AQUIFER PERFORMANCE TEST (APT)

1985

Introduction

When the impacts resulting from a proposed groundwater withdrawal cannot be adequately predicted, the Staff may request that the Applicant proposing the groundwater withdrawal develop and implement an Aquifer Performance Test (APT) program.

As an aid to the Applicant or the Permittee, the Staff has compiled a set of guidelines for developing and implementing an APT program. The guidelines are not meant to portray an inflexible attitude about the manner in which an APT program should be conducted but are only designed to point out the general and basic aspects of an APT program. Depending on circumstances, i.e. flowing wells, alternative methodologies may be necessary. These circumstances should be discussed with the Staff prior to finalizing an APT program or any well construction.

The guidelines are subdivided into separate sections dealing with:

1) the initial site investigation,

2) the construction of on-site wells,

3) the step drawdown test,

4) the background data for the constant rate discharge test,

5) the constant rate discharge test,

6) the water quality of the aquifer,

7) the analysis of constant rate discharge test data, and

8) the contents of the Hydrogeologic Report.

The Staff should be notified before any major deviations from the proposed guidelines are instituted.

The successful completion of an APT program does not necessarily result in a Staff recommendation for the allocation of the quantity of water requested by the Applicant. The data collected during an APT program, however, often supports a request for the withdrawal of groundwater.

1.0 Initial Site Investigation

1.1 The initial site investigation should be performed as the first step in an APT program. During the initial site investigation, the following items should be addressed:

1) The most probable drilling depth and yield for a proposed test production well. These should be determined by reviewing existing data such as geologic well logs and hydrogeologic reports. A preliminary cross section indicating the thickness and water

quality (if appropriate) associated with the various production and confining zones should be constructed prior to selecting a drilling depth.

2) The location of possible sources of groundwater contamination.

3) The location of adjacent surface water bodies that may interact with the groundwater system.

4) The best means of routing the discharge water from the test production well site.

5) The location, total depth, cased depth, withdrawal rate, pumping schedule, pre-pumping water level, and specific capacity of adjacent pumping wells. If possible, the water levels should be referenced to the National Geodetic Vertical Datum (NGVD).

6) The location, total depth, cased depth, and static water level of existing wells that may serve as observation wells during the constant rate discharge. If possible, the water levels should be referenced to NGVD.

7) The tentative locations, total depths, and cased depths for the proposed test production well and observation wells necessary for the constant rate discharge test (see the subsection on 'Construction of On-Site Wells' for recommended number of wells, radial distances and depths). The potential adverse impacts that proposed withdrawals may have on existing uses or environmental features should be considered when locating the test production well.

1.2 After completing the initial site investigation, the Applicant or Permittee should schedule a meeting and present the proposed APT program to the Staff for discussion. The proposed APT program should specify the location, total depth, and cased depth of the proposed test production well and observation wells; the pump discharge rate; the routing of pump discharge water; the method and frequency of collecting water level data; and the method and frequency of collecting water quality data. The proposed program should follow the criteria specified in the following sections of these guidelines unless otherwise agreed to by the Staff. All proposed APT programs should be discussed with the Staff prior to accepting bids on the installation of test wells, test production wells or any services associated with the APT program.

2.0 Construction of On-Site Wells

2.1 In most cases, a minimum of three production zone observation wells and one shallow or adjacent aquifer observation well are necessary to conduct a constant rate discharge test. The construction of observation wells may be initiated after the proposed APT program has been agreed upon.

2.2 The radial distance of the observation wells from the test production well will vary depending on the type of aquifer, its thickness, its average conductivity and stratification. Presented here are some general rules to follow for the observation well placement:

1) For confined and semi-confined aquifers the production zone observation wells should be located between 100 - 700 feet from the pumped well. (As a general rule the nearest observation well should be at a distance which is at least equal to the thickness of the aquifer being tested.)

2) For unconfined or water-table aquifers the production zone observation wells should be located between 30-400 feet from the pumped well.

3) The observation wells should be placed along a line perpendicular to the regional groundwater flow.

2.3 The observation well located furthest from the test production well may be designed to satisfy the limiting condition accompanying most Water Use Permits which requires a continuous recording water level observation well.

2.4 The production zone observation wells should have screened or open hole segments that correspond to those of the test production well.

