ARIZONA DEPARTMENT OF WATER RESOURCES

REPORT ON THE FINAL DECISION AND ORDER

THAT THE PRESCOTT ACTIVE MANAGEMENT AREA

IS NO LONGER AT SAFE-YIELD

January 12, 1999

ARIZONA DEPARTMENT OF WATER RESOURCES
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JANE DEE HULL
Governor

RITA P. PEARSON
Director

January 12, 1999

Dear Interested Parties:

Just over four months ago, I issued a preliminary determination that the Prescott Active Management Area (AMA) is no longer at "safe-yield." That determination was the beginning of a formal public process to review evidence on the groundwater conditions of the Prescott AMA. At issue is whether sufficient groundwater is available for new subdivisions that is not already committed to existing or approved but unconstructed lots and subdivisions. If the scientific evidence establishes that using groundwater for additional subdivisions would create long-term reductions in the groundwater in storage and thus threaten the stability of the water supply of both new and existing groundwater users, it is my responsibility to declare that the Prescott AMA is no longer at safe-yield and that groundwater cannot be depended upon to supply water for additional residential subdivisions. After re-examining the studies of the Arizona Department of Water Resources (Department) and examining the evidence, information and comments that have been submitted to me since I announced my preliminary determination, I have today signed a Final Decision and Order that the Prescott AMA is no longer at safe-yield.

This decision was made only after careful consideration and analysis. The Department's hydrology staff has studied groundwater conditions in the Prescott AMA for more than 15 years. One of the significant efforts of my staff during that period was the development of a Prescott AMA groundwater model. That model operates well when it is run to re-create past measured groundwater conditions in the AMA. It is reasonable to conclude that it can also create reliable predictions of the future groundwater supplies in the AMA. During the model's development, it was submitted for peer review to the United States Geological Survey (USGS) and to the University of Arizona. Both of those reviews were favorable.

My staff has also undertaken the collection and analysis of water level measurements in the AMA. They have studied data previously gathered by the USGS and the University of Arizona and have implemented an expansive data collection program for the AMA. The analysis of the available data shows that more than 70 percent of the wells examined have experienced long- term declines since the 1940's, as well as more recently, during the 1980 and 1990's.

Using the groundwater model and other available data, my staff also prepared water budgets for the AMA for each year from 1990 to 1997. In all but one of those years, the flood year of 1993, the budgets indicate that the AMA's aquifers were depleted by an average of 6,166 acre-feet (af) per year. When this information is considered, along with the fact that more than 30,000

additional lots have been approved to use groundwater in the Prescott AMA, it can reasonably be concluded that groundwater is already over allocated and not available for use by additional subdivisions in the AMA.

I have carefully considered the information and opinions provided at the public hearing in Prescott on September 26, 1998, and I have read each of the more than 400 letters sent to me during the public comment period following the hearing. Although the opinions ranged widely on whether the AMA should be declared no longer at safe-yield, consensus was apparent on a number of points. First, all of the residents of the Prescott AMA and Yavapai County share a sincere concern over the future of their community. Second, the love and respect the residents hold for the unique beauty of this area of Arizona was also evident in each of the opinions expressed.

There was less unanimity on what course of action is in the best interest of the area. Many expressed the opinion that the discrepancies between the Department's groundwater model and the model prepared by Southwest Ground-Water Consultants, Inc. (discussed below), indicate that further study of the AMA's safe-yield status is needed. Others, however, declared that enough study has been done and that the Department's study conclusively establishes that the AMA is not at safe-yield. Some even took the Department to task for not declaring the AMA out of safe-yield much earlier.

Similar disagreement was expressed on the impact of the declaration. Many opinions expressed concern over the impact of the declaration on growth and the area's economy. A number of people stated that not allowing additional subdivisions to be based on groundwater in the AMA would lead to haphazard "lot-splitting" development within the AMA and greater rural development outside the AMA. Many were also concerned over the impact this type of "unplanned" development would have on the local environment. Others, however, submitted letters pleading with the Department to protect their water supplies. They submitted personal accounts of the hardships they have faced due to unreliable water supplies. Other people expressed the opinion that overuse and depletion of groundwater supplies would eventually have a devastating impact on the economy of the area.

As mentioned above, much public comment was engendered by the discrepancies between the Department's groundwater model and the groundwater model prepared by Southwest Ground-Water Consultants, Inc., (Southwest) and submitted to the Department on behalf of Shamrock Water Company, Fain Signature Group, Fain Land and Cattle Company, Fain Family Limited Partnership, and Norman W. Fain II and Nancy L. Fain Revocable Trust (Fain Group). The Department respects the work and professionalism of Southwest and therefore examined its model with considerable interest. Southwest's model was developed by changing a number of values and assumptions in the Department's own model. After careful study, the Department identified four areas where these alterations suggest fundamental flaws in the Fain Group's model.

First, the Fain Group's model assumes that a highly productive lower volcanic aquifer extends throughout the Upper Agua Fria subbasin. Although recent evidence has demonstrated some

areas of productive volcanics in the Upper Agua Fria subbasin, the extension of this highly productive aquifer throughout the subbasin is contradicted by evidence from other wells drilled in the subbasin.

Second, the Fain Group's model employs transmissivity values (the rate at which water flows through an aquifer) in the Upper Agua Fria subbasin far in excess of the transmissivity values demonstrated by actual pumping tests.

Third, the assumption of an extensive, highly transmissive volcanic aquifer in the Upper Agua Fria subbasin resulted in the Fain Group's model using extremely high recharge values. The Fain Group's model relies on the hypothesis that in the natural or pre-development period of the Prescott AMA, recharge in the area was approximately 22,000 af per year. That figure is three to four times higher than the value used in the Department's model and is significantly higher than the estimates developed by others who have also studied the issue.

The Fain Group attempts to corroborate this extremely high recharge value by using the "Maxey-Eakin" method of estimating recharge. The Maxey-Eakin method is a climatic model that was developed for use in central Nevada. It is highly sensitive to differences in climate, geology and vegetation from those of central Nevada. The Prescott area varies considerably from central Nevada, and these variations make the application of the Maxey-Eakin method to the Prescott area highly suspect. In fact, the USGS submitted comments to the Department stating that because the Maxey-Eakin method provides recharge estimates in the Prescott area that are three to five times higher than previous estimates, those estimates should be examined closely.

Fourth, the Fain Group's model also included a large volume of natural discharges from the AMA. There is simply no hydrologic evidence to support the existence of large quantities of discharge through drains hypothesized in the model. In fact, considerable evidence contradicts the existence of these drains.

Due to these significant flaws and unsubstantiated assumptions, the Department has not found the Fain Group's model persuasive. This same conclusion was reached by Dr. William Woessner of the University of Montana and by the USGS. Dr. Woessner, a professor of hydrogeology, has coauthored an authoritative college textbook on groundwater modeling. The Department hired Dr. Woessner to examine both its model and the model submitted by the Fain Group. He was selected for his professional expertise, his reputation in the field of groundwater modeling and his lack of affiliation with any water interests in Arizona. Dr. Woessner found that the Fain Group's estimates of recharge for the Prescott AMA were not supportable. He concluded that the Department's model provided an overall more reasonable representation of the hydrogeology than did the Fain Group's model.

The USGS informed the Department in its written comments that the Fain Group's model, as it was presented to the USGS, was unlikely to have passed through the USGS review or approval system or that of a refereed journal. Thus, the Fain Group's model is unpersuasive to the Department's hydrologists, Dr. Woessner and the USGS.

These findings were not changed when, just over a month ago, the Department was informed that the Fain Group had submitted an incorrect computer file in conjunction with its study. The data set on the incorrect computer file was not a part of its model, nor was it critical to the Department's review of the Fain Group's model. Dr. Woessner concurred that the incorrect file was not material to his review.

Although the Department has serious concerns with basic assumptions underlying the Fain Group's model, even that model shows more water is leaving and being pumped from the aquifers each year than is being recharged. In spite of this, the comments submitted to the Department by the Fain Group assert that the AMA is at safe-yield. The Fain Group can reach this conclusion, however, only by using a definition of safe-yield that ignores natural losses from the aquifer. They assert that safe-yield means that groundwater pumping in the area is less than the amount of recharge, regardless of how much groundwater is naturally discharged from the aquifers.

But as was tacitly admitted during the hearing in Prescott by the attorney for the Fain Group, this definition of safe-yield, under which natural discharges from the AMA's aquifers are ignored, leads to the proposition that an AMA's aquifers can be drained dry while the AMA remains at safe-yield. The legislature enacted the Groundwater Management Act of 1980 to protect Arizona from the depletion of its aquifers. I cannot accept the position that the legislature adopted a definition of safe-yield that allows those aquifers to be drained dry.

As the Department has stated in the past, it does not believe that there is imminent danger of a widespread water crisis in the Prescott AMA. Nevertheless, for those residents of the AMA that are currently experiencing water supply problems, the crisis has already arrived. Of all the letters the Department received from people interested in these safe-yield proceedings, none is more memorable than that of a widow in the Prescott area who submitted a lengthy handwritten letter describing life with an undependable water supply while caring for her cancer-stricken husband. She movingly described how her husband, upon entering the Veterans Affairs hospital for the last time, joked that he would at least now have water when he needed it. As she was preparing to go to the funeral home to make arrangements to bury her husband, the water ran dry, leaving her with shampoo in her hair, but no way to rinse it. The Decision and Order that I have signed today will not immediately bring water or peace of mind to this widow, but it is the first step in ensuring that her travails will not become commonplace in the Prescott area.

Because the Department's technical evidence strongly supports a finding that the AMA is no longer at safe-yield and because I have found no credible evidence refuting the Department's evidence, I have concluded that the Prescott AMA is no longer at safe-yield. The time has come to bring closure to this debate and take the next step to begin to cooperatively solve the future challenges facing the AMA.

I have consulted with a number of elected and community leaders from the Prescott, Prescott Valley and ChinoValley areas during the last few weeks. Most of these leaders have encouraged me to make a final decision as soon as possible so that they can move forward with planning for a secure and sustainable water supply. I have committed the Department's resources to continue

to work with local interests to develop long-range water supply plans, to efficiently use all available resources and to evaluate the potential for importing additional water to the area.

Governor Jane Dee Hull has maintained her support for cooperative efforts among the Department, the local agencies, public officials and residents of the area to address the water management issues facing the Prescott AMA and all of Yavapai County. It is for this reason that on January 11, 1998, in her State of the State address, the Governor requested that the legislature appropriate funds this year to financially assist the efforts in addressing the future water needs in Yavapai County and throughout rural Arizona. I look forward to working with the people of the Prescott AMA and Yavapai County to ensure a secure water supply for generations to come.

