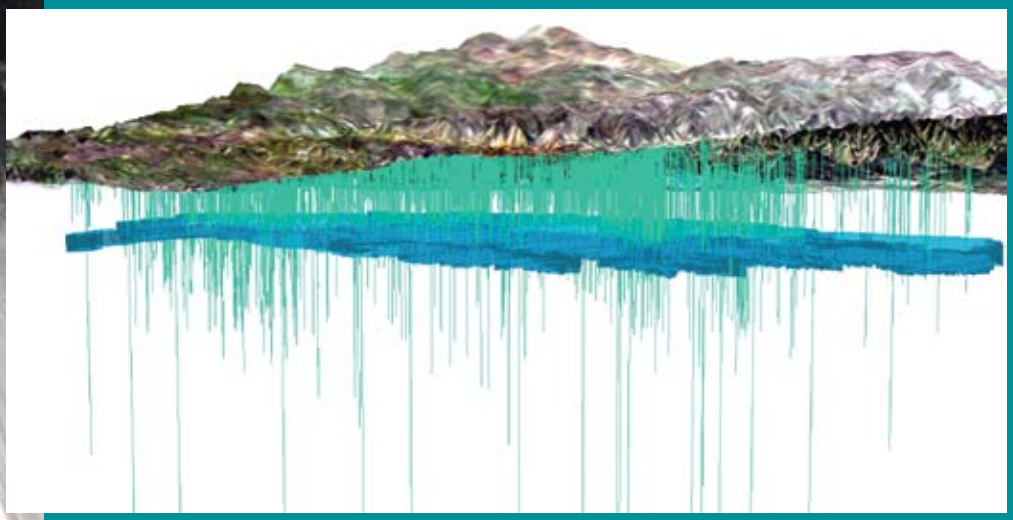
What do Groundwater Users Want?

Desired Future Conditions for Groundwater in the Texas Hill Country



Lyndon B. Johnson School of Public Affairs
The University of Texas at Austin
Policy Research Project Report

161

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What do Groundwater Users Want? Desired Future Conditions for Groundwater in the Texas Hill Country

Project directed by
David Eaton, Ph.D.
Suzanne Schwartz, J.D.
Jack Sharp, Ph.D.

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LBJ School Communications Office

Policy Research Project Participants

Students

Ahmed Abukhater, B.S., Architectural Engineering, University of Gaza, and M.S., Urban and Regional Planning, University of Illinois

Erica Allis, B.S., Geology, The University of Arkansas

Anna Bricker, B.A., Sociology, University of Denver

Brenner Brown, B.A., History, The University of Texas at Austin

Caleb Brown, B.B.A., International Business and B.A., Government, The University of Texas at Austin

Leigh Byford, B.A., Political Science, Trinity University

Michael Ciarleglio, B.S., Mechanical Engineering and Mathematics, Vanderbilt University

Sarah Davidson, B.S., Environmental Geology, Beloit College

Leslie Llado, undergraduate candidate for B.S., Environmental Geology and Hydrogeology, The University of Texas at Austin

Margaret Neill, B.S., Geoscience, Tarleton State University

Robert Ryland, B.A., Theater Production, The University of Texas at Austin

Manami Suga, B.A. and M.A., Economics, Hiroshima University

Anne Mariah Tapp, undergraduate candidate for B.A., Geography, with a minor in Geology, The University of Texas at Austin

Lamar Vieau, B.A., Asian Studies, The University of Texas at Austin

Thomas Wiles, B.A., History, The University of Texas at Austin

Project Co-Directors

Marcel Dulay, P.E., Doctoral Candidate, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin

Rima Petrossian, M.S., P.G., Doctoral Student, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin

Suzanne Pierce, Ph.D., Research Scientist, Sandia National Laboratories

Project Directors

David Eaton, Ph.D., Bess Harris Jones Centennial Professor in Natural Resource Policy Studies, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin

Suzanne Schwartz, J.D., Environmental Program Director, Center for Public Policy Dispute Resolution, The University of Texas at Austin

Jack Sharp, Ph.D., Chevron Centennial Professor, Jackson School of Geosciences, The University of Texas at Austin

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List of Acronyms

CVS	Code repository
DEMs	Digital elevation models
DFCs	Desired future conditions
DG	Data group
DLG	Digital line graphs
DOQ	Digital orthophoto quadrangle
DRGs	Digital raster graphics
GAM	Groundwater availability model
GCD	Groundwater conservation district
GIS	Geographic information systems
GMA	Groundwater management area
GMA 9	Groundwater Management Area Nine
HB	House Bill
HBA	Head and budget aspect
JRE	Java runtime environment
LBJ	Lyndon B. Johnson
MAG	Managed available groundwater
MODFLOW	Modular finite-difference groundwater flow model
NHD	National Hydrography Dataset
NWIS	National Water Information System
PHS	Phase
PRP	Policy Research Project
SG	Stakeholder group

TNRIS	Texas Natural Resource Information System
TWDB	Texas Water Development Board
TXDOT	Texas Department of Transportation
USGS	United States Geological Survey
UT	The University of Texas at Austin
WIID	Water information integration and dissemination system
ZON	Zone

Foreword

The Lyndon B. Johnson School of Public Affairs has established interdisciplinary research on policy problems as the core of its educational program. A major part of this program is the nine-month policy research project, in the course of which two or more faculty members from different disciplines direct the research of ten to thirty graduate students of diverse backgrounds on a policy issue of concern to a government or nonprofit agency. This "client orientation" brings the students face to face with administrators, legislators, and other officials active in the policy process and demonstrates that research in a policy environment demands special talents. It also illuminates the occasional difficulties of relating research findings to the world of political realities.

This policy research project is concerned with groundwater management strategies in Texas and the compliance of groundwater conservation districts (GCDs) and groundwater management areas (GMAs) with the provisions of Texas House Bill 1763. This project examines the process by which Groundwater Management Area 9 is developing its desired future conditions within the Trinity Hill Country Aquifer. The premise of this project is that a GMA can address its desired future conditions based on an effort to identify community preferences and key social and economic concerns of area residents, an assessment of available groundwater data for relevant aquifers, and an evaluation the effects of different water management scenarios to assist the GMA in development of water management practices. This study has sought to assist GMA 9 in its adoption of desired future conditions to meet the needs of its citizens and water users.

The curriculum of the LBJ School is intended not only to develop effective public servants but also to produce research that will enlighten and inform those already engaged in the policy process. The project that resulted in this report has helped to accomplish the first task; it is our hope that the report itself will contribute to the second.

Finally, it should be noted that neither the LBJ School nor The University of Texas at Austin necessarily endorses the views or findings of this report.

James Steinberg
Dean

Acknowledgments and Disclaimer

This project would not have been possible without the support of the Texas Water Development Board, district managers and board members of groundwater conservation districts within Groundwater Management Area Nine (GMA 9), staff of the Sandia National Laboratories, the Center for Public Policy Dispute Resolution (CPPDR) at The University of Texas at Austin (UT), and the Jackson School of Geosciences at UT. This report was drafted as a group effort by students in a Policy Research Project (PRP) on Texas Groundwater Management. Participants included Ahmed Abukhater (one semester), Erica Allis, Anna Bricker, Brenner Brown, Caleb Brown, Leigh Byford, Michael Ciareglio, Sarah Davidson (one semester), Leslie Llado (one semester), Margaret Neill (one semester), Robert Ryland (one semester), Manami Suga, Anne Mariah Tapp (one semester), Lamar Vieau, and Thomas Wiles (one semester). Instructors David Eaton, Suzanne Schwartz, and Jack Sharp, along with the co-instructors Marcel Dulay, Rima Petrossian, and Suzanne Pierce, provided guidance and supervision to the class. David Eaton edited the report.

The PRP research benefited from the advice and guidance from a number of faculty and research staff at UT and professional members of the Texas groundwater management community. Ron Fieseler, General Manager of the Blanco-Pedernales Groundwater Conservation District, provided leadership and direction to the class. He organized the class field trip to GMA 9, scheduled and hosted GMA 9 meetings, and provided both technical and practical guidance on groundwater policy in classroom discussions. Fieseler and his GMA 9 colleagues identified stakeholders and facilitated project stakeholder interviews. The class also thanks Suzanne Schwartz, J.D., Environmental Program Director at the CPPDR of the College of Law at UT, for organizing a conference in October 2006 on the "Decision Making and Cooperative Problem Solving: Making the DFC Process Work for Groundwater Management Areas" and allowing class members to attend. Robert Mace, Ph.D., P.G. of the Texas Water Development Board (TWDB) provided guidance on groundwater management policies and technical assistance with the groundwater availability model (GAM) and MODFLOW. Rima Petrossian, M.S., P.G., of the TWDB advised the class on a weekly basis on groundwater management and policy in Texas. Suzanne Pierce, Ph.D., and Wes Barnes, Ph.D., the Cullen Trust for Higher Education Endowed Professor in Engineering of the Department of Mechanical Engineering, provided technical instruction in modular finite-difference groundwater FLOW model (MODFLOW). Marcel Dulay, M.S., P.E., guided members of the class in the techniques of narrative interviewing and qualitative analysis of interviews.

Speakers from private businesses and state and federal agencies conveyed background information on water policy and groundwater modeling to the PRP class. The class thanks Steve Morton, J.D., and Janessa Glenn, J.D., of Jenkens & Gilchrist, P.C., for information on groundwater policy and law; Tom Lowry, Ph.D., and Vince Tidwell, Ph.D., of Sandia National Laboratories for their technical discussion on groundwater decision support systems and conflict resolution methodologies; and Miguel Pavon, M.S.,

of the Border Information Center of the TWDB for his assistance with geographic information systems (GIS).

This project was supported by a grant from the Texas Water Development Board to the Center for Public Policy Dispute Resolution of the UT College of Law and the LBJ School of Public Affairs at The University of Texas at Austin. A grant from the Sandia National Laboratories of the U.S. Department of Energy to the Environmental Science Institute of UT and to the Digital and Media Collaboratory of the Institute for Innovation, Creativity and Capital (IC^2) at UT provided significant financial support for software development. Three other sources of support included the Bess Harris Jones Centennial Professorship of Natural Resource Policy Studies, the Cross Border Institute for Resource and Development in IC^2 at UT-Austin, and the Kozmetsky Global Collaboratory at UT-Austin.

The class appreciated the advice and comments on drafts of this report provided by GMA 9 Groundwater Conservation District board members and staff members as well as from staff of the Texas Water Development Board. These persons included Robert G. Bradley, Rima Petrossian, Andy Donnelly, and Ron Fieseler. In particular, Andy Donnelly provided extensive comments on several drafts that immeasurably improved the quality of this report.

The class is thankful to Lucy Neighbors and Lori O'Neal of UT who supported the development of this project and this report. Paul Hobart and Wendy Willingham helped prepare this manuscript for publication.

None of the sponsoring units (including the LBJ School, the Jackson School, the Center for Public Policy Dispute Resolution, UT, the TWDB, any of the GCDs, or GMA 9) endorse the views or findings of this report. Any omissions or errors are the sole responsibility of the authors and editors of this report.

Executive Summary

Texas House Bill (HB) 1763, passed in 2005, introduced several changes to groundwater management in Texas. There are 16 groundwater management areas (GMAs) composed of groundwater conservation districts (GCDs), whose boundaries roughly coincide with major Texas aquifers. HB 1763 directed GMAs to define "desired future conditions" (DFCs) within their respective aquifers to be used for future planning purposes. Regional water planning groups are directed to consider each GCD's "managed available groundwater" (MAG) in their water planning. This report examines the changing methodology of groundwater management in Texas by studying the manner in which one GMA complies with the new HB 1763 mandates.

Groundwater Management Area 9 (GMA 9) includes much of the Texas Hill Country and all or part of the following Texas counties: Kerr, Bandera, Kendall, Bexar, Comal, Blanco, Hays, and Travis. GMA 9 is comprised of parts of water planning regions J, K, and L, and includes portions of three designated major aquifers, the Edwards-Trinity, Trinity, and Edwards (Balcones Fault Zone). GMA 9 includes portions of nine GCDs: Bandera County River Authority and GCD in Bandera County; Barton Springs/Edwards Aquifer Conservation District in a portion of Hays and Travis County; Blanco-Pedernales GCD in Blanco County; Edwards Aquifer Authority in a portion of Bexar County; Cow Creek GCD in Kendall County; Hays Trinity GCD in western Hays County; Headwaters GCD in Kerr County; Medina County GCD in Northern Medina County; and Middle Trinity GCD within northern Bexar County.

Project staff began this project by interviewing 27 water users within GMA 9, a group that included farmers, small business owners, land developers, individual well owners, environmentalists, and staff and board members of government agencies in the GCDs. The goal of the interview process was to understand social and economic concerns pertaining to groundwater use in GMA 9 and to describe stakeholder preferences for groundwater use. Interviewees were asked a standard set of questions to identify their preference for future groundwater use. The information obtained during interviews was used to report on metrics representing stakeholder concerns and preferences. Graduate students observed public meetings and elicited public comments from water users within GMA 9 in its process and sought to help GMA 9.

A group of students collected data from various sources about GMA 9 so as to make information accessible to GMA 9 representatives to use in the determination of DFCs. Databases containing information on the GMA 9 region were evaluated and made available to representatives throughout the region. Students also created basemaps with roads, political boundaries, geology, infrastructure, streams, and other attributes.

Members of the class developed familiarity with the existing Trinity Hill Country Groundwater Availability Model (GAM) in order to evaluate the effects of different pumping scenarios on hydraulic head values and flow from the aquifer to regional streams/springs. This GAM use sought to assist GMA 9 in development of the DFCs of

the Trinity Hill Country Aquifer. Students developed custom software to generate the input files, evaluate alternative pumping rates, produce output displays, and create a link between geographic information systems (GIS) and the GAM. The software allows GMA 9 representatives to evaluate aquifer performance in different regions under different pumping scenarios and provides a tool for displaying results.

The new initiatives outlined by HB 1763 can improve groundwater management in Texas by establishing groundwater management plans that allow the GMA to establish regional goals that would help GCDs permit groundwater use in a coordinated basis over shared aquifers. This draft describes the first stages in GMA 9's process to develop its DFCs.

Appendix 4 reports on diverse "runs" of the GAM to compute a range of choice of future GCD pumping and resulting estimates of aquifer drawdown levels. Members of the class ran simulations of future water withdrawals to observe how the pumping could affect hydraulic head values. The pumping scenarios ranged from "no increased use" from current conditions to various patterns of future water withdrawals based on and related to the Trinity Hill Country Aquifer GAM model results. Pumping scenarios are based on the expected levels of future pumping incorporated in the Trinity Hill Country Aquifer GAM, which in turn are based on county-by-county estimates of future groundwater withdrawals up to 2050, as developed through the regional planning process (Texas Water Code Section 16.053) for Texas water planning regions J, K, and L. Class members examined the drawdown implications for pumping increases and estimated future withdrawals that began as low as 0.1 times the expected future pumping withdrawals, as imbedded in the GAM model. Counties were tested for many different pumping options, such as 0.25, 0.50, up to 2.0 times the expected amount of future water withdrawals. Each test computed and displayed the level of drawdown in the Trinity Hill County aquifer in each county and the effects of each county's water withdrawals on aquifer levels of other counties. Evidence from those runs indicates that water withdrawals from any GCD affect the aquifer levels within other GCDs. One of the challenges to GMA decisions about DFCs and MAGs is that the GMA participants know how any one county's pumping can deplete the ground water resource availability in other counties.

As of May 2007 when this final project report was drafted, GMA 9 had not adopted its DFC. It is clear from the diverse public discussions that prior to any GMA recommendations there remain important issues to be addressed through research, public meetings within the GCDs, and GCD meetings. This report has sought to record the first nine months of the DFC process. This report leaves the final resolution of the GMA's DFC to the elected GCD and GMA representatives and their water users.

Chapter 1. Introduction

Prior to 2005 groundwater conservation districts (GCDs) in Texas were required to develop management plans without regard to any regional goals for aquifer management, despite the fact that many GCDs might manage over a common groundwater resource, or aquifer. One limitation on the goals which a GCD might set, however, was that GCDs were directed to develop the groundwater management plans consistent with regional water plans (which were developed by regional water planning groups for both groundwater and surface water over a defined geographic area).

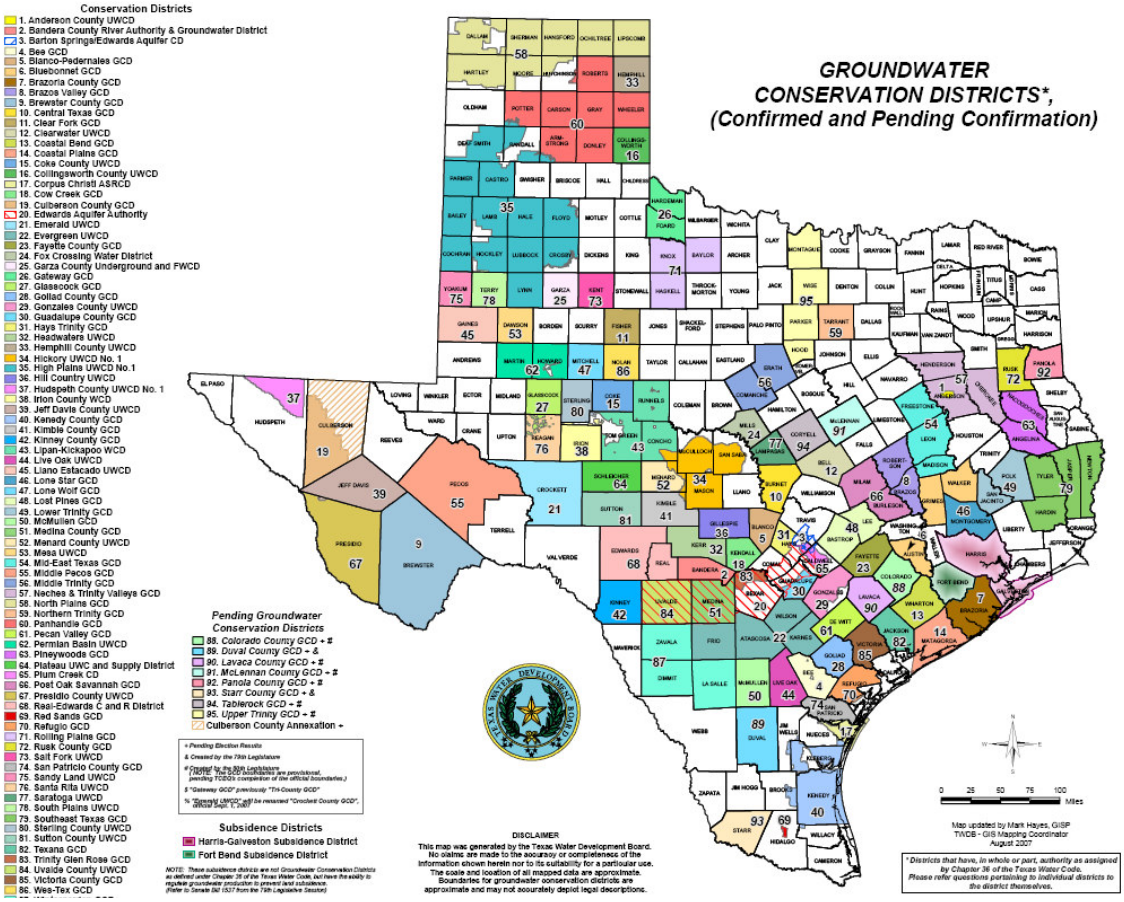
HB 1763, passed by the Texas Legislature in 2005, changed these two focuses by requiring joint planning for common groundwater resources, and also by providing that this joint groundwater planning be considered by the regional water planning groups in their planning process.

The geographic boundaries for this joint planning process was initially set in Senate Bill 2, passed in 2001, which required the Texas Water Development Board (TWDB) to delineate groundwater management areas (GMAs) in Texas (see Figure 1.1) "with the objective of providing the most suitable area for the management of groundwater resources" and, to the extent feasible, to coincide with the boundaries of groundwater reservoirs. However, any joint management over these GMAs was generally voluntary by the GCDs located therein.

HB 1763 followed four years later to require that GCDs within a GMA work together to develop "desired future conditions" (DFCs) for the aquifers within a GMA, and that management plans and rules of individual GCDs be consistent with achieving this DFC. Based on this DFC, the TWDB is required to compute the managed available groundwater (MAG) for each district in the GMA. This MAG also is provided to the regional water planning groups to be considered in the regional water planning process. GCDs further are required, to the extent possible, to "issue permits up to the point that the total volume of groundwater permitted equals" the MAG.

To determine DFCs, the GCD representatives in each GMA meet together in public meetings. Each GCD has one representative and one vote in determining the DFCs for their GMA. After adopting DFCs, each GMA provides this decision to the TWDB in the form of a written statement. Based on an existing groundwater availability model (GAM) that can be used to estimate the effects of water withdrawals on groundwater levels within an aquifer (or other process), the TWDB calculates the MAG, or the volume to be used by the GMA for permitting purposes. The TWDB then provides the MAG to both regional planning groups and each GCD. The GCDs can update their rules and management plans after the TWDB gives them their MAG, which also is provided to regional water planning groups so they use the information in developing water plans under the Texas Senate Bill 1 water planning process.

Figure 1.1
Texas Groundwater Conservation Districts



Source: Texas Water Development Board. Online. Available: http://www.twdb.state.tx.us/mapping/maps/pdf/gcd_only_8x11.pdf. Accessed: August 27, 2007.

The geological rationale for a regional aquifer rather than a political basis for determining the managed available groundwater to permit for pumping involves the fact that an aquifer which serves multiple political jurisdictions should be managed jointly. Consider two different DFCs, withdrawing water from one aquifer. If one GCD were to prefer to mine the aquifer to take water now and the other GCD were to seek to sustain groundwater levels in the future, their joint management would have unintended consequences. As there is one aquifer, as water is withdrawn by the GCD that is content to mine groundwater, it is possible that groundwater in the portion of the aquifer under the "sustainable" GCD could migrate to the portion of the aquifer under the "mining" GCD. The "mining" GCD may be able to withdraw more water than they expect is

available might be pleased, while the "sustainable" GCD whose aquifer levels fall more than they expect would be unhappy.

Table 1.1 provides examples of possible "performance measures" for deciding a DFC within an aquifer region. To aid Texas regional planning groups, the TWDB encourages each GMA to submit DFCs based on their preferences for any future period, such as for the next 50 years. The GCDs may decide on a DFC for a length of time, such as a 10, 20, 30, 40, or 50-year period. Statements about desired water levels or water quality can be used as examples of DFCs. For example, a GMA could choose spring flows to remain within 10 percent of mean values for perpetuity. Another choice would be to use a volume of groundwater to define a DFC: for example, stating that of the water now in the aquifer, 50 percent should remain after 40 years. Another option would be to define an upper limit to the decline of aquifer levels, such as an upper bound of a 110 foot drop in the average annual aquifer level over 30 years. The diversity of desired future aquifer conditions is limited only by the creativity of a GMA districts and by the capacity of a GAM model to compute the meaning of a DFC in MAG terms.

Table 1.1
Different Aquifer Desired Future Conditions

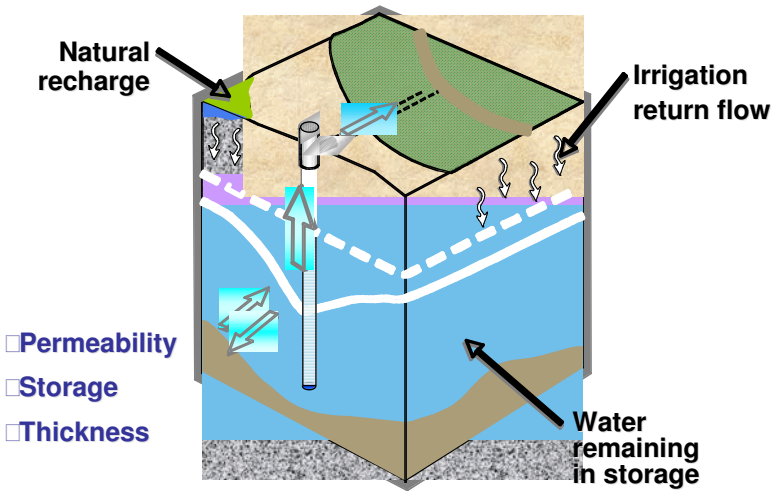
Point of Reference	Example Desired Future Conditions
Water levels	In 50 years, on average, water levels are to be no more than 100 feet lower than current levels in the aquifer
Water quality	Total dissolved solid concentration are not allowed to exceed 1000 milligrams per liter in 50 years
Spring flows	Spring flows should not fall below 10 percent lower than mean values for perpetuity
Volumes	Fifty percent of the water in an aquifer should remaining in an aquifer after 50 years

Source: Options provided by Rima Petrossian of the Texas Water Development Board, 2007.

Aquifer water quality is harder to model and the TWDB has yet to promulgate analytical tools for routine GCD use that incorporate water quality into the model. Regardless of the analytical capability, water quality is a factor to consider when deciding on a DFC for a GMA.

Figure 1.2 illustrates a model cell, such as those in a generic TWDB GAM. A GAM produces an area's MAG using hundreds of such cells. In this case the cell has a square surface while the depth of cells may vary. Water flowing into the cell may originate from the cell surface or an adjacent groundwater cell. Groundwater may exit the cell to another cell or be pumped to the surface for use. On the bottom left of Figure 1.4 the dual arrows represent horizontal flow in and out of the cells in the model. After all of the water inputs and outputs, there remains some volume of water in storage.

Figure 1.2
Groundwater Flow in Model Cell



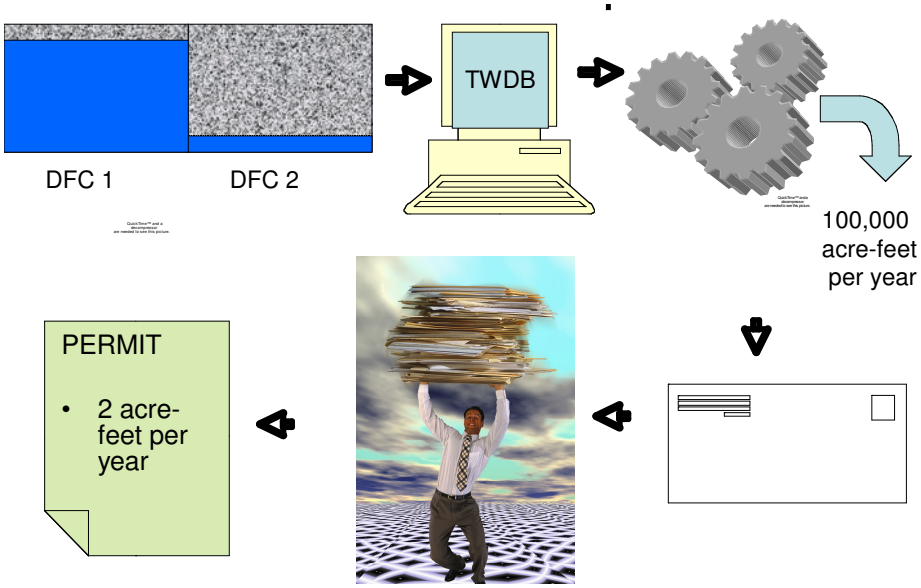
Source: Figure provided by D.B. Stephens and Associates in a contract report to the Texas Water Development Board, 2007.

Figure 1.2 is not a representation of the Trinity Hill Country Aquifer Groundwater Availability Model (the GAM), as that GAM does not included irrigation return flow. It is beyond the scope of this report to explain all of the processes illustrated in Figure 1.2. The figure is included in the report only to help readers visualize the concept of a "cell" within a GAM model.

When a GMA sets a DFC, the TWDB can convert that DFC through the GAM (or other means) into MAG (managed available groundwater). The MAG is defined as the volume of water that may be permitted by a district (GCD) in accordance with the DFC. Some interviews with water managers indicate that they interpret a MAG as a volume up to which a GCD can permit; other officials parse the concept differently. Citizens are not delighted with the ambiguity with the concept of a MAG, as some persons may interpret it as a fixed upper limit to permitting while others may believe it to be a lower bound for water withdrawals. The Texas Water Code specifies in S36.1132 that a "district, to the extent possible, shall issue permits up to the point that the total volume of a groundwater permitted equals the managed available groundwater…" There is no TWDB specification saying that a GCD cannot permit water withdrawals above or below the MAG, but a GMA is expected to make an effort to use the MAG in its process of determining how much to permit. To summarize, the GCD managers are given the MAG by the TWDB based on the GMA's DFC and then they issue permits based on this MAG.

Figure 1.5 illustrates the progression from a DFC to the permitted amount for each GCD. Each GMA gives its DFCs to the TWDB, which then uses the GAM or the best available data to produce the MAG. The MAG must be a volume of water in acre-feet per year. In the case of Figure 1.3, this amount is 100,000 acre-feet per year. The TWDB sends this number to the GCD managers and the regional water-planning group so that GCD managers can issue permits based on the MAG (in this illustration, two acre-feet per year).

Figure 1.3
From Condition to a Permit



Source: Figure provided by Rima Petrossian of the Texas Water Development Board, 2007.

The Texas Legislature established September 1, 2010, as a final deadline for submission of DFCs to the TWDB. However, GMAs will need to submit their DFCs by December 2007 if the GMA districts wish their MAGs to be an upper limit of aquifer withdrawals to be included in any of the 2011 regional water plans. Inclusion into a plan is important because only water management strategies included in a regional plan may receive TWDB money for infrastructure investment to municipalities, water supply corporations, or other water providers within the GCD, with limited exceptions.

Petitions for changes to an adopted DFC depend on a submission of a DFC. For example, water users within a GMA can file a petition with the TWDB to appeal the

approval of a DFC for their GMA. This petition must be filed after the approval of the DFC. A petitioner must provide evidence that GMA procedures were arbitrary or that the GMA's projected DFC is not reasonable. The TWDB then makes a decision about whether to revise or uphold the original DFC. DFCs are required to be submitted every five years after September 1, 2010, but as a practical matter could be revised more often should a GMA choose to do so.

In spring 2006, the Hill Country GMA 9 invited two faculty members at The University of Texas at Austin (UT), Professors Jack Sharp and David Eaton, to study their DFC process. That invitation was a result in part of a public presentation to the GMA 9 Board by two of the co-instructors of the eventual course, Suzanne Pierce and Marcel Dulay, along with Professor Sharp. As a result, Professors Eaton and Sharp decided to create a joint course within UT to follow GMA 9's DFC process and invited their colleague Suzanne Schwartz to teach the course together. In fall 2006, the TWDB authorized funds to reimburse a portion of the study's expenses as part of a grant. This partnership between GMA 9 and UT, in cooperation with TWDB, allowed graduate students an opportunity to assist GMA 9 in its efforts to meet the requirements of HB 1763. To facilitate this process, UT Professors Eaton, Schwartz, and Sharp offered a year long course entitled "Groundwater Management in Texas" as a Policy Research Project (PRP) jointly between the Jackson School of Geosciences and the Lyndon B. Johnson School of Public Affairs.

GMA 9 includes much of Texas Hill Country and portions or all of the following nine Texas counties: Kerr, Bandera, Kendall, Bexar, Comal, Medina, Blanco, Hays, and Travis. GMA 9 is comprised of parts of regional water planning groups J, K, and L. It includes portions of three designated major aquifers: the Edwards-Trinity, Trinity, and Edwards (Balcones Fault Zone). Recent population growth in the Texas Hill Country has contributed to an increase in regional water demand. To meet the rising water demand, municipalities, industries, and landowners have increased their reliance on the underlying Trinity aquifer groundwater resource. New development, recent droughts, and declining water levels have increased water users' interest in the Trinity Aquifer and have enhanced concerns that growing water demands could outstrip the sustainable water supply of the aquifer.

Prior to this study, TWDB staff had developed the Trinity Hill Country Groundwater Availability Model (GAM) to estimate groundwater availability and water levels in response to pumping and potential future droughts.[1] The Trinity Hill Country GAM was made available to the public in September 2000. The model is based on historical information on the aquifer. It incorporates results of studies on water levels, structures, hydraulic properties, and recharge rates. It was calibrated to historical water levels. The model can be used to estimate future groundwater levels and saturated thickness under drought-of-record conditions, using estimates of future groundwater demands based on demand numbers from Regional Water Planning Groups J, K, and L. The GAM model can be used to identify sensitive areas susceptible to future water-level declines due to increased demand and potential droughts.

To assist GMA 9 in setting the DFCs for the aquifer, PRP class members developed software to "wrap around" the existing GAM to facilitate computation of aquifer performance measures, for different pumping scenarios. The model was spatially georeferenced so zones could be assigned based on predicted population growth patterns within the region. Zones were assigned along highway corridors and around municipalities. Different pumping scenarios have been run in the GAM, so aquifer performance under these scenarios could be presented in public meetings to members of the GMA 9 community.

To understand the key social and economic concerns pertaining to groundwater issues in GMA 9 and preferences for groundwater use, PRP class members interviewed stakeholders representing concerned citizens, farmers, ranchers, persons who advocate subdivision growth, employees or officials of municipalities or water institutions, municipal interests, government agencies, and persons who are concerned about in-stream flows and sustainable springflows. A process that the PRP termed as "narrative elicitation" was employed to inquire as to stakeholder concerns and preferences for future groundwater use and metrics to measure success or failure. The metrics were then used to evaluate different groundwater extraction scenarios using the Trinity Hill Country GAM to provide information to GMA 9 on alternative groundwater management strategies.

Databases for each of the GCDs were reviewed to provide water users within GMA 9 with an inventory about the organization and content of groundwater and other information available to each GCD. The reason for organizing and reporting on data was to assist water users in understanding groundwater resources and use within the GMA region and within the aquifer. Basemaps for the GMA 9 region were compiled with information obtained from the Texas Natural Resource Information System (TNRIS). The maps include administrative boundaries, transportation, hydrology, flood plain, topography, and digital orthophoto quadrangles (DOQs). Maps with buffers 30 miles wide and buffers 60 miles wide were developed for each GCD and for the entire GMA 9 region. The PRP made available the verbatim reports of the stakeholder interviews, the water resource and use data, and the alternative GAM simulations of aquifer use to the public through a GMA 9 website maintained by Ron Fieseler of the Blanco-Pedernales Groundwater Conservation District. Drafts of PRP reports were uploaded to that website (http://www.blancocountygroundwater.org) so that any citizen could review any of the outcomes of the PRP class. These results also were presented in public meetings throughout GMA 9.

The active role of the PRP class ended in May 2007, and its passive role will end with the publication of this report in fall 2007. The GMA 9 process to select a DFC for the Texas Hill Country will continue until the GMA 9 board decides to adopt a DFC or decides not to adopt a DFC. This report will be provided to the public to facilitate the DFC process within GMA 9 through the website of the Blanco-Pedernales Groundwater Conservation District. Members of the PRP class will try to follow the next steps by GMA 9 and will try to report on the process leading to the consideration by GMA 9 of a DFC later in 2007.

Notes

[1] Texas Water Development Board. "Groundwater Availability of the Trinity Aquifer, Hill Country Area, Texas: Numerical Simulations through 2050," Report No. 353, Austin, Texas, September 2000.

Chapter 2. Stakeholder Consensus-Building

One key component of this study was an effort to interview GMA 9 water users about their preferences regarding their "desired future conditions" (DFC) and preferences for groundwater withdrawals from the Trinity Hill County Aquifer. To accomplish this task students within a so-called "stakeholder group" (SG) developed skills in interviewing and qualitative analysis to interpret social and economic concerns pertaining to groundwater use in GMA 9. The SG interviewed stakeholders and then used a software program ATLAS.ti® to evaluate stakeholder perspectives and identify similarities and differences of views.[1] The SG asked each of the GCD managers within GMA 9 to propose a list of interview candidates representing a variety of interests within the region. Persons interviewed included well owners, farmers, business owners, property developers, governmental officials, persons self-described as environmentalists, municipal representatives, GCD general managers and board members, and other interested citizens. The SG conducted a total of 27 stakeholder interviews, which have been coded into narratives.

SG staff classified stakeholder comments into categories: current water problems, causes of the problems, consequences of no action, possible actions, barriers to action, and ideal outcomes (see Table 2.1). These findings may be of interest to water users within GMA 9 as well as GCD districts members and general managers as they move forward in their determination of DFCs for GMA 9. The following subsections summarize SG stakeholder interviews. Each subsection includes a summary of the interviews followed by interviewee quotes. Appendix 8 lists the remarks of interviewees who agreed to waive confidentiality to allow her or his views to be attributed to the individual source. The PRP has offered all persons complete confidentiality, so any person who wished her or his remarks to remain confidential has their remarks placed in an "anonymous" section of collected interview quotations (see Appendix 8).

Table 2.1
Summary of GMA 9 Stakeholder Narratives

Current Problems	Some dry wells Some dry springs Some contaminated water supplies Urban encroachment
Causes of Water Problems	Population growth Limited water resources Drought Legal interpretations on use of groundwater Limited authority of district

Consequences if No Action	More dry wells More dry springs More water contamination Litigation
Possible Actions	Cooperation Responsible development Market incentives Public education Alternative sources and conservation Infrastructure investment
Barriers to Action	Limited resources: money, data, staff, education Mistrust Costly alternatives Resistance to change Resistance to regulation
Ideal Outcomes	Assured water availability for domestic use Spring flows Maintenance of groundwater levels

Source: Interviews with 27 GMA 9 Stakeholders.

A Land Development Stakeholder Narrative

Students interviewed a subdivision developer, real estate agents, a part-time developer, and a well driller. Each of the individuals stated that access to clean abundant water and strong water resource regulation are essential to the continued growth and well-being of the Hill Country. There was some sentiment suggesting that homes should not rely on groundwater and that home owners would be well served by a centralized water management and distribution system. These interviewees reported degradation of the quantity and quality of groundwater. They cited as legal and financial challenges: development of alternative sources of water for homes; drought in the region; irresponsible development by outsiders; and poor initial quality in portions of the region's groundwater.

The interviewees reported that if no action is taken, people with the most power and money may control access to water, resulting in a slow-down in regional growth. They stated that it can be difficult for the GCDs to manage water because their stakeholders may not be cohesive or cooperative, leading to inconsistent management hampered by resistance from some of the public to any form of water regulation. These persons who supplant land development suggested several actions designed to reduce potential water management problems, including creation of market incentives or high water rates to discourage waste, encouragement of alternative sources such as rain water or surface water, more stringent regulations to limit the size of a parcel that can be served by a well and septic system, and alternative sources of water through surface water importation. The land developers' narrative ideal outcome was for people to become good stewards of the land and to cooperate with one another to conserve water resources. Table 2.2 lists quotations from land developer interviewees.

Table 2.2
A Land Development Stakeholder Narrative

Ideal Outcomes:

- Less than 1 percent of our development does not have central water. We believe that it is better to have two holes in the ground for 275 homes than 275 holes… If you have a well on each tract it is harder to conserve water and it is much more likely to get contaminated.
- Our objective is to the get the area away from total reliance on groundwater and start using surface water; nobody was doing that before.
- Our goal is to do what TCEQ requires because they are the state agency that governs what we operate under. [We] endeavor to keep them happy because if we don't we don't get a CCN, a certificate of convenience and necessity, which allows us to provide water in an area.
- I think groundwater should be controlled like rivers and basins in Texas with river authorities like LCRA or GBRA, where you are not restricted to a county or a geographical area.
- I think [groundwater] should primarily be [controlled] at the state level like river authorities. They could generate their own revenue too like GBRA.
- It should be on a greater level [of] control so that everybody who needs the water gets the water. That makes sense.
- Water has got to be used conservatively. We can't have any area that wastes water. You've got to be a good steward of the land, including the water.
- Yes, it's a high priority that we leave this land better than when we came on it. If you looked at our projects over the last years you'd agree. We try to leave the vegetation as much as we can. We take out cedar, but try to leave natural vegetation and encourage our owners not to put in fancy lawns but to leave the land in its natural state.
- They need to get a pretty stringent set of guidelines and they need to abide by them…I don't think there should be any variances at all, except in the most extreme situations.
- You've got to put an importance on springs.

Current Problems:

- Until a few years ago…there weren't any kind of regulation…people would put out a 55-gallon drum out for a septic…in the older days you could see raw sewage going through there.
- Our water table [is] falling, it's the same old cliché that everybody uses, you keep sticking so many straws in one drink and it's going to go dry.
- Water is critical in the Hill Country. When I first came here people said in a few years all this land will be fully developed. And I said no it won't. Well why not? Because there's not adequate water. You're probably going to ask me "Do we have enough water?" And I think you know that the answer is we don't. We're going to have to import water. I just talked to guy whose dirt tanks have dried up…and he's having to haul two loads of water a day to his cattle. We've had some problems…with the lower Glen Rose drying up. We've had a lot of wells pump down this summer…we've only had one that went dry enough…that we had to drill it deeper.
- The big problem with these underground water districts throughout the State of Texas is that they are confined to a particular county or geographical area that they represent, and the water is not restricted to those areas.
- The problem really is that here we have a good district that is very cooperative to work with. But if they were like this throughout the state people wouldn't have a problem. It needs to be set up in such a way that it is consistent throughout the state. And I have heard of districts that are not easy to work with.

Causes of Water Problems:

- So much of this property up here has been bought and sold by people that are just in here for the fast buck.
- So many people have come in with no tie-in with the community; they came in, cut it up, made their money, and took off.
- There's lots of areas…in different directions out of this town, the water is of very poor quality and the quantity is very bad.
- Until a few years ago…there wasn't any kind of regulations as far as septic systems or water well drilling. In some places, with old dried-up wells, people would buy them, drill a new well, and run their sewage into the old well.
- The rate of development is governed pretty well by the economy. If there is no demand for the lots development will slow down. The demand is high now because a lot of people from other parts of Texas want to be in the Hill Country. And there's an influx of people from other states, California, Washington, areas up north.
- There's not enough volume, like there is in the Edwards, to irrigate with.
- We've had a drought this last summer…we haven't had any heavy runoff rains that cause Cibolo Creek to run and recharge the aquifer. What are the causes of the growth in this area?
- Around Boerne here on the north side of town we have high well density of wells and large capacity wells for subdivisions…that have lowered water levels…for years we've had the pumps set and never had a problem. I've noticed the value of the land has jumped up so high that land is being developed in smaller tracts. What are the causes of the growth in this area? The climate for one thing and the cheaper cost of living.

Consequences of No Action:

- What will happen if good water management fails? The negative consequences are that growth will have to slow down if we don't have adequate water to take care of the people.
- I think…it would be like the old west, whoever had the fastest gun/who had the deepest well was going to get all the water.

Barriers to Action:

- Any kind of restrictions on anything irritates people. Nobody wants to be regulated; they buy a piece of land, they should be able to do what they want to with it. It's the same deal like back during the Civil War…people came in here fighting mad about the $25 dollar fee, a $25 fee per year per well to fund the GCD, saying they weren't going to pay it."
- People are not conscious of the water tables here, they're not knowledgeable.
- Everybody wants to get near water, some kind of running water system. Most of the developers, when they buy something they buy something that's next to a river or creek or something.
- I'd rather see larger tracts but…a lot of people say they couldn't afford that because the price of the Hill Country has dramatically increased over the years.
- A woman called me to say you shouldn't be charging us for water. I said why not? Water comes from God and it should be free. And I said you have just answered why I have so many of my problems. You're right, it is free. We don't charge you for the water, we charge you for treating it and transporting it. If you want free water you get a rain barrel and it will be free.
- The subdivision requires so much landscaping according to how much you spent on your house…we had one customer that was going to wait to start his grass and the homeowners association came in and told him he had a month to get his grass started.

Resources Available:

- (The district manager) knows what he's doing and is very cooperative. He does what is necessary, implementing rules and regulations, but he is at the same time cooperative with people like us developers.
- My best aid is my attorney. He is former chairman of state water commission. He does all my water work. He does it with TCEQ. He's been in this business for years. He probably is one of the best authorities on water law in Texas. I don't do anything without him.
- We don't have a local radio station or television station so it's just the newspapers.
- If we had a four or five inch rain tomorrow, things would be looking great again.

Possible Actions:

- This county has 500-acre-feet of water from the river; I think they need to build a plant to suck that water from the river and put it back in the aquifer.
- A lot of things would be so much simpler if there were some sort of way to inform people so that they would understand why the regulations need to be put in place.
- If the government would implement some kind of a program to help a farmer or rancher go on to their place and build something to catch water, a certain amount of that will go back into the aquifer and that's going to benefit the county as a whole. You talk all you want about conservation, but you have water rates, and everything else is conversation. And that's how you get people to conserve is with rates. And we do have accelerated rates. If you use excessive water you will pay more per gallon for it than someone who conserves water. That seems to be the best way. If you charge people a higher rater for excessive use then they'll use less.
- They need to get a pretty stringent set of guidelines and they need to abide by them. I would like to see larger minimum tracts to put a well or septic system.
- I'm a believer… if you had a master plan set up with one well, some sort of water system in place…it would be better than everybody being on their own wells.
- I think that we need to start being a better steward of our natural resources. We need to implement some changes in the way we do things.
- You're probably [going to] ask me "do we have enough water?" And I think you know that the answer is we don't. We're going to have to import water… there will come a time when we are going to have to find additional water to bring in to this area. And it's out there, but it's going to take some expensive pipelines to get it here.
- It's a different world you know… used to be you bought a piece of land and you owned the water that could come out of it…but if the water isn't there then what are you going to do? So you have to work together you know.

Source: Verbatim quotations from interviews of GMA 9 stakeholders.

An Environmental Stakeholder Narrative

Three interviewees, self-described as environmentalists, reported that the main problems in this GMA are wells and surface water sources going dry during drought periods. The cause of these conditions they ascribed to population growth and the influx of retirees and families that purchase homes that operate on well water, which puts pressure on the aquifer. The interviewees stated that many of the people who move into this area are from other parts of the country and may not understand the historical or current water situation in Central Texas. The environmentalists expressed a hope that stakeholders will develop a concern for the importance of conserving water and will take initiatives to do so. The environmentalists' preference is for the GCDs to have a public education program about water regulations, water conservation, and alternative sources. The environmental interviewees stated that if actions are not taken then more wells and

surface water sources could dry up over time. Table 2.3 lists quotations from the environmental stakeholder interviewees.

Table 2.3
An Environmental Stakeholder Narrative

Ideal Outcomes

- Some people treat water as if it's oil, that it's something you can make money with. But I think it's like blood, like it's vital.
- I'm for sustainable development, but frankly I have no idea what that means in terms of water supply because we don't have enough research to establish that.
- We want people who move in here to live with nature, not against nature. There is a difference between those two concepts.

Current Problems:

- I get phone calls from people when their wells go dry.
- All I can tell you is that through this drought, 2005-2006, we've had more wells go dry in this area than we did in 1999 and 2000.
- Surface water is not a sustainable solution for Blanco County.
- You will see all the way up that the Blanco River is drying up. When we overbuild the water supply then we are going to suffer the consequences of it.
- There is no water. [A developer said] You're right. When we got into that subdivision and started drilling wells we ran into what you were telling us. There was not adequate water. And even if we found water it was such poor quality that it could not be used in a water system.
- Frankly it comes down to this is a moral issue. How will you keep hyping property in an area where there is limited.....you know they say in real estate that it's location, location, location. In Blanco Co. it's water, water, water.

Cause of Water Problems:

- We were very concerned because we realized the population was growing very rapidly without any regard to water.
- I feel that there's a real (population) crunch coming in the state of Texas, we think we can do whatever we want. I'm concerned about people moving out here. People from Houston, Dallas, Fort Worth, and from California and the East Coast to get their little piece of Texas, but it's a house of cards that could come tumbling down.
- The problem right now is we have people moving in who have not had a living experience in Blanco County. There is a lot of oral history about drought. Records show settlers in 1853 moved in a rainy year and then there was a drought. It's like a rollercoaster. In 1952, my father gauged 26 inches in a day on this ranch. Then the next year it rained 13 inches for the year, then 7 inches the year after that. Developers and buyers are from another part of Texas or out of state and want to put in vanity ponds and fill them with groundwater. They're living against nature.
- The bottom line is greed, money. The Hill Country is a major attraction. People want to live and retire in the Hill Country.
- Reporter from San Antonio paper reported on golf courses. Each 18-hole golf course in that area uses enough water for 23,000 residences.

Consequences of No Action:

- You will see all the way up that the Blanco River is drying up. When we overbuild the water supply then we are going to suffer the consequences of it.
- Developers want to make as much money as they can and then leave. When the drought started they had never developed anything outside of east Texas where it rains a lot. Their comment was "what do you do when it doesn't rain?" When you've got a population living there on your water supply then how responsible are you? Basically it comes down to fraud. Is that fraud, when you promise people water a central water system and wells. Then what happens? We have no idea what will happen when this population starts to pump water.

Barriers to Action:

- The whole concept of the management plan is based on research. And if you don't have enough monitor wells scattered over the county then you don't have good research.
- We have not had anyone turn us down for a meter. Most people don't understand that a well that pumps 25,000 gallons a day or more… that it's a commercial well and needs to have a meter on it. That's an education problem that we have, people understanding the differences in wells.
- Other GCDs have determined possible yield. We don't know. Does it take 10 or 30 acres to recharge a well? We have no idea.
- I'm for sustainable development, but frankly I have no idea what that means in terms of water supply because we don't have enough research to establish that.
- It comes back to that research base. We can't make any decisions without a solid base of information.
- We are an urban state. We need to realize that. The hold-up is in the state level because developers control the legislature too much.

Possible Actions:

- The county should encourage people… giving tax incentives for rainwater collection systems.
- The manager and the board need information.

Source: Verbatim quotations from interviews of GMA 9 stakeholders.

A Municipal Stakeholder Narrative

Municipal employees who were interviewed reported that groundwater management will become a problem and report that groundwater resources will be depleted if development continues at its current rate. Interviewees commented on the population boom in the Hill Country and its contribution to groundwater usage. They indicated that it will be difficult to manage groundwater given current levels of well monitoring and data collection. Members of this group stated that there should be future legislation to protect groundwater along with voluntary measures from communities to use only necessary groundwater. Municipal interviewees expressed a hope that water users would expand the use of programs such as rainwater harvesting and desalinization as alternatives to groundwater use and believe that education could encourage community involvement in natural resource conservation. Table 2.4 lists quotations from municipal stakeholder interviewees.

Table 2.4
A Municipal Stakeholder Narrative

Ideal Outcomes:

- The ideal thing for groundwater in my opinion would be to only use the amount of groundwater that we are sure that we can have to recharge our aquifers. An equal give and take from the aquifers is the optimum thing for groundwater in our areas and that we have a plan that takes into account the inventory or use that we have and what amount we will use in the future.
- Water is a basic thing that people don't want to worry about…you want to be able to turn on your faucet and have water come out.
- The idea of capitalism dictating what happens isn't all bad…it allows a lot of personal freedom that…
- If private individuals are going to be able to hold land, they should be able to do what they want to do…if they follow the rules... That's all you can expect of people.

Current Problems:

- The use of groundwater is increasing at such a rate that we are concerned about its long term sustainability.
- There are way too many wells in the area known for low production.
- Too many straws too close together…cause large draw downs and everyone gets upset.

Causes of Water Problems:

- We're getting much larger populations which are moving to the rural areas where the aquifers are much less monitored.
- If development goes unchecked and permits are continually allowed… especially the more unregulated development that occurs outside of the regulatory agencies of TCEQ. We are really concerned about exceptionally high permits being granted to smaller developments. And there are other concerns; we also have large petroleum pipelines that go through out the area. We are worried about possible contaminations through the pipelines and large septic fields that are coming with the large developments.
- I think that high density subdivisions may not be a suitable use for our groundwater… keep from having the high density subdivisions with multiple water wells; I think that helps to protects us also.
- Too many wells [are located] in the area known for low production.
- A lot of it is over development…before there were rules on well spacing.
- Part of the Hill Country problem is that there hasn't been slow development…people go from selling their 1,000-acres ranches and it goes to hundreds and hundreds of homes overnight.

Consequences of No Action:

- So we don't deplete it to the point that we don't have it for the historic use of our water…
- Without good checks and balances we will over-utilize the water resource. We will develop to a point that we will begin to mine the aquifers and pull water at a greater rate than the recharge is capable of putting back into our aquifers.
- I don't like to be forced any more than anyone else does, but if we don't, there may not be anything to regulate, to keep from contamination for our children.
- Without good water, without water that is suitable for people to drink, we won't be able to live here, there won't be anything here.
- As water becomes scarcer, prices will increase.
- Land values will dictate what people are willing to pay for their water.
- If no district ever gets created in Western Travis County, you're just out of luck…you'll just have to find another source of water.

