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SUBSTANTIVE POLICY STATEMENT

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

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.

NOTE! *This is a public comment draft that contains changes to ADWR's current Substantive Policy Statement on:* ***HYDROLOGIC STUDIES DEMONSTRATING PHYSICAL AVAILABILITY OF GROUNDWATER FOR ASSURED AND ADEQUATE WATER SUPPLY APPLICATIONS. ADWR —Water Management Division 3/24/2010***

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I. BACKGROUND ON HYDROLOGIC STUDIES

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). 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. 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.

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 highly 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,

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

[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.

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).

II. DEPTH CRITERIA FOR 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 III(E)(10) of this Policy).

A. DEPTH-TO-STATIC WATER LEVEL INSIDE AMAS

For projects within the Phoenix, Prescott, Santa Cruz and Tucson AMAs, the maximum 100-year depth-to-static water level is 1,000 feet below land surface (BLS). For projects within the Pinal AMA, the maximum 100-year depth-to-static water level is 1,100 feet below land surface.

B. DEPTH-TO-STATIC WATER LEVEL OUTSIDE AMAS

For projects outside AMAs, the maximum 100-year depth-to-static water level is 1,200 feet below land surface, except in locations where a sufficient 100-year supply of groundwater is demonstrated to be available in a consolidated sedimentary rock aquifer (such as, productive zones of the "R" and "C" regional aquifer systems of northern Arizona) 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).

1. Availability of Groundwater At A Lower Depth

The exception from the maximum depth-to-static water level criterion only applies in areas where sufficient groundwater naturally occurs in consolidated sedimentary rock aquifers at depths greater than 1,200 feet below land surface. The applicant must demonstrate that the volume of groundwater available at the lower depth, together with any groundwater available at a depth less than 1200 feet blow land surface, is sufficient to meet the applicant's estimated

[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.

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

water demand for 100 years. The applicant must also demonstrate that withdrawing the water from the lower depth will not cause the depth-to-static water level to exceed 1,200 feet below land surface at wells associated with issued determinations that have not been granted an exemption or cause the aquifer to go dry at wells associated with issued determinations that have been granted an exemption.

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 1,200 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.

2. Financial Capability To Pump From a Lower Depth

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 (as required by new ACC AAWS rule xxxx). Dry lot subdivisions are not eligible for the exception from the 100-year maximum depth-to-static water level criterion because the applicant cannot demonstrate the financial capability of future homeowners.

C. DRY LOT SUBDIVISIONS

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 does not recognize shared well arrangements. If the hydrologic study demonstrates that any lot 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.

III. THE HYDROLOGIC REPORT

In general, the hydrologic report 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 report must incorporate the following elements: executive summary, an introductory section, an analysis of the water demand requirements, a general description of the water supply, aquifer characterization and evaluation, results of the 100-year drawdown analysis, conclusions, references, and supporting maps, tables and other figures.

A. GENERAL REQUIREMENTS FOR MAPS, TABLES, FIGURES AND REFERENCES

1. Supporting Maps, Tables and Other Figures

Maps presented in the report 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 United States Geological Survey (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] for boundaries of 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. All maps and figures (including all labels and numbers) must be of sufficient size to allow for a detailed review. The suggested contour interval for all localized groundwater and hydrogeologic maps is twenty feet, or less. Contour intervals for all other maps should be chosen appropriately to show sufficient detail. All graphs presented in the hydrologic report must have labeled axes and show all data points.

2. References

Standard references for all cited reports, studies (including hydrologic studies prepared in support of other AAWS applications) and hydrogeologic data and information must be included in the hydrologic report.

B. EXECUTIVE SUMMARY

The Executive Summary must summarize 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 groundwater supply and how it relates to the total demand, and summarize the supporting documentation.

C. INTRODUCTION

The Introduction must provide an overview of the proposed project and how the hydrologic study proves that the groundwater supply is physically available for the proposed demand. The

Introduction must define the study area and relate it to the project (See Section III(E)(1)). 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 subdivision. 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.

D. 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 and/or 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, 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. Please see the Department's web site for the [Demand Query application] that allows an applicant to query the AAWS database and compile existing and issued AAWS demand data based on user-specified geographic search criteria.

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 are being met with groundwater or with stored water recovered outside the area of impact of storage. In certain cases, 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.

"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,

[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.

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 III(E)(15) of this Policy.

Existing uses also include exempt wells, pursuant to A.R.S. § 45-454, and groundwater withdrawal permits. 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 special use permits. If exempt wells are excluded from the study or shorter durations are used, a narrative and justification must be provided.

Within AMAs, the Department receives annual reports from groundwater users regarding existing uses. This information is available at the Department's AMA offices. Outside AMAs, information on existing uses may be obtained from annual reports submitted to the Department by community water systems, pursuant to A.R.S. § 45-343. Information on exempt wells is available from the Department's Bookstore on the ADWR-Wells 55CD, or can be viewed online at:

(https://gisweb.azwater.gov/WellRegistry/Default.aspx)

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

All estimates of existing uses and demands must be adequately justified and documented.

2. Issued AAWS Demands

Issued demands include the estimated water demands of issued certificates, water reports, including inadequate water reports, designations and analyses that are not yet served water and that will be served with groundwater or with stored water recovered outside the area of impact of storage. Issued demands also include the estimated water demands for pending, complete and correct applications.[6] Information related to issued AAWS demands is available on the Department's website. For more information about a specific area, applicants should contact the Office of Assured and Adequate Water Supply (OAWS).