2.5 The shallow or adjacent aquifer observation well(s) should be located 50 feet from the test production well and constructed such that the anisotropic characteristics of the production zone (in the water table aquifer case) or the extent of the hydraulic connection across the semi-confining layers overlying or underlying the production zones (in the leaky artesian aquifer case) can be determined.

2.6 All wells should be developed in such a manner that a good hydraulic connection exists between the wells and the zones being monitored.

2.7 During the installation of the test production well and all observation wells, cuttings should be collected every five feet or formation change, whichever comes first. When drilling Floridan Aquifer wells, cuttings should be collected every ten feet or formation change, whichever comes first.

2.8 A geophysical log for all production and observation wells is recommended. A geologic log should be made for each well and a hydrogeologic cross section for the site of investigation should be developed using the geologic and geophysical logs from each well.

3.0 Step Drawdown Test

3.1 A step drawdown test should be performed on the completed and developed test production well as the third step in the APT program. The data collected during the step drawdown test can be used to predict the drawdown that will occur within the test production well at various discharge rates.

3.2 General Guidelines

3.2.1 This test is to be performed under rainless conditions.

3.2.2 There must be a means of obtaining access to the water in the production well so that the depth to water surface (water level) within the casing can be determined by using an electric water level probe or metal measuring tape.

3.2.3 The pump used during the step drawdown test must be capable of operating at various discharge rates. A calibrated orifice weir or some other calibrated flow meter should be installed on the discharge side of the pump so that the pump discharge can be determined.

3.2.4 For a water table or unconfined aquifer, if the pumped water cannot be routed to a storage tank or off-site through an existing water distribution system, a closed conduit or plastic lined trench should be used to transport the pumped water to an area 500 feet down gradient from the production well before it is discharged onto the land surface. As an alternative, it may be possible to route the pumped water to an existing adjacent surface water body. If the well is not in the water table aquifer, then the discharge distance may be reduced to 25 feet from the production well.

3.2.5 The step drawdown test should be performed at four constant discharge rates which represent approximately 50%, 65%, 85%, and 100% of the design capacity of the production well. Start pumping at the lowest discharge rate. Each step should be pumped for a specific time interval or until the water level in the well stabilizes (whichever comes first).

3.2.5.1 The length of each step should increase as the discharge increases, with the first step lasting not less than one hour long. Each step thereafter should increase by one-half hour, i.e., the second step - 1.5 hours, the third step - 2 hours, and the fourth step - 2.5 hours.

3.2.5.2 Take drawdown measurements every 3 minutes, recording the water levels to the nearest one tenth of a foot (0.1 ft).

3.2.5.3 For each water level measurement record the time, the distance from top of the casing to the water surface, the difference between the initial water level and the depth to water surface (drawdown), and the discharge rate.

3.2.5.4 After the drawdown has been determined, the discharge valve should be adjusted to obtain the constant discharge rate for the next step. It is important to maintain the discharge rate as close to constant as possible for each step.

3.2.5.5 Repeat the procedure for each increased discharge.

3.2.6 After the final increase, stop pumping and let the water level recover to prepumping conditions (approximately within one tenth of a foot, 0.1 ft, of the prepumping level). Measure and record the recovering water levels as was done for the pumping levels. A copy of the raw data collected during the test should be provided to District Staff.

3.3 The additional head loss that occurs as groundwater flows into the test production well can be calculated using the coefficients determined by plotting the constant discharge (Q) for each step versus the specific drawdown (s/Q) fo. each step on arithmetic scale paper. The District Staff can supply additional forms and instructions for the step drawdown test upon request.

Drawdowns observed within the test production well should be adjusted for well efficiency losses. Corrected drawdowns can then be used in a distance versus drawdown plot to determine the transmissivity of the aquifer.

4.0 Background Data for the Constant Rate Discharge Test

4.1 The collection of background data is the fourth step in the APT. This data can be used to determine if there may be outside interferences that could alter the results of the test.

4.2 General Guidelines

4.2.1 Prior to initiating the constant rate discharge test, the prepumping static water level (referenced to NGVD) should be determined in all observation wells, the test production well and adjacent surface water bodies for five days prior to the test. These water levels should be determined to the nearest 1/100 foot (0.01 ft), if possible.

4.2.2 If the constant rate discharge test is to be performed within 2,000 feet of tidal water or an adjacent pumping well, a continuous water level recorder should be placed on the well nearest the tidal water or adjacent pumping well.

