVISORS

Robert L. Benner

Dr. Robert L. Benner, Chairman

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TWO-PART PUMP TEST FOR EVALUATING THE WATER-SUPPLY CAPABILITIES OF DOMESTIC WELLS

New Jersey Geological Survey Ground-Water Report Series No. 1

by
Jeffrey L. Hoffman and Robert Canace

Department of Environmental Protection
Division of Water Resources
CN029
Trenton, NJ 08625

John W. Gaston, Jr., P.E., Director
Haig F. Kasabach, State Geologist

1986

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Additional copies of this and other reports may be obtained from:

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TWO-PART PUMP TEST FOR EVALUATING THE WATER-SUPPLY CAPABILITIES OF DOMESTIC WELLS

by
Jeffrey L. Hoffman and Robert Canace

Key terms: aquifer test, water yield, well construction, constant head test
New terms: peak demand rate, peak demand test

ABSTRACT

An evaluation of the capability of a well drilled in rock to supply domestic needs can be based on predicted household water use patterns and characteristics of the well. Household water demand is estimated using a residency rate of two per bedroom and a usage rate of 100 gallons per capita daily. Water use is assumed to be split between equal morning and evening periods of peak demand. Rate of usage during peak periods is estimated at 3 gallons per minute per bathroom. Duration of the peak demand periods is estimated by dividing total usage during peak demand periods by the average rate of usage during peaks.

Capability of the well to meet peak demand and total daily demand is evaluated through a two-part pump test. The first part, a peak demand test, is a drawdown test to determine whether or not the combined well storage and aquifer contribution to well flow can meet peak needs. The second part, a constant head test, is to determine whether or not flow from the aquifer is sufficient to meet total daily needs. If so it is assumed that the aquifer can meet long-term household needs. Measurements of drawdown during the pump test are used in determining the depth at which the pump should be placed in the well and the necessary depth if the well needs to be deepened to provide additional storage.

The method does not take into account extreme droughts, interfering stresses on the aquifer from other pumping or decreasing efficiency of the well and pump due to aging.

INTRODUCTION

In response to inquiries by local health agencies and the public concerning domestic well failures, the New Jersey Geological Survey has developed a method to estimate the water supply needs of private homes and to evaluate the adequacy of wells drilled to supply those households. The method consists of a calculation to estimate total daily needs and peak demand needs of a household and a two-part pumping test to determine whether or not a well can meet these needs. The procedure is intended primarily for use in areas of consolidated bedrock (Regions 2 and 3 of the New Jersey water well construction regulations (NJAC 7:10-35), shown in figure 1).

The yield of a well is usually established by pumping the well and measuring the discharge (well flow), in gallons per minute, from the well head. Unfortunately, pump test requirements for domestic water wells have not been standardized. The New Jersey Department of Environmental Protection requires only that "each well be tested for yield and drawdown" (NJAC 7:10-3.58). No testing procedures are stipulated under the code. A variety of local ordinances regulate well testing. Most of these have been established on the basis of experience in the field or other local ordinances. Most have fixed minimum yield requirements regardless of household size for issuance of the certificate of occupancy.

The method outlined in this report is modified from a procedure developed by the Connecticut Well Drillers Association (Hunt, 1978). It supplements the Connecticut approach by providing a systematic method based on anticipated peak and long-term demand to design, perform and evaluate a pump test.

The pump test is divided into two parts. The first part, the **peak demand test**, is to see if the well can meet the predicted water demand of the house during twice-daily periods of peak use. The second part, the **constant head test**, is to measure the aquifer's ability to transmit sufficient water to the well for the total daily water demand of the household.

The pump test identifies satisfactory wells and, for wells that are not satisfactory, whether the problem lies with insufficient storage or with inability of the aquifer to transmit sufficient water to the well. Insufficient storage can be corrected by deepening the well to provide additional storage within the borehole, redrilling to a greater diameter or constructing a surface storage tank. The necessary depth to which the well must be deepened can be estimated using measurements of aquifer yield and drawdown taken during the constant head

Figure 1. Geologic regions of New Jersey as defined in water well construction regulations. (NJAC 7:10-35)

test. Insufficient aquifer yield may, in some instances, be corrected by developing the well or deepening it to encounter additional water-bearing zones.

Equations, tables and worksheets are provided to assist in the recording and analysis of pump test data. A flow diagram is also provided which shows the evaluation procedures and options should the well fail. Hypothetical examples have been included to demonstrate the method.

It must be recognized that this method is a simplified mathematical approach that cannot take into account many of the physical factors that can influence long-term well performance. These include seasonal fluctuations in ground water availability, extreme drought, permanent dewatering of fracture zones, stresses on the aquifer from nearby wells and reduction of well and pump efficiency due to clogging or wear. These factors may result in failure of wells which were rated as satisfactory at the time of testing.