Barriers to Action: • We don't have the data or inventory to know what is available • It is impossible to regulate a resource that you do not know the extent of its use or its present quantity. • We are trying to manage something that we don't even know how much we have. We are trying to manage something that we don't even know how much we use. • People are not educated on what GCDs do…GCDs manage water, not land use or development. • The management of a resource doesn't happen over a matter of months the same way a development can occur.
Possible Actions: • …To make sure that the coming generations are well educated on the uses, the needs, the sustainability-how are we going to be able to maintain the groundwater? • It [groundwater] has to be managed at the local level, at the state level and at the national level. • The more you educate people, the more awareness that there is, the more cooperation that there is. • I think education helps the planning process…allowing the public to give better input to the process. • I don't think there is an answer to it other than money. • I don't see GCD having enough power through Chapter 36.

Source: Verbatim quotations from interviews of GMA 9 stakeholders.

An Agricultural Stakeholder Narrative

Interviewees who farm within this region reported a belief that urban growth will eventually crowd them out. Farmers reported their individual use of water conservation measures, but believe that the general public views people tied to the land as wasteful. One concern of agricultural water users is that they are required to apply for a pumping permit every three years and possess no long-term guarantee of access to groundwater. They pointed out that GCDs offer them little protection because farming has not been designated as a historical use of groundwater.

One interviewee stated that as residential growth increases, not only will groundwater quantity and quality diminish, but also representation of current local interests will be reduced as new residents may not share the same values as the current more agrarian population. Farmer interviewees appreciated the fact that growth in this area will continue, yet hoped that county governments will manage and control growth effectively while retaining necessary open spaces. Table 2.5 lists quotations from agricultural stakeholder interviewees.

Table 2.5
An Agricultural Stakeholder Narrative

Ideal Outcomes: • The most ideal situation is that everyone is going to have to conserve because its not there…we can't just move 80,000 people into Blanco County and expect to have water…we've got to figure out some controlled growth, managed growth.
Current Problems: • Blanco County tried to limit subdivision density to five acres…but lost in court… If they move in at a density of one house every acre it's not going to work.
Causes of Water Problems: • The reason I feel threatened … we're the prettiest countryside…the subdivisions are coming out in our direction.
Consequences of No Action: • They are simply going to continue to build houses and there's not going to be any water and then nobody is [going to] be able to move here. • I think it's going to be a terrible thing… where they just use up everything they can and then its gone. • I'm worried that if I'm surrounded by subdivisions that use up all the water and my wells go dry… there's no recourse.
Barriers to Action: • Make sure agriculture is included, nothing in the groundwater district in Blanco says whether agriculture is included…as [an] historical user. • Some districts exempt agricultural wells from permitting. • We have to work in a community where we are under a lot of development pressure.
Possible Actions: • Some states have passed right-to-farm laws…I would love to see some policy that established farms have a right to historic use. • Education… trying to work with people as they are moving in.

Source: Verbatim quotations from interviews of GMA 9 stakeholders.

A Groundwater Conservation District Stakeholder Narrative

Staff and board members of GCDs within GMA 9 reported that the different portions of GMA 9 have water problems at different times. Representatives did foresee future problems if development continues rapidly without proper management or if there is an extended drought. One problem they noticed is that domestic wells are going dry, requiring some residents to drill deeper to access groundwater. The causes of the problems are a combination of drought, older and/or shallow wells, limited supply, and a growing population. They also felt a contributing problem in some areas is the sale of groundwater. Interviewees said that some people are not aware of the water regulations that protect users.

Interviewees expressed concern for the rapid rate of groundwater consumption in other areas. For example, some groundwater users were cited as pumping so much groundwater that it strains the aquifer that the whole area is sharing. The ideal situation

expressed by managers and board members is for the aquifer to be used in a sustainable manner so that spring flows and aquifer levels are maintained while each citizen has domestic water. Stewardship of the land and resources is important to these representatives. GCD staff and board member reported that they would like the public to perceive them as a positive community resource. They reported that if no action is taken, market forces may dictate that the richest and most powerful water users will control the resources and the districts may encounter litigation if the public is not happy with the district's decisions on when to permit withdrawals. Many GCD representatives had specific ideas about conservation action and district actions that could be taken. Table 2.6 lists quotations from GCD district members and staff interviewees.

Table 2.6
A Groundwater Conservation District Stakeholder Narrative

Conservation Actions: • Citizens or developers should purchase and set aside an area of land to remain open space to allow the aquifer to recharge. • Developers should repair their leaky distribution systems to reduce waste and help maintain the level in the aquifer. • Citizens' primary reliance should be on alternative water resources such as rainwater collection systems. • Market forces should be used to encourage these actions, not work against them.
District Actions: • The district should take a very active role in educating the people about water regulations, waste, and conservation. The public must understand that high demand resources can be locally regulated with good management. They must know the role of the GCD. • The legislature should provide a cohesive and comprehensive state-wide water plan that allows for local management. • The GCDs should build strong working relationship so they can develop a sustainable long-term plan. Controlled managed growth, through local water permitting and building authorities will help achieve sustainability. • A good sustainability plan will be based on aquifer knowledge and field data to help manage it better and effectively. This, along with working together, will build trust in among the districts that is vital when the drought plan is put into effect. Water use should be a little more flexible in times of plenty. As trust is built, districts gain more access to data, the science gets better, the management improves, and trust is strengthened—a circular effect.

Source: Verbatim quotations from interviews of GMA 9 stakeholders.

Conclusions

The strongest single inference from all the interviews is the extent of common perspectives among stakeholders on many topics relating to desired future conditions for the GMA aquifers. Many interviewees reported that they would welcome a

comprehensive groundwater management plan for the entire region. Interviewees expressed a willingness to work together and take into account the needs and preferences of other interests. Stakeholders accept as a fact that growth will continue in this region. Many interviewees stated a preference for managed sustainable growth and responsible stewardship of the land.

GMA 9 stakeholders did express disagreement on several issues, such as water use priorities (or how GMA 9 will attain MAGs through permitting), groundwater use restrictions and balancing conservation and growth (how much development will be allowed and who will control it), and how to limit pumping. There also were different views on what constitutes appropriate data or which data should be used in establishing DFCs. There were differences as well regarding the process of creating a groundwater management plan or managing under such a plan, as geological boundaries of groundwater rarely coincide with the political boundaries of institutions which are charged with the implementation of any plan. Another topic of common concern was stakeholders' frustration about data availability, or the volume, quality and degree of information appropriate for developing GCDs. The data issues are discussed in the following chapter.

Notes

[1] Atlas.ti. *Atlas.ti.* Online. Available: http://www.atlasti.com. Accessed: August 20, 2007.

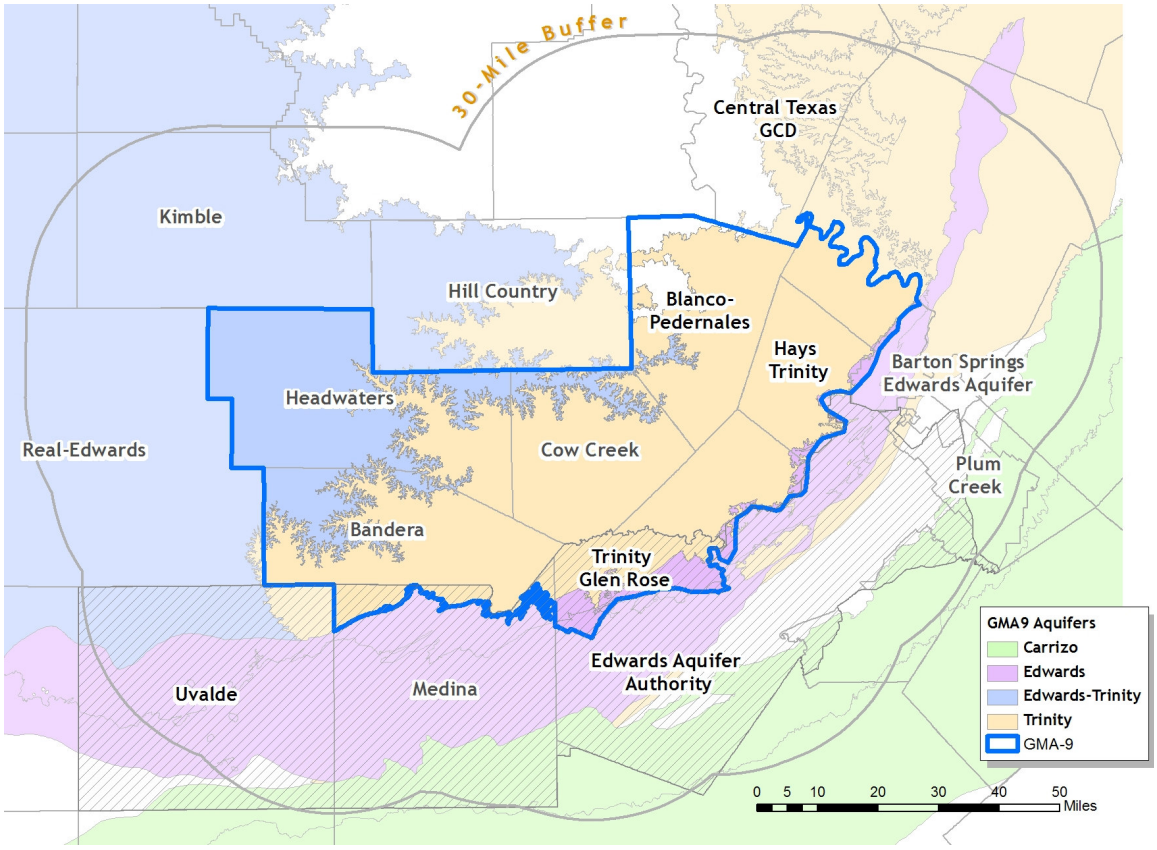
Chapter 3. Groundwater Data

Project members organized themselves as a "data group" to collect and make accessible information that could help GMA 9 representatives determine their desired future conditions (DFCs). Data group members met with GMA 9 representatives and asked them about their data needs, such as well locations, well names, water levels, historical water levels, and drilling information. Helpful steps to organize the data included formation of a master database; incorporating information from each groundwater conservation district's (GCD's) separate database; the development of basemaps (with roads, political boundaries, geology, infrastructure, streams, or other demarcation images); detailed water use data; information on cross-formational flow and surface water and groundwater interactions; and records of population growth and distribution.

Data group members then organized available and relevant data for GMA 9, including basemaps with data obtained from Texas Natural Resource Information System (TNRIS) for each GCD in GMA 9 using appropriate data layers, such as administrative boundaries, transportation, hydrology, flood plain, topography, and digital orthophoto quadrangles (DOQ). The major and minor aquifers in the GMA 9 vicinity are illustrated in Figure 3.1 as a black and white rendition of the major aquifers in lieu of the color on a computer screen, with minor aquifers indicated by name in their corresponding locations. Figure 3.2 depicts the major municipalities within GMA 9 and the surrounding area.

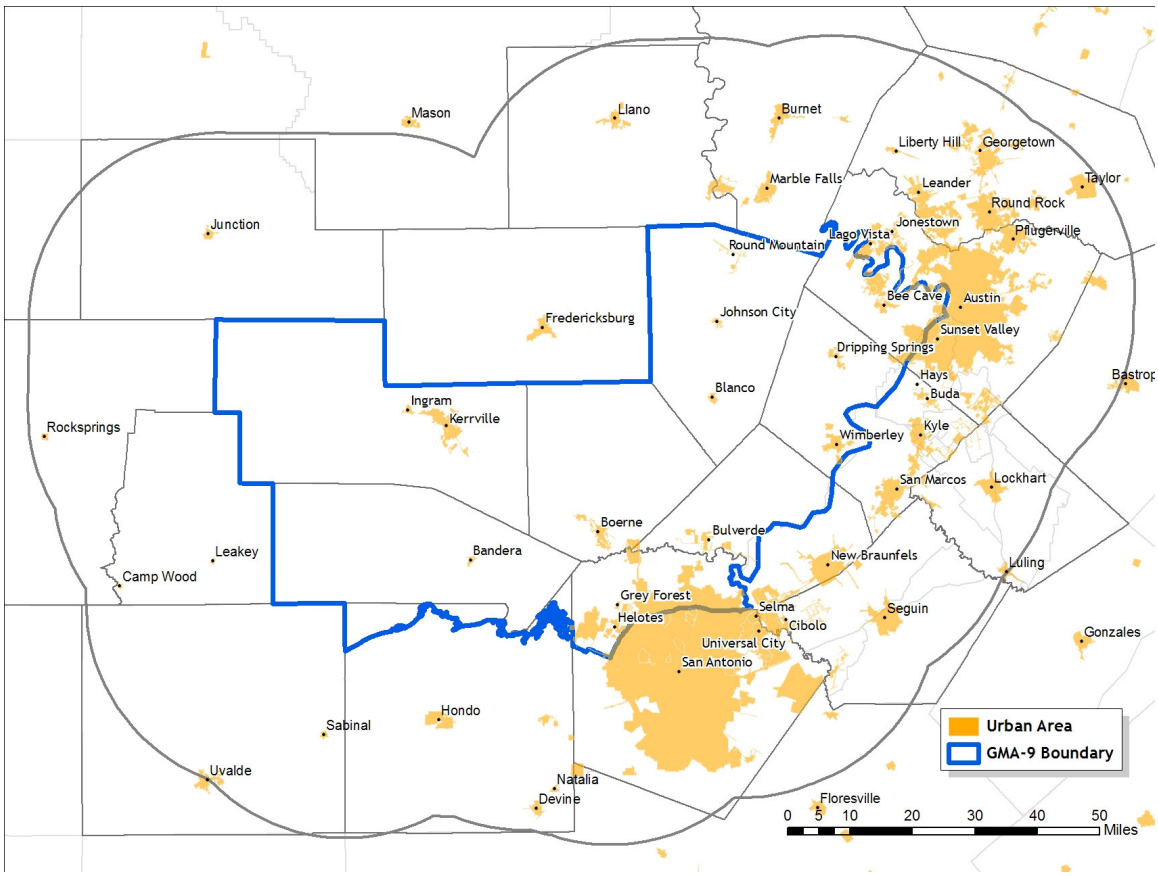
To help organize the data relevant to GMA 9, data group members collected data currently used by each GCD (including well locations, well names, drilling information, and water levels) and then analyzed the organization and content of each database by characterizing the tables and interpreting the meaning of each field. Formats are noted for inputs and units. The data group compared databases to identify common fields and those deemed to be the most important and submitted to their GCD representatives to confirm or clarify the data content. The data group also developed a table comparing each GCDs database contents.

Figure 3.1
Groundwater Management Area 9 Major Aquifers



Source: Figure created by Jules Vieau, groundwater management class, 2007.

Figure 3.2
Municipalities in the Groundwater Management Area 9 Vicinity



Source: Figure created by Jules Vieau, groundwater management class, 2007..

Information Needed to Determine DFCs

The data group collected and made accessible information to assist GMA 9 representatives in their evaluation of options for DFCs of the aquifer. For example, project staff met with GMA 9 representatives to assess data availability, organization, and need (see Appendix 7). The "wish list" presented by the GMA 9 representatives included the formation of a master database incorporating information from each GCD's separate database; the development of basemaps with roads, political boundaries, geology, infrastructure, streams, and other demarcation images; detailed water use data; information on cross-formational flow and surface water/groundwater interactions; and information on population growth and distribution.

After the meeting with GMA 9 officials, the data group members discussed how the database needs of GMA 9 could be addressed within the class's one-year time frame. GCD requests were ranked based on what tasks could be completed within the project time constraints. The development of a master database was determined to be too complex and time-consuming to be completed by part-time volunteer graduate students. The group agreed that a comparison of the GCD databases so as to identify fields and file types inconsistent from one database to the next could be accomplished within the timeframe and would be a necessary first step to creating a master database. With information from the database comparison, representatives from GMA 9 could meet and coordinate data input, field parameters, and database structure. The data group then investigated sources for GMA 9 and developed a few basemaps for the region that GMA 9 could use to illustrate spatial information.

Databases for each of the GCDs were reviewed to provide GMA 9 with information about the organization and content of the databases and the data available to assist with assigning DFCs for the aquifer. The following section provides information on each of the GCD databases.

GCD Database Descriptions

Each GCD has a database of wells, permits, and water levels. Databases were analyzed by looking at each column/field on individual spreadsheets. To clarify the meaning of data fields, the data group completed a template with the name and an interpretation of the information in each field, including the entry format, the units, and a judgment on whether the entries in the field could be restricted to particular entries or a specific entry format. After completion of the assessments, the GCDs were asked to verify the accuracy of interpretations and provide information to enable an educated guess about all information for a field. These descriptions can be used to compare the databases to determine whether they could be compiled together. For example, all GCDs might have a field for land surface elevation at a well, but they might use different units. If the GCDs could agree to a measure (for example, in feet), then the land surface elevation could be a single field in a GMA-wide database. Appendix 4 contains an analysis of the databases for six of GMA 9's GCDs. The paragraphs below discuss the GCD databases, as listed in alphabetical order.

The Bandera County River Authority and Groundwater District database can be edited and queried through Microsoft Access and Microsoft Excel. This database contains nine major data entry tables and 26 code description tables and minor tables. Some of the fields are input fields and some have a specific set of codes that can be chosen from a so-called drop-down menu: well data tables, a well registration table, a water level table, a water quality table, an infrequent constituent table, and a well casing table. In this database, locations are given in latitude/longitude. Elevations and depths seem to be measured in feet, although the table does not so specify. Although most water quality units are specified in the table, the units of concentration in the "Infrequent Constituents" table are not specified. It is also unclear what value the chemical constituents represent. Missing from this database are the aquifer parameters measured at the wells during pump

tests or other tests. For example, data are mentioned in the "Other Well Data Availability" table, but there is no field indicating where to acquire that information. The reason for the multiple TDS fields included in the "Well Registration" table also is unclear.

The Blanco-Pedernales GCD database was built in Microsoft Access and has nine major tables and 26 minor tables and code tables. The most important data entry tables are the well data table, the water level table, the water quality table, the infrequent constituent table, and the well casing table. Locations are given in latitude/longitude. Most of the lengths and depths are in feet. The casing radius seems to be in centimeters. Units for the water quality constituent concentrations are reported for each input.

The Hays-Trinity GCD database spreadsheets (Microsoft Excel) files include water wells, water well/geologic information, outcrops of a corbula bed (a relevant geologic feature), and contact points. There appears to be significant overlap in the information contained in the first two spreadsheets and the last two spreadsheets.

The Headwater GCD database spreadsheet is an .mdb file accessible in Arc Geographic Information Systems (GIS) and Microsoft Access, which can be converted to a Microsoft Excel file in Access. The fields in the spreadsheet pertain to well status and use type, location relative to potential pollution sources, or owner and property information. Based on information in the Headwater GCD database, it is unclear what personal and property information (for example, lock combinations and owner phone numbers) should be included into the GMA 9 wide database.

The Medina County GCD database consists of one basic Microsoft Excel spreadsheet and a more detailed .dbf file spreadsheet. The latter contains information on the well location, water use type, the formation being pumped from, land surface elevation, and multiple water level measurements. The meaning of the content of several additional fields was unclear.

The Trinity-Glen Rose GCD database consists of one Microsoft Excel workbook with seven worksheets. Most of the data are oriented towards the accounting of permitting fees. The worksheet "TGRGCD" contains information similar to the information in the other GCD databases regarding well location, total depth, casing information, driller information, and well identification number.

The data group compared each of the GCD databases. Many databases have fields that seem to refer to the same variable, but are written with different words or in a different format. The most common fields were well location, well owner, state well number, well elevation, well depth, depth to water, and date of the measurement of depth to water. Most of the measurements for elevation, depth to water, and well depth were in feet. Appendix 2 compares the information. If the meaning of any field was unclear, it was not used in the comparison.

Other Available Data Sources

GMA 9 overlaps three water planning regions, Water Planning Regions J, K, and L. The regional water plans include information on both surface and groundwater resources, supply, availability, use, and projected needs. Population growth and distribution projections, land use, and water management strategies are also included in the plans.

Other information sources (beyond than the GCD databases) exist. For example, the TWDB has summarized aquifer information, groundwater reports, and maps of Texas aquifers, GCDs, and GMAs. The TWDB also manages a groundwater database called the Water Information Integration and Dissemination Systems (WIID). The WIID holds location, depth, well type, owner, driller, construction and completion data, aquifer, water-level and water quality data for about 130,000 wells in Texas. The TWDB also hosts a database of submitted drillers' reports for the Texas Department of Licensing and Regulation that started in February 2001. Drillers are required to submit reports to Central Records at TCEQ, but it is optional for drillers to submit reports directly into the WIID so the well database does not include all wells.

The Texas Natural Resource Information System (TNRIS) is Texas's repository for the major categories of state digital data. The TNRIS database can be searched by quadrangle, county, or latitude/longitude location to acquire 30 meter digital elevation models (DEMs), digital raster graphics (DRGs), hillshades, elevation digital line graphs (DLG), political boundaries, and DOQs. Some information for an area of interest may not be available online but can be obtained by ordering a CD from TNRIS. TNRIS links transportation information from Texas Department of Transportation (TXDOT) files for any location of interest. Soils data for the entire state can be ordered from TNRIS.

The United State Geological Survey (USGS) can provide various surface maps and digital hydrologic unit maps and EPA river reach files. Data are available from the USGS seamless server for digital information for elevation (DEM), river networks as part of the National Hydrography Dataset (NHD), roads, political boundaries, land cover, etc. Real-time stream flow data, water quality data, and groundwater levels can also be accessed through the USGS National Water Information System (NWIS).

Many government websites offer digital data. National data can be found at the Geospatial One Stop and the National Atlas. Both of these sites offer an array of data categories such as administrative boundaries, agriculture, business, and transportation. Soils information can be found in a State Soil database (Statsgo) and a County Soil database (Ssurgo). Climate data can be found at the National Climate Data Center website. Appendix 9 lists links to online data sources.

Data Management History

The process of collecting and managing well data within the GCDs is at an early stage. House Bill 1763 that mandated that GCDs work through their GMA to arrive at consensus for desired future conditions (DFC) was passed in the 2005 legislative session. As of 2007 the Texas Legislature has not authorized funds to support data collection or

analysis by GMAs or GCDs. As of 2007, GMA 9's GCDs had different levels of funding, different ideas of best practices, and limited database management experience. No common or clearly-established methods of data collection or best practice were developed within GMA 9 to guide the GCDs.

After initial discussions with the GCDs within GMA 9, the data group began with the assumption that tracking all available well data should become a priority for each GCD. Many of the GCDs have a "backlog" of legacy paper records;[1] typically, a GCD has a small portion of the total available data in its computer database. The GCDs requested the ability to share data—especially with adjacent GCDs—so they can better judge effects of conditions in adjacent areas and the GMA as a whole.

Options Explored

The Data Group explored the option of converting each GCDs existing data to conform the TWDB's recently published "Acceptable Format" and data dictionary.[2] A second option could be to accept the TWDB format as a building block for data management and then seek out persons with appropriate skills to interpret the information. This approach could allow each GCD to choose a database complexity that suits their current situation and define a growth path that balances comprehensive data collection goals versus the reality of the GCD's limited time and financial resources.

The data collected within the TWDB database includes the representative wells used in the GAM, a data set complete in itself. The coordinates of the wells in this database could be mapped in ArcGIS over the graphic output of the GAM. The resulting maps could be validated by TWDB and then shared with stakeholders and other GCDs. Using the TWDB data as the basis would facilitate data collection and sharing in several ways. First, the TWDB database would provide the GCDs a convenient, standardized structure and allow for the GCD's existing data to be linked to the TWDB data. Second, using the TWDB database as the "kernel" for each GCD's data would provide a model to guide future data collection. Third, data following the TWDB acceptable format could be conveniently shared among GCDs and with the TWDB. Finally, because the data format within the TWDB database is fixed, basic instructions for using the data in MS Access and ArcGIS could be provided in a written form and available on the TWDB website. Some of the advantages of building a common groundwater database around the TWDB's records are that that the data:

- would become consistent and available from the TWDB;
- provide a model format and basic schema to guide future data collection;
- can be used independently or with data collected by GCDs;
- lift some of the perceived and real burdens of work from GCDs; and
- can be provided to each GCD in a relatively short period of time (months), so information would be within each GCD's control.

Implementing this recommendation would require some modest intervention by the GMA or GCDs to assign an appropriate staff member to complete the project or to hire someone to convert the TWDB information for GCD use. In public meetings, some GMA directors indicated that they could support the idea of hiring staff to improve the GMA 9 database.

Notes

[1] Interview with Miguel Pavon, Texas Natural Resource Information Systems, Austin, Texas, November, 2006.

[2] Ibid.

Chapter 4. Training Group Survey

The Center for Public Policy Dispute Resolution (CPPDR) at The University of Texas School of Law, with assistance from project graduate students, developed a survey to administer to groundwater representatives from all the groundwater conservation districts (GCDs) in Texas. The survey was administered to representatives from all GCDs in Texas who registered for a dispute resolution conference organized by the CPPDR. The survey was developed to be administered three times: once prior to the conference, once immediately after the conference to those attending the conference, and once several months after the conference to the entire group to which the first survey was administered.

The survey was designed to develop an understanding of managers' and board members' attitudes and preferences toward working together in their GCDs and groundwater management areas (GMAs). The survey also sought GCD reports in the nature of public involvement in the DFC processes and actual GMA and GCD behavioral practices of public involvement in the decision-making process.

By gathering information on these subjects and comparing pre- and post-training responses, these surveys could measure any change in attitudes and actions resulting from the specific dispute resolution training. For example, the three surveys could provide evidence of changes in attitudes toward collaboration, public involvement, as well as changes in behavioral practices before and after the training. If participants tended to change their answers to the same questions, one inference might be that dispute resolution training could have been a cause for the change. By administering both immediately after training, changes in attitude of those attending the training could be assessed. The last survey could both measure whether any change lasted over time and compare the attitudes of those who attended the training against those who did not.

The training group decided to administer the survey by using Survey Monkey® software.[1] This software allows the survey to be administered electronically over the Internet rather than in paper form. This saved the staff time and postal expenses, and provided an easy way for respondents to complete and submit the survey. The software allows survey questions and results to remain secure. The software allowed the staff to compile, sort, and analyze survey results electronically rather than by hand. Individual responses were kept anonymous.

Once the goals of the survey and method of administration were decided, the training group went through several drafts before completing the design and questions. Staff spent several work sessions discussing specific wording of survey questions and how best to represent answers on an interval scale. A rough draft of the survey was administered to all the students in the graduate class in September 2006. After taking the survey, the class participated in an open feedback session. Suggestions and corrections to the survey were incorporated in the following weeks. A revised survey was tested on staff at the TWDB, revised further, and entered into the computer software. A final draft of the

survey was emailed to the class to provide one last test run before it was formally distributed to GCD and GMA participants.

An email was sent to representatives of GCDs, including conference registrants several weeks prior to the conference asking them to complete an online survey. Registrants who had not taken the survey five days before the conference were called and encouraged to take the survey online prior to their arrival at the conference. Any conference participants who still had not completed the survey when they registered at the training were encouraged to complete a paper copy of the survey, which then was entered into the online database. Individual responses to individual questions were kept confidential. Staff used the software to maintain a record of who had or had not responded.

The dispute resolution conference was sponsored by the CPPDR at The University of Texas School of Law and supported financially by the TWDB. Representatives from 58 districts and 14 GMAs attended; there were four representatives from GMA 9. Class members were invited to observe the training program. GCD participants explored new collaboration and communication skills in the context of issues faced in the DFC process. The trainers and attendees discussed conflict analysis; held dialogue on the DFC process, negotiation and consensus-building; cooperative problem-solving; and collaborative processes. The training introduced new skills on how to be better listeners, hold more productive meetings, sense and prevent trouble in a meeting, talk about issues from an interest-based perspective (as opposed to a positional perspective), and how to work with people who may feel threatened or defensive. The results of the survey are still being collected and analyzed by CPPDR staff. Details about the survey results will be compiled by the CPPDR and given to the Texas Water Development Board in a separate report. It is beyond the scope of this report to discuss the results of the survey. The questions used in the survey can be found in Appendix 3 of this class report.

The training represents an effort to provide GCDs tools to work collaboratively in the DFC process, and to encourage GCDs and GMAs to involve stakeholders in considering DFCs. Some of the lessons learned were used to design public outreach meetings in GMA 9 during February and March 2007, as discussed in Chapter Six. The following chapter covers the PRP's groundwater modeling analysis.

Notes

[1] Survey Monkey. *Survey Monkey*. Online. Available: http://www.surveymonkey.com. Accessed: July 2, 2007.

Chapter 5. Groundwater Modeling

The Trinity Hill Country Aquifer Groundwater Availability Model (the GAM) was developed by the TWDB to simulate regional water levels and availability.[1] Three aquifers are included in this model as separate layers: the Edwards Group of the Edwards-Trinity plateau, the Upper Trinity, and the Middle Trinity. Predictive pumpage included in the initial development of the model increases groundwater pumping over time, based on projections from the regional water planning groups included in the 1997 state water plan. The TWDB published a report on the development of the model (Report 353)[2] which provides detailed information on model structure, inputs (such as pumping rates and recharge) and calibration procedures. That report contains information that summarizes model results, including saturated thickness, drawdown, and water budget analysis. A steady state model is calibrated to observed water levels from winter 1975-1976, and the transient model is calibrated to observed well levels during a 24 month period (1996-1997).[3] The model also allows a user to simulate the drought of record.

Members of the PRP class created a "Model Group" to develop software tools that could interface with the Trinity Hill Country GAM and allow users to examine alternate model runs with different pumping rates. The section below describes features and limitations of this software. The software has been used to analyze how the impact of pumping changes could affect groundwater levels throughout the aquifer. A summary of these results is included in this section, with a more thorough report attached as Appendix 4.

Trinity Hill Country GAM

The Trinity Hill Country aquifer GAM is a MODFLOW model that was developed by the TWDB to simulate regional water levels in the Trinity Hill Country Aquifer. The GAM was constructed after analysis of the Trinity aquifer's physical and hydraulic properties. Pertinent GAM information is outlined below, along with a discussion of the model calibration, performance, and limitations.

The GAM can be used to evaluate pumping from any of the three aquifers included in the model. The uppermost aquifer (layer) in the model is the Edwards group of the Edwards-Trinity (Plateau) (layer 1), followed by the Upper and Middle Trinity Aquifer layers (layers 2 and 3). The model uses a one-mile grid spacing and contains 69 rows and 115 columns. The thickness of each layer was estimated using geologic structure maps and United States Geological Survey (USGS) digital elevation models. It is beyond the scope of this report to describe how TWDB modeled the Trinity Hill County Aquifer or the detailed assumptions underlying the constraints of the GAM, as those matters are discussed in detail in the TWDB report.

The GAM was developed based on information on patterns of historic precipitations, sources of recharge to the Trinity Aquifer in the Hill Country area, historical pumping rates, and future pumping estimates consistent with Regional Water Planning Group projections of withdrawals for 50 years.[4]

Recharge conditions in the model are separated into non-drought and drought categories. Average recharge (non-drought conditions) exists within the model from the beginning of the predictive phase or 1998 and extends for the first 44 years of the simulations. Average recharge conditions are based on precipitation estimates collected from gauging stations throughout the GMA 9 region from 1960 to 1990. The drought of record in the model occurs for the last seven years, at the end of the model simulation. Drought conditions are based on precipitation estimates collected during the region's drought of record from 1950 to 1956. At the peak of this drought, recharge from precipitation dropped to half of the average (non-drought) values. The TWDB calibrated the GAM based on water levels measured in the Middle Trinity Aquifer for the winter 1975-1976 so as to assure that the calibrated steady state model reproduces the spatial distribution of water levels in the Middle Trinity Aquifer for the winter 1975-1967 within an acceptable confidence interval.[5] The TWDB then calibrated the model for transient conditions using water level fluctuations according to recharge and pumping variations in 1996 and 1997.[6] The calibrated GAM remains a generalization at a large scale of a detailed hydraulic system. Predicted and observed water levels differ by 40 feet in some places and as much as 100 feet in the north-eastern portion of the aquifer.

The GAM has many limitations including the limited sources of data for recharge and pumping over time and space and its course spatial resolutions (one mile square grids). While the model is appropriate to apply on a regional basis, it was not intended to predict water levels in any particular well or discharges to any specific spring. The model reports an average water level for each cell, although in a real aquifer a water table can vary significantly over short linear ground distances. The GAM reports average water levels over a whole year so it does not include seasonal variations that can affect any particular well. The model group varied pumping in the model to observe how water levels might be affected with changes in pumping. As a result of the uncertainty regarding springflow in the GAM, this study does not attempt to report desired future conditions in GAM springflows.

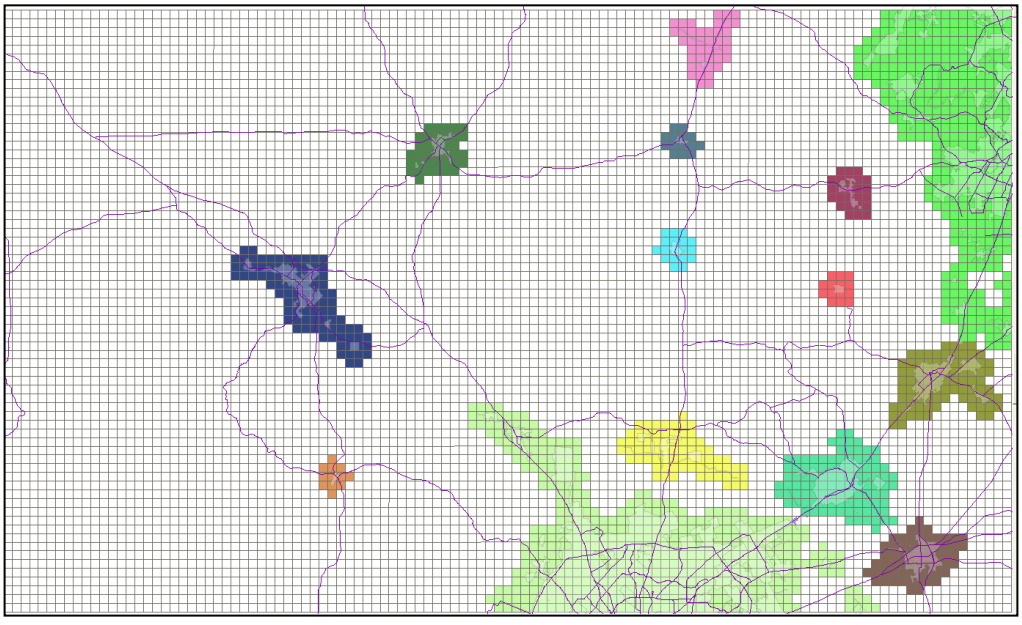
Software Description

The Trinity Hill Country GAM is endorsed by the TWDB for groundwater planning in GMA 9. One goal of this project was to help stakeholders and managers gain insight and understanding of the groundwater from that model. The software developed by this UT project is intended to allow users to explore the impacts of increased or decreased pumping in the Hill Country area in each zone so as to provide information about desired future condition options. The software provides a graphical user interface (GUI) which allows users to easily manipulate pumpage. The software saves results from each scenario and provides a graphing utility to investigate and report pumping scenarios. By March 2007 a stand alone application had been developed specifically for GMA 9. This project is written in Java and was tested in Java Runtime Environment (JRE) 1.5.08. Development took place in Eclipse 3.2, and a code repository (CVS) keeps track of changes to the software and also provides a synchronization utility between group members. Appendix 11 describes the programmatic data structures.

The model group's software allows users to report results by three types of subregions: counties, cities, and road corridors. Since the Trinity Hill County GAM itself does not contain spatially indexed data, students in the class overlaid the model grid onto a map of GMA 9 to determine the precise location of each cell in the model to create special zones for consideration in the model.

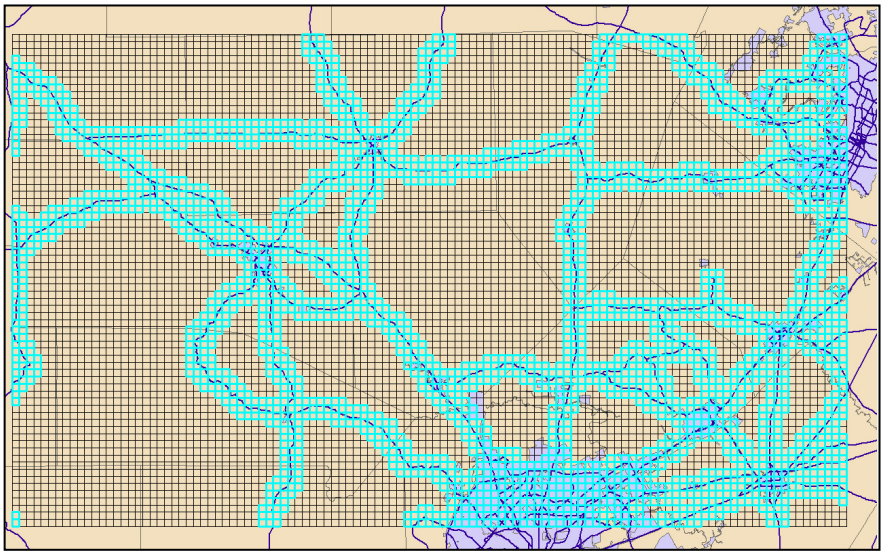
A zone has been created for each of 11 counties within the model to permit regional analyses of model inputs and outputs (not illustrated in the chapter). Fourteen other zones have been created for each city, including any cells within two miles of an urban area, one-mile grids around. Figure 5.1 shows a portion of GAM 9 with the model grid overlaid with roads and cities. A user can control the pumping and examine model outputs for any of 14 cities. This figure illustrates cities in the Texas Hill Country from Austin in the northeast to San Antonio in the south. A final zone represents expected growth corridors along major highways, an approach suggested by Ron Fieseler.[7] Cells within one mile of a major highway have been included in the potential growth zone. Figure 5.2 illustrates only a portion of the region. For a list of county and city zones, see Table 5.1.

Figure 5.1
Hill Country Town Grids Expected Growth



Source: Figure developed by the UT GMA 9 Groundwater Management Class, 2007.

Figure 5.2
Expected Growth Corridors—Highways



Source: Figure developed by the UT GMA 9 Groundwater Management Class, 2007.

Table 5.1
Zones in the Hill Country Model

Counties	Cities	Growth Corridor
Bandera	Austin	Highways
Bexar	Bandera	
Blanco	Blanco	
Comal	Bulverde	
Gillespie	Dripping Springs	
Hays	Fredericksburg	
Kendall	Johnson City	
Kerr	Kerrville	
Kimble	New Braunfels	
Medina	Round Mountain	
Travis	San Antonio	
Uvalde	San Marcos	
	Seguin	
	Wood Creek	

Source: Table developed by the UT GMA 9 Groundwater Management Class, 2007.

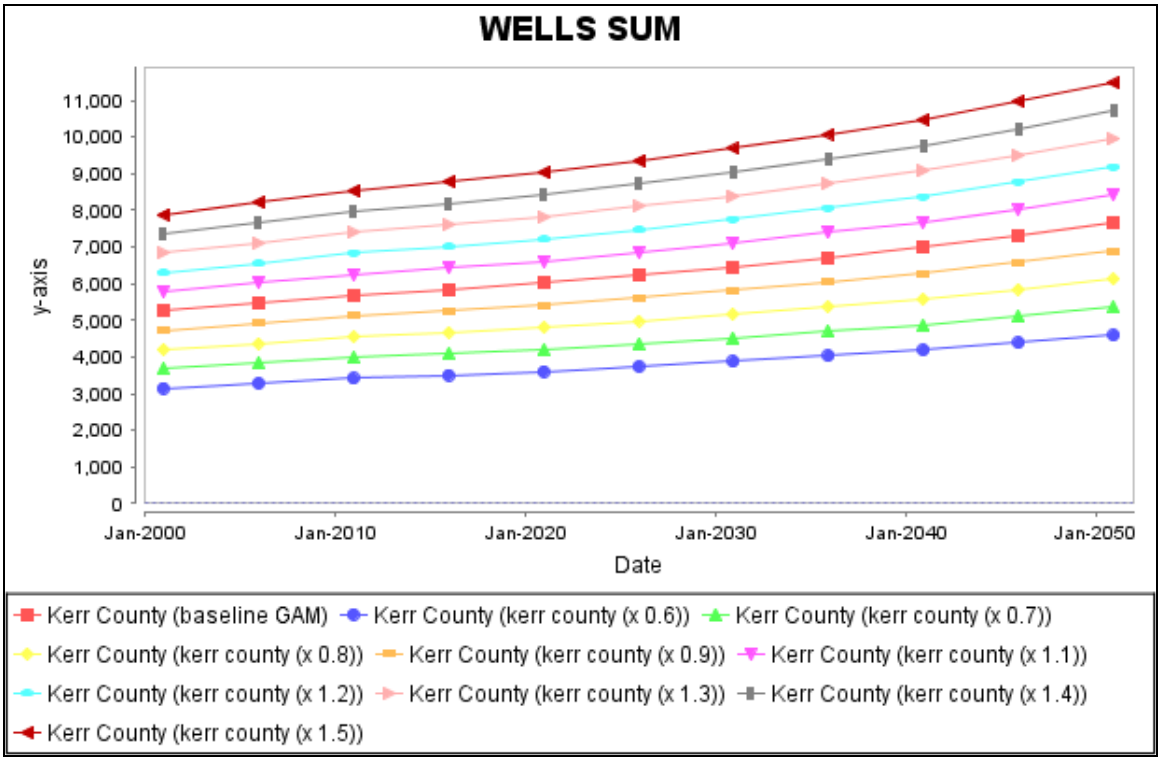
Zone-Based Pumping Scenarios

The software allows a user to edit pumping in each zone by modifying the predictive pumping data set developed with the original GAM. Appendix 4 describes a series of runs that vary pumping in each of the counties to observe how pumping can affect average groundwater head levels in that county and other counties. For simplicity, the changes to pumping are defined relative to the baseline GAM model via a pumping factor. A pumping factor of 1.1 corresponds to a 10 percent increase in the pumping specified in the baseline GAM model. Figure 5.3 reports the groundwater pumped for 10 simulations ranging from 0.6 baseline pumping to 1.5 baseline pumping in Kerr County. A factor of 0.9 indicates a reduction to 90 percent of the baseline pumping in the baseline GAM model. The software alters the pumping rates uniformly and does not change the spatial distribution of groundwater withdrawals within defined zones.

Pumping factors were chosen because they are simple to work with. The software is designed to support real time analyses as users will not have time (or the proper information) to edit pumping cell by cell. The goal of the pumping factors is to let stakeholders test how increased or decreased pumping affects groundwater head levels, the average drawdown over a specific zone, the total change in storage over the entire aquifer, or the discharge to a specific river.

There are two potential pitfalls when changing the pumping factor. Increasing the pumping factor for large pumping centers can place local stress on the model, particularly in Bexar County and southern Kendall County. Pumping factors cannot introduce new pumping in a cell where there is no pumping. It is beyond the scope of this report to provide a users' manual for the software.

Figure 5.3
Aquifer Withdrawals for Different Pumping Factors in Kerr County

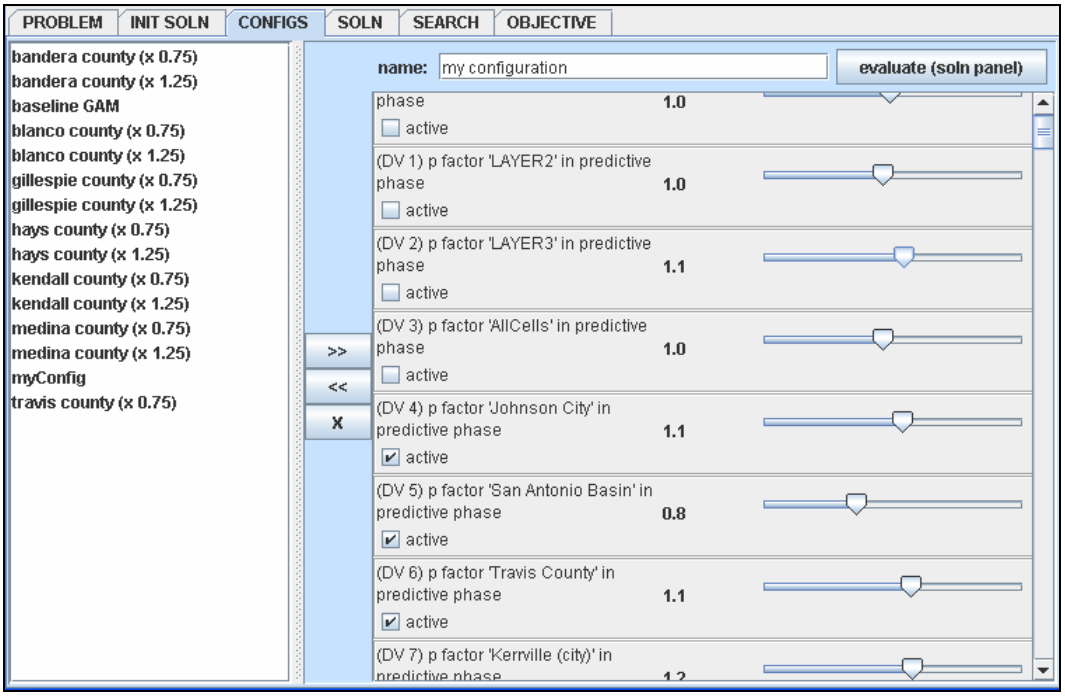


Source: Figure developed by the UT GMA 9 Groundwater Management Class, 2007

Figure 5.4 illustrates a screenshot from multiple runs and illustrates how a user can select alternative pumping scenarios. When a user initiates a run, these instructions trigger the software to fetch data from the proper output files. The graphing utility in the program interprets and presents the data as series plots or maps. Tables 5.2 and 5.3 provide information to interpret these results.

The modeling group has verified that the code managing the pumping and reading the outputs is working properly. Project staff validated the code by cross-checking outputs from the baseline model in PMWIN with those generated using the software, including hydraulic head, well discharge, and drain discharge parameters. The well files created by the software have been forwarded to the TWDB for their independent verification of software results. External validation of the graphical user interface software by TWDB staff will occur according to a schedule reflecting TWDB priorities.

Figure 5.4
Screen Shots of the CONFIGS Panel



Source: Figure developed by the UT GMA 9 Groundwater Management Class, 2007.

Table 5.2
Information for Interpreting Results

- The model will not converge for all settings. Users cannot save the results if the model does not converge.
- If pumping in a cell reduces the aquifer's level in the cell too much, MODFLOW will turn off future pumping in that cell and it will become a "dry" cell. Under high pumping many cells could be defined as dry, reducing the volume of water withdrawn from the aquifer.
- The software computes averages and sums from cells that yield water. If many cells cecome dry, summary statistics reflect those cells with pumping.
- The GAM report county-wide average head levels.
- It is not easy to measure the absolute influence of pumping from one county on average annual aquifer head level in another county. The impact in the target county is a measure of the intensity of pumping, the proximity of the two counties and the size of the target county. If the target county is small, then it is possible that pumping in a neighboring county can have a strong influence throughout the entire target county. If the target county is large, then only a fraction of it may be affected, having a limited impact on the countywide average.

Source: Table developed by the UT GMA 9 Groundwater Management Class, 2007.

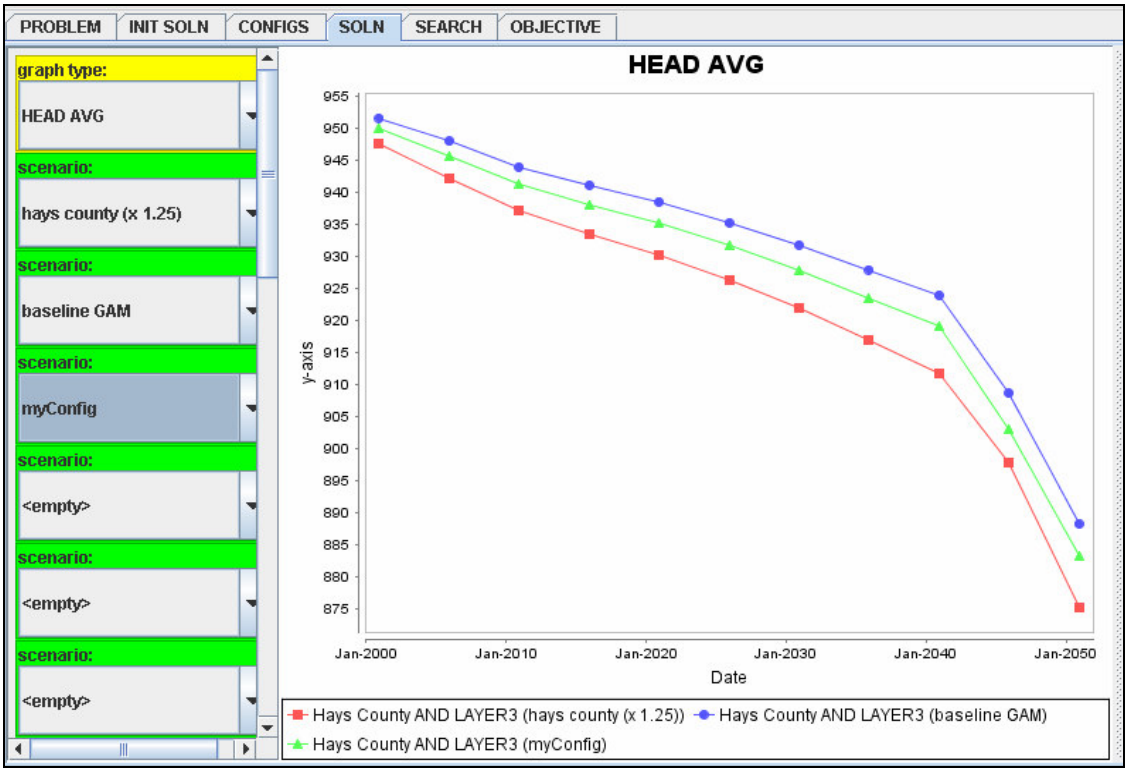
Table 5.3
Values Reported by the University of Texas "Wrapper" Program

Value Name	Units	Notes
HEAD AVG (average head)	Feet	Averaged over all the cells in the zone excluding dry cells. The average head is only computed for one specific layer at a time (never averaged across layers).
DRAWDOWN AVG (average drawdown)	Feet	The drawdown is referenced to the head levels in the model in December 1997 (stress period 26). The values are averaged over all the cells in the zone (excluding dry cells). The average drawdown is only computed for one specific layer at a time (never averaged across layers). Negative drawdown indicates that water levels have dropped compared to 1997.
DRAINS SUM (total drainage for a specific zone)	Ft^3/day	Adds zone DRAINS values
RECHARGE SUM (total recharge for a specific zone)	Ft^3/day	Sums up the RECHARGE entry in the cell by cell water budget file for every cell in the specified zone. A positive value indicates that water is entering the aquifer.
WELLS SUM (total pumping for a specific zone)	Acre-feet/year	Sums up the WELLS entry in the cell by cell water budget file, for every cell in the specified zone. A positive value indicates water is being pumped from the aquifer. The units are presented in acre-ft/year to match the planning projections.
HEAD DRYCELLS (number of dry cells)	---	The number of dry cells found in a specific zone.
DRAWDOWN CONTOUR	Feet	Shows the water level change since 1997. A negative value indicates a water level decline. Dry cells are shown in white.
HEAD CONTOUR	Feet	Shows the head level in the aquifer. Dry cells are shown in white.

Source: Table developed by the UT GMA 9 Groundwater Management Class, 2007.

