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SUBSTANTIVE POLICY STATEMENT

This substantive policy statement is advisory only. A substantive policy statement does not include internal procedural documents that only affect the internal procedures of the agency and does not impose additional requirements or penalties on regulated parties or include confidential information or rules made in accordance with the Arizona administrative procedure act. If you believe that this substantive policy statement does impose additional requirements or penalties on regulated parties you may petition the agency under Arizona Revised Statutes § 41-1033 for a review of the statement.

HYDROLOGIC STUDIES DEMONSTRATING PHYSICAL AVAILABILITY OF GROUNDWATER FOR ASSURED AND ADEQUATE WATER SUPPLY APPLICATIONS

The Assured and Adequate Water Supply Rules, A.A.C. R12-15-701 through R12-15-730, require applicants to submit hydrologic information to support certain aspects of their applications. An applicant for a physical availability determination,[1] a determination of assured water supply, or a determination of adequate water supply seeking to demonstrate physical availability of groundwater must "submit a hydrologic study, using a method of analysis approved by the Director of the Arizona Department of Water Resources (Director) that accurately describes the hydrology of the affected area." A.A.C. R12-15-716(B). The requirements for demonstrating physical availability of a groundwater supply are based on maximum depth-to-static water levels after a 100-year period. Outside Active Management Areas (AMA), the Director will allow an applicant to use a lower maximum 100-year depth-to-static water level if the applicant demonstrates financial capability to access the groundwater at the lower depth and that "[g]roundwater is available at the lower depth." A.A.C. R12-15-716(C). This Policy explains what elements the Department will require for each of these demonstrations. This document only applies to hydrologic studies seeking physical availability for a groundwater supply source. Applicants planning to utilize surface water supplies are strongly advised to meet with the Arizona Department of Water Resources (Department) staff for specific hydrologic study requirements. In addition, applicants seeking assured water supply determinations in the Santa Cruz AMA should meet with Department staff due to the unique

[1] This Policy incorporates all definitions in the Assured and Adequate Water Supply Rules. *See* A.A.C. R12-15-701.

conditions within the AMA. The Department will be preparing a separate set of guidelines for those applicants seeking assured water supply determinations within the Santa Cruz AMA.

The necessary elements of a hydrologic study may vary widely from one location to another based on numerous factors, including the hydrologic and geologic features, the water demands, and the available hydrologic data in the area. This Policy is intended to advise the public of the elements that should be included in hydrologic studies. In particular, this Policy explains the "method of analysis" that is generally appropriate for most hydrologic studies. Some locations may require more information than this Policy suggests, while other locations may require less. In most cases, a hydrologic study that properly addresses each of the elements set forth in this Policy will provide sufficient information for the Department to determine whether the application meets the requirements of A.A.C. R12-15-716(B) or A.A.C. R12-15-716(C). The Department may approve a hydrologic study that varies from this Policy, but the variations may require additional explanation from the applicant and additional review time during the application process.

The Department strongly recommends that applicants and their technical consultants[2] meet with Department representatives prior to submitting applications for which hydrologic studies are required. The Department staff will provide technical guidance on how best to meet the required criteria in the context of a specific application. This is especially true in areas that have complex hydrogeology, areas where there is limited hydrogeologic data available, and in areas experiencing rapid growth with limited groundwater supplies. After the pre-application meeting and before preparation of the hydrologic study, the applicant should submit a study proposal, including a general description of the project[3] (with approximate size and demand estimate), a regional and/or project map with cadastral data (township, range and section notations), project boundary and study area boundary (if applicable). The hydrologic study proposal should outline what data is currently available to analyze the hydrogeologic conditions, if any, and a proposal to collect and analyze any needed additional data. The Department will review the study proposal and respond back to the applicant with comments and suggestions for possible inclusion into the final hydrologic study. To arrange a pre-application meeting, the applicant should contact the Department's Office of Assured and Adequate Water Supply (OAWS).

I. DEPTH-TO-STATIC WATER LEVEL OUTSIDE AMAS

For developments outside AMAs, the maximum 100-year depth-to-static water level is 1200 feet below land surface. For determinations of adequate water supply and physical availability determinations outside AMAs, the Department will issue a variance from the maximum 100-year depth-to-static water level if two conditions are met. The applicant must demonstrate that groundwater is available in a hardrock aquifer at the lower depth and that the applicant has the financial capability to access the groundwater at the lower depth. A.A.C. R12-15-716(C).

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[2] Applicants frequently hire technical consultants to assist in evaluating hydrogeologic information. Throughout this Policy, references to "the applicant" implicitly include any technical consultant hired by the applicant.

[3] For purposes of this Policy, "project" refers to the project that is the subject of the application, i.e., the subdivision, for a certificate or water report application, or the service area, for a designation application.

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A. AVAILABILITY OF GROUNDWATER AT THE LOWER DEPTH

The variance from the maximum depth-to-static water level criterion is intended to apply only where groundwater naturally occurs in hardrock aquifers at depths greater than 1200 feet below land surface. Generally speaking hardrock aquifers in sandstone, limestone, and shale type formations would be eligible for the depth exemption. The Director will determine that groundwater is available at a depth greater than 1200 feet below land surface only if the applicant demonstrates that a volume of groundwater sufficient to meet the applicant's estimated water demand for 100-years is available at the lower depth and that withdrawing the water from the lower depth will not cause the depth-to-static water level to exceed 1200 feet below land surface in locations where the Department has issued determinations of adequate water supply without a variance.