[6] Throughout this Policy Statement, references to "issued demands" or to "issued AAWS determinations" include the estimated water demands for pending, complete and correct AAWS applications. Those terms, however, do not include issued Physical Availability Determinations or pending applications for Physical Availability Determinations.

3. Application Demand

The study must also incorporate all of the water demand associated with the proposed project. 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, 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, 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 to OAWS for approval. The Department recommends that the applicant seek approval prior to finalizing the hydrologic study.

E. WATER SUPPLY DESCRIPTION

Although the purpose of the hydrologic study is to demonstrate the physical availability of groundwater or stored water to be recovered outside the area of impact of storage for the proposed use, the study must identify all of the proposed source(s) of supply (e.g., groundwater, effluent, recovered storage credits).

F. AQUIFER CHARACTARIZATION AND EVALUATION

The hydrologic report must thoroughly characterize and evaluate the aquifer system in the study area. In some areas, the required data are readily available. 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. Determination of the Extent of the Hydrologic Study Area

Determining the appropriate size of the hydrologic study area is essential for the physical availability demonstration. The hydrologic study area should encompass an area which includes the proposed project area and surrounding lands sufficient to provide a representative understanding of regional hydrogeology, hydrologic trends and water use patterns, and how the proposed project fits into that framework. The hydrologic study area must include all existing and issued AAWS demands that may be "negatively" impacted by the applicant's proposed groundwater withdrawals. Further information on the extent of the hydrologic model area and "negative" impacts is provided in Sections IV(A)(1) and IV(F) of this in this Policy.

2. 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.

3. 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 hydrologic report 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 outcrops of bedrock.

4. Geologic Structure

The characterization and evaluation of the aquifer must describe major and minor structural features, especially faulting and fractured hydrogeologic units. This description must provide a structural interpretation related to how the faults and fractures are interconnected and the effect they have on groundwater flow and supply. The extent and degree of faulting and fracturing within the study area must be thoroughly described.

5. 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 hydrologic report 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.

6. Geologic Maps and Cross-Sections

The hydrologic report 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 report must also include illustrative geologic cross-sections showing geologic units, water-bearing units, bedrock units, volcanics, fine-grained units, and other low permeability units, geologic structures such as faults, water levels, perched groundwater zones, and the location of the proposed project area as appropriate. The number of cross-sections must be commensurate with the complexity of the hydrogeology and size of the study area. If individual well logs are used to create cross-sections, then a table must be provided that lists all information for the wells.

7. Hydrologic Information

The aquifer characterization and evaluation must present currently available hydrologic information for the study area as described in items 8 through 16, below. If no new data has been collected for the study, the narrative must explain how existing information demonstrates physical availability of groundwater. If the applicant collected new data, the hydrologic report must provide a detailed outline of the data collection procedures along with a narrative and justification.

8. 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 from other hydrologic studies are useful, caution must be used in relying on these studies to meet the requirements of a new application. Hydrologic reports that are submitted in support of applications must meet all current requirements and must have up-to-date information and data for an area. It is recommended that applicants discuss the applicability of using past studies with the Department before incorporating them into new applications.

9. 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 report. Multiple aquifers and aquacludes must also be discussed, if present.

10. Description of Wells 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. 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.

11. Aquifer Tests

For projects in areas that lack site-specific aquifer test data, the Director may require aquifer testing to determine site-specific parameters. 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 discharge rate with a minimum 48-hour test period. An on-going aquifer test may be terminated in less than the required 48 hours if the results of testing indicate that the aquifer response has "stabilized" (water level measurements flat-line, or maintain a constant drawdown/log(time) slope for a period of at least 24 hours). Water level recovery after pumping has stopped should also be monitored until water levels recover to at least 90 to 95 percent of their pre-test levels.

In some cases 48-hour tests may not be adequate to characterize the aquifer. Depending on the aquifer characteristics in the study area, the Department 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., 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.

12. 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 should be included. The narrative must explain how these parameters were determined and how the values used in the 100-year drawdown analysis were chosen. The study must use reasonably conservative aquifer parameters in the 100-year drawdown 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.

13. 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 rates from agriculture and other sources must be described and justified in accordance with Section IV(D)(5) of this Policy. 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 is demonstrating that the stored water is legally available for the project under the Assured and Adequate Water Supply Rules, or the storer or credit holder will recover the water outside the area of impact of storage. *See* A.R.S. § 45-856.01. The applicant must consult with the Department before incorporating stored water that will be recovered outside the area of impact of storage.

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, riparian uses, and baseflow, etc. The hydrologic report must include a map illustrating recharge, underflow, and discharge areas. The report must present and incorporate a conceptual water budget for the study area.

14. Groundwater Levels

The hydrologic report must present current measurements of static water levels across the study area. If no water level data are available for the study area or project location (due to a lack of drilled or accessible wells) then new wells must be drilled (as required by new ACC AAWS rule xxxx). The report 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 report 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 Department's Well Registration number (if the well is registered), 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.

15. Water Level Changes

The hydrologic report 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 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 above 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 future decline rates. If little or no data exists for the study area, then the study must assume and utilize a reasonable decline rate taking into consideration the previously mentioned factors. If a decline rate is assumed, 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 assumed 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.

16. Low Productivity Aquifer Systems

The hydrologic report 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 report 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. RESULTS OF 100-YEAR DRAWDOWN ANALYSIS

The hydrologic report must present the results of the 100-year drawdown analysis that is conducted to demonstrate that the effects of the proposed project's 100-year groundwater withdrawals meet all applicable physical availability criteria. Further details on the requirements of the 100-year drawdown analysis are presented in Section IV of this policy.