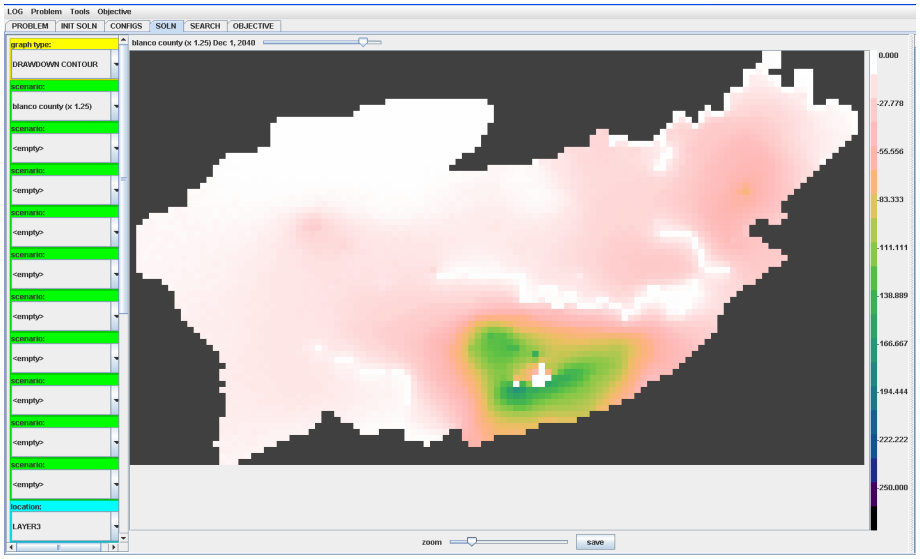
Figure 5.6 illustrates a graph of aquifer drawdown levels for three simulations related to Hays County. Figure 5.6 reproduces a screen shot of the aquifer drawdown across GMA 9 for a scenario with increased pumping in Blanco County in the year 2040. Figure 5.7 reproduces the screen image of multiple simulation runs showing diverse performance measures of aquifer performance.

Figure 5.5
Screen Shots of the SOLN Panel



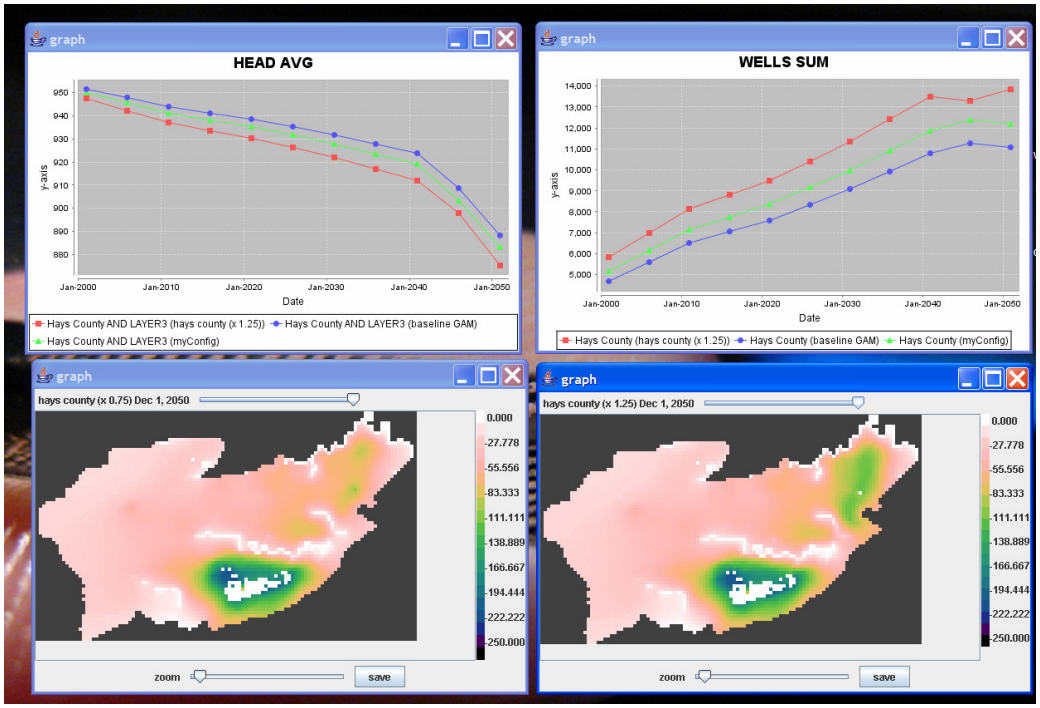
Source: UT GMA 9 Groundwater Management Class, 2007.

Figure 5.6
Screen Shot of the Graphing Capabilities



Source: Figure developed by the UT GMA 9 Groundwater Management Class, 2007.

Figure 5.7
Illustration of a Multiple Simulation Run Result

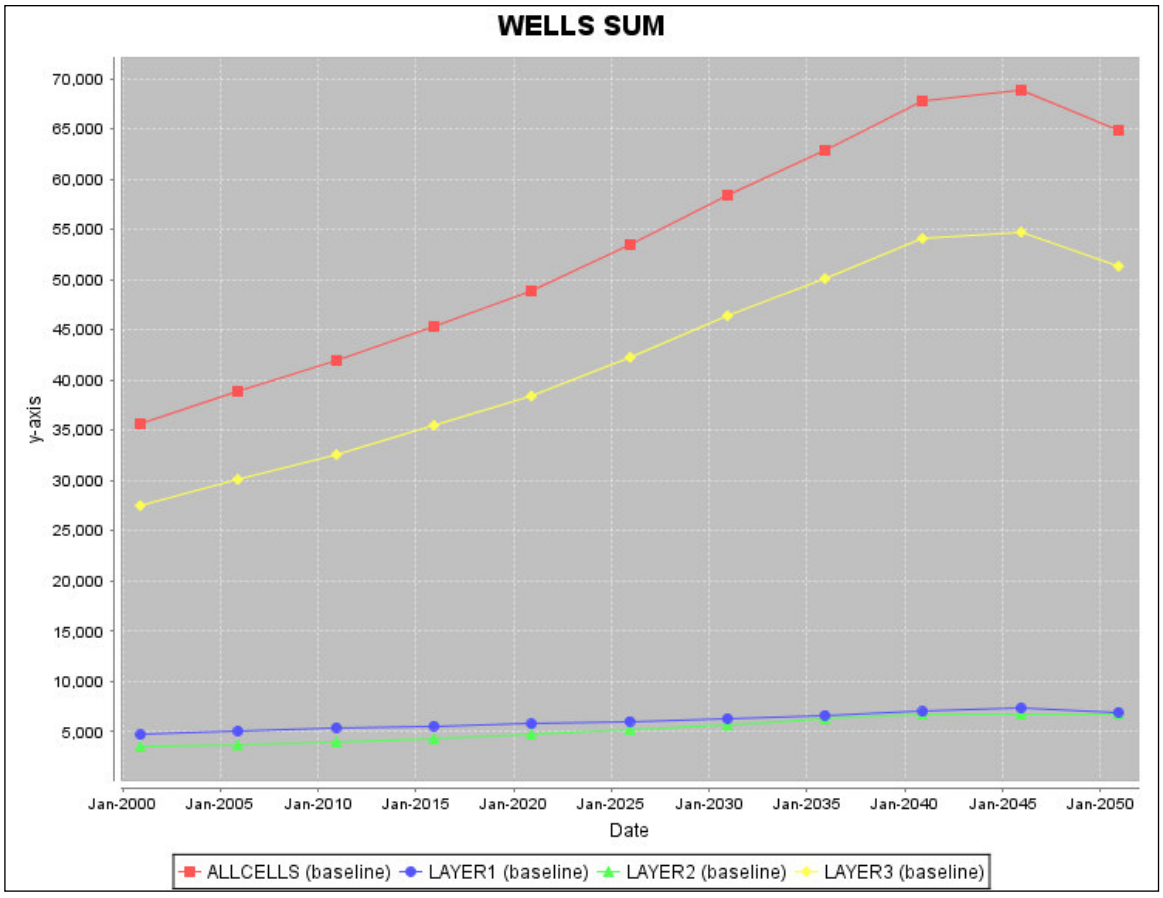


Source: Figure developed by the UT GMA 9 Groundwater Management Class, 2007.

Aquifer Results and Analysis

The modeling group ran different water use scenarios to investigate how pumping within each county affects expected average annual water levels within each county aquifer and neighboring counties. In each scenario, pumping was increased or decreased in a single county, while the pumping in the other counties followed the baseline model. This analysis involved 44 model runs which varied pumping in nine counties. For each county, the goal was to examine a range of different pumping factors, ranging from 0.25 to 2.0. The model did not converge for all of these settings, particularly in counties that already have high pumping. On average, there were five scenarios per county, considering both increases and decreases in the pumping factor. Figure 5.8 illustrates the projected increase in pumping for the baseline GMA9 model for the period 2000 through 2050. During the drought, the actual pumping in the model decreases slightly as cells go dry.

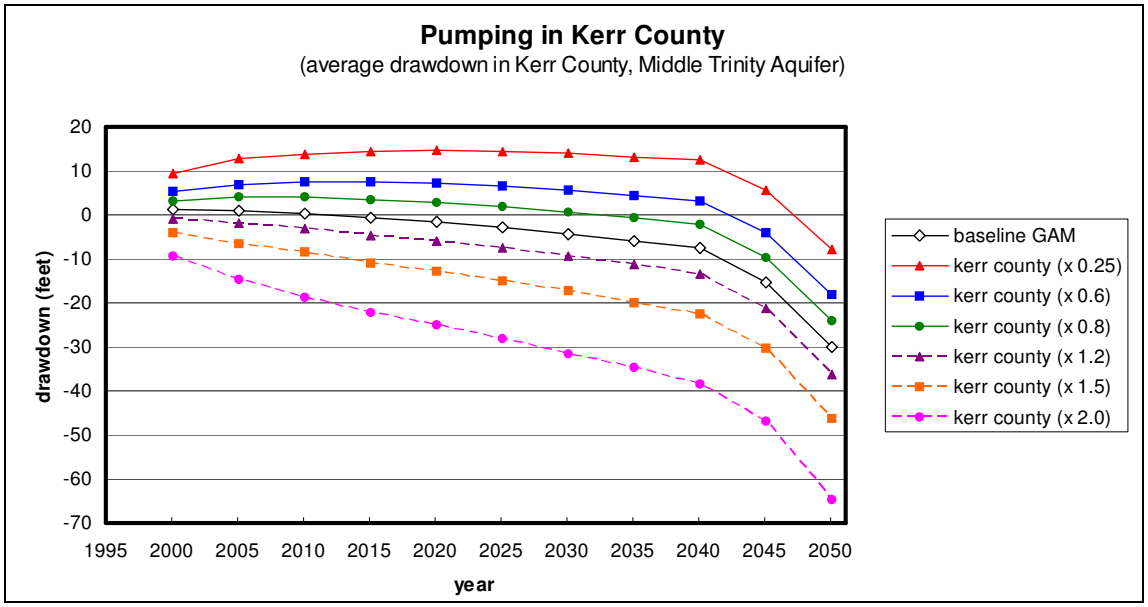
Figure 5.8
Pumping Withdrawals for the Entire Aquifer



Source: Figure developed by the UT GMA 9 Groundwater Management Class, 2007.

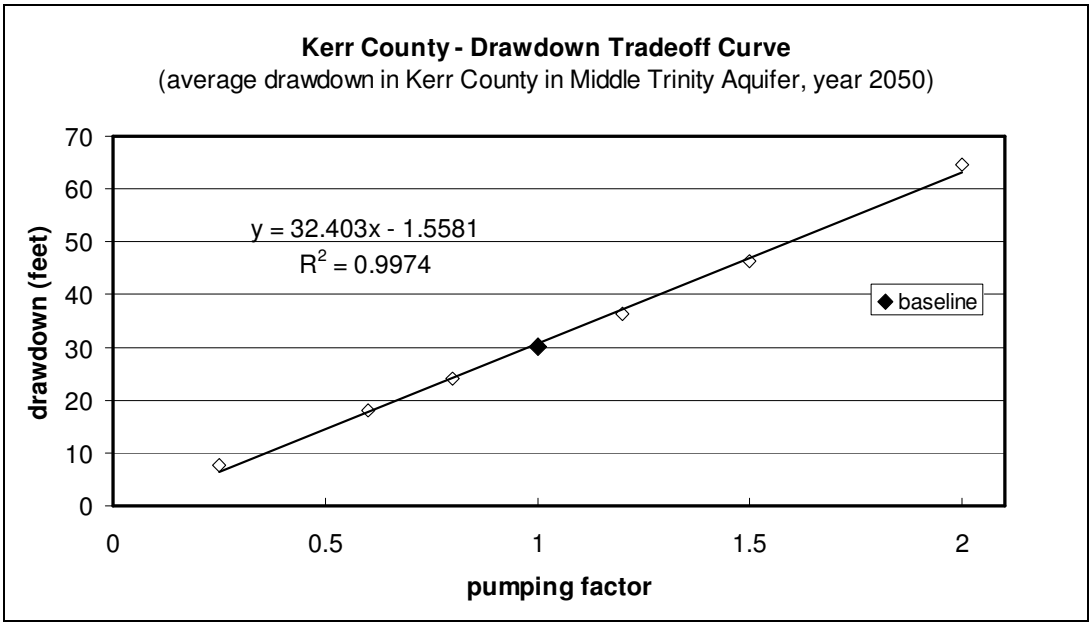
Appendix 4 reports results from a series of runs illustrating how different pumping patterns affect aquifer water levels. For example, Figure 5.9 illustrates six different scenarios adjusting the baseline pumping in Kerr County by multiplying by the following factors: 0.25, 0.6, 0.8, 1.2, 1.5, and 2.0. Figure 5.9 shows the drawdown curves as a time series at 5 year intervals for these different pumping scenarios. The impact of the drought is evident in the years 2045 and 2050, as drawdown increases. Figure 5.10 is an illustration of a regression result that indicates that head levels appear to be related linearly to pumping factors; each 10 percent increase or decrease in pumping alters the average county-wide aquifer head water levels in 2050 by about 3.2 feet in Kerr County within the range explored.

Figure 5.9
Pumping and Drawdown in Kerr County



Source: Figure developed by the UT GMA 9 Groundwater Management Class, 2007.

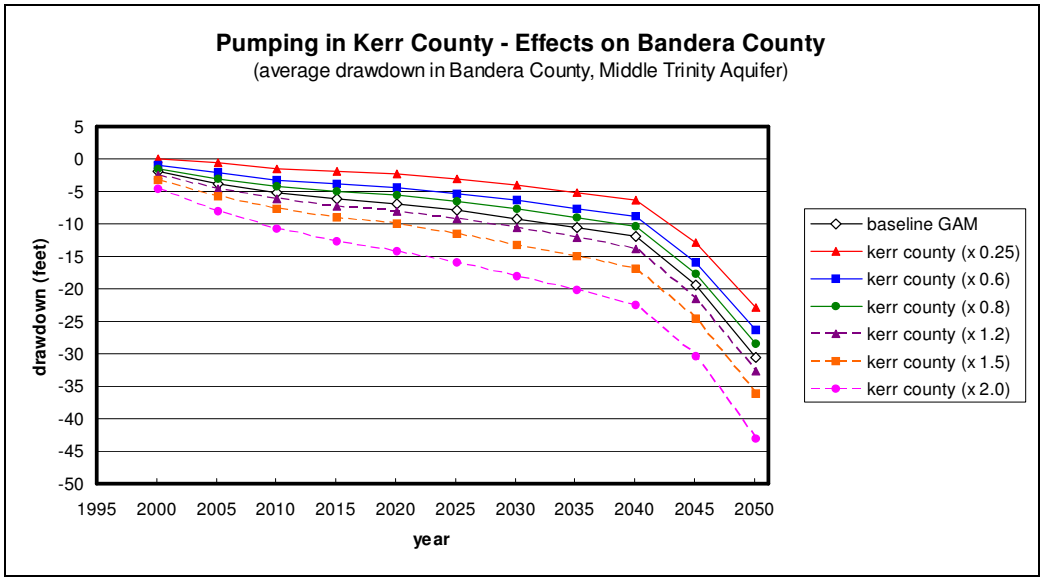
Figure 5.10
How Increased Pumping Appears to Affect Aquifer Drawdown



Source: Figure developed by the UT GMA 9 Groundwater Management Class, 2007.

Pumping changes in Kerr County affect head levels in some neighboring counties, just as pumping in neighboring counties can have an impact on Kerr County. Figure 5.12 shows that water levels in Bandera County are affected by pumping in Kerr County. A 50 percent increase in pumping in Kerr County causes an extra six feet of drawdown in Bandera County (averaged in the Middle Trinity throughout Bandera County in the year 2050). Pumping in Kerr County also affects the head levels in Kendall County (see Figure 5.12). Table 5.4 lists pumping rates, both those embedded in the GAM (for 1997 State Water Plan estimates) versus the GCD's current 2007 estimate of pumping within their counties (the so-called 2007 county estimates). Current patterns of pumping tend to be higher than the 1997 State Water Plan estimates (particularly for the Trinity Glen Rose), although there are exceptions (the Hays-Trinity GCD).

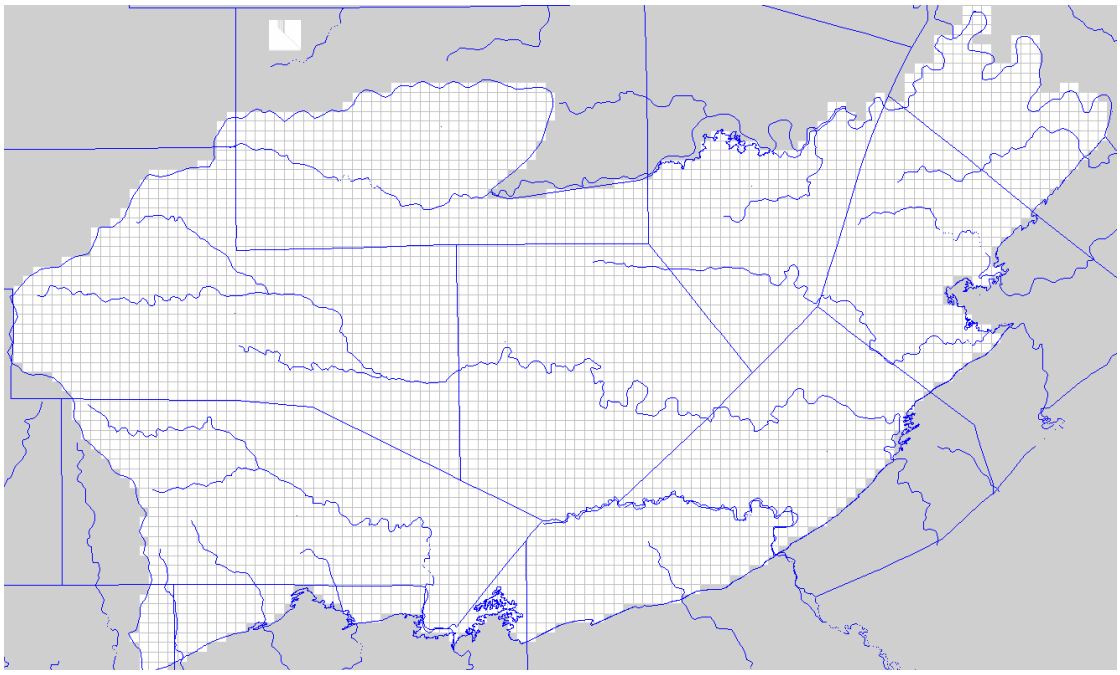
Figure 5.11
How Increased Pumping in Kerr County Affects Aquifer Drawdown in Bandera County



Source: Figure developed by the UT GMA 9 Groundwater Management Class, 2007. The legend at right indicates pumping at some multiples of the baseline pumping for Kerr County during 2000 to 2050.

Figure 5.12 is an attempt to illustrate in an approximate visual manner the interactions between pumping and water levels in several counties. An arrow from one county to another indicates that pumping in the first county (the tail of the arrow) affects on the average water levels in the adjacent county (the head of the arrow). The boldness or size of the arrow (not drawn to scale) is intended to help a reader visualize the quantities of the relative magnitude of the water level reductions. The average heads provide a quick account of the pumping interactions, but these interactions also depend on the size and proximity of the two counties, as well as the distribution of pumping; these factors are not taken into account within Figure 5.13.

Figure 5.12
County Pumping Interactions



Notes

[1] Texas Water Development Board, *Trinity Hill Country Aquifer Groundwater Availability Model*. Online. Available: http://www.twdb.state.tx.us/gam/trnt_h/trinity.htm. Accessed: July 2, 2007.

[2] Texas Water Development Board, "Groundwater Availability of the Trinity Aquifer, Hill Country Area, Texas: Numerical Simulations through 2050." No. 353, Austin, Texas, September 2000.

[3] Ibid.

[4] Ibid.

[5] Ibid., p. 77.

[6] Ibid., p. 90.

[7] Interview with Ron Fieseler, General Manager, Blanco-Pedernales Groundwater Conservation District, Austin, Texas, November 12, 2006.

Chapter 6. Public Outreach Meetings

After project staff had interviewed stakeholders, a second phase of public outreach was to invite the public to discuss the preliminary project results from stakeholder interviews, groundwater data collection, and groundwater availability modeling. One meeting was held in Johnson City on February 19, 2007, and a second meeting was held the following night in Kerrville. Additional meetings were held in Boerne on April 16, 2007, and in Wimberley on April 17, 2007. Prior to each meeting, press releases were sent to local newspapers. All of the Groundwater Conservation Districts (GCDs) posted notices informing the public of the forthcoming meetings. The goal of the meetings was to engage the public, encourage their evaluation of the initial research, and seek public advice on how GMA 9 could develop desired future conditions that reflect the preferences of the community.

The format of each public meeting followed a similar pattern to a class presentation to the GMA 9 Board in early December 2006. After an introduction from University of Texas graduate students, Ms. Rima Petrosian (representing the Texas Water Development Board) described the GMA planning process and Ron Fieseler, General Manager of the Blanco Pedernales GCD, reported on how the GCDs within GMA 9 have begun to address the challenge of determining desired future conditions (DFCs). Students from each of the groups (modeling, data, and stakeholders) presented results. Following these presentations, the public was invited to pose questions to any of the speakers or provide advice to their GCDs and GMA 9 on how to determine DFCs. This chapter discusses the contents of the public forum question and answer session.

Public Meeting in Johnson City on February 19, 2007

After initial presentations (see above), the public in attendance had time to ask questions clarifying the presentations. One of the first questions concerned managed available groundwater: whether or not the existence of "desired future conditions" (DFCs) and a volume of "managed available groundwater" (MAG) meant that any particular GCD would be required to permit a fixed volume of groundwater. Ms. Petrosian's answer was that a MAG volume is a guideline, as Texas does not stipulate that any MAG is an upper limit or a lower limit. A GCD is not required to permit the entire MAG, but could do so or the MAG could be exceeded. Further public comment addressed the concern that the MAG might become a minimum level so GCDs could feel pressured to permit the entire MAG with exempt wells adding pumping water at a level above the MAG. This led to questions as to whether or not a DFC and a MAG might lead to mining of the aquifer. Ms. Petrosian clarified that the question of "to mine or not to mine" was in fact a decision to be made by GMA 9 with advice from the stakeholders. A topic of sustainability was then raised. The response was that GMA 9 was charged with providing its own definition of sustainability through the DFC process. The process of establishing a MAG was discussed; each GCD could determine a county specific MAG from the GMA 9's total MAG, which allows for local control.

Dr. David Eaton, University of Texas faculty member, then asked the audience for their advice to the GMA districts as it considers setting desired future conditions for the Hill Country aquifers. One reply suggested that GCDs within GMA 9 establish consistent planning methods. A second respondent called for meaningful public input prior to making decisions.[1] One speaker expressed distrust among those present and their GCD districts. He stated that his prior comments and the prior comments of others, both written and verbal, had not been given appropriate consideration by their GCD districts:

> We have seen the effort to involve the public be narrowed and shut down progressively by this district and there is a tremendous amount of distrust on the part of some of us in this district, and I don't trust this district as presently constituted to make this decision on my behalf…[2]

The next respondent pointed out:

> …that this area is losing springs right and left, seeps are gone. This has got to get into your model. Three springs are stone dead. We need to find a way to crank this information into the planning. If you take the levels too low we are going to continue losing the springs, we are going to lose the tourist industry, and agriculture and wildlife management and managed hunting that is our sustainable industry in this county.[3]

Another individual informed those present that "a few years ago a survey was taken of registered voters asking what do you want to see,"[4] and the top three responses were "open space, water quality and availability, sustainability, and carrying capacity."[5] This comment was followed by an individual stating that:

> We would like to think that this county which has a low population because of poor water conditions doesn't overshoot its carrying capacity like San Antonio. We want to see better control locally over the kind of development that is being imposed on us by outsiders. We look to subdivision law (which are weak in this county), county commissioner level to the GCD which many of us worked to establish through the petition process, to try to not let us have runaway growth. DFC to me has some relationship to sustainability and carrying capacity…[6]

Dr. Eaton's second question to the audience was to ask them to choose what they would prefer: no increase in pumping in the future, versus more future pumping and the associated decline in spring flow and aquifer levels. One respondent pointed out the personal cost of maintaining wells and that this could be considered a tax on persons on a fixed income. One audience member asked for a show of hands to answer this question. The response was strongly in favor of no increased pumping, with eight for "no increase" in pumping and one supporting increased pumping.[7]

Dr. Eaton's third question was: "If you prefer to maintain average aquifer levels, where should new water come from for expected growth in the Hill Country?"[8] One individual suggested rain water collection and expressed a strong preference for no surface water

pipelines. He pointed out that "pipelines are not sustainable, during drought of record there will likely be no water at either end of the pipe."[9] The next comment was:

> Growth is not inevitable and it does not just pop out of the sky. It is a function of government policy. We need to match policy to the kind of growth that we are willing to tolerate here, rather than have it imposed on us by out-of-county developers.[10]

Another member of the audience pointed out that "the vast majority of new wells are domestic-use exempt wells and thus not subject to GCD control, and that this will continue to impact planning."[11] This comment led to a concern over assumptions of GAM models and how the elements compare to reality. One issue was whether a GCD could control the amount of pumping. A second comment was whether anyone knows how many wells there are or how much they pump today. The person stated that if a GCD does not take unregulated wells into account, then its assumptions would not track practice, and make the process of coming up with meaningful goals virtually impossible. After this discussion the meeting adjourned.

Public Meeting in Kerrville on February 20, 2007

The Groundwater Policy Research Project conducted the second public meeting in Kerrville at the Kerrville Groundwater District Headquarters on February 20, 2007. Nine members of the community were present to ask questions regarding the project's work and to suggest directions for future efforts. Class members followed a presentation format similar to the public forum in Johnson City.

The first question posed after the presentations concerned the lack of control over exempt wells. Ms. Petrosian of the TWDB staff responded that it is up to the GCD's to include in their plan an estimate of the volume of pumping from exempt wells. The questioner then pointed out that Texas is the last state in the union to abide by the rule of capture and expressed the opinion that this position should be re-examined.[12]

A second audience member asked about the consequences of not turning in DFCs by December 2007. The speaker expressed concern that Kerr County might have trouble converting their data into the TWDB format in the allotted time. Ms. Petrosian informed the speaker that the necessary data are already in place and that any extra data could be added as needed. She indicated that if the GMA could meet the December 2007 goal, then that timing would allow the GMA groundwater use preferences to be part of the regional water management plan. If, however, there is no management strategy using the MAG, the TWDB would be required by the legislation to conclude that the city or county which did not have a MAG would not qualify for funding water infrastructure projects, TWDB loans or grants. Mr. Ron Fieseler also informed the public that the DFC/MAG process is an iterative process, as data are gathered continually and models can be improved to make future planning easier and more accurate.

The next speaker asked for a clear definition on the term "limited water resources."[13] This was a term that Mr. Fieseler and Ms. Petrosian reported that they were unfamiliar

with; it was a phrase used by a stakeholder in an interview. Mr. Fieseler explained that the term was not official; the phrase "limited water resources" could be descriptive of water availability at a specific site. The speaker continued by asking why words such as "limited" and "finite" would be used to describe groundwater. Mr. Fieseler reiterated that those were terms that a stakeholder used. Dr. Eaton clarified that the term was used during a stakeholder interview and reflected the interviewed individual's opinion.

Next, a citizen asked Rima Petrosian if the Texas Water Development Board model data are updated continuously or if it is a "static model."[14] Prefacing her remarks by stating that she is not a modeler, Ms. Petrosian explained that the TWDB model for the Trinity Aquifer GAM is based on data collected from 1978-1999 and the model is calibrated on that information. The calibrated model can then be used to estimate future water levels if pumping rates in the future are changed. Mr. Fieseler clarified that models are not perfectly predictive but only tools or approximations that can be used in analysis or planning processes. One speaker pointed out that as new data are collected they should be included in the calculations of the model. Ms. Petrosian noted that she had heard this concern before and had asked the TWDB staff member responsible for model analysis about the process. She repeated that the modeler had said that the model is based on average volumes over an extended historical time period, so new data would not significantly affect the outcome of the model. She also mentioned that there is a planned revision of the TWDB model that might be ready in 2007.[15]

The next speaker noted that he was surprised that there were not more concerned citizens present. Mr. Fieseler explained that he had sent press releases to all the major newspapers in the area but had been notified that morning that the press release was not published in the local Kerrville paper.[16]

The next question addressed the vagueness of the term "future desired conditions" and why each district was not planning for a set period of time. Ms. Petrosian said that because each district and each region is in a different situation, the vagueness of "future" allows for some to plan on a 50-year horizon, 20-year, or whatever time frame works for them. Mr. Fieseler pointed out that working on a 50-year horizon would be beneficial, as the regional water planning groups involved in GMA 9 are planning on a 50-year horizon.[17]

The next speaker asked for clarification of the word "thickness" in regard to an aquifer. Dr. Jack Sharp from The University of Texas at Austin commented that the bottom of the aquifer is where the rock may become impermeable to water, and the top of the aquifer is the water table. The speaker asserted that the thickness of the aquifer does not imply that all the aquifer is productive. Mr. Fieseler and Dr. Sharp agreed. The speaker then asked whether adding the thickness of the aquifer to the model would throw off the calibration of the model. Mr. Fieseler explained that because the model computes average data, the thickness of the aquifer would take into account extremes and calibrate approximately. He reiterated that while the model is aggregated over time and space, it is "better than nothing" and considered appropriate by the TWDB for use as a forecasting tool.[18]

The next speaker brought up the issue of exempt wells and noted that well owners are "shy" abut coming in asking questions about their personal wells. Because of this, he assumes that Texas is working with "sketchy data" on exempt wells. He asked both Ms. Petrosian and Dr. Eaton how the TWDB and the LBJ project are dealing with these "sketchy data." Mr. Fieseler answered the question. His approach, he stated, is to assume that a single domestic private well uses from 75,000 gallons per year to 250,000 gallons per year, based either on a per capita per day consumptive use or water metering on private wells. The speaker re-directed the question to the TWDB, asking if those numbers were acceptable to the TWDB. Ms. Petrosian answered that they were acceptable. She stated that if any GMA comes up with its own value for the volume of pumping by exempt wells, the TWDB would probably find that amount to be acceptable.[19]

The speaker then asked about how modelers factor in prolonged droughts. Ms. Petrosian explained that droughts don't affect groundwater like they do surface water. The GAM model includes periods of drought and of wetness to find expected levels of water in the groundwater system. Mr. Fieseler further explained that drought was a matter of calibration and under some assumptions of drought the model might not converge. He also mentioned that periods of drought were being discussed within the GMA 9 and that GCD districts understand that drought is a subject of concern and will remain so. His personal goal, he said, is to calibrate the DFC so that a drought would affect as few people as possible. Mr. Fieseler pointed out that "dealing with drought" is a political decision that is based on what the community can tolerate.[20]

After the community members finished their questions, Dr. Eaton posed a number of questions to the community. The first set of questions was "What advice would you give the GMA districts as it considers setting desired future conditions for the Hill Country aquifers? What are your preferences? How would you like to manage the aquifer? Would you sustain the water levels, mine the aquifer, or do you have other suggestions?"[21]

The first commenter said that he was against mining the aquifer. The second speaker agreed and added that mining the aquifer should not be considered unless there was a way to replenish the aquifer. He noted that mining 50 percent of the groundwater over 50 years would not be "fair to our children or grandchildren."[22] The next speaker said that looking at the aquifer on a local level does not take into consideration "what we are really impacting." He said that we are "impacting the wildlife, the estuaries, protection of our coastal towns," and that it was more than an issue of drinking water.[23] The next speaker added that what he hears is that Hill Country development will not stop, but it will have to change. He said that to continue on with the "Dallas" type of development is not going to work in the Texas Hill Country. He said that outside of the official meetings, the public is saying that they want a sustainable water supply even if it means limited future water withdrawals. He suggested that for the future the Hill Country will need to come up with new designs for development. The speaker reported that the topic has not been talked about during official meetings, but that the public wants limited water resources focused on new designs for subdivisions.[24] The next speaker added that water

conservation and education must be addressed and that planning should include rainwater harvesting.[25]

Dr. Eaton's second question was: If there is going to be growth, where will the water come from, if not from groundwater? The first speaker brought up the idea of building dams to enhance water supply. The next speaker brought up brush control. Controlling, brush, he said, will aid in spring flow. Dr. Eaton's final question was: "Are there any other comments for the GMA or for the graduate students?"[26] There were no further comments and the meeting was adjourned.

Public Meeting in Boerne on April 16, 2007

A third public meeting was held in Boerne. The meeting followed a format similar to the first two meetings. After presentations, members of the audience were asked to share their questions and comments.

The first question of the Boerne public meeting was phrased in two parts. In the first part of the question the audience member asked if recharge was proportioned to the various parts of the GMA. His second question was whether the graduate student group had the ability to come up with gross groundwater resources in GMA 9 and how would that gross amount be proportioned to each individual county. The individual expressed a concern regarding how each individual county would receive a level of managed available groundwater (MAG).[27] Ms. Erica Allis, a UT student in the groundwater model group, answered the first part of this question by saying that the graphs produced by the model show a spatial distribution of the recharge. She said that in general the model indicates more recharge in the eastern parts of the GMA than the western parts.[28]

This led to a question about pumping and whether pumping in an area can affect other GCDs. Mr. Fieseler elaborated on this question, noting that the degree to which any nearby area is affected by pumping in another county varies throughout the GMA.[29] Ms. Petrosian then returned to the original question of proportioning the total MAG to various counties. She explained that the model divides up the total MAG for a GMA. She emphasized that one GAM output is a MAG for each county; the MAG is not a decision made by the TWDB.[30]

The next audience member commented:

> In the regional planning group there are some 800-pound gorillas. Are the water districts really going to have the authority to manage their water in their district (based on the given MAG) or are the 800-pound gorillas going to be able to go in there and take the water they want whether you want it or not?[31]

Mr. Fieseler answered that in his experience the regions are both inclined and legally obligated to use the numbers that are provided for the planning process. Although there could be a quarrel about the process for disputing DFCs, any individual complaint to a DFC MAG would have to be based on documentation to support their problems with the process.[32]

Another speaker asked Mr. Fieseler if the model was available on his website. Mr. Fieseler replied that it was not. Ms. Allis noted that the model was available through the TWDB and can be used by persons with previous modeling experience.[33]

The next respondent questioned whether the groundwater depth assumptions of the model varied or remained constant. Noting that Kendall County was affected by both Gillespie and Kimble county pumping, neither of which is in the model, the stakeholder asked if the cells under Kerr county accounts for the fact that water flows horizontally between counties. Ms. Allis explained that a lateral flow factor was built into the model for that purpose. Mr. Fieseler then gave examples of some of the local hydrogeology and interactions between pumping and drawdown in several counties. Mr. Fieseler also commented that despite the model not including bordering counties, there is often communication and participation between GMA 9 and the counties bordering the GMA 9 boundary.[34]

The next speaker commented on the stark contrasts between pumping and water use data along county lines. Ms. Allis noted that in some cases counties might not have been communicating with each other when they produced projections to give to the TWDB. This led to a discussion about the reliability of the model. Dr. Eaton, Ms. Petrosian, and Mr. Fieseler all shared their perceptions of the model's reliability. Dr. Eaton noted that judging reliability requires a standard, which is currently unavailable; data available to the TWDB when the model was developed were included in the GAM. Mr. Fieseler noted that the model is only a tool and could not be considered as "100 percent reliable."[35] Ms. Petrosian then added that all data in the model are based on historical values vetted by the TWDB, which reflect past pumping and aquifer properties to the degree known by TWDB. This means that the model is established on a solid base of reliable data and the projected scenarios are hypothetical.[36]

The next audience member asked about the TWDB's plan to address the stakeholder input gathered by the PRP. Ms. Petrosian replied that each GMA, not the TWDB, is responsible for responding to stakeholder input. Mr. Fiesler noted that a GMA can pick and choose recommendations; they are not obligated to fulfill all requests if they are unreasonable, extreme, or illegal.[37] This stakeholder then commented: "I would like to see a plan to address all of the issues that you collected from the stakeholders."[38]

The next speaker questioned whether stakeholders interviewed by the University of Texas team "represented" GMA 9 users adequately. This speaker asked about how the interviewees were picked, what was the geographical distribution of persons selected, and why more people were not interviewed. Ms. Leigh Byford, a student in the groundwater management class, replied by stating that all stakeholder comments would be in appendices to the final report. Ms. Byford noted that the PRP students had limited time available for their fieldwork, which restricted interviews to persons who could be interviewed within arranged time periods; she indicated that anyone could contact PRP members with information to be included in the report. With regards to representation, Ms. Byford agreed that some interests were more heavily represented than others; she reported that each "interest group" had at least three interviews.[39] In reply the speaker

reiterated that the lack of complete representation could mean that the GMA might not hear someone's point of view. Another audience member addressed the room, saying that the interview process seemed very helpful for incorporating stakeholder views into the DFCs. She noted that although improvements could be made on the process, it was at least a start in getting viewpoints beside board members into the DFCs.[40]

Mr. Fieseler also commented on the commonalities in the interviews and hypothesized whether 30 more interviews might have yielded limited new insights.[41] To finish this discussion, Ms. Petrosian noted that within Texas only GMA 9 (of all 16 of the GMAs) had decided to use public meetings to seek public advice.[42]

Another respondent asked whether the MAG is a real or artificial number. She expressed concern that if the MAG is not real then the GCDs could permit pumping based on artificial numbers. She stated:

> I'm assuming that your role is to permit this amount. So if this isn't real what are we permitting. As a well owner in Kendall County, I'm really concerned that there's an artificial number out there and that's what we are basing our permits on. And that we have developers all over the county who want to bring in 10,000 people in all areas of the county. They say they are bringing their water in from Canyon Lake but then you read that they bought the rights to drill wells. This concerns me.[43]

Several stakeholders then commented that one new element in this process is an entirely new MAG based on physical factors such as recharge instead of a value based on old reports. The next respondent addressed the need for conservation education in the GMA 9 area, mentioning that the counties in GMA 9 are affluent counties and people feel that they can pay to use all the water they want. The speaker reported his belief in education for people to the effect that if they are taught that just because a person has the money does not mean they have the right to pump all the water they want. Mr. Fieseler replied by saying that conservation, education and rainwater harvesting were mentioned by many stakeholders, but that these factors do not translate to DFCs. Mr. Fieseler encouraged people to come up with comments that can be made into DFCs, such as those that describe physical properties of the aquifer.[44]

A speaker then asked:

> How if possible is the GMA going to track or help us understand requests? For example, talking about people going over to Canyon Lake and pumping water out of that thing. What is to keep 7-10 different developers from all going into a county or municipality and saying I'm negotiating with Blanco County or Canyon and all of a sudden someone says wait a second, if these contracts are all signed we've got so many acre-feet and we're committed to sell more than we have right now.[45]

Mr. Fieseler responded to that comment by saying that the GCDs are going to begin the monitoring process eventually but it is not currently part of the law. A discussion

continued about potential problems of over-committing groundwater and surface water especially in dry years. Mr. Fieseler mentioned that one strategy to address this problem is to adjust the MAG given to each GCD, a process that could provide a "cushion" for the water used by exempt wells. Many stakeholders agreed with this idea and emphasized the need for conservative water planning and agreed that there is no need to permit up to the maximum possible MAG. Continuing this discussion, a stakeholder suggested that the growth of exempt wells could be predicted by projected rural population growth. He said that accurate knowledge of existing wells could aid this prediction process.[46]

A stakeholder commented:

> One of the problems we've got is that there is only one data point per square mile and we need about 100 data points per square mile.[47]

One stakeholder spoke at length about the ideals of a hypothetical stakeholder with little knowledge of the realities of groundwater management who promotes a DFC of no change in aquifer levels. The speaker noted that "no change" is not a realistic DFC. She commented that the head levels within the aquifers will decline: the question is how much and how fast. She ended her comment by noting that a paradigm shift in thinking is needed for this area in terms of the DFCs.[48]

Several stakeholders then agreed on the value of rainwater collection. One audience member suggested:

> I've been promoting rainwater a long time. My house, yard, and everything else is run on rainwater and it will survive a drought of record. The 800-pound gorillas do not care about dropping water levels. Along with the enforcement of DFCs, I believe that rainwater harvesting is a good idea.[49]

The meeting ended with more discussion about the dilemma of exempt well and the need for conservative approaches to the MAG.

Public Meeting in Wimberley on April 17, 2007

The fourth public meeting was held in Wimberley on April 17, 2007 at the Wimberley Community Center. The meeting format was similar to the previous three meetings; class members presented the information collected during the research process and asked the public for advice. Ms. Petrosian gave a PowerPoint presentation on the role of the Texas Water Development Board, Mr. Ron Fieseler explained the roles of the GMA and GCDs, and class members explained data collection, stakeholder outreach, modeling, and general aquifer information.

The first speaker commented that in formation of the groundwater management areas there were two areas within GMA 9 that did not have GCDs: Travis County and Comal County. He said that the rule of capture still prevails in these counties, especially in Travis County where golf courses use huge wells. Mr. Fieseler replied that GMA 9 had

been in contact with county commissioners in Travis and Comal County and said that these counties were aware of what was going on, but were not active participants.[50]

The next speaker questioned why springs were not incorporated into the groundwater model for GMA 9. He had recently attended a springs conference where the lecturer explained that springflow should be correlated to digimetric well levels. He then asked if the model was capable of correlation of digimetric well levels to springflow. Mr. Michael Ciarlegio, a student in the groundwater management class, answered the question, explaining that four major springs were represented in the model, but that the model was not calibrated to show the springflows for minor springs accurately.[51] Another community member asked whether springflow might be added to the model over time. Mr. Richard Smith, a modeler from the TWDB, replied that the model was not calibrated to the springs; the model has a grid cell size of one square mile, so springs are not included. Mr. Fieseler commented that if a groundwater district has a spring that they are concerned about, they could collect data on the spring of interest and submit that for future revisions of the model.[52]

Another speaker asked how the model accounted for weather, how the model was validated, and how the model accounted for development. Mr. Ciarlegio said the TWDB used weather data from 1960 to 1990 to find an average 2000 to 2043 yearly precipitation for the model; this average yearly precipitation was used for estimating future rainfall conditions. For the drought of record simulation from 2043 to 2050, the modelers simulated conditions of the actual drought of record between 1950 and 1956. The model is calibrated with well level measurements from the area from 1996 to 1997.[53]

The next speaker asked a question about the area represented in the model. He understood that the Upper and Middle Trinity were represented in the model, and the Lower Trinity would be modeled in the future. He said that springflow was derived from the Upper and Middle Trinity. He was concerned that if the Lower Trinity were modeled, it might seem like there was more water than was actually available and the springs could be affected adversely. He further explained that the economies of Wimberley and San Marcos would be hurt if springflow dropped. Mr. Fieseler answered that the GMA had the ability to set DFCs for individual stratigraphic units or geographic boundaries, watersheds, or counties, and could set a different DFC for the Middle Trinity as opposed to the Lower Trinity. Mr. Fieseler added that such specific DFCs might not be possible, but that DFCs could be revised every five years.[54]

Mr. Smith said that it would help with data acquisition if the speakers could state whether they were in favor of keeping the springs flowing or maximum economic development by pumping groundwater, or any other views. Dr. Eaton added that any weaknesses of the existing model could not be changed, and TWDB recognized the model as one tool that the TWDB will use in its analysis. Dr. Eaton continued, saying that the key information being sought in this meeting was to obtain the citizen or water user preferences regarding DFCs, so that information could be conveyed to the GMA districts and their GCDs.

The next respondent commented:

> I want to keep the springs flowing, my family wants to keep the springs flowing, my neighbors want to keep them flowing, there hasn't been anyone in this county who does not want to keep them flowing…[55]

The next speaker said that many significant springs have gone dry, and it seemed that the community should try to restore some flow to the springs because surface water was connected with groundwater. He reported that when people apply for permits, a GCD is not obligated to give them as much water as they asked for and they could use rainwater harvesting or other water collection methods to meet their needs.[56]

The next participant asked for clarification as to whether the TWDB supported the inclusion of springflow as a measure of performance in the DFCs. Ms. Petrosian answered his questions, saying that the model has limitations, and springflow is not readily calibrated in the model. Dr. Sharp added that research has shown that groundwater levels can be related to flow and this would be a good area for future research. Mr. Smith stated that the GCD was very young and it would take time to gather a continuous data set to better manage the situation.[57]

The next speaker asked why the TWDB had developed a model that is static if they were involved in an adaptive management situation where the model is being continuously refined. Mr. Smith said that the TWDB intended to revisit all of the models as necessary. Mr. Fieseler added that this would be a long-term process as additional data were added into the model.[58]

Another speaker asked whether development could be controlled in any way, particularly in regard to large subdivisions. Mr. Smith answered that the GCD has no authority over single family residential wells or agricultural wells but could permit community wells. Mr. Smith explained that for large community wells, the GCD could issue a permit for less than the community desired. The speaker continued, saying that with uncontrolled growth there would be more dry springs and wells.[59]

The next respondent said that one of their problems was education and "half of the comments we've heard tonight are because they don't understand the aquifer."[60] Another speaker said that, having been involved in the legislative process, "the more science we gather the more we can coordinate on desired future conditions." He said that as more science is gathered and presented as evidence, you can slowly change the system.[61]

The next speaker asked where he could find more information about the Trinity Aquifer. Mr. Fieseler answered that he could talk to his local groundwater district, search TWDB publications, or visit the TWDB website.[62]

The next audience member said:

> I live on the Blanco River in Wimberley and have a 600 foot deep Middle Trinity water well. I believe that water is the elixir that makes the Hill County magic. It is the critical resource necessary to continue our economic prosperity and to allow growth in Hays County. We are a rural county in transition that still depends

primarily on subsurface water supply. Our surface streamflows are also dependent on seeps and springs from the subsurface aquifers. When we voted to confirm the Hays-Trinity GCD in May 2003, it was to keep our streams and water wells flowing. That was the desired future condition that the public sought for the Trinity aquifer. The Hays-Trinity GCD has subsequently developed an approved groundwater management plan for the district. Its goal is a sustainable management of the Trinity aquifer to maintain 90 percent of spring leakage and baseflow during repeat of the 1950s drought of record. This goal is an acceptable quantification of that DFC which I support for Trinity Aquifer management. Clear, cool flowing wells, springs, and streams attracted most of us to make the Hill Country our home. We must continue to support our groundwater districts and our aquifer management to keep those streams flowing.[63]

The next speaker commented on behalf of the Wimberley Valley Watershed Association Board of Directors:

The WBWA supports all the goals of the Hays-Trinity GCD management plan and the general efforts of local residents and government to cooperate with the state and federal authorities to conserve land and water resources. The WBWA primary mission is to protect the water quality and springflow of Jacob's Well, Cypress Creek, Blue Hole, and Blanco River Watershed system. We support the Hays-Trinity conservation district goal to manage the aquifer to benefit people of the district while maintaining a sufficient quantity of water in the aquifer to maintain springflow and water quality in Jacobs Well and other streams, springs, and rivers flowing in the district during periods of drought. We recommend setting a drought intensity trigger of no less than 10 cfs for Jacob's Well and correlating that with local aquifer levels with the springflow to determine severity of drought measures issued by the district, local water supply, and residential well owners. We support the Water Development Board and Hays-trinity conservation district to implement water supply reduction limits in accordance with Chapter 36, capping current pumping levels from the aquifer, issuing a moratorium on expanding further any further pumping permits with alternative water supply strategies established. The WBWA supports policy that allows a 95 percent springflow during weather conditions experienced during the drought of record. We support district policies to reduce and prevent reduction of artesian pressure in the critical recharge conduits that feed Jacob's wells, major springs in the district. There is evidence that current pumping by aqua Texas and other groundwater users reduced artesian pressure by pumping from cave conduits that feed Jacob's Well. There is an indication that local pumping is currently impacting springflow, noted at the USGS gauging station at Jacob's Well. We encourage the state to create a mandate for reduction in line loss of waste in municipal and public water supply systems to no more than ten percent annually. Aqua Texas is currently losing between 40 and 50 percent of water pumped from the Trinity Aquifer. There should be fines and a timeline imposed on systems that do not meet a minimum standard of performance. We consider mandatory conservation and drought response for regulated and exempt wells. The WBWA considers

> increased funding for the Hays-Trinity GCD and full Chapter 36 recognition for the district and grants from the Water Development Board to implement a more detailed model to include springflow for Jacob's Well as an indicator of the health of the Trinity Aquifer. To improve the accuracy of Robert Mace's model and to allow the district to hire appropriate staff, acquire necessary technology to track changes to the aquifer. Also to increase state and local funding for dye tracing studies to delineate groundwater flow paths and to create an accurate recharge zone map of Jacob's Well. Also allow funding to increase a district and region-wide well monitoring program. We also want to recognize the excellent work of the board and staff to establish the current well monitoring program, especially Al Brown, former president of the Board and his excellent and detailed work to characterize the Trinity Aquifer stratigraphy. We recommend that Water Development Board funds be allocated to publish Al Brown's work on the aquifer stratigraphy in Hays County as a resource for aquifer managers and researchers. WBWA encourages state and local governments to encourage and require the use of rainwater harvesting in all new development and create incentives and programs, such as length deposit, low interest loans, and grants for current home owners. Since the estimates are that we are currently pumping over 100 acre-feet more from the Trinity than is considered sustainable to make springflow in the aquifer, and 90 percent of what's currently platted in the Wimberley area is currently undeveloped, rainwater harvesting is the most cost effective and efficient way to alleviate further degradation of the aquifer. We recommend to prevent all interbasin transfers of groundwater into or out of the district, establishing policy that any surface water coming into the district can be used to reduce current public and private water systems dependence on the aquifer. Aqua Texas and Wimberley Water Supply would be the first water supplies to receive this water, to be required in phase reductions of groundwater. Under no conditions would surface water be allowed to serve new development until the reductions in overall pumping of the aquifer are met and the adequate development of rules are enacted by Hays County and local government that adopt the recommendation of the regional water quality plan to manage pollution generated by high density development. We promote recharge enhancement programs such as brush management and the establishment of native grasses, recharge enhancement infiltration check dams. We promote strategic land conservation programs such as purchase of conservation easements, and also purchase of development rights for the Trinity-Edwards Aquifer recharge zone in Hays County to protect the remaining undeveloped lands and to protect drinking water, and springs, streams, and river flows for future generations.[64]

Another speaker commented about the model: "Water is not found in these cells. Water is found in the voids of rocks. I see little reference at all to geology in the model.[65]" He stated that there was available geologic information about Hays County that had not been used in the model, such as structure maps, isopachs, and fault information. Mr. Fieseler answered that the modeling was an ongoing process and this data would be added to the model over time.[66]

The next respondent commented that "in the real world, we play a political game."[67] He said that it was necessary to deal with the system in play, and chip at the system as we go.[68]

Another speaker commented that the current system seemed to be "the rule of the first pump."[69] He asked if there was a way that he could protect his own groundwater. Mr. Fieseler commented that it was difficult to establish a system of correlative rights; there were a variety of mechanisms to distribute water, but the districts had limited authority to regulate water distribution.[70]

The next speaker mentioned that Wimberley was one of the only areas in Texas that didn't have an alternative water source and needed help from the Texas Water Development Board to obtain surface water. He said that he wanted Jacob's Well and the springs to keep flowing. Another speaker asked for a show of hands for people who would like to have the springs, Cypress Creek, and the Blanco River to continue to flow. The majority of audience members raised their hands. The next respondent said that he had had his first rainwater collection tank delivered and was working to establish an alternative water source for his household. He recommended that new residents be made aware of alternative water collection methods.[71]

Dr. Eaton asked if anyone had any further questions or comments. There were no more comments and the meeting was adjourned.

Notes

[1] Hill Country citizen, Johnson City, Texas, February 19, 2007

[2] Hill Country citizen, Johnson City, Texas, February 19, 2007

[3] Ibid.

[4] Ibid.

[5] Ibid.

[6] Ibid.

[7] Ibid.

[8] Ibid.

[9] Ibid.