In some cases, demonstrating that groundwater is available at the lower depth requires long-term investigations, due to a lack of data and information about the deep aquifer system. In such cases, the applicant may develop a long-term plan for conducting investigations and obtaining the required information. The Department will not issue a variance until the required information is submitted and approved, but will work with the applicant to develop a plan for monitoring and testing, to help ensure that the proposed methods will yield results acceptable to the Department.

The plan must outline the steps the applicant will take and the data the applicant will collect to demonstrate the availability of the groundwater below 1200 feet below land surface. The plan should focus on advanced long-term aquifer testing, extra hydrogeologic data collection, advanced studies (such as geophysical surveys) and any other data or testing required to demonstrate the physical availability of groundwater within the deep aquifer system.

B. FINANCIAL CAPABILITY

The Director will determine that the applicant has the financial capability to obtain the groundwater at the lower depth if the applicant has drilled a well or wells at the lower depth with sufficient capacity to meet the estimated water demand of the application. Dry lot subdivisions are not eligible for the variance from the 100-year maximum depth-to-static water level criterion because the applicant cannot demonstrate the financial capability of future homeowners.

II. DEMONSTRATING PHYSICAL AVAILABILITY OF GROUNDWATER

The Department will evaluate hydrologic studies intended to demonstrate the physical availability of groundwater based on the depth-to-static water level after 100 years of pumping to meet the "total demand," as that term is described in Part II(C) of this Policy. Please see A.A.C. R12-15-716(B) for further detail. For subdivisions that will be served by a municipal provider,[4] this criterion is applied to wells located within the service area of the municipal provider, or from wells that are likely to be constructed for future use by the municipal provider. *See* Part II(E)(8) of this Policy. For dry lot developments, the Department will presume that a well will be drilled on each individual lot. The hydrologic study must incorporate this assumption. The Department

[4] Note that the term "municipal provider" includes cities, towns, private water companies, community facilities districts, and domestic water improvement districts.

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does not recognize shared well arrangements. If the hydrologic study demonstrates that any lot within a dry lot subdivision will exceed the 400-foot maximum depth-to-static water level, the Department will consider the entire project to exceed the maximum depth-to-static water level.

In general, the hydrologic study must be clearly written, contain an orderly presentation of data, and utilize currently accepted scientific practices. Well-documented, well-written, scientifically sound studies allow the Department to review the submittals more quickly and precisely. Properly prepared studies contain several common elements: delineation of the study area and project area, identification and characterization of the water supply, data availability and data collection needs, identification and characterization of the demands, identification of the project and application type, as well as maps, figures, tables, and references. The size of the area studied should be commensurate with the physical size, project demand, and anticipated impacts from the proposed project. Every hydrologic study must incorporate the following elements: executive summary, general description of the water supply, aquifer characterization and evaluation, impact analysis, conclusions, references, and supporting maps, tables and other figures.

Maps presented in the study must have a north arrow, a scale, a legend, cadastral information (township-range-section lines), and the boundary of the proposed development, study area, and/or water provider. Regional maps must incorporate a USGS topographic base map of appropriate scale, land elevation contours, highways and other prominent cultural features. If relevant, other subdivisions, boundaries of municipal providers (Certificate of Convenience and Necessity [CC&N] boundaries for a private utility, district boundaries, city corporate limits etc.), AMA and groundwater basin/sub-basin boundaries, major surface water drainages, bedrock boundaries, and any other unique regional features must also be delineated. More localized maps must also include land surface contours where relevant, major streets, other prominent cultural features, and any other local features that will clarify the locality. Applicants must label each axis and show all data points on graphs. All maps and figures (including all labels and numbers) must be of sufficient size to allow for a detailed review. For all localized groundwater and hydrogeologic maps, the contour interval is suggested to be set at twenty feet or less. For all other maps, the applicant should choose an appropriate contour interval to show sufficient detail.

In addition to standard references for all published literature (including hydrologic studies from other consultants for other proposed developments relied on by the applicant) the study must include complete references for all sources of data used within the study. Sources of geologic data, hydrologic data, and groundwater information must also be listed.

A. EXECUTIVE SUMMARY

The Executive Summary must concisely describe the proposed project, the calculated demand of the study area, and the planned water supply. For an application for a certificate, water report or analysis, the Executive Summary must provide the project location, and a general description of the project. The Executive Summary must briefly describe the 100-year physical availability of the water supply and how it relates to the total demand, and must summarize the supporting documentation.

B. INTRODUCTION

The Introduction must provide an overview of the project and how the hydrologic study proves that the planned water supply is sufficient for the total project demand for 100 years. The Introduction must define the study area and relate it to the project. For an application for a certificate, water report or analysis, the Introduction must identify whether the subdivision or development will be served by a municipal provider through a central distribution system or will be a dry lot development. If the development will be served by a municipal provider through a central distribution system, the Introduction must identify the municipal provider, if known. If more than one municipal provider will serve the subdivision, the Introduction must identify all municipal providers and explain the extent of service. The study area may extend beyond the municipal provider's service area, CC&N boundaries, or district boundaries.

The Introduction must provide a legal description of the location of the proposed project and illustrate the location with maps that include known cultural and topographical features. The Introduction must describe the general topography, the physiographic setting, and any unique physical characteristics of the area. The Introduction must state the groundwater basin(s) and sub-basin(s) in which the project is located and whether the project is located within an AMA.

