Culberson County Groundwater Conservation District Management Plan
April 19, 2000 - April 18, 2010
Revised by Board of Directors September 24, 2007

District Mission

The Culberson County Groundwater Conservation District will strive to develop, promote, and implement water conservation and management strategies to protect water resources for the preservation of the groundwater reservoirs over which the District has jurisdiction. The District will implement water strategies to prevent the extreme decline of water levels for the benefit of all water right owners, the economy, our citizens, and the environment of the territory inside the District.

Time Period for this Plan

This plan becomes effective upon adoption by the District Board of Directors and remains in effect until a revised plan is adopted or 2010, whichever is earlier.

Statement of Guiding Principles

The guiding principles in developing this management plan are to better understand the groundwater conditions, to encourage the most efficient use of groundwater, to preserve and improve groundwater quality, to increase public awareness and education, and to monitor legislative activities along with rules and orders of state agencies and the Regional Planning Group which may affect the private ownership of groundwater including the authority to manage at a local level.

The District is taking into consideration the 2007 State Water Plan in trying to assess our future water needs. The District has looked at the recommended water management strategies and cost, the ongoing issues and the select policy recommendations. We know that our water needs are expected to grow, with irrigation again making up the largest share of the needs, and that we will need to work closely with the groundwater area councils and the planning group, to ensure through the use of managed depletion the sustainable use of the local groundwater. (Please refer to pages 12-21 for GAM Run 06-03)

The District acknowledges the groundwater resources of the region are of vital importance to all citizens. The District recognizes the private ownership of land, as well as the private ownership and rights of groundwater percolating below and emphasize that nothing in the Texas Water Code shall be construed as depriving or divesting the owners their ownership rights, subject to implantation and rules promulgated by the Culberson County GCD.

The District seeks to protect the private property rights of all water rights holders, whatever group they may represent. The District upholds the private property rights of the owner to capture water from that part of the aquifer, which the landowner obtained at the time of purchase of the land surface. **The water must be used for beneficial purposes and without waste.** The aim of the District is to ensure that all water rights owners are entitled to an equal opportunity to use the groundwater beneath their land. In this pursuit, the District may require, through due process, production limitations to eliminate or reduce aquifer mining. The District asserts that all water users within the District shall be treated fairly and equally.

The District believes our most valuable natural resource water can be managed at the local level in a prudent and cost effective manner by regulating the spacing of wells and monitoring production from those wells. The administrative process of permitting and well registration are the tools necessary to facilitate the Districts capability to manage groundwater resources.

The District is continually searching for better methods of understanding the local conditions of the West Texas Bolsons (Wild Horse, Michigan Flat, and Lobo Valley Aquifers), the Capitan Reef Complex, and the Edwards-Trinity Aquifer. An accurate understanding of the aquifers and their hydrogeologic properties, as well as a quantification of resources is the foundation from which to build and maintain sound planning measures. The District Management Plan is intended as a tool to focus on thoughts and actions of those given the responsibility for the execution and performance of the District functions and activities. This plan is the guideline for the operation of the Culberson County Groundwater District.

General Description

The people of Culberson County created the District on May 2, 1998 through a local election. The District boundaries cover, more or less, the southwestern half of the county. (Please refer to the map for the exact boundaries) Current board members include Edwin Easley, chairman; Don Collins, vice-chairman; Kyle Brookshier secretary/treasurer; Howard Shelly and Vance Cottrell, John T. Jones serves as the District's manager under chapter 36.056(c) of the Texas Water Code.

The county's economy is dominated by agriculture, with farming and ranching enterprises. Farming includes pecan, alfalfa, and some specialty crops such as pumpkins, dill, and potatoes. Tourism and hunting contribute to the economy. Marble and talc mines are important to the economy as well.

Location and Extent

The District covers 1,077,638 acres or 1,673 square miles. The population of the District is approximately 2,500 citizens. Within the District is Van Horn, the county seat of Culberson County. There are no other communities within the District. Portions of the Sierra Diablo Wildlife Management Area (TPWD) are located on the western edge of the District. (Refer to the map at the end of the plan)

Irrigation areas include the Wild Horse Valley, Lobo Valley, and a small amount of irrigation in the Michigan Flat area. There are approximately 39,386.3 acres of cropland that can be irrigated (according to Farm Service Agency, 1999 data, El Paso office). The remainder of the land is classified as rangeland.

Topography

Culberson County is located in the mountains of West Texas. The District has within its boundaries the Delaware, Sierra Diablo, Apache, Beach, and Wylie Mountain Ranges. Elevations range from 4,000 to 5,800 feet above mean sea level. Interspersed between mountain ranges are the farming areas, with the Wild Horse area being to the southwest of the Delaware and Apache Mountains, and the Lobo Area being to the west of the Wylie Mountains. The District is within the Rio Grande River Basin, with some alluvial drainage to the river and some drainage going northwest into the Salt Basin.

Groundwater Usage in Culberson County

There are five distinct aquifers located within the District, with an additional aquifer located outside of the District but within the county. In the past, annual groundwater usage has varied from a high of 27,138 acre/feet to a low of 8,648 acre/feet. Annual usage for 1990 through 2003 is as follows:

1990	-	12,674 ac/feet
1991	-	12,271
1992	-	13,505
1993	-	8,736
1994	-	8,810
1995	-	8,968
1996	-	9,404
1997	-	9,886
1998	-	14,241
1999	-	15,372
2000	-	27,138
2001	-	19,128
2002	-	24,364
2003	-	24,485

This data obtained from the Texas Water Development Board, Water Resources Planning Division. The District is concerned that the irrigation data has been underestimated. The District has received the cooperation from local farmers in sharing their pumping data. In the future, and with anticipated additional data, the Board of Directors would like to address this issue.

Surface Water Resources

There is no surface water in Culberson County.

Transfer of Water Out of the District

Currently the town of Sierra Blanca imports 351 acre/feet per year from the City of Van Horn. This contract is administered by the City of Van Horn.

Current and Projected Supplies of Groundwater in Culberson County

The following data is the projected supplies of water for the various aquifers in Culberson County in the year 2050, assuming a drought of record condition.

Edwards-Trinity:

Year 2000:
266,000 ac/ft in storage, most being Freshwater (less than 1,000 mg/l TDS)

Year 2050:
266,000 ac/ft in storage, most being Freshwater (less than 1,000 mg/l TDS)
Data obtained from LBG-Guyton & Associates
Chapter 3, Proposed Regional Water Plan

Salt Basin:

Year 2000:
3,700,000 ac/ft in storage, slightly to very saline (850 - 3,000 mg/l TDS)

Year 2050:
3,700,000 ac/ft in storage, slightly to very saline (850 - 3,000 mg/l TDS)
Data obtained from Dr. Robert I Coward, geologist
Water Works, Inc., Santa Fe, New Mexico

Capitan Reef Complex:

Year 2000:
383,000 ac/ft in storage, (fresh and saline mixed)

Year 2050:
383,000 ac/ft in storage, (fresh and saline mixed)
Data obtained from LBG-Guyton & Associates
Chapter 3, Proposed Regional Water Plan

West Texas Bolsons - Wild Horse and Michigan Flat:

Year 2000:
1,365,000 ac/ft in storage, Freshwater in Wild Horse
315,000 ac/ft in storage, Freshwater in Michigan Flat
Subtotal Freshwater: 1,680,000 acre feet in storage

