The ADWR Pinal Groundwater Flow Model Update, Calibration and Sensitivity Analysis

September 8, 2015

Pinal AMA Groundwater Users Advisory Council

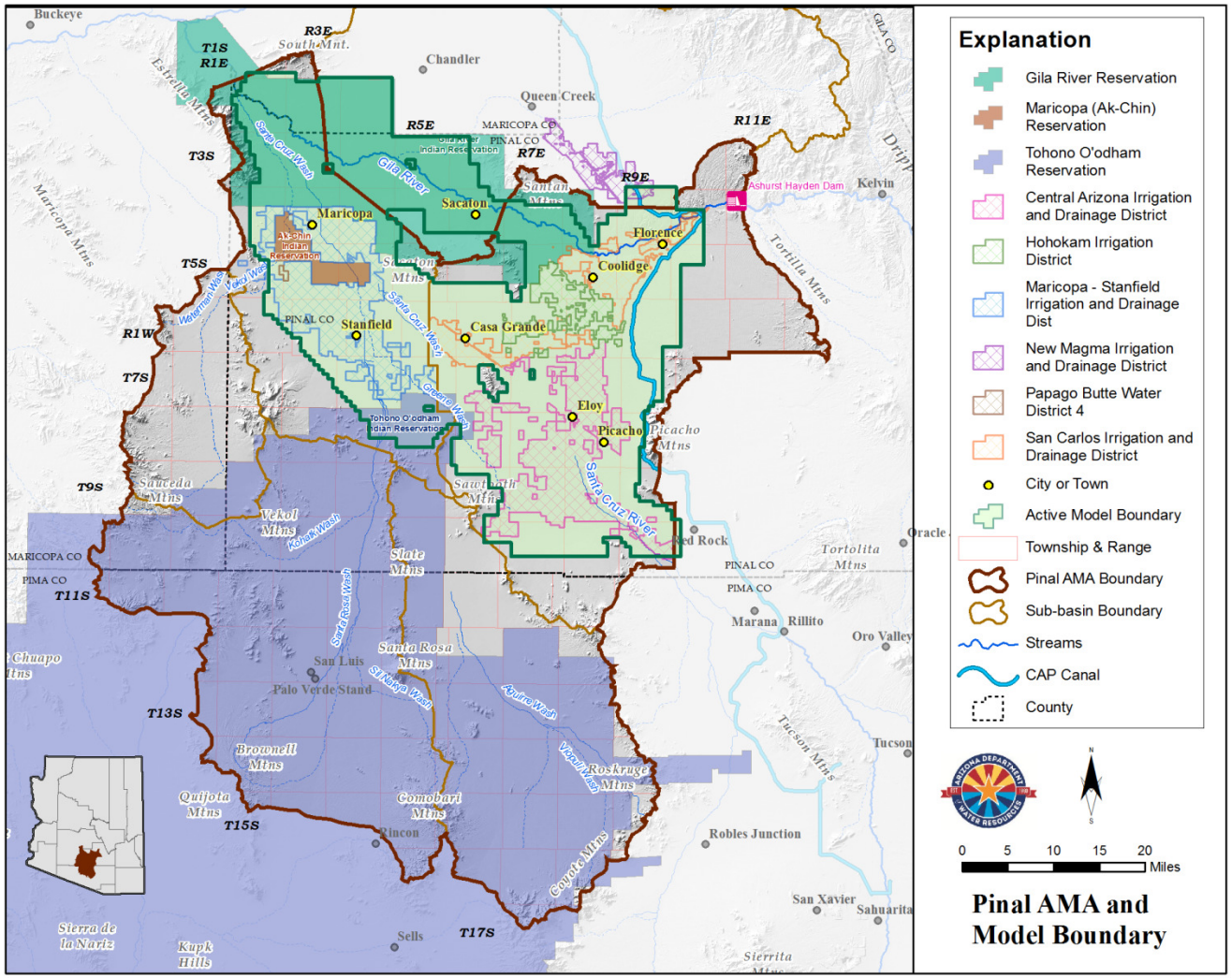
Dianne Yunker, Keith Nelson, Frank Corkhill (ADWR)

Dr. Shuyun Liu and Wes Hipke (Formerly With ADWR)

History of Groundwater Modeling in the Pinal AMA

Year	Activity/Publications	ADWR Personnel or Contractor
1989	Regional Groundwater Flow Model Phase One: Hydrogeologic Framework, Water Budget, and Phase One Recommendations.	Wickham and Corkhill
1990	Pinal Active Management Area Regional Groundwater Flow Model Phase Two: Numerical Model, Calibration Sensitivity, and Recommendations. Corkhill and Hill . Modeling Report No. 02	Corkhill and Hill
1992	Professional Review of the Pinal Active Management Area's Groundwater Budget.	Burgess & Niple
2007	New Model Development Begins	Liu, Nelson, Hipke, Corkhill, Dubas, Others
2010	Regional Groundwater Flow Model of the Pinal Active Management Area: Provisional Report - Geology Update. Modeling Report No. 20 (2010)	Liu, Dubas
2012	Steady State/Transient Model Finalized/ First Draft of Report	Liu, Nelson,
2013	Sensitivity Analysis, Error Analysis, GeoDatabase Creation, Report Figures, Report Revisions	Corkhill, Nelson, Yunker
2014	Regional Groundwater Flow Model of the Pinal Active Management Area, Arizona. Modeling Report No. 26 (2014)	Liu, Nelson,Yunker, Hipke, Corkhill
	100-Year Projections for Assured and Adequate Water Supply Group	Yunker
2015	Internal Tests Adjusting Solvers, LPF and Well Packages to Reduce Model Error	Mason and Yunker
	Pinal AMA 4th Management Plan (4MP) Projections out to 2040 (in progress) -Updated with actual volumes of pumping and recharge through 2014 -Input estimated projected volumes of pumping & recharge through 2040	Yunker
	Plan to Update Model and Experiment with new USGS Subsidence packages in the next year (to do)	Yunker, Nelson, Corkhill, Mason

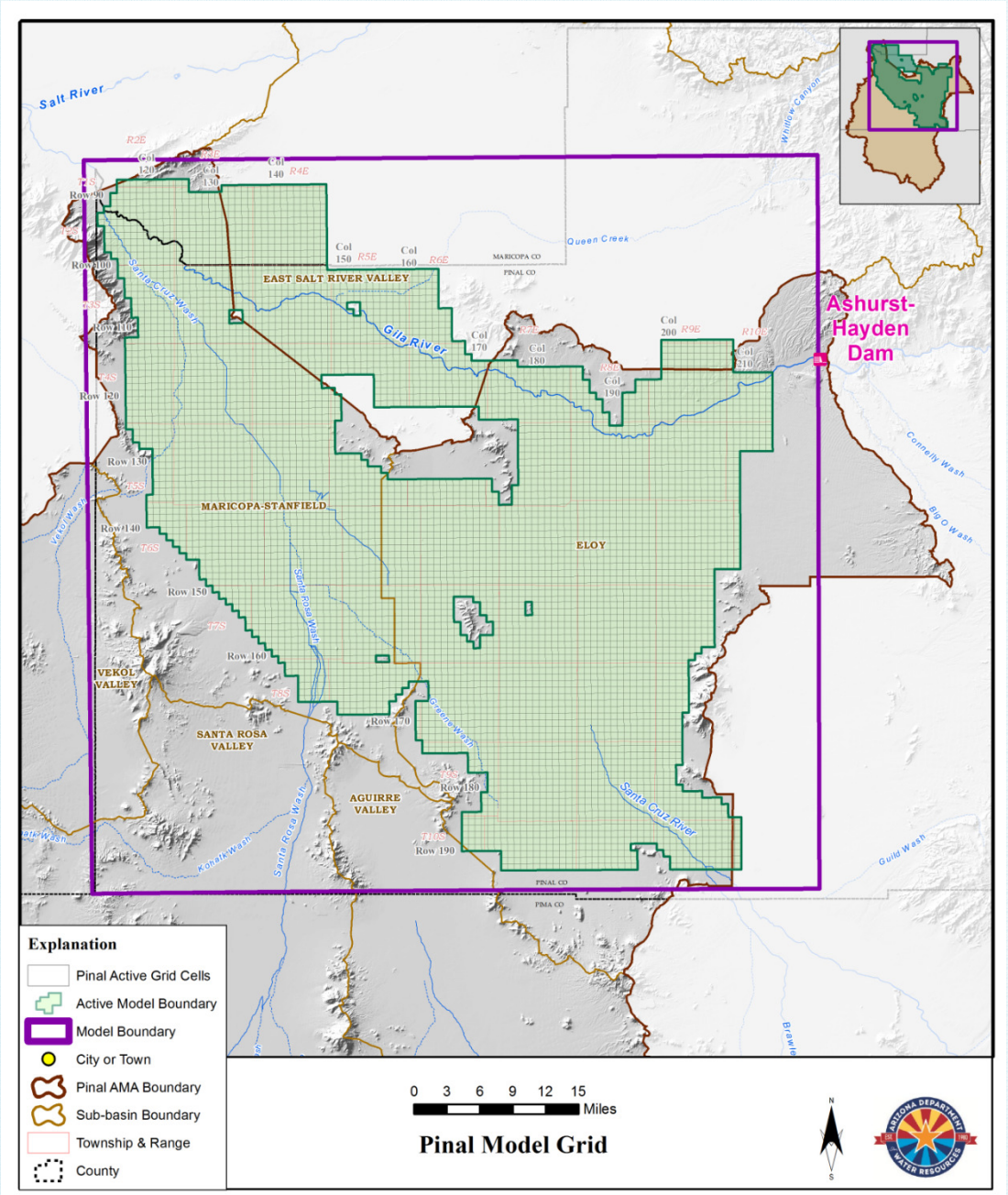
Model Location



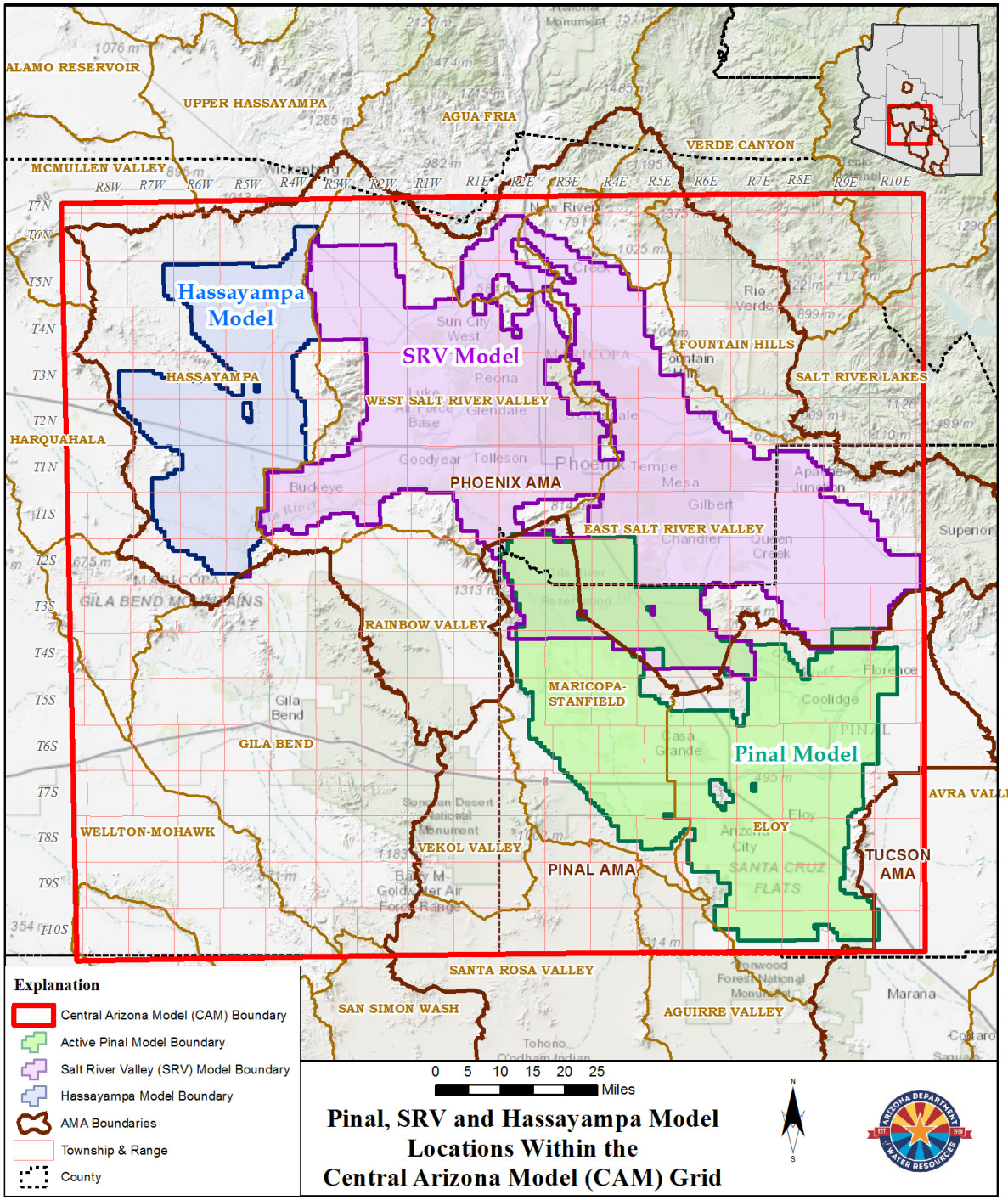
- South Central AZ Between Phoenix and Tucson
- In Portions of Pima, Pinal and Maricopa Counties
- Eloy and Maricopa-Stanfield Groundwater Basins
- Most of GRIC
- Most Active Portion of the Pinal AMA

Pinal Model - Area

- **Steady-State Period**
  - **Pre-Development (Circa 1922)**
    Before Ashurst-Hayden Dam
- **Transient Period**
  - **1923 – 2009**
    (87 Years)
- **Active Grid**
  - **52.5 Miles by 51 Miles**
  - **Cell Size - 1/2 x 1/2 Mile**
  - **106 Rows**
  - **103 Columns**
  - **6,052 Active Cells**
  - **3 Model Layers**



CAM



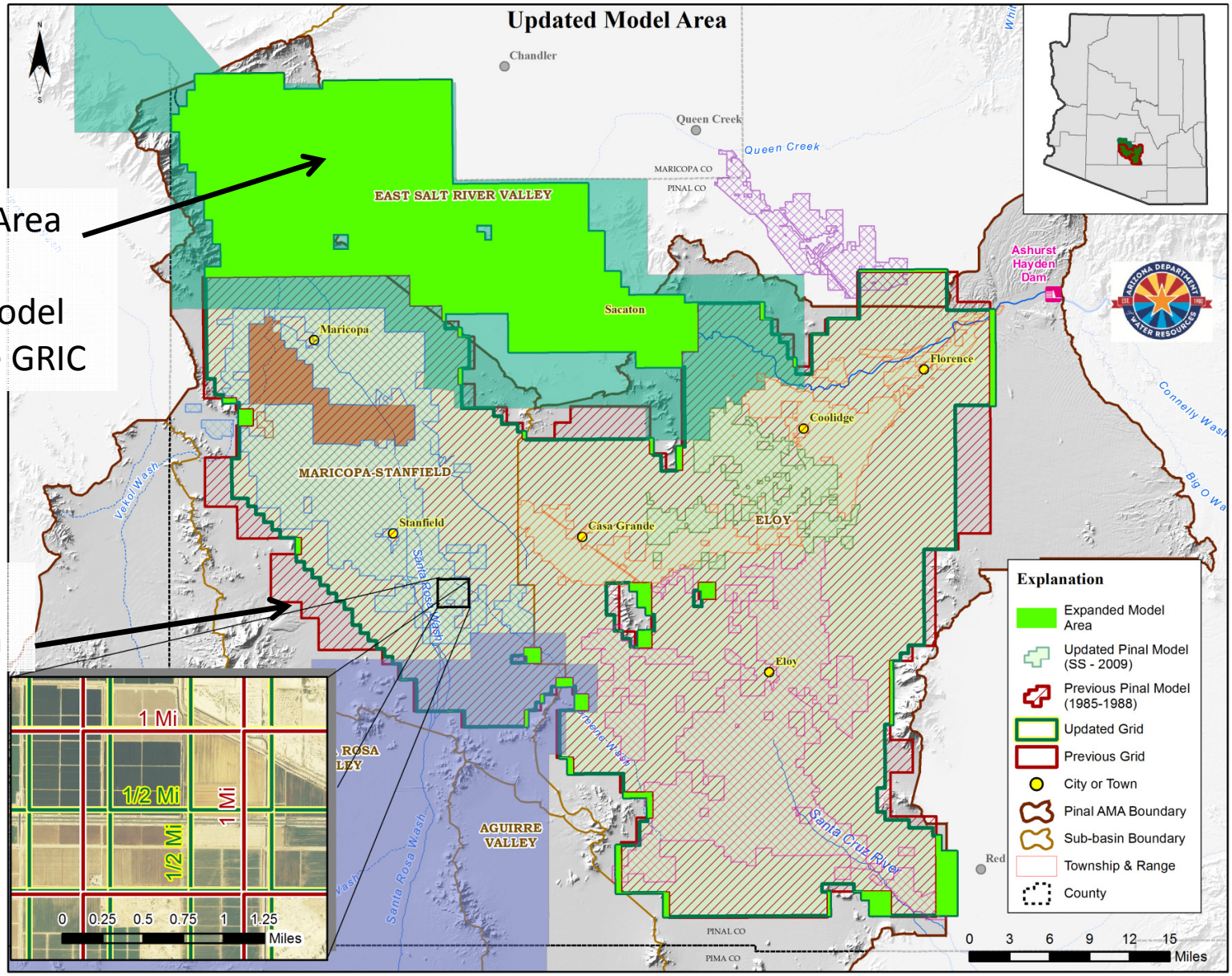
- Part of the Central Arizona Model (CAM)
- Grid was refined and aligned to use the same grid as the SRV Model in Phoenix

Updated Model Area

Additional Area Covered in Updated Model Most of the GRIC

Previous Model Area

More refined Model grid



Goals and Objectives Of the Pinal AMA Groundwater Flow Model Update

- **Create an updated groundwater model and companion geodatabase of the Pinal AMA that can be used as an analytical tool to test various water management strategies and provide technical support to regulatory programs and miscellaneous hydrologic studies**
- **Update the original Pinal AMA groundwater flow model with recent/current groundwater withdrawal and recharge information (through 2009)**
- **Enlarge model area to eliminate "problematic" artificial boundaries**
- **Refine model grid and make more consistent with updated SRV model grid.**
- **Extend the calibration backward in time to steady-state and include the period of groundwater development in the transient model calibration**
- **Add aquifer system compaction capability to the model to simulate "land subsidence"**
- **Simulate "lagged" agricultural recharge**
- **Test the model's sensitivity to variations in pumping and recharge inputs and important model parameters**
- **Test the suitability of the model calibration through error analysis, discuss model limitations and uses and recommend future model improvements**

Unique Challenges in Developing the Pinal AMA Groundwater Flow Model Update

- **Simulating Subsidence**
  - Used the SUB-WT (instead of the SUB package) lacking ability to calculate delay in release of water from distributed interbeds
  - Not Supported in GUI, requiring the model to be run in DOS and results imported back into GUI (Groundwater Vistas).

- **Estimating Agricultural Recharge Volumes and Lagging**
  - Difficult to determine volumes incidentally recharged
  - Lag to reach aquifer also difficult to calculate-part of iterative calibration

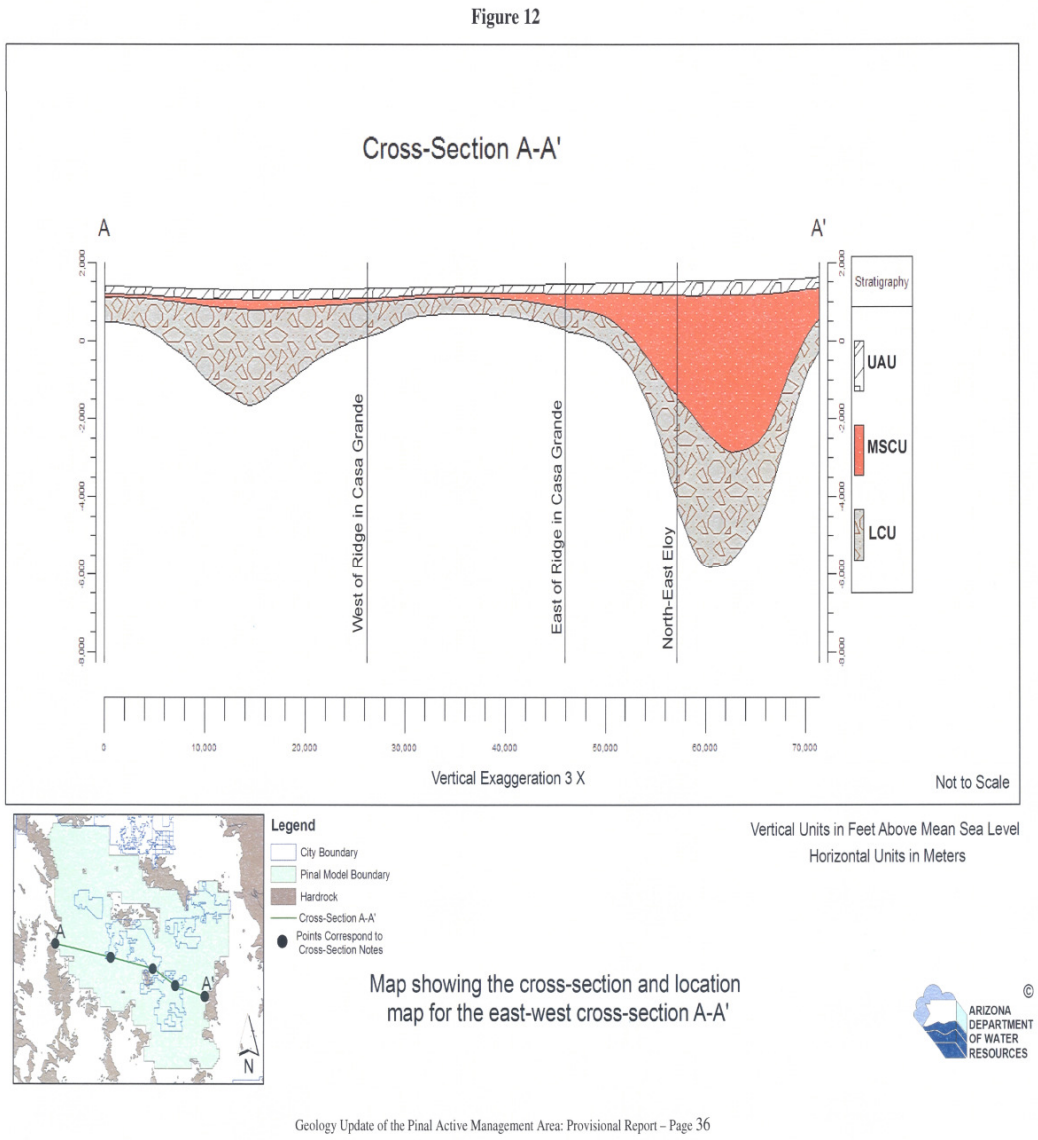
- **Pre-RoGR (Registry of Grandfathered Rights) Prior to 1984 Pumping Distribution**
  - Assumptions had to be made on locations
  - Volumes back calculated from changes in storage and water level

- **Lack of Well Construction Information**
  - Layer assignments made but often a well is constructed across layers, and the heads are a mix of various.
  - Hydrographs and Residuals appear less accurate