C. DEMAND DESCRIPTION

Applications seeking to demonstrate physical availability of groundwater must estimate the depth-to-static water level at the end of the 100-year evaluation period. This estimate must include the impact on the current depth-to-static water level from all existing uses of groundwater within the study area, demands associated with all issued determinations of assured water supply and determinations of adequate water supply within the study area ("issued demands"), and the demand associated with the application itself ("application demand").[5] For purposes of this Policy, the sum of these demands is referred to as the "total demand" in the study area. Using the total demand,[6] at the end of the 100-year evaluation period, the depth–to-static water level must not exceed the maximum depth-to-static water level described in A.A.C. R12-15-716(B)(2) or the depth of the aquifer, whichever is less.

1. Existing Uses

The evaluation of 100-year depth-to-static water levels must include the 100-year demand for existing uses within the study area that will be met with groundwater or with stored water recovered outside the area of impact of storage. Applications may represent existing uses by incorporating the current depth-to-static water level decline rate. Applicants must consult with the Department before incorporating assumptions regarding future changes in pumping patterns and aquifer conditions.

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[5] Historically, such demands have been referred to as "current, committed, and projected demands." The current rules, which became effective on September 12, 2006, define each of these terms only with respect to the demand of a particular designated provider or designation applicant. *See* A.A.C. R12-15-701(24), (26) and (57). Therefore, this Policy refers to "existing uses" and "issued demands," as these terms are explained in items 1 and 2 below.

[6] If the Department amends R12-15-716(B)(3) to require consideration of additional demands, the applicant must include those demands as part of the total demand.

"Existing uses" include all lots and parcels that receive such water from any provider and lots and parcels that are supplied by individual wells. Existing uses include agricultural, municipal, residential, industrial and commercial uses. In order to account for system losses, the Department uses the volume withdrawn, not delivered. Ongoing regional water level decline rates for the source aquifer in the study area must also be reviewed and summarized. See Part II(E)(13) of this Policy.

Existing uses also include exempt wells, pursuant to A.R.S. § 45-454, and groundwater withdrawal permits, pursuant to A.R.S. Title 45, Chapter 2, Article 7. If the number of exempt wells in the study area is relatively small, the Department may not require the wells to be incorporated in the study. Groundwater withdrawal permits may be of limited duration and therefore the impact of the associated demands may be considered for less than the 100-year period. Applicants must consult with the Department before excluding withdrawals by exempt wells from the study or using a shorter duration for groundwater withdrawal permits. If exempt wells are excluded from the study or shorter durations are used, a narrative and justification must be provided.

Information on exempt wells is available at the Department's Bookstore. Within AMAs and irrigation non-expansion areas (INA), the Department receives annual reports from persons withdrawing water from non-exempt wells. This information is available at the Department's AMA offices. Outside AMAs and INAs, information on existing uses may be obtained from annual reports submitted by private water companies to the Arizona Corporation Commission (ACC). Residential demand for a provider that is not regulated by the ACC may be obtained directly from the provider. In 2007, the Department began receiving annual reports of water use by community water systems, pursuant to A.R.S. § 45-343. The Department will respond to requests for this information in a timely manner.

The applicant may estimate existing residential demand by utilizing the demand calculator, available on the Department's website. The applicant may also derive demand numbers from groundwater flow models developed by the Department, provided that the groundwater flow model used has been updated to reflect current demand conditions.

The Department does not accept estimates of existing uses that are inadequately justified. Using inadequately justified estimates will delay review of the study until the numbers have been corrected to the Department's satisfaction.

2. Issued Demands

Issued demands include the estimated water demands of issued certificates, water reports, designations and analyses that are not already served water and that will be met with groundwater or with stored water recovered outside the area of impact of storage. Issued demands also include the estimated water demands for inadequate determinations issued by the Department. Information related to issued demands is available on the Department's website. The Department regularly updates the information to include the most recent issued demands. For more information about a specific area, applicants should contact OAWS.

3. Application Demand

The study must also incorporate all of the water demand associated with the project that will be met with groundwater or with stored water recovered outside the area of impact of storage. This volume is calculated differently for designation applications than for other types of applications. Those differences are discussed below.

a. Designation Applications

A designation applicant must demonstrate that water supplies are physically available to support the applicant's estimated water demand that will be met with groundwater or with stored water recovered outside the area of impact of storage, which will include the applicant's current demand, committed demand (recorded lots not yet receiving water), and projected demand during the term of the designation. To estimate the projected demand during the term of the designation, the applicant must estimate the 100-year demand at build-out for plats that are likely to be approved and customers that are likely to be added within the applicant's service area during the term of designation that the applicant is seeking. The minimum term is two years. A municipal provider may rely on the historical growth pattern. However, if the municipal provider is aware of new projects that may differ from the historical growth pattern, these must be taken into account. A new municipal provider may rely on build-out estimates from developers in the municipal provider's service area. After estimating growth rates, the applicant may estimate the 100-year water demand using historical water use rates or using the Department's demand calculator, available on the Department's website.

b. Other Applications

For applications for certificates, water reports, and analyses, the applicant must estimate the water demand for the subdivision or development that will be met with groundwater or with stored water recovered outside the area of impact of storage, including interior and exterior residential, commercial, industrial, parks, open space, right-of-way landscaping, schools, and golf courses associated with the project. The Department recommends utilizing the demand calculator on the Department's website. Using the demand calculator simplifies the application process, accurately estimates the demand of the application and expedites the review of the demands associated with the application. The demand calculator incorporates standard demand assumptions based on typical subdivisions and automatically applies these factors. Individual projects may or may not match these standard assumptions. If the applicant deviates from these standard assumptions, the applicant must provide appropriate supporting documentation for approval. The Department recommends that the applicant seek approval from OAWS prior to finalizing the hydrologic study.