1,050,000 ac/ft in storage, Slightly Saline in Wild Horse
105,000 ac/ft in storage, Slightly Saline in Michigan Flat
Subtotal Slightly Saline : 1,155,000 acre feet in storage

Year 2050:
1,365,000 ac/ft in storage, Freshwater in Wild Horse
315,000 ac/ft in storage, Freshwater in Michigan Flat
Subtotal Freshwater: 1,680,000 acre feet in storage

1,050,000 ac/ft in storage, Slightly Saline in Wild Horse
105,000 ac/ft in storage, Slightly Saline in Michigan Flat
Subtotal Slightly Saline: 1,155,000 acre feet in storage

Data obtained from Dr. Robert I. Coward, geologist
Water Works, Inc., Santa Fe, New Mexico

West Texas Bolsons - Lobo Valley:

Year 2000:

746,000 ac/ft in storage, most being Freshwater

Year 2050:

703,000 ac/ft in storage, most being Freshwater

Data obtained from LBG-Guyton & Associates
Chapter 3, Regional Water Plan

TOTAL OF ALL GROUNDWATER SUPPLIES (Year 2050)

FRESHWATER- 3,075,000 ACRE / FEET

SLIGHTLY SALINE TO SALINE - 4,855,000 ACRE / FEET

2007 State Water Plan Projected Water Demands/ Culberson County

RWPG Water User Group	County	River Basin	2000	2010	2020	2030	2040	2050	2060
E Van Horn	Culberson	Rio Grande	758	854	916	944	953	953	953
E County Other*	Culberson	Rio Grande	68	76	82	84	85	85	85
E Mining*	Culberson	Rio Grande	1,380	1,514	1,560	1,577	1,594	1,610	1,632
E Irrigation*	Culberson	Rio Grande	29,593	28,960	28,340	27,733	27,140	26,559	25,991
Livestock*	Culberson	Rio Grande	344	344	344	344	344	344	344
Total Projected Water Demands (acre feet per year			32,143	31,748	31,242	30,682	30,116	29,551	29,005

Projected Demands for Groundwater within Culberson County GCD

The projected demand surpluses for the Culberson County GCD are summarized in the table below. This data was obtained from the Proposed Region E - Far West Texas Plan, Chapter 4, developed by LBG-Guyton & Associates.

Water User Group	Year 2050 Surplus
1. City of Van Horn	1,074 ac/ft - no shortage
2. County - other, domestic	28 ac/ft - no shortage
3. Mining	2,073 ac/ft - no shortage
4. Irrigation	2,386 ac/ft - no shortage
5. Livestock	146 ac/ft - no shortage
Total Demands in Year 2050	**5,707 ac/ft - no shortage**

Natural Recharge in the District

The recharge occurring in the Culberson County GCD is estimated in the table below. This information is obtained from John Shoemaker & Associates (Hydrogeologic Analysis and Groundwater Flow Model of the Wild Horse Flat area Culberson County, August 31, 2001, available at the district office). **There is no recharge assumed in drought years.**

Lobo Valley	5,648 ac/ft per year assuming average rainfall of 11 inches
Wild Horse & Michigan Flat	7,844 c/ft per year assuming average rainfall of 11 inches
Edwards-Trinity	1,800 ac/ft per year assuming average rainfall of 10 inches
Capitan Reef Complex	12,500 ac/ft per year assuming average rainfall of 14 in.

Annual Volume of Flow, Recharge and Discharge to the District

The GAM results for flow within and between aquifers, recharge from precipitation, and discharge from the aquifer to the surface for the Culberson County GCD are listed in Tables 1, 2, and 3 in Appendix A. The data provided are for the Salt Basin Bolson Aquifers and the Igneous Aquifer.

Additional Amount of Natural / Artificial Recharge That Could Feasibly Be Achieved

The additional amount of natural or artificial recharge that could be realized from implementation of feasible weather modifications would be an 8% increase in rainfall. This could result in a 1,500 acre feet increase in recharge, assuming average or above average natural rainfall. This data was obtained from the direct gathering of evidence of the High Plains Water District of their weather modification program.

Management of Groundwater Supplies

The District will establish and maintain an observation network in order to monitor changing storage conditions of groundwater supplies within the District. By collecting and assimilating this data, the District will manage the supply of groundwater in order to conserve the resource while seeking to maintain the economic viability of all the resource user groups, public and private. In consideration of economic and cultural activities occurring within the District, the District will identify and engage in such activities and practices, that if implemented, would result in a reduction of groundwater use. The District will make regular assessments of wells within the monitoring network and will report those conditions to the Board of Directors. This District will undertake, as necessary, and co-operate with investigations of groundwater resources within the district and will make the results of those investigations available to the public upon adoption by the board.

The District has rules to regulate groundwater withdrawal by means of spacing regulations and production limitations within designated Production Use Measurement Areas (Rule 13.2) Extreme Decline Study Areas (Rule 13.1) will be used if the regular monitoring assessment indicates an extreme decline in the aquifer is occurring. Information currently available to the Board indicates that future demands will be well within the ability of the groundwater resources to supply; however, measures within the rules are in place to prevent over-mining and degradation of the aquifer.

The District may deny a well construction permit or limit a high production permit in accordance with the rules in the District. In making a determination to deny a permit or limit production withdrawals from a high production well, the district will consider public benefit against individual hardship after considering all testimony.

The relevant factors to be considered in making a determination to deny a permit or limit groundwater withdrawals include:

1) The purpose of the rules of the District
2) The equitable distribution of resources
3) The economic hardship resulting from grant or denial of a permit of the terms prescribed by the permit

In pursuit of the District mission to enable all water rights holders to have equal access to the groundwater under their land, the District may require reduction or limitation of groundwater withdrawal to amounts that will not cause detrimental mining of the aquifer. To achieve this purpose, the District may, at the Board's discretion, amend or revoke any permit after notice and hearing. The determination to seek the amendment or revocation of a permit by the District will be based upon aquifer conditions observed by the District through the Extreme Decline Study Area Process. The District will enforce the terms and conditions of permits and the rules of the District by enjoining the permit holder in a court of competent jurisdiction as provided for in TWC 36.102.

Actions, Procedures, Performance and Avoidance for Plan Implementation

The District will implement the provisions of this plan and will utilize the provision of this plan as a guidepost for determining the direction or priority for all District activities. All operations of the District, all agreements entered into by the District and any additional planning efforts in which the District may participate will be consistent with the provisions of this plan.

The District will adopt rules relating to the permitting of wells and production of groundwater. The rules adopted by the District shall be pursuant to TWC 36 and the provisions of this plan. All rules will be adhered to and enforced. The promulgation and enforcement of the rules will be based upon the best technical evidence available.

The District shall treat citizens with equality. Citizens may apply to the District for discretion in enforcement of the rules on the grounds of adverse economic effects or unique local conditions. In granting of discretion of any rule, the Board shall consider the potential for adverse affects on adjacent landowners. The exercise of said discretion by the Board shall not be construed as limiting the power of the Board.

The District will seek the cooperation in the implementation of the plan and management of groundwater supplies within the District. All activities of the District will be undertaken in co-operation and coordinated with the appropriate state, regional or local water management entity.

The methodology that the District will use to trace its progress on an annual basis in achieving all of its management goals will be as follows:

The District manager will prepare and present an annual report to the Board of Directors on District performance in regards to achieving management goals and objectives (during the last monthly Board of Directors meeting each fiscal year, beginning with Nov., 2002). The report will include the number of instances each activity was engaged in during the year, referenced to the expenditure of staff time and budget so that the effectiveness and efficiency of each activity may be evaluated.