[10] Ibid.

[11] Ibid.

[12] Hill Country citizen, Kerrville, Texas, February 20, 2007.

[13] Ibid.

[14] Ibid.

[15] Rima Petroisan, Kerrville, Texas, February 20, 2007.

[16] Ron Fieseler, Kerrville, Texas, February 20, 2007

[17] Ibid.

[18] Ibid.

[19] Rima Petroisan, Kerrville, Texas, February 20, 2007.

[20] Ron Fieseler, Kerrville, Texas, February 20, 2007

[21] David Eaton, Kerrville, Texas, February 20, 2007.

[22] Hill Country citizen, Kerrville, Texas, February 20, 2007.

[23] Ibid.

[24] Hill Country citizen, Kerrville, Texas, February 20, 2007.

[25] Hill Country citizen, Kerrville, Texas, February 20, 2007.

[26] David Eaton, Kerrville, Texas, February 20, 2007.

[27] Hill Country citizen, Boerne, Texas, April 16, 2007.

[28] Erica Allis, Boerne, Texas, April 16, 2007.

[29] Ron Fieseler, Boerne, Texas, April 16, 2007.

[30] Erica Allis, Boerne, Texas, April 16, 2007.

[31] Hill Country citizen, Boerne, Texas, April 16, 2007.

[32] Ron Fieseler, Boerne, Texas, April 16, 2007.

[33] Erica Allis, Boerne, Texas, April 16, 2007.

[34] Ron Fieseler, Boerne, Texas, April 16, 2007.

[35] Ibid.

[36] Rima Petroisan, Boerne, Texas, April 16, 2007.

[37] Ron Fieseler, Boerne, Texas, April 16, 2007.

[38] Hill Country citizen, Boerne, Texas, April 16, 2007.

[39] Leigh Byford, Boerne, Texas, April 16, 2007.

[40] Hill Country citizen, Boerne, Texas, April 16, 2007.

[41] Ron Fieseler, Boerne, Texas, April 16, 2007.

[42] Rima Petroisan, Boerne, Texas, April 16, 2007.

[43] Hill Country citizen, Boerne, Texas, April 16, 2007.

[44] Ron Fieseler, Boerne, Texas, April 16, 2007.

[45] Hill Country citizen, Boerne, Texas, April 16, 2007.

[46] Ibid.

[47] Ibid.

[48] Ibid.

[49] Ibid.

[50] Ron Fieseler, Wimberley, Texas, April 17, 2007.

[51] Michael Ciarlegio, Wimberley, Texas, April 17, 2007.

[52] Ron Fieseler, Wimberley, Texas, April 17, 2007.

[53] Michael Ciarlegio, Wimberley, Texas, April 17, 2007.

[54] Ron Fieseler, Wimberley, Texas, April 17, 2007.

[55] Hill Country Citizen, Wimberley, Texas, April 17, 2007.

[56] Ibid.

[57] Richard Smith, Wimberley, Texas, April 17, 2007.

[58] Ron Fieseler, Wimberley, Texas, April 17, 2007.

[59] Hill Country Citizen, Wimberley, Texas, April 17, 2007.

[60] Ibid.

[61] Ibid.

[62] Ron Fieseler, Wimberley, Texas, April 17, 2007.

[63] Hill Country citizen, Wimberley, Texas, April 17, 2007.

[64] Ibid.

[65] Ibid.

[66] Ibid.

[67] Ibid.

[68] Ibid.

[69] Ibid.

[70] Ron Fieseler, Wimberley, Texas, April 17, 2007.

[71] Hill Country citizen, Wimberley, Texas, April 17, 2007.

Chapter 7. Towards Desired Future Conditions for Ground Water in the Texas Hill Country

With the passage of House Bill 1763 and its groundwater management planning requirements, the Texas Legislature asked groundwater conservation districts to cooperate in planning. The Texas Water Development Board (TWDB) provided financial support for this joint effort between Groundwater Management Area 9 and representatives of The University of Texas at Austin's Jackson School of Geosciences, the LBJ School of Public Affairs, and Law School to observe GMA 9's groundwater planning. Graduate students in the class agreed to assist GMA 9 in its consideration of desired future groundwater conditions. This chapter describes the outcome of this process, including efforts to understand stakeholder views, evaluation of TWDB's groundwater data, and the use of interviews of GMA water users about their preferences for future groundwater use. A key outcome was the development of a "wrapper" program to help GMA users simulate future groundwater use. A second product has been the summary of quotations of numerous GMA 9 stakeholders who either live or work in GMA 9. After an initial presentation to the GMA 9 Board of Directors in December 2006, class members led four public meetings in February, March, and April of 2007.

As this process evolved, many GMA 9 stakeholders reported that they needed to understand the meaning of the "desired future conditions." The stakeholder process centered on interviewing GMA 9 water users (representing a variety of interests) about their preferences for the future of their aquifer as well as conducting public meetings. Accumulating and aligning appropriate groundwater data has been another focus of this research. Prior to 2007, each groundwater conservation district (GCD) within GMA 9 had been using unique data formats, making integration of data across GCDs difficult. The TWDB has created what they term an "acceptable format" which represents one approach the GCDs within GMA 9 could use to integrate their diverse data bases. More accurate data formatting will facilitate future data integration.

The graduate class tool that has generated the most interest within the GMA has been the groundwater availability model or GAM, as provided by the TWDB, but embedded within a class-developed software that allows GMA stakeholders to test alternate pumping scenarios. GMA stakeholders have been trained with and used the wrapped GAM to analyze a variety of pumping scenarios for individual counties, specific growth corridors, and for the entire GMA.

During the nine months that students elicited public input, assessed data resources, and developed software tools to enhance the ease of use of the Hill Country Aquifer GAM, the process of how the GCDs would move forward to develop actual DFC recommendations has remained opaque. Many stakeholders expressed concern over their own knowledge of groundwater within GMA 9 and sought more information on the science and issues surrounding groundwater. A related issue is the need to develop more and better information on groundwater resource management. Many stakeholders commented on the limited public awareness of the groundwater planning effort within

GMA 9, though some persons stated that awareness is greater now than it was a decade ago. Based on the limited turnout for public meetings, it appears that participation in public forums on groundwater management may be self-limited to a group of stakeholders with economic, scientific, and policy concerns, such as developers, businesses interests, geologists, environmentalists, and government representatives. Participants concluded that education of the public about groundwater issues should be increased, perhaps via schools or through other public awareness campaigns. A number of stakeholders stated that the process through which stakeholders are heard by the GMA could be improved, so as to help more "average" citizens (including domestic well-owners) become more aware, informed, and involved. Many stakeholders expressed an interest in more and better information as to how the GAM model works. Sharing information among districts, the TWDB, and the various other government entities involved in the process could require greater communication among all players. Standard expectations regarding future data collection could ease the sharing of information. For example, GCDs within the GMA already meet together regularly and communicate across political and geographical boundaries.

All interviewed stakeholders concurred with the opinion that population growth and withdrawals of groundwater will continue to increase for the foreseeable future within GMA 9. For example, many stakeholders expressed concerns over the sustainability of seeps and springs in GMA 9. While the model does not report flow of actual seeps and springs, stakeholders' concern over their fate was so widespread that GAM modelers might consider investigating ways to bring springflows into the GAM, particularly since springs have significant economic and environmental impacts on the Hill Country region. There was strong support among stakeholders for the TWDB to enhance the GAM model to reflect current water use data (such as exempt wells) and future changes to help groundwater managers and policy makers fulfill their responsibilities. The unfunded mandate of HB 1763 appears to be a continued challenge for GCD managers. Groundwater data collection and monitoring, current TWDB budget constraints, and current GCD budgets limit options for new improvements to the GAM.

One inference to be drawn from interviews is that desired future conditions are likely to reflect projected population growth and potential groundwater use, including exempt wells (those wells from which pumping is below the threshold to require a permit). If the GMA 9 districts can agree on acceptable drawdown levels over time, these levels can then be proposed as the GMA's "desired future conditions," so individual GCDs can permit users to make future water withdrawals. Each of the GCD districts indicate that they plan to work closely with TWDB on model development and data sharing in order to reduce the potential for conflicting numbers and mistrust among agencies.

As this project drew to a close in May 2007, staff for each of the GCDs asked the class to train them in the use of the wrapper around the GAM so that they could evaluate alternative future groundwater withdrawal scenarios. Each scenario provides some useful information, such as the depth of decline in the average county groundwater levels over time. These results are likely to be key measures of performance as GMA 9 seeks to establish its desired future groundwater conditions.

Appendix 4 reports the results of a range of analyses of how future pumping options affect average annual county aquifer levels. Members of the class simulated future water withdrawals to observe how pumping in each county could affect average annual aquifer levels. The range of pumping volume varies from "no increased use" (compared to current conditions) to various patterns of future water withdrawals based on and related to the Trinity Hill Country Aquifer GAM model results. Pumping scenarios are based on the expected levels of future pumping incorporated in the Trinity Hill Country Aquifer GAM, which in turn are based on county-by-county estimates of future groundwater withdrawals for the period of 2007 to 2050 developed through Texas' Senate Bill 1 process for Texas water planning regions J, K and L.

Appendix 4 reports how pumping increases and estimated future withdrawals that began as low as 0.1 times the expected future pumping rates can be analyzed in the GAM model. Counties were tested for 0.25, 0.50, up to 2.0 times the expected amount of future water withdrawals. For each test, the GAM computed and displayed the level of drawdown in the county aquifer and the consequences of pumping in any county upon the aquifer levels of other counties. GAM results indicate that water withdrawals from any GCD affect the aquifer levels within other GCDs. One of the challenges to GMA decisions about DFCs and MAGs is that each county's action will affect ground water resource availability in other counties.

As of May 2007 when this final project report was drafted, GMA 9 had not adopted its DFC. It is clear from public discussion that prior to any GMA recommendations there remain important issues to be addressed through research, public meetings within the GCDs, and GCD districts meetings. This report has sought to record the first nine months of the DFC process. This report leaves the final resolution of the GMA's DFC and MAG to the elected GCD and GMA representatives.

Note to the Appendices

The appendices contain information that some GMA 9 stakeholders and water users might find useful. Appendix 1 contains the Texas Water Development Board (TWDB) acceptable data format. Appendix 2 includes TWDB formats for water levels. Using these formats could help GMA 9 and other GMAs collect, share, and utilize data. Appendix 3 lists the Survey Monkey conference survey questions. Appendix 4 presents the modeling scenarios for each GMA 9 county and illustrates options for future groundwater use based on the assumptions within the model.

Appendix 5 lists the public meetings held within GMA 9 that the class attended and documented. Appendix 6 depicts a map of known wells within the district. Appendix 7 contains notes from the GMA 9 data inquiry meeting, held in Johnson City. Appendix 8 presents the transcribed interviews of participants, both those who waived confidentiality (interviews are listed by name) and those persons who preferred to have anonymity. Appendix 9 presents links to online data sources. Appendix 10 lists sample interview questions the modeling group asked GMA 9 stakeholders.

Appendix 1.
Texas Water Development Board Acceptable Data Format

Table A1. 1
Minimum Number of Fields for Well Data

state well #	**lat**	**long**	**owner**	**driller**	**aq. code**	**aq. ID**	**date drilled**	**well depth**	**water use**	
number	number	number	text (char 22)	text (char 20)	text (char 8)	number	text (char 8)	number	text	Field type*
3458901	320203	954518	Newman	Rekhop Drilling	124WLCX	10	2/15/1967	560	H	
3458904	320058	954506	Brushy Creek W.S.C.	Lanford Drilling Co.	124WLCX	10	1943	1032	P	
3458905	320136	954724	Ann Adair	Unknown	124QNCT	24	1935	67	H	
3459701	320132	954252	Anlaco, Inc.	West & Rekhop	124WLCX	10	3/19/1963	560	H	

Source: Provided by the Texas Water Development Board.

* The number of characters allowed in a data field is listed in parentheses.

Table A1. 2
Deluxe Number of Fields for Well Data Information with Codes from TWDB UM-50

state well #	county	basin	zone	region #	prev. #	lat	long	owner	owner 2	driller	driller	source_of _coords	aquifer code
number	number	number	number	numbe r	text (8)	number	number	text (22)	text (22)	text (20)	text (20)	text	text (8)
3458901	1	8	2	7		320203	954518	Newman		Rekhop Drilling		1	124WLCX
3458902	1	8	2	7		320116	954554	Wiggins & Hyde		Continental Oil Co.		3	NOT-APPL
3458904	1	8	2	7		320058	954506	Brushy Creek W.S.C.	Well #4	Lanford Drilling Co.		1	124WLCX
3458905	1	8	2	7		320136	954724	Ann Adair		Unknown		1	124QNCT
3459701	1	8	2	7		320132	954252	Anlaco, Inc.		West & Rekhop	drilling	1	124WLCX

(continued on next page)

Deluxe Number of Fields for Well Data Information with Codes from TWDB UM-50 *(continued)*

Aquifer_ ID 1	Aquifer_ ID 2	Aquifer_ ID 3	elevation	method of elev	date drilled (8 digits)	well type	well depth	source of depth	lift	power	horsepower
number	number	number	number	text	text (8)	text	number	text	text	text	text (7)
10				M	2151967	W	560		S	E	1.50
22				M	1943	P	5224				
10				M	10091986	W	1032	D	S	E	50.00
24				M		W	67	M	J	E	
10				M	3191963	W	560		S	E	

aquifer code	Aquifer_ ID 1	Aquifer_ ID 2	Aquifer_ ID 3	primary water use	secondary water use	water level avail? (C, M, H, R)	quality? (Y,N)	well logs available?
text (8)	number	number	number	text	text	text	text	text
124WLCX	10			H	S	M	N	
NOT-APPL	22					N	N	E
124WLCX	10			P		M	Y	DE
124QNCT	24			H	S	N	Y	
124WLCX	10			H		M	Y	

Source: Provided by the Texas Water Development Board.

Appendix 2.
TWDB Acceptable Data Format for Water Levels

Depth to water is measured from ground level (land surface datum), not from the measuring point. The method used to obtain the measurements should be listed.

Table A2. 1
Minimum Number of Fields for Water Level Measurements

State Well #	Depth to Water	Month	Day	Year
Number	Number	Number	Number	Number
2732401	-125.25	2	15	2000
7802702	-187.10	2	7	2000
7802709	-197.25	2	7	2000
7809105	-21.40	2	7	2000
7809305	-167.35	2	7	2000
7809507	-214.50	2	1	2000
7818206	-25.80	2	3	2000
7811301	-173.50	1	10	2000
7723602	-312.50	2	2	2000
6858302	-190.50	1	10	2000
7723602	-362.50	1	11	2000
6741102	-178.75	1	31	2000
6749201	-102.10	1	31	2000
6749202	-78.75	1	31	2000
6750101	-73.10	1	24	2000
6848502	-32.10	1	20	2000
6848601	-90.40	1	20	2000
6848812	-33.75	1	20	2000
6848907	-112.20	1	20	2000
6853902	-213.25	1	24	2000
6854506	-43.40	1	20	2000
6854602	-156.30	1	20	2000
6854901	-111.25	1	20	2000
6855407	-48.50	1	20	2000
6855704	-52.80	1	19	2000
6856101	-94.50	1	19	2000

Source: Provided by the Texas Water Development Board.

Table A2. 2
Deluxe Number of Fields for Water Level Measurements with Remarks from TWDB UM-50

State W.#	Depth	Month	Day	Year	Measure.#	Meas.Agcy.	Method	Remark
Number	Number	Number	Number	Number	Text (2 char)	Text (2 char)	Text (1 char)	Text (2 char)
2732401	-125.25	2	15	2000	1	6	1	
2732803		2	15	2000	1	6	1	41
7802702	-187.10	2	7	2000	1	6	1	
7802709	-197.25	2	7	2000	1	6	1	
7809105	-21.40	2	7	2000	1	6	1	
7809305	-167.35	2	7	2000	1	6	1	
7809507	-214.50	2	1	2000	1	6	1	
7818206	-25.80	2	3	2000	1	6	1	
7811301	-173.50	1	10	2000	1	6	1	
7723602	-312.50	2	2	2000	1	6	1	
6858302	-190.50	1	10	2000	1	6	1	
7811301		1	6	2000	1	6	1	61
7723602	-362.50	1	11	2000	1	6	1	
6741102	-178.75	1	31	2000	1	6	1	
6749201	-102.10	1	31	2000	1	6	1	
6749202	-78.75	1	31	2000	1	6	1	
6750101	-73.10	1	24	2000	1	6	1	
6848502	-32.10	1	20	2000	1	6	1	
6848601	-90.40	1	20	2000	1	6	1	
6848812	-33.75	1	20	2000	1	6	1	
6848907	-112.20	1	20	2000	1	6	1	
6853902	-213.25	1	24	2000	1	6	1	
6854506	-43.40	1	20	2000	1	6	1	
6854602	-156.30	1	20	2000	1	6	1	
6854901	-111.25	1	20	2000	1	6	1	

6855407	-48.50	1	20	2000	1	6	1	
6855704	-52.80	1	19	2000	1	6	1	
6856101	-94.50	1	19	2000	1	6	1	

Source: Provided by the Texas Water Development Board.

Appendix 3.
Conference Survey Questions

Groundwater Management Final Survey (via Survey Monkey©)

Part I

As you begin the questionnaire, please answer the following questions about yourself.

1. **I am a board member or an employee of a Groundwater Conservation District.**
   - ☐ **Yes**
   - ☐ **No**

2. **I have participated in discussions regarding my groundwater district for:**
   - ☐ **0-1 year**
   - ☐ **1-5 years**
   - ☐ **5-10 years**
   - ☐ **10-20 years**
   - ☐ **Over 20 years**

3. **What is the GMA number in which your district is located (or numbers if you are in multiple GMAs)?** _____

4. **How long has your groundwater conservation district been in existence?**
   - ☐ **Less than 3 years**
   - ☐ **3-5 years**
   - ☐ **6-10 years**
   - ☐ **11-20 years**
   - ☐ **More than 20 years**

Part II

Now we would like to get your thoughts regarding both your Groundwater Management Area (GMA) and your Groundwater Conservation District (GCD). For each item, please indicate how strongly you agree or disagree with the statement. ***Note: The word "Public" is defined here as all persons who are NOT GMA or District members. The "public" can include other political subdivisions, entites, and individuals who have an interest in your GMA or District's work.)***

For my GMA:

*** 5. I understand the issues that are important to other districts in my GMA.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

*** 6. I understand the issues that are important to the public in my GMA.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

*** 7. I know how to involve the public effectively in the practices of my GMA.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

*** 8. I am able to work effectively toward agreement with other GMA members on decisions relating to my GMA..**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

*** 9. It is beneficial to involve the public in the current process my GMA is using to determine its desired future condition.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

*** 10. It is beneficial to keep the public informed about the process being used by my GMA to determine its desired future condition.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

For my District:

*** 11. I know how to involve the public effectively in the practices of my District.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

*** 12. I am able to work effectively toward agreement on decisions with other employees and/or members of my District's board.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

*** 13. It is beneficial to involve the public in my District's decision-making process.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

*** 14. It is beneficial to keep the public informed about the progress of my District's processes.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

As you know, statute requires that any GMA final decision on establishing a desired future condition (DFC) must be made formally by a supermajority (*more than two-thirds of the votes, with more than two-thirds of the members present*). However, other decisions may be made using other decision-making methods. For your GMA's decision-making processes other than the final DFC vote, please rank your preferences for the following alternative decision-making methods on a scale of 1-5 (1= most preferred; 5= least preferred).

*** 15. Excluding the final decision on a desired future condition, decisions in my GMA should be made by:**

Majority or supermajority vote

- ☐ **1**
- ☐ **2**
- ☐ **3**
- ☐ **4**
- ☐ **5**

Working together as members until everyone can agree on a solution

- ☐ **1**
- ☐ **2**
- ☐ **3**
- ☐ **4**
- ☐ **5**

Negotiating as many differences as possible among members, but using a vote to reach the final decision

- ☐ **1**
- ☐ **2**
- ☐ **3**
- ☐ **4**
- ☐ **5**

Working together with the public until the public and members can all agree on a solution

- ☐ **1**
- ☐ **2**
- ☐ **3**
- ☐ **4**
- ☐ **5**

Negotiating as many differences as possible among the public and the members, but using a vote to reach the final decision

- ☐ **1**
- ☐ **2**
- ☐ **3**
- ☐ **4**
- ☐ **5**

Now, for your District's decision-making processes, please rank your preferences for the following decision-making methods on a scale of 1-5 (1= most preferred; 5= least preferred).

16. My District should make decisions by:

Majority or supermajority vote

- ☐ **1**
- ☐ **2**
- ☐ **3**
- ☐ **4**
- ☐ **5**

Working together as members until everyone can agree on a solution

- ☐ **1**
- ☐ **2**
- ☐ **3**

☐ **4**
☐ **5**

Negotiating as many differences as possible among members, but using a vote to reach the final decision

☐ **1**
☐ **2**
☐ **3**
☐ **4**
☐ **5**

Working together with the public until the public and members can all agree on a solution

☐ **1**
☐ **2**
☐ **3**
☐ **4**
☐ **5**

Negotiating as many differences as possible among the public and the members, but using a vote to reach the final decision

☐ **1**
☐ **2**
☐ **3**
☐ **4**
☐ **5**

Part III. Actions in your GMA/District

We appreciate all the help you've given so far. For this final set of questions, we'd like to ask you some questions about how your GMA and your District make decisions and involve the public.

*** 17. The public is able to participate in the process my GMA is using to determine its desired future condition (other than the final statutorily required supermajority vote) by:**

☐ **Submitting written comments**
☐ **Speaking at public meetings**
☐ **Actively participating in developing solutions but not voting**
☐ **Being part of a group that makes decisions**

*** 18. The public is able to participate in the processes of my District by:**

☐ **Submitting written comments**
☐ **Speaking at public meetings**
☐ **Actively participating in developing solutions but not voting**
☐ **Being part of a group that makes decisions**

*** 19. In my GMA, members work very well together.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

*** 20. When there is disagreement within my GMA, to what extent are there attempts to reach an accord?**

- ☐ **To a great extent. Agreement among all members is important.**
- ☐ **Somewhat. It is important to at least hear what dissenters have to say.**
- ☐ **Not at all. You can't please everyone all the time.**

*** 21. In my District, members work very well together.**

- ☐ **Strongly Disagree**
- ☐ **Disagree**
- ☐ **Neutral**
- ☐ **Agree**
- ☐ **Strongly Agree**

*** 22. When there is disagreement within my District, to what extent are there attempts to reach an accord?**

- ☐ **To a great extent. Agreement among all members is important.**
- ☐ **Somewhat. It is important to at least hear what dissenters have to say.**
- ☐ **Not at all. You can't please everyone all the time.**

Appendix 4.
Options for Future Groundwater Use

The purpose of Appendix 4 is to provide a comprehensive if limited set of results of how pumping in any county or GCD affects average annual groundwater levels in that county and adjacent counties. The appendix includes county sections, one each for Bandera, Bexar, Blanco, Comal, Hays, Kendall, Kerr, Medina, and Travis Counties. A final section examines what could occur if no increases in pumping over 2007 GAM average rates are allowed within GMA 9.

Each of the county sections reports a similar set of figures. Table A4.1 lists the types of figures and the reference number of each figure in every of the county section. This section will discuss the meaning of each type of figure. As those meanings are consistent among counties, it is unnecessary to repeat such a detailed discussion in each county section.

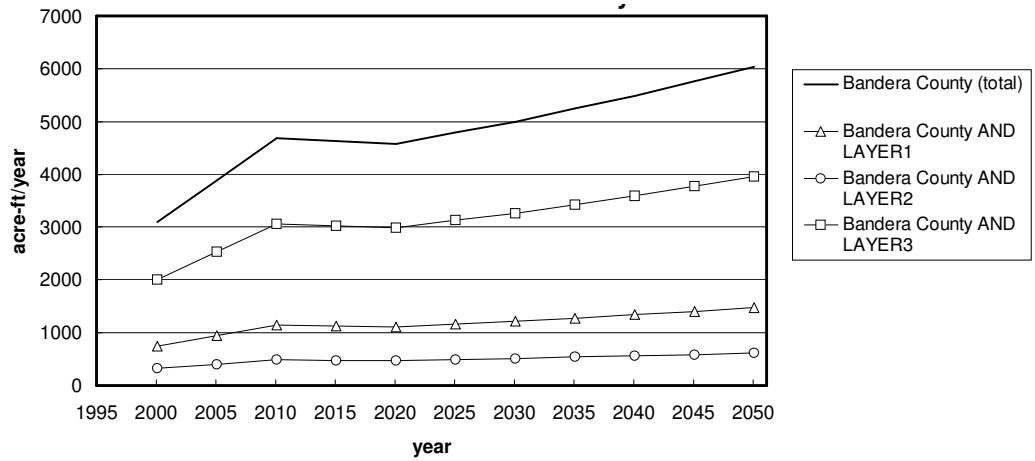
The first type of figure, such as A4.1, illustrates the pumping withdrawals for the baseline GAM from each layer in the model for Bandera County. For example the RWPG estimates a steady increase in pumping during the year 2000 to 2010, a slow drop off of pumping during 2010 to 2020, followed by a steady increase in pumping during 2020 to 2050. The Figure A4.1 (and others of this type) break down pumping volumes to the various groundwater layers appropriate in the county; in Bandera County there are three, Edwards Group, Upper Trinity, and Middle Trinity. Parallel figures A4.14, A4.27, A4.40, A4.52, A4.65, A4.78, A4.91, and A4.103 are similar in intent and content to Figure A4.1.

The baseline GAM is the unaltered groundwater availability model from the Texas Water Development Board, created in 2000 and described in Report 353. Figure A4.1 illustrates pumping withdrawals for the baseline GAM from each layer in the model in Bandera County. Layer 1 represents the Edwards Group of the Edwards Trinity Plateau, Layer 2 represents the Upper Trinity Aquifer, and Layer 3 represents the Middle Trinity Aquifer. For each layer, the pumping rate is computed by adding all pumping in the active cells within Bandera County. The pumping schedule in the baseline GAM is based on water use estimates from the Regional Water Planning Groups (RWPG). Figure 1 shows the withdrawal rates as they occur in the model. Figure A4.2 shows the projected withdrawal rates from the RWPG. Withdrawals in the model may not match the estimated demand if dry cells in the model prevent pumping from taking place (pumping or extraction cannot occur in a dry cell), and failures to pump would reduce the overall yield in the model simulation.

The second type of figure in the series (see Figure A4.2) provides a histogram with information on the RWPG estimates for county-wide withdrawals in various years. For example, Figure A4.2 illustrates the estimated volume of withdrawals for 1975, 1996, 1997, 2000, 2010, 2020, 2030, 2040, and 2050. The figures of this type in the remaining

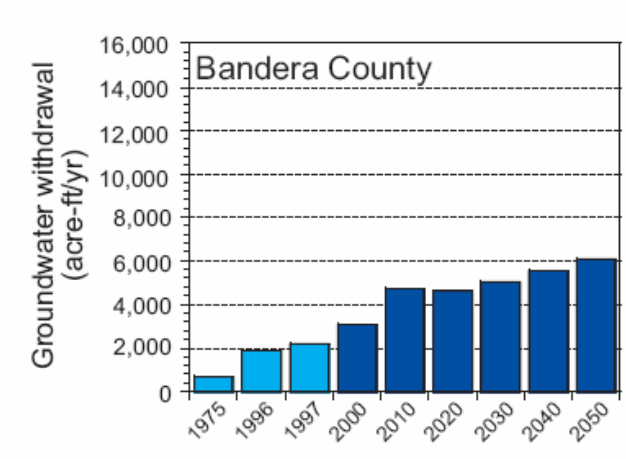
sections of this chapter are Figure A4.15, A4.28, A4.41, A4.53, A4.66, A4.79, A4.92, and A4.104.

Figure A4. 1
Pumping Withdrawals in Baseline GAM: Bandera County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 2
Bandera County Groundwater Withdrawal



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Table A4. 1
Figures in Each County Section

Content	Bandera	Bexar	Blanco	Comal	Hays	Kendall	Kerr	Medina	Travis
Baseline GAM pumping	A4.1	A4.14	A4.27	A4.40	A4.52	A4.65	A4. 78	A4.91	A4.103
Groundwater withdrawn	A4.2	A4.15	A4.28	A4.41	A4.53	A4.66	A4.79	A4.92	A4.104
(own county)									
Average county drawdown	A4.3	A4.16	A4.29	A4.42	A4.54	A4.67	A4. 80	A4.93	A4.105
(own county)									
Withdrawal by pumping factor	A4.4	A4.17	A4.30	A4.43	A4.55	A4.68	A4. 81	A4.94	A4.106
(own county)									
Pumping effects on Bandera	x	A4.18	A4.31	A4.44	A4.56	A4.69	A4. 82	A4.95	A4.107
Pumping effects on Bexar	A4.5	x	A4.32	A4.45	A4.57	A4.70	A4. 83	A4.96	A4.108
Pumping effects on Blanco	A4.6	A4.19	x	A4.46	A4.58	A4.71	A4. 84	A4.97	A4.109
Pumping effects on Comal	A4.7	A4.20	A4.33	x	A4.59	A4.72	A4. 85	A4.98	A4.110
Pumping effects on Hays	A4.8	A4.21	A4.34	A4.47	x	A4.73	A4. 86	A4.99	A4.111
Pumping effects on Kendall	A4.9	A4.22	A4.35	A4.48	A4.60	x	A4. 87	A4.100	A4.112
Pumping effects on Kerr	A4.10	A4.23	A4.36	A4.49	A4.61	A4.74	x	A4.101	A4.113
Pumping effects on Medina	A4.11	A4.24	A4.37	A4.50	A4.62	A4.75	A4.88	x	A4.114
Pumping effects on Travis	A4.12	A4.25	A4.38	A4.51	A4.63	A4.76	A4.89	A4.102	x
Pumping effects from all counties	A4.13	A4.26	A4.39	x	A4.64	A4.77	A4.90	x	A4.115
(on own county)									

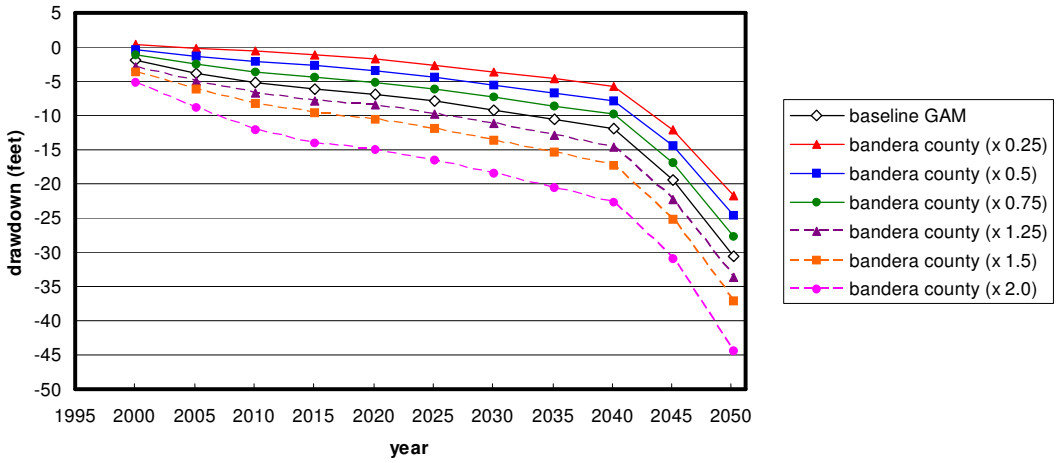
The third type of figure (see Figure A4.3), illustrates the average county aquifer drawdown (such as in Bandera County) measured in feet, resulting for the pattern of county pumping. In the case of Bandera County (see Figure A4.3) there are seven alternate future pumping traces illustrated, all related to the baseline GAM withdrawals denoted in Figures A4.1 and A4.2. In the case of Bandera County, those options are 0.25, 0.5, 0.75, 1.0, 1.25, 1.5, and 2.0 times the baseline GAM water withdrawals. For example, pumping at 25 percent of the baseline results in a drawdown of the expected average aquifer level in the county. The drops are modest and close to linear for the first 40 years (5 feet over 40 years, or a aquifer mining rate of 0.125 feet per year). The expected average aquifer level in the county declines by 22 feet, or 2.2 feet drawdown per year. Comparable but larger drawdown occurs with increased pumping levels.

Figure A4.4 is the fourth type of figure that illustrates pumping withdrawals for the various pumping factors. The figure indicates the annual acre-feet per year withdrawal rate. Note that all seven options are multiples of the baseline GAM, from 25 percent up to 200 percent of those rates which have been established by the regional water planning process. For example, the pumping withdrawal for the 25 percent case represents less than 2000 acre-feet per year throughout the 50 year period while the 200 percent of base case example withdrawals start the year 2000 at over 600 acre-feet per year.

Figures A4.5 through A4.12 are similar in that they illustrate how pumping in Bandera County affects the expected average aquifer levels in other counties within GMA 9, for Bexar County (Figure A4.5) to Blanco (A4.6), Comal (A4.7), Hayes (A4.8), Kendall (A4.9), Kerr (A4.10), Medina (A4.11), and Travis (A4.12) Counties. The seven alternative futures in each of these figures correspond to the pumping rates of Figure A4.4.

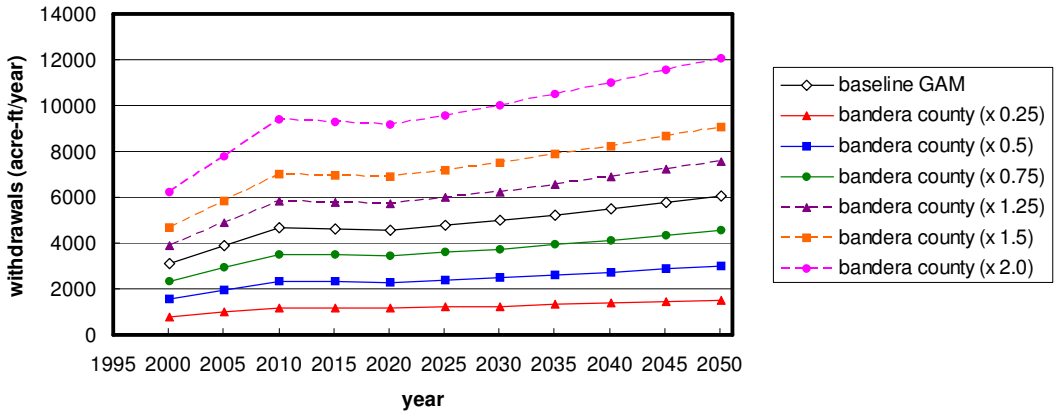
One assumption behind the “county impact” volumes is that these figures are that all other GMA 9 pumping (other than the county indicated) follows the expected average pattern of the baseline GAM. Fore example, all 7 of the pumping scenarios in Figure A4.4 do not appear to make much of a difference to the average aquifer levels in Bexar County. From the highest rate of pumping (up to 12,000 acre-feet per year in 2050) to the lowest rate (1,800 acre-feet per year in 2050) in Bandera County, the change in the expected average aquifer load in Bexar County is on the order of at most a few feet. Figure A4.5 shows that withdrawals in Bandera County do not affect strongly the average aquifer level in Bexar County. Bandera County withdrawals have similar effects on Blanco, Comal, and Hays Counties (Figures A4.6 through A4.9). Pumping in Bandera County has much more of a consequence on the expected average aquifer levels in Kerr County (Figure A4.10) and Medina County (Figure A4.11). For example, there is a change in the expected average drawdown in Kerr County of 18 feet for the 25 percent of baseline GAM pumping, versus nearly a 30 foot drawdown for 200 percent of the baseline GAM pumping—this means an incremental consequence of up to 12 additional feet of aquifer drawdown in Kerr County for increased pumping in Bandera County.

Figure A4. 3
Pumping in Bandera County (average drawdown)



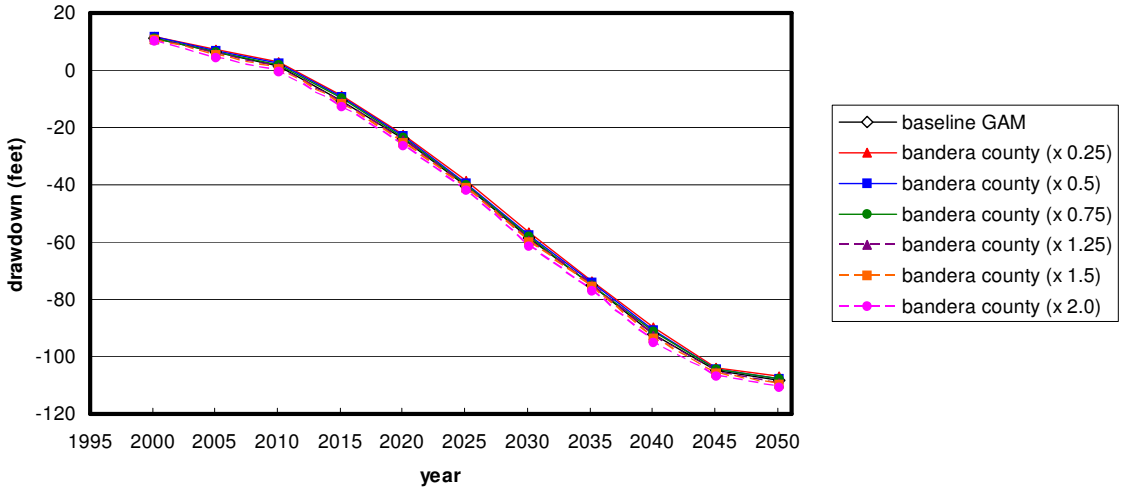
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 4
Pumping Withdrawal for Various Pumping Factors: Bandera County



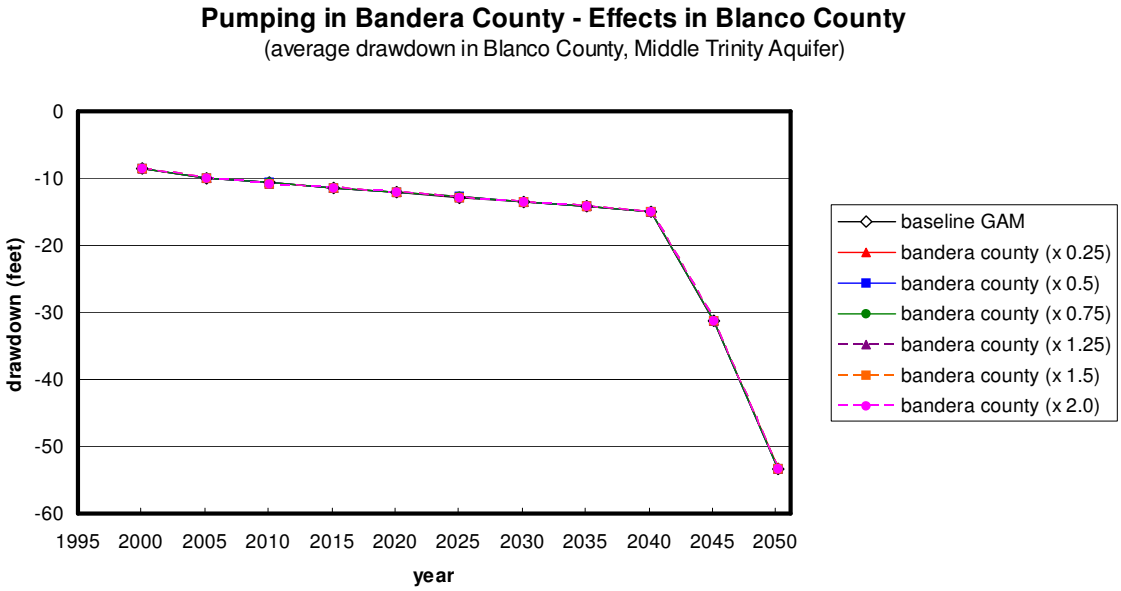
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 5
Pumping in Bandera County – Effects in Bexar County



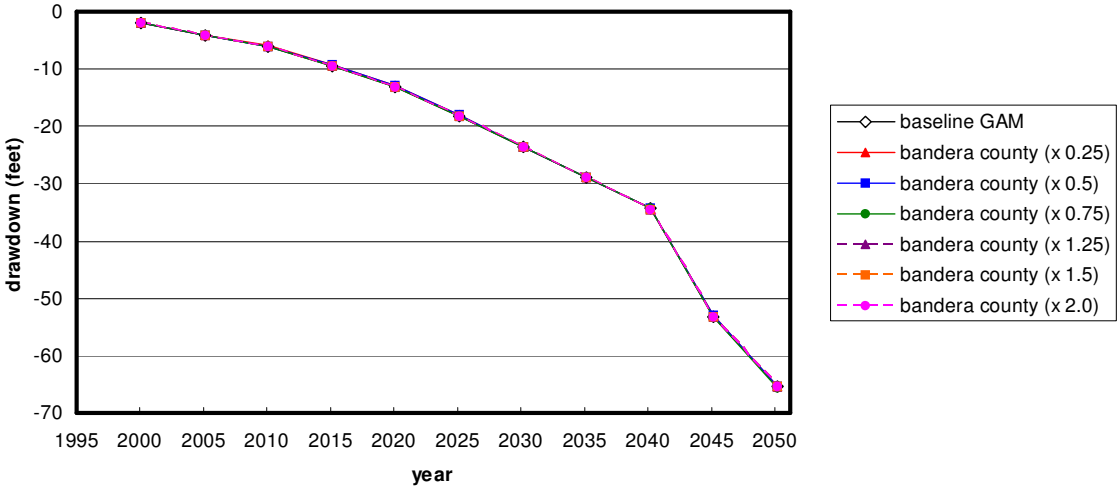
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 6
Pumping in Bandera County – Effects in Blanco County



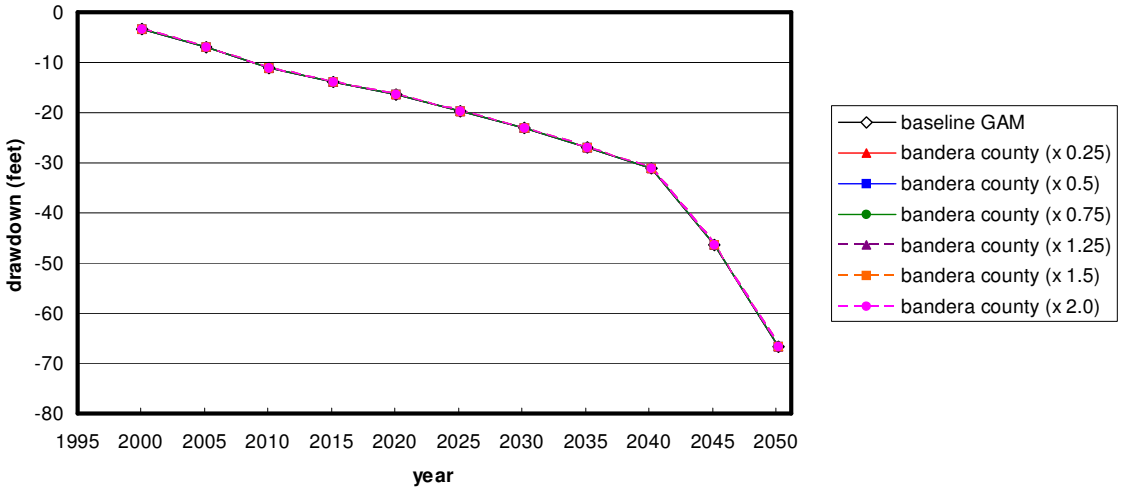
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 7
Pumping in Bandera County – Effects in Comal County



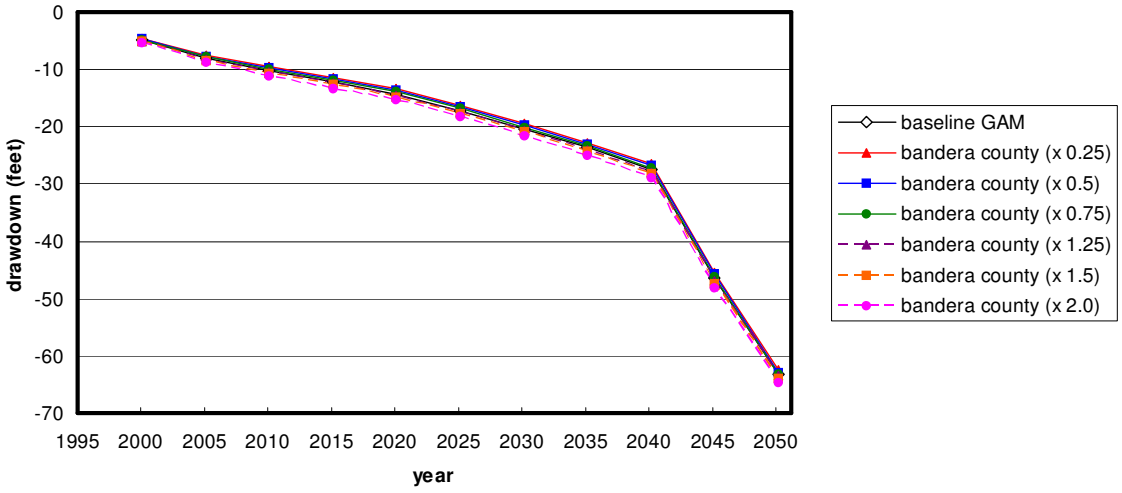
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 8
Pumping in Bandera County – Effects in Hays County



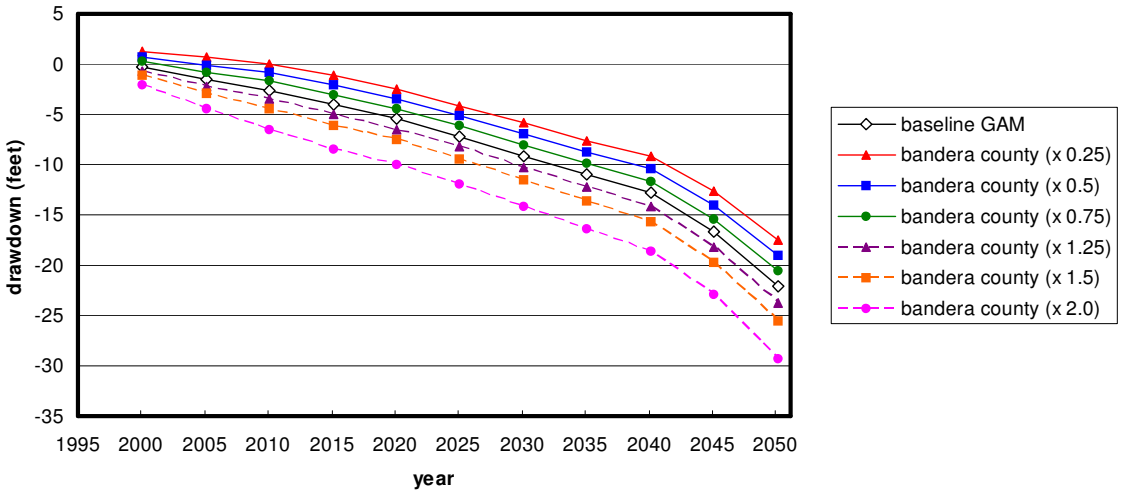
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 9
Pumping in Bandera County – Effects in Kendall County



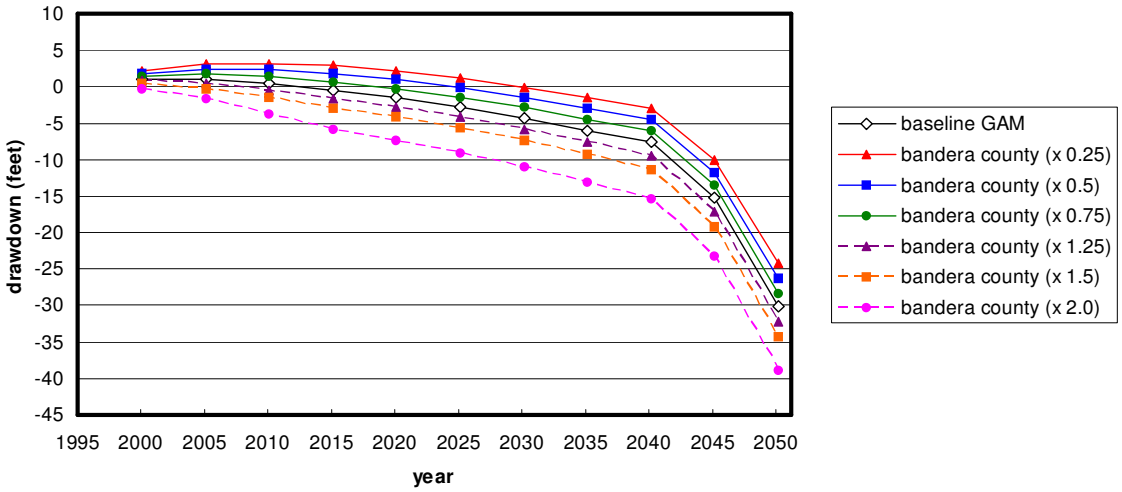
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 10
Pumping in Bandera County – Effects in Kerr County



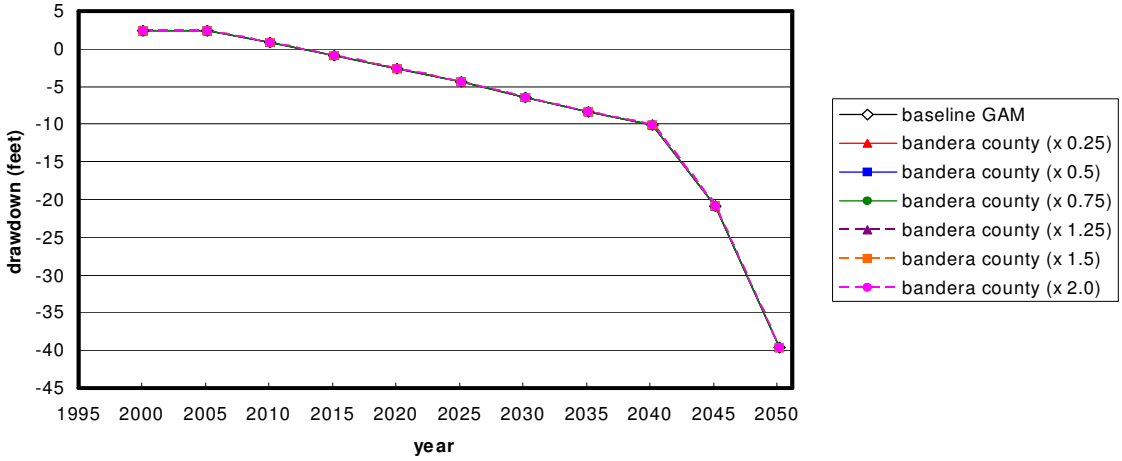
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 11
Pumping in Bandera County – Effects in Medina County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

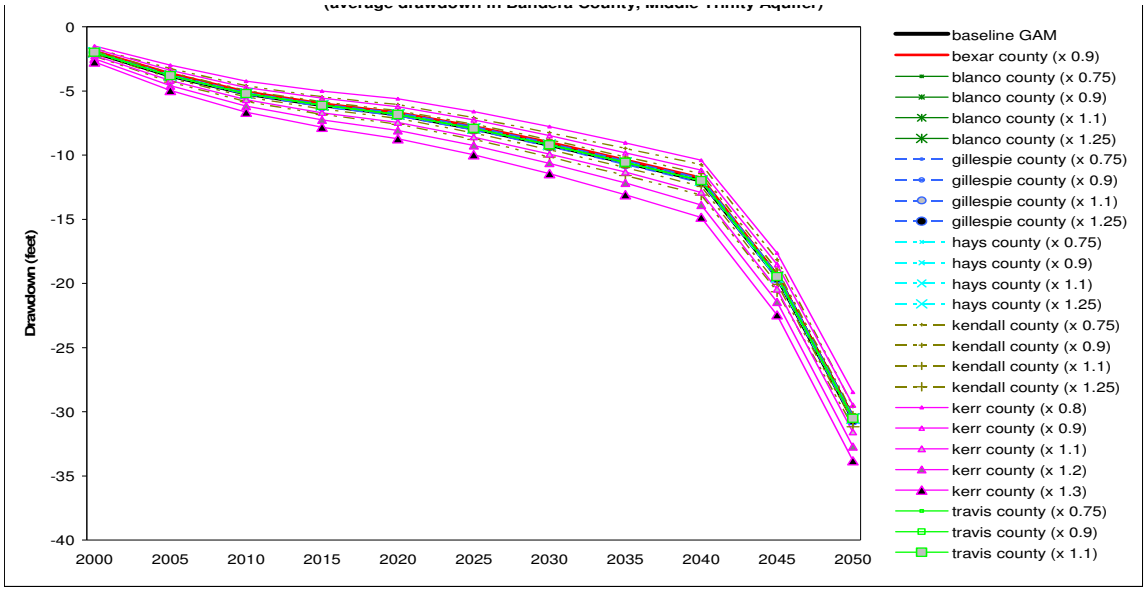
Figure A4. 12
Pumping in Bandera County – Effects in Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

The final type of figure illustrates a summary of how pumping in other counties affect the aquifer level in Bandera County. Over the 50 year period the drawdown in the average aquifer levels in Bandera County can vary up to six feet as pumping from other GMA 9 counties vary from 0.75 to 1.3 from the baseline GAM, all other factors held constant. In other words, the impact of Bandera County's aquifer levels for pumping on other counties is modest, but regional effects do occur. Kerr County withdrawals have the largest marginal effects (see Figure A4.13).