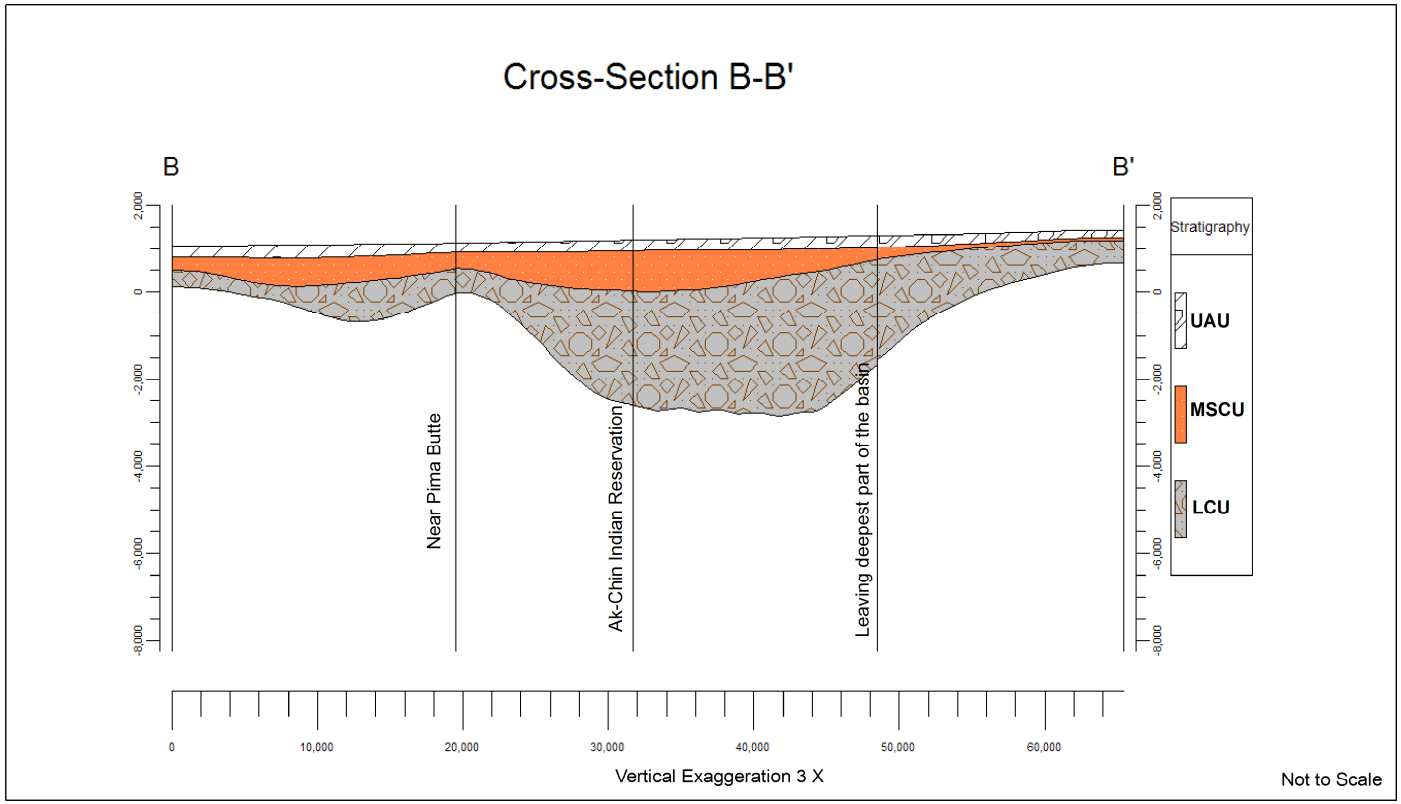
- **Steep Vertical Gradients Between Layers**
  - Difficult to model but important to note
  - Perched conditions with cascading water in wells
  - Dry cells and a small percent pumping withdrawn not simulated

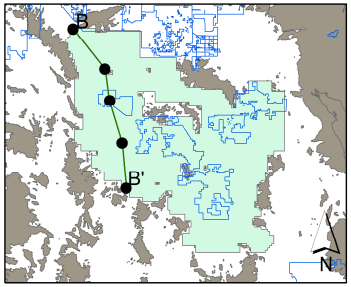
The Three Major Hydrogeologic Units Are Represented By Individual Model Layers

- Added 3rd Model Layer-Original only had 2
- Cross Section-Maricopa to Eloy and Picacho Mountains
- Upper Alluvial Unit (UA) is coarser grained sands and gravels
- Middle Silt and Clay Unit (MCSU)
- Lower Conglomerate Unit (LCU) also coarse grain but less water productive than UAU



The Three Major Hydrogeologic Units Are Represented By Individual Model Layers





Legend

- City Boundary
- Pinal Model Boundary
- Hardrock
- Cross-Section B-B'
- Points Correspond to Cross-Section Notes

Vertical Units in Feet Above Mean Sea Level
Horizontal Units in Meters

Map showing the cross-section and location map for the north-south cross-section B-B' through the Maricopa-Stanfield sub-basin

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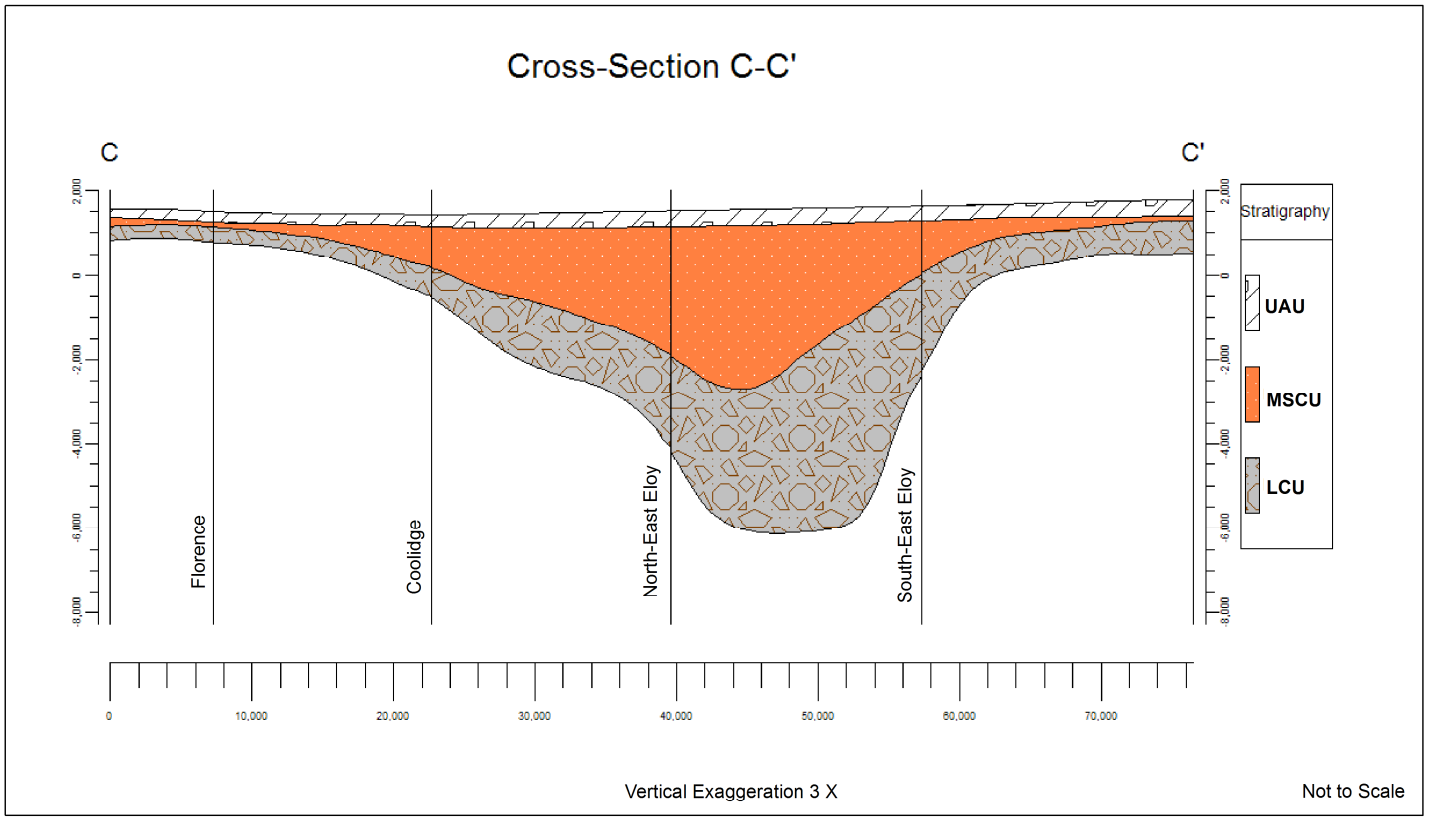
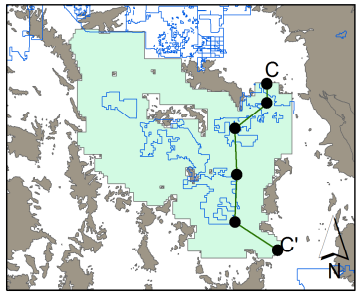
The Three Major Hydrogeologic Units Are Represented By Individual Model Layers





Legend

- City Boundary
- Pinal Model Boundary
- Hardrock
- Cross-Section C-C'
- Points Correspond to Cross-Section Notes

Vertical Units in Feet Above Mean Sea Level
Horizontal Units in Meters

Map showing the cross-section and location map for the north-south cross-section C-C' through the Eloy sub-basin

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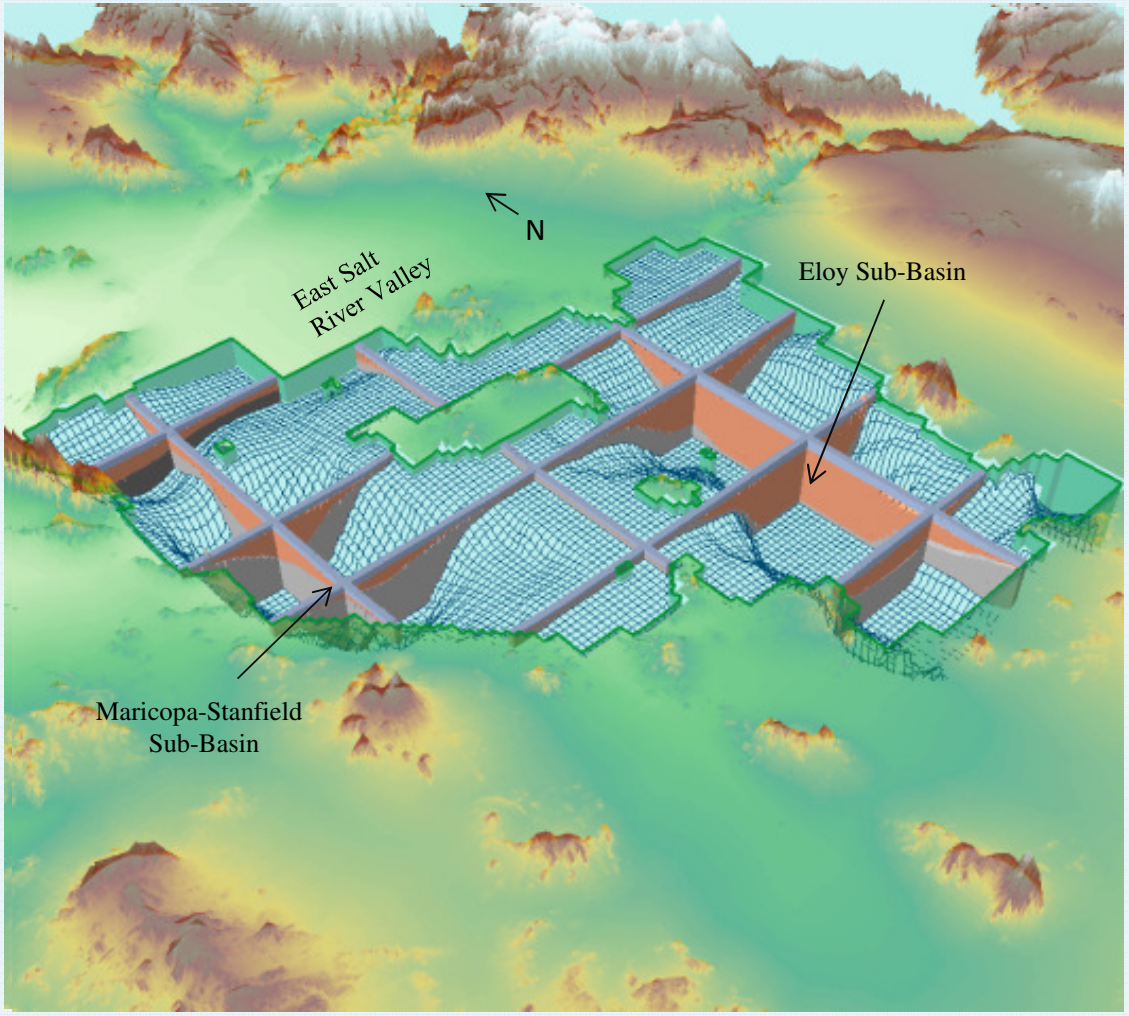
3D View of The Three Major Hydrogeologic Units



Cross Sections-Modeled Layer Thicknesses

Animation

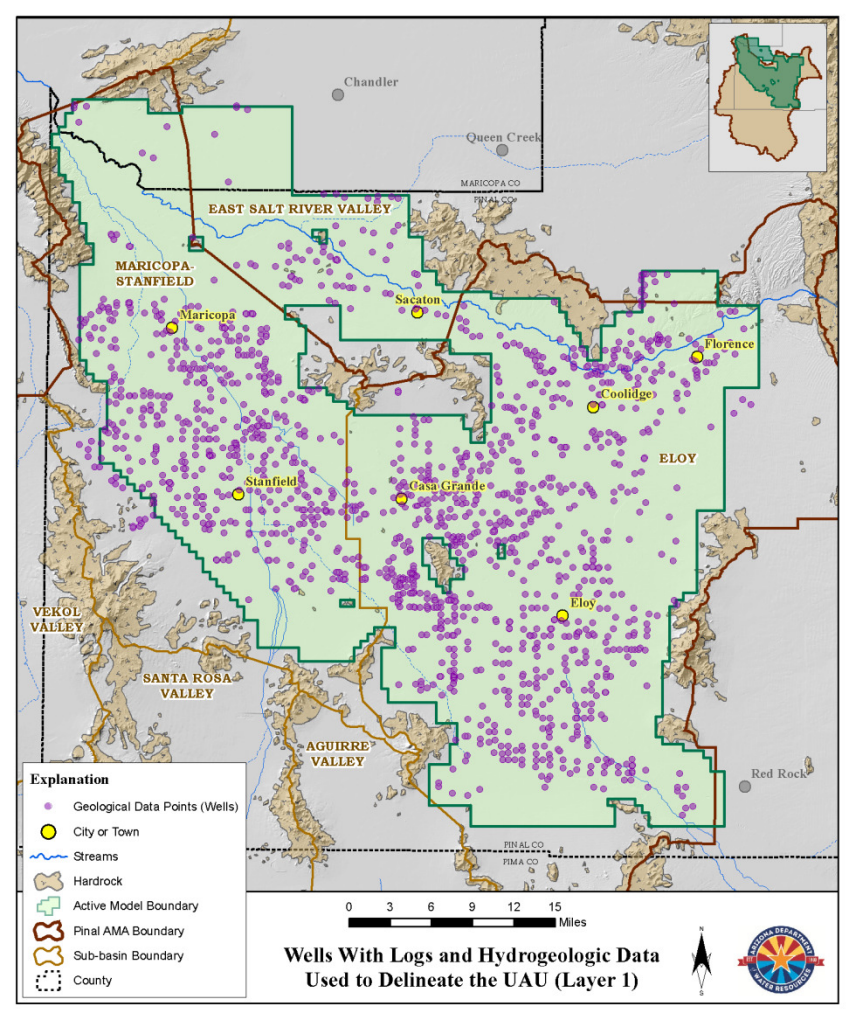
Vertical Exaggeration 3X

Bottom of Layer 1 (UAU)

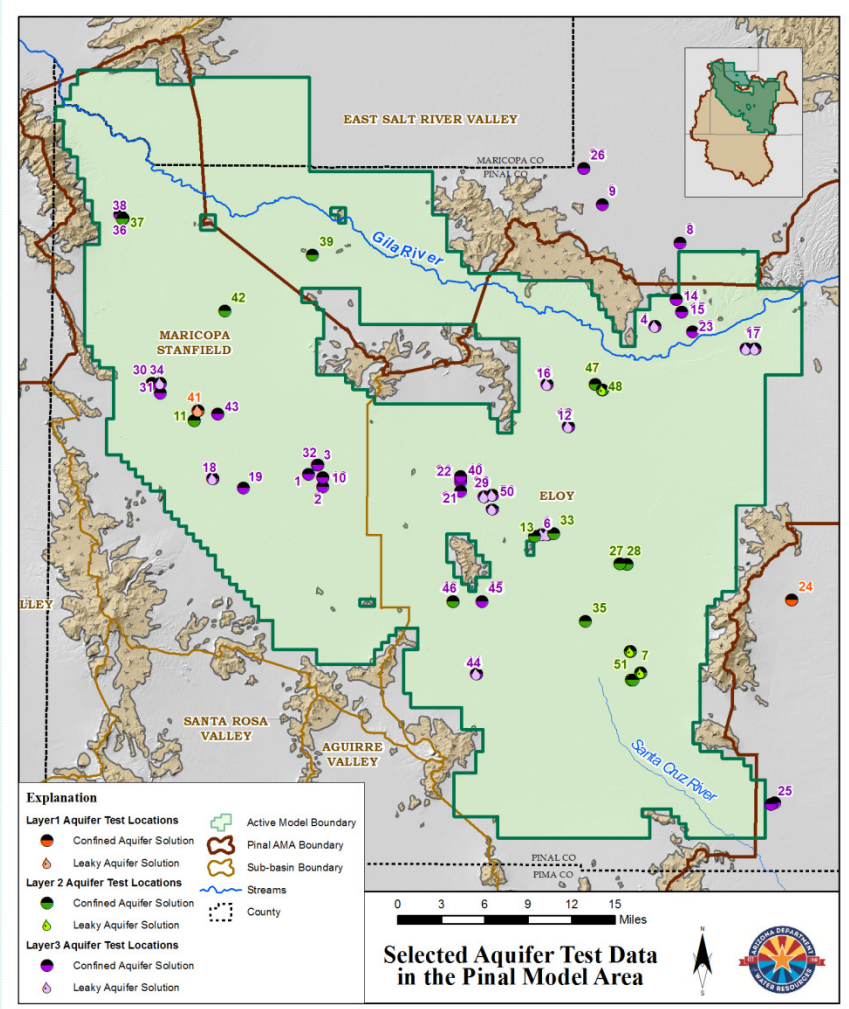
Bottom of Layer 2 (MCSU)
It was truncated at 2,800 feet in some areas

Bottom of Model & Layer 3 (LCU).
It was truncated at 3,000 feet in some areas.

Hydrogeologic Data Analysis for Model Development



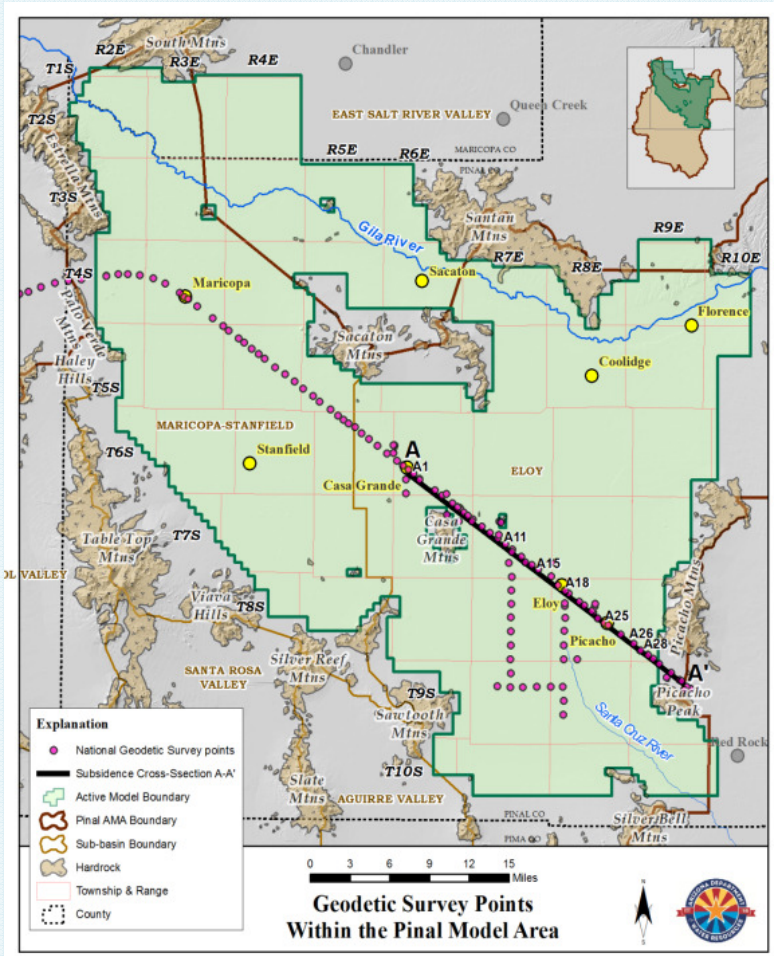
Thousands of well logs reviewed across all 3 layers

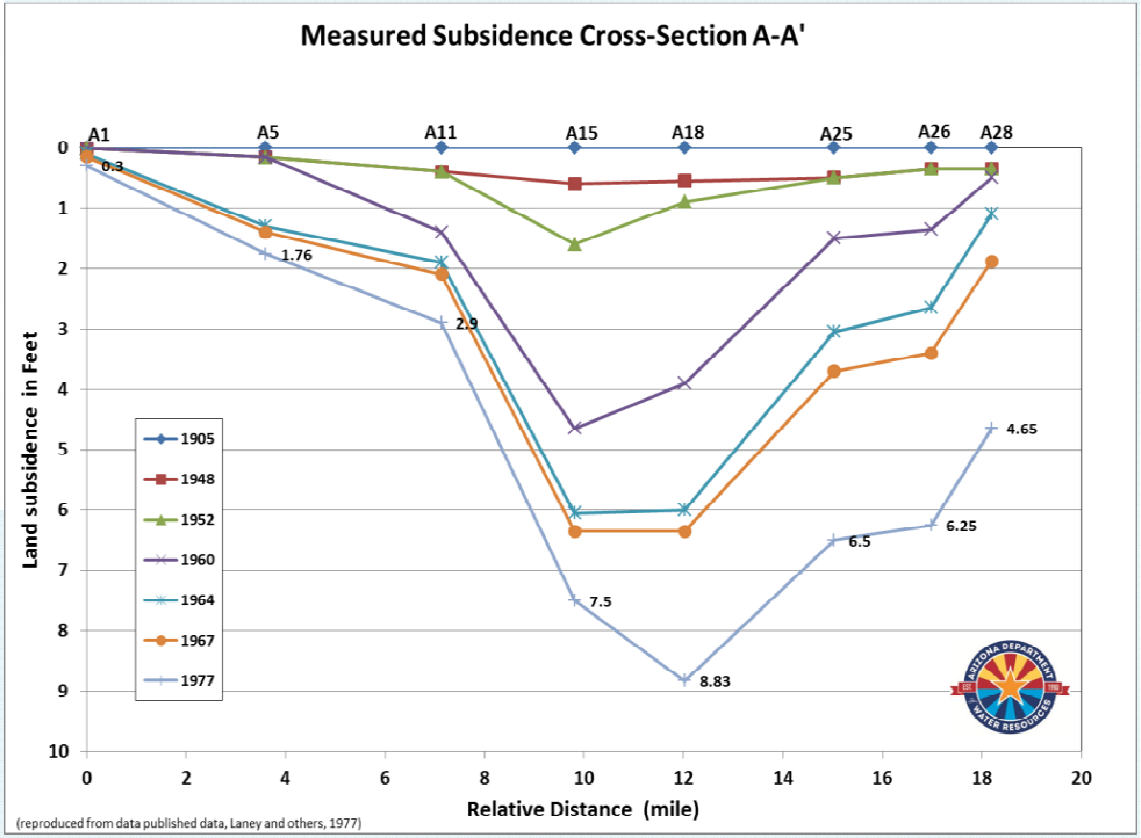


51 Aquifer Tests From AWS Applications Provided Valuable T, K, Sy Aquifer Characteristics

National Geodetic Survey Points Along Cross Section A-A'

Historic Land Subsidence In the Pinal AMA





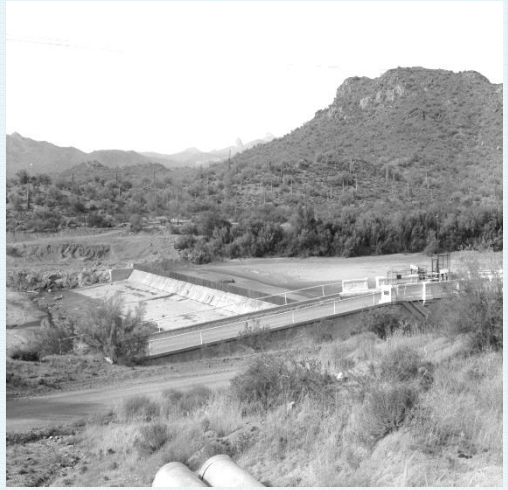
- Decades of NGS leveling Data
- Almost 9 Feet Near Eloy by 1977
- Change in Land Surface Elevation
- One time release of water from compression & permanent loss of aquifer storage space.