The annual report will be maintained on file at the District office.

Goals, Management Objectives, and Performance Standards

Goal 1.0 **Implement a system to improve the basic understanding of groundwater conditions in the District**

Management Objective:

1.1 Annually, obtain all the new information Water Resource agencies have on Culberson County wells

Performance Standard:

1.1a - Annually, report to the Board of Directors on the number of requests made for information requested and received

Management Objective:

1.2 Strive to obtain 3 additional observation wells yearly

Performance Standard

1.2a - Report to the Board of Directors annually on all new observation wells by aquifer

Management Objective:

1.3 Drill or obtain one to three monitoring wells in each aquifer by the year 2008

Performance Standard

1.3a - Report to the board annually on monitor wells obtained either through the used of abandoned wells or drilling new wells

Management Objective:

1.4 Determine the location of all newly permitted wells on a district map, and establish a procedure to map 50% of all existing wells by the year 2008

Performance Standard

1.4a - Annually provide a list of all new wells and current well inventory of old wells that have been added

Goal 2.0 **Implement management strategies that will provide for the most efficient use of**
groundwater

Management Objective:

2.1 Disperse educational information at least once yearly regarding the current conservation practices for efficient use of water resources.

Performance Standard:

2.1a Each year, report to the board on the number of articles in the local newspaper pertaining to current conservation practices for efficient use of groundwater

2.1b Report to the board on literature packets handed out.

Management Objective:

2.2 Each year, enforce rules regarding the registration for all new wells and the Permitting of production wells

Performance Standard:

2.2a - Report to the Board on a monthly basis the number of permits issued and wells registered

2.2b- Monitor a procedure to have non-exempt wells operating under Permits by 2008

Management Objective:
2.3 Each year, require all drillers to submit a drilling log or acceptable alternative for each new well drilled within the District

Performance Standard:
2.3a - Monthly, report to the Board of Director's on the number of driller's records and reports received each month

Management Objective:
2.4 Each month by the year 2004, require well service personnel to provide updated Static levels on all wells serviced in Culberson County GCD.

Performance Standard:
2.4a - Each year, provide a report to the Board indicating the number of letters sent to well service businesses by the year 2004

2.4b - Each year, provide a report to the Board indicating the number of new static levels recorded in the District office by the year 2004

Goal 3.0 Each year strive to prevent the waste of water

Management Objective:
3.1 Investigate all wasteful practices reported within the District

Performance Standard:
3.1a - Annual report to the Board of Directors listing the number of wasteful practices (Reported and Investigated.

Goal 4.0 Minimize the influence of pumping of wells on the degradation of the aquifers by regulating the spacing of wells and by use of a Production Use Measurement Area.

Management Objective:
4.1 Each year enforce all existing rules regulating the spacing of wells

Performance Standard:
4.1a Beginning in November, 2000, determine the percent of wells drilled annually complying with spacing requirements as set forth by the District Rules

4.1b Annually, report to the Board of Directors on the numbers of wells drilled and the percent of wells drilled within compliance of the spacing requirements.

Management Objective:
4.2 Annually, and if appropriate, designate wells that have shown an extreme decline to be placed into an Extreme Decline Study Area (Section 13 of Rules)

Performance Standard:
4.2a Prepare an annual report of all wells that have shown a substantial decline over a three year period

4.2b Maintain a current report at the District office of all EDSA studies

Management Objective:

4.3 If data so indicates, use the EDSA to institute a Production Use Measurement Area to limit groundwater withdrawals from a specific area

Performance Standard:

4.3a Quarterly, supply the Board and the PUMA committee with status reports of any PUMA in the District

Goal 5.0 Minimize the potential for contamination of groundwater by new or existing wells.

Management Objective:

5.1 Each year, enforce rules for the drilling, completing, and equipping of water wells to ensure that all new wells are completed properly to protect the groundwater

Performance Standard:

5.1a By 2008 set up check list to ensure that, 100% of new wells drilled annually are constructed to standards set forth by the TNRCC and District Rules and report annually to the Board

Management Objective

5.2 Each year budget a minimum of $4,000 per year for capping abandoned or unusable wells as a service to landowners

Performance Standard:

5.2a Report the annual number of wells capped by the District

Goal 6.0 Monitor water exported out of the district

Management Objective:

6.1 Each year, monitor the water leaving the district through exportation for the purpose of planning and data inventory

Performance Standard:

6.1a Annually report to the Board the amount of water being exported out of the district

Goal 7.0 Implement management strategies that will address drought conditions.

<u>Management Objectives</u>

7.1 - The District will monitor the Palmer Drought Severity Index (PDSI) by the Texas Climatic Divisions. If the (PDSI) indicates that the District Will experience severe drought conditions, the District will notify all public water suppliers within the District.

<u>Performance Standards</u>

7.1 a – The District staff will monitor the PDSI and report findings and actions to the District Board on a quarterly basis.

Goal 8.0 Implement management strategies that will promote water conservation recharge Enhancement, Rainwater Harvesting, Precipitation Enhancement, or Brush Control, where appropriate and cost effective (Implementing TWC§ 36.1071(a)(7)).

Precipitation enhancement is not an appropriate or cost-effective program for the District

at this time because there is not an existing precipitation enhancement program operating in nearby counties in which the District could participate and shear costs. The cost of operating a single-county precipitation enhancement program is prohibitive and would require the District to increase taxes in Culberson County.

Management Objectives

8.1 Disperse educational information at least once yearly regarding the current conservation efficient use of water resources.

Performance Standard

8.1 a – Each year, report to the Board of Directors the number of water conservation Literature packets handed out.

8.2 Each year, the District will promote rainwater harvesting by posting information on rainwater harvesting on the District web site.

Performance Standard

8.2 a – Each year, the annual report will include a copy of the information on rainwater that is provided on the District web site.

8.3 Each year, the District will provide information relating to recharge enhancement and brush control on the District web site.

Performance Standard

8.3 a – Each year, the District annual report will include a copy of the information that has been provided on the District web site relating to recharge enhancement and brush control.

Goal 9.0 Desired future conditions of Aquifers within the District (50 Years)

Not enough good information available at this time. It is our plan to have completed our studies by the end of 2007 and be able to set our D.F.C. at that time.

SB1 MANAGEMENT GOALS DETERMINED NOT APPLICABLE

Goal 1.0 Control and Prevention of Subsidence

The rigid geologic framework of the region precludes significant subsidence from occurring.

Goal 2.0 Addressing natural resource issues that impact the use and availability of groundwater or that are impacted by the use of groundwater

The District has no documented occurrences of endangered or threatened species dependent upon groundwater resources.

Goal 3.0 Conjunctive Surface Management Issues

There is no surface water in the Culberson County Groundwater Conservation District.

Appendix A.

GAM Run 06-02

by Andrew C. A. Donnelly, P.G.
Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-3132
March 1, 2006

REQUESTOR:

Mr. John Jones on behalf of the Culberson County Groundwater Conservation District (GCD).

DESCRIPTION OF REQUEST:

Mr. Jones requested a Groundwater Availability Model (GAM) run using the GAM for the Igneous and parts of the West Texas Bolsons aquifers. Mr. Jones requested that we determine water budgets in both the Igneous and parts of West Texas Bolsons aquifer.