Sincerely,

Rita P. Pearson
Director

RPP:clc

ARIZONA DEPARTMENT OF WATER RESOURCES

BEFORE THE DIRECTOR

IN THE MATTER OF THE DETERMINATION OF WHETHER THE PRESCOTT ACTIVE MANAGEMENT AREA IS NO LONGER AT SAFE-YIELD	**FINAL DECISION AND ORDER**

On August 28, 1998, the Director of the Arizona Department of Water Resources issued a Preliminary Determination that the Prescott Active Management Area is no longer at safe-yield. That Preliminary Determination was made pursuant to 1998 Ariz. Sess. Laws, Chapter 86, and A.A.C. R-12-15-705(D). In accordance with A.A.C. R-12-15-705(E), the Director conducted a public hearing in Prescott, Arizona, on September 26, 1998, to hear oral testimony and to receive documentary evidence on the issue of whether the Prescott Active Management Area is no longer at safe-yield. Additional public comment and information were received by the Director during a public comment period which followed the hearing pursuant to A.A.C. R-12-15-705(E).

Having considered the studies conducted by the Arizona Department of Water Resources and all information and evidence submitted at the hearing and during the public comment period,

IT IS HEREBY ORDERED:

1. That it is the determination of the Director of the Arizona Department of Water Resources that the Prescott Active Management Area is no longer at safe-yield.

2. That the Report on the Final Decision and Order that the Prescott Active Management Area is No Longer at Safe-Yield, which explains the evidence upon which this Final Decision and Order is based, is adopted.

3. That in calculating the volume of groundwater which may be withdrawn consistent with the achievement of the management goal of the Prescott Active Management Area for the purposes of A.R.S. § 45-576(H)(2), the Director shall apply the formula set forth in

A.A.C. R-12-15-705(F), as that formula is amended by 1998 Ariz. Sess. Laws, Chapter 86.

This Final Decision and Order is subject to rehearing or review and judicial review as provided in A.R.S. § 45-114(C). A party choosing to file a motion for rehearing or review shall file that motion no later than March 4, 1999.

Given under my hand and Official Seal of the Arizona Department of Water Resources this 12th day of January, 1999.

(S E A L)

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Rita P. Pearson
Director

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FINAL DECISION AND ORDER REPORT

I. Introduction

A. Background

On August 28, 1998, the Director (Director) of the Arizona Department of Water Resources (Department) issued a Preliminary Determination that the Prescott Active Management Area (AMA) is no longer at "safe-yield." That determination, made pursuant to 1998 Ariz. Sess. Laws, Chapter 86, and A.A.C. R-12-15-705(D), began a public process to review evidence and determine whether groundwater is still available in the AMA that can be allocated for use by new subdivisions without those new demands and uses causing or contributing to a long-term reduction of the current groundwater reserves in the AMA.

Concurrently with issuing that Preliminary Determination, the Department issued a Preliminary Determination Report[1] that explained the evidence that led the Director to issue the Preliminary Determination. At the same time, the Director issued notice that a hearing would be conducted in order to collect evidence and make a final determination as to whether the Prescott AMA is no longer at safe-yield. That hearing was held on Saturday, September 26, 1998, at the Prescott High School Arts Center, Prescott, Arizona. Following the hearing, a public comment period allowed the public to submit their written comments on the safe-yield issue to the Director.

To assist with these proceedings, the Department contracted with Dr. William Woessner of the University of Montana. Dr. Woessner, a professor of hydrogeology, has coauthored an authoritative college textbook on groundwater modeling. The Department hired Dr. Woessner for his professional expertise, his reputation in the field of groundwater modeling and his lack of affiliation with any water interests in Arizona. Dr. Woessner attended the hearing in September.

As a part of its studies of the Prescott AMA, the Department developed a computerized groundwater model of the Prescott AMA. At the September hearing and during the public

[1] *See* Appendix A.

comment period, a second groundwater model of the Prescott AMA was presented to the Department by Shamrock Water Company, Fain Signature Group, Fain Land and Cattle Company, Fain Family Limited Partnership and the Norman W. Fain II and Nancy L. Fain Revocable Trust (Fain Group). The Department submitted both its own groundwater model and the Fain Group model to Dr. Woessner. Following his review, Dr. Woessner authored an independent analysis and evaluation of the two models.[2]

B. Final Decision and Order

After reviewing the Department's Preliminary Determination Report, the comments made at the public hearing on September 26, all of the written comments and Dr. Woessner's report, the Director of the Department of Water Resources has signed a Final Decision and Order that the Prescott AMA is no longer at safe-yield. This Final Report presents the evidence that led to the Director signing the Final Decision and Order.

II. Re-Adoption and Review of Preliminary Determination Report

A. Re-Adoption and Incorporation of Preliminary Determination Report

After having reviewed all of the information submitted in these proceedings, the Director finds that the information and evidence presented in the Department's August 28, 1998, Preliminary Determination Report is relevant and material to the Final Decision and Order. Therefore, the Director re-adopts and incorporates by this reference the Preliminary Determination Report. However, a review of certain key information contained in the Preliminary Determination Report is appropriate.

B. Safe-Yield and the Assured Water Supply Program

These proceedings to determine whether the Prescott AMA is no longer at safe-yield arise out of the Assured Water Supply (AWS) Program. The AWS Program is administered by the Department under A.R.S. § 45-576. Under the AWS Program, people proposing to offer subdivided lands for sale or lease within an AMA are required to demonstrate to the Department that a proposed subdivision has a water supply that is assured to last for at least 100 years.

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[2] *See* Appendix B.

There are a number of requirements that must be met by an applicant in the AWS Program. One of the most significant of these requirements is that the projected water use of the proposed subdivision be "consistent with the management plan and achievement of the management goal" for the AMA in which the subdivision will be located.[3] In the Prescott AMA, the groundwater management goal is safe-yield.[4] Safe-yield is defined by statute to mean:

> [a] groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial recharge in the active management area.[5]

Thus, under the AWS Program, the Department approves an AWS application for a new subdivision only if the projected water use for that subdivision will not interfere with the "long-term balance" of the amount of groundwater stored in the AMA.

In 1995, when the Department adopted the current AWS Rules,[6] the evidence available at the time indicated that there might still be groundwater available in the Prescott AMA that could be committed for use to new subdivisions without those additional groundwater uses interfering with the long-term balance or safe-yield of groundwater storage in the area. The AWS Rules anticipated, however, ongoing monitoring of the Prescott AMA. They provide that when the Director of the Department finds that there is no longer groundwater available to be committed to new subdivisions without causing a depletion of the groundwater in storage in the AMA, the Director is to declare the AMA no longer to be in safe-yield and, under the AWS Rules, limit the amount of groundwater that can be used to establish assured water supplies to additional subdivisions.

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[3] A.R.S. § 45-576(I)(2).

[4] A.R.S. § 45-562(A).

[5] A.R.S. § 45-561(12).

[6] A.A.C. R-12-15-701 *et seq.*

C. Water Level Measurements in the Prescott AMA

The Department has undertaken extensive data collection and analysis of water levels in the Prescott AMA. Data are available from as early as 1940 from measurements and study conducted by the University of Arizona, the United States Geological Survey (USGS) and, more recently, the Department of Water Resources. In 1995, the Department implemented an expanded monitoring plan.

The Department has analyzed the data for water level trends over the periods between 1940 and 1994, between 1982 and 1998 and between 1994 and 1998. Data from all three periods indicate gradual but definite ongoing water level declines in approximately 73 percent of the wells for which data was available. Figure 1 shows the network of 57 index wells and five surface water monitoring gauges in place in 1997, as well as proposed stream gauges for increased surface water monitoring and five new index wells. Figure 2 shows the actual water level changes at wells measured in both 1982 and 1998. Table 1 summarizes the changes in water level during the 1982 to 1998 period and the 1994 to 1998 period.

D. Water Budgets: 1990-1997

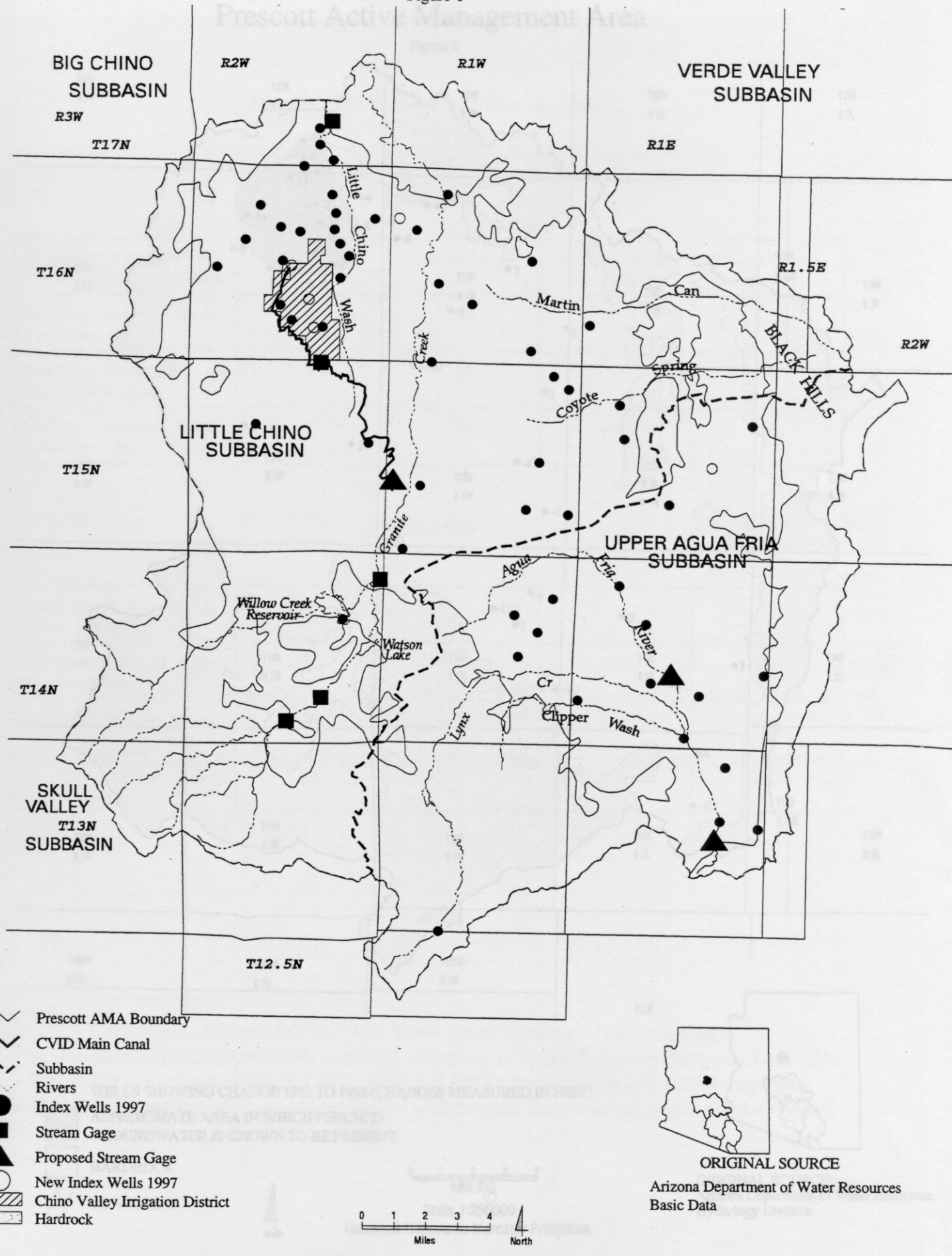
An annual water budget for the AMA compares the amount of water going into the AMA's aquifers each year with the amount leaving those aquifers. The Department prepared annual water budgets for each year from 1990 to 1997. The budgets are summarized in Table 2. These budgets indicate that the total amount of groundwater leaving the AMA's aquifers significantly exceeds groundwater recharge in the AMA for each year except for the flood year of 1993. Thus, for seven out of eight years, the AMA's aquifers were overdrafted. From 1990 through 1997, groundwater storage was depleted by an average of 6,166 acre-feet (af) per year.