BASIS AND BACKGROUND

A method for estimating the water needs of individual households and evaluating domestic wells was developed by the Connecticut Well Drillers Association (Hunt, 1978). The impetus for the development of the **Connecticut minimum well formula** was an objection to a requirement by the Federal Housing Authority that a home have a well with a yield of 5 gpm (gallons per minute) or more to qualify for loan assistance. The Well Drillers Association, convinced that 5 gpm was an unreasonable across-the-board requirement, demonstrated that smaller yields could be certified as adequate for domestic needs if household demand were taken into account. The Connecticut minimum well formula:

1. estimates **peak load** (household water demand, in gallons, within each of two daily peak use periods);
2. estimates **peak time** (the length of peak use periods in minutes);
3. evaluates the capability of the well to meet the peak demand of the household, and;
4. establishes a minimum pump capacity and pump installation depth to assure an adequate supply.

In the Connecticut method, if the well can deliver the peak load within the peak time it is considered to be satisfactory. This determines whether or not the well can supply peak needs. But like many domestic well tests, it does not evaluate the long-term ability of the aquifer to supply the well. Also, for a well which fails the pump test, the Connecticut method does not determine whether the cause of failure is inadequate storage or inability of the aquifer to transmit sufficient water. The two-part pump test presented here uses a peak demand test followed by a constant head test. The constant head test measures the rate at which water can move from the aquifer to the well. This test determines whether or not the aquifer can transmit sufficient water for long-term needs. If the well fails either test, the constant head test provides guidance as to how the well might be modified to meet the household demand. For instance, if the well can meet the total daily demand but not the peak demand, the constant head test results can be used to estimate the depth to which the well would have to be drilled to provide sufficient storage in the bore-hole to meet the peak demand. If flow from the aquifer falls short of total daily demand, then the well must be deepened to encounter additional water-bearing zones or redrilled at another location, but the test cannot provide an estimate of the required well depth.

ASSUMPTIONS

In order to calculate peak load and peak time, the Connecticut formula and the modification presented here rely on four assumptions concerning water use. The assumptions are conservative. While one or more of the assumptions may not be met by a particular household, there is a sufficient margin of safety that water use estimates will be valid for determining the adequacy of wells for most peak periods for most families. Orndorff (1966) reported that on days when intensive chores are performed the peak demand may be several times the average demand. The assumptions are not valid for these days. The assumptions are:

1. Each person uses 100 gpd (gallons per day).

   Comments: The use of 100 gpd per capita is consistent with *Standards for the Construction of Public Non-Community and Non-Public Water Supplies* (NJAC 7:10-3.32), in which this value is applied as a planning criterion. This is a conservative figure which exceeds most measured values for water consumption. Reported average per capita consumption is approximately half this volume, or about 50 gpd (U. S. Environmental Protection Agency, 1978; Orndorff, 1966, p. 30, table 7). Average per capita consumptions of up to 80 gpd have been reported (Linaweaver and others, 1967, p. 2). In addition, in a detailed study of domestic water use Orndorff (1966) found that though total usage increases with family size, per capita usage decreases. This provides an additional margin of safety for larger families.

2. Two people occupy each bedroom.

   Comments: The average residency rate in the United States in 1980 was reported to be 2.75 residents per dwelling (U.S. Department of Commerce, 1981, table 10). Inasmuch as most new dwellings have two or more bedrooms, an estimate of two people per bedroom is conservative and allows for later addition of bedrooms or higher-than-average occupancy rates.

3. Most daily water usage occurs during two peak periods.

   Comments: In his study of domestic water use Orndorff (1966, p. 23) concluded that "peak demands tend to occur during two particular times of the day." One of these is in the morning and the other in the evening. While most water use occurs during these peaks, there is additional use at other times. Because of water use during off-peak times, it is reasonable that no more than half the total daily water use will occur during a single peak demand period. Differences in habitual water use patterns among families will thus seldom be such that peak water use will be underestimated.

4. Water flows through fixtures at the rate of three gallons per minute per bathroom during peak periods.

   Comments: This is the key assumption in estimating peak time (the duration of peak demand periods). In the Connecticut formula it is assumed that water use during peak time is in large part bathroom use. Orndorff (1966) points out that, although a normal daily peak demand can be determined statistically, water demand of particular households is established by habitual patterns. Bathroom use would be the prime example.

   New Jersey's *Standards for the Construction of Public Non-Community and Non-Public Water Systems* (NJAC 7:10- 3.10, et seq., 1978) require that water sys-

tems provide a minimum flow rate of 2 gpm at each plumbing fixture. Orndorff reported average peak demand rates of 1.60 gpm for a subdivision served by on-site wells and 2.29 gpm in homes served by an external water source. The use of 3 gpm provides a margin of safety above measured rates of water usage and the requirements established for domestic water supply systems.

