Guidance for New Source Water Testing Procedures for Public Drinking Water Systems

Idaho Department of Environmental Quality

December 2007

Acknowledgments

The Idaho Department of Environmental Quality (DEQ) would like to acknowledge the efforts of the following people, who provided expertise and insights for this guidance.

Gary Stevens

Barry N. Burnell

Gerry Winter

Ed Squires

Ed Hagan

Lisa Hansen

Table of Contents

Background

New public water systems are being proposed in areas not currently serviced by established public utilities. The proposed public water systems use newly completed wells to supply water for consumptive use and lawn irrigation to the homeowners. Wells are sometimes completed in aquifers that may have marginal conditions for long-term production and this could result in decreased water quantities with time. There have been occasions where production rates have greatly decreased and wells have lost the ability to provide adequate volumes of water, thereby leaving owners of public water systems and their patrons, with very expensive well rehabilitation costs. Or in some cases the public water system owners have decided to connect to near-by existing public water systems or developing a new water well and distribution systems from more distant locations. In these instances, the maximum allowable long-term production rate (adequate yield) might have been better predicted using more comprehensive testing and analysis of new public drinking water wells.

This guidance defines adequate yield for a proposed community water system and provides suggested aquifer testing methods, procedures and analysis necessary for predicting the long-term production capabilities of new water wells. The goal of this guidance is provide options for supporters of new public water supply wells on how to determine aquifer and well construction characteristic that will demonstrate the ability to provide sufficient water to the development. The testing procedures will provide information that can be used for choosing the characteristics of the permanent water well pump and will provide baseline information that would help diagnose any future potential well maintenance issues.

Introduction

Purpose

DEQ approval of a new water system well is dependent upon a water well evaluation demonstrating acceptable ground water quality and sufficient quantity. This guidance, which proposes a procedure for evaluating the potential long-term yield from a new community well, consists of three parts: 1) Aquifer Testing, 2) Data Analysis, and 3) Projection of Long-Term Drawdown. The applicant should consult with a knowledgeable and experienced ground water professional prior to the initiation of any testing and analysis.

Scope

This guidance provides procedures that address aquifer testing requirements, as per IDAPA 58.01.08.510.06, after the well has been constructed and developed. This guidance provides information regarding DEQ's option to require additional site specific investigations if aquifer yield, sustainability, or water quality are questionable, per IDAPA 58.01.08.510.06.e. The construction of the production well should maximize the efficiency of the well and reduce long-term maintenance. The well should also be constructed and designed in accordance with AWWA-A100-06 and/or EPA 570/9-75-000. The production well shall comply with the minimum well construction standards per IDAPA 58.01.08.510.03.

1.0 Aquifer Testing

1.A Conceptualization

Develop a conceptual understanding of the ground water system. The applicant should collect all available information regarding the geology/hydrogeology of the area. This information should include, but not be limited to: driller's logs, published geologic/ hydrogeologic reports, geologic maps, topographic maps, and satellite imagery. Conceptualization and characterization should be in general accordance with ASTM D5979, Standard Guide for Conceptualization and Characterization of Ground Water Systems.

1.B Testing Selection

Based on the conceptual model developed as described in 1.A, select an aquifer test that will determine aquifer characteristics and define the presence of hydraulic boundary conditions, so that long term yield may be reasonably projected. The selection of the appropriate hydraulic testing procedures should be in general accordance with ASTM D4043, Standard Guide for Selection of Aquifer Test Method in Determining of Hydraulic Properties by Well Techniques.

1.C Testing

The aquifer test should be performed in general accordance with ASTM D4050, Standard Test Method (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems, or should follow operating procedures suggested in EPA/540/S-93/503.

1.C.1 Pretest

A pretest as determined from the conceptualization and test selection described in 1.A and 1.B above should be performed to determine the constant pump rate that can be maintained throughout the length of the desired test. A step test would be beneficial in determining this rate, along with measuring the well efficiency. This test should be performed at a time so that static water level returns to at least 95% of static conditions, or projected static conditions if there is an antecedent trend present (see below), before beginning the long-term aquifer test.

Depending on aquifer conditions, it maybe necessary to measure antecedent water level trends and the potential to affect water level drawdown data. These antecedent trends may be caused by precipitation, area pumping, or changes in barometric pressure. Depending on aquifer conditions, it may be necessary to measure atmospheric pressures and/or discharge rates and record pump schedules from area wells. In all cases, the measurements should be made before, during, and after the aquifer test for a period sufficient to correct the drawdown and recovery data if necessary.