4.2.3 The magnitude of the water level fluctuations indicated by the hydrograph will indicate if the raw drawdown and recovery data collected during the constant rate discharge test should be adjusted.

4.2.4 The time distribution and volume of adjacent pumpage and rainfall occurring 24 hours prior to initiating the constant rate discharge test should be recorded.

4.2.5 If possible, adjacent pumpage should be curtailed and rainfall should not occur two hours prior to initiating the constant rate discharge test. If pumpage cannot be curtailed, it is preferred that adjacent pumpage be done at a constant rate for 12 hours prior to and for the duration of the test.

5.0 Constant Rate Discharge Test

5.1 The constant rate discharge test should be conducted as the fifth step in the APT program. In general, when a constant rate discharge test is conducted within the Biscayne Aquifer, a twelve hour discharge period is recommended and in other areas of the District, a three day or greater discharge period is recommended.

5.2 Procedure and Guidelines

5.2.1 Not less than two hours prior to initiating the constant rate discharge test, the valve located on the discharge site of the test production well pump should be adjusted so that the initial discharge of the pump will be close to the constant discharge rate selected for the test. The discharge rate should approach the design capacity of the well.

5.2.2 The actual pump discharge should be recorded throughout the test. A calibrated orifice weir or some other calibrated flow meter should be installed on the discharge side of the pump so that the pump discharge can be determined.

5.2.3 If the pumped water cannot be routed to a storage tank or off-site through an existing water distribution system, a closed conduit or plastic lined trench should be used to transport the pumped water to an area 500 feet down gradient from the test production well before it is discharged onto the land surface. As an alternative, it may be possible to route the pumped water to an existing adjacent surface water body.

5.2.4 Drawdown and recovery water level measurements should be made to the nearest 1/100 foot (0.01 ft). Measurements should be made with a steel tape, graduated surveyor's chain, electric probe, continuous analog water level recorder or analog/digital recorder, or pressure-transducer recorder.

5.2.5 A predetermined schedule for measuring drawdowns should be initiated as soon as the test production well pump starts to discharge. It is suggested that drawdown measurements be made according to the following schedule:

Frequency of Measurement	Time after Pumping Stopped
Approx. every 15 seconds	0 to 2 minutes
Approx. every 30 seconds	2 to 5 minutes
Approx. every 1 minute	5 to 15 minutes
Approx. every 5 minutes	15 to 60 minutes
Approx. every 10 minutes	60 to 120 minutes
Approx. every 0.5 hour	2 to 5 hours
Approx. every 1 hour	5 to 72 hours (5 to 12 hrs. for Biscayne Aquifer Test)

5.2.6 After pumping the well at a constant rate for the agreed upon discharge period, the pump is stopped and recovery water level measurements are made. Recovery data should be collected for a four hour period after the pump is stopped or until water levels have recovered within 0.05 feet of the initial static water level. It is suggested that recovery measurements be made according to the following schedule:

Frequency of Measurement	Time after Pumping Stopped
Approx. every 15 seconds	0 to 2 minutes
Approx. every 30 seconds	2 to 5 minutes
Approx. every 1 minute	5 to 15 minutes
Approx. every 5 minutes	15 to 60 minutes
Approx. every 10 minutes	60 to 120 minutes
Approx. every 0.5 hour	2 to 4 hours

5.2.7 Rainfall that occurred during the constant rate discharge test should be recorded. The constant rate discharge test should be terminated if water levels in observation wells start to rise due to the effects of recharge from rainfall. Some fluctuations may be due to tidal or barometric effects.

5.2.8 A copy of all raw data collected during the constant rate discharge test should be provided to District Staff.

6.0 Water Quality of the Aquifer

6.1 As part of the APT, it is important to determine how the water quality of an aquifer responds to imposed stress.

6.2 This is done by sampling the water for chloride concentrations and conductivity at the following times:

1) during the step drawdown test (at the beginning of each step and at the end of the test),

2) before the APT begins, and

3) at the end of the APT.

6.3 This data shall be submitted along with the other test data.

7.0 Analysis of Constant Rate Discharge Test Data

7.1 As the sixth step of the program, the constant rate discharge test raw data should be analyzed by means of analytical or graphical techniques which are based on theory which reasonably depicts on-site conditions. The analysis should determine the transmissivity (gpd/ft) and storage coefficient of the production zone as well as the leakance (gpd/ft3) of any overlying confining zones. Recharge from surface water sources should be considered in the analysis. An attempt should be made to explain inconsistencies in the observed data. When necessary, the raw drawdown and recovery data should be adjusted to account for the effects of tidal fluctuations, adjacent pumpage, recharge from surface water, and partial penetration.