In Dr. Woessner's review of the Department's Preliminary Determination Report, he stated that the Department's water budgets for the AMA would be improved if they recognized the variability of such values as recharge and discharge. Dr. Woessner proposed use of "confidence limits" to bracket the range of uncertainty of the water budget components.

The confidence limits proposed by Dr. Woessner were +\-50 percent of the actual estimated recharge, and +\-25 percent of the actual estimated groundwater pumpage. A confidence limit of +\-50 percent was also applied to groundwater discharge. Using these

Groundwater and Surfacewater Monitoring Locations 1997

Figure 1



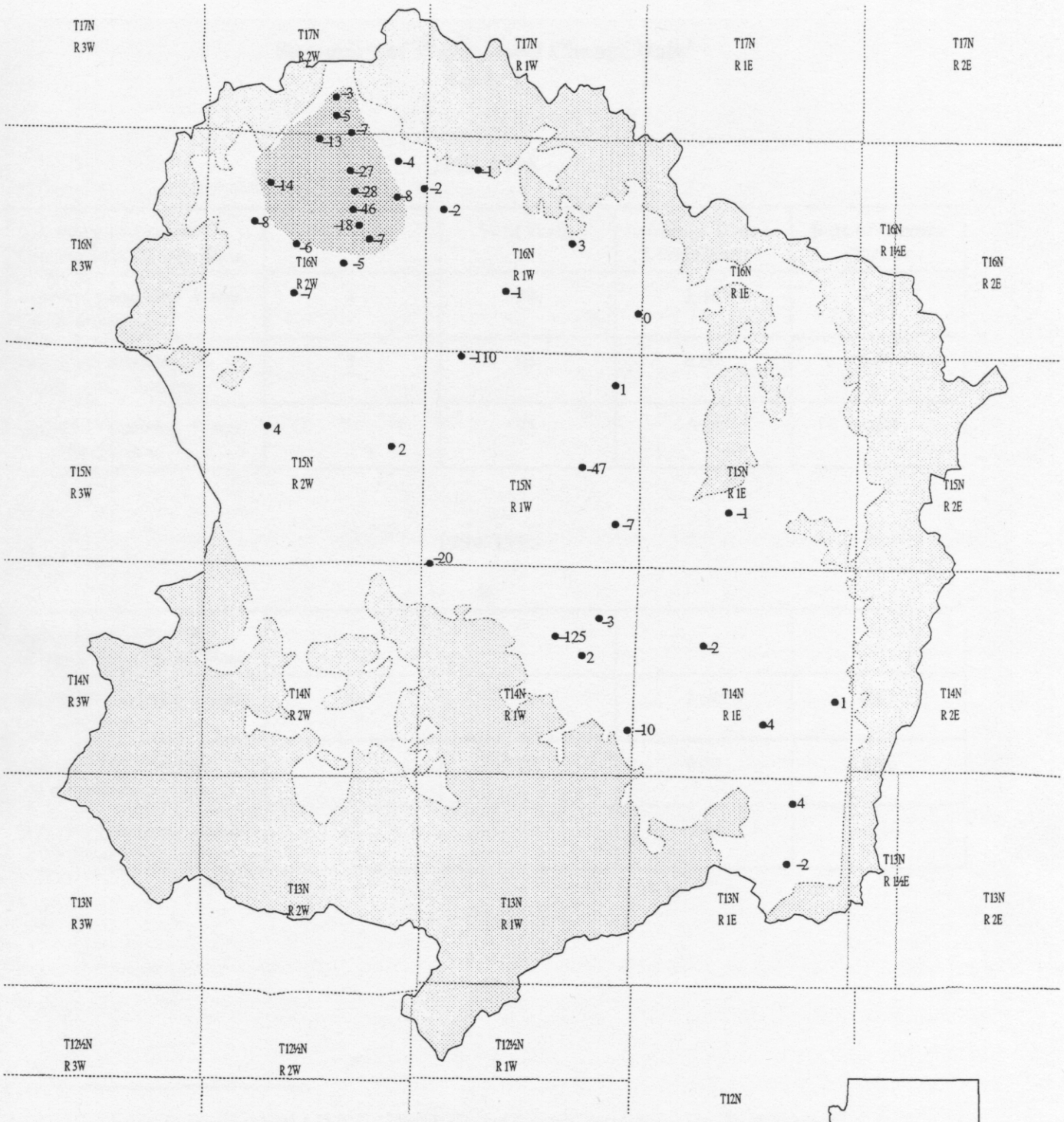
ORIGINAL SOURCE

Arizona Department of Water Resources
Basic Data

Water Level Changes Between 1982 and 1998

Prescott Active Management Area

Figure 2



● WELLS SHOWING CHANGE 1982 TO 1998 (CHANGES MEASURED IN FEET)

APPROXIMATE AREA IN WHICH PERCHED GROUNDWATER IS KNOWN TO BE PRESENT

HARDROCK

TOWNSHIPS

North

0 1 2 3 4
MILES

Scale 1:260000

Universal Transverse Mercator Projection

ORIGINAL SOURCE:
Arizona Department of Water Resources
Hydrology Division

Summary of Water Level Change Data[1]
Table 1

1982-1998

Summary of 1982-98 Water Level Change Data	# of Wells	% of Wells	Average Water Level Change	Rate of Change (Ft/Yr)
# of Wells Showing Water Level Increases	8	22	2.48	0.15
# of Wells Showing No Water Level Changes	1	03	0.00	0.00
# of Wells Showing Water Level Declines	27	75	-9.45	-0.59

1994-1998

Summary of 1994-98 Water Level Change Data				
# of Wells Showing Water Level Increases	8	18	2.68	0.67
# of Wells Showing No Water Level Changes	4	09	0.00	0.00
# of Wells Showing Water Level Declines	33	73	-5.83	-1.46

[1] Data obtained from ADWR GWSI Water Level Database. See Preliminary Determination Report, Appendix B, Exhibit 2, Summary of Water Level Measurement Data from GWSI Wells in the Prescott AMA (1982, 1994 and 1998), for complete information regarding well location numbers, aquifers and subbasins, well owners, the period of record, depth-to-water for each year and changes in water levels.

Prescott Active Management Area 1990-1997 Groundwater Budget

Table 2

	1990	1991	1992	1993	1994	1995	1996	1997
GROUNDWATER DEMAND								
MUNICIPAL GROUNDWATER WITHDRAWALS	**8289**	**8657**	**8756**	**9595**	**10044**	**10303**	**11635**	**11594**
City of Prescott	5014	5221	5056	5633	5656	5664	6352	6509
Shamrock Water Company	1795	1854	2019	2232	2615	3010	3439	3353
Small Provider	279	335	364	464	493	463	537	521
Exempt Wells	1201	1257	1317	1266	1280	1166	1307	1211
AGRICULTURAL GROUNDWATER WITHDRAWA	**6032**	**5943**	**4613**	**6460**	**6134**	**5316**	**6629**	**6260**
Irrigation Grandfathered Rights	6032	5943	4613	6460	6134	5316	6629	6260
INDUSTRIAL GROUNDWATER WITHDRAWALS	**444**	**486**	**443**	**500**	**533**	**555**	**688**	**626**
Turf Facilities	349	399	313	343	357	391	502	434
Non-Turf Facilities	95	87	130	157	176	164	186	192
NATURAL SYSTEM DISCHARGES	**4850**	**4850**	**4850**	**4850**	**4850**	**4850**	**4850**	**4850**
Del Rio Springs Underflow from AMA	1500	1500	1500	1500	1500	1500	1500	1500
Del Rio Springs Baseflow from AMA	2100	2100	2100	2100	2100	2100	2100	2100
Upper Agua Fria Baseflow from AMA	1250	1250	1250	1250	1250	1250	1250	1250
GROUNDWATER RECHARGE								
INCIDENTAL RECHARGE	**4578**	**8128**	**7640**	**9744**	**4512**	**7988**	**4942**	**4651**
Agricultural Incidental Recharge	2413	3396	2756	3967	2875	4053	2906	2669
CVID Canal Losses	0	2548	2277	3449	1053	3001	635	412
Industrial Incidental Recharge	35	56	48	56	53	59	72	60
Effluent Discharged into Agua Fria	0	0	0	0	531	875	1329	1510
Effluent Recharged with No Credits	2131	2128	2559	2272	0	0	0	0
NATURAL SYSTEM RECHARGE	**4600**	**4600**	**4600**	**23320**	**4600**	**8920**	**4600**	**4600**
Upper Agua Fria Natural Recharge	2550	2550	2550	2550	2550	2550	2550	2550
Little Chino Natural Recharge	2050	2050	2050	2050	2050	2050	2050	2050
Granite Creek Flood Recharge	0	0	0	18720	0	4320	0	0
CHANGE IN STORAGE								
TOTAL GROUNDWATER DEMAND	19615	19946	18662	21405	21561	21024	23802	23330
TOTAL GROUNDWATER RECHARGE	9178	12728	12240	33064	9112	16908	9542	9251
TOTAL GROUNDWATER OVERDRAFT	**-10437**	**-7218**	**-6422**	**11659**	**-12449**	**-4116**	**-14261**	**-14079**
City of Prescott Effluent Recharge Credits	0	0	0	0	1940	2098	1688	2270
CHANGE IN GROUNDWATER STORAGE	**-10437**	**-7218**	**-6422**	**11659**	**-10509**	**-2018**	**-12573**	**-11809**

Arizona Department of Water Resources Hydrology Division. For further information see Arizona Department of Water Resources Preliminary Determination Report on the Safe-Yield Status of the Prescott Active Management Area, August 28, 1998, Appendix C, Exhibit 1 for Prescott Active Management Area Water Budget which includes renewable supplies (surface water and effluent), as well as a list and discussion of assumptions and references used in developing this budget.

confidence limits, the Department prepared "best case" and "worst case" water budgets for 1997. Figure 3 shows the estimated water budget for 1997 with the confidence limits recommended by Dr. Woessner.