Figure A4. 13
Effects in Bandera County – Pumping in Other Counties



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

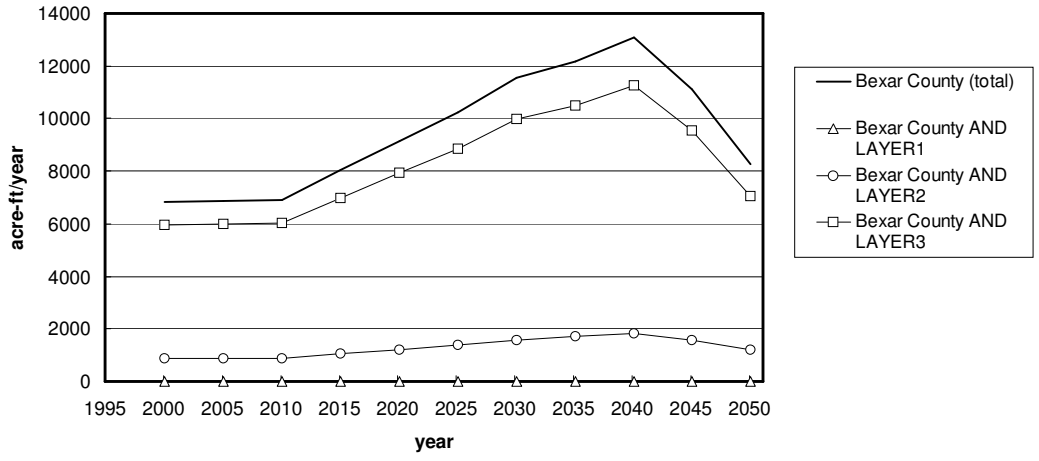
Bexar County

This section of Appendix 4 describes alternative pumping rates for Bexar County and how those average aquifer head levels within GMA 9. Figures A4.14 and A4.15 illustrate baseline GAM groundwater withdrawals. The baseline GAM is the unaltered groundwater availability model from the Texas Water Development Board, created in 2000 and described in Report 353.[1] Figure A4.14 illustrates pumping withdrawals for the baseline GAM from each layer in the model in Bexar County. Layer 1 represents the Edwards Group of the Edwards Trinity Plateau, Layer 2 represents the Upper Trinity Aquifer, and Layer 3 represents the Middle Trinity Aquifer.

For each layer, the pumping rate is computed by adding all pumping in the active cells that reside within Bexar County. The pumping schedule in the baseline GAM is based on water use estimates from RWPGs.[2] Figure A4.14 shows the withdrawal rates as they occur in the model. Figure A4.15 shows the projected withdrawal rates from the RWPG.[3] Withdrawals in the model may not match the estimated demand if dry cells in the model prevent pumping from taking place as pumping or extraction cannot occur in a dry cell, this would result in a reduction of the overall yield in the model simulation.

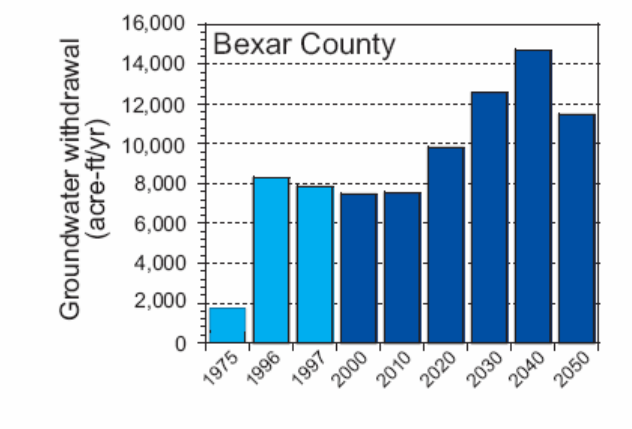
Figures A4.17 illustrate the range of simulated withdrawals 0.25 to 1.3 of baseline GAM pumping and their representative expected annual aquifer head levels in Bexar County. The Bexar County average drawdown is more severe than in Bandera County, as the 25 percent of baseline GAM example yields a drawdown of close to 98 feet in 50 years. Figures A4.18 to A4.25 illustrate the effect on Bexar County pumping on other counties, from Bandera (Figure A4.18) to Travis (Figure A4.25). With the exception of Comal County (Figure A4.20) and Median County (Figure A4.24), the marginal effects of increased pumping in Bexar County have modest impacts on the average aquifer levels in other counties. Pumping in other counties do have marginal impacts on Bexar County's average aquifer level (Figure A4.26), as even modest differences in pumping (from 0.75 to 1.3 times the baseline GAM) affect Bexar County's average drawdown.

Figure A4. 14
Pumping Withdrawals in Baseline GAM: Bexar County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

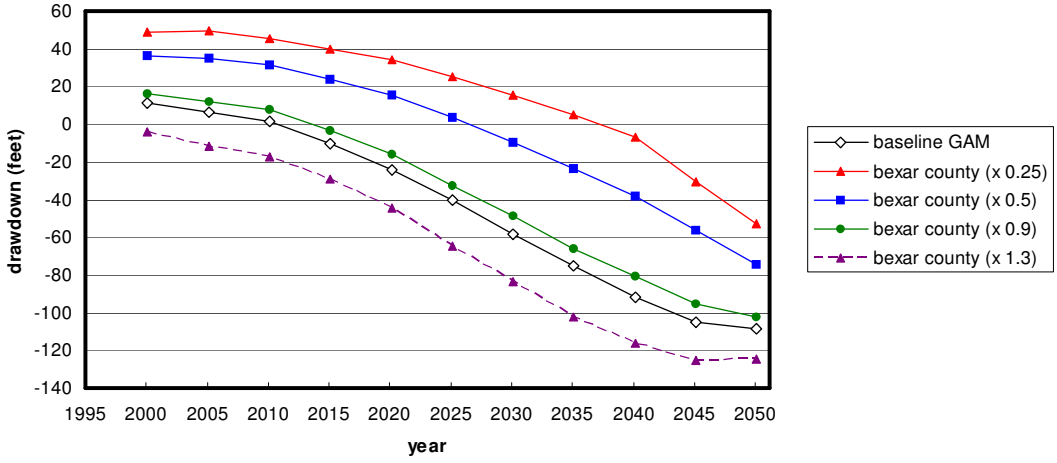
Figure A4. 15
Bexar County Groundwater Withdrawal



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

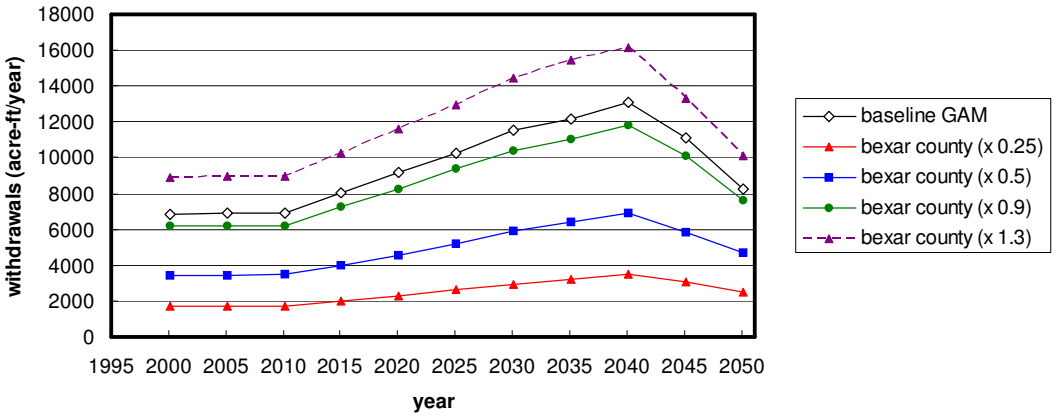
Alternate Pumping Factors

Figure A4. 16
Pumping in Bexar County (average drawdown)



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

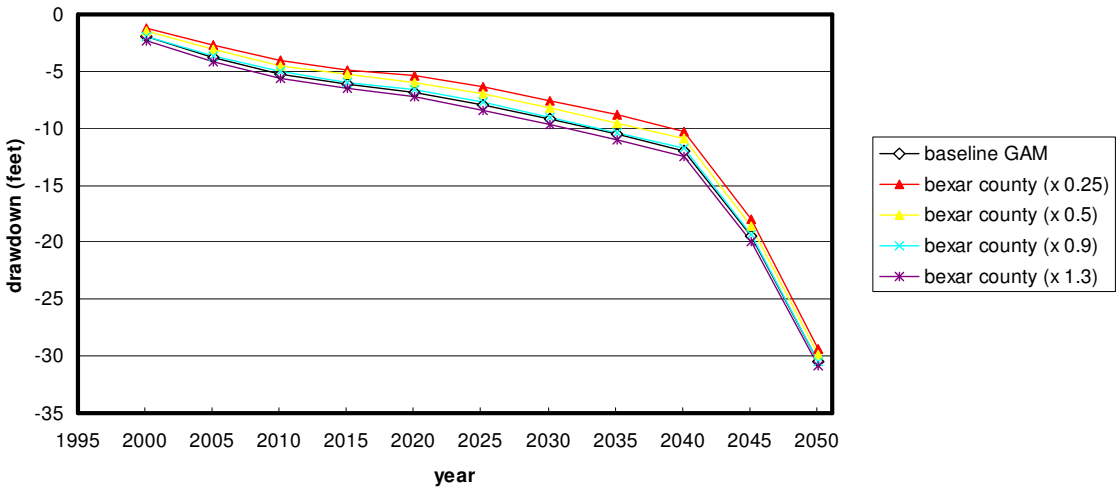
Figure A4. 17
Pumping Withdrawals for Various Pumping Factors



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

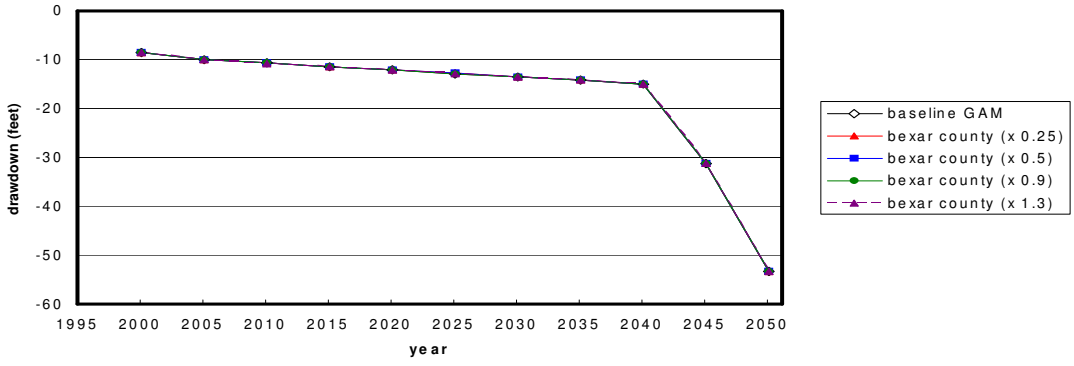
Pumping Impacts on Other Counties

Figure A4. 18
Pumping in Bexar County – Effects in Bandera County



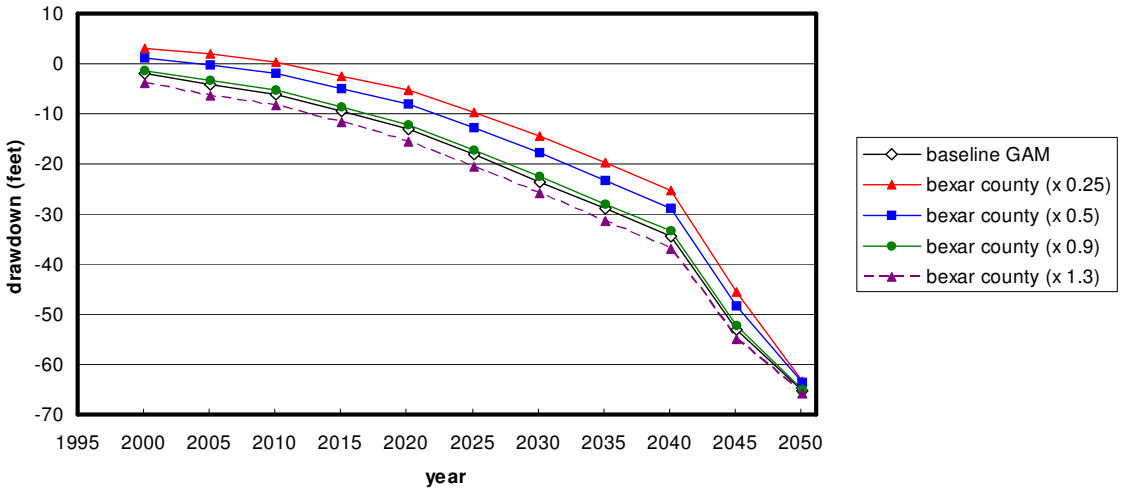
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 19
Pumping in Bexar County – Effects in Blanco County



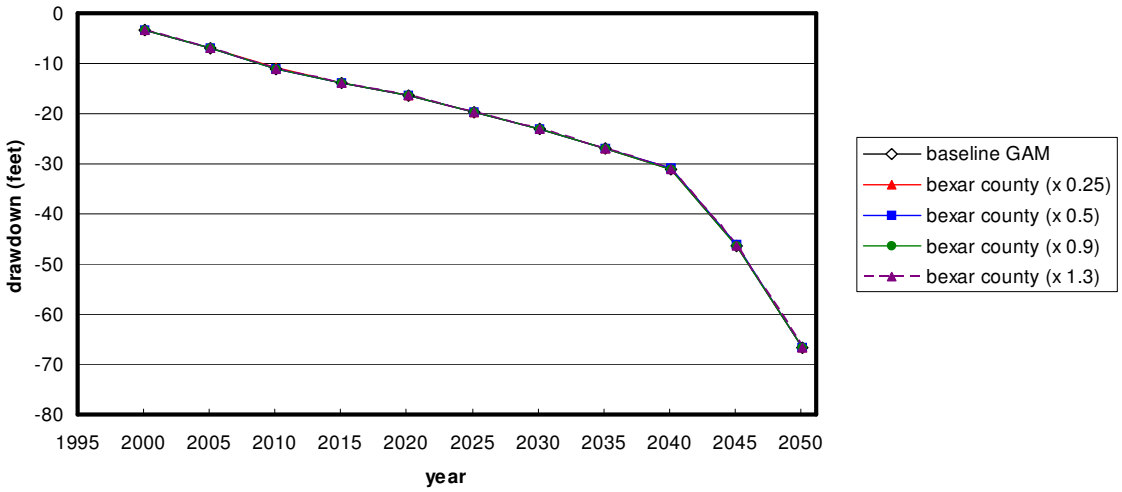
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 20
Pumping in Bexar County – Effects in Comal County



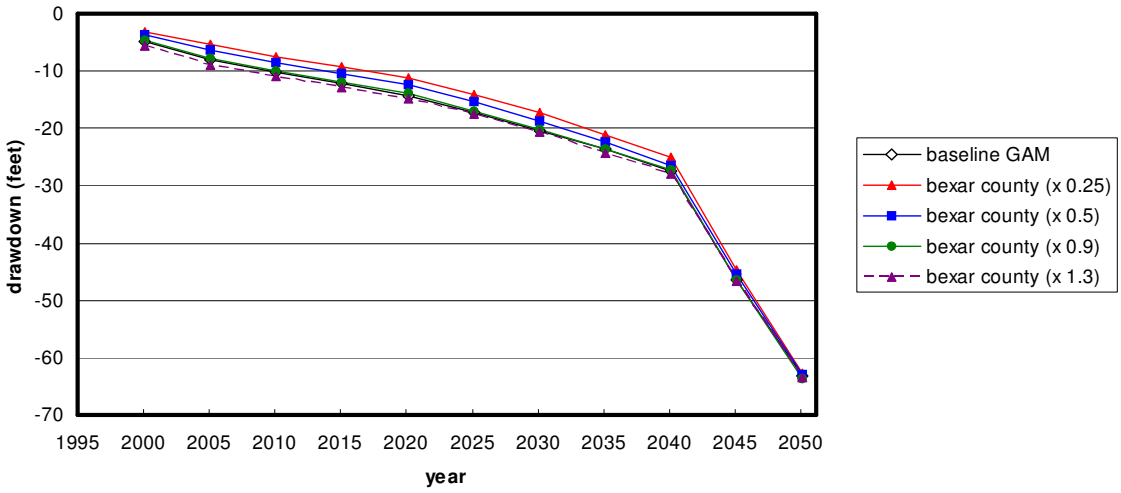
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 21
Pumping in Bexar County – Effects in Hays County



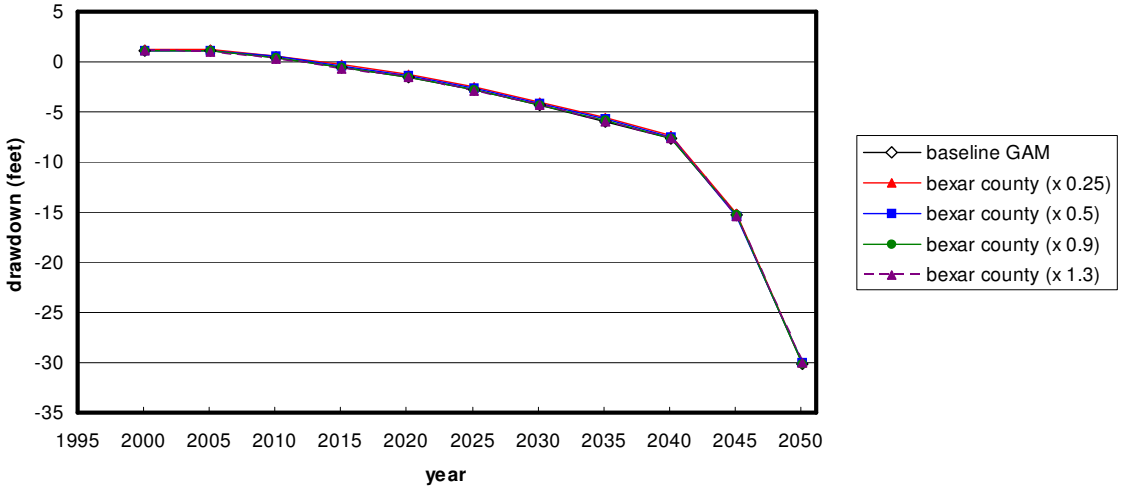
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 22
Pumping in Bexar County – Effects in Kendall County



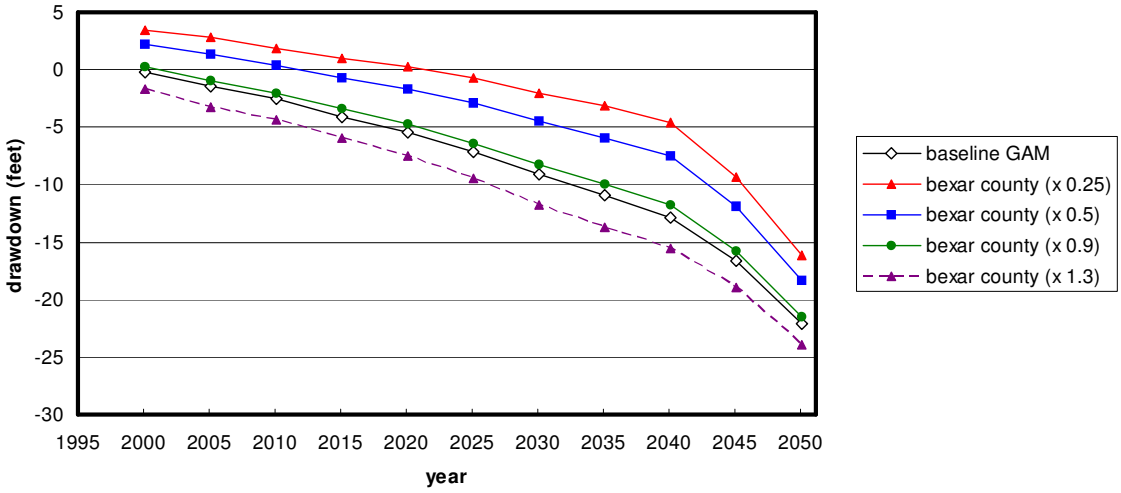
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 23
Pumping in Bexar County – Effects in Kerr County



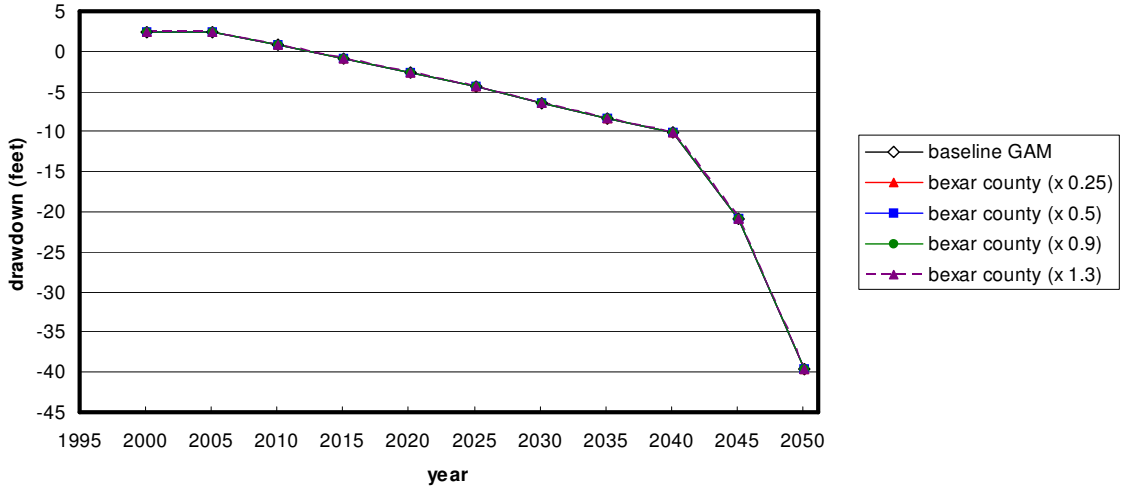
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 24
Pumping in Bexar County – Effects in Medina County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

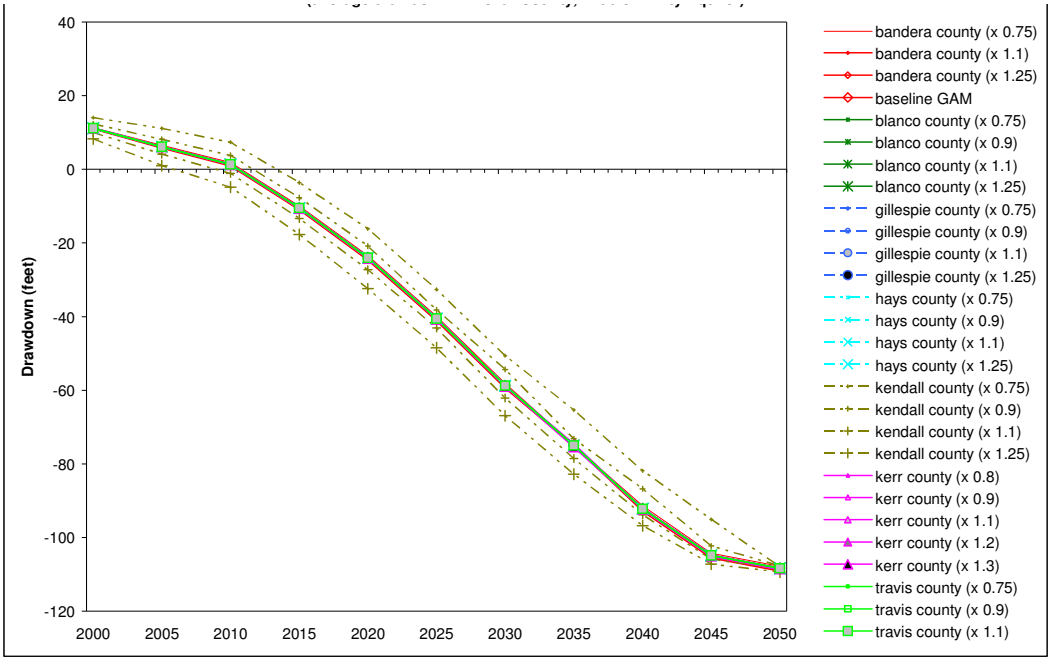
Figure A4. 25
Pumping in Bexar County – Effects in Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Effects from Pumping in Other Counties

Figure A4. 26
Effects in Bexar County – Pumping in other Counties



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

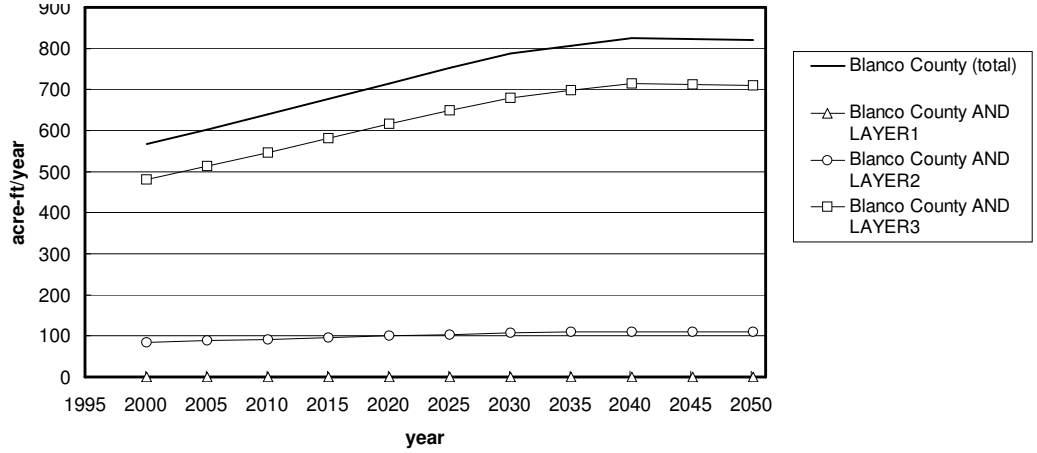
Blanco County

This section of Appendix 4 describes alternative pumping rates for Blanco County and their influence on average groundwater levels within GMA 9. Figures A4.27 and A4.28 introduce the TWDB's estimate of expected pumping levels in Blanco County in acre-feet per year for the 50 year period of 2000 to 2050 as developed in the TWDB's regional water plan. The volume pumping increased from less than 600 acre-feet per year over time, to slightly more than 800 acre-feet per year by 2050. The baseline GAM is the unaltered groundwater availability model from the Texas Water Development Board, created in 2000 and described in Report 353.[4] Figure A4.27 illustrates pumping withdrawals for the baseline GAM from each layer in the model in Blanco County. Layer 1 represents the Edwards Group of the Edwards Trinity Plateau, layer 2 represents the Upper Trinity Aquifer, and Layer 3 represents the Middle Trinity Aquifer.

For each layer, the pumping rate is computed by adding all pumping in the active cells within Blanco County. The pumping schedule in the baseline GAM is based on water use estimates from the RWPGs.[5] Figure A4.27 shows the withdrawal rates *as they occur in the model.* Figure A4.28 shows the projected withdrawal rates from the RWPG.[6] Withdrawals in the model may not match the estimated demand if dry cells in the model prevent pumping from taking place pumping or extraction cannot occur in a dry cell, this would result in a reduction of the overall yield in the model simulation.

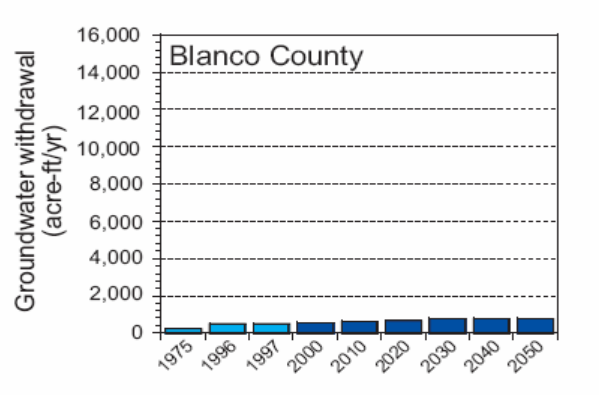
Average drawdown in Blanco County is expected to increase by on the order of less than 1/10 feet per year, except during the drawdown period from 2040 to 2050, when aquifer levels are estimated to fall at a rate of over 3 feet per year (see figures A4.29 and A4.30), depending on the level of pumping. The section of figures A4.31 through A4.38 indicate that diverse rates of pumping in Blanco County have modest (and hardly measurable) consequences for average annual aquifer levels in Bandera, Bexar, Comal, Hays, Kendall, Kerr, Medina, and Travis Counties. Pumping in these counties have modest marginal effects on average aquifer drawdown in Blanco County (see Figure A4.39).

Figure A4. 27
Pumping Withdrawals in Baseline GAM: Blanco County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

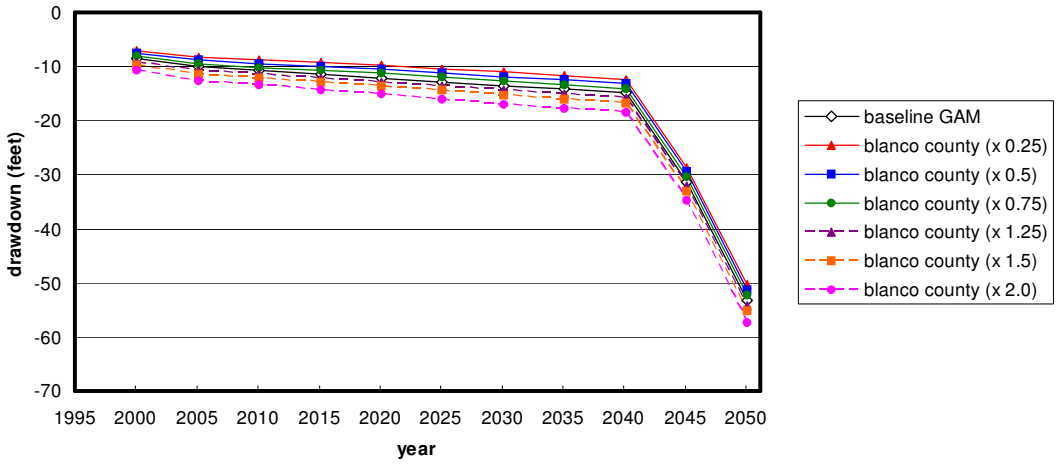
Figure A4. 28
Blanco County Groundwater Withdrawals



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

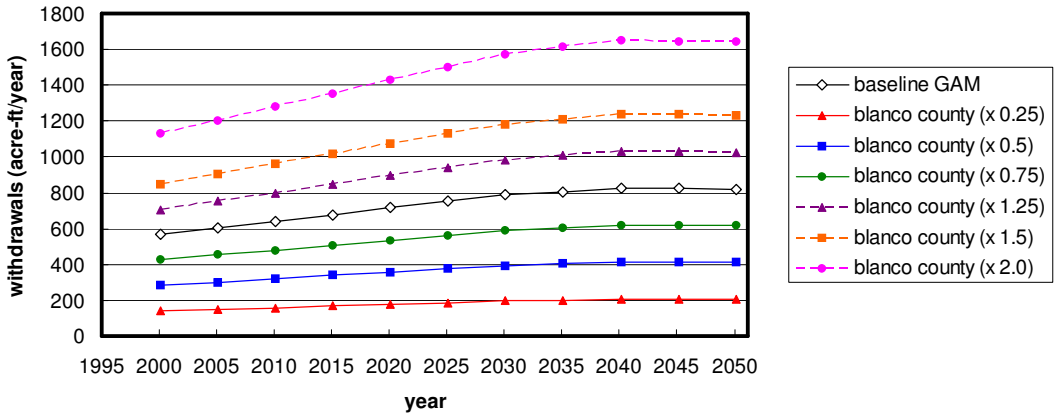
Alternate Pumping Factors

Figure A4. 29
Pumping in Blanco County (average drawdown)



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

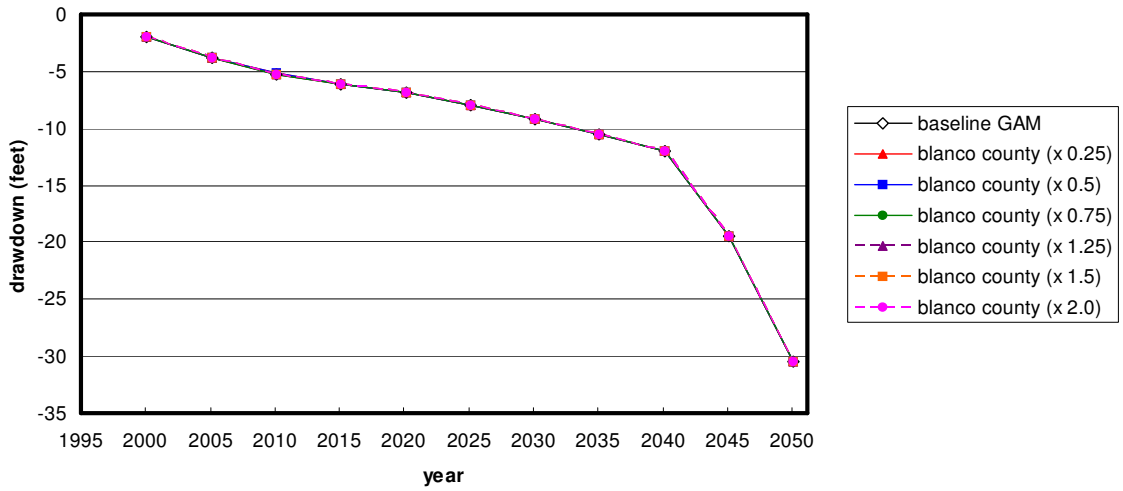
Figure A4. 30
Pumping Withdrawals for Various Pumping Factors: Blanco County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

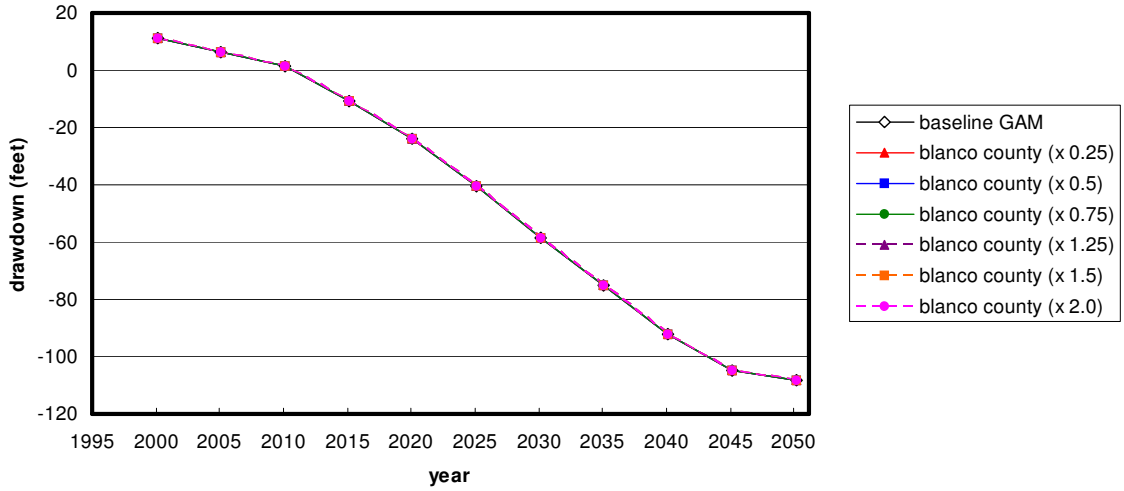
Pumping Impacts on Other Counties

Figure A4. 31
Pumping in Blanco County – Effects in Bandera County



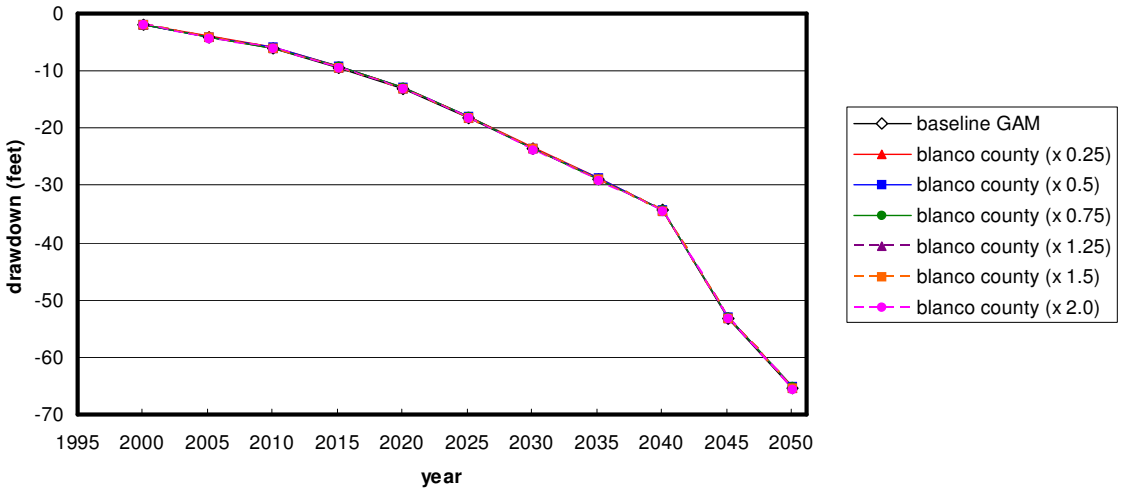
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 32
Pumping in Blanco County – Effects in Bexar County



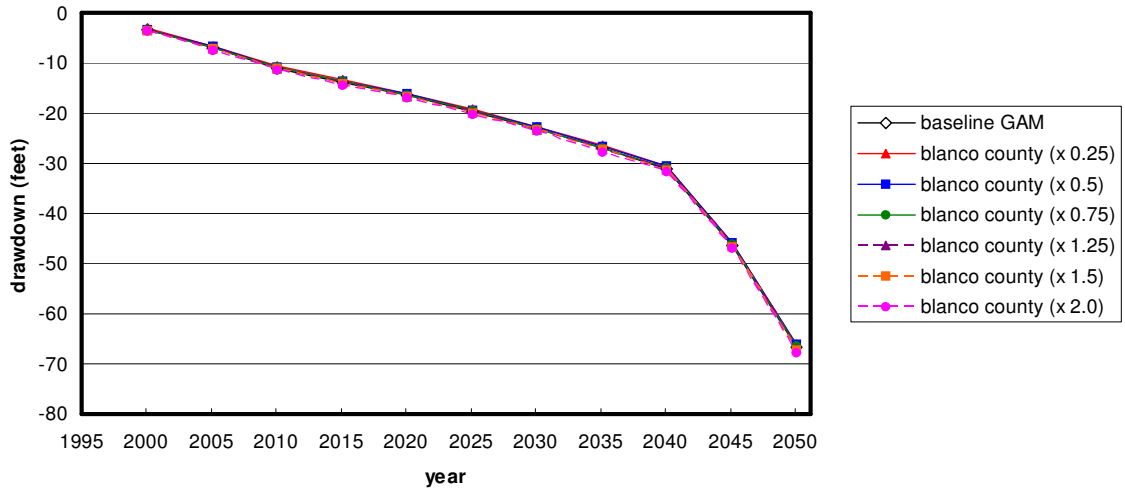
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 33
Pumping in Blanco County – Effects in Comal County



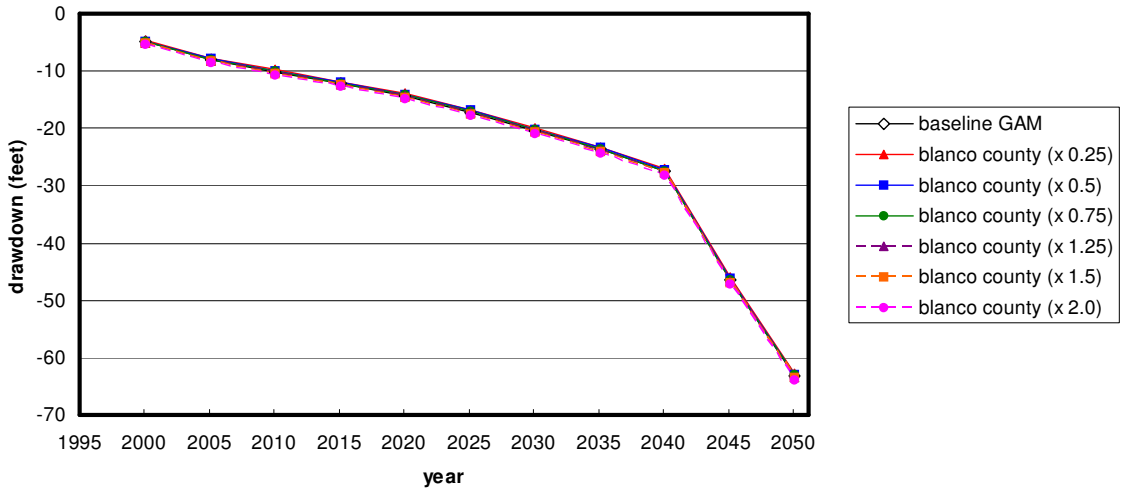
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 34
Pumping in Blanco County – Effects in Hays County



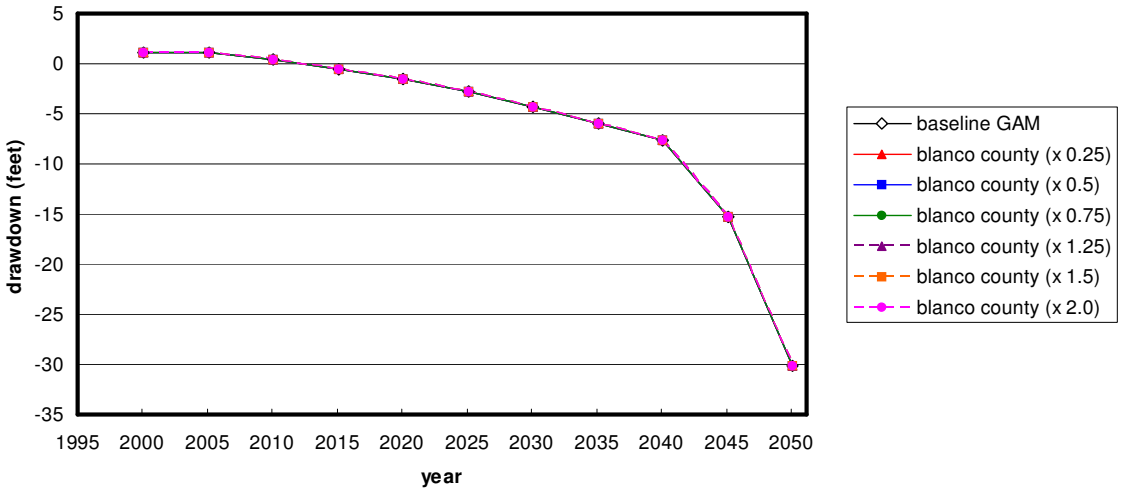
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 35
Pumping in Blanco County – Effects in Kendall County



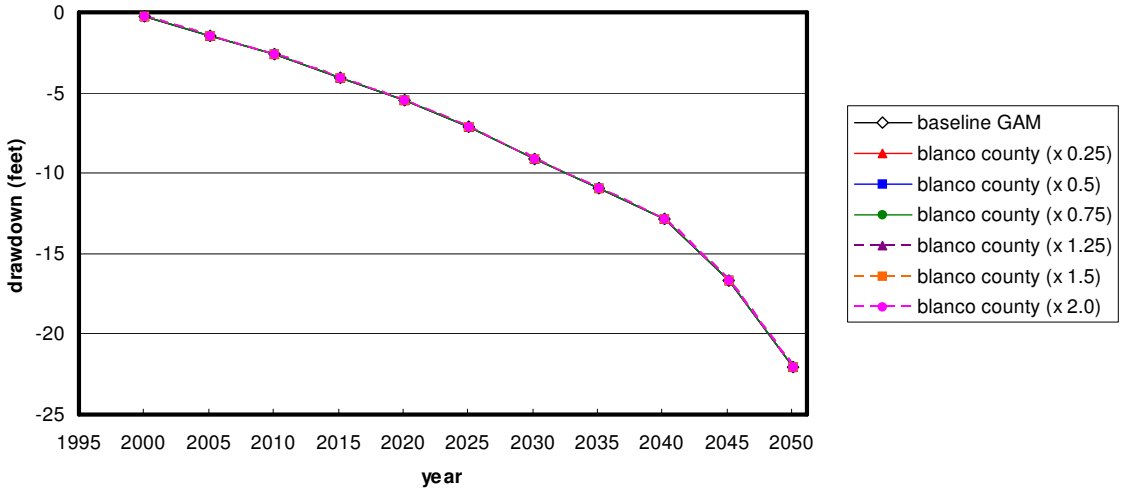
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 36
Pumping in Blanco County – Effects in Kerr County



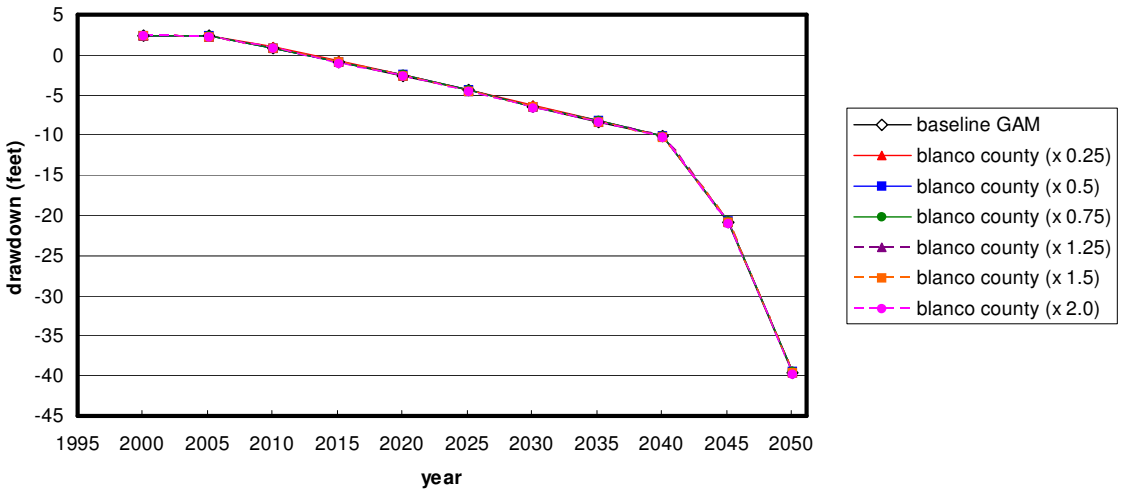
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 37
Pumping in Blanco County – Effects in Medina County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 38
Pumping in Blanco County – Effects in Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Effects from Pumping in Other Counties

Figure A4. 39
Effects in Blanco County – Pumping in other Counties

Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

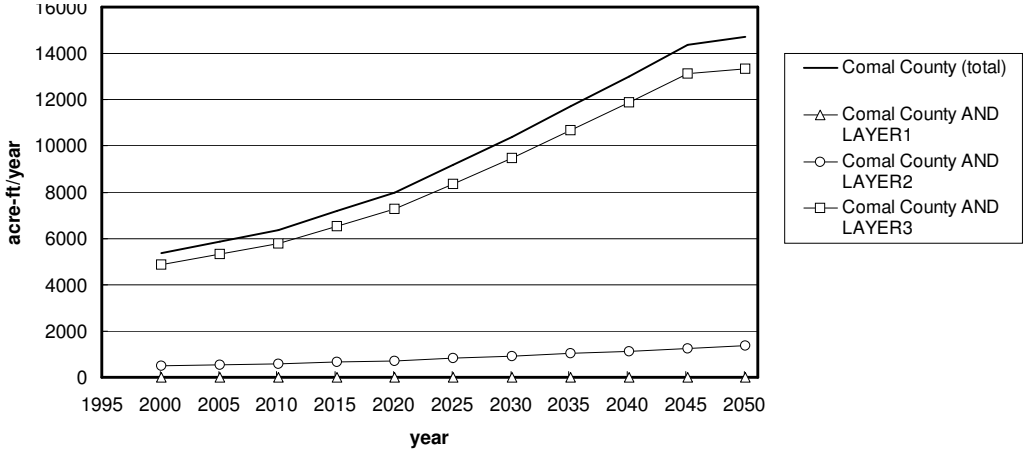
Comal County

Figures A4.41 to A4.51 illustrate the interaction of pumping in Comal County with the remainder of GMA 9. Figures A4.40 and A4.41 show the pumping rates projected by the TWDB. The baseline GAM varies pumping from close to acre-feet per year and withdrawals are expected to increase over 15,000 acre-feet per year by 2050 (see Figure A4.41). The baseline GAM is the unaltered groundwater availability model from the Texas Water Development Board, created in 2000 and described in Report 353.[7] Figure A4.40 illustrates pumping withdrawals for the baseline GAM from each layer in the model in Comal County. Layer 1 represents the Edwards Group of the Edwards Trinity Plateau, Layer 2 represents the Upper Trinity Aquifer, and Layer 3 represents the Middle Trinity Aquifer.

For each layer, the pumping rate is computed by adding all pumping in the active cells within Comal County. The pumping schedule in the baseline GAM is based on water use estimates from the RWPGs.[8] Figure A4.40 shows the withdrawal rates as they occur in the model. Figure A4.41 shows the projected withdrawal rates from the RWPG.[9] Withdrawals in the model may not match the estimated demand if dry cells in the model prevent pumping from taking place. As pumping or extraction cannot occur in dry cell, this would result in a reduction of the overall yield in the model simulation.

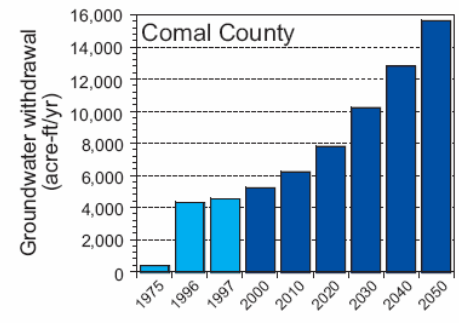
These pumping increases are reflected in the average county aquifer head levels, which decline at a rate of more than one incremental foot per year over the 50 year planning horizon of the baseline GAM (Figure A4.42). Only the pumping return for Comal County converged at 50 percent of baseline GAM with withdrawal rates (see Figure A4.43). Changes in pumping in Comal County have a limited effect on groundwater levels in Bandera (Figure A4.44), Blanco (Figure A4.46), Hays (Figure A4.47), Kendall (figure (A4.48), Kerr (Figure A4.49), Median (Figure A4.50) and Travis (Figure A4.51) counties. The relative level of groundwater withdrawals in Comal County does have a modest incremental influence in average aquifer levels in Bexar County. For example, reducing Comal pumping to 50 percent of GAM projections reduces Bexar County's drawdown by between 5 and 10 feet during the period of 2000 to 2050 (Figure A4.45). Data were not available for a comprehensive assessment of how pumping in other counties would influence average Comal County aquifer levels.