D. WATER SUPPLY DESCRIPTION

The study must describe the proposed source of supply. This description must characterize all types of water to be used by the applicant (e.g., groundwater, surface water, effluent, recovered storage credits). A brief summary of how the applicant intends to demonstrate the legal

availability of the water should be included as well as brief description of how the source water(s) will be available on a continuous basis for the 100-year time period.

E. AQUIFER CHARACTARIZATION AND EVALUATION

The hydrologic study must present a complete aquifer characterization and evaluation. In some areas, the required data is readily available. In those cases, the applicant must include a narrative discussing the available data and explaining why the existing data is sufficient. Other areas with little groundwater exploration and/or complex hydrogeology will require additional fieldwork to generate the necessary data. On request, the Department will assist the applicant in determining what additional data will be required. The required elements of the aquifer characterization and evaluation are described below.

1. Geologic Background

All geologic units in the study area must, at a minimum, be described with formation/unit names, lithologic descriptions, thicknesses, and whether the unit is water-bearing. The description must give special attention to hardrock, volcanic, fractured strata, and clay units. The description must also identify geologic information sources and discuss geologic data uncertainties and needs.

2. Geologic Bedrock

The aquifer characterization and evaluation must describe the depth to the bedrock in the study area and how groundwater supplies may be affected by the depths found in the study area. Sources used to evaluate the depth to bedrock must be listed, as well as any potential sources of error in the bedrock data. The geologic bedrock description must also include a map showing bedrock depths below land surface with a contour interval of 100 feet or less (with an emphasis on the first 400 feet below land surface) and any surface expressions of bedrock.

3. Geologic Structure

The aquifer characterization and evaluation must describe major and minor structural features, especially faulting and fractured groundwater flow. This description must provide a structural interpretation related to impacts on groundwater flow and supply. The extent and degree of faulting and fracturing within the study area must be thoroughly described.

4. Geophysical Information

To the extent that geophysical information is available, the aquifer characterization and evaluation must present all geophysical logs with data and locations of data points and any additional geophysical studies relevant to water supply, such as gravity, resistivity or other studies. The narrative must discuss interpretation, conclusions, and limitations of the geophysical data. The study must include a map illustrating the locations of geophysical data points and lines. If the report concludes that additional geophysical data is required to help determine physical availability of groundwater, then the study must provide a narrative and justification for all planned activities.

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5. Geologic Maps and Cross-Sections

The aquifer characterization and evaluation must include a geologic map showing detailed surface geology with structural features, a descriptive key, a narrative describing the map, and the location of cross-section lines. The applicant must also submit appropriate geologic cross-sections illustrating geologic units, including water-bearing units, bedrock units, volcanics, fine-grained units, and other low permeability units, geologic structures such as faults, wells listing total depth, water levels, perched groundwater zones, and the location of the project area as appropriate.

6. Previous Studies

The aquifer characterization and evaluation may incorporate data, such as water levels and aquifer parameters, from previous studies. Other hydrologic studies within the study area may add to the general understanding of the groundwater system. Site-specific information such as current water levels and aquifer parameters from previous studies may prove useful. While data used from other studies are useful, caution must be used in relying on these studies. All information must be updated and compared to recently collected data. It is recommended that applicants discuss the applicability of using past studies with the Department before use in applications.

7. Aquifer Description

The aquifer characterization and evaluation must provide, at a minimum, a detailed description of water-bearing units, including thickness, confined/unconfined conditions, lateral extent, lithologic characteristics, range of saturated thickness with details concerning how the range was established, uniformity in vertical and lateral extent as well as lithology, and productivity (achievable long-term pumping rate). The range of variability of the water producing aquifer(s) in the study area must also be detailed in the study. Multiple aquifers and aquacludes must also be discussed, if present.

8. Description of Well(s) to Be Used

The aquifer characterization and evaluation must demonstrate that wells of a sufficient capacity currently exist and/or will be constructed in a timely manner to serve the proposed uses for 100-years. A narrative must be provided on existing and future wells that details and justifies, if available, cadastral location, estimated saturated thickness and depth to bedrock in each well, current or estimated pumping capacity of each well, estimated or current water level in each well, number of wells needed to meet application demand, well construction, specific capacity of wells, and condition of existing wells.

For projects that will be served by a central distribution system, the well site must be owned or leased by the applicant or by the applicant's municipal provider. The well site must be located within the area where the municipal provider is legally authorized to operate and serve water, such as the district boundary or the boundary described in the CC&N. Within AMAs, if the well site is not located within the municipal provider's service area, the applicant must demonstrate

how the service area will be expanded to include the well site. Outside AMAs, if the well site is a significant distance from the municipal provider's operating distribution system, the applicant must demonstrate how the well will be connected to the municipal provider's system.