METHODS:

To determine the water budgets in the Culberson County GCD area, we used the GAM for the Igneous and parts of the West Texas Bolsons aquifers and ran a standard transient calibration-verification model run, which includes the years 1980 to 1999. The portions of the West Texas Bolsons aquifer included in the GAM are Wildhorse Flat, Michigan Flat, Ryan Flat, and Lobo Flat and are locally referred to as being part of the Salt Basin Bolson aquifer. In this report, to avoid confusion with other parts of the West Texas Bolsons aquifer, we refer to the West Texas Bolsons aquifer modeled in this GAM as the Salt Basin Bolson aquifer.

The pumpage that we used in the model run was that which was developed for the transient calibration/verification run, which represents the best estimate of historic pumpage.

PARAMETERS AND ASSUMPTIONS:

- See Beach and others (2004) for assumptions and limitations of the GAM for the Igneous and West Texas Bolsons aquifers.

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the entire GAM for the period of 1990 to 2000 is 64 feet, or four percent of the range of measured water levels (Beach and others, 2004).

- The model includes three layers, representing the Salt Basin Bolson aquifer (Layer 1), the Igneous aquifer (Layer 2), and the underlying Cretaceous and Permian units (Layer 3).

- We simulated a 51-year time period for the model run, representing 1950 to 2000.

- We used all of the input parameters for the model, including pumpage and recharge, determined through the calibration of the transient model covering the years 1950 to 2000.

- The GAM uses drains to simulate discharge to streams. Drains are included in both the Salt Basin Bolson aquifer and Igneous aquifer layers of the model.

- The GAM uses general-head boundaries (GHB) to simulate cross-formational flow into and out of layer 3, which represents the Cretaceous and Permian units underlying the Igneous aquifer.

- The GAM uses the MODFLOW evapotranspiration package (ET) to simulate discharge of water to evaporation and transpiration.

- The GAM includes pumpage representing rural domestic, municipal, industrial, irrigation, and livestock uses.

RESULTS:

Water budgets for the district area for the Salt Basin Bolson and Igneous aquifers are presented in Tables 1 and 2, respectively. This table shows the average annual flow, in acre-feet, of water into (Inflow) and out of (Outflow) each aquifer in the Culberson County GCD area for the years 1980 to 1999. The components of the budgets shown in Table 1 include:

- Storage—This component is water stored in the aquifer. The storage component that is included in "Inflow" is water that is removed from storage in the aquifer (that is, water levels decline). The storage component that is included in "Outflow" is water that is added back into storage in the aquifer (that is, water levels increase). This component of the budget is often seen as water both going into and out of the aquifer because this is a county-wide budget, and water levels will decline in some areas (water is being removed from storage) and will rise in others (water is being added to storage).

- Wells—This is water produced from wells in each aquifer. In the GAM for the Igneous and parts of the West Texas Bolsons aquifers, this component is always shown as "Outflow" from an aquifer, because all wells included in the GAM produce (rather than inject) water. Wells are modeled in the GAM for the Igneous and parts of the West Texas Bolsons aquifers using the MODFLOW Well package.

- Streams and springs—This is water that drains from an aquifer if water levels are above the elevation of the spring or seep. This component is always shown as "Outflow", or discharge, from an aquifer. The loss of groundwater to streams and springs is modeled in the GAM for the Igneous and parts of the West Texas Bolsons aquifers using the MODFLOW Drain package.

- Recharge—This component normally simulates a really distributed recharge due to precipitation falling on the outcrop areas of aquifers. However, in the GAM for the Igneous and parts of the West Texas Bolsons aquifers, the recharge package also includes recharge from alluvial fans and stream beds which occurs along the mountain fronts in discrete locations. Recharge is always shown as "Inflow" into an aquifer and is modeled in the GAM for the Igneous and parts of the West Texas Bolsons aquifer using the MODFLOW Recharge package. The GAM assumes that precipitation recharge to the Salt Basin Bolson aquifer is zero.

- Evapotranspiration—This is water that flows out of an aquifer due to direct evaporation and plant transpiration. This component of the budget will always be shown as "Outflow". Evapotranspiration is modeled in the GAM for the Igneous and parts of the West Texas Bolsons aquifers using the MODFLOW Evapotranspiration (EVT) package.

- Vertical flow between aquifers—This describes the vertical flow, or leakage, between two aquifers. This flow is controlled by the water levels in each aquifer and aquifer properties of each aquifer that define the amount of leakage that can occur. "Inflow" to an aquifer from an overlying or underlying aquifer will always equal the "Outflow" from the other aquifer.

- Lateral flow between counties—This component describes lateral flow within the aquifer between Culberson and adjacent counties.

It is important to note that sub-regional water budgets for individual areas, such as the Culberson County GCD area, are not exact. This is due to the one-half mile spacing of the model grid and because we assumed each model cell is assigned to a single county. The water budgets for an individual cell containing a county boundary are assigned to either one county or the other and therefore very minor variations in the county-wide budgets may be observed.

Overall average annual water budgets for precipitation recharge, average surface water inflow, average surface water outflow, average inflow into the district, average outflow from the district, average net interaquifer flow (upper), and average interaquifer flow (lower) are presented in Table 3. This is a summary of the budgets provided in Tables 1 and 2. Please note that in Table 3, negative values indicate a net outflow from that aquifer. Therefore, there is a net outflow from the Igneous aquifer to the aquifer above it of 5,267 acre-feet per year, and a corresponding net inflow of 5,267 acre-feet per year in the Salt Basin Bolson aquifer from the Igneous aquifer below it.

Table 1. Summary of water budgets for the Culberson County GCD area in the Salt Basin Bolson aquifer for 1980 to 1999. Flows reported in acre-feet per year.

	Inflow	Outflow
Storage	5,040	3,090
Wells	0	15,749
Springs and Streams*	0	494
Recharge**	2,109	0
Evapotranspiration	0	0
Vertical flow between Igneous Aquifer	12,979	7,712
Lateral flow into District	6,900	0

*Springs and streams were modeled using the MODFLOW drain package
**Recharge for the Salt Basin Bolson aquifer represents alluvial fan and stream bed recharge only.

Table 2. Summary of water budgets for the Culberson County GCD area in the Igneous aquifer for 1980 to 1999. Flows reported in acre-feet per year.

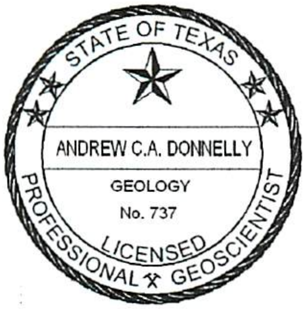
	Inflow	Outflow
Storage	489	14
Wells	0	0
Springs and Streams	0	0
Recharge	903	0
Evapotranspiration	0	449
Vertical flow between Salt Basin Bolson Aquifer	7,712	12,979
Vertical flow between Cretaceous and Permian Aquifers	12,978	9,499
Lateral flow into District	857	0

Table 3. Summary of overall water budgets for the Culberson County GCD area for 1980 to 1999. Flows reported in acre-feet per year.

	Precip-itation Recharge	Average Surface Water Inflow	Average Surface Water Outflow	Average Inflow into District	Average Outflow from District	Average Net Inter-aquifer Flow (upper)	Average net Inter-aquifer Flow (lower)
Salt Basin Bolson Aquifer	0	2,109	0	6,900	0	--	5,267
Igneous Aquifer	903	0	0	857	0	-5,267	3,479

REFERENCES:

Beach, J. A., Ashworth, J. B., Finch, Jr., S. T., Chastain-Howley, A., Calhoun, K., Urbanczyk, K. M., Sharp, J. M., and Olson, J., 2004, Groundwater availability model for the Igneous and parts of the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) aquifers: contract report to the Texas Water Development Board, 208 p.