Surface Water Features

Gila River -from mountains east of the AMA, released at Ashurst Hayden Dam

Santa Cruz River - from Avra Valley from the Tucson AMA

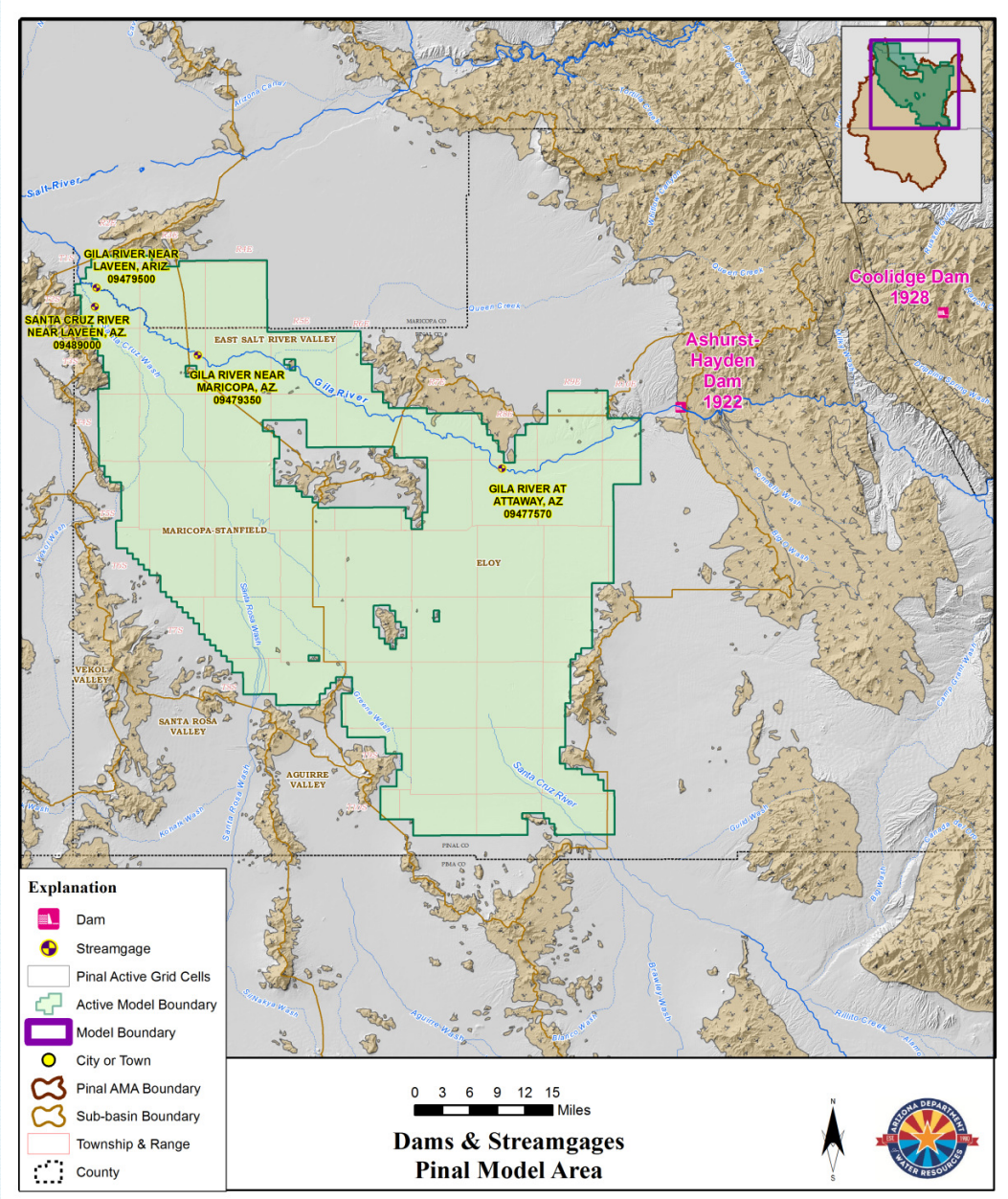
Ashurst Hayden Dam
completed in 1922
Diverts water for delivery to the San Carolos Irrigation Project (SCIP)



Made Gila River mostly ephemeral –eliminating stream recharge except for wetter years

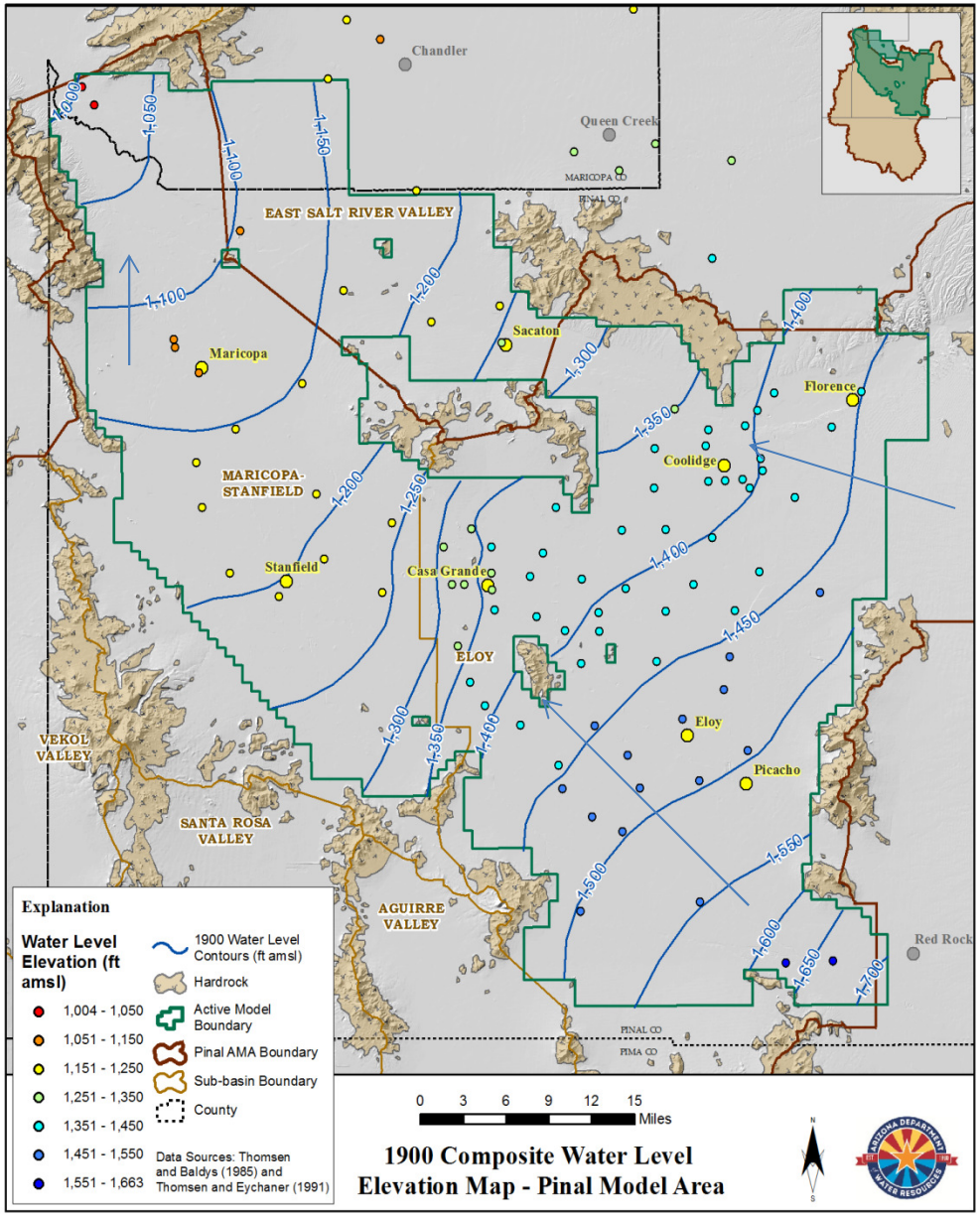
Coolidge Dam
completed in 1928

USGS Gages – Flow records used to calculate maximum potential infiltration

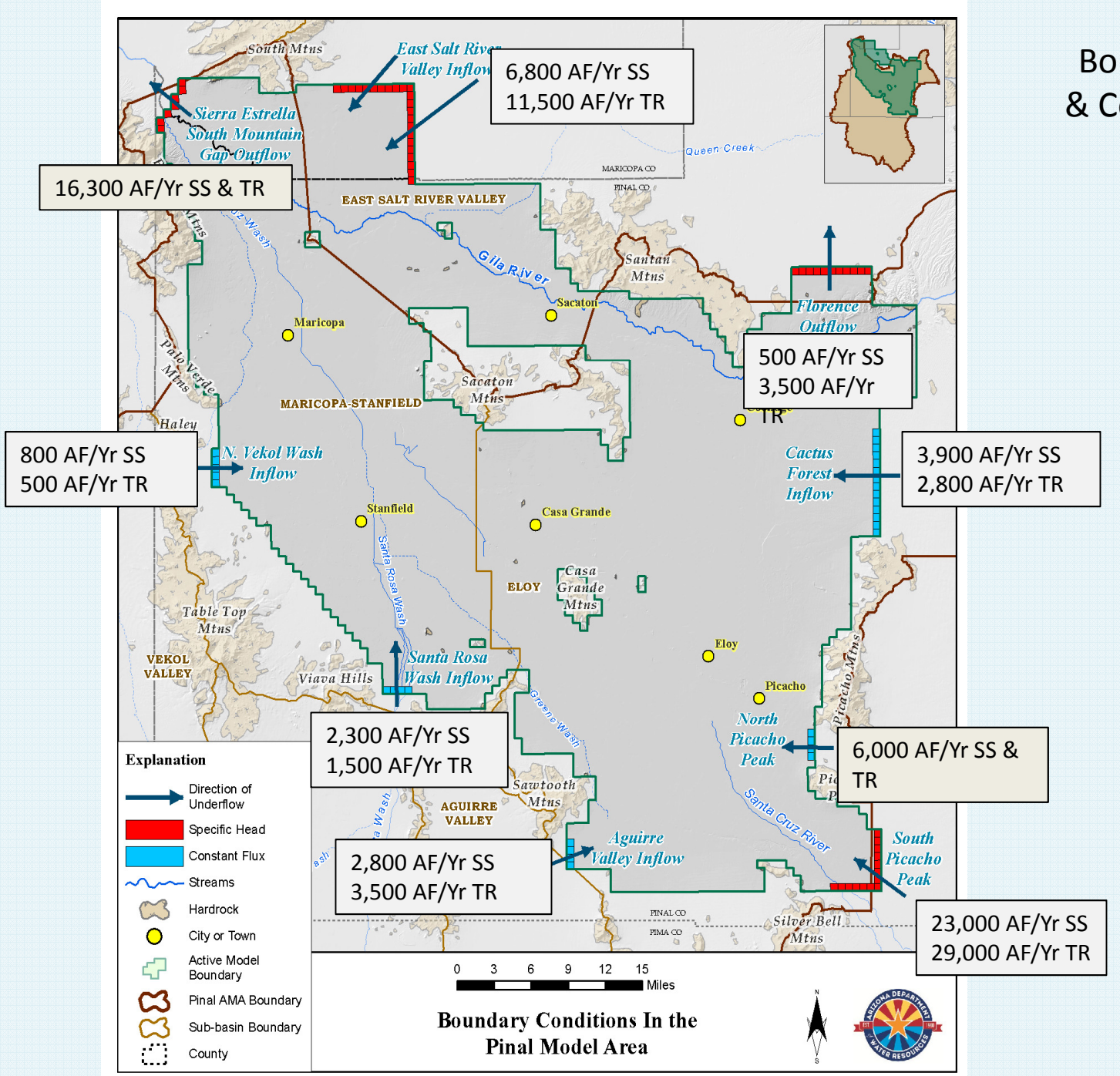


The Steady – State Groundwater System Pre-Development

- Very Uniform
- Southeast to Northwest Flow
- Gila River was perennial (flowing)



Boundary Conditions & Conceptual Volumes



SS=Steady State
TR = Transient

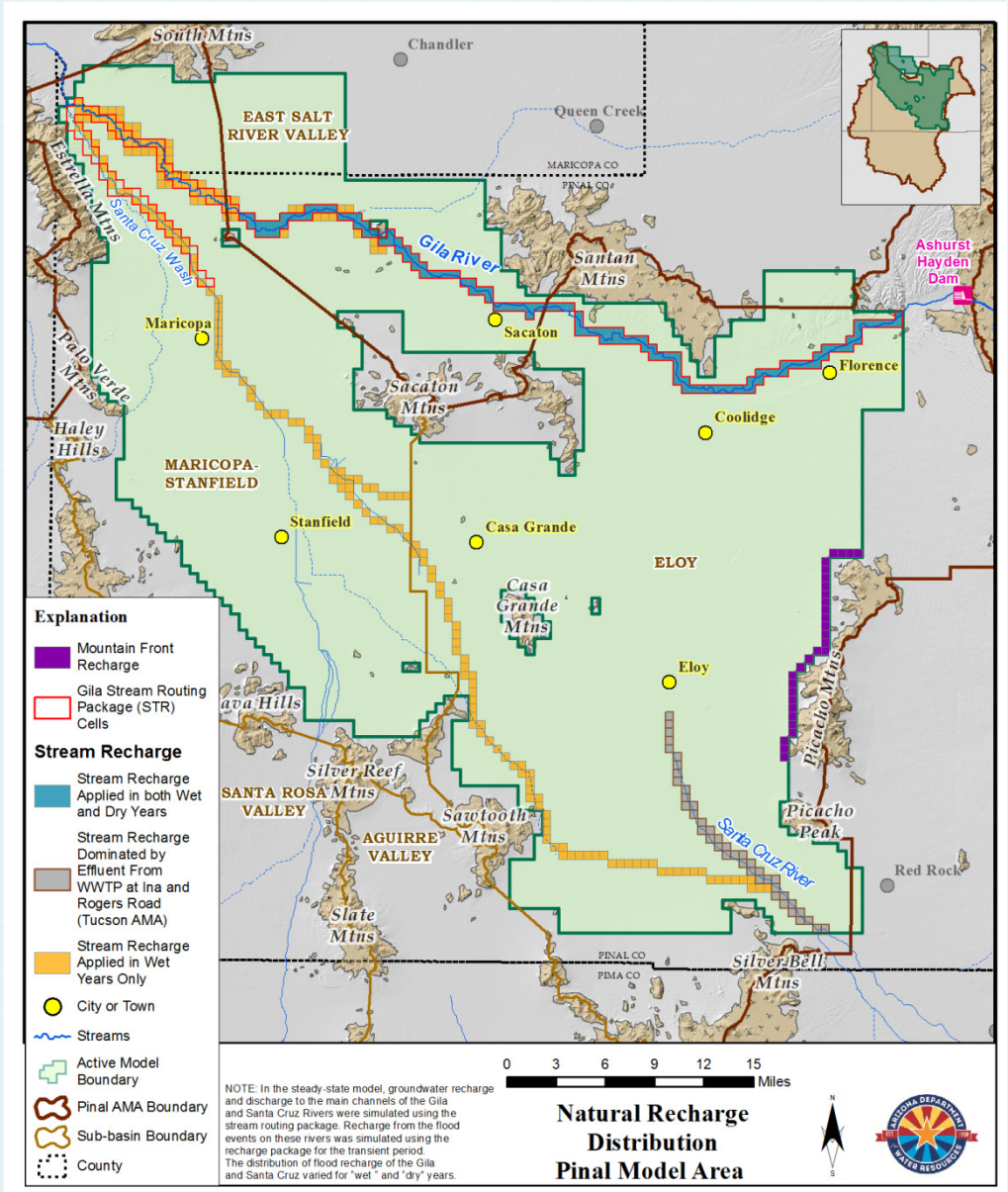
- **Specific Heads**-The heads are set and the model simulates associated flux
- **Constant Flux**-the Flux is set and the model simulates associated heads

Selected Underflow Estimates in the Pinal Model Area

(All Estimates are Rounded to Nearest 100 Acre-Feet Per year)

Underflow Components	USGS Turner, and others (1943)	USGS Thomsen and Eychaner (1991)	USGS Thomsen and Porcello (1991)	USGS Freethey and Anderson (1986)	USGS Pool, and others (2001)	ASLD Hardt and Cattany (1965)	Pre-Development Average	ADWR Freihoefer, and others (2009)	ADWR Mason and Ikeya (1998)	ADWR Mason and Hipke (2013)	ADWR Wickham and Corkhill (1989)	ADWR Corkhill And Hill (1991)	Post Development Average
	Pre-development or Early Development							Post-development					
S. Picacho Peak Inflow (between Silverbell Mtns & Picacho Peak)	23,000 to 24,000	19,000		15,000 to 30,000	20,000 to 23,000	25,000	23,000			11,600 to 32,700	35,300	29,000	28,800
N. Picacho Peak Inflow (between Picacho Peak & Picacho Mtns)					4,000 to 8,000		6,000						6,000*
Cactus Forest Inflow (between Picacho Mtns & Tortilla Mtns)	2,500			<1,000	5,500 to 11,000		3,900				2,800		2,800
Aguirre Inflow (between Silverbell Mtns and Sawtooth Mtns)	2,500			1,000 to 5,000			2,800				4,100	2,900	3,500
Santa Rosa Wash Inflow (near Vaiva Vo)	1,500			1,000 to 5,000			2,300						1,500*
N. Vekol Wash Inflow (between Table Top Mtns. And Halley Hills)	500			<1,000			800						500*
East SRV Inflow (southeast of South Mountain)			6,500 to 7,000				6,800		11,600				11,600
Total Estimated Groundwater Inflow							44,800						54,700
Florence Outflow (between Santan and Tortilla Mtns)			(500)				(500)	(2,800)			(4,200)	(3,300)	(3,400)
Sierra Estrella and South Mountain Gap Outflow		(10,000)		(15,000) to (30,000)			(16,300)						(16,300)*
Total Estimated Groundwater Outflow							(16,800)						(19,700)

Sources of Natural Recharge In the Pinal Model Area

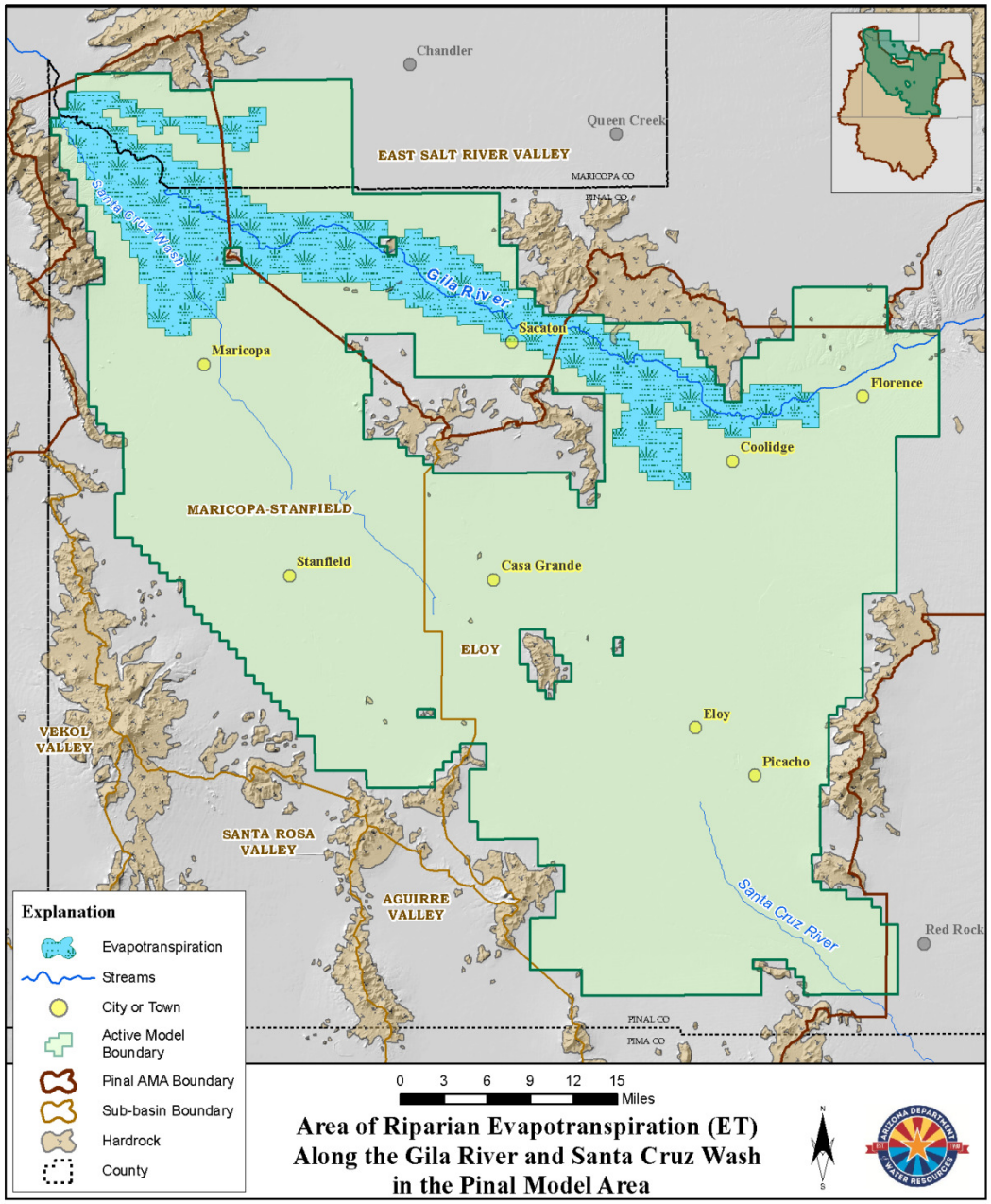


- **Mountain Front Recharge**-500 AFA along the Picacho Mountains.
- **Stream Recharge**
  - Steady State-Used Streamflow Routing Package (SFR)
  - Transient-Used Recharge Package & modified for wet vs. dry years.
  - Gila River recharge ranged from 290 AFY in 2002 to 745,223 AFY in 1993.
  - Average of 40,704 AFY
  - Median 9,627 AFY.
- **Effluent Dominated Stream Recharge**-Used Data from WWTP Releases

Riparian Evapotranspiration

ET along Gila River

- Evapotranspiration (EVT) Package Used to simulate it.
- Major Outflow during predevelopment
- The Riparian area (mesquite bosque) along the Gila died "out" over the years as the water table decline below the extinction depth of the trees. Most all the wood was harvested