1.C.2 Observation Wells

It should be determined if additional wells are available in the area and appropriate to measure water level drawdown during the aquifer test. The information derived from the water level drawdown data in the observation wells can be used to determine aquifer properties, specifically storativity. The drawdown in the observation wells can be critically helpful with determining the location and impacts from boundary conditions (including other pumping wells) and/or geographic changes in aquifer properties.

1.C.3 Discharge Rates

The aquifer and/or pumping tests require accurate and continuous measurement of discharge rate and water level drawdown. The discharge rate should be in general accordance with ASTM D5737, Standard Guide for Methods for Measuring Well Discharge. The methods of measuring discharge rate are generally:

1) using an in-line flow meter with volume totalizer;
2) measuring a fixed volume over time with a bucket or 55-gallon drum;
3) using a sharp crested weir; or
4) using a circular orifice weir constructed with an optimally sized orifice plate and manometer.

A sharp crested weir should be used and constructed in general accordance with ASTM D5737. A circular orifice weir and manometer should be used and constructed in general accordance with ASTM D5716, Standard Test Method for Measuring the Rate of Well Discharge by Circular Orifice Weir.

If an in-line meter is to be used, the discharge rate should be measured simultaneously with one of the other methods described above with sufficient frequency to calibrate and cross-check the discharge rate against the in-line meter data.

1.C.4 Discharge Water

Discharge water should be pumped to a location as distant from the wellhead as practicable if there is any possibility that the discharged water may infiltrate to the aquifer and affect water level drawdown data. The discharge location should generally be in a down gradient location as far from the wellhead as possible. If a surface water body is present and the ground water quality meets regulatory requirements, the water could be discharged into the surface water body with the appropriate discharge permits, or short term activity exemption as authorized in the Surface Water Quality Standards IDAPA 58.01.02.080.02 and written permission of the surface water body administrator or watermaster.

1.C.5 Water Level Drawdown Measurement

The water level drawdown can be measured with an electric tape (e-tape) and/or pressure transducers with the correct depth and pressure ranges. It is suggested that a pressure transducer be installed and confirmation drawdown data be obtained with manual readings at the pumping well and distant observation wells. The pressure transducer should be programmed so that there is a sufficient number of data points obtained in the early time data. See ASTM D4050 or EPA/540/S-93/503 for suggested schedule. All measurements should be obtained to the nearest 0.01 foot.

1.C.6 Recovery

Recovery data should be measured until the water levels are at least 90% of the pre-pumping level, or projected pre-pumping level if an antecedent trend is present. It is imperative that a check valve be installed within the discharge plumbing to obtain accurate recovery water levels.

1.C.7 Pump Times

The aquifer test should be pumped continuously for a minimum of 24 hours. Longer pump times may be anticipated depending on the requirements of the aquifer test such as interception of boundaries and the acquisition of enough data for comparison to type curves. Exceptions to the 24-hour minimum can be made on a case by case basis at the discretion of DEQ. If it is expected or decided that the aquifer test will be less than 24 hours, DEQ should be consulted before or during the test before termination occurs.

1.C.8 Documentation

Documentation for the aquifer test should, at a minimum, consist of the following:

1.C.8.a A map showing the location of the pumping well with respect to any observation or nearby pumping wells, including distances to the same. The map should also identify any potential or perceived boundary conditions that may affect the aquifer test and also the details of the pump discharge location and configuration.

1.C.8.b The driller's log and/or as-built construction diagram for the pumping well and any observation wells used.

1.C.8.c The kind of pump and type of power source (generator, power line, direct drive, etc.) used, along with pump placement location within the well.

1.C.8.d The date, times, elapsed times, measured water level data, discharge rates, and any observations or measured physical parameters of the discharged water obtained as part of the pumping pretest.

1.C.8.e The date, times, elapsed times and water level data, measured in the observation well or wells obtained as part of the aquifer test.

1.C.8.f The equipment, personnel, and methods used for measuring water level drawdown and discharge rates.

2.0 Data Analysis

2.A Objective

The objective of the data analysis is to determine: 1) a representative transmissivity and, in multiple well tests, storativity of the aquifer; and 2) the effects of boundary conditions.