For making calculations, it is assumed that water flows through the fixtures of a half bath at 1.5 gpm.

THEORY

Calculation of Household Water Demand

In order to establish conditions for a pump test, it is necessary to quantify the total daily demand and peak demand which will be placed on the well. Total daily demand is a function of the number of residents and per capita usage. Peak demand can be quantified in terms of volume, time and rate. The total volume of water the household will require during each of two daily periods of peak demand is the **peak load.** The average rate of use during peak demand times is the **peak demand rate.** The length of time within which the peak load demand for water will be exerted is the **peak time.**

To quantify the concepts of peak load, peak time and peak demand rate the following assumptions, discussed above, are applied:

1. each person uses 100 gallons per day.
2. two people occupy a bedroom.
3. most daily water usage occurs during two peak periods.
4. water flows through fixtures at the rate of three gallons per minute per bathroom during peak periods.

Under these assumptions equations for peak load, peak time and peak demand rate can be expressed as:

$$\text{peak load (gallons)} = \frac{\text{(no. of bedrooms) (persons/bedroom) (gallons/person/day)}}{\text{peak periods/day}}$$

$$= \frac{\text{(no. of bedrooms) (2) (100)}}{2} = \text{(no. of bedrooms) (100)} \quad (1)$$

$$\text{peak demand rate (gpm)} = \text{(gpm/bathroom) (no. of bathrooms)}$$

$$= \text{(3) (no. of bathrooms)} \quad (2)$$

$$\text{peak time (minutes)} = \frac{\text{peak load (gallons)}}{\text{peak demand rate (gpm)}} \quad (3)$$

As an example, a three bedroom house with two bathrooms will have:

$$\text{peak load} = 3 \text{ bedrooms} \times 100 \text{ gallons/bedroom}$$

$$= 300 \text{ gallons}$$

$$\text{peak demand rate} = 3 \text{ gpm/bathroom} \times 2 \text{ bathrooms}$$

$$= 6 \text{ gpm}$$

$$\text{peak time} = 300 \text{ gallons}/6 \text{ gpm}$$

$$= 50.0 \text{ minutes}$$

Pump Test Design

Well flow (discharge) is a combination of water pumped from the standing column of water in a well (the **well storage contribution**) and water flowing into the well from the aquifer (the **aquifer contribution**). In any well evaluation it is necessary to recognize that the well acts as a water storage area. Water is taken from well storage during peak demand times and gradually replenished from the aquifer during off-peak times.

At the beginning of the two-part pump test, the water in a well is at the static level: the water in the well and aquifer are at the same pressure and there is no net flow into or out of the well. As soon as the pump goes on for the peak demand test, water is removed from the casing and the water level drops. Because the pressure is now lower in the well than in the aquifer, water will flow from the aquifer into the well. Until the water level stops dropping, the discharge pumped from the well includes well storage and aquifer contribution components. In general, though certainly not always, the aquifer contribution will increase as the water level in the well drops.

For the constant head test the water level must be stable or nearly stable, neither dropping nor rising rapidly. The water level may stabilize during the peak demand test due to increase in aquifer contribution, or it may be stabilized by decreasing the pumping rate. When the water level and pumping rate are stable the well is said to be at equilibrium, the pumping to be at a constant head pumping rate and the water to be at a constant head level.

Peak Demand Test

The peak demand part of the two-part test determines whether or not the volume of water stored in the well plus the volume which will flow from the aquifer to the well during peak time will be sufficient for peak needs. The well is allowed to come to its static level, then is pumped at the peak demand rate for the peak time. A well for which the combined well storage and aquifer contributions are insufficient will fail before the expiration of the peak time.

Constant Head Test

The constant head test determines whether or not the aquifer contribution will meet long-term needs. An accurate measurement of the aquifer contribution can be made when the well is being pumped under constant head conditions. If a well is being pumped but the water level is not changing, the volume of water stored in the well is not changing. The well storage contribution is therefore zero and all water flowing from the well is coming from the aquifer; the aquifer contribution is equal to the measured pumping rate. If the aquifer contribution rate is less than the flow required for total daily needs (see tables 3 and 4), the well fails this portion of the test.

Test Results

If the well passes the constant head test but fails the peak demand test, the aquifer can supply enough water on a daily basis, but additional storage is required for peak demand needs. Storage may be provided in either the well or a surface storage tank.

If a well fails the constant head test it will not supply enough water on a daily average to meet household needs regardless of whether or not it passed the peak demand test. Aquifer contribution must be increased by developing, deepening or relocating the well.