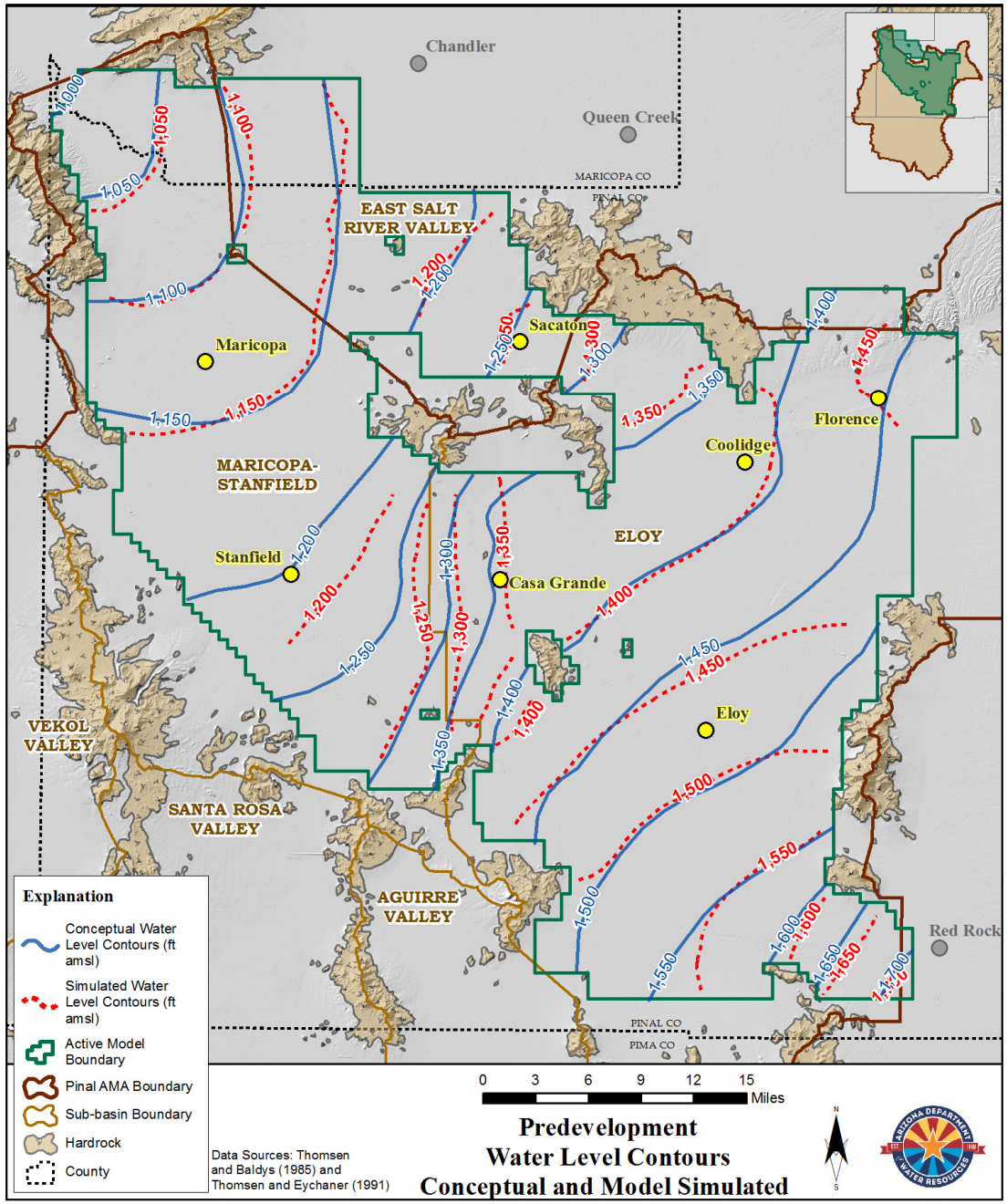


Conceptual and Simulated Steady-State Water Budgets

	Conceptual Steady-state Budget (AFY)	Model Simulated Steady-state Budget (Base Solution) (AFY)
Inflow		
Total Underflow	45,600	37,794
Mountain Front Recharge	500	499
Stream Infiltration recharge	94,000	92,642
Total Inflow	140,100	130,935
Outflow		
ET	97,100	95,870
Stream Discharge	21,300	20,377
Total underflow	16,800	14,688
Total Outflow	135,200	130,935

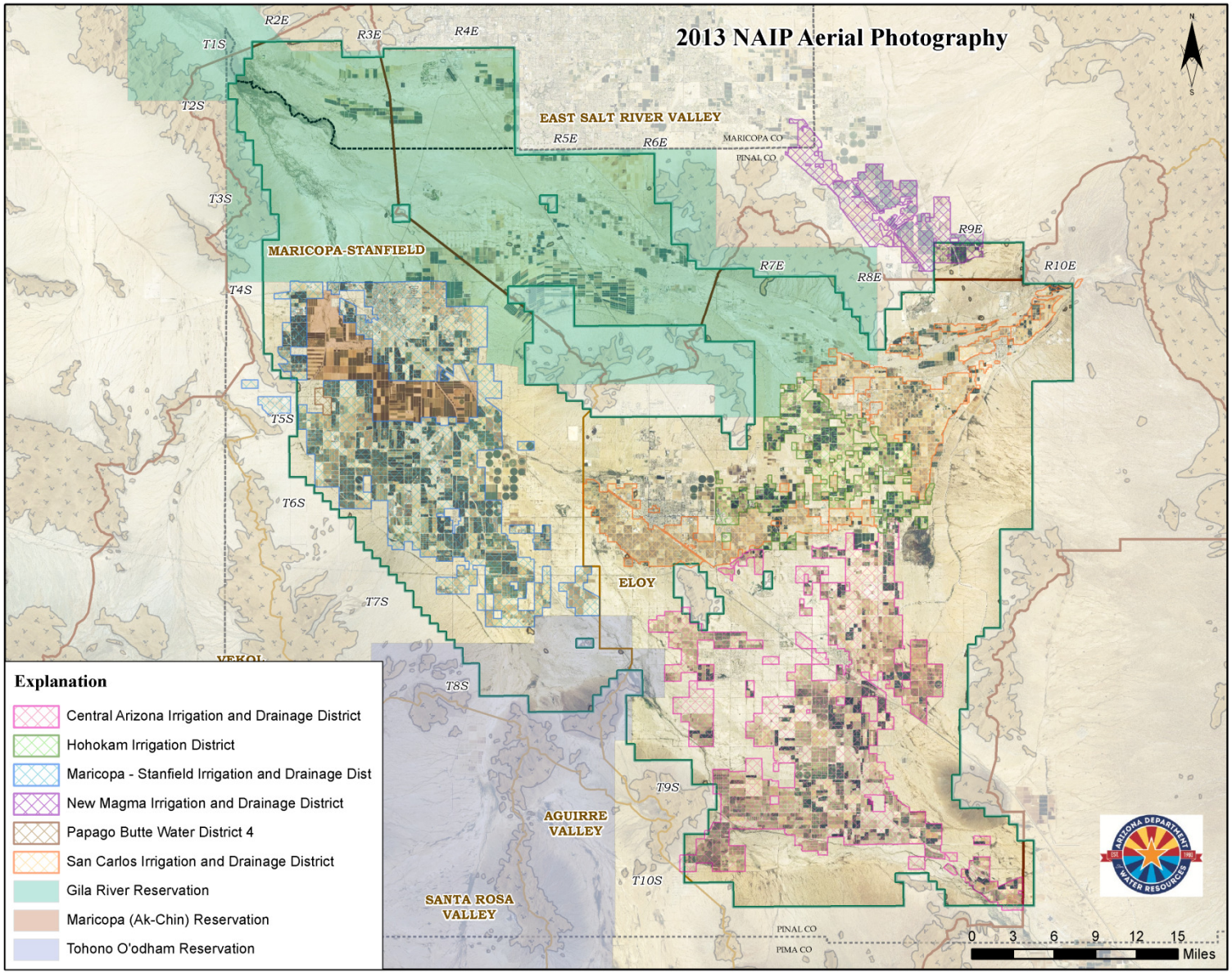
1 Components of the Conceptual Water Budget Were Estimated Independently and Therefore the Total Conceptual Steady-state Inflow and Outflow Does Not Match Exactly

Steady-State Model Results



- Observed (blue) Vs. Model Simulated (red)
- Similar values and gradients
- Close correspondence = Good Calibration
- Steady State Calibration Establishes Confidence in distribution of Aquifer Characteristics.

2013 Aerial Photography of the Model Area with Major Irrigation Districts and Areas of Indian Agriculture

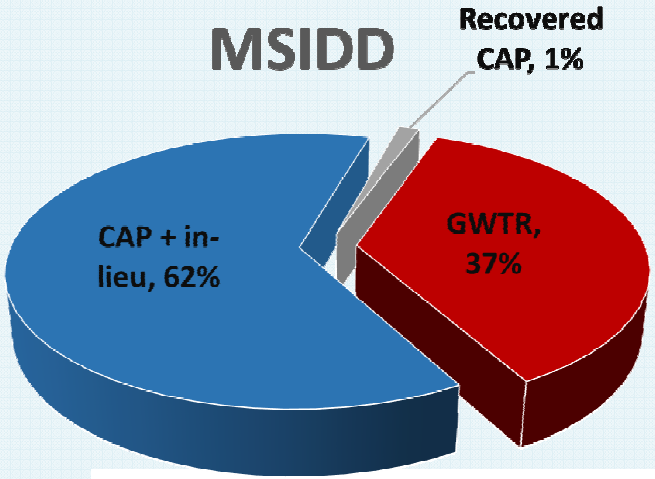


Non-Indian Irrigation Districts Water Supply Percentages

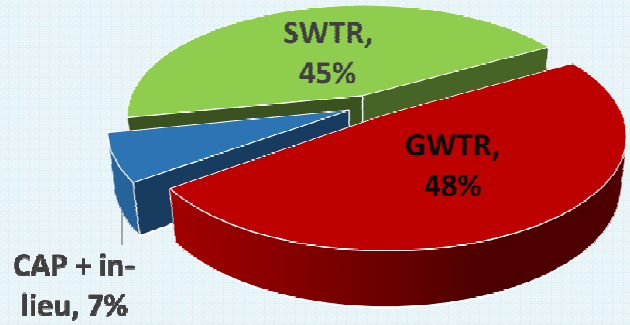
Average 2009 – 2013*

*Based on analysis from ADWR Data Management

MSIDD



SCIDD



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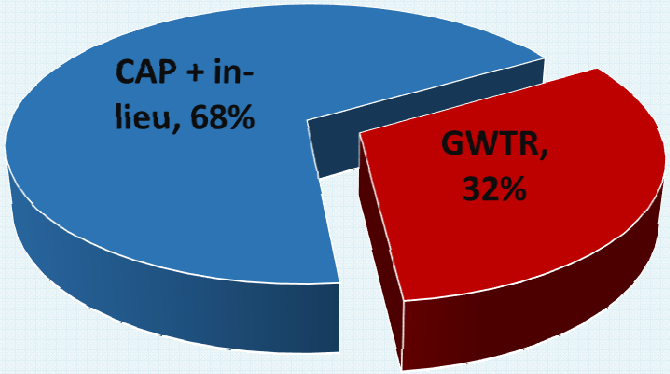

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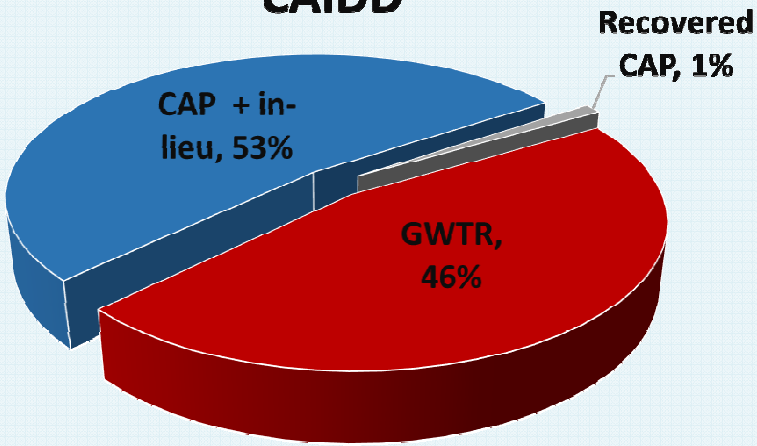
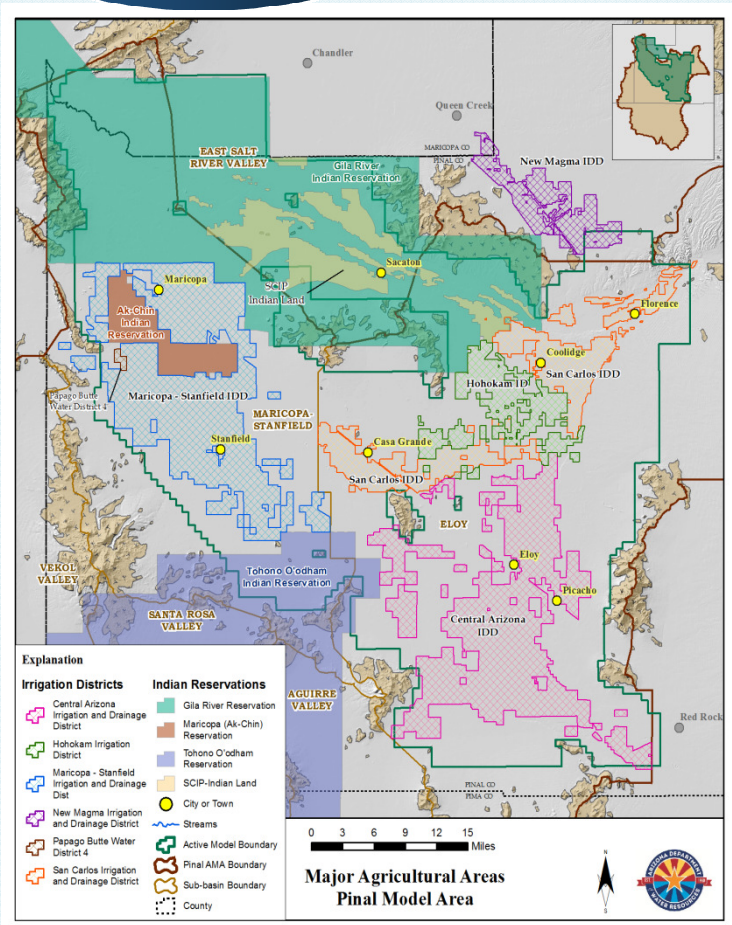
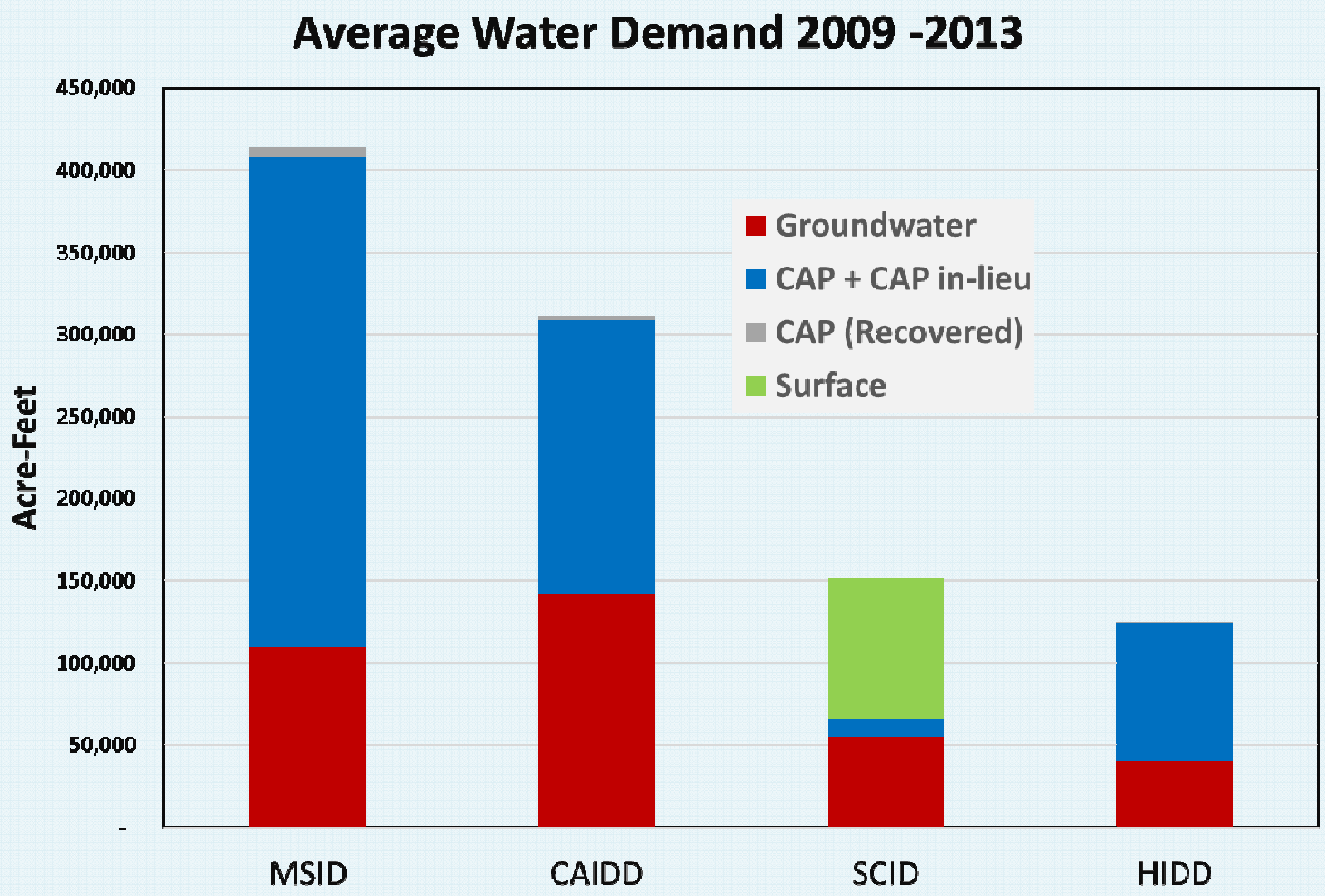


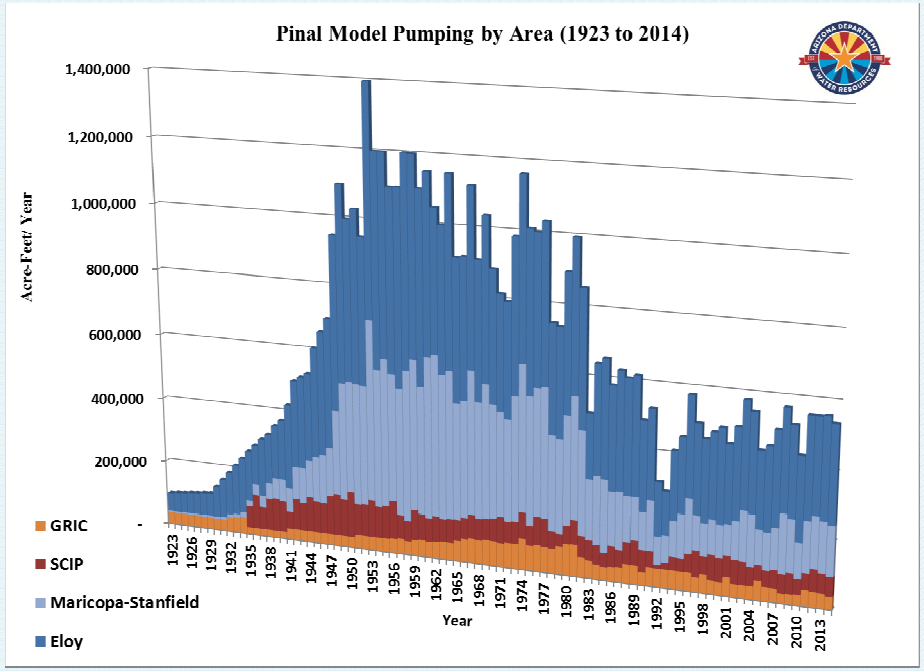


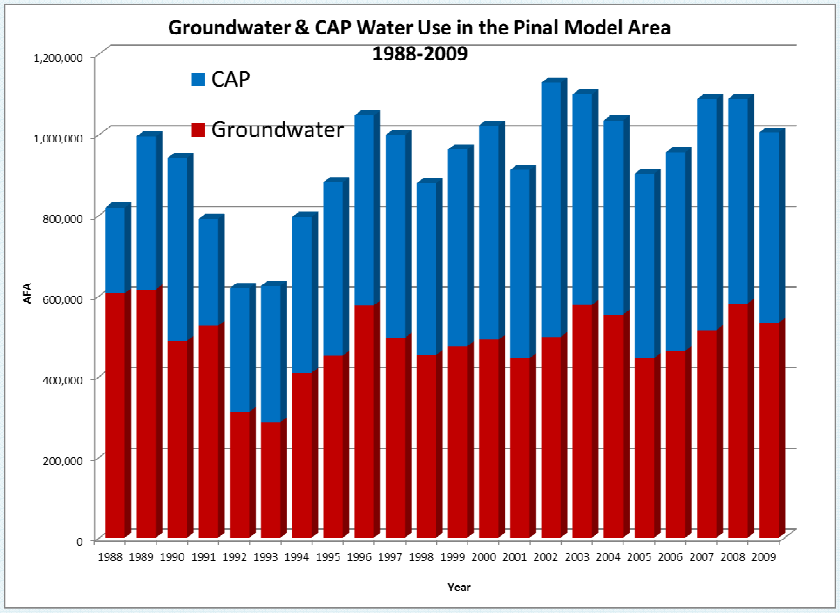
Non-Indian Irrigation Districts
Average Demands & Supplies



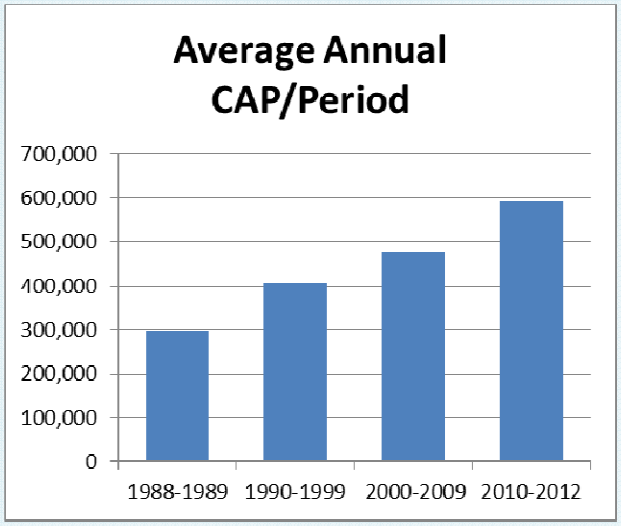
*Based on analysis by ADWR Data Management Section

Major Irrigation Districts and Areas of Indian Agriculture, Historical Groundwater Pumping and CAP Agricultural Water Deliveries In the Pinal AMA