9. Aquifer Tests

The number of aquifer tests conducted must be commensurate with the size of the project, the proposed volume of the groundwater withdrawal, and the complexity of the geohydrology of the aquifer system. Aquifer tests incorporating observation wells are the preferred testing methodology. However, in instances where a multiple well test is not practical, single well tests from one or more wells may suffice. Volume and duration of the aquifer test(s) must be sufficient to stress the aquifer in order to derive accurate aquifer parameters. The test(s) must be conducted at a constant rate discharge with a minimum 48-hour drawdown test period, unless the aquifer is stressed in less than 48 hours. In some cases, 48-hour tests may not be adequate to characterize the aquifer. The Department, depending on the aquifer characteristics in the study area, may require additional aquifer testing on wells in the study area and may also request longer duration aquifer tests. Discussion of the aquifer testing must include drawdown/recovery data in both tabular and graphic formats. The location of the aquifer test(s) must be directly related to the withdrawal points and withdrawal volumes associated with the proposed project. If the number of existing wells located in the study area is insufficient and/or unsatisfactory for use in performing aquifer tests (i.e., not similar to the proposed wells in construction, design, aquifer source, etc.), the applicant must drill and test wells to provide this data. The applicant must conduct the test(s) on the source aquifer that will supply the project. The narrative must justify the aquifer testing, including the number and duration of tests needed, as well as subsequent analysis and interpretation. An appropriate analytical method of analysis must be chosen and justified. In some cases a simple Theis or Cooper Jacob analysis may not be appropriate. While additional methods, such as slug tests, specific capacity well data, and driller's log program, may support the data from the aquifer test in some circumstances, the Department will not accept these methods as evidence of physical availability without additional support. The applicant is encouraged to meet with the Department to discuss the aquifer test design and analysis methods before implementation. All aquifer test data collected by the applicant or data used to estimate aquifer parameters must be submitted in electronic form.

10. Aquifer Parameters

The aquifer characterization and evaluation must describe hydraulic conductivity, transmissivity, specific yield, storage coefficient, and other relevant aquifer parameters for each aquifer unit. If appropriate, a description of how aquifer parameters vary both vertically and horizontally must be included. The narrative must explain how these parameters were determined and how the values used in the impact analysis were chosen. The study must use reasonably conservative aquifer parameters in the impact analysis. The study must include tables and graphs that clearly present any aquifer test data. Tables must show the range of values. This section must also include maps showing the distribution of parameter values across the study area.

11. Aquifer Recharge/Discharge

The aquifer characterization and evaluation must describe natural recharge and discharge and, if applicable, assign and justify a recharge and/or discharge rate. The description must include mountain front recharge and precipitation sources, and losing reaches of ephemeral, intermittent, and perennial streams. Incidental recharge from agriculture and other sources must be described and a rate justified in accordance with section II.C of this guideline. The study must account for anticipated agricultural urbanization. The study may incorporate underflow from adjacent groundwater basins if data for the adjacent basins demonstrate that the underflow will continue to contribute to the aquifer throughout the 100-year period. The study may include artificial recharge in the groundwater supplies only if the applicant demonstrates that the stored water is physically, continuously and legally available for the project under the Assured and Adequate Water Supply Rules.[7] *See* A.R.S. § 45-856.01. Outflow from the aquifer must also be described and may include underflow to adjacent basins as well as other sources of natural groundwater discharge such as from springs, evapotranspiration, and baseflow, etc. The discussion must include a map illustrating recharge, underflow, and discharge areas. In some cases the study should present and incorporate a conceptual water budget for the study area.

12. Groundwater Levels

The study must present current measurements of static water levels across the study area. If no water levels are available for the study area or project location (due to a lack of drilled or accessible wells) then new wells must be drilled. The study must describe which wells were accessible and justify the number of measurements taken. If the water levels used in the report were collected by an entity other than the Department or the USGS, then a narrative must describe the quality assurance and quality control used in collecting and processing the water level data. The study must present measurements in tabular format with both elevation above mean sea level and depth-to–static water levels below land surface. The data table must also show the cadastral location of each well used, ownership, well type, measurement date, and measuring point information. Maps of water level elevations and depth-to-static water levels below land surface must incorporate these measurements, with plotted well locations and water level depths below land surface, contoured water elevations (using twenty foot contour intervals or less), and illustrated groundwater flow directions. If the study area includes more than one aquifer, the study must include data tables and water level maps for each aquifer. The study may use other advanced geophysical methods of estimating water levels in an area but these methods cannot replace actual drilling of wells and measuring of groundwater levels. These studies may help support actual water level measurements from new wells in areas where there are no pre-existing wells.

13. Changes in Water Levels

The study must discuss water level decline rates and include hydrographs with trend analyses, when available, for both a long-term period of record (25 years or longer) and a short-term

[7] If stored water will be recovered outside the area of impact of storage, the applicant need not demonstrate that the stored water is legally available for the project. Applicants should consult the Department before incorporating stored water that will be recovered outside the area of impact of storage.

period of record (the last 5-10 years) for wells within the study area. The discussion must include an estimate of the decline rate based on the decline rate data and fully support the estimate. The decline rate must take into consideration the local and regional conditions that may affect the proposed project area, currently or in the future. The area and the groundwater conditions should be examined to see if drought, reduced natural recharge, or other natural or anthropogenic events will have an impact on decline rates. If little or no data exists for the study area, then the study must estimate and utilize a reasonable decline rate. If a decline rate is estimated, then the study must list the potential range of current and future anticipated decline rates. Applicants must consult with the Department before relying on an estimated decline rate and must provide a narrative and justification for use of the assumed decline rate in the study. The discussion must incorporate a map illustrating the wells used for the decline rate estimate and the decline rate for each well.