G. CONCLUSIONS

The hydrologic report must provide conclusions concerning the physical availability of a 100-year assured or adequate water supply that are based on the results of the 100-year drawdown analysis (see Section IV of this policy for further information on the requirements of the 100-year drawdown analysis).

IV. 100-YEAR DRAWDOWN ANALYSIS

The 100-year drawdown analysis must demonstrate that pumping groundwater or recovering stored water outside the area of impact of storage to meet the total demand (as the term is described in Part III(D) of this Policy) in the study area will not cause the depth-to-static water levels to exceed either of the following: (1) the maximum 100-year depth-to-static water levels set forth in A.A.C. R12-15-716(B)(2); or (2) the depth to bedrock. If there are limited well data related to the depth of the aquifer, the maximum depth of the deepest well in the project area must be used as the depth to bedrock (as required by new ACC AAWS rule xxxx).

A. GENERAL BACKGROUND ON AAWS GROUNDWATER MODELS

Groundwater models submitted to the Department as part of the required hydrologic report must meet three main criteria. First, the groundwater model used in the study must be appropriate to replicate and analyze the hydrogeology within the project study area. Second, the model must be properly constructed and calibrated (if applicable) and the results must meet accepted standards of accuracy. Third, the model results must support the findings, conclusions and recommendations presented in the hydrologic report.

1. Determination of the Minimum Extent of the Hydrologic Model Area

The hydrologic model area or model domain is determined by a detailed review of any naturally occurring hydrologic or physical boundaries (i.e. mountain ranges, groundwater divides, faults, etc.) that bound the area of interest, and that may appreciably impact the local hydrology at the location of the proposed project's withdrawals. The model area must also include all existing and issued AAWS demands that are impacted by one foot, or more, of projected drawdown after 100 years of the applicant's proposed groundwater withdrawals (this area is sometimes referred to as the area of "hydrologic impact" or the area of "interest or concern" of the proposed project).

In situations where the total groundwater demand is low and there are limited data available in the project area, it may be unnecessary or impractical to extend the model area to the physical boundaries of an aquifer system, However, these situations should be discussed with the Department before the final model domain is determined.

2. Boundary Conditions

Accounting for boundary conditions that have been identified in the conceptual modeling phase is a critical component of model design. Impermeable "no-flow" boundaries are a common occurrence in groundwater flow systems. Such conditions are commonly found along the margins of basin-fill aquifer systems where saturated alluvial sediments pinch-out and terminate against impermeable bedrock formations.

No-flow boundaries limit the lateral spread of a well's cone of depression. As a consequence, there is an increase in the drawdown that is caused by a pumping well compared to the drawdown that would occur if the boundary did not exist. Research conducted by the Department indicates that the model area must include no-flow boundaries that are located within 10 miles of any pumping well that is included in the model area.

B. <u>SELECTING A MODELING METHOD</u>

1. Model Selection Considerations

The selection of an appropriate groundwater modeling method is fundamental to any AAWS hydrologic study. There are two types of groundwater flow models that are accepted by the Department – analytical and numerical. 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. This section defines a general approach to selecting an appropriate model. More details on specific modeling methods are provided in Parts IV(C) and (D) of this Policy.

The Department will consider the following factors when determining the type of modeling method that is appropriate for a particular AAWS application:

- The minimum extent of the model area (a large model area generally requires a numerical model)
- Hydrogeologic complexity of the aquifer system (aquifer systems with complex hydrogeology generally require a numerical model)
- The availability of pumping, recharge (natural and artificial), water level, and geologic data (well logs, geophysical data, well construction, etc.) at the time of the application within the local and regional aquifer (hydrogeologic data availability is an important factor that is considered when determining appropriate modeling methods; limited data availability may not support the development of a numerical model)
- The location and quantification of other stresses and boundary conditions such as evapotranspiration, groundwater underflow and groundwater discharge (complex boundary conditions generally require a numerical model)
- The estimated groundwater demand of the proposed AAWS project (a large project demand generally requires a numerical model)
- The number and total groundwater demands of issued AAWS determinations and GIU permits (a larger number and volume of issued AAWS determinations and GIU permits generally requires a numerical model)
- The groundwater demand of other "non-AAWS" uses actively pumping at the time of application (a significantly large volume and distribution of non-AAWS uses generally require a numerical model)
- The availability and applicability of a previously developed groundwater model for the study area

The selection of an appropriate modeling method is very dependent upon site-specific and hydrogeologic conditions, and it can be advantageous to use an existing numerical groundwater flow model that has been updated and revised for AAWS purposes. However, if an existing numerical model is not available, development of a new numerical model will be required when the relevant factors indicate that a numerical model should be used. The selection of an appropriate modeling method should be discussed with the Department during the pre-application meeting prior to the submittal of an AAWS application.

Regardless of the method selected, 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.

The Department's initial agreement that a given model or modeling method is appropriate to use for a particular application does not constitute a final approval of the model that the applicant may ultimately submit to the Department to support its application. For example, the Department may agree to the general use of the updated SRV model for a particular AAWS application. However, until the Department has actually reviewed the version of the SRV model submitted by the applicant, the Department cannot know whether any modifications or updates that the applicant may have made were sufficient and correct.

After the Department agrees to a particular modeling method or study proposal, the applicant should complete the hydrologic study and submit it with the application within a reasonable period of time. Otherwise, if hydrologic conditions change or if the Department receives new information regarding the hydrology in the area, the Department may require the applicant to incorporate the new information and, if necessary, to modify the methodology. If it appears that the applicant will be unable to submit the hydrologic study within one year after the Department agrees to the methodology or proposal, the applicant should seek confirmation from the Department that the methodology or proposal would still be appropriate.