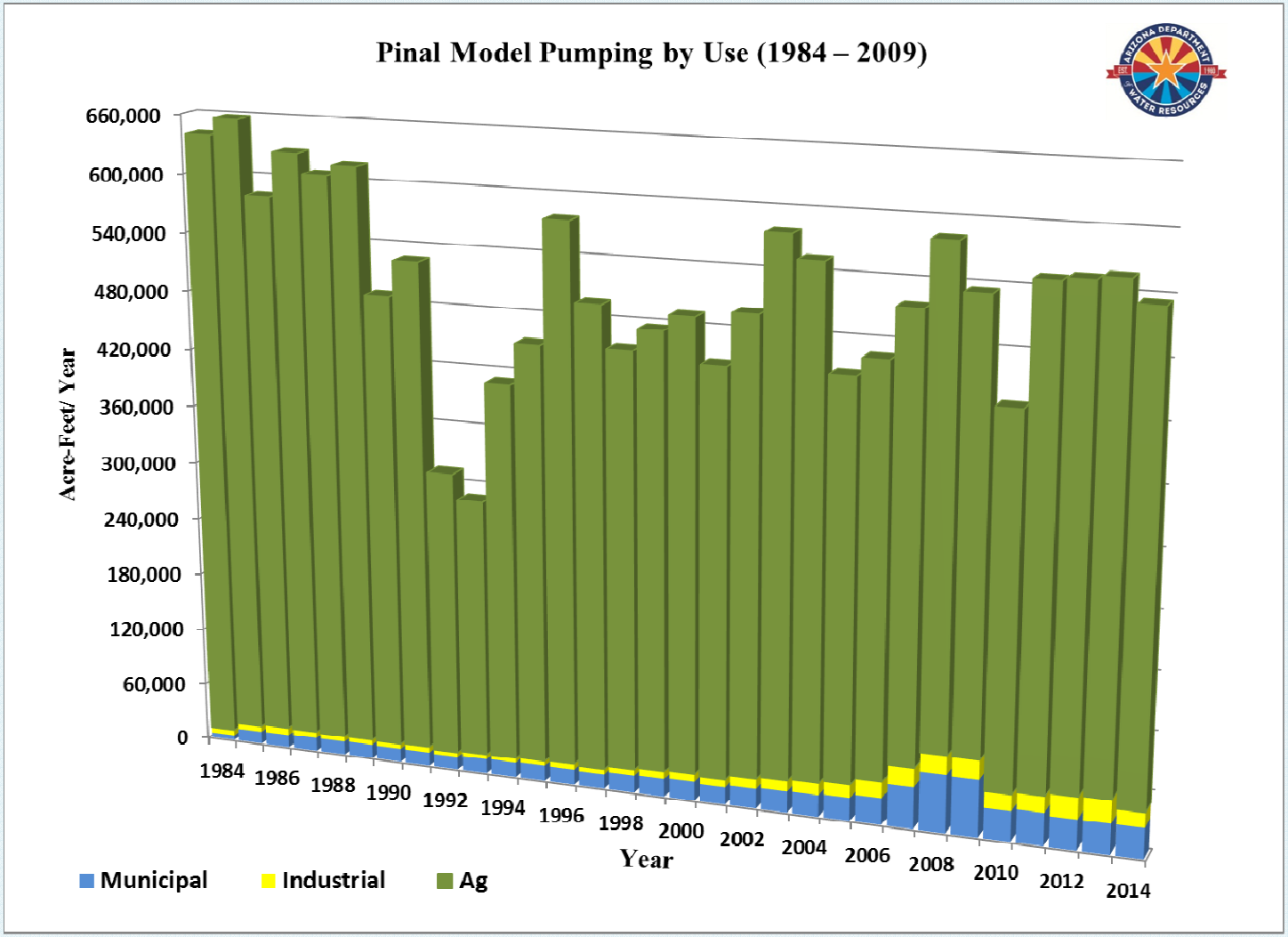




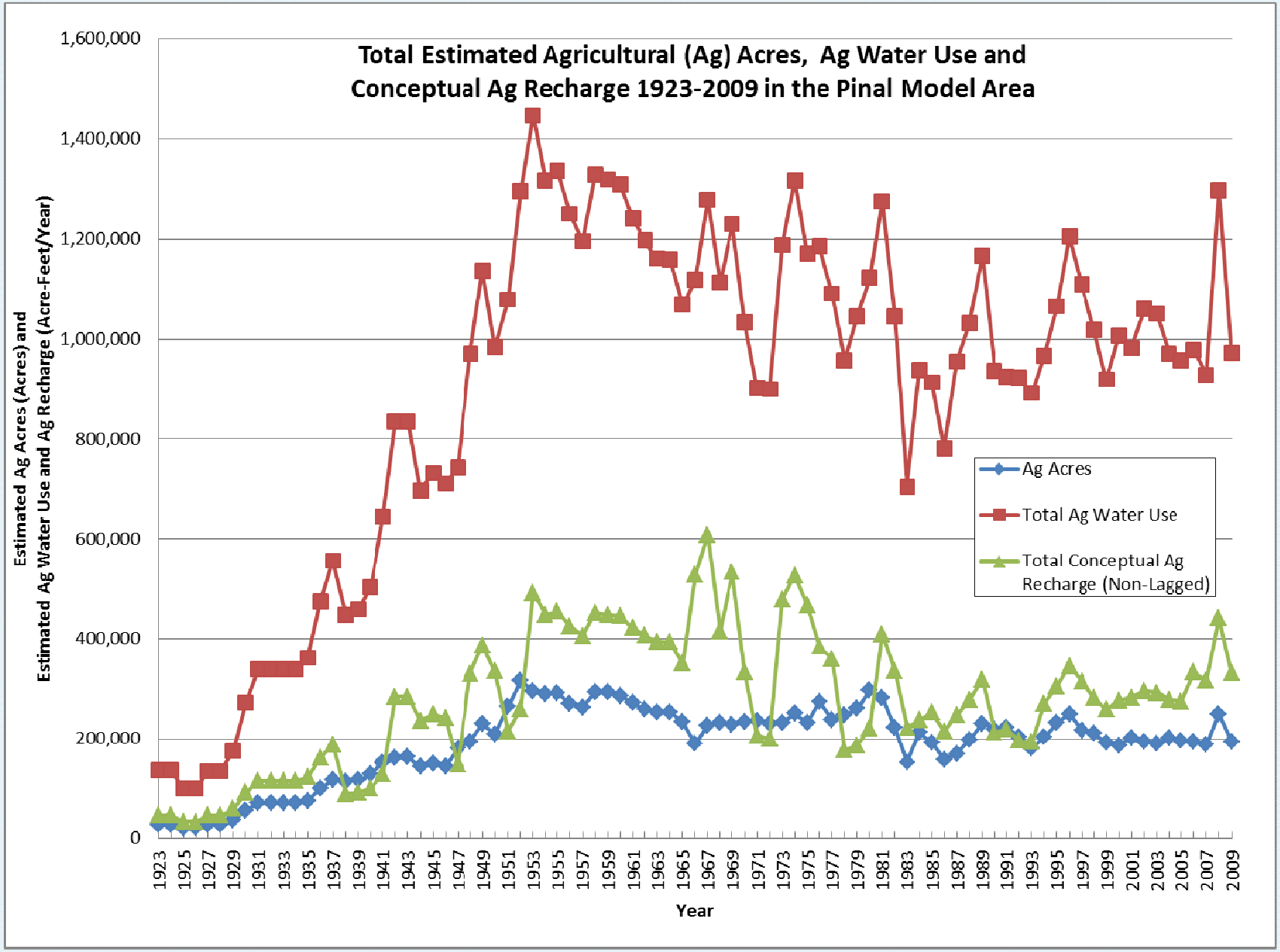
Average Annual CAP AG Water Use In The Pinal AMA (Acre-Feet)				
Irrigation District	1988-1989	1990-1999	2000-2009	2010-2012
Hohokam IDD	10,875	44,860	67,199	40,920
Central Arizona IDD	71,169	119,358	153,950	131,898
Maricopa-Stanfield IDD	153,223	150,889	150,287	133,909
GRIC-Pinal GSFs	0	0	0	155,574
San Carlos ID	0	9,542	9,210	13,172
GRIC	0	7,803	23,873	37,886
Ak-Chin	60,697	73,081	73,943	77,484
Average Annual CAP/Period	295,963	405,534	478,462	590,843
Total CAP Per Time Period	591,925	4,055,339	4,784,617	1,772,528



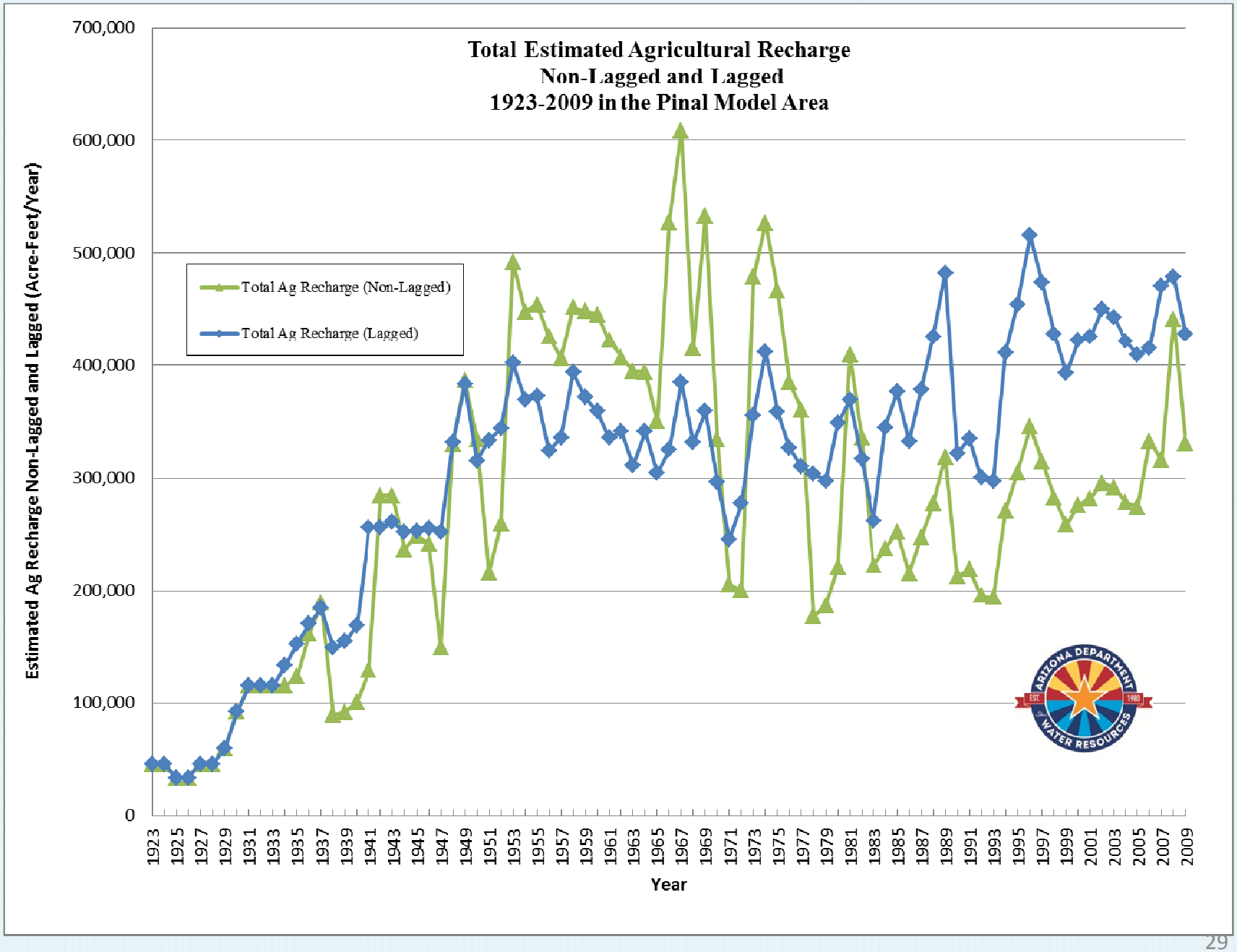
ADWR Has Received Annual Groundwater Use Data Since 1984



- Pumping from Registry of Grandfathered Rights (RoGR)
- Portions of Municipal and Industrial increased through 2009 but has since been reduced.
- Agricultural Pumping Continues to Dominate.

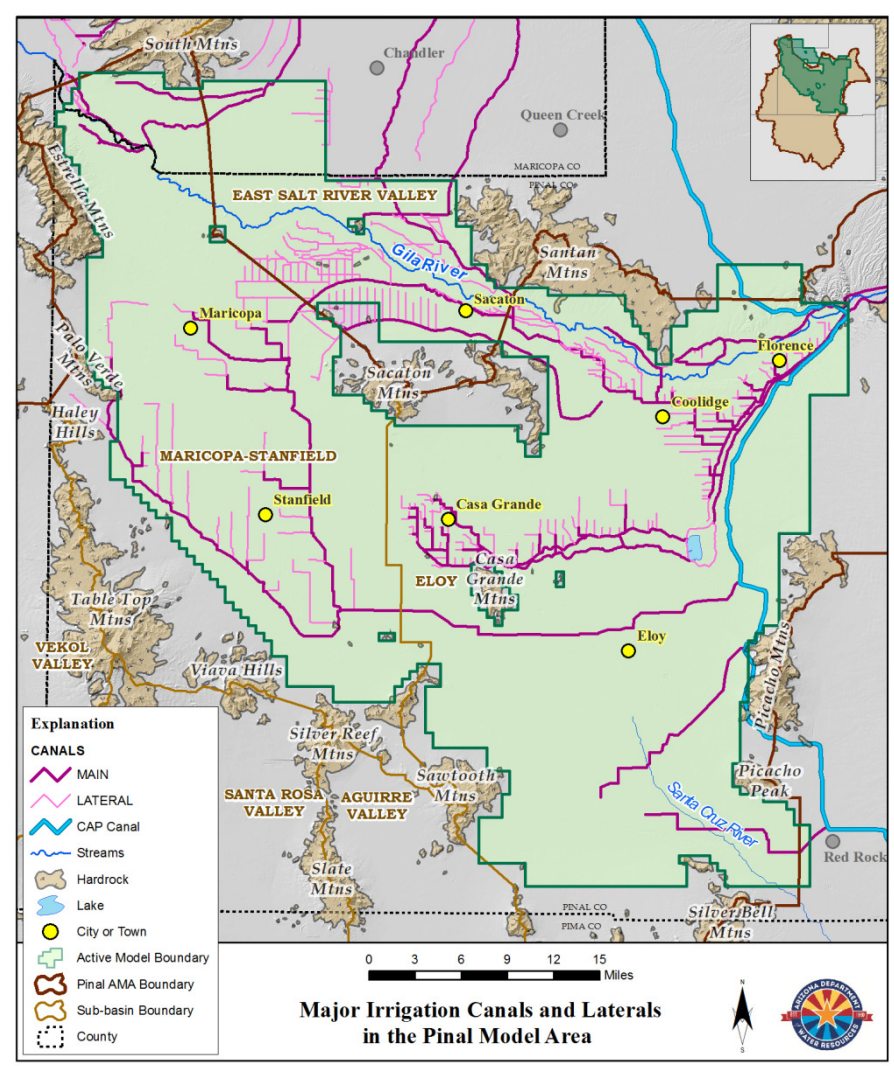

Total Estimated Agricultural (Ag) Acres, Ag Water Use and Conceptual Ag Recharge 1923-2009 in the Pinal Model Area
Estimated Ag Acres (Acres) and Estimated Ag Water Use and Ag Recharge (Acre-Feet/Year)
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Year
Ag Acres
Total Ag Water Use
Total Conceptual Ag Recharge (Non-Lagged)

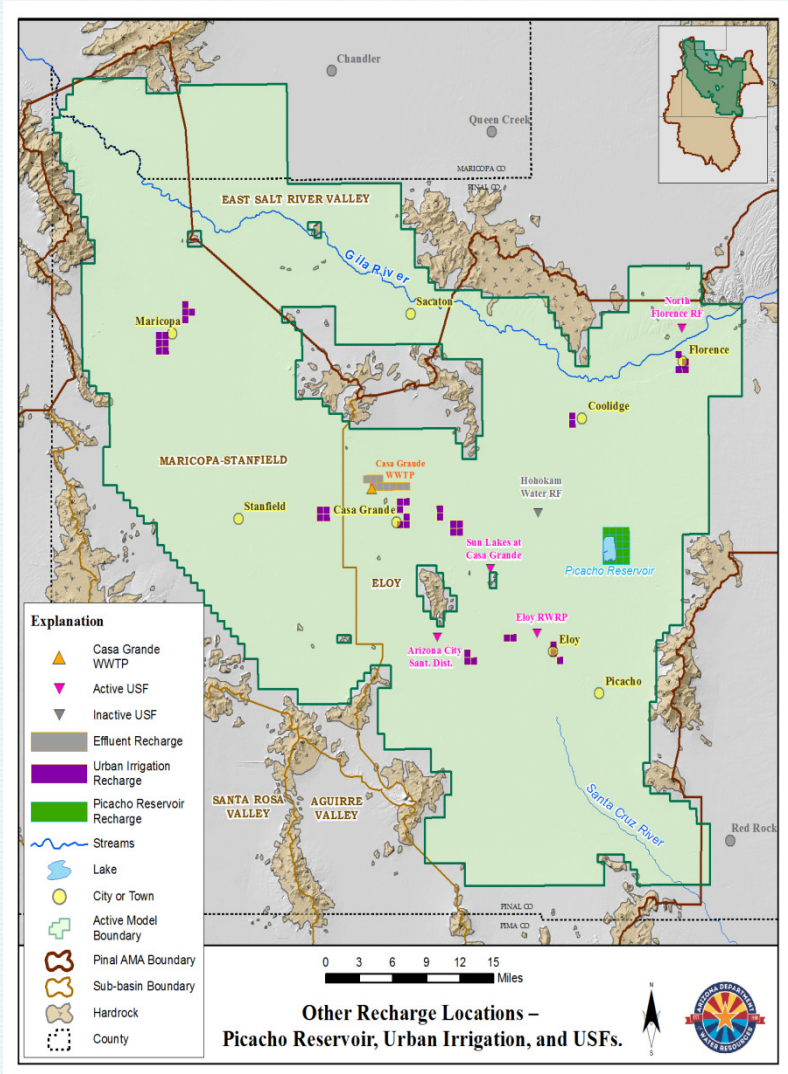
Agricultural Recharge Lagging



Additional Sources of Incidental Recharge In Transient Model

- Unlined Canals
- CAP Canal





- Urban & Turf Irrigation
- Picacho Reservoir

Conceptual Water Budgets For SS and Transient Periods (1923-2009)

Time	SS[2]	1923-1929	1930- 1939	1940-1949	1950-1959	1960-1969	1970-1979	1980- 1989	1990-1999	2000-2009
Inflows										
Groundwater Underflow (Total For all Model Boundaries)[1]	45,600	47,000	48,000	49,000	50,000	51,000	52,000	53,000	54,000	54,700
Agricultural Recharge (non-lagged)	0	44,600	120,800	239,100	393,600	459,000	350,200	308,000	283,000	324,700
Canal Recharge (SCIP and CAP)	0	0	66,200	89,200	72,000	95,100	114,100	170,800	125,500	95,400
Picacho Reservoir Recharge	0	0	5,400	6,700	4,800	6,000	6,000	7,300	5,100	2,500
Mountain Front Recharge	500	500	500	500	500	500	500	500	500	500
Gila River Flood Recharge	94,000	24,100	17,300	7,900	15,200	15,800	28,000	90,400	111,300	18,000
Santa Cruz River Recharge (flood and effluent from TAMA)	0	0	0	6,000	13,800	10.000	31,700	36,500	23,700	26,500
Effluent and Artificial Recharge	0	0	0	0	0	0	0	1,300	1,400	1,900
Urban Irrigation	0	0	0	0	0	0	0	800	900	1,800
Total of Estimated Inflow Components	140,100	116,200	258,200	398,400	549,900	627,410	582,500	668,600	605,400	526,000
Outflows										
Groundwater Underflow (Total For all Model Boundaries)[1,3]	16,800	17,000	17,300	17,600	17,900	18,200	18,500	18,800	19,100	19,700
Pumping	0	83,600	244,600	635,400	1,142,500	1,036,900	917,300	702,600	445,600	490,900
Evapotranspiration (Gila & Santa Cruz areas only on GRIC)[3]	97,100	64,300	29,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000
Gila and Santa Cruz River Groundwater Discharge[3,4]	21,300	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total of Estimated Outflow Components	135,200	164,900	290,900	676,000	1,183,400	1,078,100	958,800	744,400	487,700	533,600

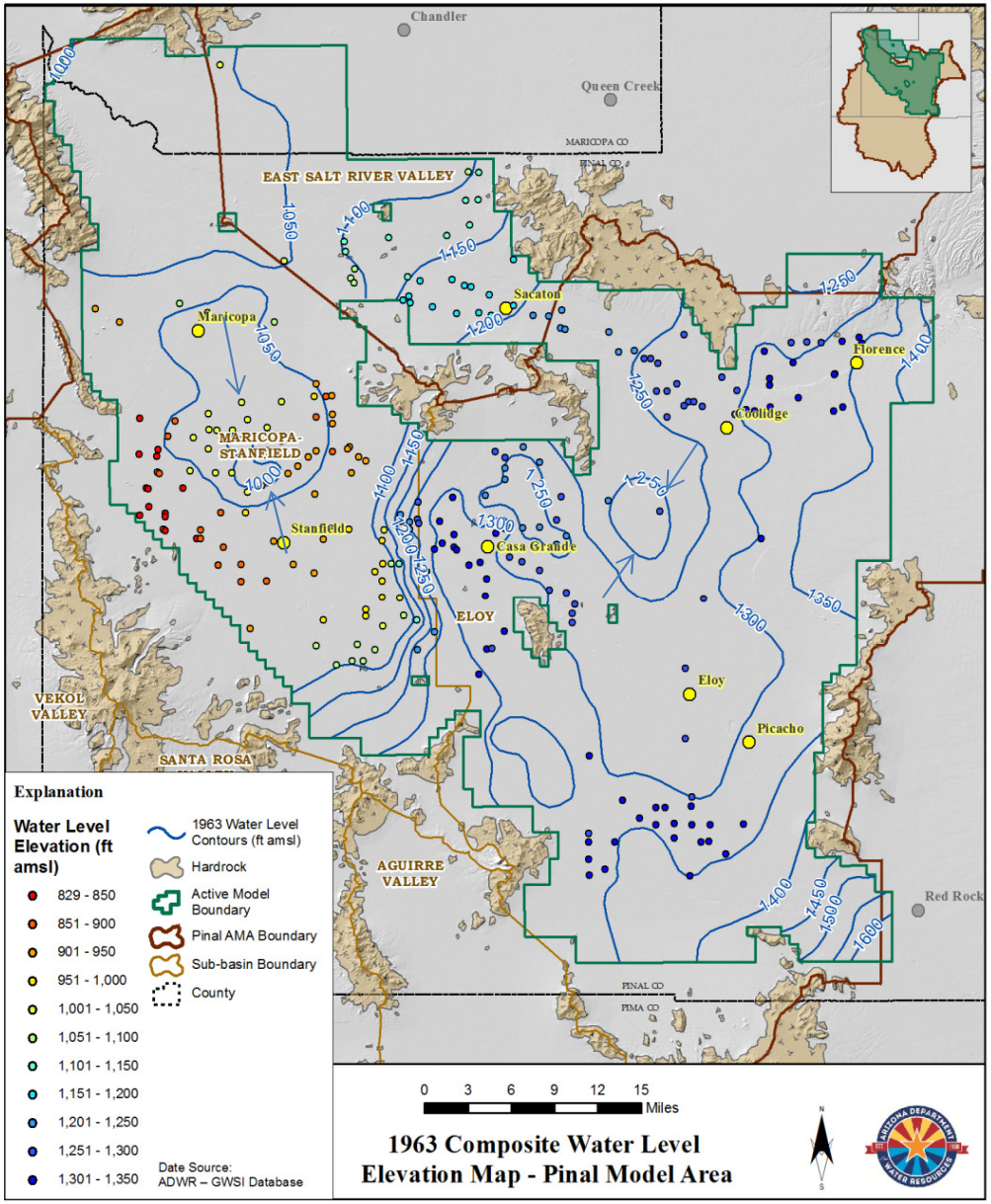
1 Estimates for periods from 1923-1999 based on interpolation between SS and 2000-2009 average rates

2 Conceptual estimates of SS Inflows and Outflows were independently developed and do not balance exactly

3 The close physical proximity between areas of groundwater underflow at the northwest model boundary, riparian ET and groundwater discharge to the channels of the Gila River and Santa Cruz Wash can be problematic for numerical model simulation.
Although these components of groundwater discharge may be independently estimated from available data, each component's individual simulation using a groundwater model is complicated due to their interactive head-dependency.