The seal appearing on this document was authorized by Andrew C.A. Donnelly, P.G. 737, on March 1, 2006.

GAM Run 06-03

by Andrew C. A. Donnelly, P.G.
Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-3132
March 8, 2006

REQUESTOR:

Mr. John Jones on behalf of the Culberson County Groundwater Conservation District (GCD).

DESCRIPTION OF REQUEST:

Mr. Jones requested a Groundwater Availability Model (GAM) run using the GAM for the Igneous and parts of the West Texas Bolsons aquifers. Mr. Jones requested that we evaluate the impact of pumpage on water levels in the West Texas Bolsons aquifer.

METHODS:

To determine the impacts of pumping on water levels in the Culberson County GCD, we used the GAM for the Igneous and parts of the West Texas Bolsons aquifers and increased pumpage to the West Texas Bolsons aquifer incrementally, essentially providing a "sensitivity analysis" of water levels to pumpage. The portions of the West Texas Bolsons aquifer included the GAM are Wildhorse Flat, Michigan Flat, Ryan Flat, and Lobo Flat and are locally referred to as being part of the Salt Basin Bolson aquifer. To avoid confusion with other parts of the West Texas Bolsons aquifer, we refer to the West Texas Bolsons aquifer in this GAM as the Salt Basin Bolson aquifer in this report.

The baseline pumpage that we used in the predictive runs was the year 2000 estimated historic pumpage from the transient calibration/verification run. This year was the last of the historic pumpage estimates and therefore was considered to be the most accurate recent pumpage estimate for the model area. The year 2000 baseline pumpage was repeated for each year in the predictive model runs. We added an additional zero to two acre-feet per acre per year in all of Culberson County to this baseline pumpage for our predictive model runs.

It is important to note that many model cells in the Salt Basin Bolson aquifers contained significant pumpage in the 2000 historic pumpage estimate. When creating uniform pumpage rates for the predictive runs, we only changed the pumpage in a model cell if the existing pumpage was less than the desired uniform pumpage rate. For those cells with higher rates of pumping in the baseline 2000 pumpage data set than what was desired in the model run, the existing pumpage was used.

In these model runs, only the Salt Basin Bolson aquifer was evaluated. This was done for two reasons. First, most of the Igneous aquifer in Culberson County began the predictive model run dry. Second, the 2000 estimated historic pumpage included no pumpage from the Igneous aquifer in Culberson County, and therefore we assumed that this aquifer should not be included in this evaluation.

PARAMETERS AND ASSUMPTIONS:

- See Beach and others (2004) for assumptions and limitations of the GAM for the Igneous and West Texas Bolsons aquifers.
- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the entire GAM for the period of 1990 to 2000 is 64 feet, or four percent of the range of measured water levels (Beach and others, 2004).
- The model includes three layers, representing the Salt Basin Bolson aquifer (Layer 1), the Igneous aquifer (Layer 2), and the underlying Cretaceous and Permian units (Layer 3).
- We simulated a 50-year time period for the predictive model runs.
- We used an average annual recharge based on recharge determined through the calibration of the transient model covering the years 1950 to 2000.
- We used the year 2000 historic pumpage estimate as the baseline pumpage. Pumpage is included in the model for all three layers, although pumpage in Layer 3, representing the underlying Cretaceous and Permian units, is minimal, and no pumpage is present in Culberson County from Layer 3 in the model.
- We added an additional zero to two acre-feet per acre per year to the baseline year 2000 historic estimated pumpage for the Salt Basin Bolson aquifer.
- The GAM uses drains to simulate discharge to streams. Drains are included in both the Salt Basin Bolson aquifer and Igneous aquifer layers of the model. Drain parameters were held at conditions representing the 2000 stress period for the predictive simulations.
- The GAM uses general-head boundaries (GHB) to simulate cross-formational flow into and out of layer 3, which represents the Cretaceous and Permian units underlying the Igneous aquifer. GHB parameters were held at conditions representing the 2000 stress period for the predictive simulations.
- The GAM uses the MODFLOW evapotranspiration package (ET) to simulate discharge of water to evaporation and transpiration. ET parameters were held at conditions representing the 2000 stress period for the predictive simulations.
- The GAM includes pumpage representing rural domestic, municipal, industrial, irrigation, and livestock uses.

RESULTS:

The Salt Basin Bolson aquifer is present in limited extent in Culberson County (Figure 1). Initial (2000) water levels range from approximately 3,860 feet above mean sea level where Ryan Flat crosses the Jeff Davis-Culberson county line to approximately 3,520 feet above mean sea level in the center of Wild Horse Flat (Figure 2). Initial (2000) saturated thicknesses range from zero at the Bolson margins to nearly 1,000 feet in portions of the center of the Bolson (Figure 3). As shown in these figures, portions of the aquifer were dry at the start of all of the predictive model runs (black cells are dry areas). Based on the model-derived specific yield of the Salt Basin Bolson aquifer of six percent, the total groundwater in storage in the aquifer at the start of the predictive model runs is approximately 4,970,000 acre-feet in the Culberson County GCD area.

Table 1 summarizes the pumping rates for the Salt Basin Bolson aquifer with these GAM runs for the Culberson County GCD area. As can be seen in this table, the annual amount of groundwater pumped from the aquifer from the district area in the model runs ranges from more than 30,000 acre-feet per year to the nearly 370,000 acre-feet per year that is currently permitted. It should be noted that 84 percent of the 2000 estimated pumpage is in the Salt Basin Bolson aquifer in Culberson County, and therefore the baseline pumpage value in Table 1 is relatively high.

Table 1. Summary of annual pumpage from the Salt Basin Bolson aquifer in the GAM runs from the Culberson County GCD area (in acre-feet per year)

Pumpage Rate (acre-feet per acre per year)	Total Culberson County GCD Area Pumpage
Baseline 2000 Pumpage Rate	30,283
0.05	38,598
0.10	47,022
0.25	72,293
0.50	114,437
1.0	198,932
2.0	368,154

It is important to note that the volumes in Table 1 are based on the initial (2000) active area in the Salt Basin Bolson aquifer in the predictive runs. This active area decreases (and therefore annual pumpage also decreases) as parts of the aquifer dry up during the model runs. In MODFLOW, when the water level in a model cell falls below the bottom of the cell, the cell goes dry. Because the cell no longer has water in it, MODFLOW turns the cell off. When a cell goes dry, the model is indicating that there is not enough water flowing into the cell (for example, recharge) or there is too much water being removed from the cell (for example, pumping) to keep water in the cell. If pumping is the primary factor, the model is saying that the pumping may be too great for the aquifer in this area.

When MODFLOW shuts a cell off, that cell is off for the rest of the simulation. In reality, the aquifer will probably not go dry because pumping will become uneconomical before the aquifer goes dry in any particular area. However, the GAM is suggesting that these areas may experience water supply problems sometime in the next 50 years.

The impact of pumping at the 2000 estimated pumpage rates over 50 years is shown in Figure 4. This figure indicates that water levels decline approximately 50 feet across the extent of the aquifer from the initial water levels (Figure 2). This is because of the relatively high pumpage included in the Salt Basin Bolson aquifer in Culberson County in the 2000 estimate pumpage, as noted above.