2. Conditions When a Numerical Model Must be Used

Numerical models are required in areas where previously approved numerical model projections indicate that the projected 100-year depth-to-water is less than 100 feet above the applicable maximum depth-to-water limit or the depth of the aquifer (as required by new ACC AAWS rule xxxx). Numerical models will be required in most other situations as well based on the factors listed in subsection (B)(1) of this Section). As required by (new ACC AAWS rule xxxx) an applicant must obtain approval from the Department to use an analytical model unless the conditions for the pre-approved use of an analytical model are met (these conditions are outlined in the next section of this policy).

3. Conditions When an Analytical Model May be Used Without Prior Approval

While a numerical groundwater flow model is usually required, there are some limited situations when it is appropriate to use an analytical groundwater flow model to demonstrate physical availability. The Department has identified certain conditions when an analytical model will be acceptable for demonstrating the 100-year physical availability of an AAWS application without a detailed review of the factors listed in Part IV(C)(2) of this Policy (as specified by new ACC AAWS rule xxxx). These conditions are listed below (all conditions must be met).

- The demand of the proposed project is less than or equal to 100 acre-feet per year;
- There is more than 500 feet of available saturated thickness of the aquifer above the maximum allowable 100-year depth-to-water or above bedrock (whichever is more shallow);
- The projected water level decline rate for each well within the model area is less than or equal to 2 feet per year over 100 years;
- There are no more than a total of five issued AAWS determinations and/or general industrial use (GIU) permits in the study area; and
- The 100-year water level decline that will be caused by all issued AAWS determinations and/or GIU permits in the model area is less than or equal to 100 feet.

If one or more of the conditions listed above are not met, the Department may still approve an analytical modeling approach after detailed discussion with the applicant and a review of the area's hydrology.

a. Proposed Project Demand

The maximum allowable proposed demand for use of an analytical model without prior approval from the Department is 100 acre-feet/year. This volume of demand is an appropriate limit for the pre-approved use of the analytical modeling approach because it would cause relatively small 100-year drawdowns in most aquifer settings, and it will allow applicants with small projects (approximately 200 lots or less) the opportunity to demonstrate physical availability without a more expensive numerical model. This volume limit also makes it unlikely that there will be negative impacts to existing AAWS determinations within the model area.

b. Available Saturated Thickness of Source Aquifer

The available saturated thickness of the source aquifer above the maximum 100-year depth-to-water level or bedrock must be greater than 500 feet to qualify for pre-approved use of the analytical modeling methodology. In areas where the proven bottom of the aquifer is deeper than the applicable maximum 100-year depth-to-water level, the available saturated thickness is calculated by subtracting the current depth-to-water BLS from the maximum 100-year depth-to-water level. For example, if the current depth-to-water is 450 feet BLS at the proposed location(s) of the applicant's AAWS wells, and the wells are located in the Phoenix, Tucson, Santa Cruz or Prescott AMAs, then the available saturated thickness would be 550 feet (1,000 feet – 450 feet = 550 feet). Assuming the same depth-to-water, the available saturated thickness in the Pinal AMA would be 650 feet (1,100 feet – 450 feet = 650 feet), and outside AMAs the available saturated thickness would be 750 feet (1,200 feet – 450 feet = 750 feet).

In areas where existing well depths do not exceed the maximum 100-year depth-to-water level or where bedrock is shallower than the maximum 100-year depth-to-water level, the available saturated thickness is calculated by subtracting the current depth-to-water from either the maximum depth of wells located in the area of the proposed withdrawals or the known depth-to-bedrock, whichever applies.

The available saturated thickness calculations should be based on current depth-to-water data that have been collected by the Department, the USGS or other approved sources and that are recorded in the Department's Groundwater Site Inventory (GWSI) database.

c. Current and Projected Water Level Decline Rate

The current water level decline rate in the model area may be used to project the future 100-year water level decline rate in the area if all local and regional factors that may affect the decline rate are taken into consideration (as previously described in Part III(E)(15). The current water level decline rate in the model area must be determined from water level data that have been collected by the Department, the USGS or other approved sources and that are recorded in the Department's GWSI database. The use of the analytical modeling method is not pre-approved if projected water level decline rates exceed 2 feet per year for 100 years for any well located within the model area.

d. Existing AAWS Determinations

The demand from issued AAWS determinations and/or GIU permits within the approved model area must be included in the 100-year depth-to-water calculation. Only a total five issued AAWS determinations and/or GIU permits may be located within the approved model area.

e. Projected Allowable Drawdown Caused by Existing AAWS Determinations

The total projected 100-year drawdown at the location(s) of the applicant's proposed new groundwater withdrawals that are caused by issued AAWS determinations and GIU permits cannot exceed 100 feet.

4. Accounting for New Data and Information in Models

Periodically, new hydrogeologic information and/or data becomes available after the applicant has submitted an AAWS application and before the hydrologic study is ultimately reviewed by the Department. When available, it is always important to incorporate new data and/or interpretations into a model. However, the Department acknowledges that there must be a point in time after which an applicant should not be required to add data or modify interpretations of hydrogeologic conditions. In recognition of this situation, the Department will not require an applicant to add new data to a model that becomes available after the date the applicant filed the application and hydrologic study. However, until the application is determined to be complete and correct, it will always be necessary to incorporate into the hydrologic study the demand from any AAWS determinations issued after the application was filed and the demand from any other AAWS applications determined to be complete and correct after the application was filed. Additionally, regardless of the status of an applicant's AAWS application, the Department may inform the applicant of any new hydrogeologic data that may become available and recommend (but not require) its inclusion in the applicant's model.