Depth Required for Adequate Storage

If, for a well which has passed the constant head test but failed the peak demand test, storage is to be provided by deepening the well, the necessary well depth can be calculated from results of the constant head test. Two assumptions are necessary. The first is that there is no aquifer contribution until the drawdown in the well reaches the level measured

during the constant head test. This is a conservative assumption. There is indeed aquifer contribution before the water level falls this far, but the rate is not measured during the test and is thus unknown. The second assumption is that as soon as the drawdown in the well reaches the level measured during the constant head test, the aquifer contribution begins at the rate measured at the conclusion of the constant head test and does not increase as the drawdown increases. This, also, is a conservative assumption, but is reasonable in that in a bedrock aquifer the most significant water-bearing zones are commonly associated with weathered fractures within several tens of feet of the soil/rock interface. Additional drawdown below the fractured or weathered zone may not induce much more water to flow into the well.

The volume of water which will enter the well from the aquifer during peak demand periods can be estimated using these assumptions. Subtracting this volume from the peak load gives the total volume of storage needed. Conversion of storage volume to additional depth required for drawdown is discussed under *Additional Drawdown for Wells Without Adequate Storage* in the *Implementation* section, below.

Surface Storage Tanks

The effect of surface storage of water on the well depth required for reliable peak supply can be taken into account by subtracting the available volume in the storage vessel from the peak demand. This gives the volume which must come from the well during each peak demand period. Dividing this lower volume by the peak demand rate gives the length of time the pump must operate during the peak demand period. The calculation of the necessary volume of well storage then proceeds as discussed above. The peak demand test should be carried out using the lower value for pumping time. The surface storage tank must, of course, be refilled, but if the well has passed the constant head test it should be possible to fill between peak demand periods.

Normally a domestic water supply system includes a hydropneumatic tank. A conventional hydropneumatic tank is intended primarily for maintenance of water pressure and contributes little to available water storage. Only that volume of water which drains from the tank before declining pressure causes the well pump to switch on contributes to available storage. This can be referred to as the available storage volume of the tank. An additional tank, dedicated to water storage and equipped as necessary to deliver water to the plumbing system of the house at the required pressure, could conceivably be installed.

Total Well Depth and Pump Placement

The pump must be placed in a well so as to allow for the maximum drawdown measured during the peak demand test. Pump size must be based on the required water pressure in the plumbing and the anticipated drawdown. Too deep of a pump setting can be as undesirable as too shallow a setting if the pump cannot deliver water at the required pressure. A balance must be struck between obtaining the storage advantage of maximum drawdown and ensuring adequate water pressure. This report attempts to prevent well failure caused by setting the pump at too shallow a depth.

IMPLEMENTATION

Testing of domestic wells is not usually conducted in a manner that establishes long-term performance capability. In fact, estimates of well yield are frequently made during drilling. In particular this is true with air rotary drilling when estimates of yield are based on the quantity of water lifted from the well with an air compressor. For an accurate test a pump with a discharge rate control is necessary; this might include the use of valves or a throttle on a generator used to power a pump.

An effective pump test must determine whether the well can supply both peak needs and total daily needs. In the method presented here, this is done using a two-part pumping test. The first part is the peak demand test and the second is the constant head test. Both of these must be performed in one continuous testing session. *It is important to note that the well is not considered to be satisfactory until it passes both tests during one continuous session.*

Peak Demand Test

The peak demand test is a drawdown pumping test to determine if the well can supply the water needed by the household during times of peak water demand. In this test the well is pumped at the peak demand rate estimated for the household for a time equal to or greater than the estimated peak time. If pumping can be maintained at this rate for the peak time, then the well should be able to support the peak needs of the household. If this pumping cannot be maintained, storage in the well is insufficient. The constant head test will provide further information as to the nature of the difficulty.

Constant Head Test

The constant head test is to determine if flow from the aquifer to the well can replenish water removed from the well during peak demand periods. In this test the pumping rate is adjusted so that the drawdown stabilizes. When the water in the well is at a constant level, one is certain that all of the discharge is coming from the aquifer, none from well storage. If under this constant head pumping condition the aquifer can supply the total daily household needs, then long-term needs can most probably be met. For the purposes of this report a constant head condition exists when the pumping rate is held steady and the water level changes at a rate of less than 6 inches per hour.

Outline of Testing Procedure

Planning of a pump test and evaluation of the results (figure 2) can be summarized as follows:

1. The well is constructed in accordance with state and local requirements.
2. The **peak demand rate** and **peak time** are calculated from the number of bedrooms and bathrooms using equations 2 and 3 or tables 1 and 2. Unless surface storage is to be taken into account, these are the required discharge rate and duration of the peak demand pump test.
3. The peak demand test is performed. For this test the pump should be positioned so as to take full advantage of the available drawdown in the well. The static water level in the well is measured prior to pumping. Then the well is pumped at the peak demand rate for the peak demand time. If pumping cannot be sustained at this rate the well fails the peak demand pump test. The water level at the completion of the peak demand test must be measured accurately for it is used to measure drawdown during the constant head test and, later, used to establish the pump setting.
4. The **constant head test** is undertaken *immediately* upon completion of the peak demand test regardless of whether or not the well passed the peak demand test.