The impact of pumping rates of 0.05, 0.10, 0.25, 0.50, 1.0, and 2.0 acre-feet per acre per year on water levels in the Salt Basin Bolson aquifer after fifty years are shown in Figures 5, 6, 7, 8, 9, and 10, respectively. These figures show that as more water is pumped from the aquifer, water levels steadily decline and the aquifer dries up. The GAM assumes that no recharge occurs to the Salt Basin Bolson aquifer, with the exception of a small amount of recharge through alluvial fan or streambed in limited locations (Beach and others, 2004). Therefore, nearly all of the groundwater being pumped from the Salt Basin Bolson aquifer is being removed from storage. The net inflow of water from the underlying Igneous aquifer is approximately 5,000 acre-feet per year during the transient run for the entire extent of the Salt Basin Bolson aquifer, of which Culberson County comprises approximately half of the active portion in the year 2000 (Beach and others, 2004). As shown in Table 1, the amount of pumpage in most of the model runs is far greater than the amount of water entering the aquifer from the Igneous aquifer, even when taking into account that the net flux of water entering the Salt Basin Bolson aquifer from the underlying Igneous aquifer will increase as water levels decline.

REFERENCES:

Beach, J. A., Ashworth, J. B., Finch, Jr., S. T., Chastain-Howley, A., Calhoun, K., Urbanczyk, K. M., Sharp, J. M., and Olson, J., 2004, Groundwater availability model for the Igneous and parts of the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) aquifers: contract report to the Texas Water Development Board, 208 p.

The seal appearing on this document was authorized by Andrew C.A. Donnelly, P.G. 737, on March 8, 2006.

Figure 1. Extent of the Salt Basin Bolson aquifer in the GAM. Model cells in red are active cells that contain pumpage in 2000. Model cells in white are active cells without pumpage. The actual extent of the Salt Basin Bolson aquifer is shown in tan.

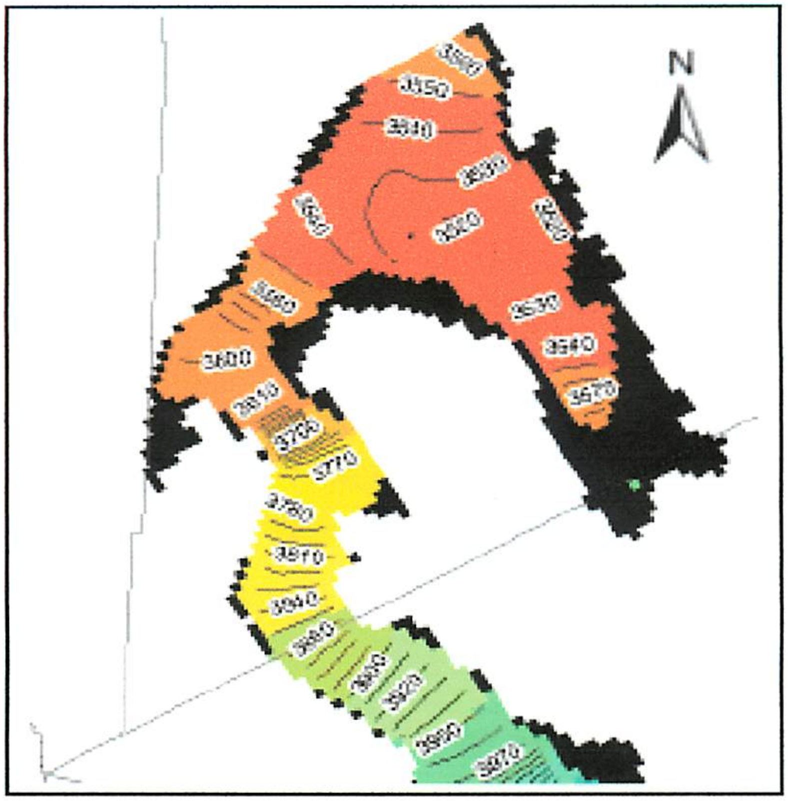


Figure 2. Initial water levels in the Salt Basin Bolson aquifer in the year 2000. Contour interval is 10 feet. Black areas are where the aquifer is dry.

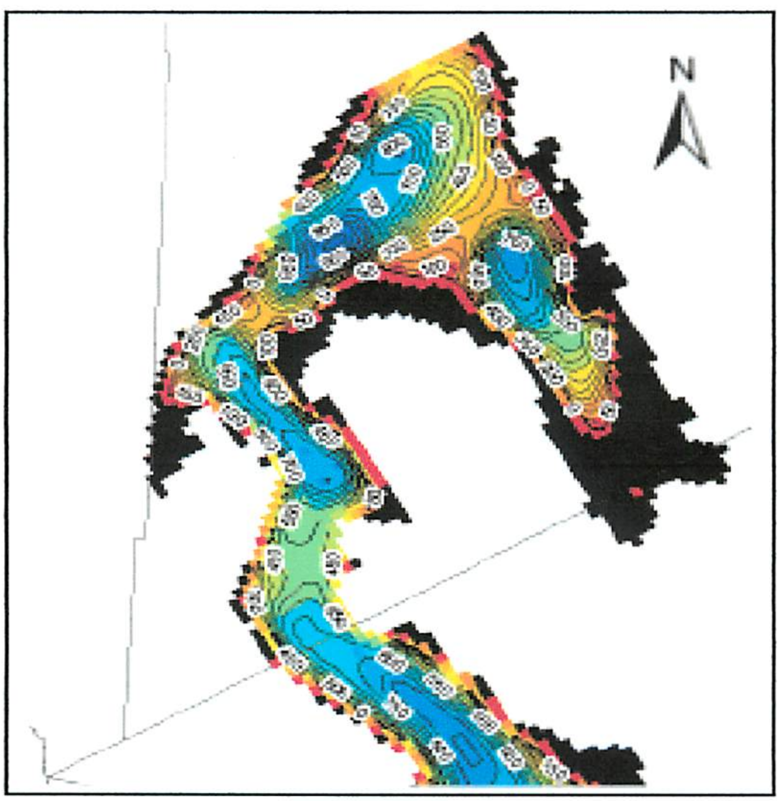
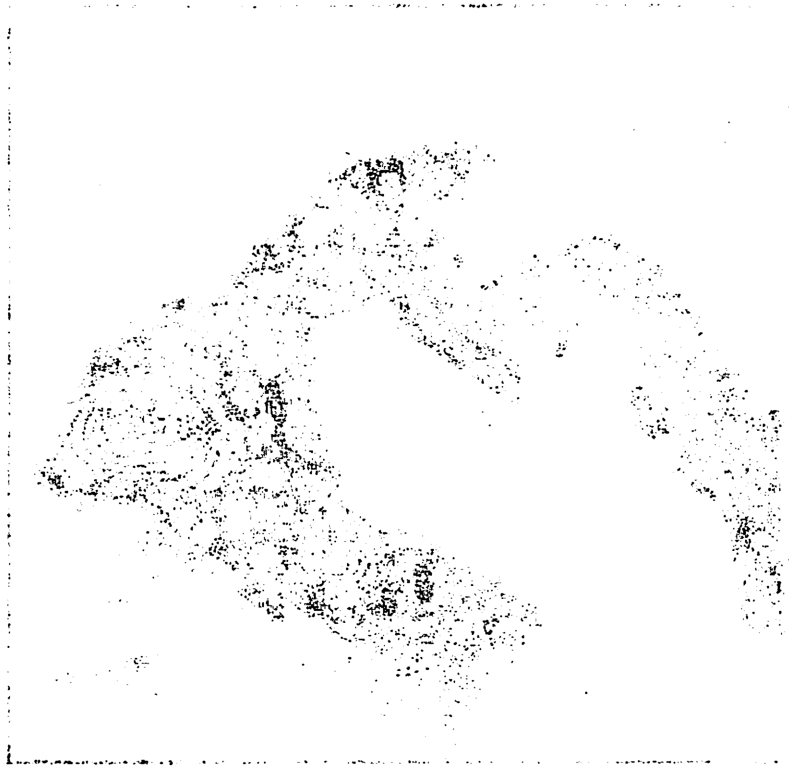


Figure 3. Initial saturated thicknesses in the Salt Basin Bolson aquifer in the year 2000. Contour interval is 50 feet. Black areas are where the aquifer is dry.