C. NUMERICAL MODELS

1. Limitations/Advantages of Numerical Models

As discussed in Part IV(B)(2) of this Policy, a numerical model will be required for most AAWS applications, unless the project meets the criteria in Part IV(B)(3) for pre-approved use of an analytical model or the Department agrees that an analytical model is appropriate. In general, the decision to prepare a numerical model for the 100-year drawdown analysis should be based on how much groundwater is potentially available in the model 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 significantly more modeling expertise than analytical models
- Generally more data intensive than analytical solutions
- Generally more costly to develop than other types of models

The advantages of a numerical model include the following capabilities:

- Capable of representing complex hydrogeologic systems
- Calibrated to historic and observed conditions
- Boundary conditions can be simulated more accurately
- Account for changes in aquifer parameters during dewatering
- Capable of simulating several hydrogeologic units using multiple model layers
- Capable of simulating varying spatial distributions of aquifer parameters
- Integration of time-varying stresses through the model simulation period
- Can easily include recharge and other demand values
- Sensitivity and error analysis of the model is possible

2. Suitability of Existing Numerical Models for AAWS Hydrologic Studies

The Department has developed numerical groundwater flow models for each of the state's Active Management Areas (AMAs). The Department and the USGS have also developed numerical groundwater flow models covering other areas of the state. These models are among the best tools available for regional and localized hydrogeologic analysis. However, each model has known limitations and all models must be periodically updated with new data to keep them current. In many cases, models may be sufficient to use with little or no revision. However, it is vital that an applicant review the model for the applicant's specific purpose and address any issues before using the model in support of an AAWS application. Issues may involve the accuracy of the model calibration in the area of interest, appropriateness of model cell size, correspondence of model geologic structure and aquifer parameters with known field data, appropriateness of boundary conditions, etc. Applicants are strongly advised to meet with the Department to discuss any concerns prior to developing a hydrologic study and using an existing regional groundwater flow model.

If the use of a regional model is appropriate for the proposed project, the applicant should incorporate any localized data that has been or will be collected into the regional model. This includes aquifer parameters, hydrogeologic information, or other information that would make the regional model a better tool to investigate impacts for a specific localized area.

3. Appropriate Model Cell Size

Determining the appropriate numerical groundwater flow model cell size for numerical models for AAWS purposes has been a long-standing concern. The concern arises from the fact that numerical models average the simulated drawdown of a well over the entire area of a model cell, thereby under-predicting the maximum drawdown at and near the well compared to an analytical model. However, as the radial distance from the well increases, the two modeling methods provide comparable predictions of future drawdown.

Differences in drawdown projections from the two types of models were evaluated using a number of theoretical numerical groundwater flow model simulations with varying grid sizes, pumping rates and aquifer parameters. Results of running these simulations for 100 years were

then compared to results obtained from comparable analytical groundwater flow model simulations.

The comparisons confirmed that numerical models under-predict the maximum 100-year drawdown of a well (compared to an analytical model) at the well site, but the differences in predicted drawdown between analytical and numerical model results decreased with decreasing model cell size. Based on this evaluation, it is acceptable to conduct 100-year AAWS hydrologic studies using numerical models with horizontal cell dimensions of .5 mile x .5 mile (2,640 feet x 2,640 feet) or less, assuming all other aspects of the model are also found to be acceptable.

4. Boundary Conditions

Accounting for boundary conditions that have been identified in the conceptual modeling phase is a critical component of numerical model design. The following sections discuss hydrologic boundary conditions.

a. No-Flow Boundaries

As mentioned in Part IV(A)(2) of this Policy, no-flow boundaries limit the lateral spread of a well's cone of depression. As a consequence, there is an increase in the drawdown that is caused by a well's pumping compared to the drawdown that would occur if the boundary did not exist. Department research indicates that it is necessary for models to include no-flow boundaries that are located within 10 miles of any pumping well that is included in the hydrologic model.

b. Artificial Boundaries

Artificial boundaries are sometimes used in numerical models to limit the extent of the model area. In some cases, "conservative" no-flow conditions are assumed at artificial boundaries for the 100-year AAWS projection period. In general, this approach is acceptable. However, artificial no-flow boundaries cannot be utilized as a means to eliminate the evaluation of potential negative impacts on issued AAWS determinations and/or GIU permits that are located within the area of hydrologic impact of the proposed project's well(s). Likewise, artificial no-flow boundary conditions cannot be used to eliminate or reduce the impacts that other groundwater uses located outside the model boundary may have on the proposed project's 100-year depth-to-water. If artificial boundaries are used in a numerical model, they must be located at a sufficient distance from any existing or proposed AAWS pumping locations to ensure that the effects of artificial boundary will have a negligible impact on the outcome of the hydrologic study. If this is not possible, then very conservative assumptions regarding these boundary conditions must be made and tested (using modeling sensitivity analysis or other methods) to demonstrate that the assumed future boundary condition is appropriate. Applicants and their consultants should discuss the use of any artificial boundary conditions with the Department during the development of the conceptual model.

5. Assumptions for 100-Year Numerical Model Projections

a. Crop Consumptive Use, Irrigation Efficiency and Ag Recharge

Assumptions for determining crop consumptive use, irrigation efficiency and agricultural recharge to be used for hydrologic studies must be based on the most recent data and estimates that have been approved by the Department. Crop consumptive use and irrigation efficiency data are published in each AMA's most recent Management Plan. For areas outside AMAs, these parameters may be estimated from data published by the Department and other approved sources for comparable areas with similar farming conditions. Additionally, substantial information on agricultural recharge rates and irrigation efficiencies is available in various Department model reports that can be downloaded from the Department website. However, applicants should consult with the Department to determine appropriate values for these parameters.