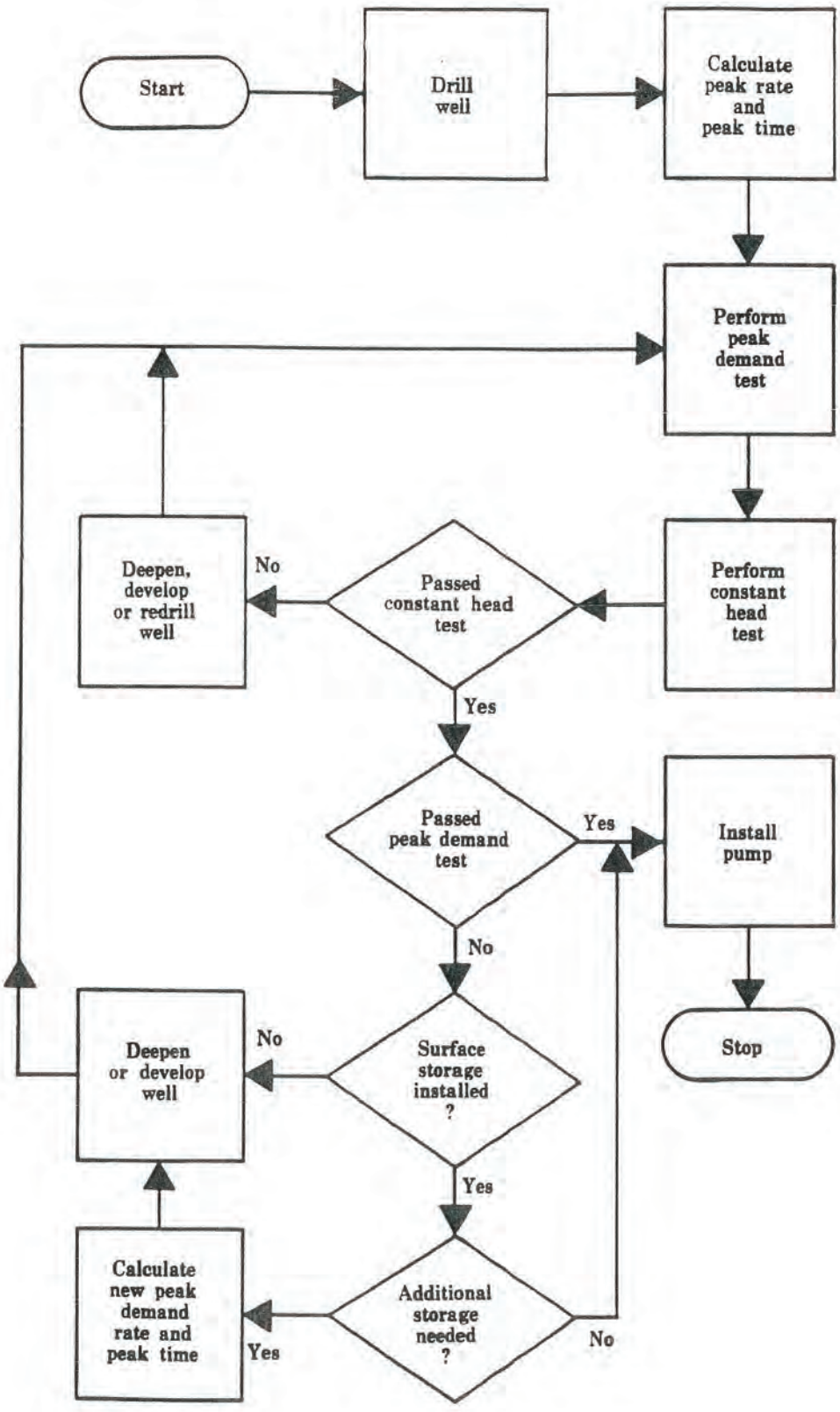

Figure 2. Flow chart of performance and evaluation of pump test.

The well is not allowed to recover from the peak demand test. In the constant head test the pumping rate is lessened, if necessary, to a rate at which the drawdown shows insignificant change with time. A **constant head condition** exists if the head changes at a rate of less than 0.5 feet (6 inches) per hour under a constant pumping rate. The pumping rate which maintains this condition is termed a **constant head pumping rate.** The water level at the constant head pumping rate must be measured accurately. The difference between this level and the static water level is the **constant head drawdown.** The constant head pumping rate should be as close as possible to the peak demand pumping rate, but the main objective is to achieve a stable water level while pumping. Too low a discharge rate will result in underestimation of the capabilities of the aquifer and may lead to overdeepening of the well.

5. The constant head pumping rate is converted to gallons per day (table 3) and compared to the total daily demand of the household. If the discharge rate during the constant head test will provide the total daily water demand, the well passes the constant head test. If not, it fails.