As illustrated by Figure 3, the "best case" budget reflects a 997 af increase in groundwater storage, assuming that the maximum amount of recharge and the minimum amount of groundwater discharge and pumpage occurred during the year. The "worst case" scenario reflects a loss in groundwater storage of 24,615 af, assuming that the minimum recharge and the maximum amount of groundwater discharge and pumpage occurred during the year. The range in the budget estimates indicate that groundwater overdraft conditions are far more probable than surplus conditions. Even under the "best case" scenario, the 997 af of surplus is dwarfed by the additional 10,000 af annual demand on groundwater resources of the area that is already committed to approved but unconstructed subdivisions.[7]

E. Hydrogeologic Studies and the Groundwater Flow Model of the Prescott AMA

The Department has been studying the groundwater conditions of the Prescott AMA for more than 15 years. One of the key efforts of that study was the development of a computerized groundwater model for the AMA, which was completed in 1995. Extensive data were collected and input into the model.[8] The goal of the model is to re-create, with accuracy, past groundwater conditions so that the model can be used with confidence to predict future groundwater conditions. External peer review of the model was conducted by the USGS and Dr. Tom Maddock III of the University of Arizona. Both external reviews concluded that the model was well constructed and a good representation of the groundwater flow system of the Prescott AMA.

A principal use of the model has been to corroborate the estimates of recharge and discharge used in the annual water budgets prepared by the Department. The Department also

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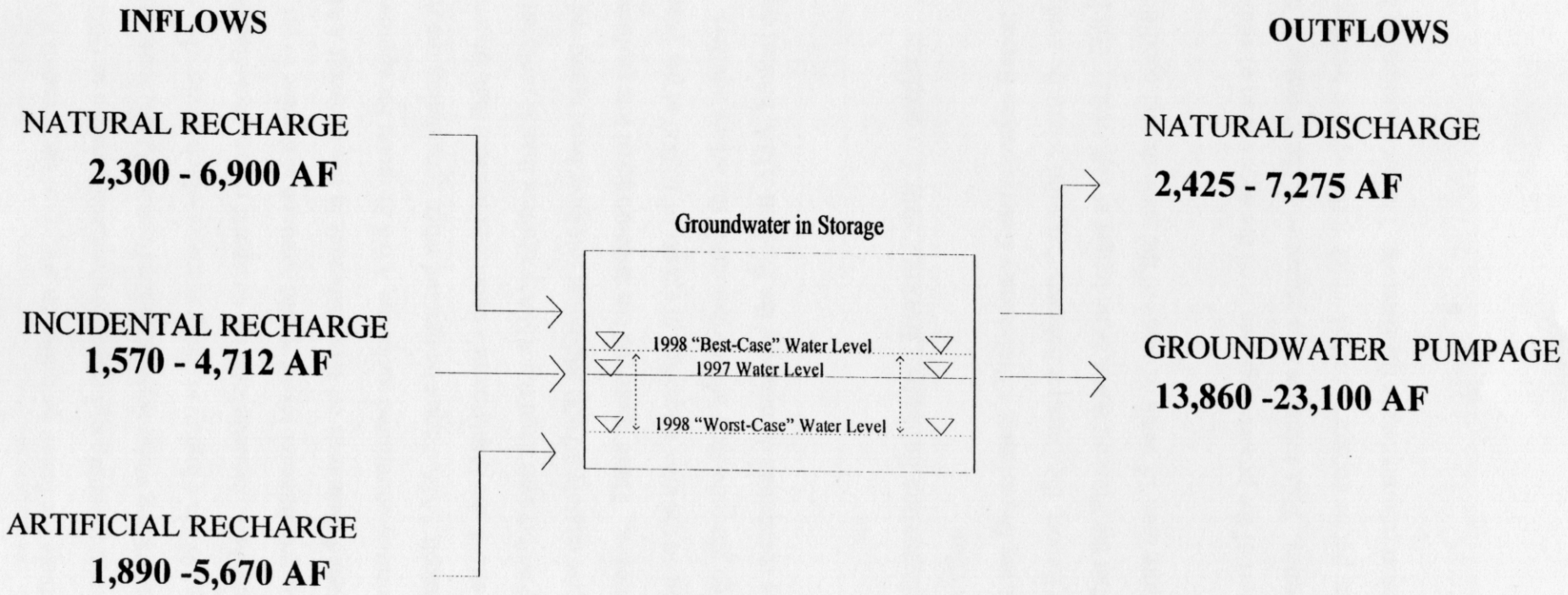
[7] Committed demands are more fully discussed in Part F of this Section.

[8] Complete documentation of the assumptions and procedures used in developing data used for the model is found in Corkhill, E.F., and Mason, D.A., September 1995, Hydrogeology and Simulation of Groundwater Flow, Prescott Active Management Area, Yavapai County, Arizona, Arizona Department of Water Resources, Modeling Report No. 9, 143 p.

1997 PRESCOTT AMA WATER BUDGET
WITH PROPOSED UNCERTAINTY RANGES

Figure 3



	CHANGE-IN-GROUNDWATER STORAGE	=	INFLOWS -OUTFLOWS
BEST-CASE BUDGET (Assuming 50% more recharge, 50% less natural discharge, and 25% less pumpage)	+997 AF	=	17,282 AF -16,285 AF
ACTUAL BUDGET (Based on actual 1997 data or estimates)	-11,809 AF	=	11,521 AF -23,330 AF
WORST-CASE BUDGET (Assuming 50% less recharge, 50% more natural discharge, and 25% more pumpage)	-24,615 AF	=	5,760 AF -30,375 AF

Prepared 1/05/98

Based on uncertainty ranges proposed by Woessner (1998)

Recharge and natural discharge range of uncertainty is +/- 50 % of actual 1997 data or estimates
Pumpage range of uncertainty is +/- 25 % of actual 1997 data or estimates
Some data or estimates are better known than the proposed range of uncertainty indicates

used the model to evaluate the future groundwater supply of the Prescott AMA through 2025. It assumed that groundwater pumping and recharge remained constant at 1992 levels. Given the ongoing growth and increasing water demand in the Prescott AMA, static pumping values over the 33 years following 1992 is a highly unlikely scenario which obviously underestimates future groundwater use in the AMA. Nonetheless, the computer model projected that, even under these optimistic assumptions, groundwater levels would continue to decline in the AMA.

F. Committed Demands on Groundwater in the Prescott AMA

Groundwater already committed under the AWS Program for approved but unconstructed subdivisions in the Prescott AMA cannot be ignored when considering the AMA's safe-yield status. As previously stated, the Department's data demonstrates that, on average, more groundwater is already withdrawn from the AMA's aquifers than is replaced. In addition to these current uses, approximately 30,000 additional lots have been approved under the AWS Program to use groundwater. These approved but unconstructed lots represent an additional potential future demand on the area's aquifers in excess of 10,000 af per year. This committed demand, if developed on groundwater, will further strain the area's aquifers.

Table 3 lists the committed demand for the Prescott AMA, broken down by different categories.

III. Hydrologic Information Submitted During Public Proceedings

A. Introduction

As explained in the Department's Preliminary Determination Report and summarized in Section II of this Final Report, the Director believes that solid scientific evidence has been gathered establishing that the Prescott AMA is no longer at safe-yield. The Department's evidence is based on more than 15 years of study of the groundwater conditions of the Prescott AMA.

An important part of the proceedings has been the solicitation of additional scientific evidence from other parties. This evidence was presented to the Director at the public hearing in Prescott and through the public comment period which followed that hearing. A number of people submitted technical information to the Director. The most extensive comments were

Prescott Active Management Area Committed Demand as of January 1, 1999

Table 3

	Lots	Committed Demand (af/yr)
City of Prescott Service Area		
Recorded Undeveloped Lots	4,299	1,553.00
Grandfathered Plats Approved, Not Yet Recorded	7,575	2,736.44
Shamrock Water Company		
Recorded Undeveloped Lots	3,291	1,255.00
Grandfathered, Complete/Correct Applications	7,455	3,674.69
Pending Applications, Not Yet Determined Complete/Correct	1,720	1,022.04
Town of Prescott Valley		
Recorded Undeveloped Lots	1,028	349.52
Grandfathered, Complete/Correct Applications	3,603	1,316.84
Town of Chino Valley/Yavapai County/Other Water Providers		
Recorded Undeveloped Lots	2,845	985.39
Grandfathered, Complete/Correct Applications	290	96.91
Prescott AMA Totals		
Recorded Undeveloped Lots	**11,463**	**4,142.91**
Grandfathered, Complete/Correct Applications	**18,923**	**7,824.88**
Subtotal	**30,386**	**11,967.79**
Pending Applications, Not Yet Determined Complete/Correct	**1,720**	**1,022.04**
Grand Total	**32,106**	**12,989.83**

Arizona Department of Water Resources, Office of Assured and Adequate Water Supply, 1998

Grandfathered, Complete/Correct Applications, are those applications that were submitted to the Department by August 20, 1998 and determined to be complete and correct. These applications meet the requirements of SB 1124.

Pending Applications, Not Yet Determined Complete/Correct, are those application submitted shortly before the August 20, 1998 deadline that are still under review. If they are determined complete and correct, they will also meet the requirements of SB 1124.

submitted by the Fain Group. In addition to lengthy comments on the Department's Preliminary Determination Report, the Fain Group submitted a second groundwater model of the Prescott AMA to the Department for its review. That model was prepared by Southwest Ground-Water Consultants, Inc. Members of the Fain Group also requested and received one hour of time at the Prescott hearing to present its groundwater model and provide other information to the Director.

The Department also obtained the services of Dr. William Woessner of the University of Montana to review the Department's evidence, as well as the Fain Group model. After reviewing the two studies, Dr. Woessner submitted a report on his findings to the Director.

The Director has reviewed the Department's evidence and has studied the comments and groundwater model submitted by the Fain Group. The Director has also reviewed the information and opinions submitted by other people during the hearing and public comment period, as well as the report submitted by Dr. Woessner. From this review, the Director has concluded that none of the evidence submitted contradicts her preliminary determination that the AMA is no longer at safe-yield.