Agricultural recharge projections should be based on the agricultural water demand and irrigation efficiency determined appropriate for future farming activities. Inside the AMAs, this would include the efficiencies required in the most recent Management Plan for the applicable AMA. Projected agricultural recharge estimates may reflect "lag-time" (if applicable) to account for the time required for deep percolation through the vadose zone. However, lag effects must not be used to justify and maintain artificially high recharge rates that extend well beyond the time that the agricultural recharge rate should have stabilized based on assumed urbanization rates and depth-to-water (usually no more than 25 years into the 100-year AAWS projection period).

b. Canal and Reservoir Recharge

Future estimates of incidental recharge from canals, laterals and reservoirs may be projected based on current seepage estimates approved by the Department for such features. Future recharge estimates should account for any projected lining of currently unlined features, or any potential abandonment or partial use of systems based on projected changes in future water deliveries. Substantial information on canal and reservoir seepage is available in various Department model reports that can be downloaded from the Department's website. However, applicants should consult with the Department to determine appropriate values for this recharge component.

c. Natural Recharge for Rivers and Streams and Along Mountain Fronts

Projections of natural recharge for rivers and streams and along mountain fronts should be based on the Department's most current estimates of these factors. Substantial information on natural recharge for rivers and streams and along mountain fronts is available in various Department model reports that can be downloaded from the Department's website. However, applicants should consult with the Department to determine appropriate values or methods to estimate these model inputs.

d. Groundwater Underflow

Projections or methods to simulate future groundwater underflow to or from adjacent basins must be based on assumed future conditions in those areas. Substantial information on groundwater underflow is available in various Department model reports that can be downloaded from the Department's website. However, applicants should consult with the Department to determine appropriate values or methods to simulate these fluxes.

e. Riparian Evapotranspiration

Where applicable, projections of evapotranspiration of groundwater from riparian areas should be based on currently accepted estimates. Substantial information on riparian evapotranspiration is available in various Department model reports that can be downloaded from the Department's website. However, applicants should consult with the Department to determine appropriate values for these parameters.

f. Recovery of Existing Long-Term Storage Credits

The recovery of existing long-term storage credits within the model area must be simulated for 100-year physical availability demonstrations. If the owners of existing long-term credits have provided the Department with a schedule of recovery volumes and locations where recovery will occur, those schedules must be accounted for by others submitting applications for AAWS determinations. If no recovery schedule has been submitted by the owners of existing credits, then the applicant must consult with the Department to determine where those credits should be simulated for recovery.

6. Requirements of Numerical Modeling Reports

a. Numerical Model Approach and Model Inputs

When a numerical model is used for the 100-year drawdown analysis, the hydrologic report must discuss the following:

- The report 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 report must provide a detailed description of how the model was developed. The following is the minimum information needed:
    - If an existing model is utilized, the report 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 report 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 report must describe the conceptual model of the aquifer(s) in the study area including the description of the data and interpretation used to construct the conceptual

model. The report must also include a table listing the components and range of aquifer parameters for the conceptual model.

- The report 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 report 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 report must describe any special model features or packages and any unique model inputs or methodologies.
- The report must explain the input of the total demand (as described in Part III(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 wells are not yet constructed to serve demands from issued AAWS determinations or the application demand, the demand must be placed in the center of the project or 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 report must also present a tabular listing of projected wells and their demands. The report must identify the sources of information for demand input.
- The report must describe how the model was calibrated, including the standards established before calibration and the history of groundwater development for the model area.
- The report must describe the historic periods of the groundwater system and how they were used in the steady state and transient model calibrations.
- The report 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 report should also discuss which model packages were used and for what purposes.
- The report must describe the stress periods, including the sub-division of time-steps within each stress period
- The report 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 report 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, automated methods of parameter estimation and inverse model calibration (using PEST, UCODE, etc.) and sensitivity analysis must be fully discussed and documented.

- The report 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.

b. Numerical Model Results

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

- The report 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 report should 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 report 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 report must discuss the simulated changes to the model boundary fluxes, including how the changes affect the model results.
- The report 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), and ratio of the RMS error to the total head loss of the model. The report 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 report must discuss whether the residual model error at the end of the model calibration period is acceptable in the area of the proposed project wells. Model calibration errors, particularly the over-simulation of calibrated final heads in the proposed project area can unacceptably bias the 100-year drawdown analysis. Model calibration errors (head residuals) that are greater than or equal to - 20 feet (as calculated by $Head_{obs} - Head_{simulated}$) in the area of proposed project wells, must be reduced to less than -20 feet, or alternative methods that account for the initial head bias must be used in the final evaluation of the predicted 100 year depth-to-water.
- The report must discuss the sensitivity analysis including parameters that were varied, effect on model output, and other inputs used.
- The report 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 report 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 the model and planned improvements.