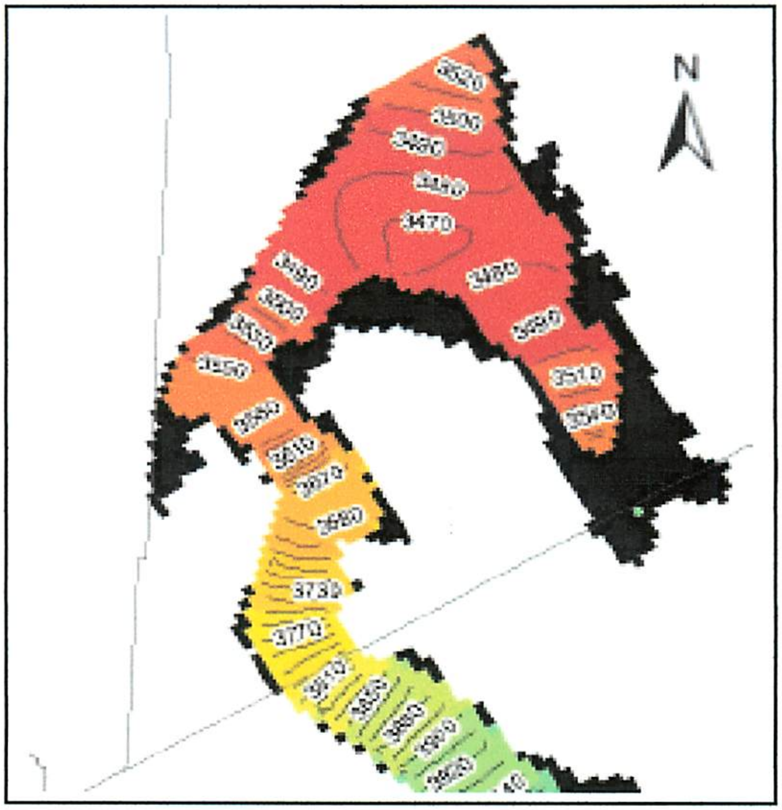


Figure 4. Water levels in the Salt Basin Bolson aquifer after 50 years with the 2000 estimated historic pumpage rate. Contour interval is 10 feet.

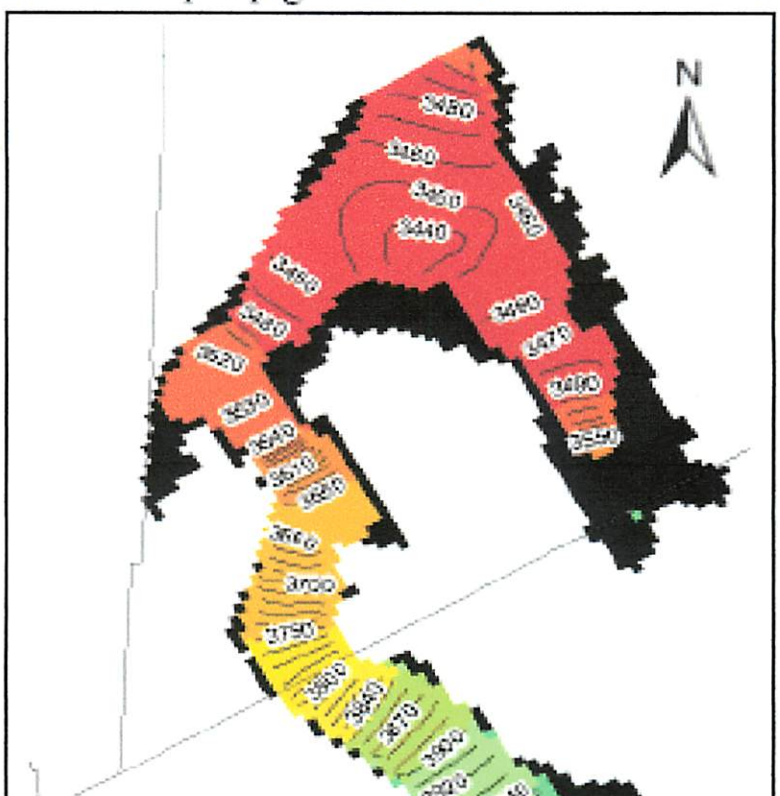


Figure 5. Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 0.05 acre-feet per acre per year. Contour interval is 10 feet.

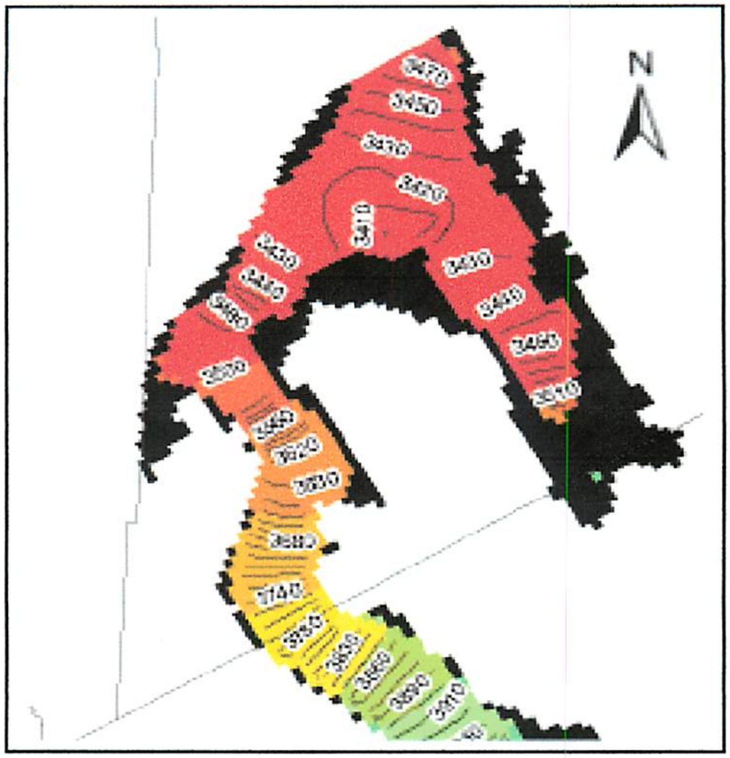


Figure 6. Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 0.10 acre-feet per acre per year. Contour interval is 10 feet.