B. Dr. Woessner's Conclusions

After reviewing both the Department model and the Fain Group model, Dr. Woessner issued a report of his findings. For ease of reference, the executive summary of that report is reproduced here in its entirety:

> This report addresses the task of evaluating two groundwater models, Corkhill and Mason (1995) and Southwest Ground-water Consultants, Inc. (1998) for accuracy and pertinence to the Prescott AMA "safe yield" determination. In completing this task, I assessed: 1) each conceptual model; 2) the formulation of the numerical models; 3) the calibration of the numerical models with the steady-state pre-development (1940) data; 3) [*sic*] the calibration of the models with the transient groundwater-development (1940-1993) data; and 4)[*sic*] the overall reasonableness of the modeling results compared with the basin hydrogeologic conditions. In addition, an evaluation of the applicability of the modeling results to address the question of basin safe yield was completed. I reviewed pertinent literature, and data and analyses provided by ADWR and SGWC as well as using supplied input files to run both the steady-state and transient models.
> Based on my analyses, I concluded the following:
>
> 1) The ADWR model (Corkhill and Mason, 1995) provided an overall more reasonable representation of the hydrogeology and associated water balance components than did the model presented in the SGWC report (1998). This

judgment is principally based on the better calibration of the ADWR model to basin pre-development (1940) groundwater conditions and the groundwater development period. It also is based on what I consider to be a poorly supported SGWC conceptual model. The conceptual model required large volumes of "underflow" to discharge at rates and locations not well supported by hydrogeologic data. The SGWC model yield poor calibrations with measured fluxes at Del Rio Springs and baseflow to the Agua Fria River near Humboldt.

2) The ADWR model will most likely appropriately reproduce trends in the water levels and discharges in the Prescott AMA as currently formulated. However, I recommend using the ADWR model as an active management tool, with annual re-calibration to new field data.

3) The water balance analyses presented in the ADWR safe yield determination report needs to include confidence intervals related to the inherent uncertainty in "measured" or simulated values.

4) Suggesting possible confidence intervals for recharge (+/- 50%) and groundwater demand values (+/- 25%) and assuming that the safe yield definition would allow for capture of all natural basin discharge, under the best case conditions groundwater input would exceed present demand by a few thousand acre ft annually. Current worst case conditions would indicate safe yield is being exceeded by over 9,600 acft/y.

5) If the committed groundwater demand, 10,000 to 13,000 acft/y, reported by ADWR is utilized, the Prescott AMA will, without question, be out of safe yield conditions.

C. Recharge Values

One of the most startling differences between the Department's groundwater model and the Fain Group model are the values used for recharge. Recharge is water from precipitation, rivers, streams and uses by man that slowly percolates into aquifers, providing a replacement for water that is lost through natural discharge from the aquifers or from groundwater pumping. Recharge is, therefore, a key consideration in determining whether groundwater supplies in aquifers are increasing or decreasing.

For the Department's model, the Department's hydrologists determined that it was appropriate to use an average annual recharge value of 7,000 af for the "pre-development" or pre-1940 period. In contrast, the Fain Group model uses a pre-development recharge value of 22,000

af. The Fain Group model uses recharge values over three times those used by the Department. Thus, the Fain Group model indicates that significantly more groundwater is available for use in the AMA, if the water could be captured.

After having reviewed the information submitted and its own data, the Department finds that its recharge values are the most appropriate for use in the groundwater model for the Prescott AMA. The Department's value for natural recharge is similar in range to previous studies conducted on this issue.[9] The Fain Group has criticized the 1967 Schwalen study, which estimated recharge in the Little Chino subbasin to be about 5,000 af per year and the 1988 Wilson study, which estimated recharge in the Upper Agua Fria subbasin to be 2,000 to 3,000 af per year. But the Fain Group's assertion that the Schwalen study was limited to the artesian basin is incorrect given the Schwalen statement that his analysis of recharge extends to ". . . the fractures and jointing in the rock boundaries of the basin."[10] The Fain Group also criticizes the Wilson study, asserting that Wilson provided "no basis" for his assertion that recharge in the Upper Agua Fria subbasin is 2,000 to 3,000 af per year. Unfortunately, the Fain Group provides no scientific evidence supporting its assertion of additional recharge in that area.

It is not easy to determine the amount of recharge that occurs in an area, and scientific disagreement is possible, even probable. Criticism of any scientific study can be made, including criticism of the Schwalen and Wilson studies. It remains fact, though, that those two independent studies arrived at recharge values in the same range as that of the Department.

To support its assertions that recharge in the Prescott area is 22,000 af per year, the Fain Group relies primarily on corroboration by the "Maxey-Eakin" method, developed in the 1940's for use in central Nevada. The Fain Group points out that if the Maxey-Eakin method is applied to the Prescott AMA, recharge is estimated to be 33,351 af per year, or enough water to cover over 300 acres with 100 feet of water each year.

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[9] *See* Arizona Department of Water Resources Preliminary Determination Report on the Safe-Yield Status of the Prescott Active Management Area, August 28, 1998, pp.29-30.

[10] Schwalen, H.C., 1967, Little Chino Valley Artesian Area and Groundwater Basin, Technical Bulletin 178, Agricultural Experiment Station, University of Arizona, Tucson, Arizona, 63 p., p. 51.

The Maxey-Eakin method is a climatic model that was developed to estimate recharge for groundwater basins in central Nevada. Given the differences between that area and the Prescott AMA, the Maxey-Eakin method's predictive reliability for the Prescott area is questionable. The climate, geology and vegetation of the two areas vary considerably in ways that directly impact recharge.

For example, climatic comparisons have shown that central and eastern Nevada receives a far greater percentage of annual precipitation as winter snowfall than does the Prescott area. For example, Ruby Lake, Nevada receives about 12 inches of mean annual precipitation, while Prescott receives about 19 inches. The mean annual snowfall at Ruby Lake, however, is about 50 inches per year, while the mean annual snowfall for Prescott is about 23 inches per year.[11] These differences in snowfall are significant, because snowmelt provides a prolonged source of moisture for recharge. Thus, varying snowfall can greatly influence recharge.

The vegetative cover, even in many of the higher, wetter areas of central Nevada, is far different from the vegetative cover in the Prescott AMA. In central Nevada, relatively treeless, steep-sloped, high elevation mountain ranges are common. Vegetation covering the highland slopes are typical of the Northern Desert Shrub plant association[12] and includes Sage Brush, Rabbit Brush, Juniper and Pinon Pine, although groves of Aspen, White Fir and other alpine vegetation may line mountain streams. The vegetative cover around Prescott, in comparison, is far denser. In the lower elevations of the groundwater basin, Gramma Grass grows in abundance, transitioning to Manzanita and Juniper at higher elevations. The mountainous watershed areas of the Prescott AMA are well known for their dense Ponderosa Pine forests. This denser vegetative cover, of course, consumes water that might otherwise recharge the

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[11] Ruffner, 1980, Climates of the States National Oceanic and Atmospheric Administration Narrative Summaries, Tables and Maps for each State with Overview of State Climatologist Programs, Second Ed., Vol. 1, Alabama-North Dakota, Gale Research Company, Detroit, Michigan, pp. 44 and 481.

[12] Maxey, G.B., and Eakin, T.E., 1949, Groundwater in White River Valley, White Pine Nye, and Lincoln Counties, Nevada, State of Nevada's Office of the State Engineer, Water Resources, Bulletin No. 8, 59 p., p. 25.

aquifers.

Other key differences between the two areas are morphologic and geologic. The groundwater basins of central Nevada, which were studied by Maxey and Eakin, are generally larger and more elongated than the Prescott groundwater basin. For example, the White River Valley, which was studied by Maxey and Eakin, covers an area of 1,620 square miles. The valley is about 70 miles long and ranges in width from approximately 20 to 30 miles.[13] By comparison, the Prescott AMA is about 485 square miles, measuring approximately 25 miles in length and 22 miles in width. One consequence of the White River Valley's size and shape is that streamflow must generally travel much longer distances to exit the valley, thus providing more opportunity for infiltration and recharge to occur than in the Prescott groundwater basin area. The White River flows approximately 50 miles down the central axis of the White River Valley before exiting into an adjacent groundwater basin.[14] In the Prescott AMA, the maximum distance water flows in ephemeral streams which cross the groundwater basin is approximately 10 to 15 miles.[15]

Additionally, many of the mountain ranges of central and eastern Nevada are composed of carbonate rocks. As noted by Maxey and Eakin, some water transmitted from the mountainous recharge area by cavernous limestone aquifers may also recharge the groundwater reservoirs of the valley fill.[16] These rocks may provide more locations for direct infiltration and recharge through fractures than the less permeable igneous and metamorphic rocks which surround much of the Prescott groundwater basin.

It should also be noted that the Maxey-Eakin method has not been without its critics. Although the Fain Group cites a 1992 study by Avon and Durban as supporting the method,

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[13] Maxey and Eakin, Water Resources Bulletin, No. 8, p. 12.

[14] Maxey and Eakin, Water Resources Bulletin, No. 8, plate 1, p. 15.

[15] Corkhill and Mason, Modeling Report No. 9, Fig. 6.

[16] Maxey and Eakin, Water Resources Bulletin, No. 8, abstract.

other authors concluded that the predictive capability of the Maxey-Eakin method is suspect.[17] According to Avon and Durban, "other authors have dismissed the reliability of the Maxey-Eakin method."[18] For example, a group of hydrologists from Nevada concluded that, "[i]t is clear from the variability of the coefficients of the several predictive equations, including Maxey-Eakin, that none of these can be used to reliably predict recharge."[19] Another group of authors discuss the low accuracy of simple precipitation-recharge relations, such as used in the Maxey-Eakin method, noting that the variables in the equation are subject to such broad discrepancies that they are "unusable for prediction, despite being derived from a large, carefully assembled database."[20]

The Fain Group's comments discuss several other methods for estimating recharge for the Prescott AMA. Its comparison of the Prescott area to the Payson area ignores the differences between the size and nature of the aquifers in the two areas. Payson does not have a large regional aquifer like Prescott. Further, the variability of reported recharge estimates for the Payson area is large and uncertain. The Fain Group also suggests using a regression equation developed for estimating mountain front recharge by the USGS. The Department's hydrologists applied that equation, using the precipitation figure provided by the Fain Group, and the recharge calculated by this equation was approximately 6,200 af per year, which compares favorably with the Department's estimate of 7,000 af of recharge each year.

In Dr. Woessner's review of the Department's model and the Fain Group's model, Dr. Woessner found that estimates of recharge in the Prescott area could vary by as much as 50

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[17] Avon, L., and Durban, T.J., 1992, Evaluation of the Maxey-Eakin Method for Calculating Recharge to Ground-Water Basins in Nevada, Las Vegas Valley Water District Cooperative Water Project, Series Report No. 7, 44 p., p. 30.