The report must discuss results of the 100-year drawdown analysis, including:

- The report must discuss the 100-year model simulated 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 report must discuss the observed changes to the model boundary fluxes, including how the changes affect the model results.
- The report must provide contour maps of model projected 100-year water level elevations (heads), water level changes (drawdowns) and depth-to-static water level.
- The report must discuss any area where the model shows dewatering or depths to groundwater greater than the maximum allowable depth-to-static water level after 100-years.
- The report must discuss any area where the simulated water level is above the land surface anytime during the simulated 100-year model run.
- The report must present a map showing the saturated thickness above the 100-year depth-to-static water depth limit.
- The report must discuss any simulated reversal of groundwater flow gradients or development of groundwater divides.
- The report 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 report must provide the determination of the final 100-year depth–to-static water level according to A.A.C. R12-15-716(B).

c. Numerical Model Conclusions

The final section of the hydrologic report 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. The report must also discuss any projected "negative" impacts to any existing or issued AAAWS demands.

D. ANALYTICAL MODELS

1. Limitations/Advantages of Analytical Models

Before seeking the Department's agreement to use an analytical model, the applicant should 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 proposing to use 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 a 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 (transmissivity, specific yield/storage coefficient)
- Normally cannot automatically convert from confined to unconfined storage conditions during simulation
- 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

2. Requirements of Analytical Modeling Reports

When an analytical model is used for the 100-year drawdown analysis, the following must be discussed in the hydrologic report:

a. Analytical Model Approach and Model Inputs

- Applicability of analytical modeling approach to the project area site conditions (using limitations and advantages identified in Part IV(C)(1) of this Policy and how the model was used to simulate different supply/demand scenarios.
- Narrative and justification of how the analytical model was developed:
    - The report must describe how the hydrogeologic conceptual model as well as the analytical model were 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 report 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 report must describe the input of demands into the model (as described in Part III(D) 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 100-year drawdown analysis must include all demands assigned to each well, using updated values and actual well sites, incorporating proven pumping volumes. If the wells proposed to serve demands from issued AAWS determinations or the 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 report must identify all sources of information for demand input.
- A comprehensive 100-year drawdown analysis must be conducted that includes the total AAWS demand (as described in Part III(D) of this Policy) and not a separate analysis for each demand component and/or project in the area of concern.

b. Analytical Model Results

- The report must discuss the analytical model results including all assumptions and limitations used in the model development. The report must include:
  - Documentation of model results, including a narrative describing inputs and outputs and an electronic copy of datasets (input/output files).
  - The report must include contour maps that show the results of the 100-year drawdown analysis (contour intervals must be appropriate to show sufficient detail in the area of the proposed project's wells). Maps must be provided that show the projected 100-year depth-to-static water level and the projected 100-year water level drawdown from the proposed project's withdrawals. At a minimum, the maps must show the locations of hardrock/bedrock boundaries, township, range and section delineation, project outline, and the locations of any other existing and/or issued AAWS determinations and/or GIU permits that are impacted by one foot or more of projected drawdown from the proposed project's 100-year withdrawals.

c. Analytical Model Conclusions

The final section of the hydrologic report 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. The report must also discuss any projected "negative" impacts to any existing or issued AAWS determinations and/or GIU permits (see Part IV(F) for further detail on negative impacts).

E. SUPPLEMENTAL METHODS OF GROUNDWATER SUPPLY ANALYSIS

1. 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 100-year drawdown 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.

2. Estimation of Groundwater In Storage (Tank Analogy)

The tank analogy method can also be used to support the results from a more complex 100-year drawdown 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.

F. NEGATIVE IMPACTS TO EXISTING AND ISSUED USES

As required by (new ACC AAWS rule xxxx), a new AAWS application's estimated demand cannot cause the 100-year depth-to-static water level of any previously issued AAWS determinations to drop below the maximum allowable 100-year depth-to-static water level or known depth of the source aquifer. In addition, because GIU permits are issued only upon a determination that there is an "assured water supply" (as defined in A.R.S. § 45-515(A)(6)) for the intended use, a new AAWS application cannot cause the aquifer to be de-watered at the location of wells associated with a GIU permit.

The following discussion applies to 100-year drawdown analyses provided by either analytical or numerical models. However, due to the fundamental differences in the manner that analytical and numerical models are designed and constructed (including differences in the methodology used to account for existing groundwater uses), some issues may be pertinent to only one modeling methodology or the other. The hydrologic report must include a discussion of any modification(s) or attempts to modify simulated well locations or pumping depths that may have been made to address any form of negative impact that may have been projected by the 100-year drawdown analysis.

1. Municipal Pumping

If the 100-year drawdown analysis for an AAWS application indicates that a well associated with a municipal provider that serves a use that is included in a determination of AAWS is impacted such that the water level at the well exceeds the maximum allowable 100-year depth-to-static water level or that the water level reaches the bottom of the aquifer (goes dry) during the 100-year period, the applicant must reduce its own projected groundwater demands or move its wells to mitigate the impacts to the provider's well. If the applicant is unable to mitigate the impacts on the well, the applicant must seek an alternative water supply.

2. Exempt Wells

Wells that pump 35 gallons per minute or less for non-irrigation use are classified as exempt wells. An applicant for a new AAWS determination cannot impact an exempt well that serves a use included in an issued AAWS determination in a manner that causes the water level at the well to exceed the maximum allowable 100-year depth-to-static water level or to reach the bottom of the aquifer (go dry). If the exempt well is not used to serve a use included in an issued AAWS determination, then there is no protection afforded to the well.

3. Irrigation District Pumping for Non-AAWS Use

Irrigation districts exist both within and outside AMAs. When demonstrating physical availability for an AAWS application, the applicant must take into account the groundwater withdrawals from an irrigation district's wells based on the average historic groundwater withdrawals from those wells.