14. Low Productivity Aquifer Systems

The study must describe hardrock areas, volcanic units, fractured strata, and fine-grained units within the study area that affect the groundwater system and its supply. The study must include a detailed description of the lithology of the units, description of boundary conditions, supporting drillers' logs, geophysical logs, and other data sources. The Department does not consider units exhibiting fractured flow or very low permeabilities, such as volcanics, clay units, or fractured strata, to be dependable aquifers. To help demonstrate long-term dependability of such systems, standard aquifer analytical techniques cannot be used. Applicants should consult with Department staff before relying on fractured or low permeable aquifers as a source of supply.

F. IMPACT ANALYSIS

The impact analysis must demonstrate that pumping groundwater or stored water recovered outside the area of storage to meet the total demand (as the term is described in Part II(C) of this Policy) in the study area will not cause the depth-to-static water levels to exceed any of the following: (1) the maximum 100-year depth-to-static water levels set forth in A.A.C. R12-15-716(B)(2); (2) the depth to bedrock; (3) the maximum depth of the deepest well in the project area if there is limited well data related to the depth of the aquifer; or (4) the proven saturated thickness of the source aquifer.

For projects within the Phoenix, Prescott, Santa Cruz, and Tucson AMAs, the maximum 100-year depth-to-static water level is 1000 feet below land surface. For projects within the Pinal AMA, the maximum 100-year depth-to-static water level is 1100 feet below land surface. For projects outside the AMAs, the maximum 100-year depth-to-static water level is 1200 feet below land surface, unless the Department issues a variance pursuant to A.A.C. R12-15-716(C). For dry lot subdivisions located within or outside AMAs, the maximum 100-year depth-to-static water level is 400 feet below land surface. *See* A.A.C. R12-15-716(B)(2).

Notwithstanding the maximum 100-year depth-to-static water levels, if the depth to bedrock is shallower than the maximum 100-year depth-to-static water level, the depth of the bedrock is used as the limiting factor. For areas that have limited data on the depth of the aquifer, the

deepest well in the study area will be used as the maximum allowable depth-to-static water level. Additionally, the 100-year drawdown must not exceed the proven saturated thickness.

The Department recognizes both analytical and numerical models as acceptable techniques for evaluating the physical availability of groundwater. In some cases, other simplified approaches, such as estimating groundwater flux through the project area and calculation of total groundwater in storage through a tank analogy, may support groundwater supply estimates. However, the Department will not accept these methods as the sole basis for the physical supply estimates.

The applicant must use the most appropriate modeling approach for the study area. Applicants should consult with Department staff prior to selecting a modeling method. When choosing and constructing a groundwater model, the applicant must consider the amount of data available, the complexity of the hydrogeology of the study area, the location and size of the project, and the total demand for the study area, as described in Part II(C) of this Policy as it relates to the total available groundwater supply. The applicant must also consider the limitations and advantages of both analytical and numerical models. Regardless of the method used, the model must represent the hydrogeologic conditions throughout the study area. The model must be fully supported with current and sufficient data from the study area and must predict the impact on the aquifer system as accurately as possible, utilizing the total groundwater demand. The hydrologic study must detail and justify the use of the selected modeling technique.

1. Analytical Models

a. Limitations/Advantages of Analytical Models

The applicant must consider whether an analytical model is appropriate for the specific study area. In general, the applicant should take into consideration how much groundwater is potentially available, hydrogeologic conditions, available data/data needs, applicability of an analytical approach, and other benefits and/or limitations before using an analytical model for the impact analysis.

The limitations of an analytical model include:

- Limited total number of wells that can be input into model (for large area with a large number of wells or image wells this may pose a problem).
- *Only single value(s) can be input for aquifer parameters (transmissitvity, specific yield/storage coefficient).*
- Only a relatively simplistic model can be developed (cannot easily represent complex hydrogeology).
- May have to use a horizontal water table (flat, no gradient) which may not accurately represent groundwater conditions (some analytical models allow for a sloping regional water table).
- Assumption of a uniform aquifer thickness, fully penetrating wells, and fully saturated aquifer.

- *Difficulty in assigning and inputting demands into the model.*
- Boundary conditions (such as hardrock areas and inflow/outflow boundaries) may be difficult to accurately simulate.
- Model is based on assumed conditions and is not calibrated to historic or observed conditions.
- Use of assumed water table conditions must be corrected for transmissivity value reduction as saturated thickness decreases with dewatering.

The advantages of an analytical model include:

- Ease of use.
- Applicability to areas with non-complex/homogeneous hydrogeology.
- Relatively low cost and short development time for construction of model.
- Generally useful when there is a small demand and a large groundwater supply and few competing applications in the general study area.

b. Use of an Analytical Model

When an analytical model is used for the impact analysis the following must be discussed in the hydrologic study:

- Applicability of analytical modeling approach to the project area site conditions (using above limitations and advantages) and how the model was used to simulate different supply/demand scenarios.
- Narrative and justification of how the analytical model was developed:
    - The study must describe how the hydrogeologic conceptual model as well as the analytical model was constructed, including the area covered by the model, identification of hardrock/bedrock boundaries, hydrologic features and boundaries that have been simulated using image wells, conditions of the source aquifer (such as confined/unconfined conditions), well and image well locations, and aquifer units and bedrock depths.
    - The applicant must justify the aquifer parameters/values and sources of data used in the model (must use conservative values within range of parameters for drawdown analysis) and describe the range and distribution of parameters with map(s) showing distribution and values.
    - The applicant must describe the input of demands into the model (as described in Part II(C) of this Policy). This discussion must address whether the model analysis incorporates ongoing decline rates to represent existing uses or specific values assigned to specific wells. If the model does not account for demand assigned to specific wells, then the decline rate for the study area must be projected for a 100-year time period and incorporated in the overall impact analysis to determine the 100-year depth-to-static water level. The applicant must input all demands assigned to each well, using updated values and actual well sites, incorporating proven pumping volumes. If the wells proposed to serve issued demand or application demand have not yet been constructed, the demand must be represented in a reasonable fashion (i.e., the minimum number of wells realistically anticipated to serve the project), incorporating physical characteristics

of existing wells located at a maximum distance of one quarter mile from the anticipated well sites. If no wells exist within one quarter mile of the proposed well sites, the applicant must demonstrate that other wells are representative of the conditions for the proposed wells or drill new wells to obtain the required information. The discussion must specify the size of the area utilized for input of demand and include a map identifying the locations of wells used to input demand. The study must identify all sources of information for demand input.

- The study must utilize a comprehensive analytical model for the impact analysis and not a separate analysis for each demand component and/or project in the area of concern.

c. Model Results

- The study must discuss the analytical model results including all assumptions and limitations used in the model development. The study must include:
  - Documentation of model results including a narrative describing inputs and outputs and an electronic copy of datasets (input/output files).
  - Final 100-year groundwater supply determinations for model area. Maps of final projected 100-year depth to water and 100-year water level drawdowns must be provided that include, at a minimum, hardrock/bedrock boundaries, township, range and section delineation, project outline, and contoured water level drawdowns using a reasonable contour interval.
- The study must provide the determination of the final 100-year depth–to-static water level according to A.A.C. R12-15-716(B).
- The study must provide a discussion of how the conceptual model fits the data and how well the analytical model results represent the conceptual model, including the geologic and hydrologic parameters and utilization of actual data.
- The study must provide a summary of the model with a justification for use in the area of concern.

2. Numerical Models

a. Limitations/Advantages of Numerical Models

Like analytical models, the applicant must consider whether a numerical model is appropriate for the specific study area. In general, the decision to prepare a numerical model for the impact analysis should be based on how much groundwater is potentially available in the study area, complexity of the hydrogeologic conditions, available data/data needs, applicability of a numerical approach, and other benefits and limits of a numerical model.

The limitations of a numerical model include:

- Numerical models require more time to construct.
- Data needs are significant.
- Experitise in preparation of numerical solutions is critical.
- Data collection may be needed to substantiate the conceptual model.

The advantages of a numerical model include the following capabilities:

- Can represent complex hydrogeologic systems.
- Can be calibrated to historic and observed conditions.
- Boundary conditions can be simulated more accurately.
- Account for changes in aquifer parameters during dewatering.
- Can input multiple model layers.
- Can input a range of aquifer parameters.
- Can integrate multiple time steps and changes through the model time period.
- Can easily include recharge and other demand values.
- Sensitivity and error analysis of the model is possible.

b. Use of a numerical model

When a numerical model is used for the impact analysis, the study must discuss the following:

- The study must provide justification for the model code chosen and applicability of the model to the hydrogeology of the study area. Also, the modeling standards applied (such as ASTM, USGS, or other sources) must be referenced.
- The study must provide a detailed description of how the model was developed. The following is the minimal information needed:
    - If an existing model is utilized, the applicant must justify the applicability of the existing model, including a description and documentation of any changes made to the model and any recalibration of steady state and transient phases of the model.
      The study must also explain the purpose of the existing model and applicability to applicant's study area, including the relevance of the existing model's structure and data sources to the specific area of the applicant's study.
    - The study must describe the conceptual model of the aquifer(s) in the study area including a description of the data and interpretation used to construct the conceptual model. The study must also include a table listing the components and range of aquifer parameters for the conceptual model.
    - The study must describe the conceptual water budget for the study area including the data used to construct the water budget, a table listing the components and volumes in the conceptual water budget and whether the volumes used in the model are in the conservative range of values.
    - The study must describe the numerical model construction including the size of model grid (number of rows/columns), cell size, number of layers and how layering was assigned.
    - The study must describe any special model features or packages and any unique model inputs or methodologies.
    - The study must explain the input of the total demand (as described in Part II(C) of this Policy) as well as demands outside the study area that could impact the project. The applicant must input all specific demands using updated values and actual well sites incorporating proven pumping volumes. If the wells proposed to

serve issued demand or application demand have not yet been constructed, the demand must be placed in the center of the project or in the proposed well site, incorporating characteristics (such as pumping rates and construction details) of existing wells located within one quarter mile of the anticipated well sites. Model cells used to represent proposed well sites must reasonably incorporate local hydrologic parameters. The discussion must specify the size of the area utilized for input of demand and include a map identifying the locations of wells used to input demand. The study must also present a tabular listing of projected wells and their demands. The study must identify the sources of information for demand input.