[18] Avon and Durban, Series Report No. 7, p. 30.

[19] Watson, P., *et al*., 1976, "Quantitative Evaluation of a Method for Estimating Recharge to the Desert Basins of Nevada," Journal of Hydrology, Vol. 3, p. 335.

[20] Lerner, D.N., *et al.*, 1990, "Groundwater Recharge: A Guide to Understanding and Estimating Natural Recharge," International Contributions to Hydrology, Vol. 8, Verlag Heinz Heise GmbH & Co., 345 p., as cited in Avon, L., and Durban, T.J., 1992, Evaluation of the Maxey-Eakin Method for Calculating Recharge to Ground-Water Basins in Nevada, Las Vegas Valley Water District Cooperative Water Project, Series Report No. 7, 44 p., p. 30.

percent from the values used by the Department's model. Based on Dr. Woessner's suggested variables, recharge in the Prescott area during the pre-development period could range between 3,500 and 10,500 af per year. Dr. Woessner then concluded that the annual amount of recharge in the AMA occurring during recent history could range between 4,650 and 13,950 af per year. Dr. Woessner also found, however, that the 300 percent increase represented by the 22,000 af per year used for the recharge value by the Fain Group was not reasonable.[21]

The USGS and the Salt River Project (SRP) also submitted comments to the Department expressing doubt over the amount of recharge used in the Fain Group model. The USGS stated that the fact that the Maxey-Eakin method provides recharge estimates that are three to five times higher than previous estimates seems cause to examine that estimate closely.[22] SRP noted that these recharge values are far higher than values estimated by others and far greater than seems physically possible.[23]

Finally, the Department feels confident in its recharge value because of the correlation between its model runs and actual historic water levels. One of the great tests of the accuracy of a groundwater model is the extent to which the variables used in the equation can re-create measured data. As is more fully discussed in Part G, Section III of the Final Report, the Department's model tracks measured historic water levels well. As is also discussed in that part, the Fain Group model, using its value of 22,000 af of recharge per year, does not reproduce those measured water levels. Therefore, the Department concludes that pre-development, or natural, recharge values of approximately 7,000 af per year, are appropriate for the Prescott AMA.

D. Discharge/Drains

The issue of drains and discharges from the AMA is closely related to the issue of

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[21] Woessner, W.W., 1998, Evaluation of Two Groundwater Models of the Prescott Active Management Area: Arizona Department of Water Resources Model (1995) and Southwest Ground-Water Consultants, Inc., Model (1998), p. 26.

[22] United States Geological Survey, Written Comments Concerning the Safe-Yield Status of the Prescott AMA, October 26, 1998.

[23] Salt River Project, Written Comments Concerning the Safe-Yield Status of the Prescott AMA, October 26, 1998, p. 4.

recharge. Because the Fain Group study hypothesizes large quantities of recharge during the pre-development era in the AMA, it must also hypothesize that a large quantity of water is discharged from the AMA at a number of drainage, or discharge, points.

The Department's hydrology staff has been unable to identify any scientific evidence which supports the existence of discharge from the AMA in the quantity asserted by the Fain Group. For example, their study indicates that significant discharge is occurring through subflow to the Big Chino and along the Agua Fria River near Humboldt. It purports to support these discharges with groundwater contour maps indicating water moving out of the AMA. In both of these instances, however, the Department has been unable to identify some of the data plotted on the maps.[24] In both of these instances, the Department cannot substantiate the water levels indicating water exiting the AMA. In fact, the water level measurements available to the Department indicate different water levels and different directions in the water movement. Further, the data available to the Department suggests that the path suggested by the Fain Group study for water exiting the AMA is blocked by bedrock.

In another instance, the Fain Group study relies upon a 1997 study by Knauth and Greenbie for the hypothesis that 25 percent of the baseflow of the Verde River at the Paulden measuring gauge is made up of groundwater exiting the Little Chino subbasin. This conclusion is unsupported by the Knauth and Greenbie study, which finds that the "source" of the Verde River baseflow is mainly water exiting the Black Mesa aquifer, an aquifer which is not included in the Prescott AMA.[25]

In its comments to the Department, the USGS also expressed doubts regarding these "unknown drains" in the Fain Group study. The Department concurs that there is simply no evidence which supports these large discharges from the AMA's aquifers.

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[24] Fain Group Study, Figure 9, water elevation level labeled 4,258; Figure 10, water level value labeled 4490.00 at approximate cadastral location A(13-01)13caa.

[25] Dr. Knauth has confirmed in a recent phone conversation, held on December 7, 1998, with Department staff, that his 1997 study reached no conclusions concerning the source of Granite Creek sub-flow or the isotopic composition of the Verde River at the Paulden gauge.

E. Aquifer Characteristics

Another significant difference between the Department's model and the Fain Group model is found in the assumptions made about the aquifers that underlie the Prescott AMA. As was described more fully in the Preliminary Determination Report, the aquifers in the Prescott AMA are made of up of three layers--a Basement Unit, Lower Volcanic Unit and an Upper Alluvial Unit. These layers are found in both the Little Chino and the Upper Agua Fria groundwater basins. The extent and thickness of the layers, however, vary across the two basins. The Lower Volcanic Unit is by far the greatest water producing aquifer in the AMA.

The Department's studies indicate that the Lower Volcanic Unit is most extensive in the Little Chino subbasin, although the Department recognizes that productive volcanic rocks are also present in the Agua Fria subbasin. In the Agua Fria subbasin, however, the highly productive volcanic formations are a more localized feature. The evidence reviewed by the Department does not support the hypothesis that a thick, highly productive volcanic unit is a representative characteristic of the Upper Agua Fria subbasin.

The Fain Group study asserts that the highly productive volcanic units are widespread in the Upper Agua Fria subbasin, but the well log data and well pump test data supplied to the Department by Shamrock Water Company in many of its hydrogeologic reports do not support that theory.[26]

For example, the results of exploration well drilling by the Shamrock Water Company has revealed that essentially no volcanic rocks exist at a well location in the north central portion of the Upper Agua Fria subbasin, slightly less that two miles northeast of Shamrock's Upper System well field.[27] The well log for this well reveals that the well was drilled to a depth of 948 feet, where bedrock schist was encountered. Of that 948 feet, only ten feet, at a depth of 440 feet, was a volcanic formation.

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[26] Southwest Ground-Water Consultants, Inc., in association with Hydro Research, 1998, Hydrogeology and Groundwater Modeling Report for the Prescott Active Management Area, Yavapai County, Arizona, Prepared for Shamrock Water Co., 38 p., Table 4.

[27] Cadstral location B(14-1)01ccc.

Shamrock's reports indicate other evidence that volcanic units are limited in the Upper Agua Fria subbasin. Recent exploration and production well drilling by Shamrock in the eastern and central portions of the Upper Agua Fria subbasin further support the opinion that the thicknesses, productivities and transmissivities of volcanic rocks in the Upper Agua Fria subbasin are generally far less than those observed in most locations in the Little Chino subbasin. For example, one recently drilled well[28] penetrated 750 feet of alluvial material before penetrating 78 feet of basalt, or volcanic formations. Bedrock schist was found to underlie the basalt at a depth of 828 feet. The reported transmissivity of that well was about 5,600 gallons per day per foot (gpd/ft).

Another recently drilled Shamrock Water Company production well[29] penetrated about 700 feet of alluvium before penetrating a 111-foot thick basalt layer which overlies bedrock granite. The reported transmissivity of this well ranged from about 2,800 to 9,700 gpd/ft.

Only one well, a recently deepened Shamrock well[30] in the far northwestern portion of the Upper Agua Fria subbasin, compares to the transmissivity values common in the Little Chino subbasin. This well penetrated about 400 feet of basalt and has a reported transmissivity of about 104,000 gpd/ft. The City of Prescott's production wells in the Little Chino subbasin all penetrate several hundred feet of basalt and have transmissivities which range from 58,000 to 296,000 gpd/ft. The average transmissivity of the five City of Prescott wells is approximately 180,000 gpd/ft.

There is simply little comparison between the thickness, productivity and transmissivity of volcanic formations in Little Chino and Upper Agua Fria subbasins. Based on the data, it is clear that the original approach by the Department to modeling the regional aquifer system of the Upper Agua Fria subbasin remains appropriate.

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[28] Shamrock well A(14-1)08bbb.

[29] "Kurtz" well A(14-1)28dac2.

[30] Shamrock Water Company Upper System "Fat Chance" well B(14-1) 10adb.

F. Water Levels

As explained in detail in the Preliminary Determination Report, water level measurements from wells in the Prescott AMA reveal widespread and significant water level declines over both short-term and long-term periods. Comments by the Fain Group suggest that the data is faulty and that the Department has misinterpreted that data. The Department respectfully disagrees.

For example, the Fain Group criticizes the Department for using water level measurements from wells for which no well logs and construction data exist and from wells which are used to produce water. It is true that a number of the wells used by the Department in its monitoring program are quite old and have no construction data, however, the oldest wells for which there is often no construction information also provide data over the longest period of time. It is entirely possible to make logical inferences and conclusions concerning water levels from such wells, even when well logs and construction records are not available.

The Department also disagrees with the assertion that production wells should not be used for monitoring. It is standard practice to use production wells to measure water levels. While it is true that areas of drawdown will be the greatest immediately in the area around a production well, the Department collects its data in the winter months when the wells are used less frequently and wells are most representative of static water level conditions.

The Fain Group also states that the Department failed to consider climatic conditions in examining water level information. In fact, the Department's Preliminary Determination Report did discuss the impacts of climatic conditions in evaluating both the short-term and long-term trends.[31] The results of that analysis revealed that during a period of slightly higher than average precipitation, 1982 to 1998, 75 percent of the wells measured showed water level declines which averaged just over nine feet. The data also showed that during the short-term drier period of 1994 to 1998, 73 percent of the wells measured showed declines averaging less than six feet.

Finally, the Department also disagrees with the Fain Group's assertions that the

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[31] *See* ADWR Preliminary Determination Report, p. 16.

Department should have used a "weighted averaging" approach in analyzing its water level measurements. They suggest that the measurements at certain locations should be given a weighted, or greater, significance than at other locations. While there is no doubt that improper averaging can lead to erroneous conclusions, the regional distribution of water level data used by the Department was sufficient to prevent erroneous conclusions regarding the basin-wide groundwater conditions.[32] By contrast, the weighted-average approach advanced by the Fain Group is an example of how improper "averaging" can lead to erroneous conclusions.

G. Groundwater Models

As previously discussed, the Fain Group submitted a groundwater model that was based on the Department's model, but which, after substantial alteration, indicates that significantly more groundwater is available in the AMA than the Department's model. The discrepancies between these two models have led members of the public to call for a third study by an independent expert. This suggestion, however, presupposes that the two models are of equal scientific merit.