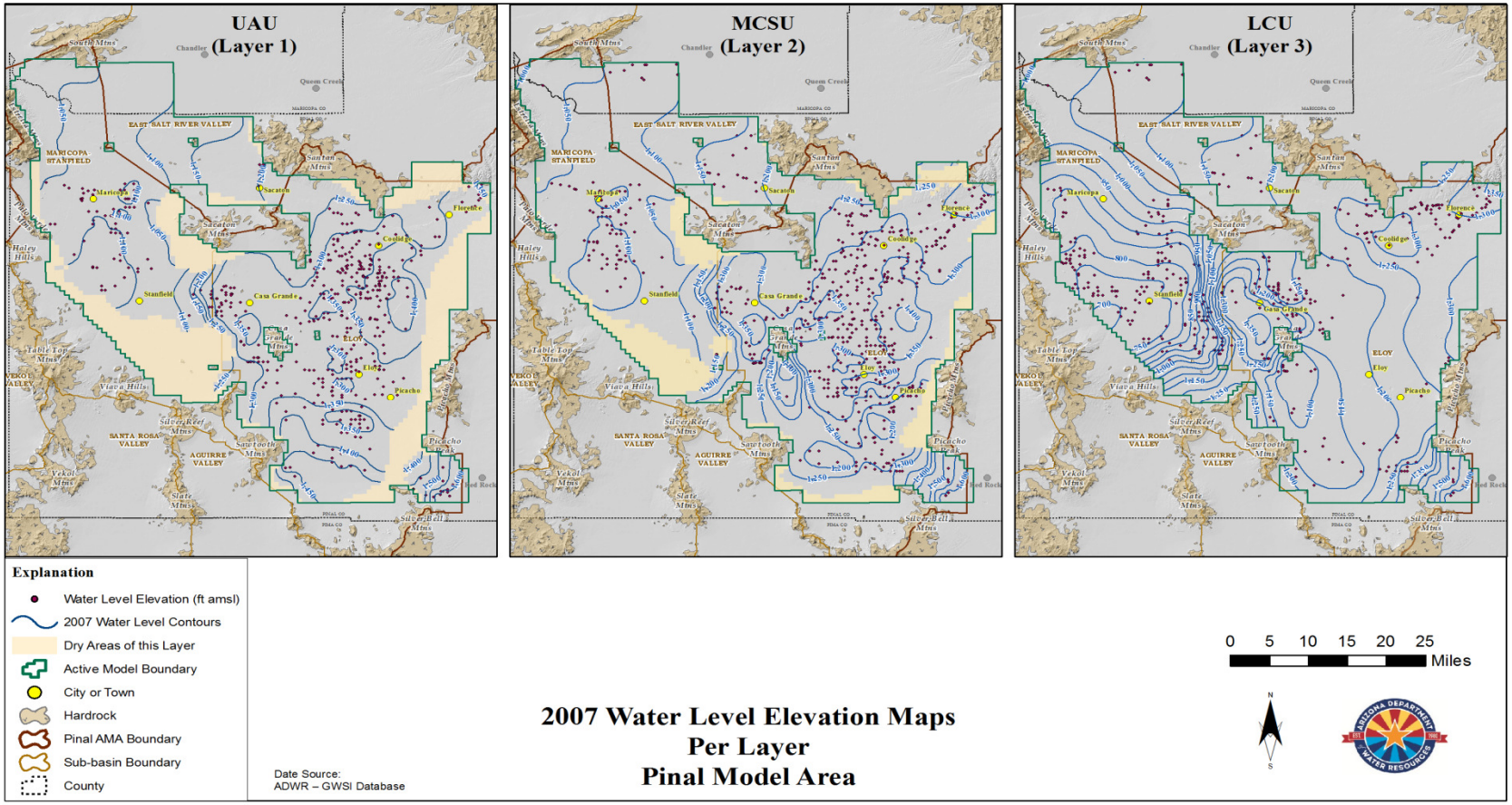
4 NA = Not Available. Independent estimate of this head-dependent recharge component were not made for transient calibration period

The Groundwater System Had Changed Substantially By 1963



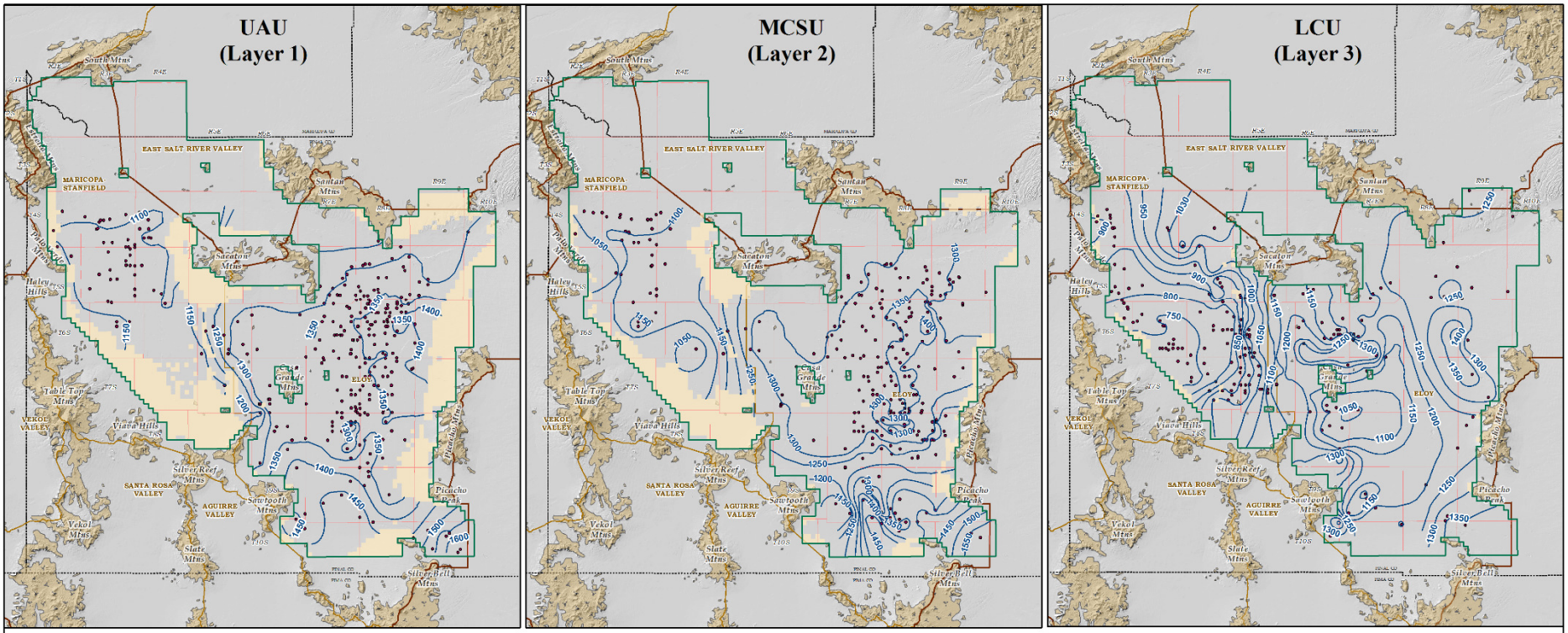
- Heavy Pumping Starts to Alter Flow System
- Cones of Depression Form
- Flow Still coming from Avra Valley and exiting toward West SRV

A Very Complex Groundwater System Has Evolved By 2007



- More decades of pumping lead to more complex groundwater system
- Additional cones of depression formed
- More complicated vertical gradients and the necessity to analyze per hydrologic layer.

Water Levels based on Measurements Made During the 2013 Sweep



Explanation

- 2013 Water Level Elevation (ft amsl)
- 2013 Water Level Contours
- Dry Areas of this Layer (Simulated)
- Active Model Boundary
- Hardrock
- Pinal AMA Boundary
- Sub-basin Boundary
- Township & Range
- County

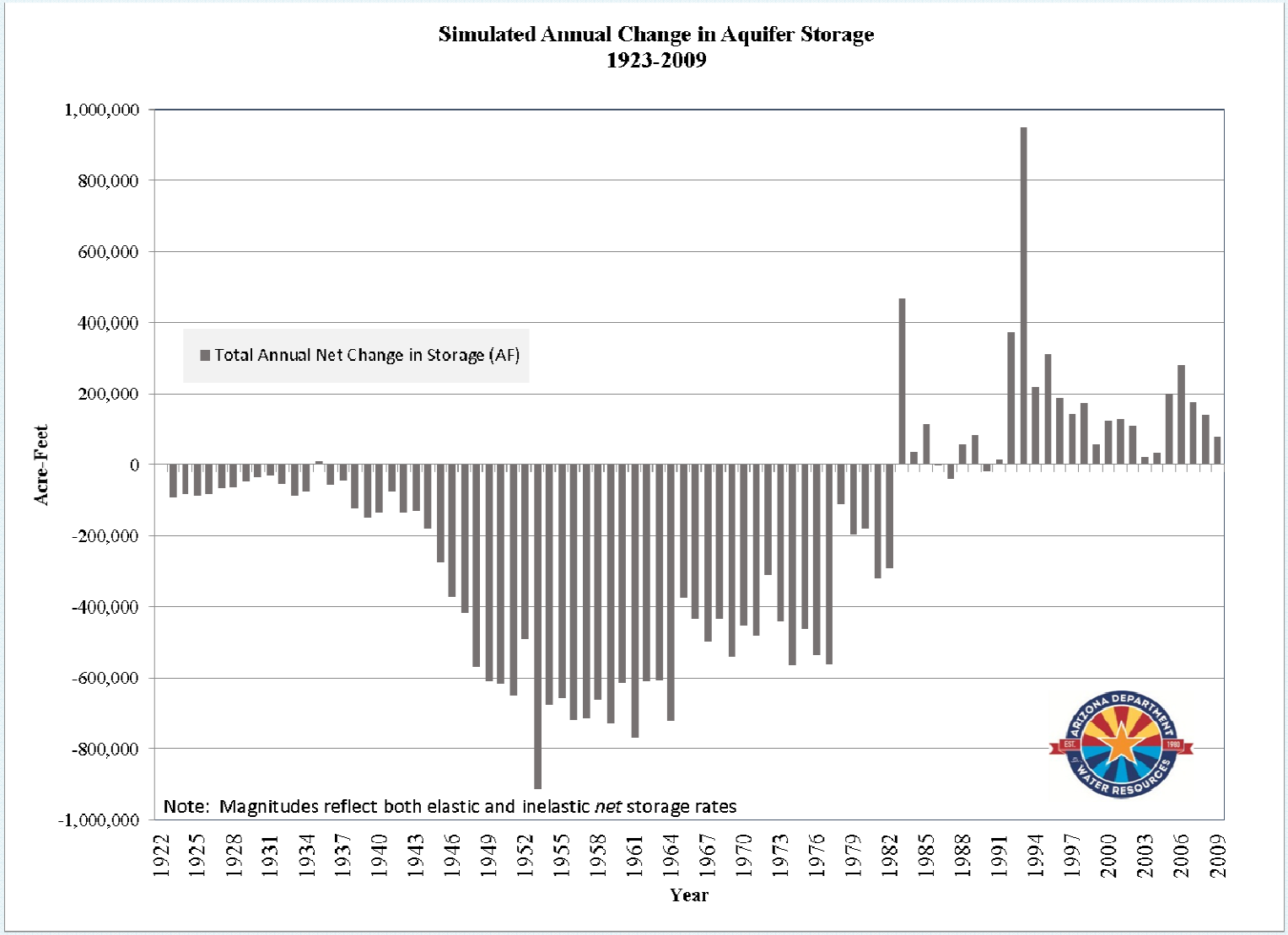
Date Source:
ADWR – GWSI Database

2013 Water Level Elevation Contours
Based on Measured Data From
Most Recent Sweep
Per Layer
Pinal Model Area

0 5 10 15 20 25 Miles

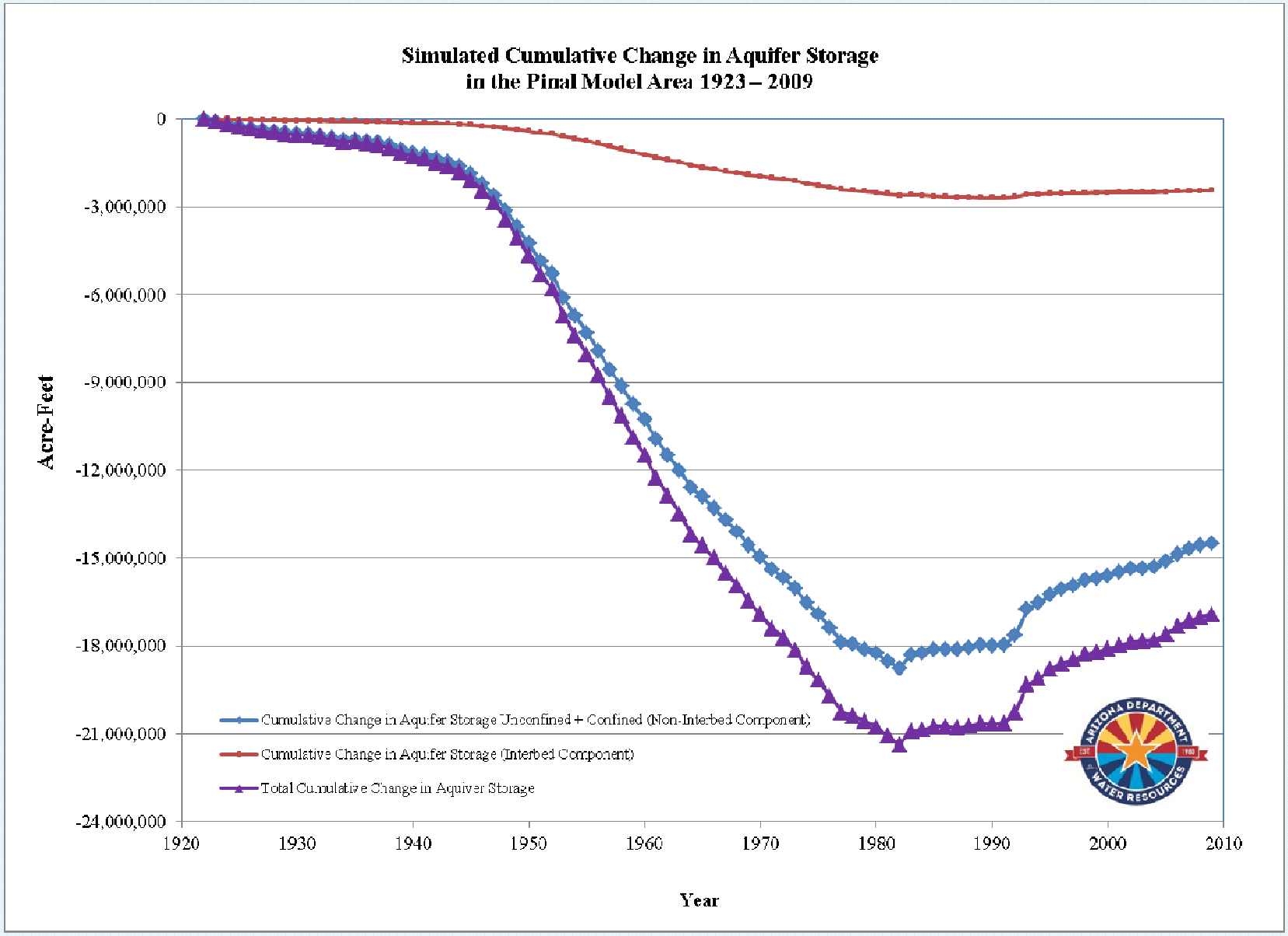
N
S

Simulated Annual Change in Storage

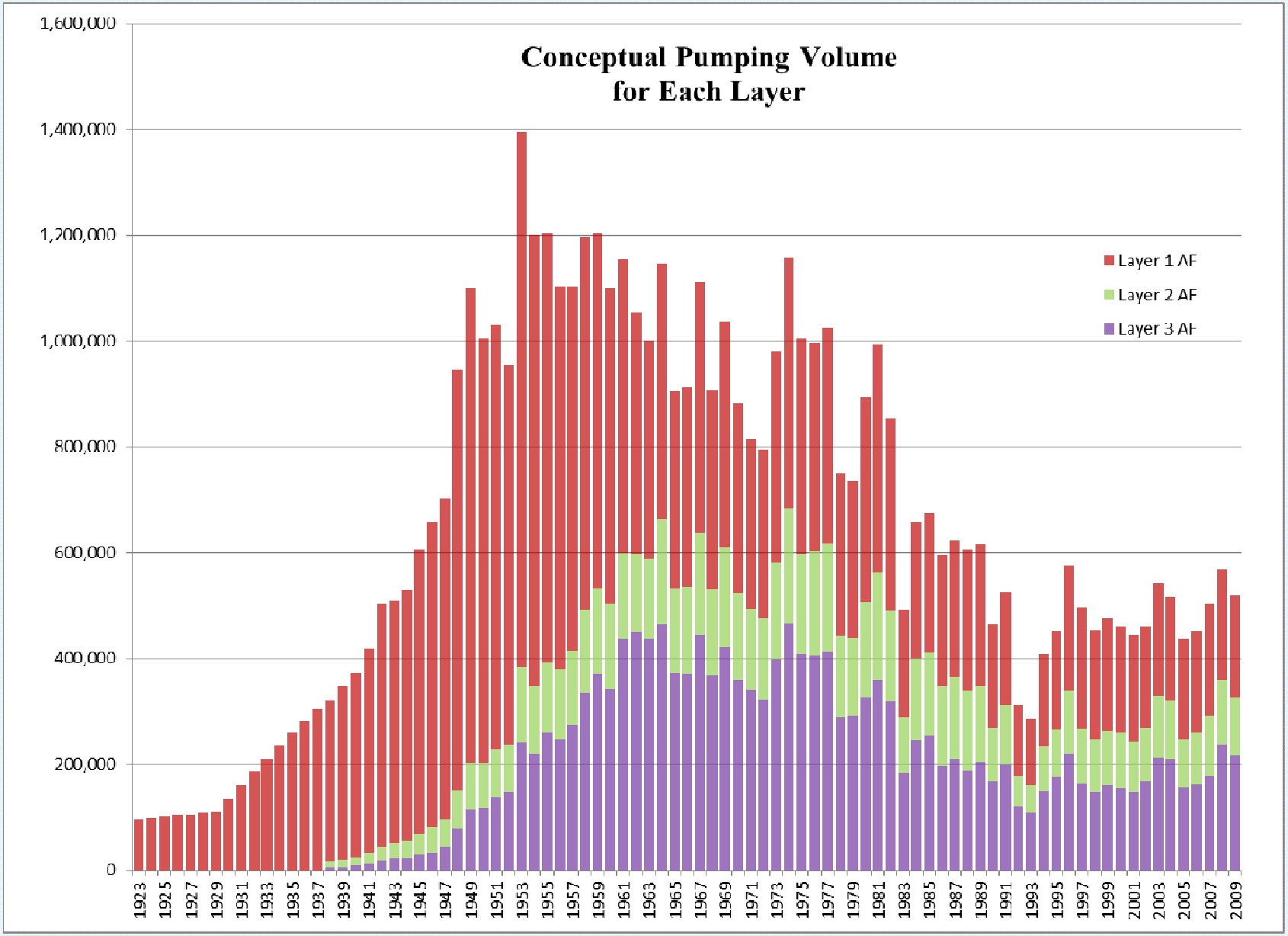


- More water removed most years, especially 1940s-1980
- More recharged in recent years, especially late 1980s on

Simulated Cumulative Change in Storage



Conceptual Vs. Simulated Pumping Volumes

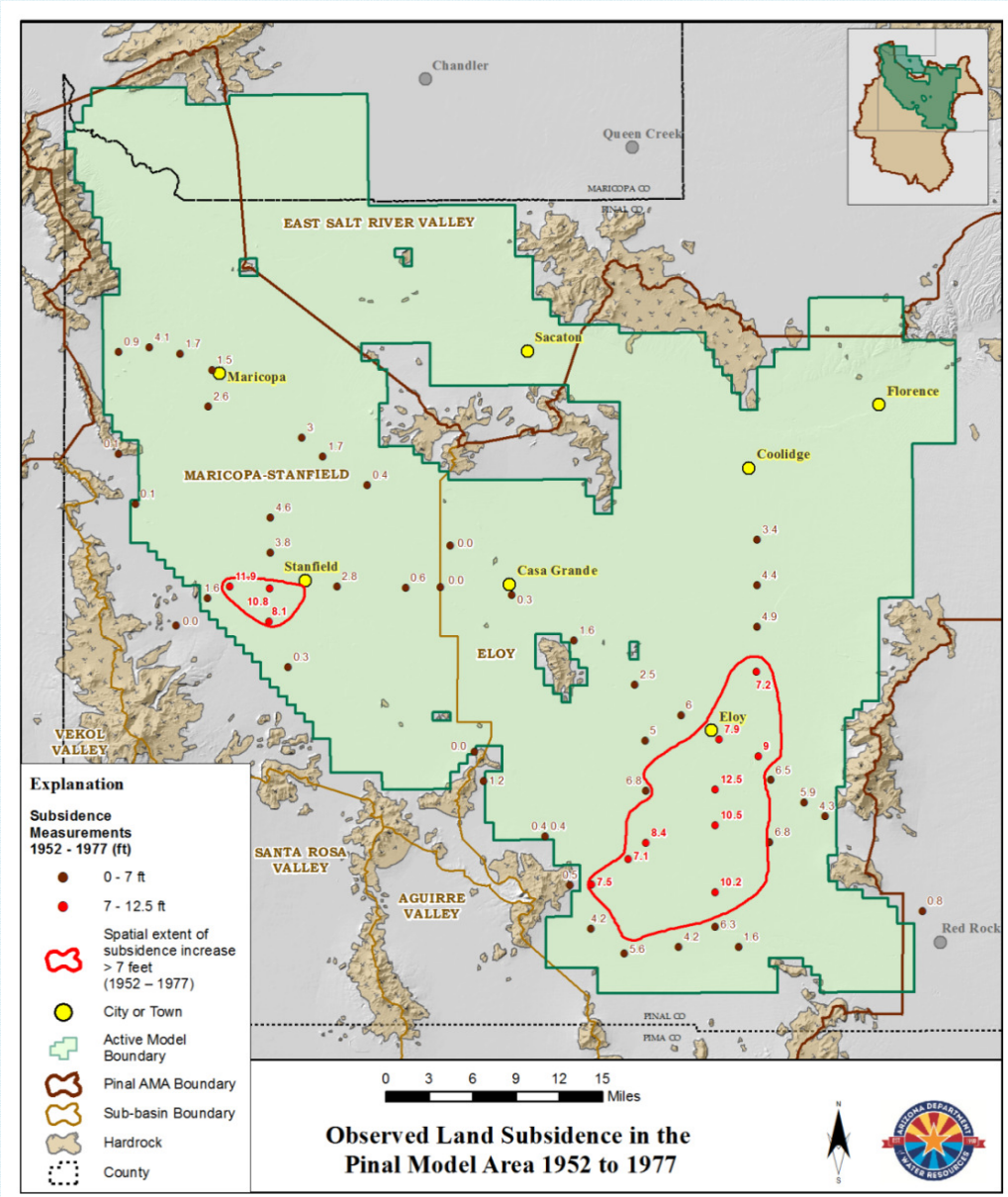


Classic Signs of Land Subsidence

Protruding Well Casing and Well Pad
Central Eloy Sub-basin

Earth Fissures
SW Eloy Sub-basin

Land Subsidence Caused By Groundwater Pumping Has Impacted Large Areas of the AMA



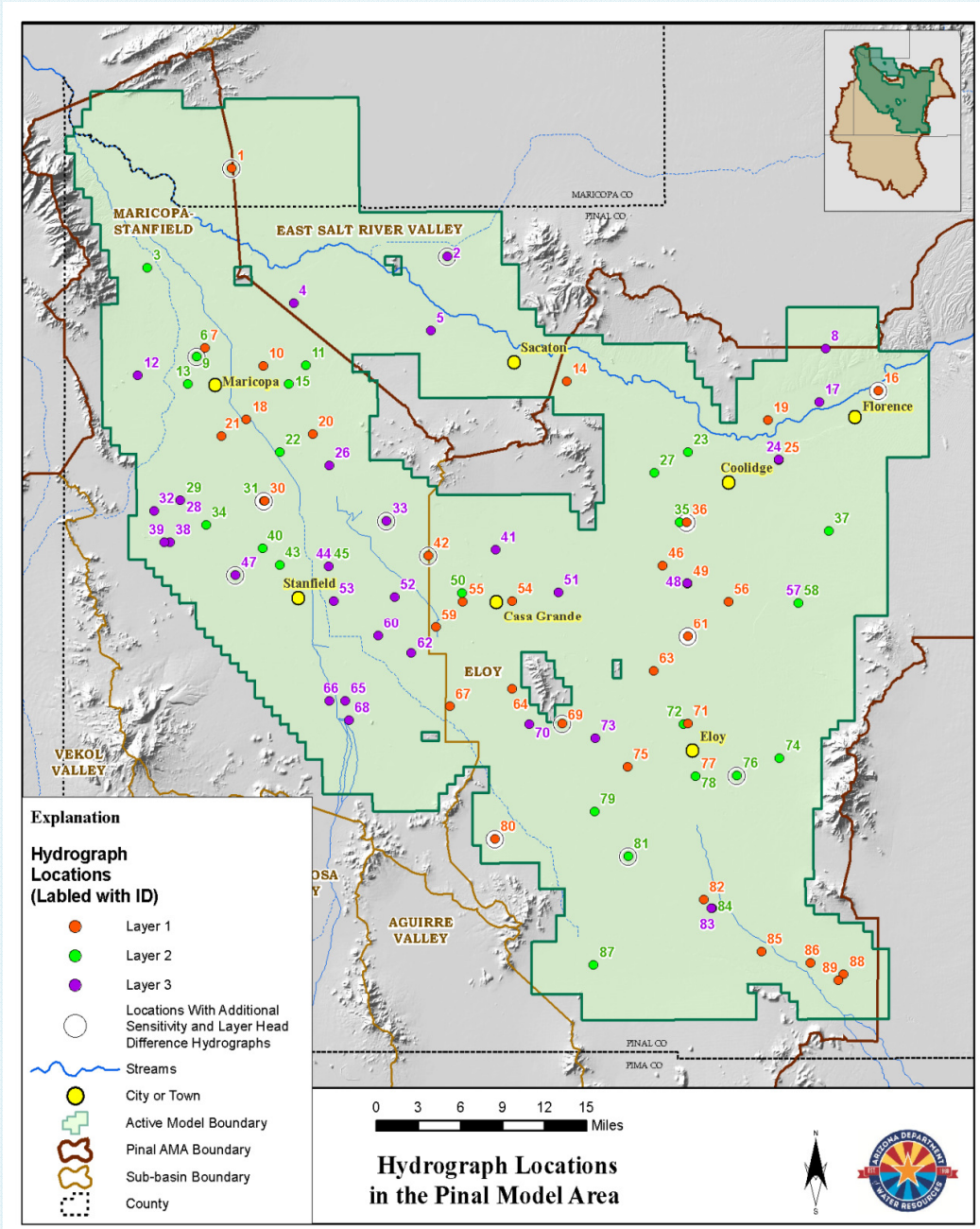
- Areas with over 7 feet of subsidence
- Withdrawal of Water from Pore Space
- Compression of Fine Grained Sediments