- The applicant must describe how the model was calibrated including the standards established before calibration and the history of groundwater development for the model area.
- The study must describe the historic periods of the groundwater system and how they were used in the steady state and transient model calibrations.
- The study must describe the initial conditions for the model such as how the starting heads were developed, how the boundary fluxes were estimated and are presented, estimated future changes in boundary fluxes due to adjustments in groundwater pumping, and cell type (active, inactive, constant head, general head, constant flux, etc.). The study should also discuss which model packages were used and for what purposes.
- The study must describe the stress periods, including the sub-division of time-steps within each stress period.
- The study must describe the final model design, including the range and distribution of hydrologic parameters and maps of values (aquifer parameters, storage values, layer isopachs, etc).
- The study must describe the current model stresses, including pumpage (municipal, agricultural, and other) and recharge (incidental, natural, and artificial).
- The study must describe other model stresses including riparian areas (evapotranspiration distribution), baseflow, spring discharge, and other local stresses and justification for including or excluding them.
- If used, stochastic methods of model calibration (parameter estimation) and sensitivity analysis must be discussed with the Department before implementation.
- The applicant must include maps that support the model, such as a map of water level conditions with data points (elevation and depth) and a map of initial simulated starting water level heads.

c. Model Results

The applicant must discuss the numerical model calibration results, including the following:

- The study must discuss the assumptions and limitations of the model. The discussion must identify appropriate model uses, including whether the model grid spacing is sufficiently fine to accurately simulate local drawdown cones near specific wells or whether the model is more regional in scope. The study must also discuss whether actual

water levels in individual pumped wells are likely to be lower than indicated by the model, depending on local aquifer properties, well location, and well construction.

- The study must include the following: (1) a comparison of the model-simulated water budget results to the conceptual water budget for steady state and transient simulations; (2) a comparison of the model-generated change in storage to the estimated change in storage; (3) water level maps comparing simulated versus observed water level elevations; and (4) hydrographs comparing simulated heads to observed heads through time. A narrative discussion of these comparisons must also be included.
- The study must discuss the simulated changes to the model boundary fluxes, including how the changes affect the model results.
- The study must discuss the analysis and presentation of model error, including statistical evaluation of model-wide average error, mean error (ME), mean absolute error (MAE), root mean square error of the residuals (RMS), ratio of the RMS error to the total head loss of the model. The study must present a map of the distribution of residuals, a scatter plot of head residuals and observed heads, a scatter plot of actual measured heads contrasted with simulated heads, a frequency distribution (table or graph) of the residuals, percent discrepancies over 1 percent of cumulative water budget inflow/outflow balance, and justification of percent discrepancies over 1 percent.
- The study must discuss the sensitivity analysis, including parameters that were varied, effect on model output, and other inputs used.
- The study must include a map of observed simulated flow contours and a map of steady state and/or transient contours overlain with a map of the final simulated heads for the model calibration.
- The study must discuss any recommendations for improvements to the model, including data collection needed to improve model results, model code/construction, conceptual model improvements, and future use of model and planned improvements.
- The study must discuss the 100-year numerical model results including the assumptions and limitations of the model and a map of 100-year water levels with water level drawdowns plotted.
    - The study must discuss the 100-year model water budget, including a total cumulative and zone budget (if necessary), and comparison of simulated and projected model stresses (pumping, recharge, storage, and any other model stresses).
    - The study must discuss the observed changes to the model boundary fluxes, including how the changes affect the model results over the 100-year period.
    - The study must provide maps of simulated flow contours after 100 years that include a map of 100-year transient simulations, map of the 100-year depth-to–static water level, map of the final simulated heads, and a map of the total drawdown for the 100-year portion of the simulation.
    - The study must discuss any area where the model shows dewatering or depths to groundwater are greater than the maximum allowable depth-to-static water level after 100-years.
    - The study must discuss any area where the water level is above the land surface anytime during the simulated 100-year model run.
    - The study must present a map showing the saturated thickness above the 100-year depth-to-static water depth limit.

- The study must discuss any reversal of groundwater flow gradients or development of groundwater divides over the 100-year period.
- The study must provide documentation of model error, including percent discrepancy of the 100-year model simulation and justification if percent discrepancy is over 1 percent.
- The study must provide the determination of the final 100-year depth–to-static water level according to A.A.C. R12-15-716(B).

3. Estimation of Groundwater Flux through the Study Area

The estimation of flux through a study area can be used to support the results from a more complex impact analysis as presented above. All flux calculations must use conservative aquifer parameters. The study must provide all calculations and variables, including formula, gradients, aquifer parameters, and width of the flowpath. A narrative must be provided that clearly describes the process used to derive the groundwater flux volume. Maps must be provided that show the study area and all applicable information.

4. Estimation of Total Groundwater in Storage (Tank Analogy)

The tank analysis method can also be used to support the results from a more complex impact analysis. The analysis must include the available estimated volume of groundwater in storage, the potential range of the estimate, potential sources of error in the estimate, effects of low yield hydrogeologic units (such as fine-grained beds), and sources of information. A narrative must clearly describe the process used to estimate the groundwater in storage volume.

G. CONCLUSIONS

The final section of the hydrologic study must summarize the salient features of the study and offer a set of conclusions concerning the physical availability of the water supply for 100 years.

III. EFFECTIVE DATE

This Policy shall become effective immediately. The Director may modify or revoke this Policy at any time.

Herbert R. Guenther, Director
Arizona Department of Water Resources

8-31-07
Date

Printed on recycled paper. Each ton of recycled paper saves 7,000 gallons of water.