A groundwater model is a tool used to improve our understanding of groundwater conditions by first replicating the past and then using the model to predict the future. Measured and estimated information regarding groundwater recharge, discharge and pumpage is input into a computer. Estimates of future conditions are also input, and the computer model is run to predict the impacts on groundwater storage. The best way to test the model's accuracy on its predictions into the future is to run the model and compare the results of the computer run with known past conditions. If the model can reproduce water level measurements from past years, it is logical to conclude that the model is well calibrated and will accurately predict future trends in water levels.

The Fain Group has stressed the importance of calibrating and verifying groundwater models. It is critical of the verification of the Department's model. While the Fain Group states that its model reproduces measured water levels less accurately then the Department's model, it

[32] See Figure 1 of this Final Report.

claims its "error statistics are within accepted modeling criteria."[33] The Department does not agree.

Using information compiled and listed in the Fain Group comments, the Department compared the predictive accuracy of the two models. For example, in comparing the two models to actual water measurements in 1940 in the Upper Alluvial Unit of the Prescott AMA, the Department's model had a mean absolute error of 9.51 feet. The Fain Group model had a mean absolute error of 13.5 feet, approximately 30 percent greater than the Department's model. Comparing the model results in the same period for the Lower Volcanic Unit, the Department's model had a mean absolute error of 8.3 feet, compared to 13.97 feet for the Fain Group model, or 41 percent greater than the Department model.[34]

Similar results are reached when the two models are run for comparison with actual water level measurements taken in 1993. In the Upper Alluvial Unit, the Department's model had a reported mean absolute error of 22.9 feet. The Fain Group model had a reported absolute mean error of 45.5 feet, or about 99 percent greater than the Department's. In the Lower Volcanic Unit, the Department's model produced a reported mean absolute error of 16.8 feet. The Fain Group's model produced a reported absolute mean error of 53.7 feet, or approximately 220 percent greater than the Department's model.[35]

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[33] Shamrock Water Company, Fain Signature Group, Fain Land and Cattle Company, Fain Family Limited Trust, and Norman W. Fain and Nancy L. Fain Revocable Trust, Response to the Arizona Department of Water Resources' Preliminary Determination Report on the Safe-Yield Status of the Prescott Active Management Area, October 26, 1998, p. 39.

[34] It should be noted that the model areas of the Department's model and the Fain Group's model are somewhat different, and the 1940 water level measurements used by the Department for its steady-state error analysis are somewhat different than those used by the Fain Group for its error analysis. Woessner, Evaluation of Two Groundwater Models, Appendix B.

[35] It should be noted that the model areas of the Department's model and the Fain Group model are somewhat different, and the 1993 water level measurements used by the Department for its transient error analysis are different than those used by the Fain Group for its transient error analysis.

The Fain Group has also asserted that the Department's model is not "verified," as that term is used by groundwater modelers. This assertion is accurate, however, it is not accurate that the Fain Group model has been appropriately verified. "Verification" commonly refers to a process under which a model is tested by running the model to re-create a selected period of time. During this verification process, no model inputs are adjusted from their original estimates, and the model is then compared to measured data to determine the model's accuracy.

The Department's model was to use the period 1982 to 1993 for its verification. The results of the model run, however, indicated that the Department's original recharge estimates from flood events on Granite Creek had been over estimated. Therefore, the Department's plan to use the 1982 to 1993 period as a verification period was abandoned in favor of improving the long-term calibration of the model by reducing recharge estimates.[36] As reviewed previously, the calibration of the Department's model has resulted in its ability to successfully re-create measured, historic water data.

When the Fain Group verified its model, which is based on the Department's model, it had the benefit of the Department's previous work on quantifying recharge from flood flow events on Granite Creek. But when the Fain Group's model uses this information in conjunction with its other alterations to the Department's original model, the results of its model run were unacceptably inaccurate when compared with measured data. Further, the degree of inaccuracy increased through the verification period of 1980 to 1993. For example, between 1980 and 1993, the Fain Group's mean absolute error for the Upper Alluvial Unit increased by 21 percent and the mean absolute error for the Lower Volcanic Unit increased by 58 percent. Given this error margin produced by the Fain Group model, the Department cannot accept the Fain Group's assertion in its comments that its model is verified for the period 1980 to 1993.[37]

Other experts have noted the inability of the Fain Group model to re-create measured data. Dr. Woessner found in his report that the weakness of the Fain Group model is the inability of the steady state (1940 pre-development) model to match observed groundwater discharge at

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[36] Corkhill and Mason, Modeling Report No. 9, p. 105.

[37] *See* Shamrock, *et al.*, Response, p. 40.

Del Rio Springs and the Agua Fria River at Humboldt.[38] He also stated that the Fain Group model over predicts groundwater discharge at the Agua Fria River and at Del Rio Springs and under predicts the response of the aquifers to pumping.[39] In comparison, Dr. Woessner found that the Department's model performed strongly in matching pre-development and post-development groundwater flow directions, water flows and groundwater levels to recorded data. Dr. Woessner also stated:

> Based on my analysis of the two models, I conclude the ADWR model represents the hydrologic conditions of the Prescott AMA more fully and reasonably than the SGWC [Fain Group] model.[40]

The USGS also noted deficiencies in the Fain Group model. In comments submitted to the Department, the USGS stated that it would be unlikely that the Fain Group model report, as they examined it, could have passed through the USGS review or approval system or that of a refereed journal. The USGS also noted that, in general, the Fain Group model report provided insufficient information to adequately assess the model calibrations.[41]

The Fain Group provided to the Department the results of a peer review conducted by Mr. Michael Darr of the draft model report, dated June 19, 1998. Although Mr. Darr's review found that some of the alteration by the Fain Group to the Department's model was appropriate, he also noted that further work was needed in defining recharge quantities and in defining the discharge points and quantities.

The major inaccuracies demonstrated by the Fain Group model are a clear indication that the major modifications to the Department's model involving the extent of the volcanic aquifer in the Upper Agua Fria subbasin, the transmissivities, the natural recharge and the locations of groundwater discharge were unreasonable and unsupported by real-world data and observation. A peer review of both models conducted by Dr. Woessner, cited above, offered similar critiques

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[38] Woessner, Evaluation of Two Groundwater Models, p. 25.

[39] Woessner, Evaluation of Two Groundwater Models, p. 25.

[40] Woessner, Evaluation of Two Groundwater Models, p. 25.

[41] United States Geological Survey, Written Comments.

of the Fain Group model. Dr. Woessner also determined the Department model to be a reasonable portrayal of the AMA. For these reasons, the Department does not believe that the discrepancies between the Department's model and the Fain Group model require further study or examination.

H. Groundwater Storage

One person submitted comments to the Director criticizing the Department's failure to provide estimates of the volume of groundwater in storage in the Prescott AMA. The Department's estimates of groundwater storage are based on model simulated aquifer area, thickness and storativity. The total estimated groundwater storage in the Upper Agua Fria subbasin is approximately 880,000 af. The total groundwater storage estimated by the Department's model for the Little Chino subbasin is 2,260,000 af, for an AMA-wide total of 3,140,000 af. The Fain Group model produces an estimate of groundwater storage in the AMA of 3,300,000 af.[42]

IV. Public Comment

A. Public Process

In addition to scientific and technical information, the Director received a large number of comments and opinions from people in the Prescott AMA and Yavapai County who are interested in the outcome of the safe-yield determination. The first formal opportunity for the public to provide comments on the safe-yield issue was at the public hearing in Prescott on September 26, 1998. Approximately 40 people spoke to the Director at that hearing.

The second formal opportunity for public comment was during the written comment period which followed the hearing. The Director received a large volume of written comments, and the comments continued to arrive following the official close of the public comment period. Because of the importance of the issues to those who had submitted written comments, the Director decided that consideration of the opinions of all who had taken the time to submit them

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[42] Southwest Ground-Water Consultants, Inc., Hydrology and Groundwater Modeling Report for the Prescott Active Management Area, p. 22.

was more important than strict adherence to the public comment deadline. Therefore, all written comments submitted to the Director on the issue of safe-yield in the Prescott AMA were read and considered.

Just over 400 letters and e-mails were submitted.[43] In addition, the Department received a number of telephone calls, a petition and the results of an informal poll. The number of letters submitted that generally favored a declaration at this time was 155. An additional thirty people signed a petition requesting that the declaration be made at this time. An informal poll submitted by the Dewey/Humboldt Community Organization indicated that, at one of their meetings, 22 people favored the declaration at this time, while five did not. The number of letters submitted which generally did not want a declaration made at this time was 246.

Of those people submitting letters generally supporting a declaration at this time, 82 of the letters were from residents of Prescott, 21 from Prescott Valley, 18 from Dewey, five from Chino Valley, three were submitted from both Camp Verde and Cottonwood, two from Humboldt and one letter was submitted each from Clarkdale, Jerome and Paulden. The remainder of the letters did not identify a return address. Approximately ten of these letters were identified as businesses, including two letters from well drillers and two from realtors.

Of those people who were generally opposed to a declaration at this time and who included a return address, 88 were from Prescott Valley, 65 from Prescott, 55 from Chino Valley, 16 from Dewey and one letter was submitted each from Humboldt, Mayer and Sedona. Two or three form letters accounted for a significant number of these filings. Approximately 63 letters were identified as businesses, including 16 realtors. Representatives of the Prescott Valley Economic Development Foundation and the Prescott Valley Chamber of Commerce submitted several letters opposing declaration at this time. Fourteen members of the Chino Valley Homemakers also submitted letters opposing declaration, as did the Humboldt School

[43] Because of duplicate submissions, multiple submissions from the same people, letters signed by more than one person, and other factors, the exact number of submissions could be calculated in a number of different ways. The numbers used in this section are not intended to be a scientific or exact calculation of the submissions but to provide a general overview of the comments submitted to the Director.

Superintendent on behalf of the Humboldt Unified School District.

For efficiency in responding to the comments, the Department has categorized the issues raised at the hearing and through written comments. A summary of the issues raised by the comments and the Department's responses to those issues follow in this Section.

B. Impacts of the Declaration on the Prescott Area

The comments provided to the Director demonstrate that there is considerable disagreement among members of the public regarding the impact a safe-yield declaration would have on the Prescott area. Several people suggested that the consequences of not limiting future growth based on groundwater would be more significant to the area than any short-term problems caused by the declaration. Some people noted that the Prescott AMA is a high desert and has limited water resources. It was asserted that the area cannot continue to ignore the consequences of unlimited growth dependent upon groundwater.