Figure A4. 40
Pumping Withdrawals in Baseline GAM: Comal County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

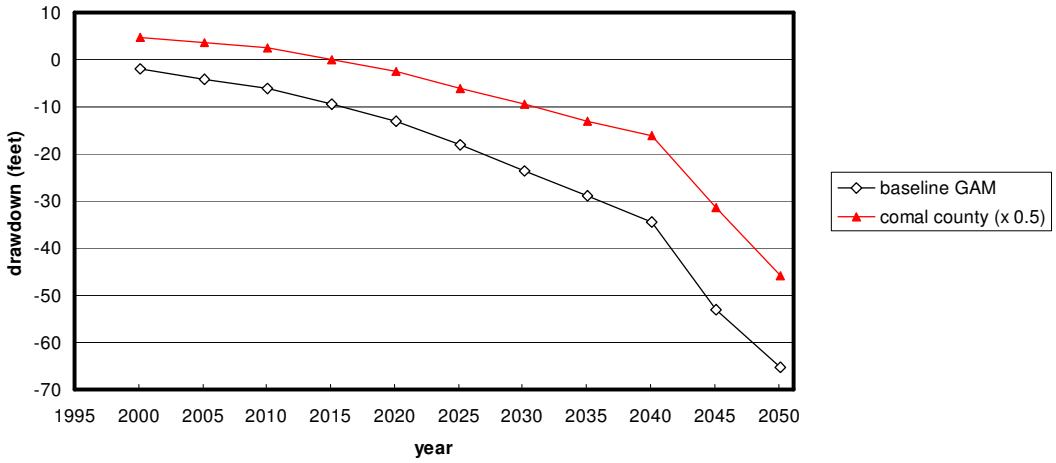
Figure A4. 41
Comal County Groundwater Withdrawal



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

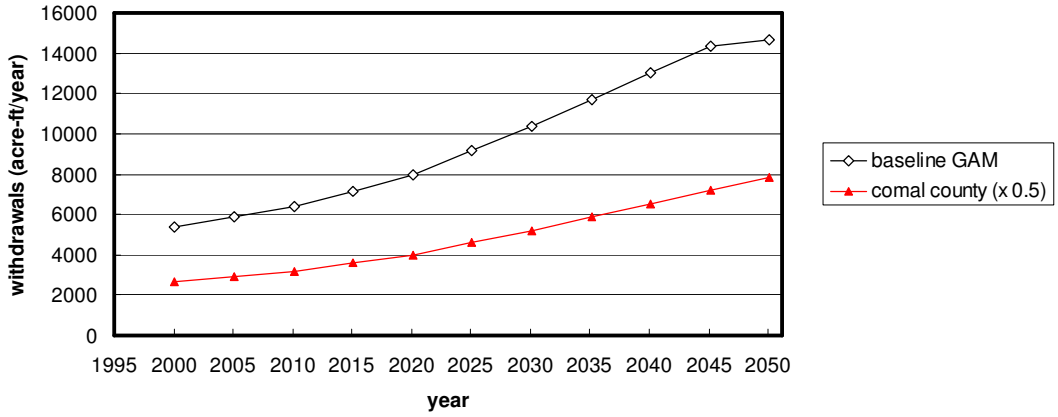
Alternate Pumping Factors

Figure A4. 42
Pumping in Comal County (average drawdown)



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

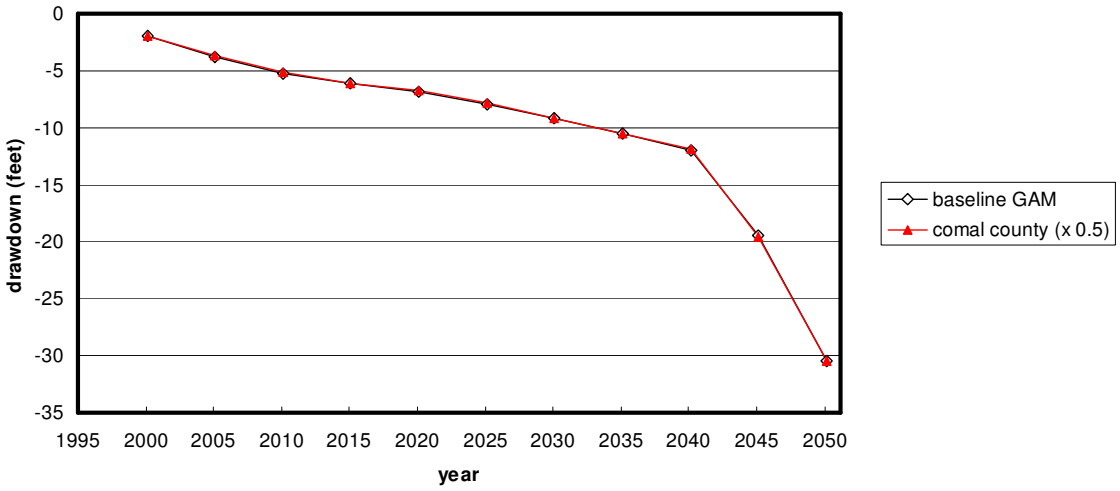
Figure A4. 43
Pumping Withdrawals for Various Pumping Factors: Comal County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

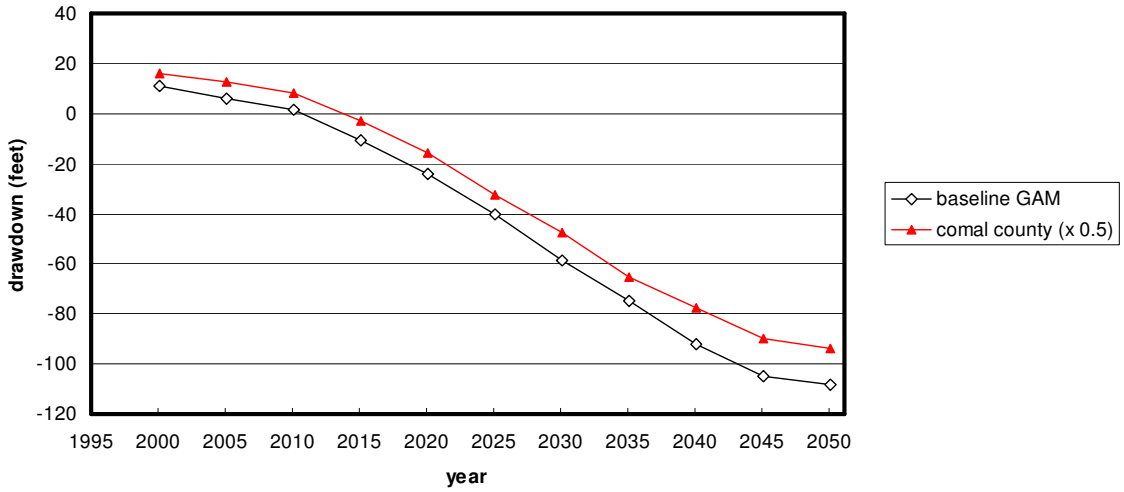
Pumping Impacts on Other Counties

Figure A4. 44
Pumping in Comal County – Effects in Bandera County



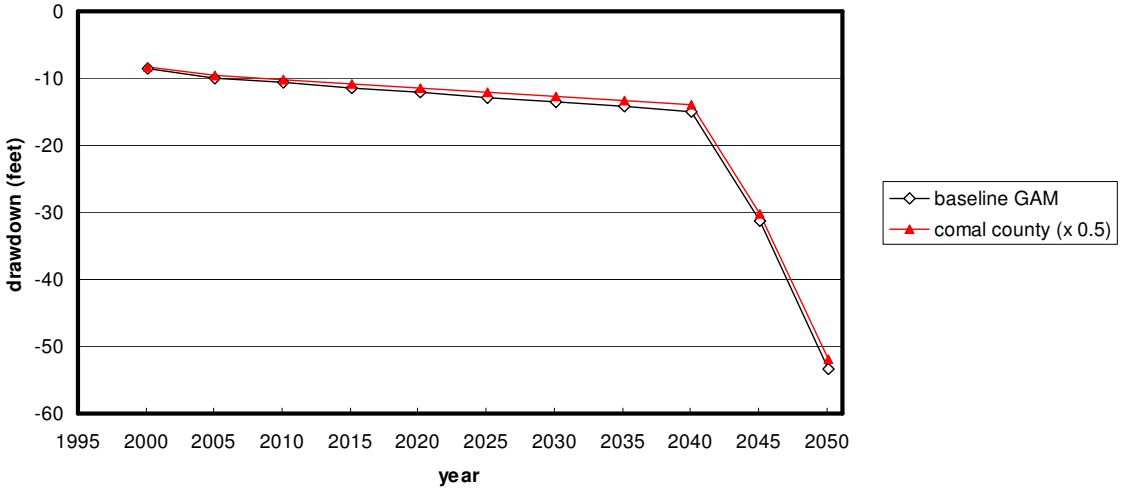
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 45
Pumping in Comal County – Effects in Bexar County



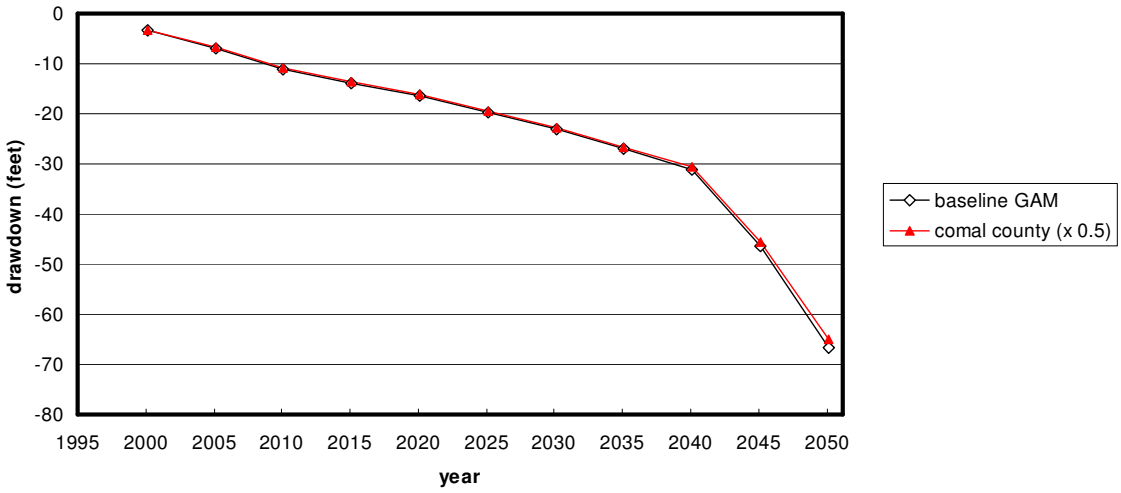
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 46
Pumping in Comal County – Effects in Blanco County



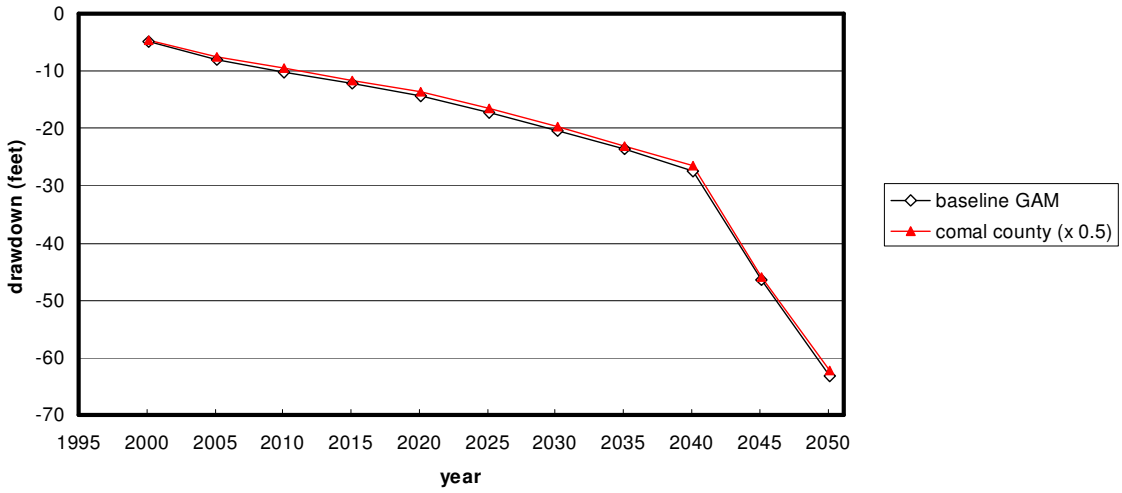
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 47
Pumping in Comal County – Effects in Hays County



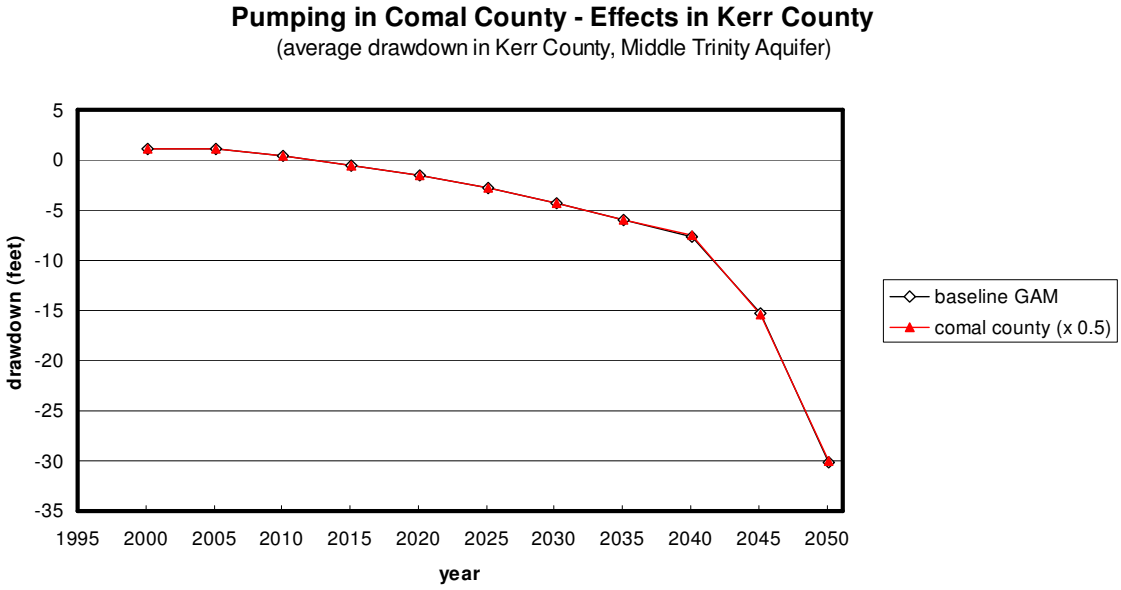
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 48
Pumping in Comal County – Effects in Kendall County



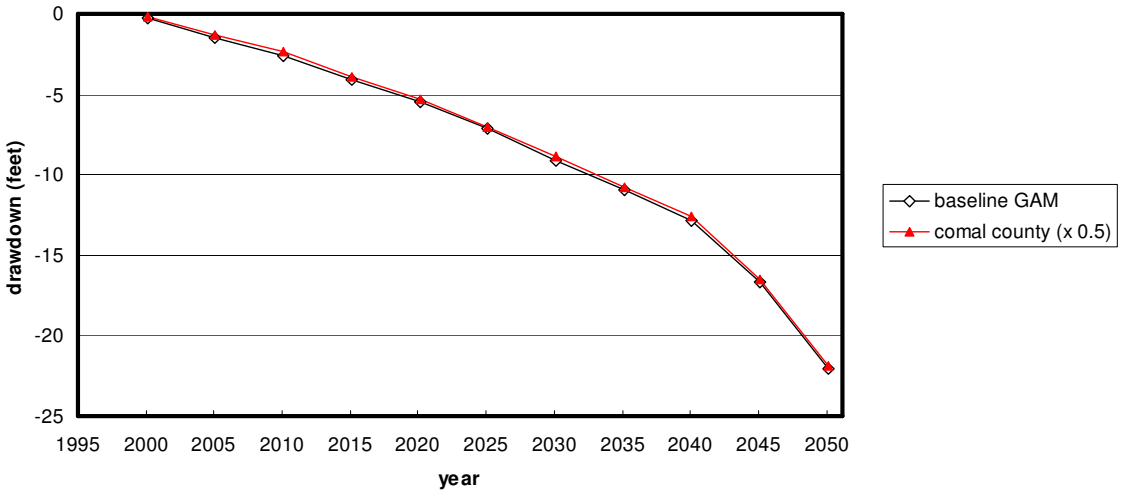
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 49
Pumping in Comal County – Effects in Kerr County



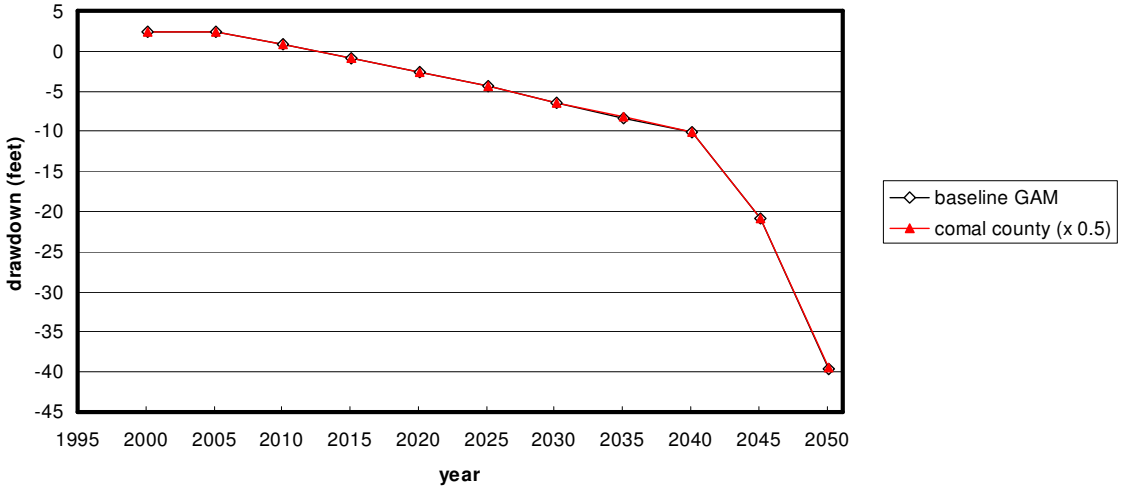
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 50
Pumping in Comal County – Effects in Medina County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 51
Pumping in Comal County – Effects in Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

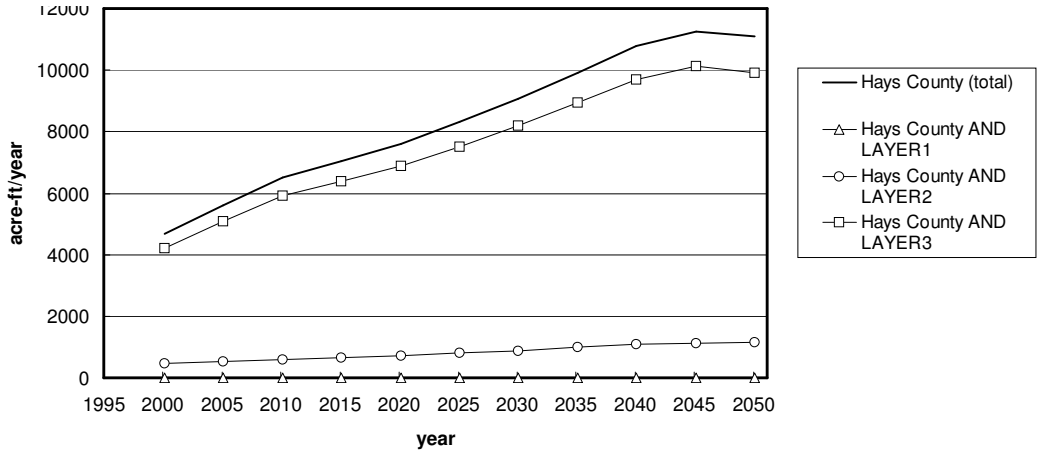
Hays County

Pumping in Hays County affects its own and other counties' aquifer levels (see Figures A4.52 through A4.64). Figures A4.52 and A4.53 show baseline GAM assumptions regarding average annual water withdrawals, ranging from slightly more than 4,000 acre-feet per year in 2000 to close to 12,000 acre-feet per year in 2050. The baseline GAM is the unaltered groundwater availability model from the Texas Water Development Board, created in 2000 and described in Report 353.[10] Figure A4.52 illustrates pumping withdrawals for the baseline GAM from each layer in the model in Hays County. Layer 1 represents the Edwards Group of the Edwards Trinity Plateau, Layer 2 represents the Upper Trinity Aquifer, and Layer 3 represents the Middle Trinity Aquifer.

For each layer, the pumping rate is computed by adding all pumping in the active cells within Hays County. The pumping schedule in the baseline GAM is based on water use estimates from the RWPGs.[11] Figure A4.52 shows the withdrawal rates as they occur in the model. Figure A4.53 shows the projected withdrawal rates from the RWPG.[12] Withdrawals in the model may not match the estimated demand if dry cells in the model prevent pumping from taking place. As pumping or extraction cannot occur in a dry cell, this would reduce the model simulation's overall yield.

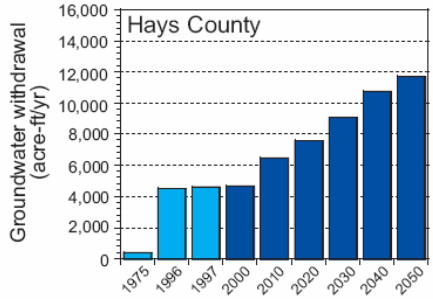
The class examined 5 alternative pumping scenarios for the baseline GAM, from 25 percent of GAM pumping to 150 percent of GAM pumping (see Figure A4.54 and Figure A4.55). These different Hays County pumping scenarios have little consequence for average aquifer drawdown in most counties. Variation in Comal County pumping does appear to influence relative average annual county aquifer drawdown in Blanco County (see Figure A4.58) and even more in Travis County (see Figure A4.63). Relative pumping rates in those other counties do not make much of a difference in Hays County's average aquifer drawdown (see Figure A4.64), at least over the range between 0.75 to 1.3 times baseline GAM withdrawal rates.

Figure A4. 52
Pumping Withdrawals in Baseline GAM: Hays County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

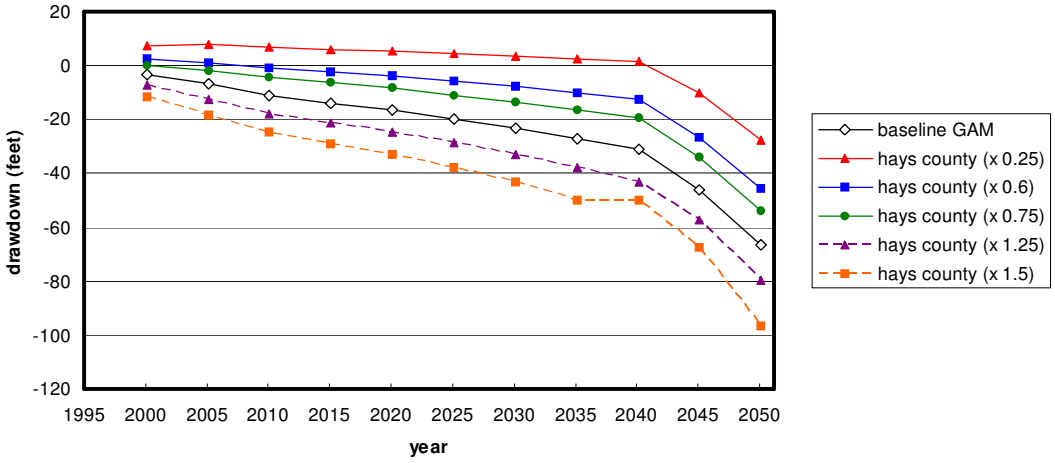
Figure A4. 53
Hays County Groundwater Withdrawal



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

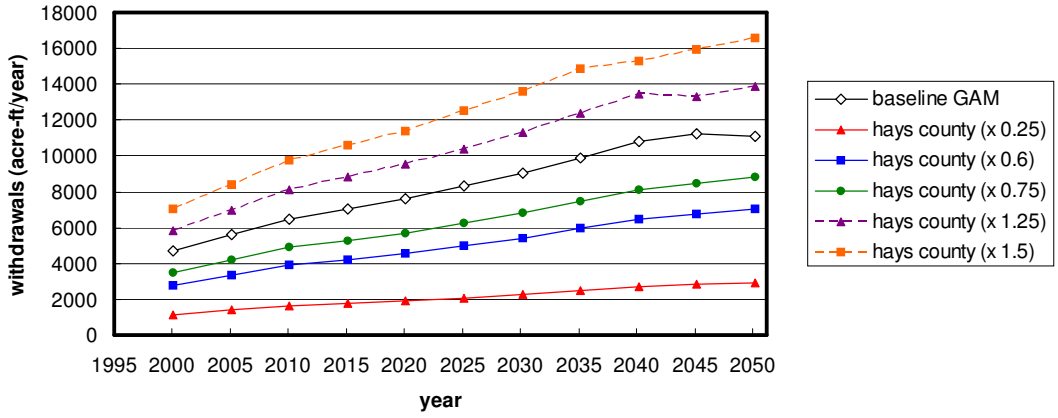
Alternate Pumping Factors

Figure A4. 54
Pumping in Hays County (average drawdown)



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

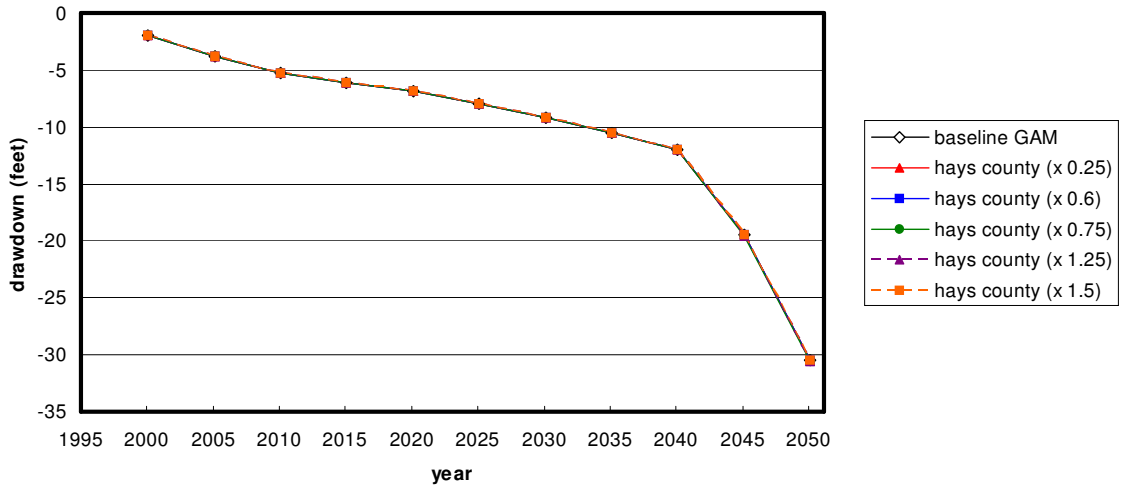
Figure A4. 55
Pumping Withdrawals for Various Pumping Factors: Hays County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

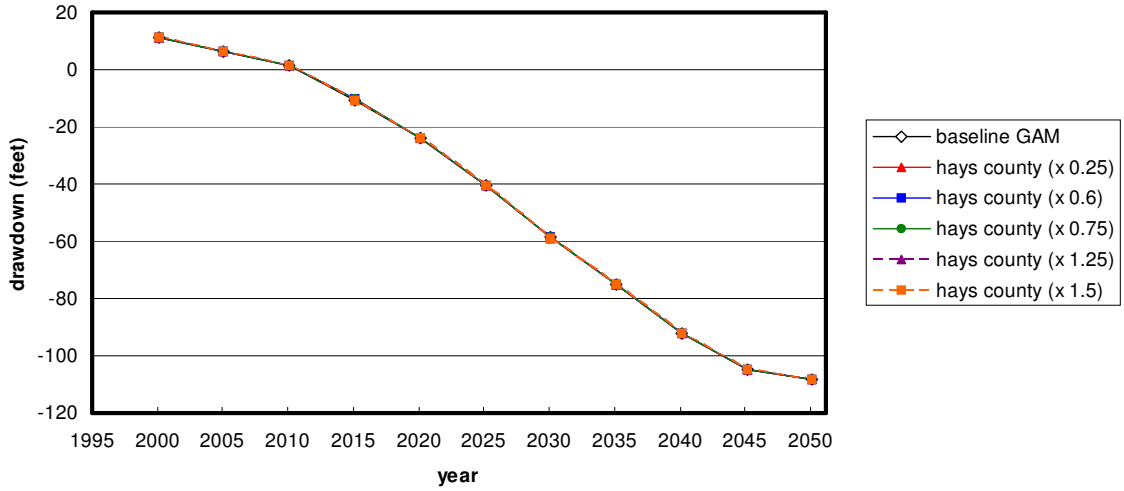
Pumping Impacts on Other Counties

Figure A4. 56
Pumping in Hays County – Effects in Bandera County



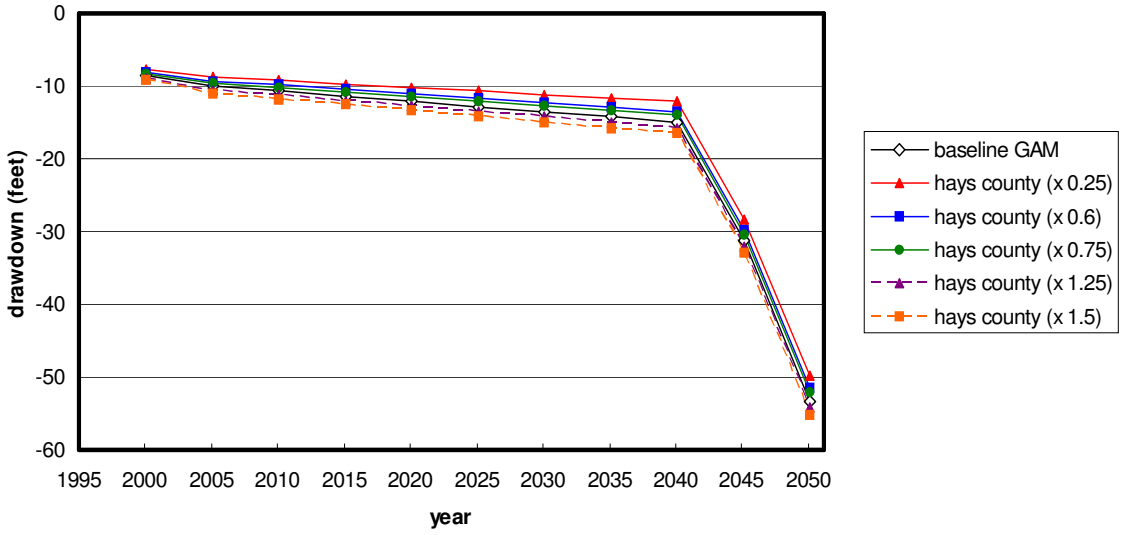
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 57
Pumping in Hays County – Effects in Bexar County



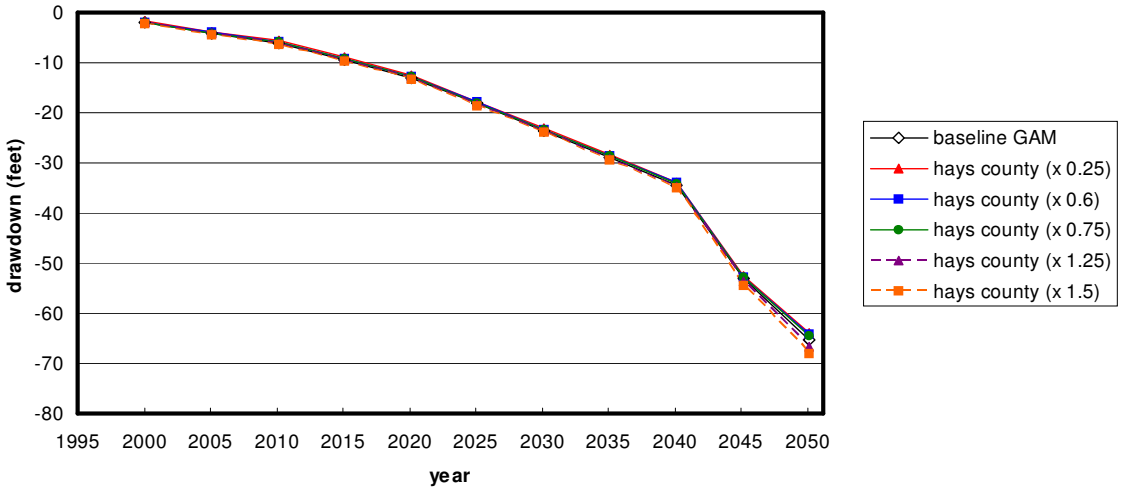
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 58
Pumping in Hays County – Effects in Blanco County



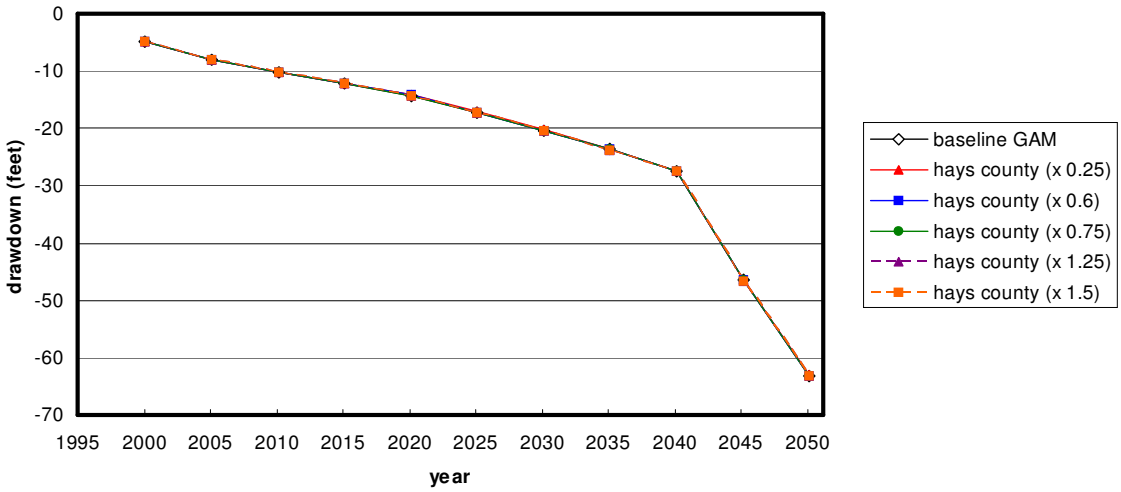
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 59
Pumping in Hays County – Effects in Comal County



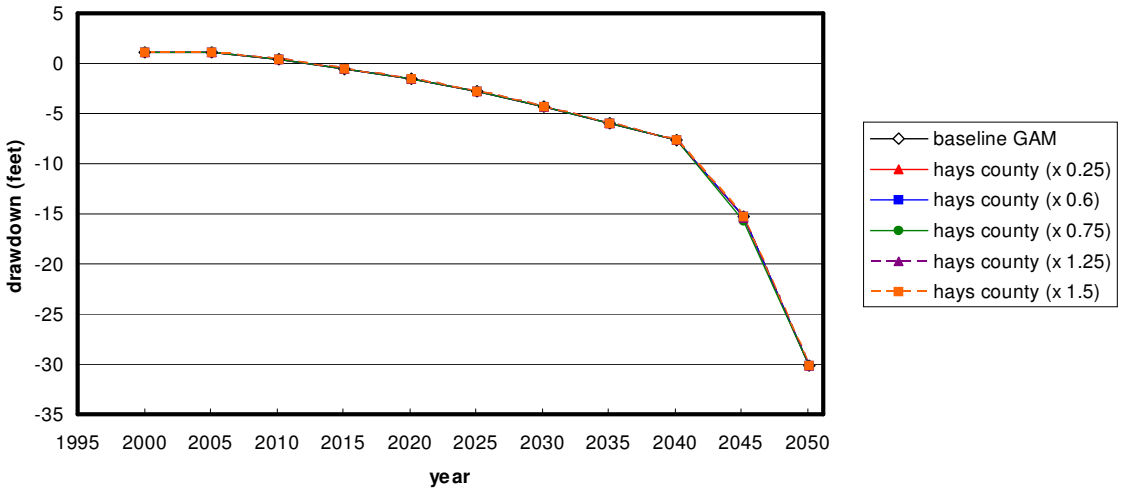
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 60
Pumping in Hays County – Effects in Kendall County



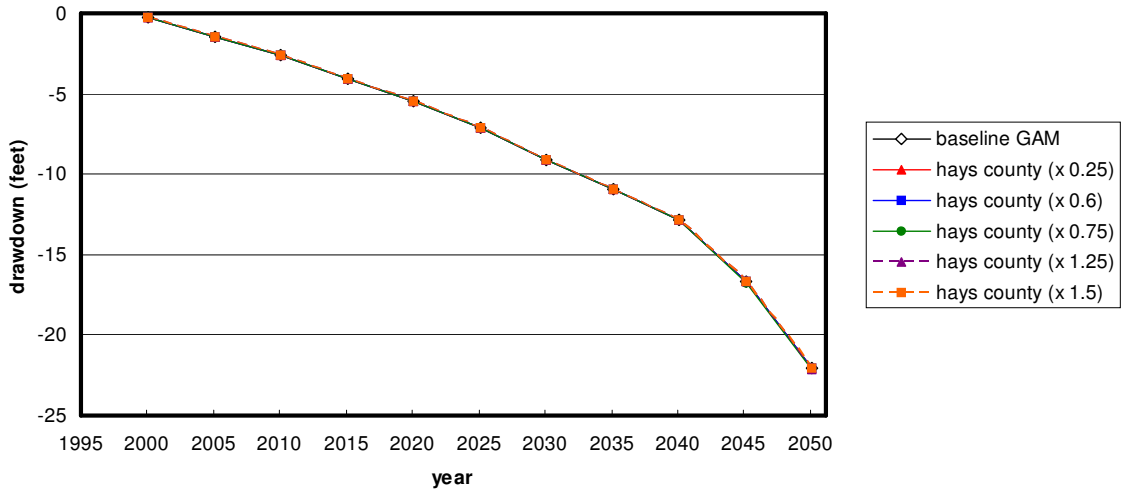
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 61
Pumping in Hays County – Effects in Kerr County



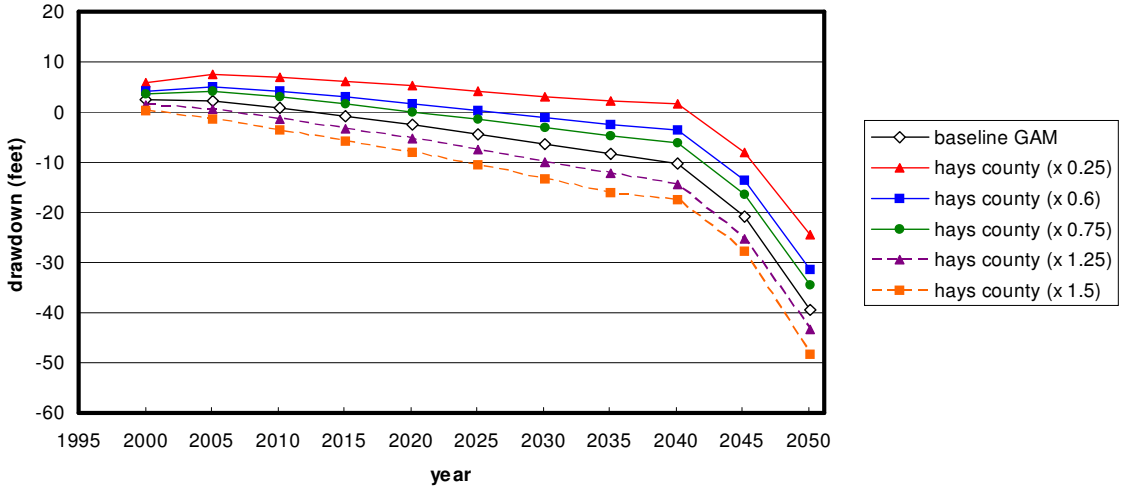
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 62
Pumping in Hays County – Effects in Medina County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 63
Pumping in Hays County – Effects in Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Effects from Pumping in Other Counties

Figure A4. 64
Effects in Hays County – Pumping in other Counties

Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

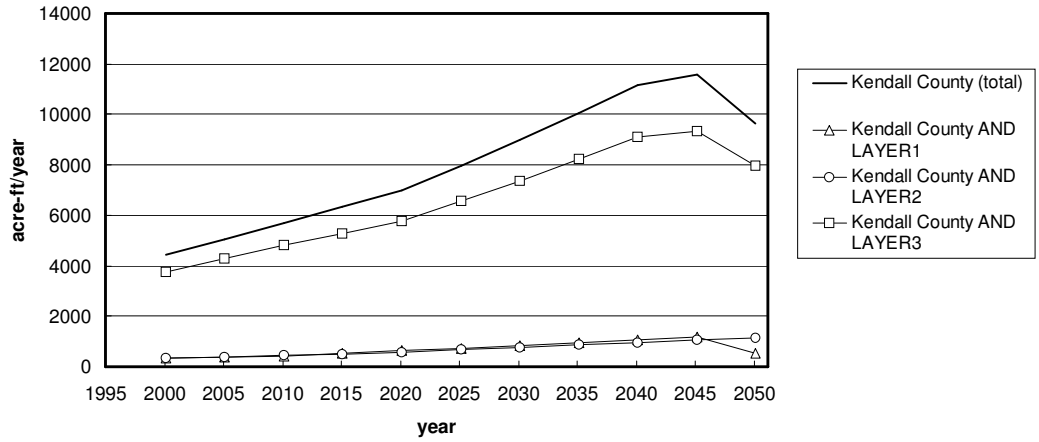
Kendall County

Kendall County pumping affects average groundwater aquifer levels within GMA 9. Figures A4.65 and A4.66 illustrate the GAM's assumptions regarding future average groundwater withdrawals in Kendall County, which increase from about 4,000 acre-feet per year in 2000 to about 11,000 acre-feet per year in 2050. The baseline GAM is the unaltered groundwater availability model from the Texas Water Development Board, created in 2000 and described in Report 353.[13] Figure A4.65 illustrates pumping withdrawals for the baseline GAM from each layer in the model in Kendall County. Layer 1 represents the Edwards Group of the Edwards Trinity Plateau, Layer 2 represents the Upper Trinity Aquifer, and Layer 3 represents the Middle Trinity Aquifer.

For each layer, the pumping rate is computed by adding all pumping in the active cells within Kendall County. The pumping schedule in the baseline GAM is based on water use estimates from the RWPGs.[14] Figure A4.65 shows the withdrawal rates as they occur in the model. Figure A4.66 shows the projected withdrawal rates from the RWPG.[15] Withdrawals in the model may not match the estimated demand if dry cells in the model prevent pumping from taking place. As pumping or extraction cannot occur in a dry cell, dry cells reduce the overall yield in the model simulation.

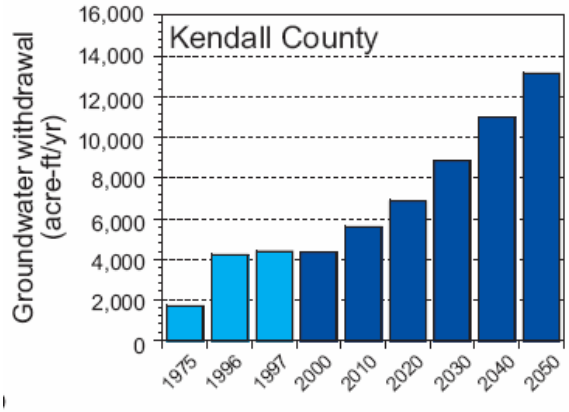
To examine the effects of alternative pumping levels, class members tested rates from 50 percent of the baseline GAM to 150 percent (Figure A4.67). Various pumping levels in Kendall County do affect the relative drawdown in average aquifer levels in a number of counties, including Bandera (Figure A4.69), Bexar (Figure A4.70), and Median (Figure A4.75). Pumping in Kendall County has a less pronounced influence on relative aquifer drawdown in Blanco (Figure A4.71), Comal (Figure A4.72), Kerr (figure A4.74) and particularly Travis (Figure A4.76) counties. Relative levels of pumping in the other counties appear to have only a modest influence on average aquifer drawdown in Kendall County (Figure A4.77).

Figure A4. 65
Pumping Withdrawals in Baseline GAM: Kendall County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

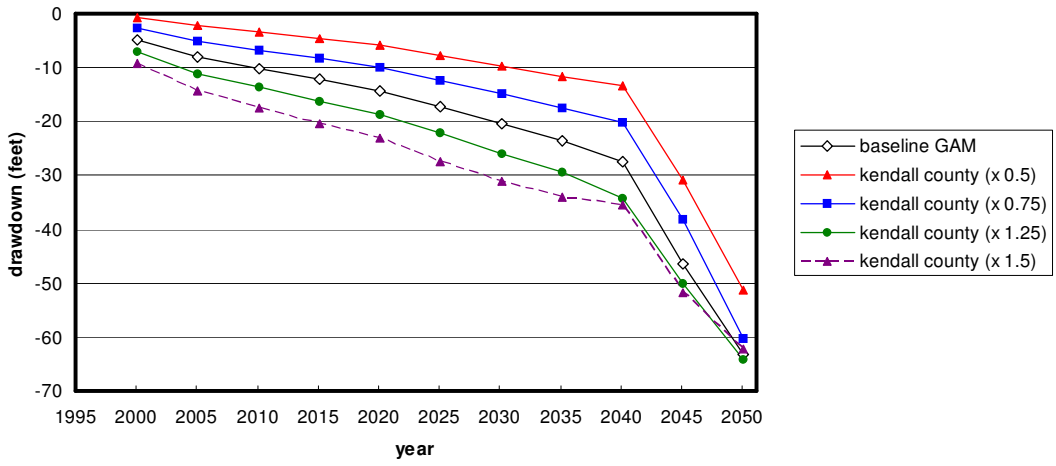
Figure A4. 66
Kendall County Groundwater Withdrawal



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

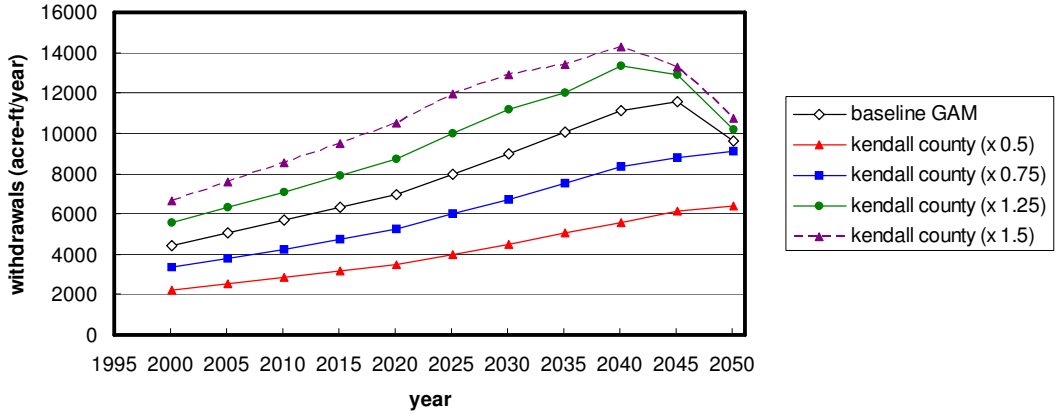
Alternate Pumping Factors

Figure A4. 67
Pumping in Kendall County (average drawdown)



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

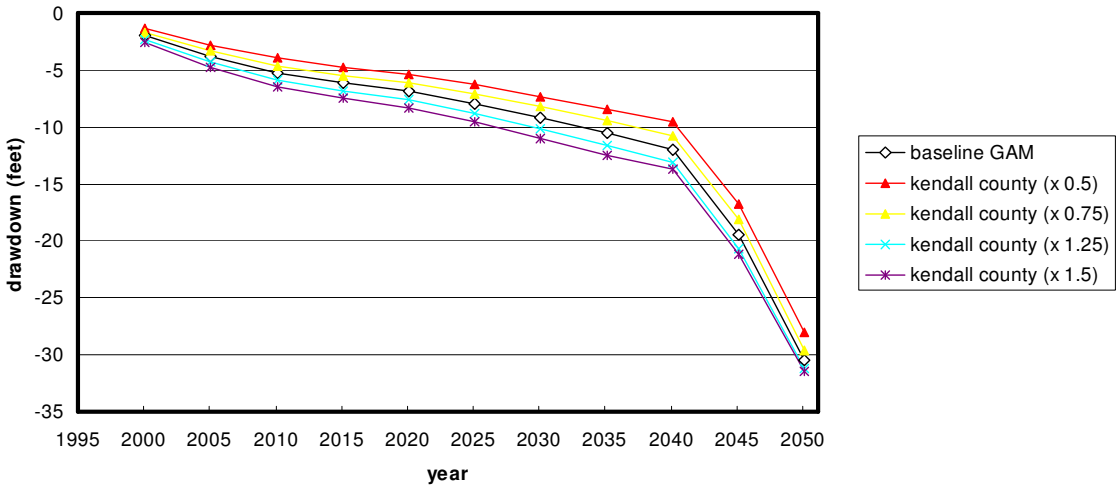
Figure A4. 68
Pumping Withdrawals for Various Pumping Factors: Kendall County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

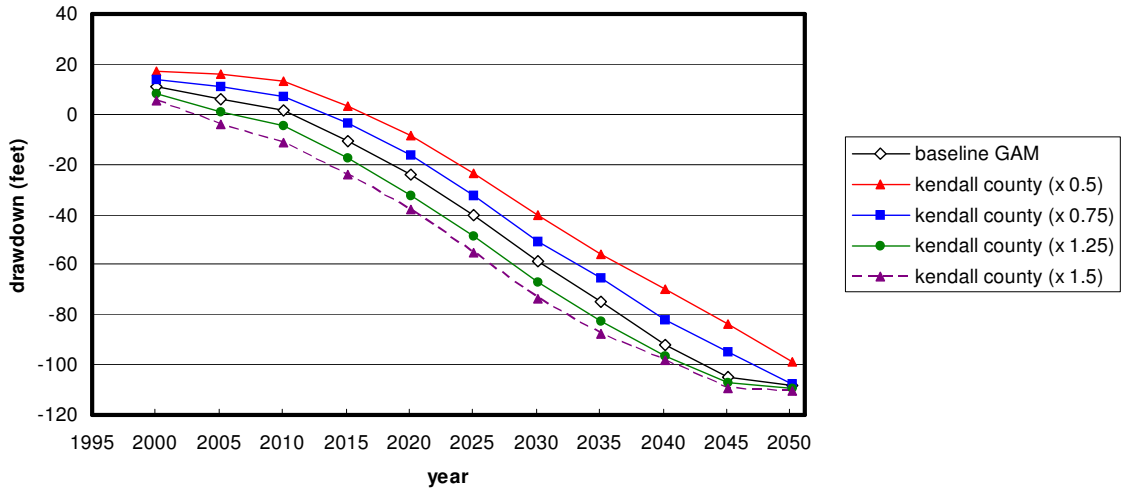
Pumping Impacts on Other Counties

Figure A4. 69
Pumping in Kendall County – Effects in Bandera County



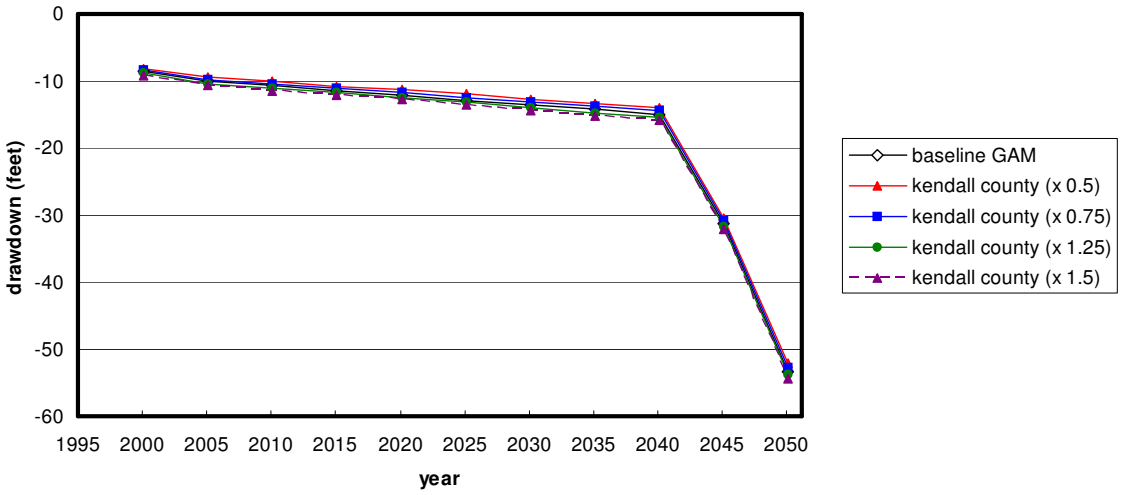
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 70
Pumping in Kendall County – Effects in Bexar County