2.B Analysis Process

The aquifer test data analysis method will be dependent on the conceptual model described in 1.A above. The aquifer test data analysis should be conducted in general accordance with the following ASTM standard guides; D4105, D4106, D5269, D5270, D5786, D5920. There are numerous books and publications describing aquifer test data analysis that include, but are not limited to: *Aquifer Testing* (Dawson and Istok, 1991), *Analysis and Evaluation of Pumping Test Data* (Kruseman and de Ridder, 2000*), Production Well Analysis* (Kasenow, 1996) and *Groundwater and Wells* (Driscoll, 1986).

2.C Software Applications

There are also available a number of software programs that can used to complete the data analysis of aquifer test drawdown data that include, but are not limited to: *Aqtesolv* (Hydrosolv, Inc.), *Aquifer Test* (Scientific Software Group) and *Aquifer*^{win32} (Environmental Simulations, Inc.).

2.D Calculations

The drawdown and recovery test data from both the pumped well and observation well(s) (if applicable) should be used and the calculated aquifer properties compared and reported.

2.E Documentation

Documentation for the aquifer test data analysis should, at a minimum, consist of the following:

- The data analysis method used.
- Justification for using this method.
- Any aquifer property and well construction data used in the data analysis.
- Plots showing both drawdown data and type curves used.
- Plots showing both recovery data and type curves used.
- Calculated transmissivity and storativity data for each well used.

3.0 Projection of Long-Term Drawdown

3.A Purpose

The purpose of predicting long-term drawdown is to evaluate whether the aquifer, based on aquifer test data, will provide sufficient yield to support the proposed public water system consumptive use. The predicted drawdown should be calculated from aquifer parameters determined from the aquifer test, the required long-term pumping rate, and an assumed continuous pump period of one year. Available drawdown is defined as the distance between the static water level and the pump intake. The pump intake should be no deeper than the top of the well screen or uppermost water bearing unit.

3.B Determination

The long-term pumping rate (LTPR) should be determined as follows:

LTPR = Number of households x (800 gallons per day* + Irrigation required per day**).

Where: Number of households = Total projected households that will be served by the public water supply well.

* 800 gallons per day = Rate of water per day necessary for domestic drinking water as described in IDAPA 58.01.08.552.01.a.

** Irrigation = Rate of water per day necessary for landscaping irrigation as described in IDAPA 58.01.08.552.01.d.

3.C Drawdown

The drawdown should be determined using the transmissivity and storativity values calculated in 2.B above. If storativity values are available from the aquifer test then these should be used. If only a single well test was completed and storativity values cannot be calculated then the following values should be used: 1) 1.0×10^{-2} for an unconfined aquifer, or 2) 1.0×10^{-4} for a confined aquifer.

3.D Calculations

The drawdown in the pumping well using the LTPR results should be calculated for pumping continuously for one year using the Theis equation (Fetter, 1988; Freeze and Cherry, 1979) or other appropriate analytical method. If there are significant boundary conditions then either image wells (Ferris et al., 1962) or a numerical model should be employed to determine the effects on production rates over time. If there are significant changes in the aquifer properties over the area of concern then the use of a numerical model would be appropriate. If a model is to be used, a ground water professional should be consulted. The ground water model should be constructed in general accordance with

the following ASTM standard guides: D5718, D5490, D5490, D5609, D5610, D5611, D5920.

3.E Documentation

Documentation for the predicted long-term drawdown should at a minimum consist of the following:

- The analytical method used to calculate drawdown or description of the numerical model.
- Justification for using this method.
- Equations and calculations with all parameters defined, if an analytical method is used.
- If a numerical model is used, documentation should be in general accordance with ASTM D5718.

Limitations

The predicted drawdown is based on the hydraulic test data, which reflect current and potential short-term conditions. Both the aquifer properties and boundary conditions can change over time causing a significant reduction in the long-term discharge rate of the well. **A reduction in discharge rate may be such that there is insufficient water to meet the needs of the public water system. The use of the procedures in this guidance does not constitute a measure of safe or sustained yield. Approval by DEQ does not guarantee the necessary well discharge volume or rate from the water source in perpetuity.**

If you have any questions, please contact one of the offices listed in appendix A.

References

Dawson, K.J., 1991. Aquifer Testing: Design and Analysis of Pumping and Slug Tests. Lewis Publishers Inc., Chelsea, Michigan.