Eighty-eight letters expressed concern that the area's groundwater supplies are being threatened. A number of people stated that water levels are dropping in domestic wells and that some of those wells are running dry. They noted that it is very expensive to have those wells deepened. Two well drillers wrote in support of the declaration that the AMA is no longer at safe-yield, even though the declaration might be against their economic self-interests. They stated that they felt obligated to inform the Department that they have had to drill deeper in recent years and have noted that water levels in the area are declining.

On the other hand, approximately 60 people submitted comments opining that a final declaration that the Prescott AMA is no longer at safe-yield will have numerous adverse impacts on the area. By limiting groundwater use in new subdivisions, they were concerned that the declaration would push development outside the AMA into rural areas. Development within the AMA, it was asserted, would occur through "lot splitting" rather than "master planned communities." A risk of groundwater contamination could result because of the numerous septic tanks and shallow wells used by unplanned development. There was also significant concern expressed about the effect the declaration would have on growth and the economy in the area.

The Department believes that there should be no immediate consequences to development in the area from a declaration. Last summer, numerous applications for assured

water supplies for new developments in the Prescott AMA were filed with and processed by the Department. There are now over 30,000 lots approved by the Department through the AWS Program that can yet be developed using groundwater. The population of the AMA could double if all currently approved but unbuilt lots are built upon. The City of Prescott has estimated that the approved subdivisions within its borders alone would not be fully built out for 40 years. Thus, there is no reason to believe that an immediate crisis will be caused by this declaration. There is time to explore options under which additional growth can be based upon a dependable water supply that does not threaten the water supplies of existing users.

These potential future consequences must be weighed against the possibility of existing water users running out of groundwater. As it has stated in the past, the Department does not believe that there is imminent danger of a widespread water supply crisis. A number of comments that were submitted to the Director, however, contained personal accounts of being without water because of declining groundwater levels. For those people, the crisis has already arrived.

C. Further Study

Differing opinions were offered on the issue of whether additional scientific study was needed before making a declaration that the Prescott AMA is not at safe-yield. Just over 200 of the letters called for delaying a declaration to allow time for additional study. Some of these people called for "peer reviews" of the Department's and the Fain Group's groundwater models, some advocated a third "independent" study be conducted and others advocated further study without specifying between these two options. Approximately seven people submitted comments critical of the Department's study. The vast majority of those requesting additional study, however, did so because the conclusions of the two studies are so disparate, they felt a third study must be needed.

Conversely, approximately 40 people were of the opinion that enough study has been done. A few commenters stated that the declaration that the AMA was not at safe-yield was long over due. A number of these commenters agreed with the Department's studies and stated that the Department had no vested interest in the proceedings and, therefore, was most likely to present objective data.

It is the Director's conclusion that the Declaration that the Prescott AMA is no longer at safe-yield is overwhelmingly supported by the Department's study and that no purpose is served by delaying the declaration to undertake additional study. The Department's hydrologists have spent over 15 years studying water conditions in the Prescott AMA. One result of that study has been the Department's groundwater model of the Prescott AMA. As explained more fully earlier in this Report, the Department's model substantially replicates historic water levels in the AMA and has been judged by a number of sources to be a good tool for water management in the AMA. As also discussed earlier, the Department has significant concerns regarding the competing model that has been submitted during these safe-yield proceedings.

Thus, while the Department understands and appreciates the comments expressed regarding the need to avoid precipitous action until more study is completed, it is the Department's view that additional study and debate on the AMA's safe-yield status at this point would only divert resources that could be better invested in looking for solutions to the area's long-term water management needs. The Department would not take such a significant action as declaring the Prescott AMA to be no longer at safe-yield if the scientific evidence did not overwhelmingly support that finding.

D. Concern that a Declaration is Irrevocable

Approximately 80 people submitted comments to the Director expressing concern over the irrevocability of a declaration that the AMA is no longer at safe-yield. They pointed out that because there is no immediate water crisis, the declaration should not be made prematurely. However, the overwhelming credible evidence demonstrates that the Prescott AMA is no longer at safe-yield and has not been at safe-yield for some time. Delaying the declaration will only postpone the date at which serious discussions will begin on how to ensure that all current and future residents of the AMA will have a dependable water supply.

Given the current depletion of the AMA's aquifers and the amount of groundwater-based development already approved, it is highly unlikely that there will be a future change of circumstances allowing groundwater pumping without further depletion of the AMA's reserves. If circumstances do change, however, and additional sustainable groundwater supplies in excess of current and committed demands are demonstrated to exist, it would be appropriate to change

the rules, either legislatively or administratively, that currently govern these issues.

E. Growth in the Prescott Area

As already discussed in this Section, a number of people have expressed concern that the declaration will limit growth in the Prescott area and adversely affect the local economy. On the other hand, a number of people also stated that growth in the Prescott area is out of control and that the Director should make a declaration to prevent further growth.

The Department of Water Resources takes no position on the issue of growth in the Prescott area. The Department's only concern is that the area's existing population, and any growth that does occur, have secure and reliable water supplies. Because the overwhelming scientific evidence establishes that all available groundwater in the area has been committed to existing and already approved subdivisions, the Department has taken steps to ensure that future growth will not rely upon groundwater and will not take groundwater away from existing users.

F. Local Control

The issue of whether to allow further development based upon groundwater was felt by 17 people to be of such significance to the Prescott area that it should be left to local control and not imposed by an agency of the State of Arizona. A few people felt that such decisions should not be left to local officials.

The Groundwater Management Act, A.R.S. §§ 45-401 *et seq.*, vests the Department of Water Resources with the responsibility of ensuring the reliability of the state's water resources. The Department, however, fully understands the importance of this decision to the Prescott area. Throughout these proceedings, the Department has used its best efforts to make the proceedings open to the public and to solicit the opinions and thoughts of Prescott area officials and members of the public. The Department has examined and carefully considered all opinions provided at the September hearing and provided in writing following the hearing.

G. Impacts on the Verde River

The comments submitted to the Department, particularly by residents of Yavapai County outside of the Prescott AMA, expressed concern over the impact significant groundwater pumping has on the flows of the Verde River. It is the Department's view that the connection between pumping in the AMA and the Verde River is unclear and needs additional studies. It is

one of the pressing regional issues that requires attention and provides a good example of the issues that will continue to lack attention if more study, time and resources are expended on further studies and debate about the safe-yield status of the AMA.

H. Definition of Safe-Yield

The Fain Group has submitted comments asserting that the Department has misinterpreted the definition of safe-yield in these proceedings. As was quoted earlier, Arizona law defines safe-yield to mean:

> [a] groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial recharge in the active management area.[44]

The Fain Group asserts, through a lengthy recitation of case law and legislative history, that "DWR must balance groundwater withdrawals and recharge from natural and artificial sources. Outflows from the Prescott AMA are not to be considered in this balancing process."[45] The Department disagrees with this legal argument and finds that this interpretation leads to a result which contradicts legislative intent in passing the Groundwater Management Act in 1980.

Although the recitation of legal history in the Fain Group's comments is extensive, no case or statute is cited which prohibits natural discharges from being considered in a safe-yield definition. The Fain Group is correct in its assertion that this issue has never been *considered* by an Arizona court. It is not correct in its implications that Arizona courts have affirmatively rejected natural discharges from the definition of safe-yield.

The Department does agree that it is bound by legislative intent in applying the statutory definition of safe-yield. For this reason, the natural outflows of an AMA cannot be ignored. The express legislative policy of the Groundwater Management Act is to act to stop the "withdrawal of groundwater [that] is greatly in excess of the safe annual yield and that . . . is threatening to

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[44] A.R.S. § 45-561(12).

[45] Shamrock Water Company, *et al.*, Response, p. 13.

destroy the economy of certain areas."[46] The legislature declared safe-yield to be the groundwater management goal of three out of the four AMA's originally created in 1980.[47]

But under the definition of safe-yield advanced by the Fain Group, the natural discharges of the aquifers must be ignored. Under this definition, all of the "credits" to the aquifers are to be considered in achieving a long-term balance, but only some of the "debits." By ignoring the debit from the AMA's aquifers caused by natural discharge, the aquifers can be overdrafted and depleted. As was tacitly admitted by the Fain Group's attorney at the Prescott hearing, the aquifers could be drained dry, but still meet this purported definition of safe-yield.[48]

The Department cannot accept the proposition that the legislature adopted a comprehensive Groundwater Management Act to protect the state from depleting its groundwater supplies, but adopted a management goal for the majority of the population of the state which allows those groundwater supplies to be drained. The long-term balance between groundwater withdrawals and recharge, specified by A.R.S. § 45-561(12), cannot be obtained without considering the significant loss of groundwater from the aquifers caused by natural discharge.

It should be noted that the definition of safe-yield asserted by the Fain Group is crucial to its position that the AMA is still at safe-yield. The groundwater model it has submitted to the Department indicates that the AMA's aquifers are being overdrafted, that is, that more groundwater is leaving than is entering the AMA's aquifers. Thus, only by ignoring the natural discharges of the area's aquifers can they assert that the AMA is at safe-yield.

V. Conclusion

Fifteen years of study by the hydrology staff of the Arizona Department of Water Resources has compiled substantial evidence that the aquifers of the Prescott AMA are currently being depleted by groundwater pumping and natural discharge. The evidence establishes that

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[46] A.R.S. § 45-401(A).

[47] A.R.S. § 45-562(A).

[48] Transcript of Proceedings, Safe-Yield Status Hearing of Prescott Active Management Area, October 26, 1998, pp 139-42.

water levels across the AMA are experiencing short-term and long-term declines. Ten thousand acre-feet per year of additional groundwater is already committed to approved but unconstructed lots and subdivisions. The sum of current and committed demand for groundwater without question exceeds the amount of natural and artificial recharge to the AMA's aquifers. None of the evidence submitted to the Director refutes these findings.

For these reasons, the Director of the Department has concluded that the commitment of additional groundwater to future subdivisions would threaten the reliability of the water supply to those future subdivisions, as well as to existing groundwater users. The Prescott AMA, therefore, has been found to be no longer at safe-yield and water providers and future subdivisions which apply to the Department for an Assured Water Supply will be required to acquire renewable water to meet the subdivision's needs, in accordance with A.A.C. R-12-15-705(F), as that rule was amended by 1998 Ariz. Sess. Laws, Chapter 86.

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Rita P. Pearson, Director
Arizona Department of Water Resources

APPENDICES

Appendix A — **Arizona Department of Water Resources Preliminary Determination Report on the Safe-Yield Status of the Prescott Active Management Area, August 28, 1998**

Appendix B — **Woessner, W.W., 1998, Evaluation of Two Groundwater Models of the Prescott Active Management Area: Arizona Department of Water Resources Model (1995) and Southwest Ground-Water Consultants, Inc., Model (1998)**