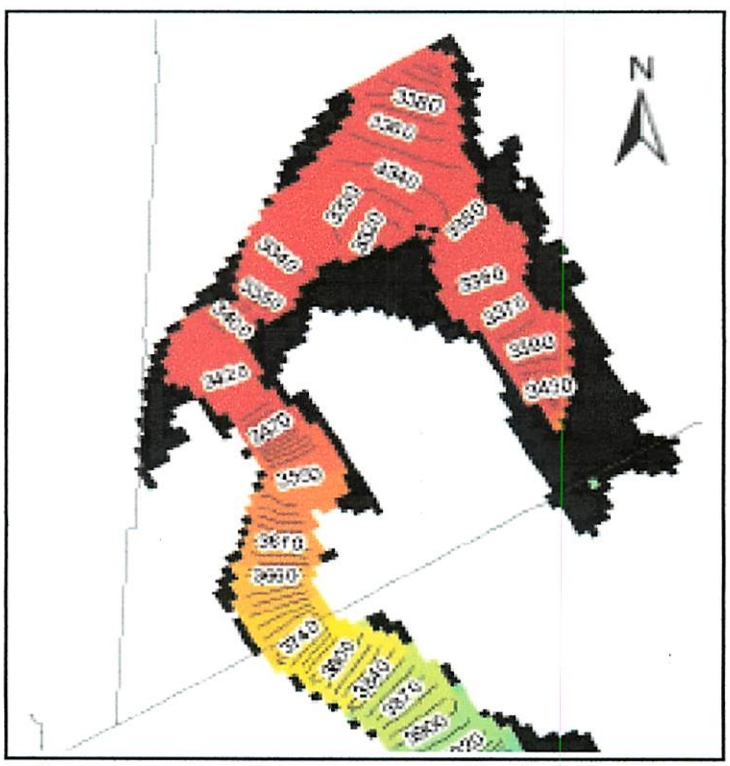


Figure 7. Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 0.25 acre-feet per acre per year. Contour interval is 10 feet.

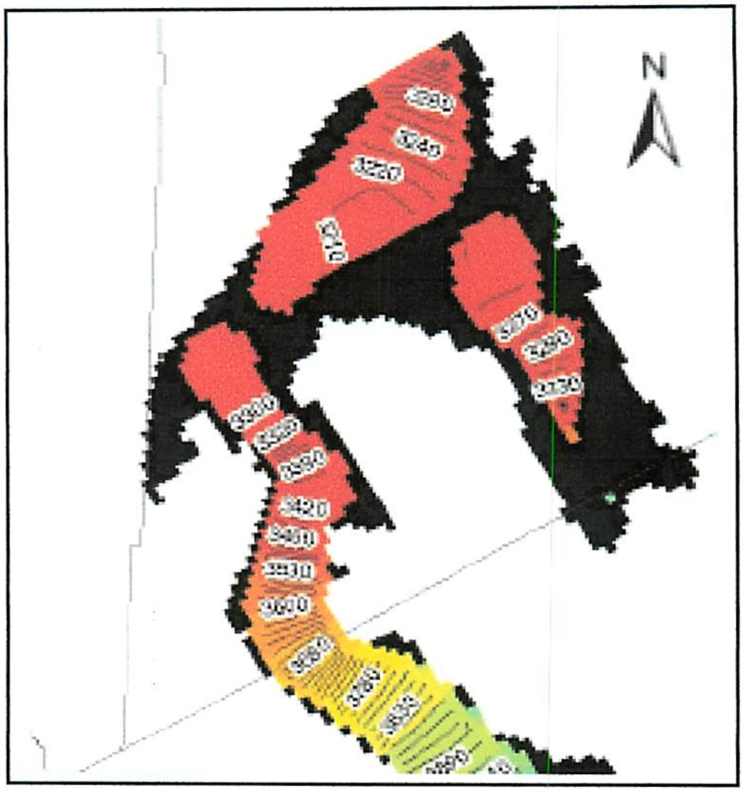


Figure 8. Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 0.50 acre-feet per acre per year. Contour interval is 10 feet.

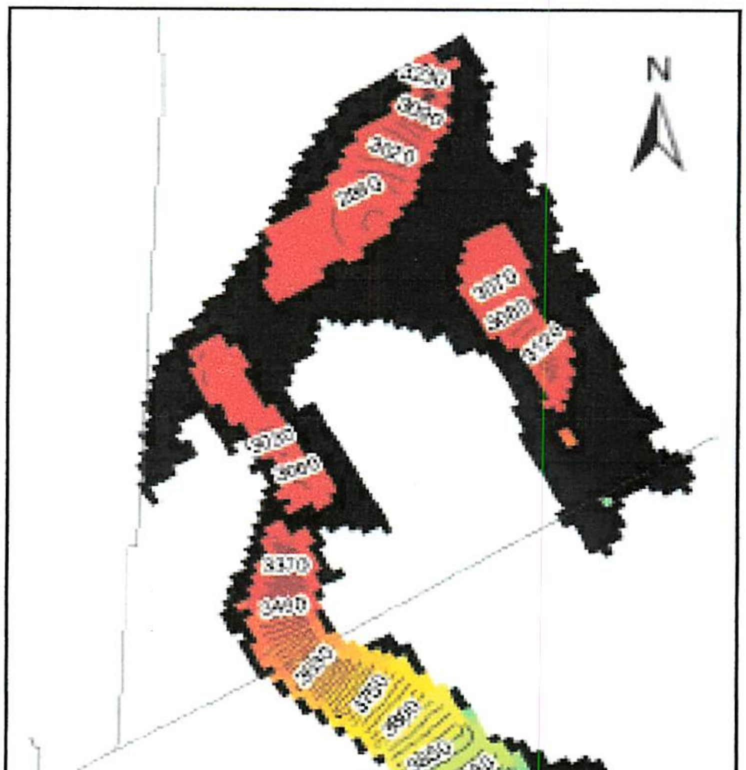


Figure 9. Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 1.0 acre-feet per acre per year. Contour interval is 10 feet.

Figure 10. Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 2.0 acre-feet per acre per year. Contour interval is 10 feet.

GAM Run 06-02 Clarification Memo

by Andrew C. A. Donnelly, P.G.
Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-3132
May 25, 2007

DESCRIPTION OF ORIGINAL REQUEST:

Mr. John Jones requested a groundwater availability model run using the groundwater availability model for the Igneous and parts of the West Texas Bolsons aquifers. Mr. Jones requested that we determine water budgets in both the Igneous and parts of West Texas Bolsons aquifer.

CLARIFICATION:

The original GAM06-02 report placed all of the recharge for Layer 1 (Salt Basin Bolson Aquifer) as surface water inflow, even though it was included in the MODFLOW recharge package. This was based on the assumption that all water included in the model in the recharge package in Layer 1 was from the infiltration of water in alluvial fans and streambeds, as stated in the original model report (Beach and others, 2004). However, the inflow of water through alluvial fans and streambeds in an environment such as Culberson County can also be interpreted to be the immediate result of localized precipitation and, therefore, is precipitation recharge. Therefore, the overall budgets presented in Table 3 of the original report have been updated. The 2,109 acre-feet per year that was previously attributed to surface water inflow in the Salt Basin Bolson Aquifer is now attributed to precipitation recharge. A revised Table 3 is presented below.

Table 3. Summary of overall water budgets for the Culberson County Groundwater Conservation District area for 1980 to 1999. Flows reported in acre-feet per year.

	Precipitation recharge	Average surface water inflow	Average surface water outflow	Average inflow into District	Average outflow from District	Average net interaquifer flow (upper)	Average net interaquifer flow (lower)
Salt Basin Bolson Aquifer	2,109	0	0	6,900	0	--	5,267
Igneous Aquifer	903	0	0	857	0	-5,267	3,479