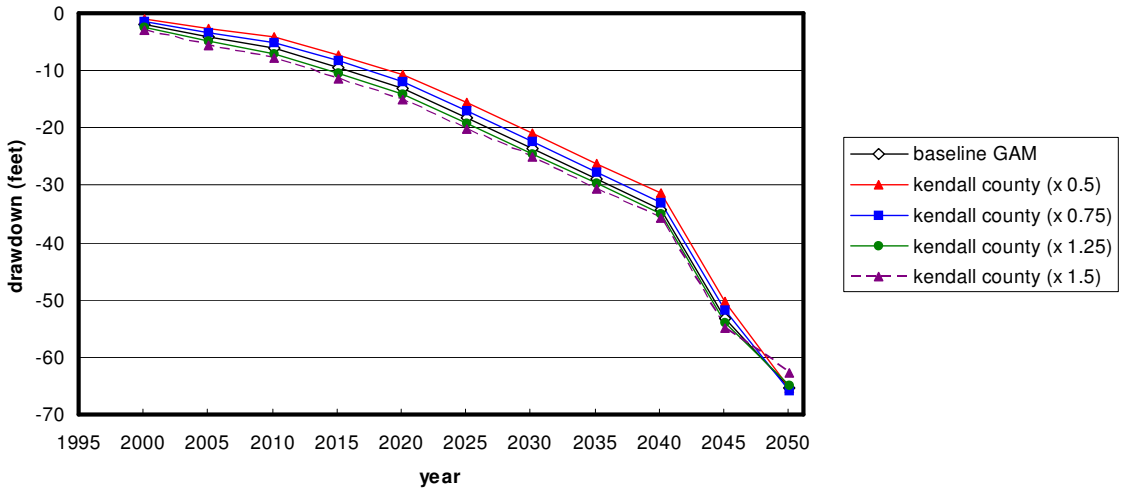
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 71
Pumping in Kendall County – Effects in Blanco County



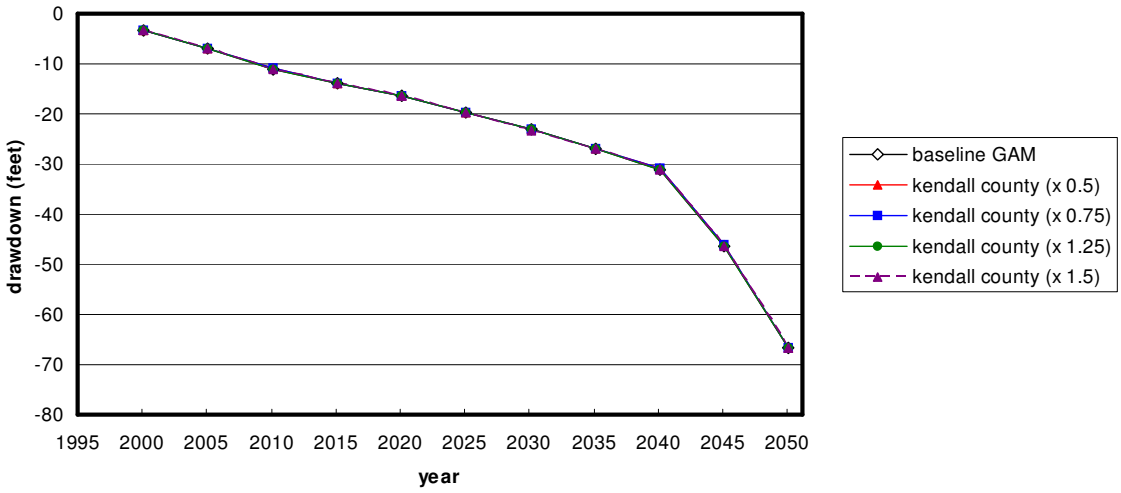
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 72
Pumping in Kendall County – Effects in Comal County



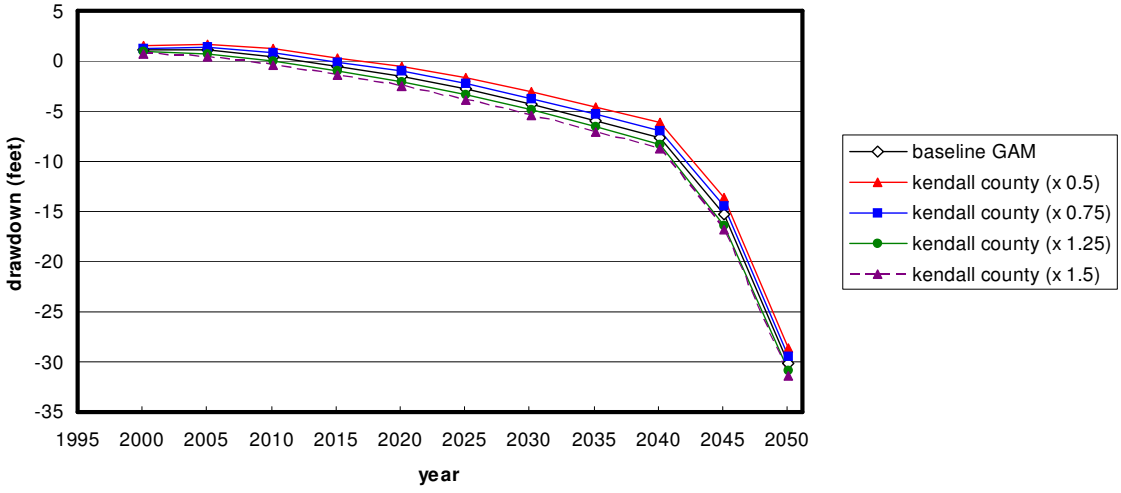
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 73
Pumping in Kendall County – Effects in Hays County



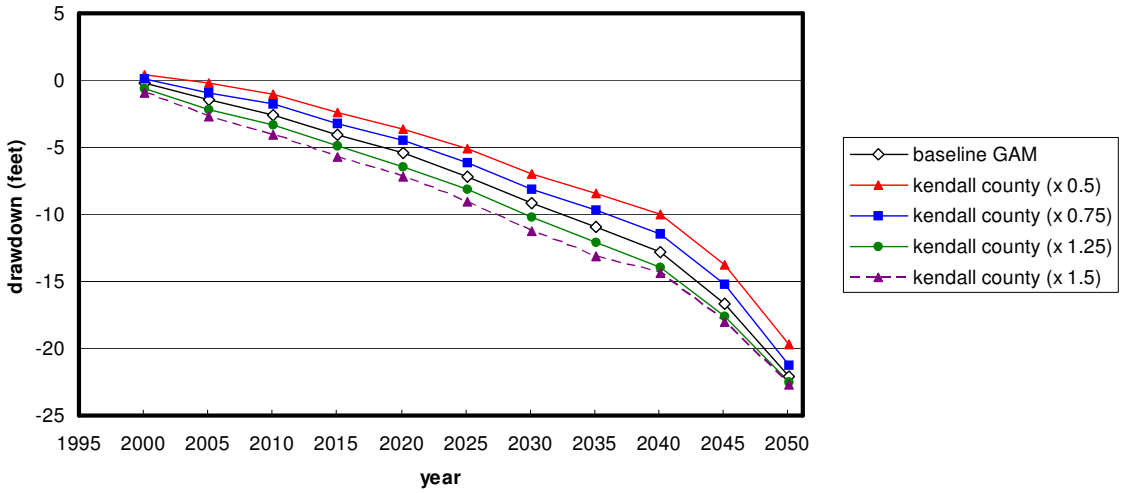
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 74
Pumping in Kendall County – Effects in Kerr County



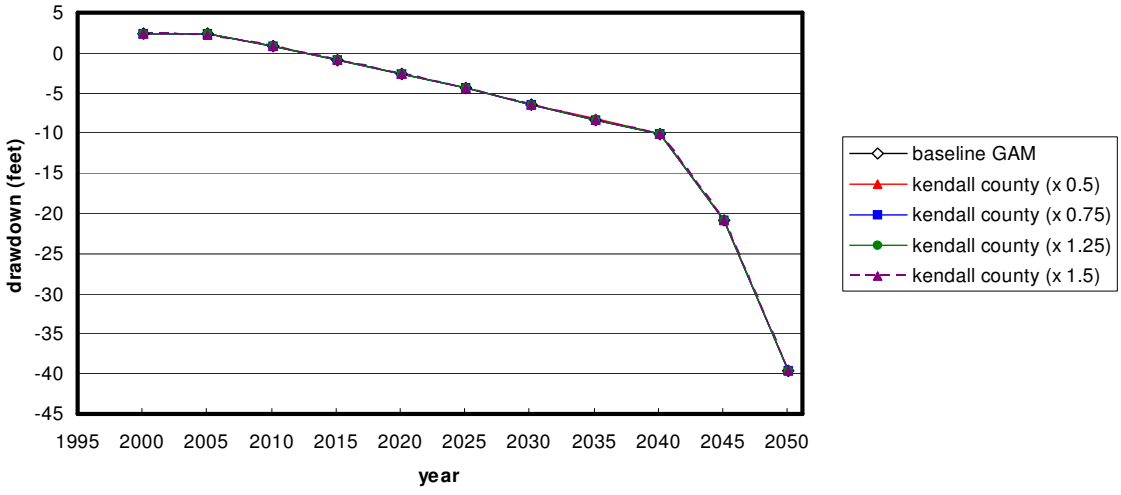
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 75
Pumping in Kendall County – Effects in Medina County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 76
Pumping in Kendall County – Effects in Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Effects from Pumping in Other Counties

Figure A4. 77
Effects in Kendall County – Pumping in other Counties

Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

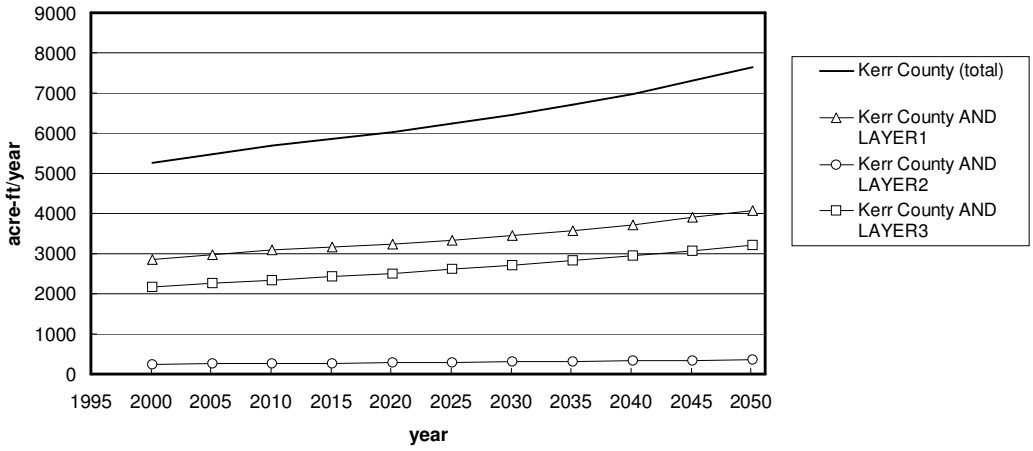
Kerr County

This Appendix 4 section addresses the influence of pumping in Kerr County on relative aquifer drawdown levels within GMA 9. Figures A4.78 and A4.79 illustrate the GAM assumptions for pumping in Kerr County over the period of 2000 to 2050. GAM withdrawal rates rise from over 5,000 acre-feet per year in 2000 to nearly 8,000 acre-feet per year in 2050. The baseline GAM is the unaltered groundwater availability model from the Texas Water Development Board, created in 2000 and described in Report 353.[16] Figure A4.78 illustrates pumping withdrawals for the baseline GAM from each layer in the model in Kerr County. Layer 1 represents the Edwards Group of the Edwards Trinity Plateau, Layer 2 represents the Upper Trinity Aquifer, and Layer 3 represents the Middle Trinity Aquifer.

For each layer, the pumping rate is computed by adding all pumping in the active cells within Kerr County. The pumping schedule in the baseline GAM is based on water use estimates from the RWPGs.[17] Figure A4.78 shows the withdrawal rates as they occur in the model. Figure A4.79 shows the projected withdrawal rates from the RWPG.[18] Withdrawals in the model may not match the estimated demand if dry cells in the model prevent pumping from taking place. As pumping or extraction cannot occur in a dry cell, any dry cells reduce the overall yield in the model simulation.

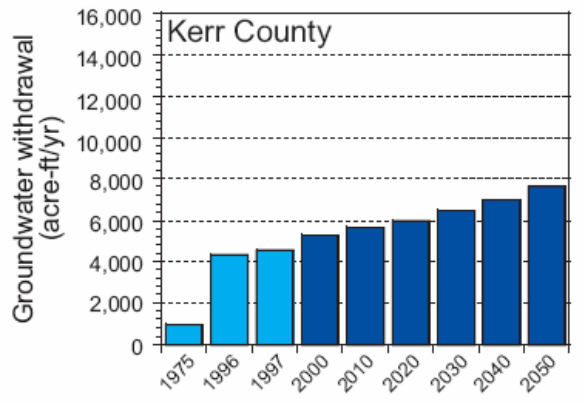
The class computed six alternative pumping rates for Kerr County, from 25 percent to 200 percent of the withdrawals assumed by the baseline GAM (Figure A4.81). These pumping rates draw down the average aquifer levels within Kerr County by 2040 by between not much at all (at 25 percent of GAM) to quite a bit (40 feet) at 200 percent of GAM rates. Alternative withdrawal patterns in Kerr County had significant inter-regional influence within GMA 9 in Bandera County (Figure A4.82) and Medina County (Figure A4.88). Kerr County pumping had only modest influence on the average drawdown in the aquifers within the other counties (figures A4.83, A4.84, A4.86, A4.82, and A4.89). Modest variation in the pumping rates in other counties (from 0.75 to 1.25 of GAM assumptions) had a modest influence on Kerr County withdrawals, although there were exceptions, particularly Bandera County (Figure A4.90).

Figure A4. 78
Pumping Withdrawals in Baseline GAM: Kerr County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

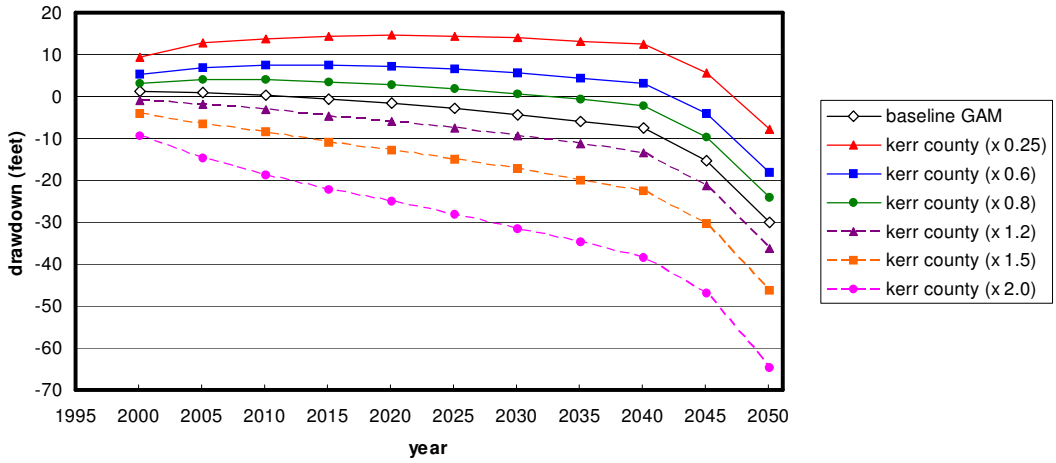
Figure A4. 79
Kerr County Groundwater Withdrawal



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

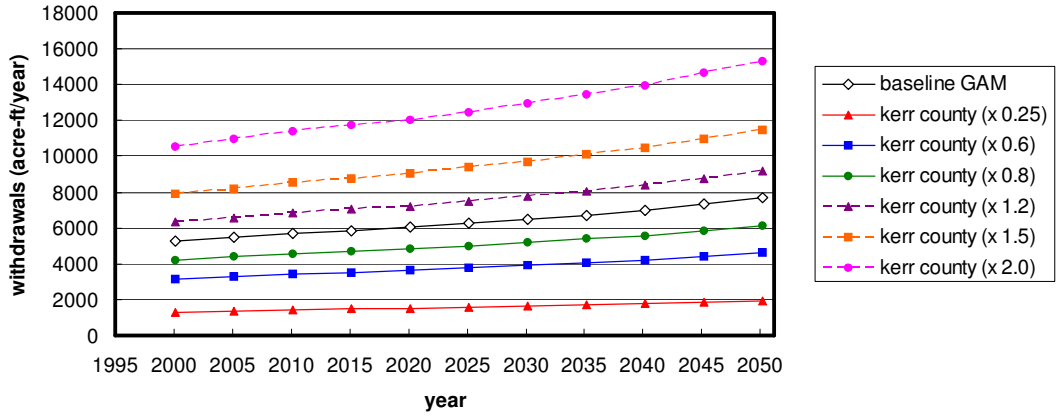
Alternate Pumping Factors

Figure A4. 80
Pumping in Kerr County (average withdrawal)



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

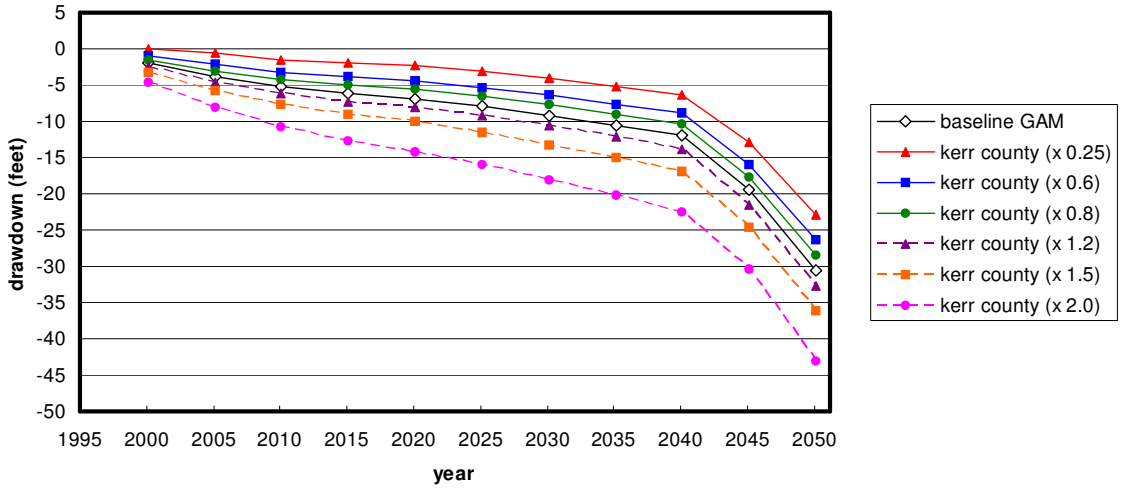
Figure A4. 81
Pumping Withdrawals for Various Pumping Factors



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

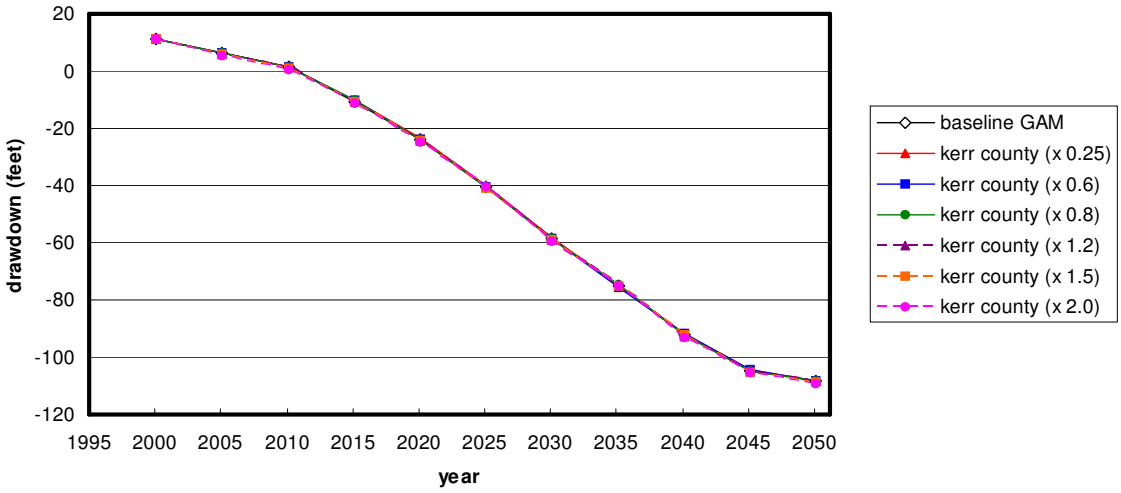
Pumping Impacts on Other Counties

Figure A4. 82
Pumping in Kerr County – Effects on Bandera County



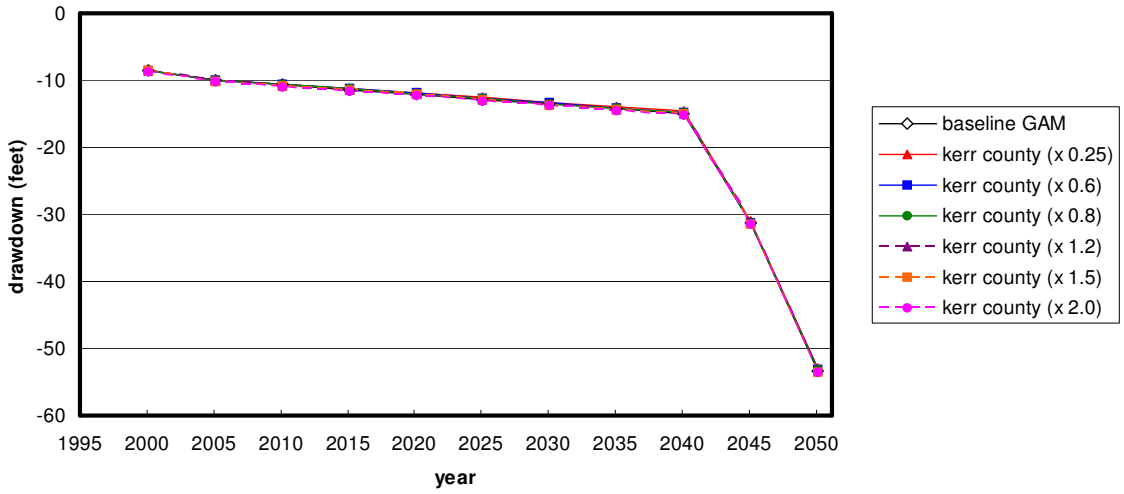
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 83
Pumping in Kerr County – Effects in Bexar County



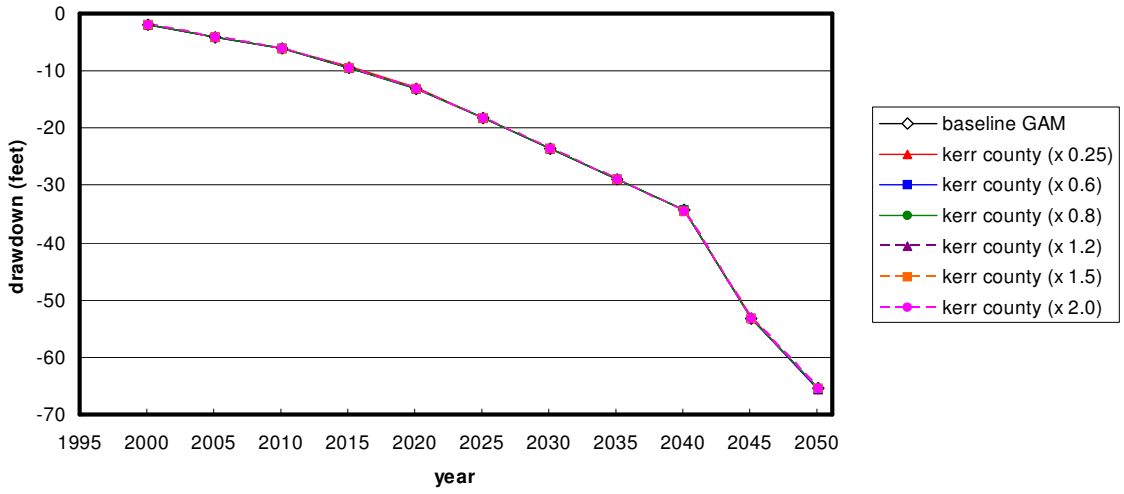
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 84
Pumping in Kerr County – Effects in Blanco County



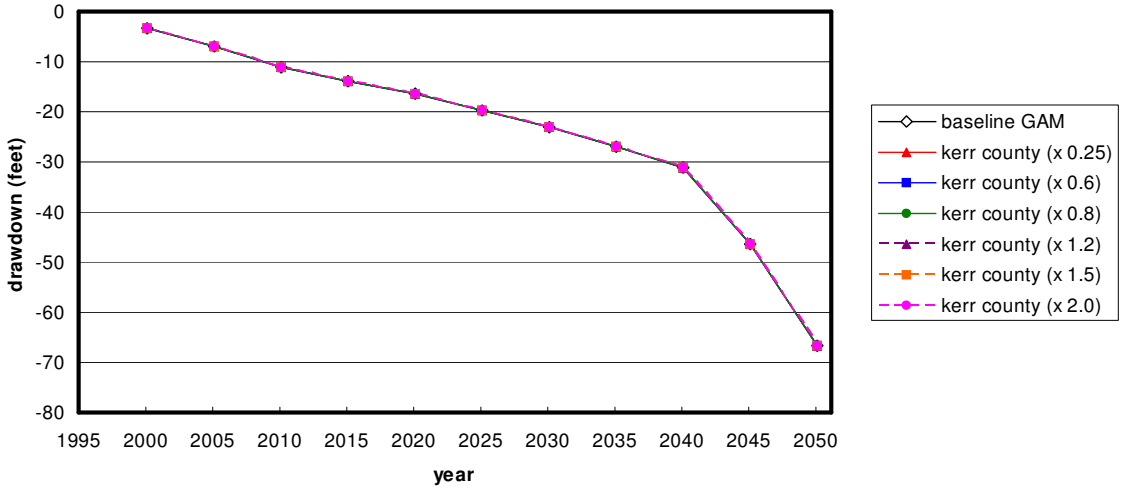
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 85
Pumping in Kerr County – Effects in Comal County



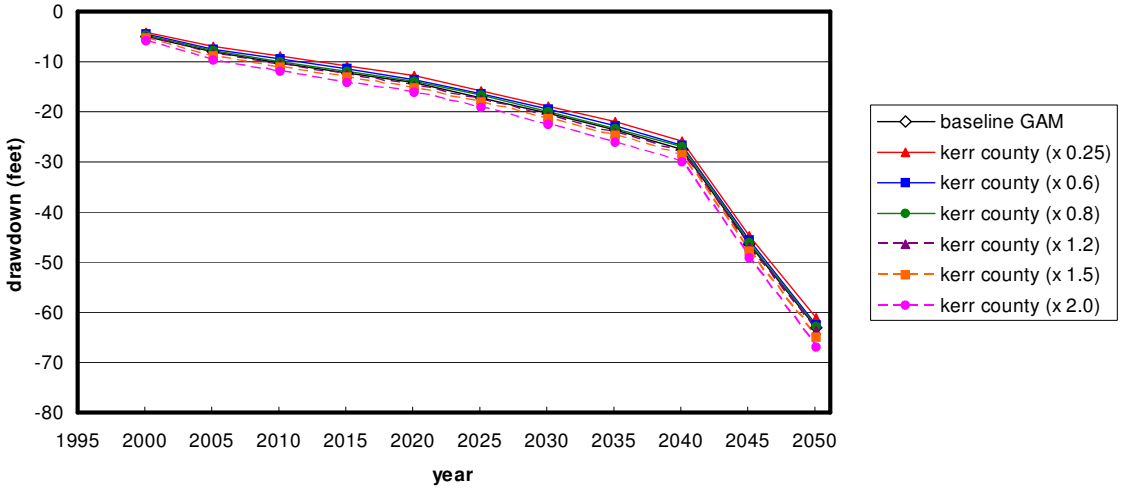
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 86
Pumping in Kerr County – Effects in Hays County



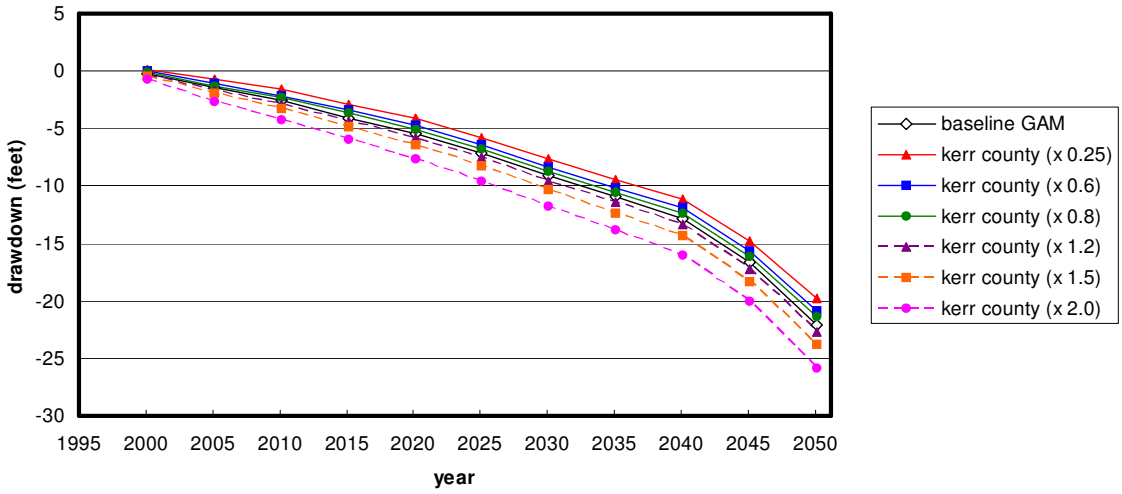
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 87
Pumping in Kerr County – Effects in Kendall County



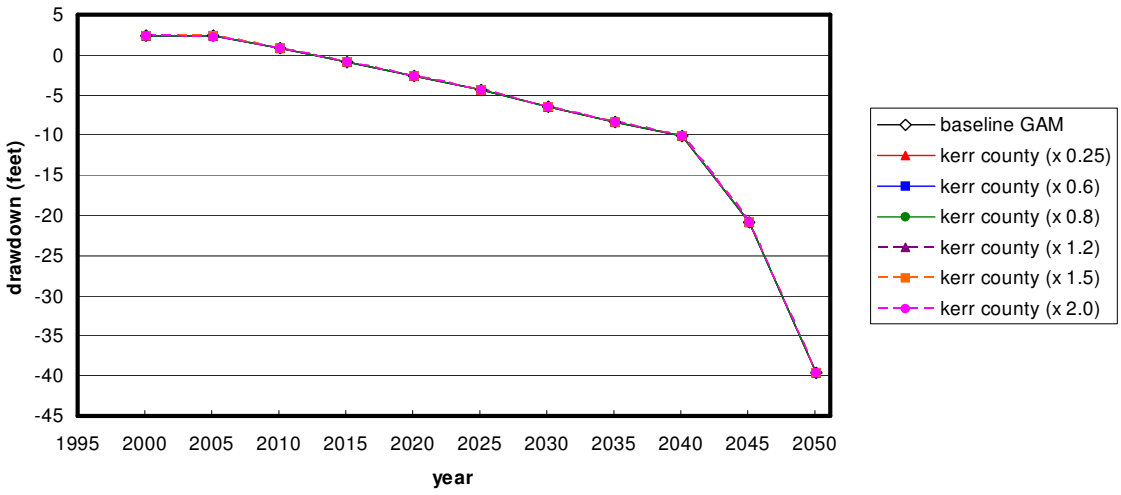
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 88
Pumping in Kerr County – Effects in Medina County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 89
Pumping in Kerr County – Effects in Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Effects from Pumping in Other Counties

Figure A4. 90
Effects in Kerr County – Pumping in other Counties

Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

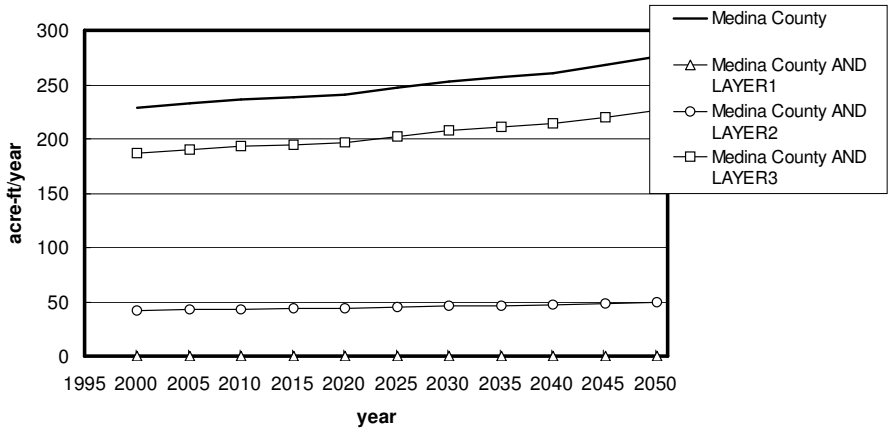
Medina County

This section of Appendix 4 examines how pumping in Medina County affects its own and adjacent counties' groundwater drawdown levels. Two figures provide information on the baseline GAM withdrawals, Figure A4.91 and A4.92. Withdrawals between 2000 and 2050 are modest, ranging between 200 and 300 acre-feet per year. The baseline GAM is the unaltered groundwater availability model from the Texas Water Development Board, created in 2000 and described in Report 353.[19] Figure A4.91 illustrates pumping withdrawals for the baseline GAM from each layer in the model in Medina County. Layer 1 represents the Edwards Group of the Edwards Trinity Plateau, Layer 2 represents the Upper Trinity Aquifer, and Layer 3 represents the Middle Trinity Aquifer.

For each layer, the pumping rate is computed by adding all pumping in the active cells within Kendall County. The pumping schedule in the baseline GAM is based on water use estimates from the RWPGs.[20] Figure A4.91 shows the withdrawal rates as they occur in the model.[21] Figure A4.92 shows the projected withdrawal rates from the RWPG.[22] Withdrawals in the model may not match the estimated demand if dry cells in the model prevent pumping from taking place. As pumping or extraction cannot occur in a dry cell, any dry cells reduce the overall yield in the model simulation.

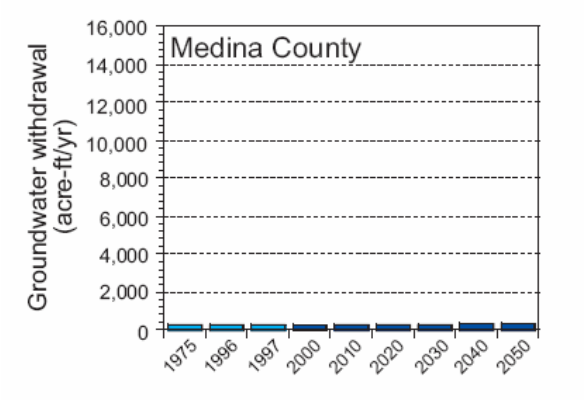
To examine the alternative consequences of altered pumping rates, the PRP class tested pumping rates of between 25 percent of GAM to as much as 200 percent of GAM rates (Figure A4.94). These different withdrawal rates had a modest effect on average aquifer drawdown between 2000 and 2050—drawdown levels differed by about three feet in any year from the low to the high pumping rates. Medina County pumping hardly affected average aquifer drawdown in all of the counties, including Bandera (Figure A4.95), Bexar (A4.96), Comal (Figure A4.98), Hays (Figure A4.99), Kendall (Figure A4.100), Kerr (Figure A4.101) and Travis (Figure A4.102) counties. Data were not available to illustrate how pumping in the other counties of GMA 9 affected the average aquifer drawdown in Median County.

Figure A4. 91
Pumping Withdrawals in Baseline GAM: Medina County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

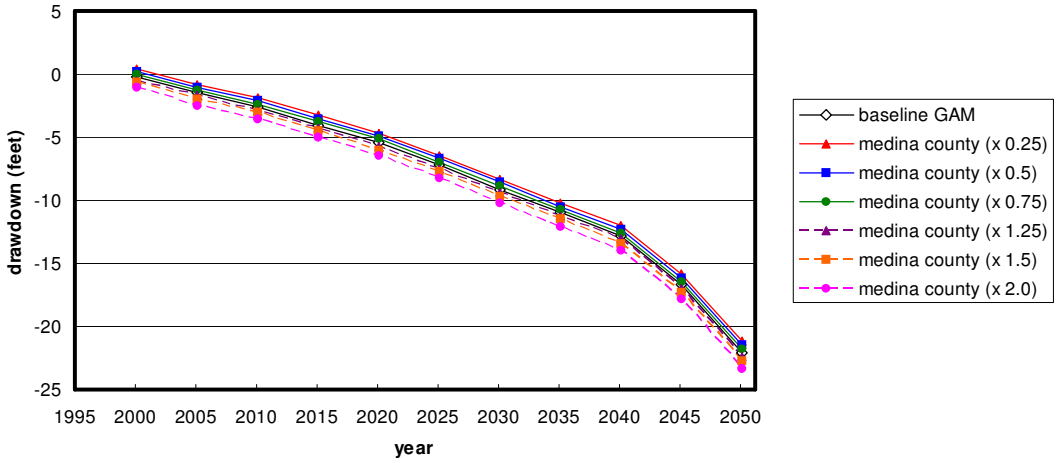
Figure A4. 92
Medina County Groundwater Withdrawal



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

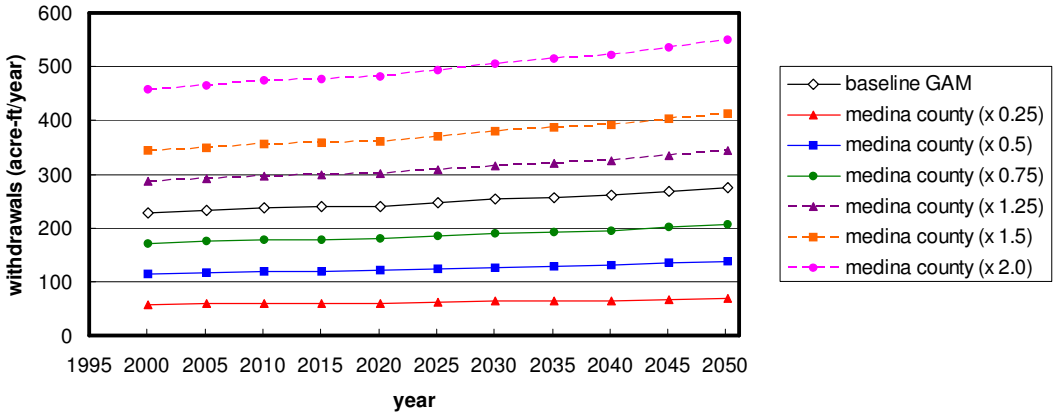
Alternate Pumping Factors

Figure A4. 93
Pumping in Medina County (average drawdown)



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

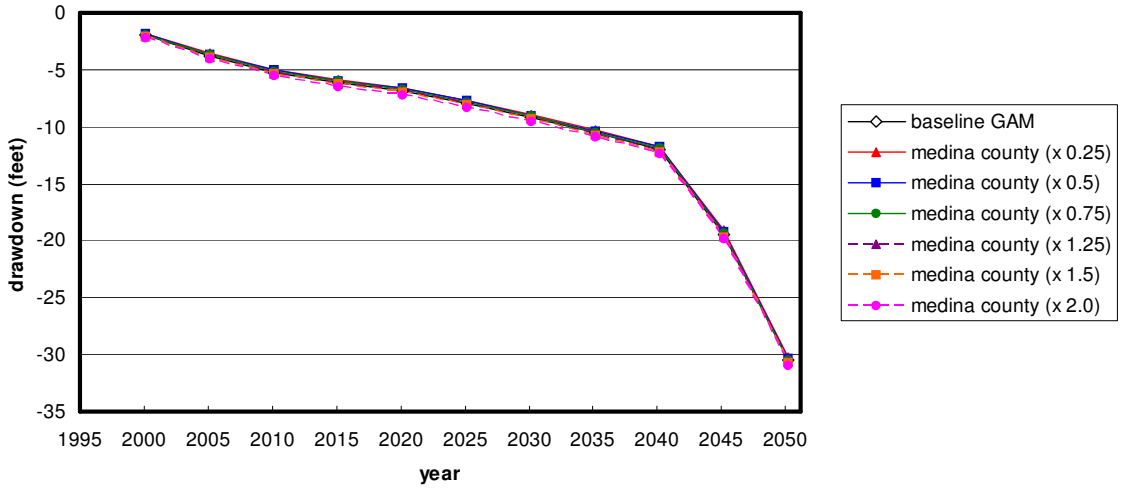
Figure A4. 94
Pumping Withdrawals for Various Pumping Factors



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

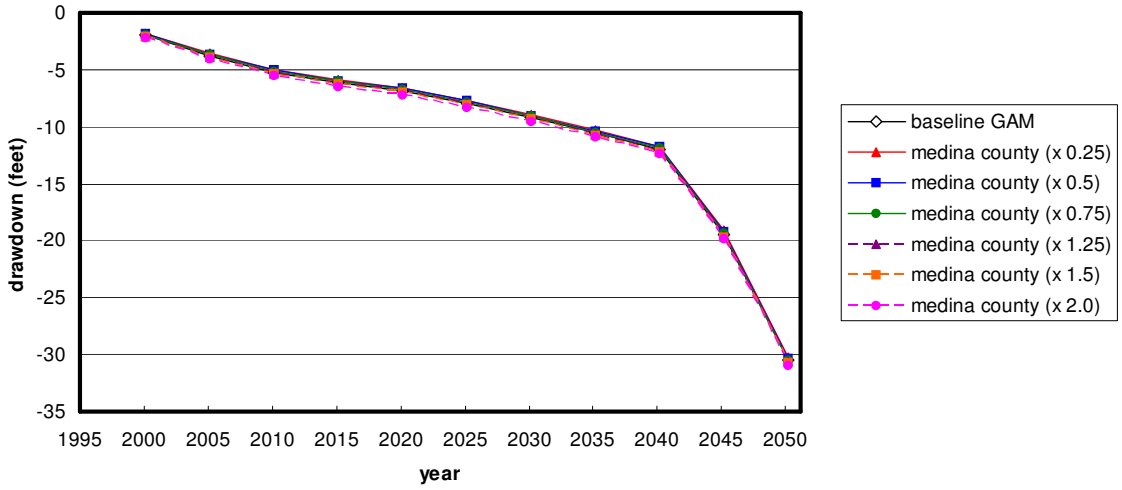
Pumping Impacts on Other Counties

Figure A4. 95
Pumping in Medina County – Effects on Bandera County



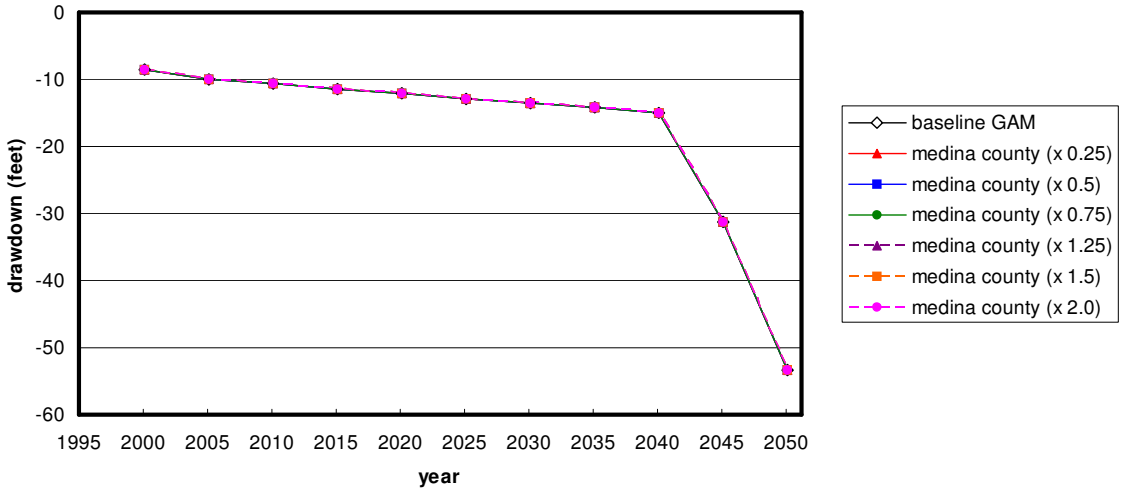
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 96
Pumping in Median County – Effects on Bexar County



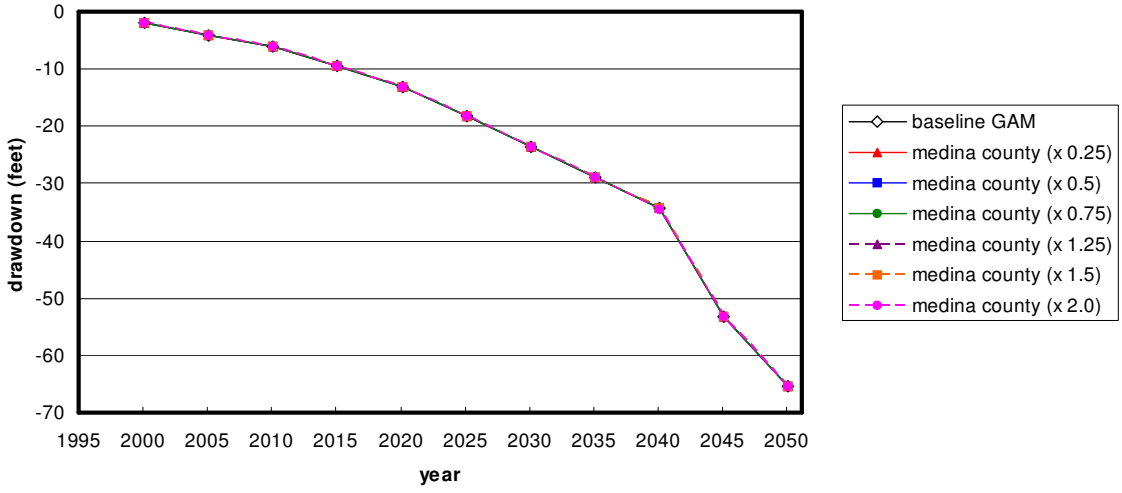
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 97
Pumping in Median County – Effects in Blanco County



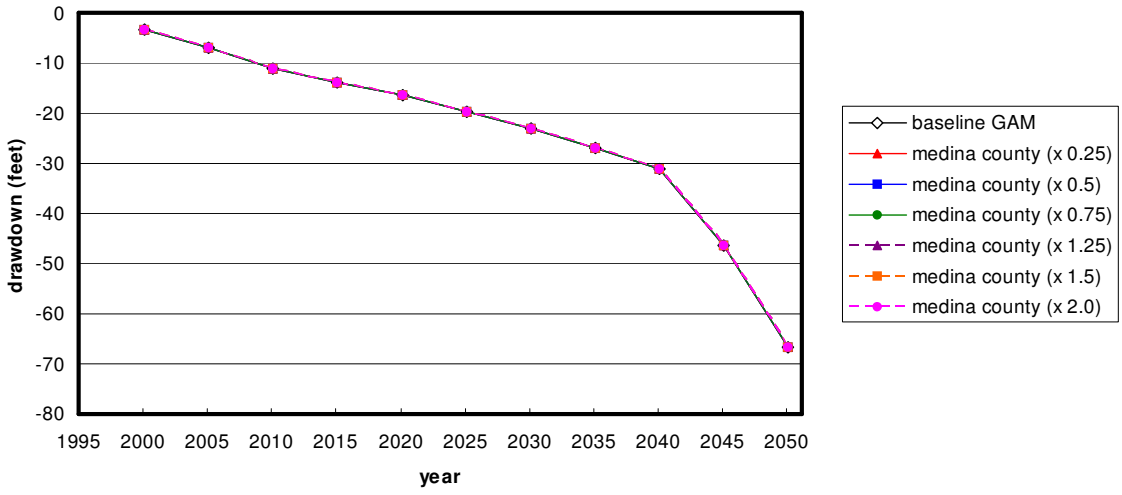
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 98
Pumping in Medina County – Effects in Comal County



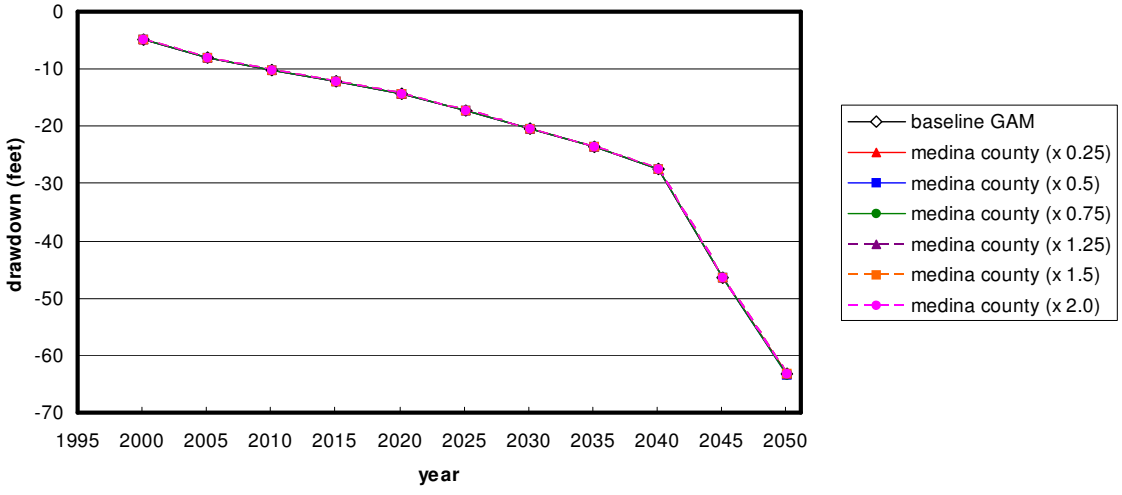
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 99
Pumping in Medina County – Effects in Hays County



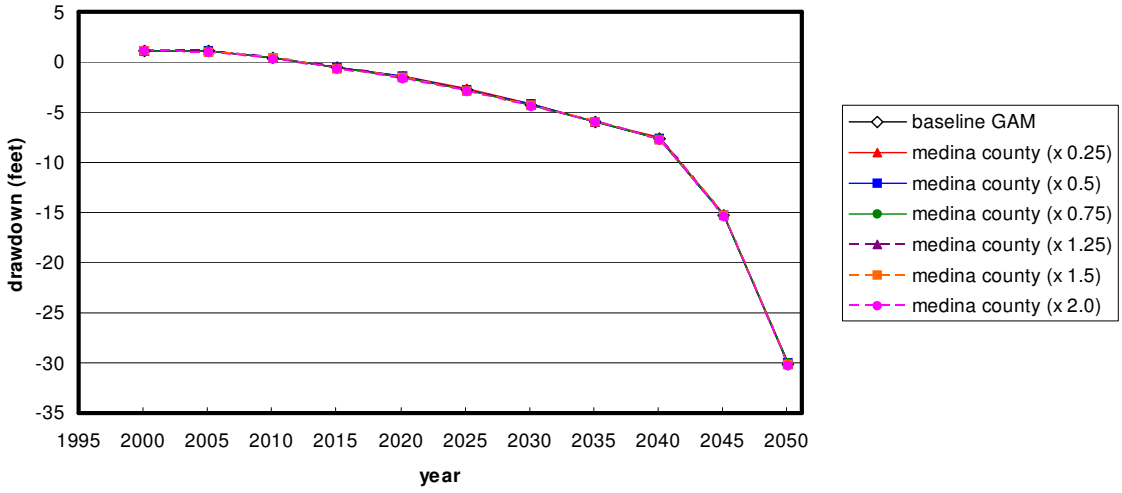
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 100
Pumping in Medina County – Effects in Kendall County



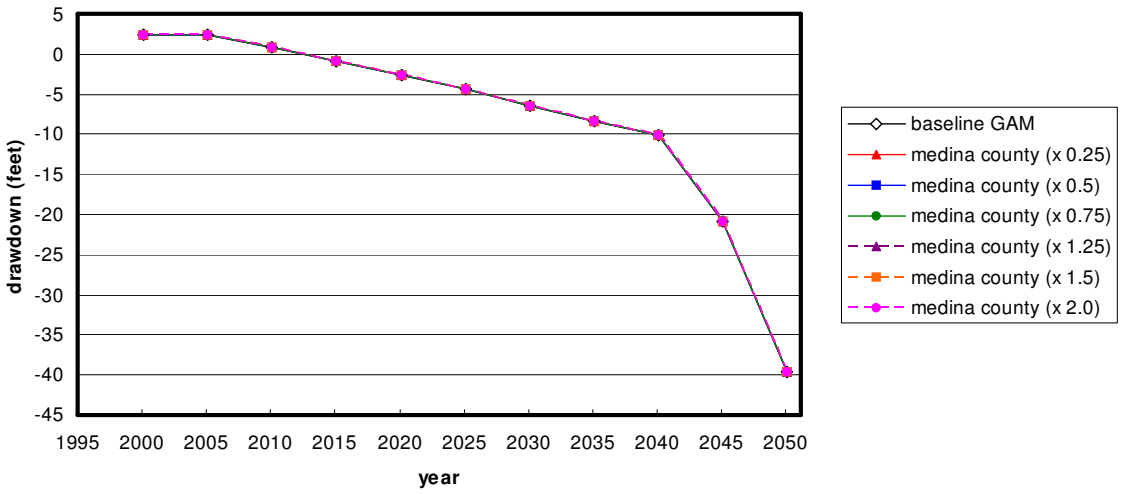
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 101
Pumping in Medina County – Effects in Kerr County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 102
Pumping in Medina County – Effects in Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Effects from Pumping in Other Counties

Data were not available on how pumping in other counties affects Medina County.