Model-Simulated Transient Water Budgets
With and Without Subsidence (SUB-SWT) Package

1923 - 2009 Simulated Water Budget (No SUB-SWT Simulation)	87 Year Cum. Total	Annualized Volume Over 87 Years	1923 - 2009 Simulated Water Budget (With SUB-SWT Simulation)	87 Year Cum. Total	Annualized Volume Over 87 Years	87 Year Difference (No SUB-SWT - SUB-SWT)
	AF	AFA		AF	AFA	AF
STORAGE	26,069,789	299,653	STORAGE	23,601,928	271,287	2,467,860
CONSTANT HEAD	2,742,529	31,523	CONSTANT Head	2,651,417	30,476	91,112
WELLS	1,222,018	14,046	WELLS	1,183,118	13,599	38,900
ET	0	0	ET	0	0	0
RECHARGE	39,086,318	449,268	RECHARGE	39,086,318	449,268	0
STREAM LEAKAGE	84,415	970	STREAM Leakage	105,928	1,218	-21,513
INTERBED Storage	0		INTERBED Storage	3,063,095	39,270	-3,063,095
TOTAL IN	69,203,398	795,441	TOTAL IN	69,690,083	801,035	-486,685
OUT:			OUT:			

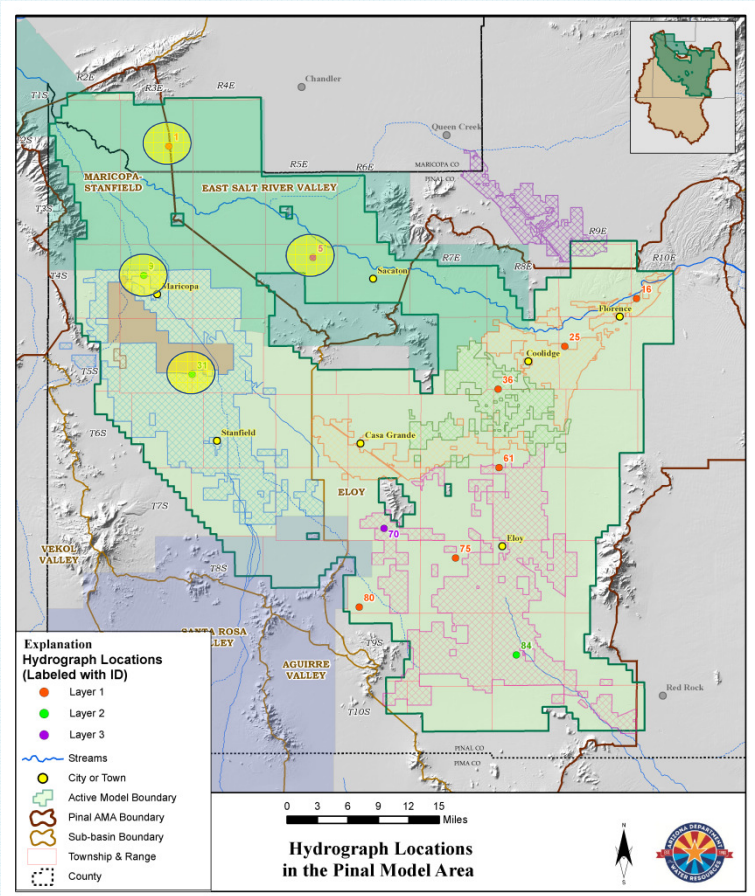
STORAGE	9,844,526	113,155	STORAGE	9,113,814	104,756	730,713
CONSTANT HEAD	1,912,784	21,986	CONSTANT Head	2,028,463	23,315	-115,679
WELLS	55,275,482	635,350	WELLS	55,397,153	636,289	-121,671
ET	1,202,102	13,817	ET	1,278,522	14,696	-76,421
RECHARGE	0	0	RECHARGE	0	0	0
STREAM LEAKAGE	963,036	11,069	STREAM Leakage	1,038,626	11,938	-75,590
INTERBED Storage	0		INTERBED Storage	627,669	7,215	-627,669
TOTAL OUT	69,198,806	795,388	TOTAL OUT	69,483,471	890,813	2,467,860
IN - OUT	5,296	61	IN - out	206,686	2,376	-201,390
PERCENT DISCREPANCY			PERCENT Discrepancy			
Change in Storage	-16,225,262	-186,497	Change in Storage	-14,488,115	-166,503	-1,737,148
Change in Interbed Storage	0	0	Change in Interbed Storage	-2,435,426	-27,993	2,435,426
Total change in storage	-16,225,262	-186,497	Total change in storage	-16,923,540	-194,523	698,278

Locations of Wells Used to Evaluate the Model Calibration



- 89 Hydrograph Locations
  - 33 in Layer 1
  - 27 in Layer 2
  - 29 in Layer 3
- 14 Of those also included in sensitivity analysis.
  - 7 in Layer 1
  - 4 in Layer 2
  - 3 in Layer 3

Selected Observed and Simulated Hydrographs

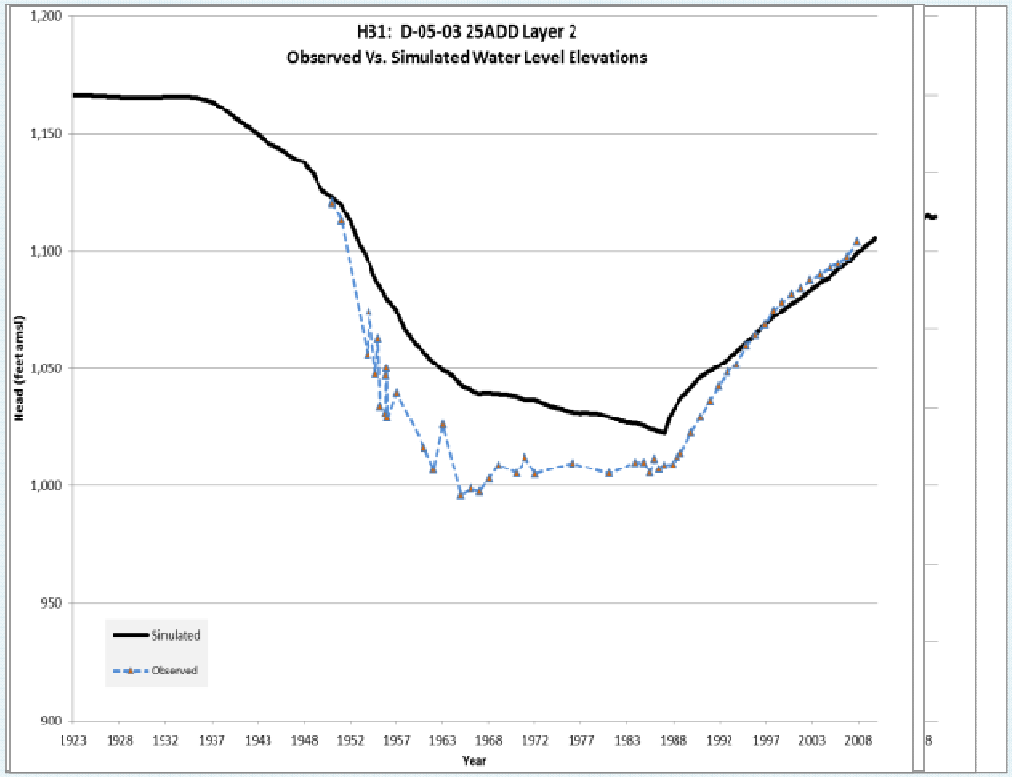


H1: Maricopa-Stanfield Sub-basin GRIC – Lone Butte Area

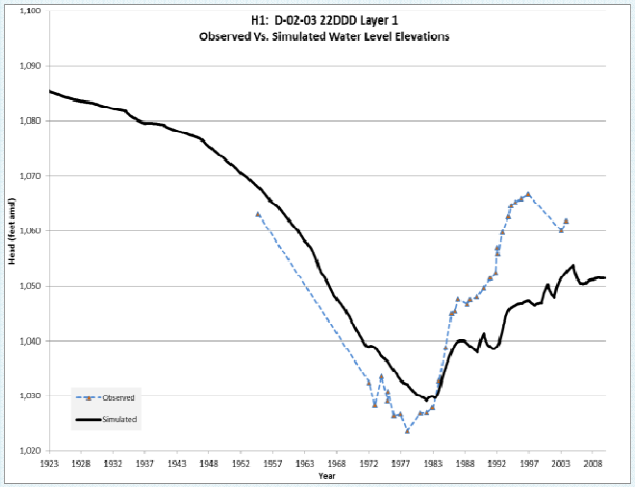
H5: ESRV Sub-basin GRIC/SCIP Area – about 9 Miles WNW of Sacaton

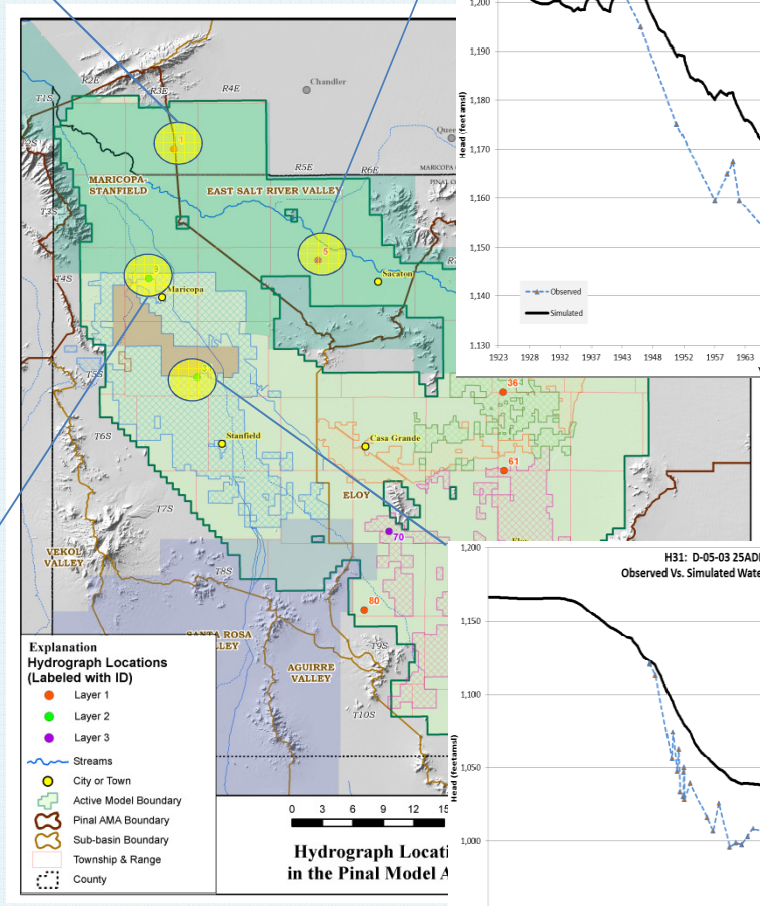
H9: Maricopa-Stanfield Sub-basin MSIDD Area – Near Maricopa

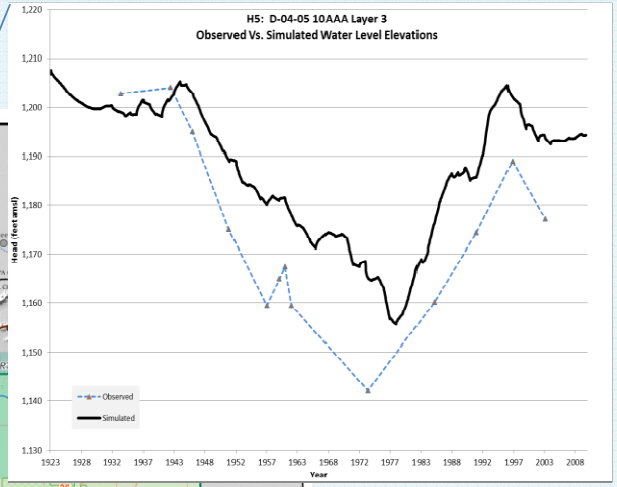
H31: Maricopa-Stanfield Sub-basin MSIDD/ S. Ak-Chin Area – 6 Miles NE of Stanfield