6. The results of the two tests are evaluated. The four possible outcomes are:

   a. Peak demand test—Pass
      Constant head test—Pass

      This well can supply the home with enough water. The pump should be installed as discussed under *Total Well Depth and Pump Placement* below.

   b. Peak demand test—Pass
      Constant head test—Fail

      This well, when full, can supply peak demand needs. However, more water will be withdrawn each day than can be replaced by the aquifer. This well will prove inadequate sooner or later. It must be deepened, developed or redrilled at a new location to provide a larger aquifer contribution. In bedrock aquifers the well may not encounter additional water-bearing zones at greater depth. The aquifer may not provide sufficient supply for domestic needs. If the well is redrilled, developed or deepened it must be retested.

   c. Peak demand test—Fail
      Constant head test—Pass

      This well lacks sufficient water from combined well storage and aquifer flow to meet peak needs. The aquifer contribution is, however, sufficient to meet total daily needs. More storage must be supplied to satisfy short-term peak demands. This can be accomplished by deepening the well and lowering the pump, redrilling to a greater diameter or adding a water storage tank. If the well is to be deepened, a method for calculating additional required depth is described in *Additional Drawdown for Wells Without Adequate Storage*, below. If a water storage tank is installed see *Surface Storage Tanks*, above. If the well is redrilled or developed it must be retested.

   d. Peak demand test—Fail
      Constant head test—Fail

      This well has neither sufficient storage nor sufficient aquifer contribution to ensure an adequate household supply. It must be deepened to encounter additional water-bearing zones, developed to increase flow to the well or a new well drilled elsewhere. Depending on the success of efforts to increase flow from the aquifer, storage may have to be increased. The well must be retested when any of the above procedures are completed.

Additional Drawdown for Wells Without Adequate Storage

A well that fails the peak demand test but passes the constant head test can be made satisfactory by providing additional storage. If additional storage is created by deepening the well, the necessary additional volume of storage and corresponding necessary available drawdown are found by calculating as follows:

A. *Assured volume:* The assured volume of water in the well is the volume in the well between the static water level and the constant head pumping level. Calculate this volume by multiplying the constant head drawdown by the storage capacity per foot of well casing (1.4 gallons per foot for a 6-inch well).

B. *Assured time:* This is the time it will take to pump the assured volume from the well. It is calculated by dividing the assured volume by the peak demand rate.

C. *Shortfall volume:* This is the volume of water which must be supplied after the assured volume has been withdrawn from the well. It is calculated by subtracting the assured volume from the peak load.

D. *Shortfall time:* This is the time within which the well must supply the shortfall volume. It is calculated by subtracting the assured time from the peak time.

E. *Aquifer contribution volume:* This is the volume of water the aquifer is predicted to supply to the well during the shortfall time. During the shortfall time water is assumed to be moving from the aquifer to the well at the aquifer contribution rate measured during the constant head test. Aquifer contribution volume is calculated by multiplying the aquifer contribution rate by the shortfall time.

F. *Additional well storage volume:* This is the volume of water which must be withdrawn from well storage after the assured volume has been pumped. It is calculated by subtracting the aquifer contribution volume from the shortfall volume.

G. *Additional well drawdown:* This is the additional drawdown required beyond the constant head drawdown. It is calculated by dividing the required additional well storage volume by the storage capacity per foot of well casing (1.4 gallons per foot for a 6-inch well).

Equations for this sequence of calculations are:

A. assured volume
   = constant head drawdown X storage capacity per foot of well casing

B. assured time = assured volume/peak demand rate

C. shortfall volume = peak load - assured volume

ADDITIONAL CONSIDERATIONS

The two-part pump test is a means of evaluating the capability of a well to supply domestic needs. The interpretation of test results is mathematical and may not take into account all the physical factors that affect a particular well. Some additional considerations are listed below:

1. *Seasonal recharge variations:* Pump tests performed during times of seasonally high ground water may not accurately predict performance during times of reduced water availability. A well that passes a pumping test in the spring, during high water-table conditions, may not be able to provide an adequate supply in summer or during drought periods when the water table is lower. Tests performed between June and October are more reliable than those performed in the rest of the year in determining if a well will satisfy household water demands.

2. *Low aquifer contribution:* The aquifer contribution as defined in this report is the volume of water that flows from the aquifer to the well during pumping. Table 4 shows that a one-bedroom house requires 200 gallons per day, which is equivalent to 0.14 gallons per minute. This is an extremely low aquifer contribution value. Experience has shown that a well with an aquifer contribution of less than 0.5 gpm (720 gpd) is a marginally dependable source of water for domestic use. It is recommended that a minimum cut-off of 0.5 gpm be established for the aquifer contribution.