Driscoll, F.G., 1986. Groundwater and Wells. Johnston Filtration Systems Inc., St. Paul, Minnesota.

Environmental Simulations, Inc., AQUIFER^{win32}, New York.

Ferris, J.G., D.B. Knowles, R.H. Brown, and R.W. Stallman, 1962. Theory of Aquifer Tests, U.S. Geological Survey Water-Supply Paper 1536 E.

Fetter, C.W., 1988. Applied Hydrogeology. Merill Publishing Company, Columbus, Ohio.

Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice Hall, Inc., New Jersey.

Hydrosolv, Inc., AQTESOLV for Windows, Reston, Virginia.

Kasenow, M., 1996. Production Well Analysis: New Methods and a Computer Program in Well Hydraulics. Water Resources Publications LLC., Highlands Ranch, Colorado.

Kruseman, G.P. and N.A.de Ridder, 2000. Analysis and Evaluation of Pumping Test Data. Publication 47, International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands.

Scientific Software Group, Inc., AQUIFER TEST, Sandy, Utah.

Appendix A: DEQ Regional and District Health Department Offices

DEQ maintains regional offices in Boise, Coeur d'Alene, Idaho Falls, Lewiston, Pocatello and Twin Falls (Figure 1). Each region's staff consists of specialists in air quality, water quality, and waste management and remediation issues. They are knowledgeable about environmental issues in their particular regions and work directly with citizens, businesses, and industries to implement the state's environmental policies and programs. Contact information for each office is in Table A.

Figure 1. Map of DEQ regions.

Table A. DEQ regional office contact information

Boise Regional Office	1445 N. Orchard	Boise, ID 83706	ph: (208) 373-0550 fax: (208) 373-0287
Coeur d'Alene Regional Office	2110 Ironwood Pkwy	Coeur d'Alene, ID 83814	ph: (208) 769-1422 fax: (208) 769-1404
Idaho Falls Regional Office	900 N. Skyline, Suite B	Idaho Falls, ID 83402	ph: (208) 528-2650 fax: (208) 528-2695
Lewiston Regional Office	1118 "F" Street	Lewiston, ID 83501	ph: (208) 799-4370 fax: (208) 799-3451 toll free: (877) 541-3304
Pocatello Regional Office	444 Hospital Way, #300	Pocatello, ID 83201	ph: (208) 236-6160 fax: (208) 236-6168
Twin Falls Regional Office	1363 Fillmore St.	Twin Falls, ID 83301	ph: (208) 736-2190 fax: (208) 736-2194

For questions regarding *subsurface disposal*, contact the appropriate Idaho Health District, listed in Table B.

Table B. Contact information for District Health Departments

Idaho District Health Department	Counties Served
Health District I Panhandle Health District 8500 N. Atlas Road Hayden, ID 83835 (208) 415-5200 http://www2.state.id.us/phd1/	Benewah, Bonner, Boundary, Kootenai, Shoshone
Health District II North Central District Health 215 10th Street Lewiston, ID 83501 (208) 799-3100 http://www.ncdhd.us/	Clearwater, Idaho, Latah, Lewis, Nez Perce
Health District III Southwest District 920 Main Street Caldwell, ID 83605-3700 (208) 455-5345 http://www.publichealthidaho.com/	Adams, Canyon, Gem, Owyhee, Payette, Washington
Health District IV Central District Health 707 North Armstrong Place Boise, ID 83704-0825 (208) 327-7450 http://www.phd4.state.id.us/	Ada, Boise, Elmore, Owyhee
Health District V South Central District Health 1020 Washington Street North Twin Falls, ID 83301-3156 (208) 734-5900 http://www.phd5.idaho.gov/	Blaine, Camas, Cassia, Gooding, Jerome, Lincoln, Minidoka, Twin Falls
Health District VI Southeastern District 1901 Alvin Ricken Drive Pocatello, ID 83201 (208) 233-9080 http://www2.state.id.us/phd6/	Bannock, Bear Lake, Bingham, Butte , Caribou, Franklin, Oneida, Power
Health District VII 254 E Street Idaho Falls, ID 83402-3597 (208) 522-0310 http://www2.state.id.us/phd7/	Bonneville, Clark, Custer, Fremont, Jefferson, Lemhi, Madison, Teton