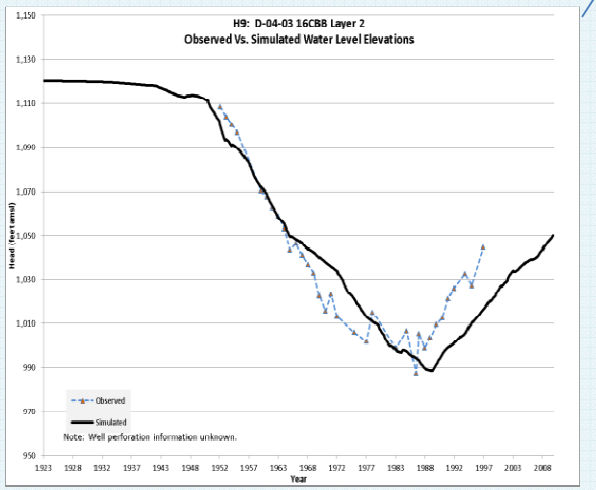


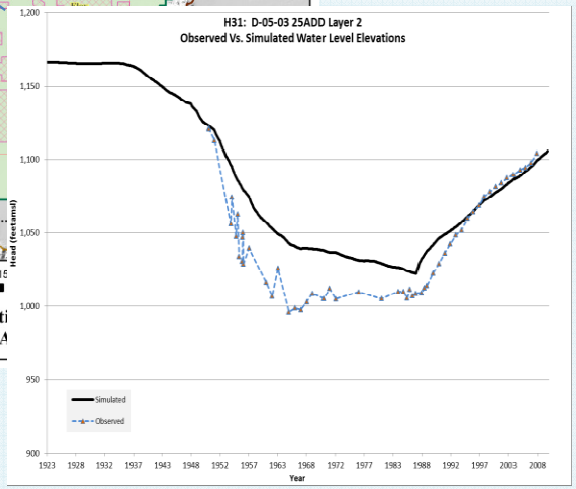
ESRV & Maricopa-Stanfield Sub-Basins



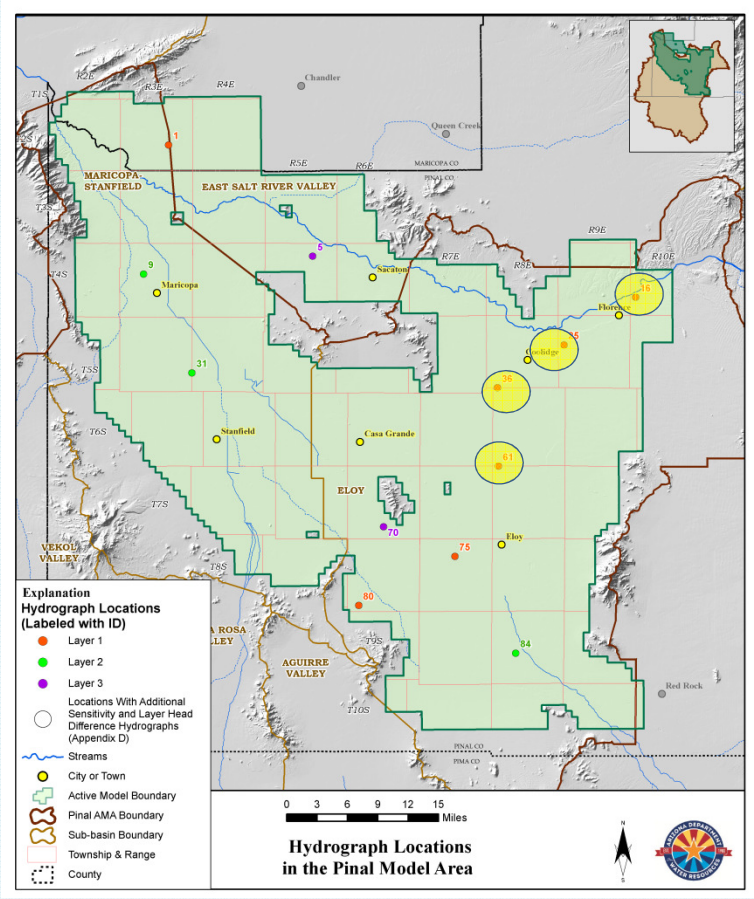


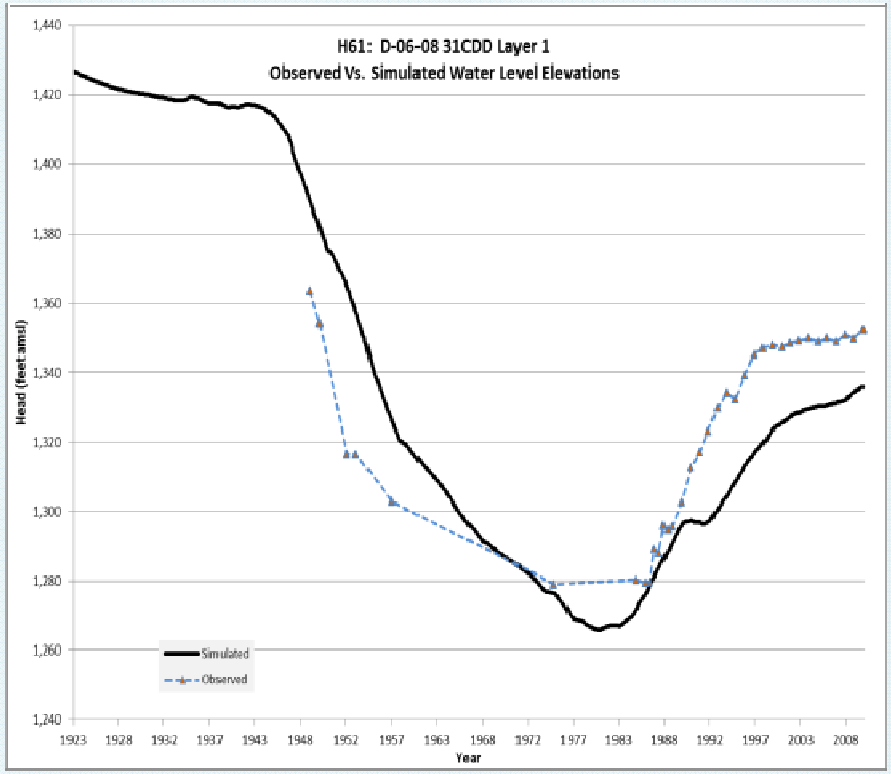




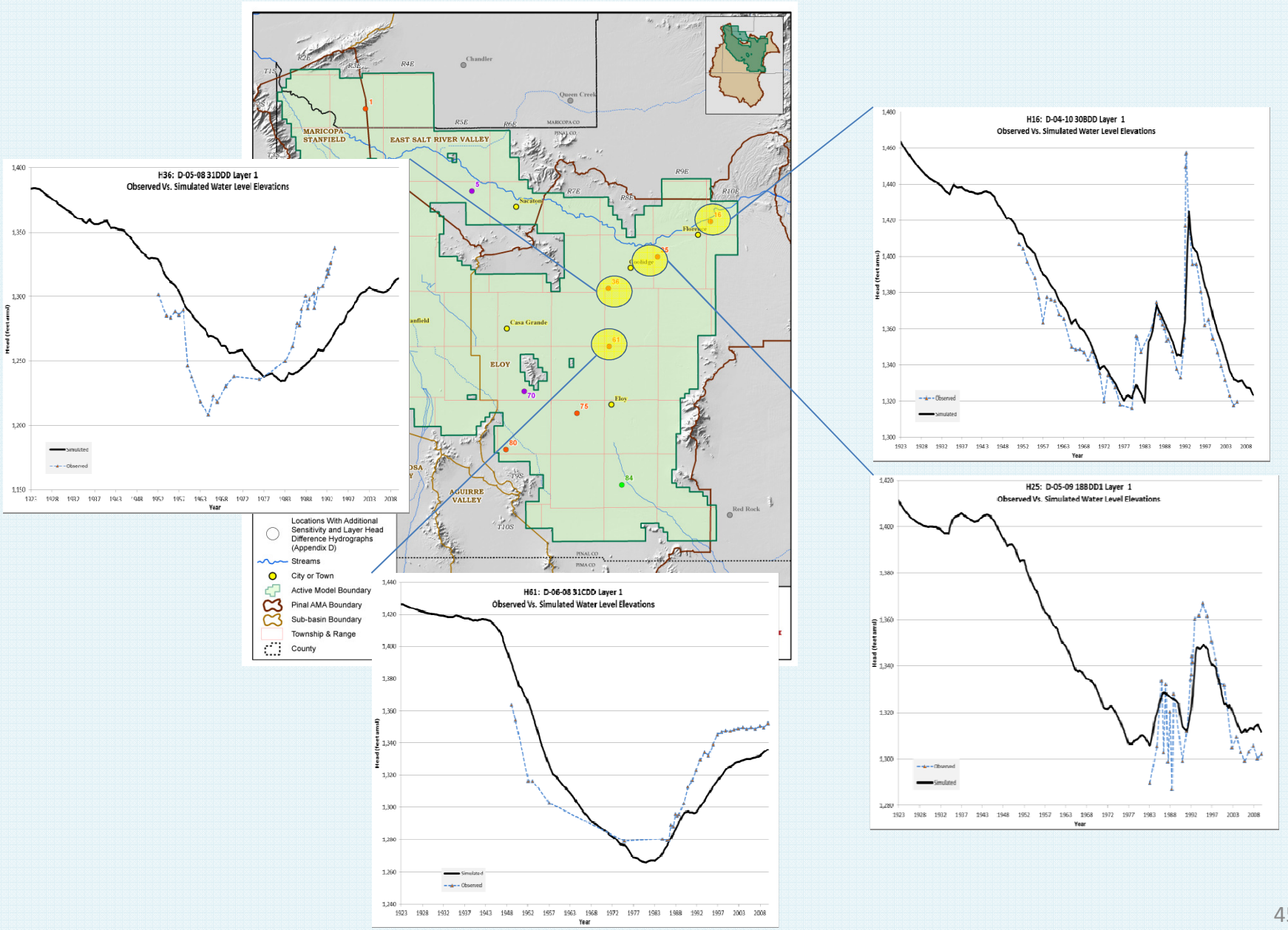


Northern Part of Eloy Sub-Basin Hydrographs

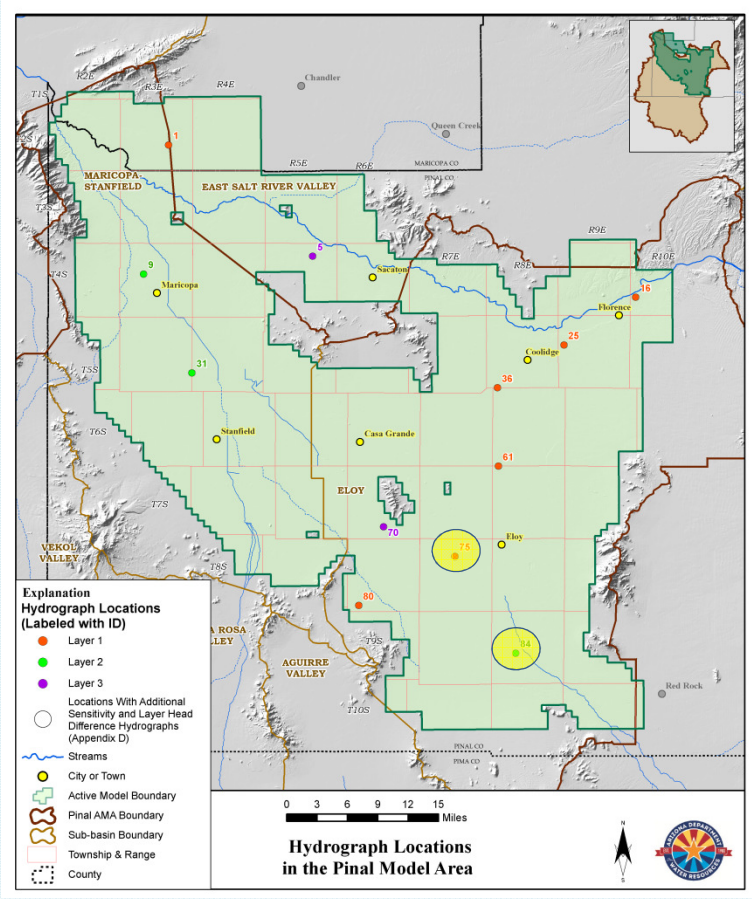




Northern Part of Eloy Sub-Basin Hydrographs



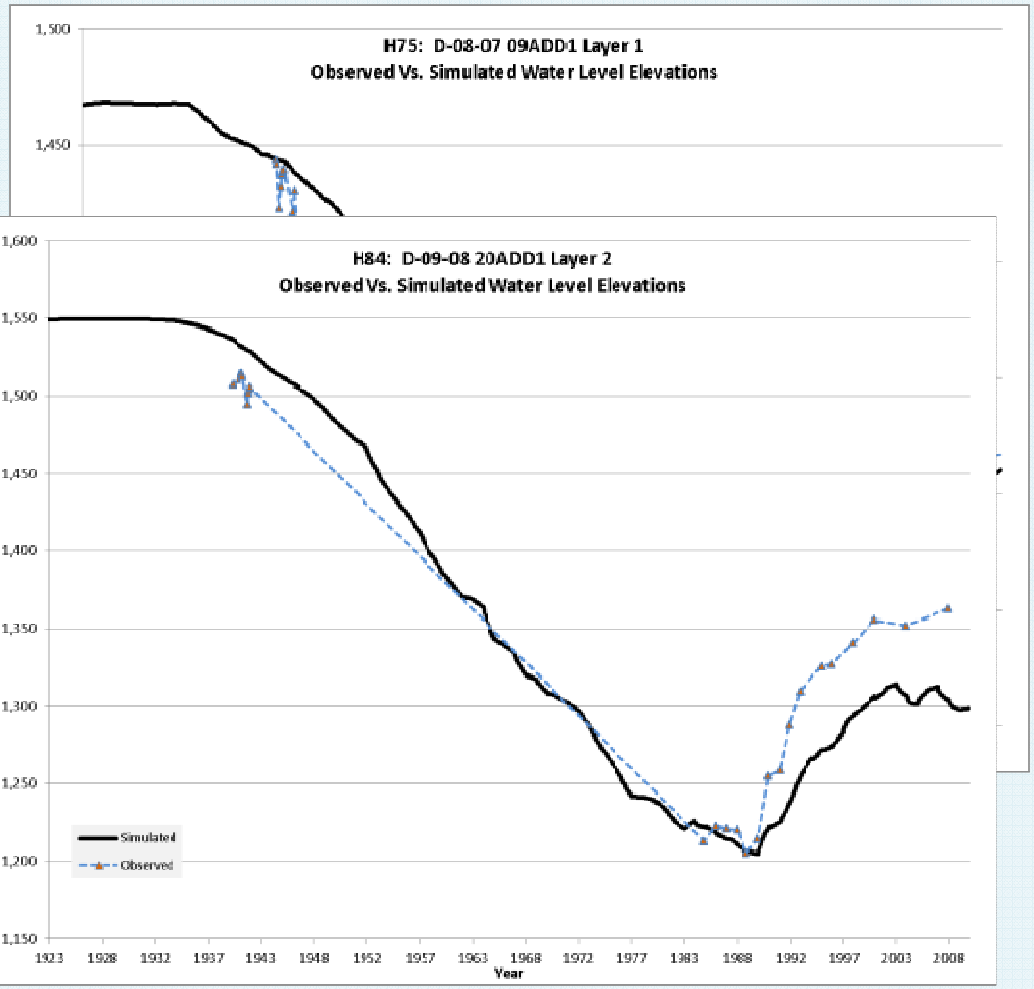
Southern Part of Eloy Sub-Basin Hydrographs



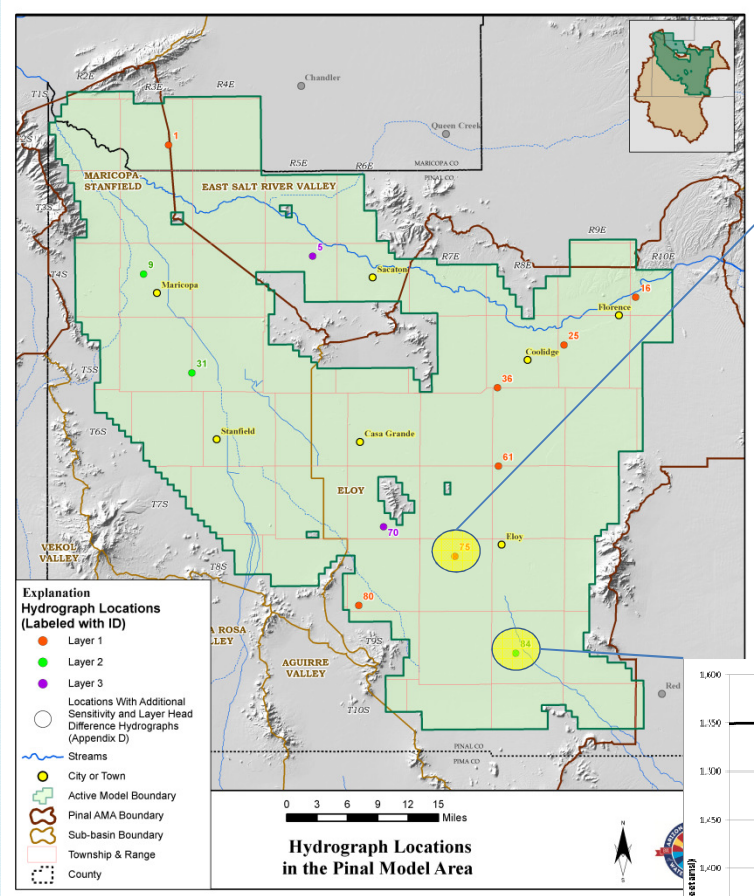
H70: Eloy Sub-basin
Non-District Area About 10 Miles SSW of Casa Grande Mtn.

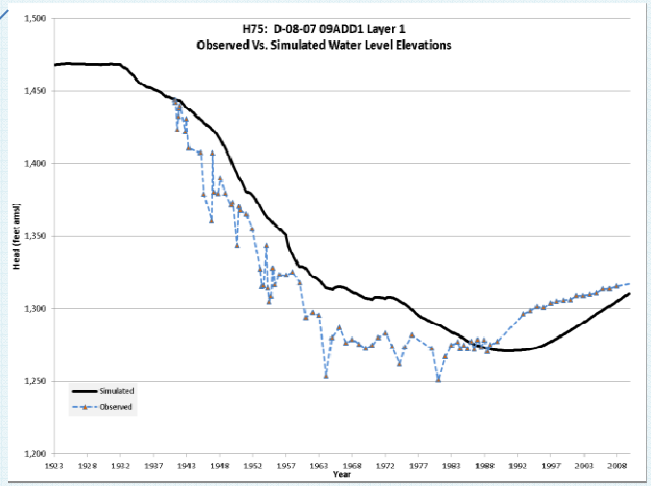
H80: Eloy Sub-basin
H84: Eloy Sub-basin
Non-District Area About 10 Miles SSW of Casa Grande Mtn.

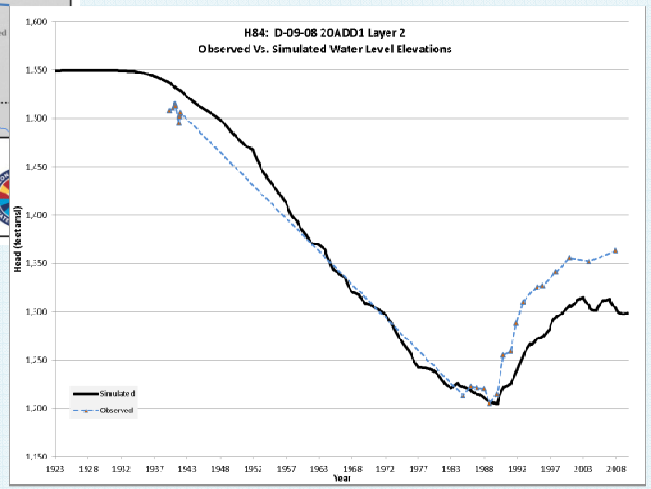
H75: Eloy Sub-basin
CAIDD Area, 2 Miles SE of Eloy



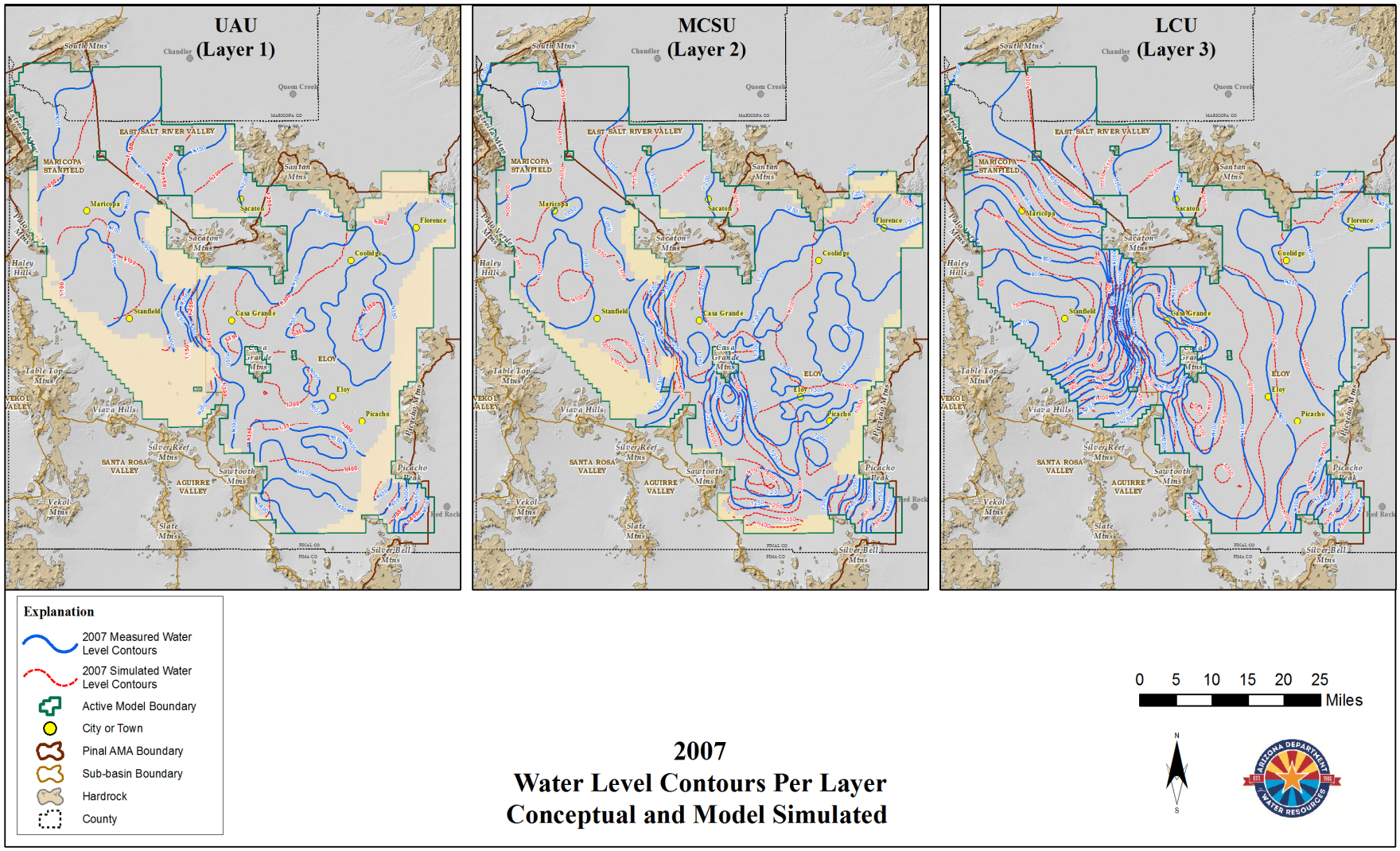
Southern Part of Eloy Sub-Basin Hydrographs



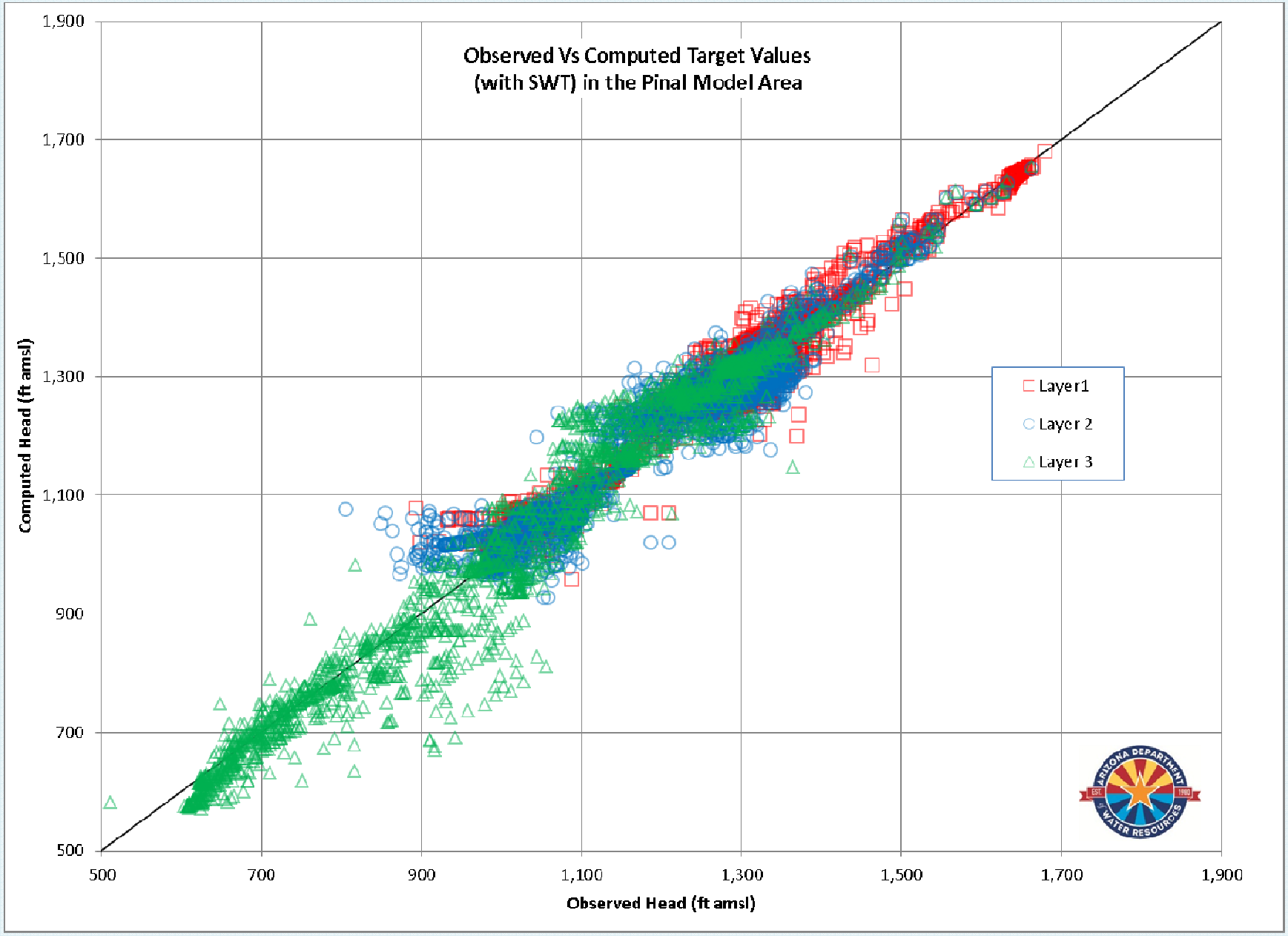




The Model Simulates the Complexities of Today's Hydrologic System



2007
Water Level Contours Per Layer
Conceptual and Model Simulated


Observed Vs Computed Target Values
(with SWT) in the Pinal Model Area
Computed Head (ft amsl)
Observed Head (ft amsl)
1,900
1,700
1,500
1,300
1,100
900
700
500
500
700
900
1,100
1,300
1,500
1,700
1,900
Layer1
Layer 2
Layer 3

Model Error Analysis Statistics

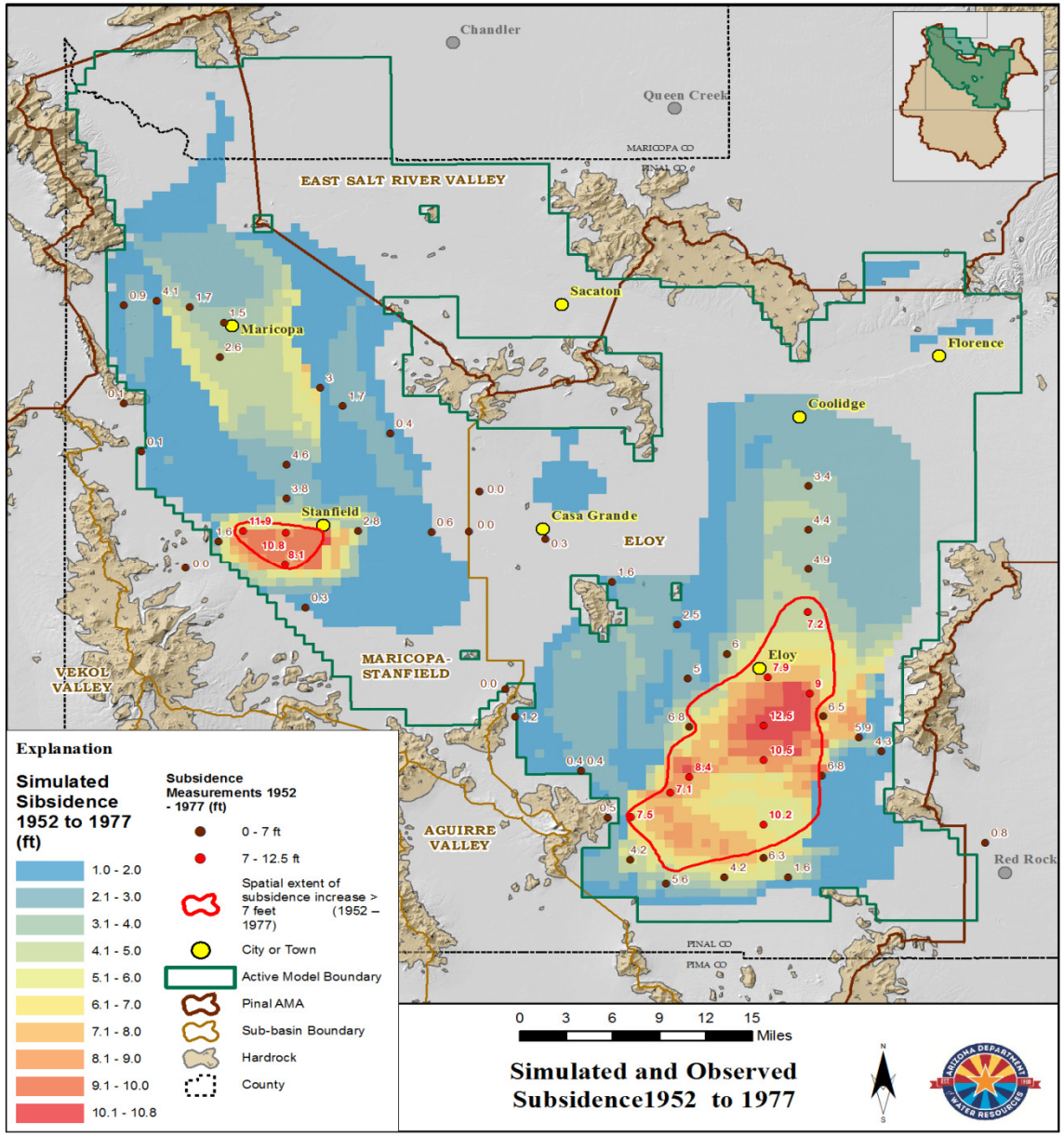
Year	Stress Period	Number of Targets (ft)	Mean Error (ME) (ft)	Absolute Mean Error (MAE) (ft)	Standard Deviation (ft)	Minimum Residual (ft)	Maximum Residual (ft)	Root Mean Squared Error (RMSE) (ft)	RMSE as % of Total Head Change
Steady-state	1	243	4.8	8.3	11.1	-33.2	47.9	12.1	1.86%
1941	20	100	0.3	11.3	15.4	-33.4	40.4	15.4	2.83%
1952	31	143	-2.5	20.6	24.9	-54.4	79.5	25.0	4.21%
1963	42	283	-33.5	45.4	45.0	-203.4	107.5	56.1	6.97%
1976	55	152	-5.9	47.3	66.6	-272.5	223.0	66.6	7.06%
1984	63	1,561	-10.4	28.7	38.7	-184.8	189.3	40.1	4.05%
1988	67	840	0.1	35.0	48.0	-215.5	252.2	48.0	4.96%
2007	86	1,244	5.1	26.1	32.6	-107.3	166.1	33.0	3.68%
All Targets	1 ~ 88	8,031	-3.1	29.3	40.8	-272.5	252.2	40.9	3.69%

Note:

1. Head Residual = Observed Head –Model Simulated Head

2. All targets include the targets used for the selected calibration periods and the additional targets used for hydrographs in between the calibration years.

The Model Simulates the Areas of Historic Land Subsidence



- Historical Subsidence Vs. Model Simulated Subsidence.
- Good Job Modeling-Most Severe (red tones) coincide with largest measured subsidence.
- Simulation of Subsidence extend to the end of simulation (2009)

Model Projections for the 4th Management Plan

- Updated Model Pumping & Recharge through 2014.
- Will be adding projections for 2015 – 2040 based on anticipated volumes from Water Management, based on input from the GUAC, irrigation Districts and GRIC
  - What are the anticipated demands?
  - What percentage of the demands will be met with groundwater?

?

  - Plan to input a 'most likely' and a 'shortage' scenario into the Pinal Model to obtain anticipated
    - Water Level Elevations/Depths to Water
    - Changes in aquifer storage
    - Subsidence

Recommendations On Future Data Collection, Model Updates and Calibrations

1. **Use Updated MODFLOW Versions and More Advanced Packages and Improved Settings**
   - Utilize the latest USGS Subsidence Package
   - Possible use of new versions of MODFLOW, Solvers, more refined grids, etc.
   - Continue to Improve Model Calibration, especially in In Areas of Significant Vertical Hydraulic Gradient.
   - Improve simulation by possibly using multi-node well package (MNW) for dynamic layer specific withdrawals and the Unsaturated Zone Flow (UZF) to better simulate recharge lag time.
   - Fine tune solver settings to assure optimal mass balance and model error

2. **Continue to support ADWR's Geophysics/Surveying Unit**
   - Collect Land Subsidence Data And Analyze Using Interferometric Synthetic Aperture Radar (INSAR)
   - Conduct Periodic Microgravity Measurements For Aquifer Storage Monitoring in coordination with USGS

3. **Maintain Current GWSI Annual "Index" Line WL Measurements. Conduct Periodic WL "Sweeps"**

4. **Update Model Pumping and Recharge Data At Least Every 5 Years (Done for 4MP!)**
   (RoGR Information from Annual Reports & Data from GRIC, SCIP and Ak-Chin)

CONCLUSIONS

- The model update has been successful in accomplishing major goals and objectives

- The model is acceptably calibrated in most areas for most purposes. However, potential uses of the model should be evaluated before the model is determined to be appropriate “as-is” for any specific use

- The model should be very useful for scenario development and testing future water management strategies, as we’ve done for the AWS and are doing with the 4MP.

- The model is a major repository of hydrologic , geologic and water use data, and can serve as a source of valuable information for many related hydrogeologic studies

The Model & Report was finalized in February 2014. ADWR Model Report No. 26, available on ADWR's website here (AZWater.gov > Divisions> Hydrology>Groundwater Modeling>Pinal Homepage:
http://www.azwater.gov/azdwr/Hydrology/Modeling/Pinal_Home.htm

Questions, please contact

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602-771-8415