3. *Addition or withdrawal of water during drilling:* During drilling water may be added to the aquifer or withdrawn depending upon the drilling method used. Immediately after completion of drilling the heads in the aquifer near the well may not be at static (unstressed) levels. The pump test should be conducted after any stresses induced by the drilling process have dissipated. A 12-hour recovery period is recommended between completion of drilling and performance of the pump test.

4. *Storage capacity:* Chapter 199 of NJAC 7:10-3.85 specifies minimum hydropneumatic tank sizes. These tanks maintain pressure in household water systems. They provide some storage, but this is not their primary purpose. They never empty completely, so the available storage in these tanks is less than their total volume. The presence of tanks specified in the regulations, or larger tanks dedicated solely to water storage, may be taken into account when calculating peak demand volumes.

5. *Large households:* The assumptions that relate dwelling size to household water demand may not be applicable to large dwellings that are not fully occupied. For homes with more than 5 bedrooms or 3 bathrooms it may prove advisable to use a different method to predict peak demand time, peak load and peak demand rate.

6. *Pump discharge:* In areas of vertical fracturing and thin or permeable overburden, water discharged at the surface may quickly infiltrate to the water table. If a pump test is conducted at such a site and the water pumped from the well is discharged at the well head, the water may return to the well as artificial recharge. Because this recharge will not be present during normal operation of the well, aquifer contribution will be overestimated. Water should be discharged at a distance from the well head in order to minimize this possibility.

7. *Drawdown safety factor:* A drawdown safety factor of 10 feet was recommended above. That is, the pump is to be set 10 feet below the drawdown level measured during the peak demand pump test. This level may be increased if a well is drilled in an aquifer known for large water level fluctuations.

8. *Well diameter:* Normally, domestic wells drilled in rock aquifers have a diameter of 6 inches. This provides approximately 1.4 gallons of storage per foot of drawdown in the casing. Increasing the well diameter will increase the storage per foot of well depth. The increased storage can be accounted for by using the appropriate value for the storage capacity per foot of drawdown.

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TABLES

Table 1: Duration of **peak time** in minutes as a function of the numbers of bedrooms and bathrooms in a dwelling.

		Number of Bathrooms				
		1	1½	2	2½	3
Number of Bedrooms	1	33.3	22.2	16.7	13.3	11.1
	2	66.7	44.4	33.3	26.7	22.2
	3	100.0	66.7	50.0	40.0	33.3
	4	133.3	88.8	66.7	53.3	44.4
	5	166.7	111.1	83.3	66.7	55.5

Table 2: **Peak demand rate** as a function of the number of bathrooms in a dwelling.

Number of Bathrooms	Peak Demand Rate (gpm)
1	3
1½	4.5
2	6
2½	7.5
3	9

Table 3: **Flow volumes** in gallons per minute corresponding to flow volumes in gallons per day.

Flow Volume (gpm)	Flow Volume (gpd)
0.01	14.4
0.02	28.8
0.05	72.0
0.1	144.0
0.2	288.0
0.3	432.0
0.4	576.0
0.5	720.0
0.6	864.0
0.7	1,008.0
0.8	1,152.0
0.9	1,296.0
1.0	1,440.0
2.0	2,880.0
5.0	7,200.0
10.0	14,400.0

Table 4: **Daily demand volume** and **peak load as a function** of the number of bedrooms in a **dwelling.**

Number of Bedrooms	Daily Demand Volume (gallons)	Peak Load (gallons)
1	200	100
2	400	200
3	600	300
4	800	400
5	1,000	500

DOMESTIC WELL WORKSHEET FOR TWO-PART PUMP TEST

(sheet 1 of 2)

PUMP TEST

Test Design

Preliminary Well Summary

1. Depth of well ..... _____ feet
2. Static water level (depth to water from top of casing) ..... _____ feet
3. Number of hours between well completion and measurement of static water level ..... _____ hours

Dwelling Summary

4. Number of bedrooms ..... _____
5. Number of bathrooms ..... _____

Peak Demand Test Requirements

6. Peak time (required minimum duration of test, from table 1) .. _____ minutes
7. Peak demand rate (required minimum discharge rate from pump during test, from table 2) ..... _____ gpm
8. Peak load (from table 4) ..... _____ gallons

Test Measurements

Peak Demand Test

9. Depth to water at beginning of test (static water level) ..... _____ feet
10. Depth to pump at end of test ..... _____ feet
11. Discharge rate measured during test (use minimum observed) .... _____ gpm
12. Duration of test ..... _____ minutes
13. Depth to water at end of test ..... _____ feet
14. Drawdown at end of peak demand test ..... line 13—line 9 = _____ feet

Constant Head Test

15. Constant head pumping rate ..... _____ gpm
16. Duration of pumping at constant head rate ..... _____ minutes
17. Depth to water at end of test ..... _____ feet
18. Drawdown at end of constant head test ..... line 17—line 9 = _____ feet