7.2 As an aid in analyzing data collected from a water table aquifer system, the Applicant or the Permittee may want to refer to the works of Neuman (1975) on fully penetrating water table wells with no storage capacity, Papadopulos (1967) on fully penetrating non-leaky artesian wells with storage capacity, Streltsova (1974) on partially penetrating water table wells with no storage capacity and Boulton and Streltsova (1976) on partially penetrating water table wells with storage capacity.

7.3 As an aid in analyzing data collected from a leaky artesian aquifer system, the Applicant or Permittee may want to refer to the works of Hantush and Jacob (1955) and Hantush (1959) on fully penetrating leaky artesian aquifer wells with no storage capacity and no aquitard storage changes, Hantush (1964) on partially penetrating leaky artesian aquifer wells with no storage capacity and aquitard storage changes, Papadopulos (1967) on fully penetrating non-leaky artesian aquifer wells with storage capacity and Hantush (1961) and Weeks (1969) on the effects of partial penetration of aquifer wells with no storage capacity.

7.4 Additional useful references dealing with the analysis of data collected during a constant rate discharge test are Kruseman and De Ridder (1970), Lohman (1972) and Walton (1970). The above references are fully cited in the attached bibliography.

8.0 Hydrogeologic Study

8.1 As the final step in an APT program, the Applicant or Permittee should assemble a hydrogeologic study report.

8.2 Items to be Included in the Report

8.2.1 A section describing the geologic and hydrogeologic conditions that exist at the site of investigation. The description should incorporate a hydrogeologic cross section developed from the geologic and geophysical well logs compiled for the test production well and the three production zone observation wells. The cross section should indicate the thickness and relative location of each production zone and confining zone as well as the water quality and the relative head for each zone.

8.2.2 A section describing the construction of the test production well, the four observation wells required for the constant rate discharge test and any other adjacent wells. The cased and uncased depth of each well should be indicated on a hydrogeologic cross section. The locations of pertinent wells and surface water bodies should be indicated on a 7 1/2 minute USGS quadrangle map. The report should indicate the distance from each well or surface water body to the test production well.

8.2.3 A section describing the procedure used for running the step drawdown test and the constant rate discharge test as well as the technique used in determining the discharge of the test production well, in routing the pumped water away from the test production well, and in determining the changes in water levels.

8.2.4 A section describing how the data collected during the step drawdown test and the constant rate discharge test was analyzed to determine the hydraulic characteristics of the hydrogeologic system. Use the terms s, Q, t, and r, where s = drawdown, Q = discharge, t = time, and r = radius from pumped well, to describe the data.

8.2.4.1 The analysis of the data collected during the step drawdown test should include a plot of Q vs. s/Q.

8.2.4.2 The analysis of the data collected during the constant rate discharge test should include individual plot figures indicating the drawdown data collected from each well. These should be plots of:

1) log t/r2 vs. log s on log-log paper (K and E Log paper, No. 46-7522, should be used when plotting constant rate discharge test data so that published type curves can be used to check indicated match points), and

2) log t/r2 vs. s on semi-log paper.

8.2.4.3 In addition, one plot of log r vs. s for each well on semi-log paper.

8.2.4.4 Any of the above figures not discussed in the text of the Hydrogeologic Report should be included in the Report's Appendix. If a graphical solution involving type curves is used in the determination of the aquifer characteristics, the pertinent curves and match points should be provided. The report should indicate the basis for selecting the value of transmissivity, storage coefficient and leakance most representative of the hydrogeologic system.

8.2.5 A section describing the impacts that proposed withdrawals will have on water levels and water quality within the selected production zone and adjacent confining zones or production zones.

8.2.5.1 If the proposed withdrawals are from a water table aquifer system, the Applicant or Permittee should calculate the theoretical time variant cone of depression that would develop in the absence of rainfall after 30, 60, 90 and 180 days of pumpage at the proposed withdrawal rate. The calculations for a water table aquifer system should utilize the most representative transmissivity value derived from the APT program and an appropriate storage coefficient.