If the 100-year drawdown analysis for an AAWS application indicates that a well associated with an irrigation district not serving an AAWS use is impacted during the 100-year period such that the water level exceeds the depth of the well, the applicant must first assume that the well will be deepened and continue to simulate the average historic pumping of the well from a deeper portion of the aquifer (that is, from a deeper model layer in numerical models) over the 100-year period. If, however, the well cannot be deepened due to physical constraints of the aquifer, then the applicant must make reasonable efforts to move the well to a location within the existing boundaries of the irrigation district where the well can withdraw groundwater and continue to simulate the demands from the well over the 100-year period. If, after the applicant has made reasonable efforts to deepen the well or to move it to another location within the boundaries of the irrigation district, the well still is impacted such that the water level at the well reaches the bottom of the aquifer (goes dry) during the 100-year period, the applicant does not need to continue simulating that pumping for the remainder of the 100-year period.

4. Irrigation Grandfathered Rights

If the 100-year drawdown analysis for an application for an assured water supply determination indicates that a well associated with an irrigation grandfathered right (IGFR) is impacted during the 100-year period such that the water level exceeds the depth of the well, the applicant must first assume that the well will be deepened and continue to simulate the average of the historic pumping of the well from a deeper portion of the aquifer (a lower model layer) over the 100-year

period. If, however, the well cannot be deepened due to physical constraints in the aquifer, then the applicant must make reasonable efforts to move the well to a location where the well can withdraw groundwater and continue to simulate the demands for the well over the 100-year period. If, after the applicant has made reasonable efforts to deepen the well or to move it to another location, the well still is impacted such that the water level at the well reaches the bottom of the aquifer (goes dry) during the 100-year period, the applicant does not need to continue simulating that pumping for the remainder of the 100-year period.

Outside AMAs there are no IGFRs; however, agricultural pumping must be simulated as an existing use in the hydrologic model. The same criteria for demonstrating impacts to IGFR wells within the AMAs must be used for wells pumping groundwater for agricultural uses outside AMAs.

5. Non-Irrigation Grandfathered Rights (GFR)

If the 100-year drawdown analysis for an application for an assured water supply determination indicates that a well associated with a non-irrigation grandfathered right (GFR) is impacted during the 100-year period such that the water level exceeds the depth of the well, the applicant must first assume that the well will be deepened and continue to simulate the average historic pumping of the well over the 100-year period. If the well cannot be deepened due to physical constraints in the aquifer, then the applicant must make reasonable efforts to move the well to a location where the well can withdraw groundwater and continue to simulate the demands for the well over the 100-year period. If, after the applicant has made reasonable efforts to deepen the well or move it to another location, the well still is impacted such that the water level at the well reaches the bottom of the aquifer (goes dry) during the 100-year period, the applicant does not need to continue simulating that pumping for the remainder of the 100-year period.

Outside AMAs, there are no GFRs; however, non-irrigation pumping must be simulated as an existing use in the hydrologic study. The same criteria for demonstrating impacts to GFR wells within the AMAs must be used for wells pumping groundwater for non-irrigation uses outside of the AMAs.

6. Groundwater Withdrawal Permits

If the 100-year drawdown analysis for an AAWS application indicates that a well associated with a GIU permit is impacted such that the water level reaches the bottom of the aquifer (goes dry) during the 100-year period, the applicant must reduce its own projected groundwater demands or move its wells to mitigate the impacts to the well associated with the GIU permit. If the applicant is unable to mitigate the impacts on the well, the applicant must seek an alternative water supply or the application will be denied.

For a groundwater withdrawal permit other than a GIU permit, there is no requirement that an applicant for an assured water supply determination reduce its own projected groundwater demands or move its wells to mitigate any impacts to a well associated with the permit. However, the applicant must make reasonable efforts to continue to incorporate withdrawals from the well in order to demonstrate that groundwater will be physically available to the

applicant, as set forth in the AAWS Rules. Therefore, if the 100-year drawdown analysis for an application for an assured water supply determination indicates that a well associated with a groundwater withdrawal permit other than a GIU permit is impacted during the term of the permit such that the water level exceeds the depth of the well, the applicant must assume that the well will be deepened and continue to simulate the average of the historic pumping of the groundwater withdrawal permit, or a reasonable volume for a permit issued within the previous 2 years, for the remaining term of the permit. If, after the applicant has made reasonable efforts to deepen the well, the well still is impacted such that the water level at the well reaches the bottom of the aquifer (goes dry) during the remaining term of the permit, the applicant does not need to continue simulating that pumping for the remaining term of the permit.

7. Indian Tribes

There are 28 Indian communities throughout Arizona. The associated demands on these tribal lands are relatively unknown, with some exceptions. Generally each tribe has the right to access the groundwater for their demands, without regulation by the State. However, some of these tribes have specific settlement agreements for water supplies that address groundwater. There are provisions in a few of the settlement agreements that specifically limit groundwater pumping on-reservation or in areas adjacent to the reservation, either pursuant to State law or by agreement of the parties to the settlement. All applications for AAWS determinations must take these special provisions that limit pumping into account.

If the 100-year drawdown analysis for an AAWS application indicates that a well on a reservation will be impacted during the 100-year period such that the water level exceeds the depth of the well, the applicant must assume that the well will be deepened. If the well is impacted such that the water level at the well reaches the bottom of the aquifer (goes dry), then the applicant must make reasonable efforts to move the well to a location on the reservation where the well can withdraw groundwater and continue to simulate the demands from the well over the 100-year period. If, after the applicant has made reasonable efforts to continue to incorporate the withdrawals, the impacts cannot be mitigated by the above methods, the applicant does not need to continue simulating that pumping for the remainder of the 100-year period.

V. 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

Date