Evaluation of Results

19. Peak demand test duration. If line 12 is less than line 6 then well fails peak demand test ..... _____ pass or fail
20. Peak demand pump test rate. If line 11 is less than line 7 then well fails peak demand test ..... _____ pass or fail
21. Calculate aquifer contribution (multiply line 15 by 1440 or use table 3) ..... _____ gpd
22. Daily home water demand (from table 4) ..... _____ gpd
23. Aquifer contribution rate. If line 21 is less than line 22 then well fails constant head pump test ... _____ pass or fail

DOMESTIC WELL WORKSHEET FOR TWO-PART PUMP TEST

(sheet 2 of 2)

Actions Based on Test Results

Peak demand test	Constant head test	Action
24. pass	pass	Go to *Pump Placement and Minimum Well Depth* (lines 35-37).
25. fail	pass	The well must be developed to increase yield, deepened to increase storage or surface storage installed. If the well is deepened or developed, it must be retested. Go to lines 28-34 (*Additional Drawdown for a 6-inch Well With Insufficient Storage*)
26. pass	fail	The well must be developed, deepened or redrilled at a new location to increase yield. It must then be retested.
27. fail	fail	

ADDITIONAL DRAWDOWN FOR A 6-INCH DIAMETER WELL WITH INSUFFICIENT STORAGE

28. Assured volume ..... line 18 X 1.4 gallons/foot = _____ gallons
29. Assured time ..... line 28/line 7 = _____ minutes
30. Shortfall volume ..... line 8 - line 28 = _____ gallons
31. Shortfall time .... line 6 - line 29 = _____ minute
32. Aquifer contribution volume ..... line 15 X line 31 = _____ gallons
33. Required additional storage ..... line 30 - line 32 = _____ gallons
34. Additional drawdown needed in well ..... line 33/1.4 gal/ft. = _____ feet

TOTAL WELL DEPTH AND PUMP PLACEMENT

35. Minimum total drawdown needed ..... line 14 + 10 feet = _____ feet
36. Depth below top of casing to place pump ..... line 9 + line 35 = _____ feet
37. Minimum total depth of well ..... line 36 + 10 feet = _____ feet

GLOSSARY

Aquifer contribution: the proportion of the well flow at any given time which comes directly from the aquifer.

Aquifer contribution rate: the maximum rate at which water can flow from an aquifer to a well. Here assumed to equal the pumping rate measured in the constant head test.

Aquifer contribution volume: the total volume of water which flows from the aquifer to the well during the shortfall time.

Assured time: the time it will take to pump the assured volume from the well at the peak demand rate.

Assured volume: the volume of water in a well below the static level and above the constant head level.

Constant head: a stable water level attained under a constant pumping rate. For this report a rate of change of less than 0.5 feet (6 inches) per hour is taken as stable.

Constant head drawdown: the drawdown in a well when a constant head condition has been attained. Here measured from the static water level at the end of the constant head test.

Constant head level: the water level in a well at the end of the constant head test. Measured from the top of the casing.

Constant head pumping rate: a constant pumping rate at which a stable water level is attained. The pumping rate during the constant head test.

Constant head test: a pumping test in which pumping rate and drawdown are kept constant with time. For this report a rate of change of less than 0.5 feet (6 inches) per hour is taken as constant.

Drawdown: the decline in the water level in a well during pumping. Measured from the static water level prior to pumping.

Hydropneumatic tank: a tank which uses compressed air to maintain pressure in a water supply system. It is only secondarily a water storage tank.

Peak demand rate: the average rate of water use by a household during peak demand periods.

Peak demand test: a pumping test conducted to evaluate the capability of a well to supply peak demand needs of a household. The test is conducted at a rate equal to or greater than the peak demand rate for the peak time.

Peak load: the volume of water required by a household during each peak demand period. In this report, the peak load is assumed to be half the estimated total daily household water consumption.

Peak time: the length in minutes of each of two daily peak demand periods.

Shortfall time: the time needed to pump the shortfall volume from a well at the peak demand pumping rate.

Shortfall volume: the volume of water needed in addition to the assured volume to make up the peak load.

Static level: the water level in a well before a pumping test when all effects of drilling and previous pumping on the aquifer have dissipated and the well is in equilibrium with atmospheric pressure.

Storage contribution: the proportion of the well flow at any given time which comes from storage in the well.

Well flow: the flow rate of water from a well at a given time. It is the sum of the aquifer contribution and the well storage contribution.

Well storage: the volume of water stored within a well which is available for pumping.

UNITS OF MEASUREMENT

Foot-pound-second (english) units of measurement are used in this report. These can be converted to International Standard (SI) units as follows:

Multiply	by	to obtain
inches	2.54	centimeters
feet	0.305	meters
gallons	3.79×10^{-3}	cubic meters
gallons/minute	6.31×10^{-2}	liters/second
gallons/day	3.79×10^{-3}	cubic meters/day