8.2.5.2 If the proposed withdrawals are from a leaky artesian aquifer system, the Applicant or Permittee should calculate the theoretical steady state cone of depression that would develop at the proposed withdrawal rate. The calculations for a leaky artesian system should utilize the most representative transmissivity and leakance values derived from the APT program.

8.2.5.3 In all cases, the Applicant or Permittee should calculate the cumulative cone of depression when withdrawals from multiple wells are proposed.

8.2.5.4 The resultant cones of depression should be indicated on a 7 1/2 minute USGS quadrangle map.

8.2.5.5 The Applicant should also address the impacts that lowered water levels will have on the surrounding environmental features (including wetlands), adjacent existing legal uses, water bodies, etc.

8.2.6 A section tabulating all water level, rainfall, pump discharge and adjacent pumping data collected throughout the APT program. Copies of hydrographs should also be included in this section. All water levels should be referenced to the National Geodetic Vertical Datum (NGVD).

STEP DRAWDOWN TEST
1985

Introduction

District Staff has compiled a set of guidelines for performing a Step Drawdown Test (SDT). These guidelines are presented here as an evaluation aid for the Applicant or Permittee. The SDT is used by the SFWMD to evaluate the water yielding capacity of the aquifer. In addition, the test is used to determine the efficiency of the wells used by the Permittee.

1.0 General Guidelines

1.1 This test is to be performed under rainless conditions.

1.2 There must be a means of obtaining access to the water in the production well so that the depth to water surface (water level) within the casing can be determined by using an electric water level probe or metal measuring tape.

1.3 The pump used during the SDT must be capable of operating at various discharge rates. A calibrated orifice weir or some other calibrated flow meter should be installed on the discharge side of the pump so that the pump discharge can be determined.

1.4 Routing of Discharge Water

1.4.1 For a water table or unconfined aquifer, if the pumped water cannot be routed to a storage tank or off-site through an existing water distribution system, a closed conduit or plastic lined trench should be used to transport the pumped water to an area 600 feet down gradient from the production well before it is discharged onto the land surface. As an alternative, it may be possible to route the pumped water to an existing adjacent surface water body.

1.4.2 If the well is not in the water table aquifer, then the discharge distance may be reduced to 25 feet from the production well.

1.5 The SDT should be performed at four constant discharge rates which represent approximately 50%, 65%, 85%, and 100% of the design capacity of the production well.

1.5.1 Start pumping at the lowest discharge rate.

1.5.2 Each step should be pumped for a specific time interval or until the water level in the well stabilizes (whichever comes first).

1.5.3 The length of each step should increase as the discharge increases, with the first step lasting not less than one hour long. Each step thereafter should increase by one-half hour, i.e., the second step - 1.5 hours, the third step - 2 hours, and the fourth step - 2.5 hours.

1.5.4 Take drawdown measurements every 3 minutes, recording the water levels to the nearest one tenth of a foot (0.1 ft).

1.5.5 For each water level measurement record the time, the distance from top of the casing to the water surface, the difference between the initial water level and the depth to water surface (drawdown), and the discharge rate.

1.5.6 After the drawdown has been determined, the discharge valve should be adjusted to obtain the constant discharge rate for the next step. It is important to maintain the discharge rate as close to constant as possible for each step.

1.5.7 Repeat the procedure for each increased discharge.

1.6 After the final increase, stop pumping and let the water level recover to prepumping conditions (approximately within one tenth of a foot, 0.1 ft, of the prepumping level). Measure and record the recovering water levels as was done for the pumping levels.

2.0 Water quality aspects of the aquifer should be determined by sampling the water for chloride concentrations and conductivity at the beginning of each step and at the end of the test.

3.0 A copy of the raw data collected during the test should be provided to District Staff. Sample forms for data collection are attached.

Step Drawdown Form

Permit number:____________ Application number:_______________

Applicant's Name:___________________________

Project Name:_______________________________

Project Location: Section:___ Township:___ Range:___

Weather Conditions:_________________________

Test Operator:_____________ Test Date:____________

Pump Characteristics: Power:___HP; Discharge Diameter:___IN

Flow Meter Type:__________________

Static water Level:____FT from the Top of Casing

Discharge Rate (GPM)	Time (MIN)	Depth from Top of Casing to water Surface (FT)	Drawdown* (FT)	Chloride Conc. (MG/L)	Conductivity (MICROMHOS/CM)

* Drawdown is the static water level minus pumping level.

NOTE: Attach copy of well log and completion report.