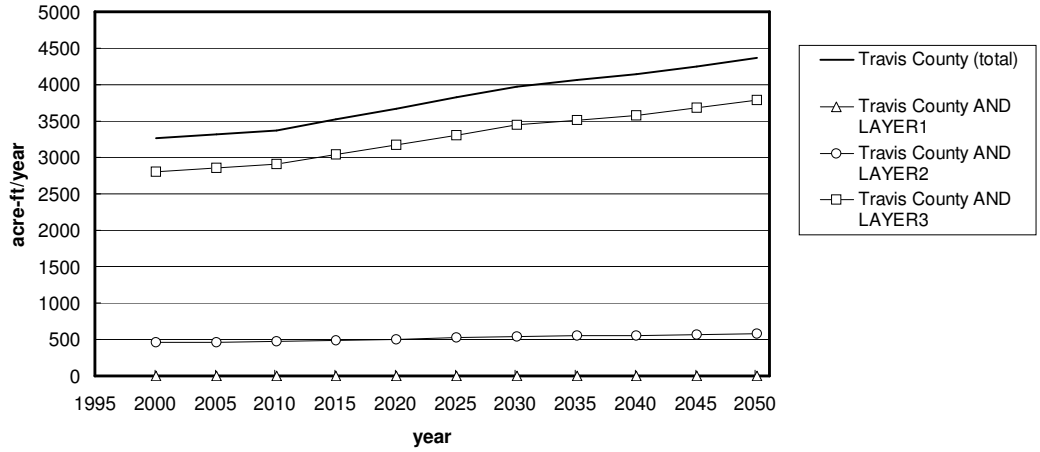
Travis County

This section examines the impact of water withdrawals from the Hill County Trinity Aquifer in Travis County on average aquifer levels in GMA 9 counties. Figures A4.103 and A4.104 illustrate the volume of pumping included in the GMA 9 GAM, which range from about 3,500 acre-feet per in 2010 to about 4,500 acre-feet per year by 2050. The baseline GAM is the unaltered groundwater availability model from the Texas Water Development Board, created in 2000 and described in Report 353.[23] Figure A4.103 illustrates pumping withdrawals for the baseline GAM from each layer in the model in Travis County. Layer 1 represents the Edwards Group of the Edwards Trinity Plateau, Layer 2 represents the Upper Trinity Aquifer, and Layer 3 represents the Middle Trinity Aquifer.

For each layer, the pumping rate is computed by adding all pumping in the active cells within Travis County. The pumping schedule in the baseline GAM is based on water use estimates from the RWPGs.[24] Figure A4.103 shows the withdrawal rates as they occur in the model. Figure A4.104 shows the projected withdrawal rates from the RWPG.[25] Withdrawals in the model may not match the estimated demand if dry cells in the model prevent pumping from taking place. As pumping or extraction cannot occur in a dry cell, any dry cells reduce the overall yield in the model simulation.

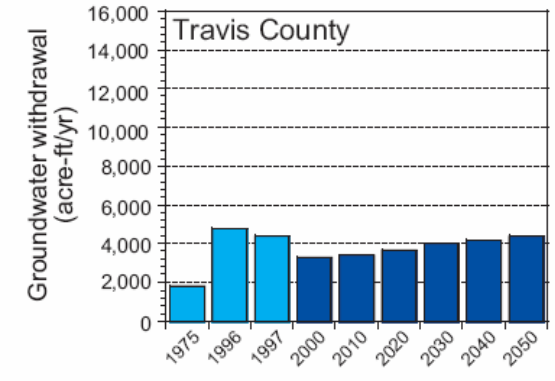
The PRP class examined five pumping options to the baseline GAM, from 25 percent to 150 percent of the pumping inherent in the GAM (Figure A4.106), which yields average aquifer drawdown levels that vary by 40 feet in 2050, minus 20 to minus 60 feet drawdown (Figure A4.105). Travis County groundwater withdrawals have limited influence on average aquifer drawdown in seven counties: Bandera (Figure A4.107), Bexar (Figure A4.110), Kendall (Figure A4.112), Kerr (Figure A4.113), and Medina (Figure A4.114) Counties. Travis County groundwater pumping has a modest impact on average Hays County aquifer drawdown, with about five feet of difference in the average drawdown in Hays County from pumping in Travis County that ranges from 25 percent to 150 percent of expected GAM pumping. Pumping in other counties does affect Travis County's average aquifer drawdown, particularly pumping from Hays County.

Figure A4. 103
Pumping Withdrawals in Baseline GAM: Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

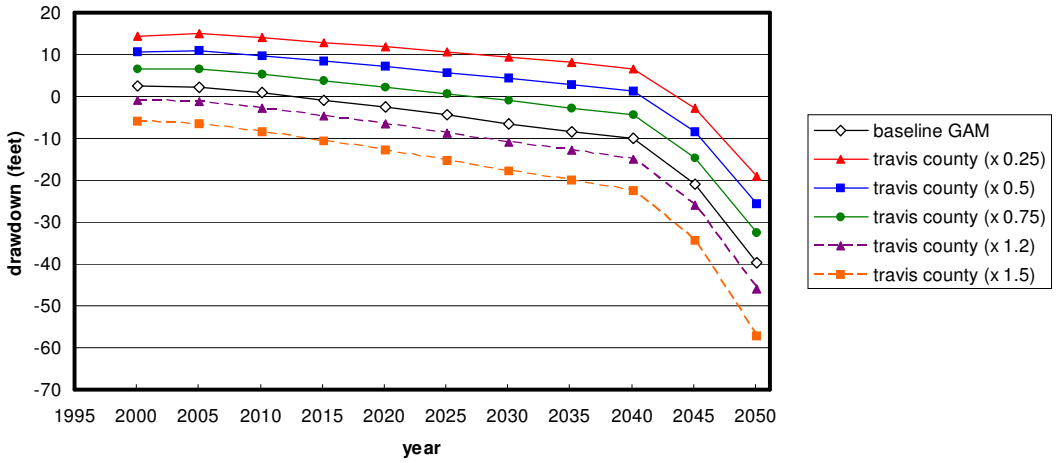
Figure A4. 104
Travis County Groundwater Withdrawals



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

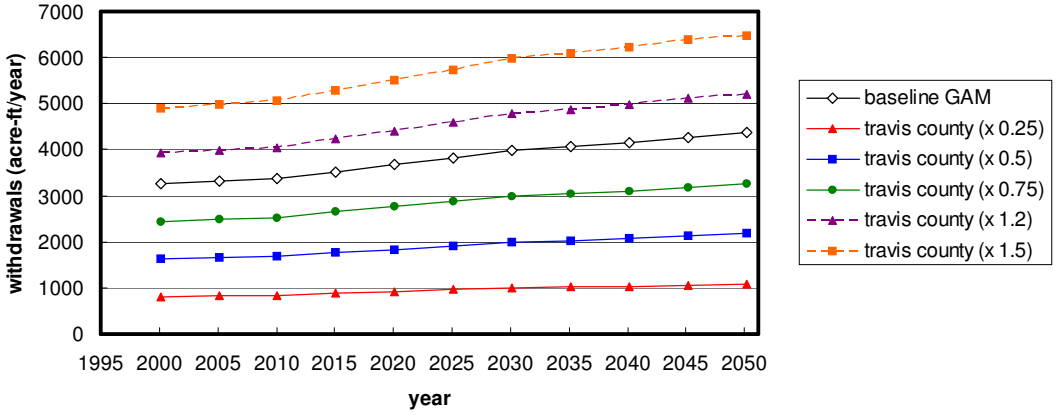
Alternate Pumping Factors

Figure A4. 105
Pumping in Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

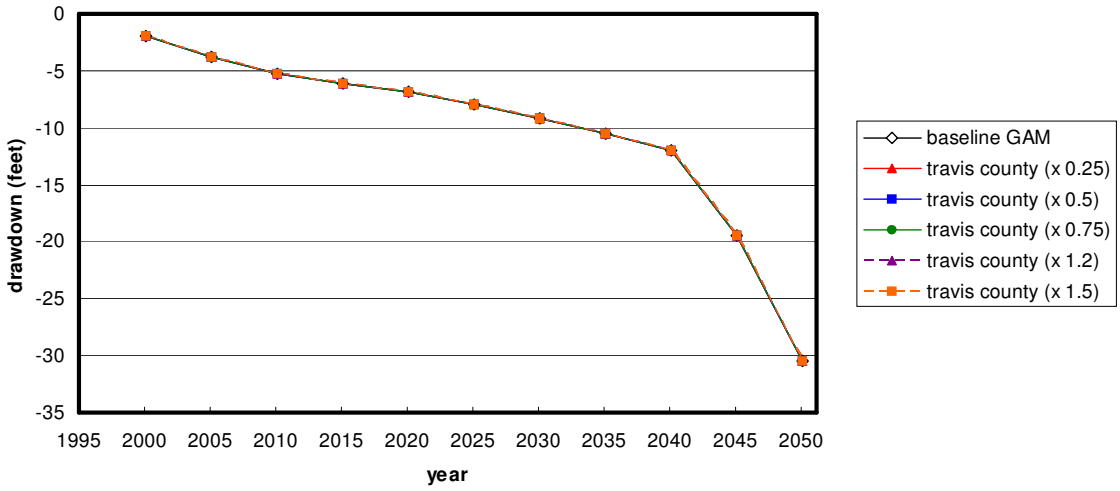
Figure A4. 106
Pumping Withdrawals for Various Pumping Factors: Travis County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

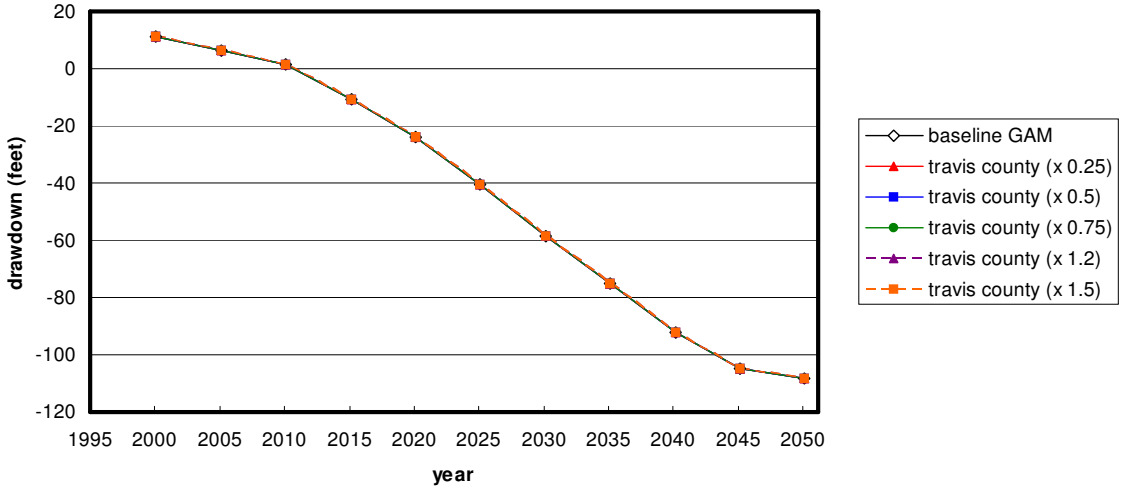
Pumping Impacts on Other Counties

Figure A4. 107
Pumping in Travis County – Effects in Bandera County



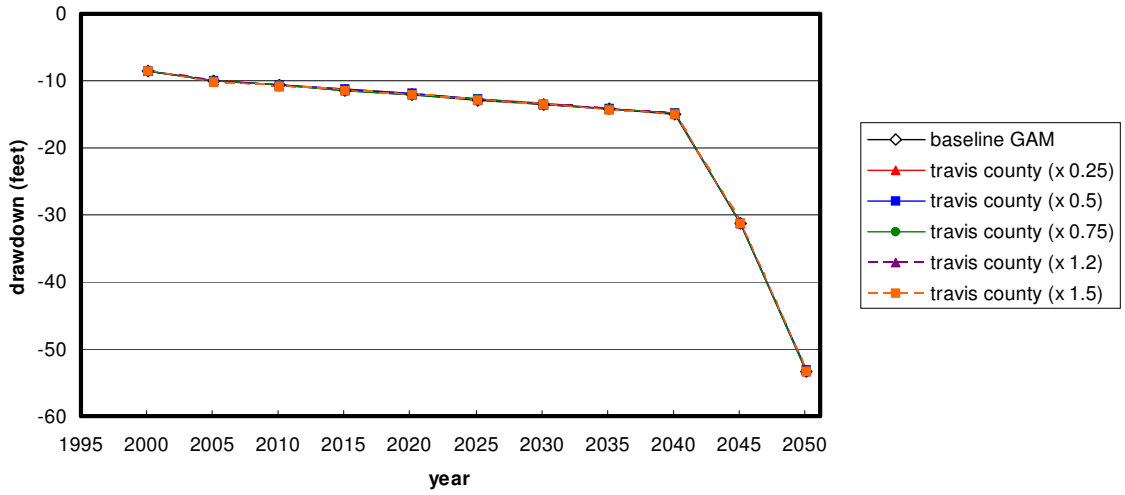
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 108
Pumping in Travis County – Effects in Bexar County



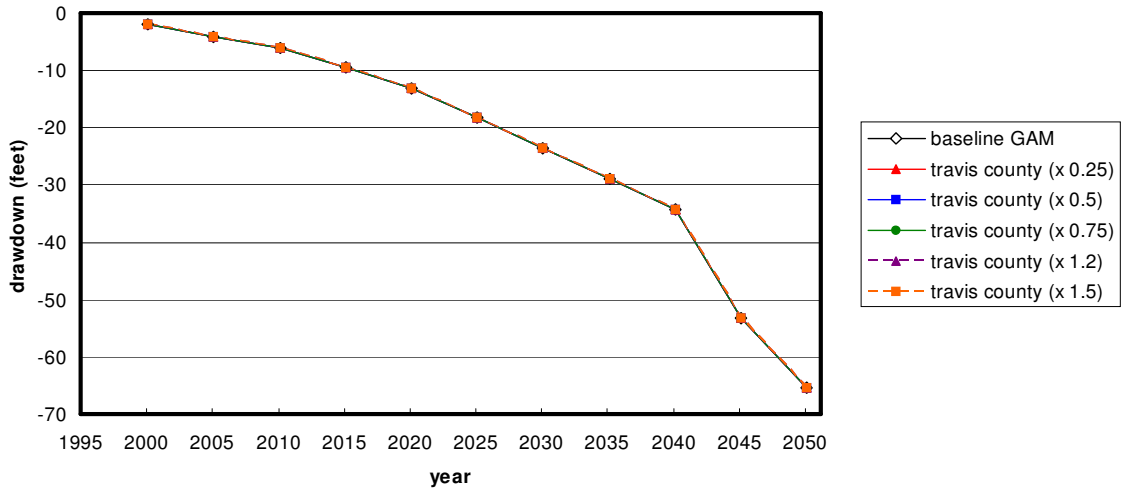
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 109
Pumping in Travis County – Effects in Blanco County



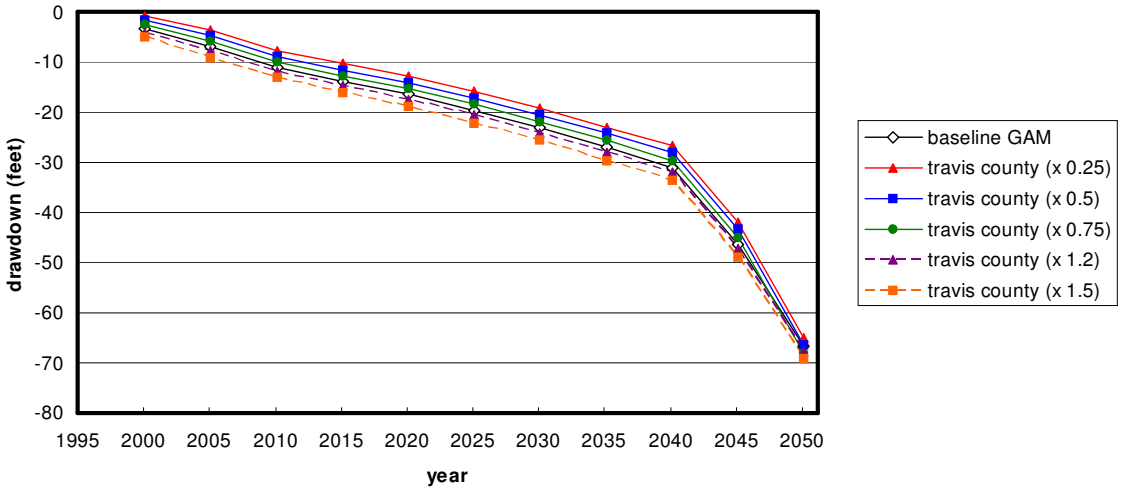
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 110
Pumping in Travis County – Effects in Comal County



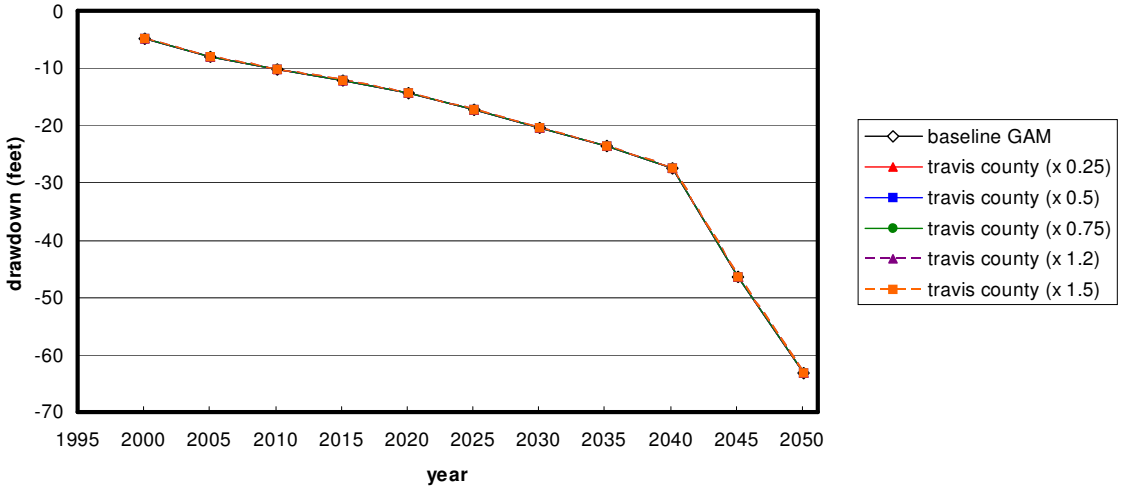
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 111
Pumping in Travis County – Effects in Hays County



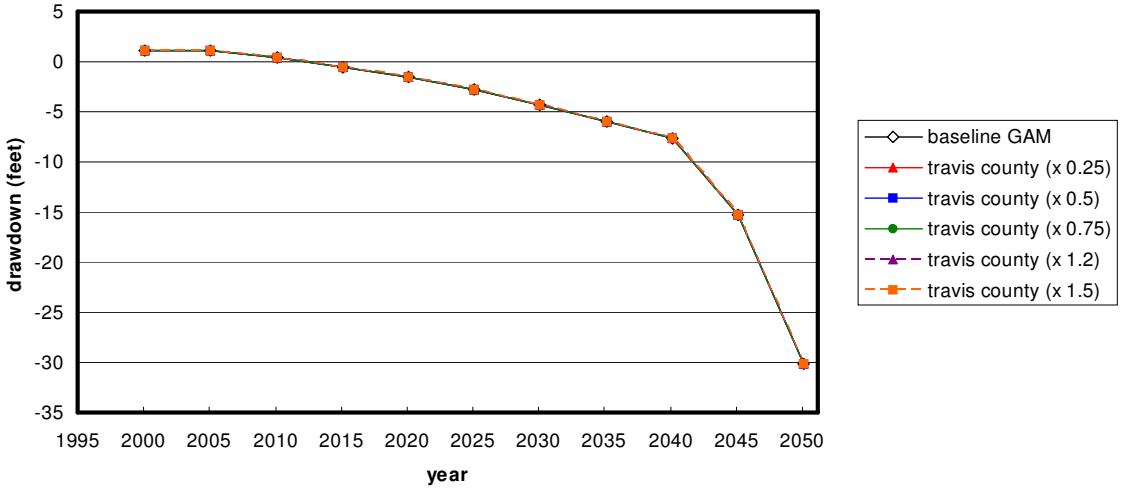
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 112
Pumping in Travis County – Effects in Kendall County



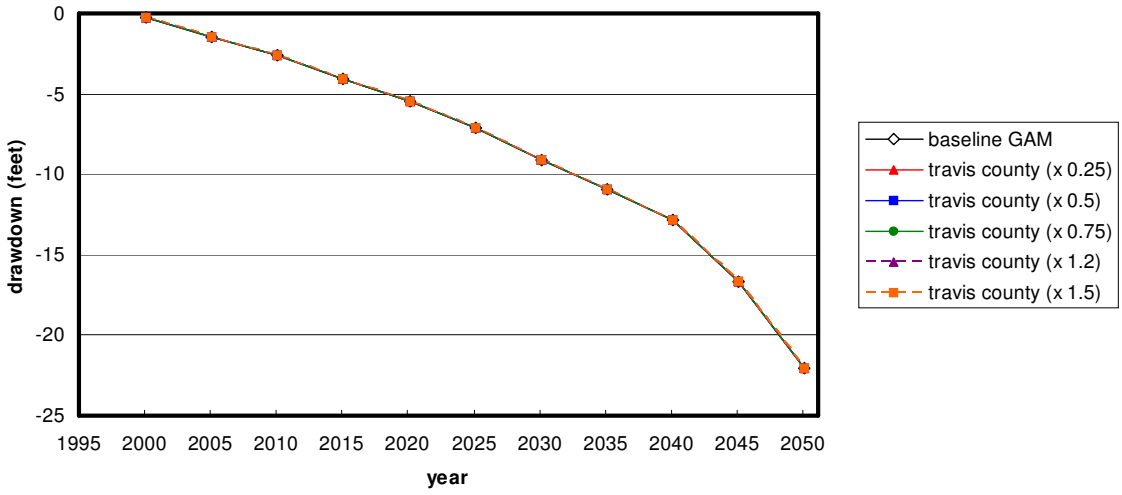
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 113
Pumping in Travis County – Effects in Kerr County



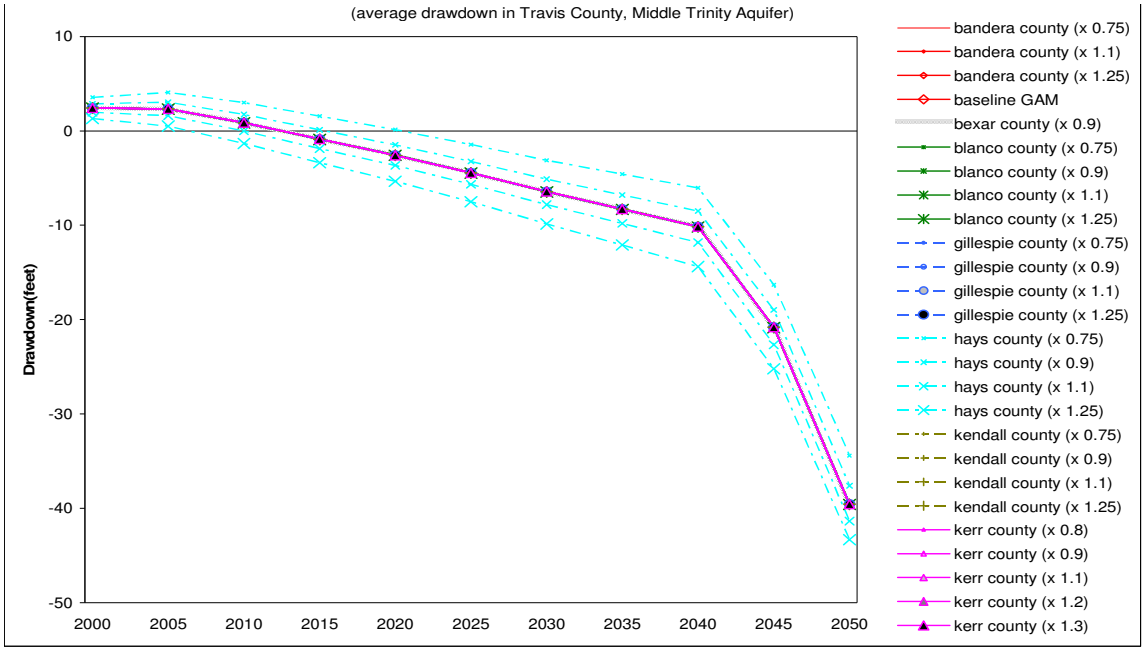
Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 114
Pumping in Travis County – Effects in Medina County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 115
Effects in Travis County – Pumping in other Counties



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

No Increases in Pumping

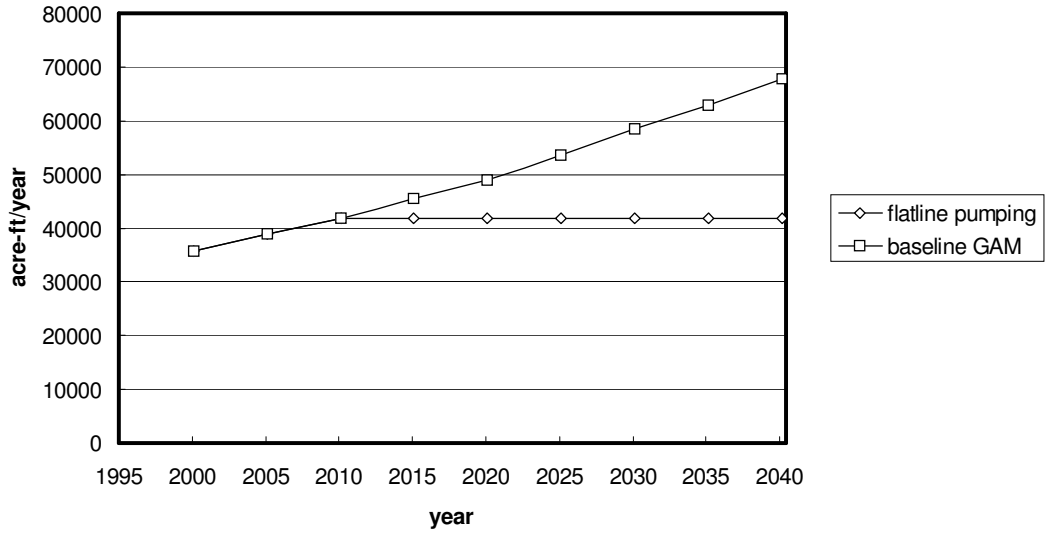
Some GMA 9 stakeholders have expressed an interest in exploring what might occur if each of the GCDs refused to permit additional pumping beyond current levels and would somehow be able to prevent any future pumping by new exempt wells. A special model run was created to simulate the consequences on average aquifer drawdown from a case where pumping beyond current levels was allowed. Pumping rates for the years 2010-2040 are held constant at the 2010 levels as prohibited. The pumping rates in 2010 are taken from the baseline GAM pumping projections, which may or may not be an accurate reflection of expected rates of withdrawal in 2010. Figures A4.116 and A4.117 are intended to show the general aquifer response if further increases in pumping are prohibited.

The drawdown curves are computed as the change in head from December 1997. In terms of hydraulic heads, 1997 may have been a "high" year in some counties and a "low" year in other counties. Figures A4.116 and A4.117 describe how the aquifer

behaves relative to the 1997 head levels, which is a somewhat arbitrary point. The important feature to examine is how the drawdown changes over time. Figure A4.116 compares baseline GAM withdrawals to the 'flat line pumping' option. Figure A4.117 illustrates that in all counties the average rate of drawdown can be substantially reduced by prohibiting further pumping. While the head levels in the Middle Trinity Aquifer continue to decline after 2020, the rate is so modest as to be hard to measure.

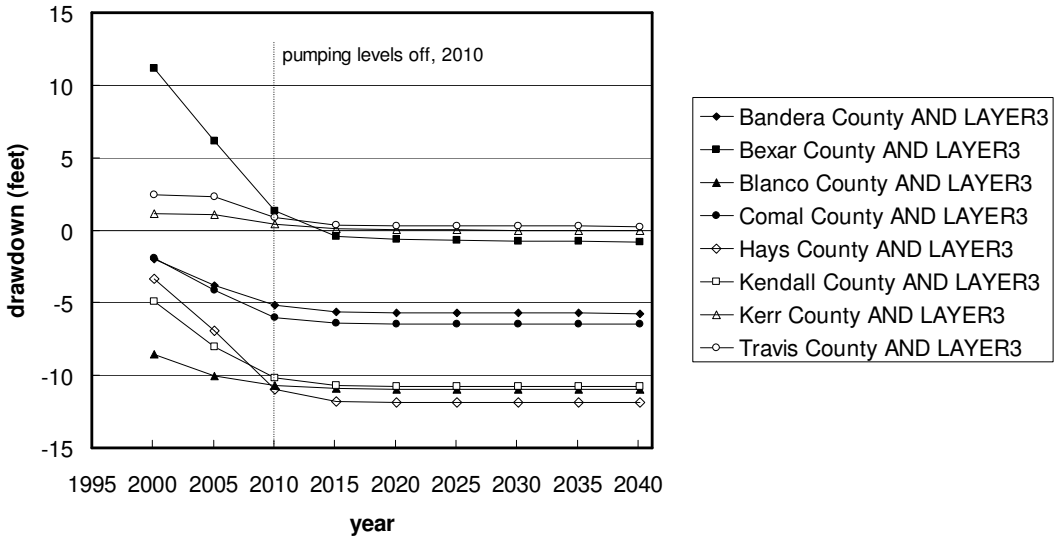
This "flat line" scenario requires GMA 9 GCDs to prohibit further pumping, which would exceed their legal authority. If any one GCD were to increase withdrawals, then drawdown will occur in that GCD and any neighboring GCD influenced by withdrawals in that county. These results indicate that the key consideration in expected annual aquifer drawdown in any county is the volume of pumping allowed through permitted and exempt wells. Withdrawals in any county can be affected by increased pumping in some adjacent counties, with Bexar County bearing the most sensitivity to external influences.

Figure A4. 116
Total Aquifer Withdrawals



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Figure A4. 117
Average Drawdown in Each County



Source: Provided by UT GMA 9 Groundwater Management Class 2007 from data in TWDB Report 353.

Notes

[1] Texas Water Development Board. "Groundwater Availability of the Trinity Aquifer, Hill Country Area, Texas: Numerical Simulations Through 2050," Report No. 353, Austin, Texas, September 2000.

[2] Ibid.

[3] Ibid.

[4] Ibid.

[5] Ibid.

[6] Ibid.

[7] Ibid.

[8] Ibid.

[9] Ibid.

[10] Ibid.

[11] Ibid.

[12] Ibid.

[13] Ibid.

[14] Ibid.

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Ibid.

[20] Ibid.

[21] Ibid.

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] Ibid.

Appendix 5.
Public Meetings and Forums

Four public meetings and an in-class presentation were held to introduce stakeholders to the DFC process, disseminate the findings of the PRP, and gather more public input on DFCs for GMA 9 and feedback on the process. These meetings and the agenda for each are listed below.

A5. 1
Agenda for All Public Meetings

Introductions

PowerPoint Slide Presentations:

- DFC Process: Rima Petrossian, TWDB
- GMA 9 Update and Info: Ron Fieseler, BPGCD
- Stakeholder Group Report
- Modeling Group Report
- Data Group Report
- Questions, Comments, and Feedback

Moderator: David Eaton, Ph.D., LBJ School of Public Affairs

Source: Table developed by UT GMA 9 Groundwater Management Class, 2007.

A5. 2
Public Meetings

Monday, February 19, 2007, 6:30 pm - Johnson City, TX
Pedernales Electric Cooperative Headquarters Auditorium, 201 S. Avenue F

Tuesday, February 20, 2007, 6:30 pm - Kerrville, TX
Guadalupe Basin Natural Resource Center Lecture Hall, 125 Lehmann Drive

Monday, April 16, 2007, 6:30 pm - Boerne, TX
Kendall County Historical Courthouse, Commissioners Court Room, 204 E. San Antonio St.

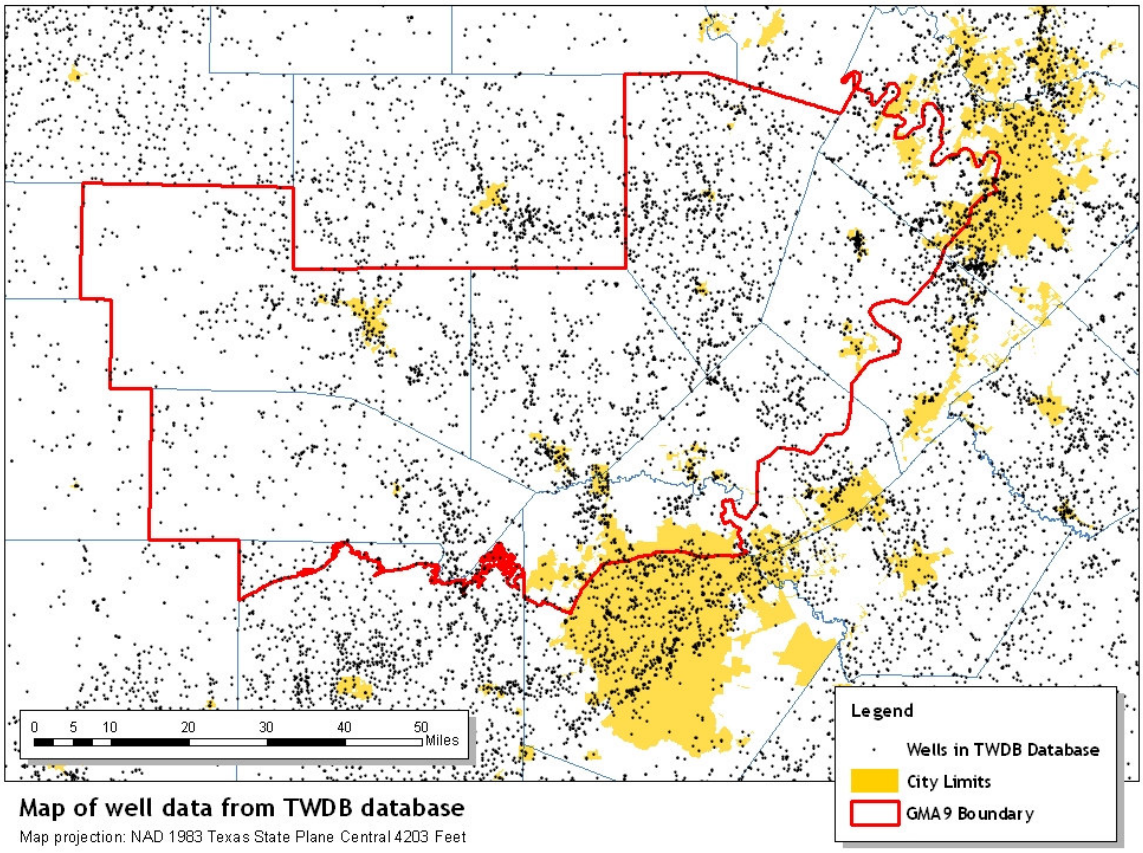
Tuesday, April 17, 2007, 6:30 pm – Wimberley, TX
Wimberley Community Center, Blanco Room, 14070 Ranch Road 12

Tuesday, March 22, 2007, 2:00 pm – Austin, TX
Lyndon B. Johnson School of Public Affairs, University of Texas at Austin
Sid Richardson Hall Room 3.102

Source: Table developed by UT GMA 9 Groundwater Management Class, 2007..

Appendix 6.
Location of Wells within GMA 9

A6. 1
Map of Well Data in GMA 9



Source: Figure created by Jules Vieau, groundwater management class, 2007.

Appendix 7.
GMA 9 Data Inquiry Meeting: Johnson City, Texas, October 11, 2006

Current situation

GIS and Other Databases

Database structures varies from district to district

- GCDs tended to develop databases independently tailored to district needs and budget limitations
- Data and detail collected vary widely
  - One GCD enters driller's log data
  - Another has difficulty keeping up with data entry
- Data collected lacks uniformity
  - Some commonality
  - Database schema varies

Different database applications

- Most use MS Access and MS Excel

GIS Applications

- Broad interest in using ESRI software but only some districts use ArcGIS or ArcView
- Reasons for not using ESRI include high cost and difficulty of use
- Others use MapInfo (e.g. Hays-Trinity) or a freeware viewer

General comments

GMA 9 GCDs are not able to easily share data

- Data is not well organized and is not uniform
- Different nomenclature
- Datum and projections vary
- Data is not documented
  - Most shape files did not have metadata documenting the data source, processing history, or how obtained
  - Many did not identify the projection or datum

Some GCDs stated they lack good base maps for their areas including:

Administrative boundaries

- County roads
- Transportation
- Railroads
- Pipelines
- Rivers, streams and creeks
- Flood plain
- Driveways
- Topography
- DOQs

Data Sources

- County GIS data
- Appraisal districts
- Government records
- Existing Maps
- GPS point data collected by GCDs
- Paper records and documents
- Historical water usage data from municipal water supply billing

GMA 9 GCD Information Needs Wish List

GIS and Database Needs

A common database: a "master database"

- Common nomenclature and data structure
- Combines data from all districts
- Facilitate sharing of data
- Ability to perform a cross-GCD query

Central repository

- Facilitate off-site backup
- Available online with Web access to data and maps

Need good base maps for all GCDs

- See "General Comments" above for detail

Other GIS layers needed:

- Geology layer
- Well maps

GIS data linked with other available data sources; for example:

- County Appraisal District parcel databases
- PDF of well log data
- Monitoring-well data
- Water-quality data
- Water use information from water supply billing data

Access to GIS data with ease of use for "end-users"

Growth and population trends

- Distribution
- Demographics
  - Relationship between income/wealth/landscaping and water use
  - Rural users tend to use less water per capita/acre than urban users

Survey of water usage attitudes

Assistance with Sulfate studies

- Blanco, Kerr, Bandera Counties cited
- Many wells without casing

Assistance with dye and isotope tracing studies and mapping of same

Next Steps

Requested GCDs send their databases and GIS files to us for evaluation

- Requested contact info for county data sources such as appraisal districts, water suppliers, 911-addressing et cetera

We will send to the GMA 9 GCDs:

- Our reviewed compilation of their expressed needs and wish list for corrections
- A roster of the Groundwater PRP including group assignment and contact info

Appendix 8.
Individual Stakeholder Interviews

Members of the UT GMA 9 groundwater management class interviewed residents within Groundwater Management Area 9 in the Texas Hill Country during October and November 2006, and February 2007. The interviewers included Annie Bricker, Brenner Brown, Caleb Brown, Leigh Byford, Marcel Dulay, David Eaton, Leslie Llado, Rob Ryland, Manami Suga, Mariah Tapp, and Thomas Wiles. The class asked for names of persons willing to be interviewed in a public meeting in September 2006 through a written request to each of the groundwater conservation district (GCD) managers. Persons were selected to be interviewed because they were willing to participate, were residents of GMA9, and had an interest in groundwater management. Each interview was conducted by one or two persons for a period of 30 minutes to one hour. Each person was asked a similar set of questions about their concerns and recommendations regarding groundwater management in their region. Each interviewee read and signed a form approved by the UT-Austin Institutional Review Board stating that their participation in the project would remain confidential unless the interviewee granted the class permission to use his or her name in this report. The content of each interview is summarized briefly below, categorized by the seven narrative codes:

- Problem: problems with groundwater in the area;
- Cause: the root of the groundwater problems in the area;
- No action: possible consequences if nothing is done to address the identified problems;
- Actions: possible actions to address the problems;
- Resources: existing assets that will help carry out those actions;
- Barriers: obstacles that may prevent resolving the problems; and
- Ideal: the best situation of the aquifer and groundwater management in the future.

During April to July 2007 David Eaton asked each interviewee whether she or he would be willing to have her or his remarks appear in the final report with his/her name associated. All persons whose interviews are listed provided a response in writing authorizing the class to include their interview remarks. The remarks of any person who preferred to remain anonymous are not included or reported but remain anonymous.

Frank Arnosky

Interview by Leigh Byford and Anna Bricker with Frank Arnosky, Owner, Arnosky Farms, Blanco County, Texas, November 3, 2006. Coded by Brenner Brown.

Frank Arnosky owns and operates Arnosky Family farms with his wife in north east Blanco County. Arnosky Farms has been in operation for 16 years and has grown to the point where they now sell their products at the farm. Frank and his wife are both concerned with ecology and have endeavored to utilize aggressive conservation measures in their farming practices. Having been a farmer in this area during this period of unparalleled growth, Frank has seen firsthand the developments of water quantity issues in the Blanco-Pedernales Groundwater Conservation District. Because Arnosky Farms is located in the eastern part of Blanco County where groundwater is plentiful, Frank has yet to experience problems with water availability. Because farmers are required to apply for a pumping permit every three years, Arnosky's concern is that they have no long-term guarantee of groundwater use. Frank points out that because farming has not been designated a "historical user of groundwater" the GCD offers him little protection. Another concern for the Arnosky family is the disappearance of the American farm and the fact that subdivisions are "pushing out" farms. He reports that as residential growth increases, groundwater quantity and quality will diminish. He also states that representation of current local interests will diminish as new residents may not share the same values as the more agrarian current population. Frank appreciates the fact that growth in this area will continue, yet he hopes that county governments will retain necessary open spaces and be empowered to manage and control that growth effectively.

Problem

- Blanco County tried to limit subdivision density to five acres…but lost in court…a density of one house every acre is not going to work.

Cause

- If they move in at a density of one house every acre it's not going to work.
- The reason I feel threatened … we're the prettiest countryside…the subdivisions are coming out in our direction.

No Action

- They are simply going to continue to build houses… there's not going to be any water and then nobody is going to be able to move here.
- I think its going to be a terrible thing… where they just use up everything they can and then it's gone.
- I'm worried that if I'm surrounded by subdivisions that use up all the water and my wells go dry… there's no recourse.

Resources

- Some states have passed right to farm laws…I would love to see some policy that established farms have a right to "historic use."

- Education… trying to work with people as they are moving in.

Barriers

- Make sure agriculture is included in the groundwater district in Blanco as a historical user.

- Some districts exempt agricultural well from permitting.

- We have to work in a community where we are under a lot of development pressure.

Ideal

- The ideal situation is that everyone is going to have to conserve because its not there…we can't just move 80,000 people into Blanco County and expect to have water…we've got to figure out some controlled growth, managed growth.

Paul Babb

Interview Tom Wiles, Caleb Brown, and Leigh Byford with Paul Babb, Blanco-Pedernales Groundwater Conservation District, Austin, Texas, October 17, 2006. Coded by Tom Wiles.

Paul Babb is the assistant to Ron Fieseler at the Blanco-Pedernales Groundwater Conservation District (BPGCD). His duties include measuring wells and conducting pump tests. He resides outside of the BPGCD on a ranch in Travis County, Texas, and has a private well. He is familiar with the issues faced by Hill Country residents both from an employee and a landowner perspective. While he recognizes that there are problems with decreasing water availability due to overdevelopment and the associated high well density, he maintains that the situation is not all that bad. His ideal situation is that: you turn on the faucet and water comes out. He is uncomfortable with the idea that, as a landowner, his rights to the water might be limited by legislation and thinks that the current way of doing things works pretty well. He believes the legislation to be too weak to resolve anything and the solution is to allow market forces and preserving individual landowner rights.

Problem

- There are way too many wells in an area known for low production.

- Too many straws too close together…cause large draw downs and everyone gets upset.

Cause

- A lot of it is over development…before there were rules on well spacing.
- Part of the Hill Country's problem is that there hasn't been slow development…people go from selling their thousand acres ranches and it goes to hundreds and hundreds of homes overnight.

No Action

- As water becomes scarcer, prices will increase.
- Land values will dictate what people are willing to pay for their water.
- If no district ever gets created in Western Travis County, you're just out of luck…you'll just have to find another source of water.

Resources

- Most counties have groundwater availability studies, if they have someone to review them…that's supposed to help mitigate problems from development.
- The state wants to have a clearer idea of what's going to happen in an area…also (the state wants) a continuity of management over an area.
- I think education helps the planning process…allowing the public to give better input to the process.

Barriers

- People are not educated on what GCDs do…GCDs manage water not land use or development.
- The management of a resource doesn't happen over a matter of months the same way a development can occur.
- I don't think there is an answer to it other than money.
- I don't see GCD having enough power through Chapter 36.

Ideal

- Water is a basic thing that people don't want to worry about…you want to be able to turn on your faucet and have water come out.

- The idea of capitalism dictating what happens isn't all bad…it allows a lot of personal freedom that way.

- If private individuals are going to be able to hold land, they should be able to do what they want to do…if they follow the rules that's all you can expect of people.

Stuart Barron

Interview by Leigh Byford and Leslie Llado with Stuart Barron, City of Kerrville, Kerrville, Texas, February 20, 2007. Coded by Anne Mariah Tapp.

Stuart Barron focused on communication among local governments, water management organizations and GCDs. He believes that good communication among these organizations will lead to more transparent water permit limits and agreements on water use. In his job Mr. Barron sees individuals move to the area who may not know of the need for water conservation. Mr. Barron reports that education for both adults and children is an important component in water resource management. He mentioned excess use of water for lawns and swimming pools as a problem. In addition he approved of voluntary water rationing for citizens as a tool for water conservation.

Problem

- Developing some sort of unified use of water permit limits.

- Irrigation and keeping peoples' yards green.

Cause

- Demand on the aquifer, demand on groundwater and surface water irrigation.

No-Action

- If they continued on the path they are on now, they'll use the water until nothing comes out of the spigot.

Action

- Find a way to educate people who don't read the newspaper and don't go to public meetings to plant drought resistant grass and lawns.

Resources

- Go to the schools and talk to the kids about conserving water and planning for the future.

Barriers

- The different groundwater districts will have a hard time being uniform if they don't communicate often.
- Droughts make things happen and floods make things happen; during the normal course of the year when everything is going fine nobody wants or needs to do anything with water.

Ideal

- It would be good for developers, planners, counties, and cities to have a unified allowance of water and good communication with the regulators so that they're all talking together to find some good ways to deal with these permitting issues.

Randy Bass

Interview by Anne Mariah Tapp and Rob Ryland with Randy Bass, J-Tucker Pump Company, Kerrville, Texas, February 20, 2007. Coded by Anne Mariah Tap.

Randy Bass is a well driller based outside of Kerrville. His main concerns centered on overuse of the aquifer. Although Mr. Bass did not expect a crisis in the next 50 years, he reported that eventual water scarcity is inevitable. As an ideal, Mr. Bass suggested that recharge would accommodate growth in water use. Mr. Bass mentioned the nature of karst aquifers leading to quicker recharge than other types of aquifers. He emphasized the necessity of meeting the needs both of the environment and the citizens of the area. He noted that he is in an interesting economic position as a well driller because as wells go dry, his business increases, even though in a drought there could be no water remaining for drilling.

Problem

- No one really knows how much water we have to work with.
- If you've taken more water out than what's coming back, then you know you've got a problem

Cause

- The area population continues to grow.
- More demand for water.
- Limitations with what we can take out of the surface water
- A potential problem of having enough water for the future population.

No Action

- If we don't have enough water then it is going to restrict my business because if we don't have it, I can't go get it.
- At some point in time the population will be great enough that you could overcome what's actually coming back in and over a period of say 50 years you may deplete it (the aquifer).

Resources

- Conservation is going to be more important but we have to do it in a reasonable manner.

Ideal

- That the aquifer level remains relatively constant.
- Enough recharge to take care of any population growth.
- Groundwater is going to be a whole lot more important than oil… We need to conserve groundwater in a reasonable manner that not only takes care of the water but also of the people involved in it. There has to be a balancing act between what we have available against what we need.

Shirley Beck

Interview by Caleb Brown with Shirley Beck, a concerned citizen of Blanco, Texas, November 4, 2006. Coded by Leigh Byford.

Ms. Beck is a citizen of Blanco, Texas who consented to an interview. For Ms. Beck, the main water problems in this district are wells and surface water sources going dry during drought periods. The main cause is population growth. The influx of retirees and families that purchase homes which operate on well water puts too much pressure on the aquifer. The people who move in to this area are from other parts of Texas or the United States and they do not understand the historical or current water situation in Central Texas. In the ideal situation, everyone in this area would understand the importance of conserving water and would do so. To get to this ideal level, developers should do their part to openly engage their customers on water issues and alternative sources. The district should have a public education program about water regulations, water conservation, and alternative sources. The government should use market incentives like tax breaks to encourage consumers to use alternative sources of water such as rainwater collection. Ms. Beck reports there may be serious consequences if these actions are not taken, as more wells and surface water sources will dry up over time. Ms. Beck states that her district needs assistance with data collection and analysis so that they can make

good decisions for their management plan and that the district is seriously hindered by the lack of scientific information on the aquifers.

Problem

- I get phone calls from people when their wells go dry.
- All I can tell you is that through this drought, 2005-2006, we've had more wells go dry in this area than we did in '99 and 2000.
- Surface water is not a sustainable solution for Blanco Co.
- You will see all the way up that the Blanco River is drying up. When we overbuild the water supply then we are going to suffer the consequences of it.
- There is no water. [A developer said] "You're right." When we got into that subdivision and started drilling wells we ran into what you were telling us. There was not adequate water… and even if we found water, it was such poor quality that it could not be used in a water system.
- Frankly it comes down to: this is a moral issue. How will you keep hyping property in an area where there is limited...you know they say in real estate that it's location, location, location. In Blanco County it's water, water, water.

Cause

- We were very concerned because we realized the population was growing very rapidly without any regard to water.
- I feel that there's a real (population) crunch coming in the State of Texas… we think we can do whatever we want. I'm concerned about people moving out here. People from Houston, Dallas/Fort Worth, California and the East Coast get their little piece of Texas, but it's a house of cards that could come tumbling down.
- The problem right now is we have people [moving in] who have not had a living experience in Blanco County. There is a lot of oral history about drought. Records show settlers in 1853 moved in a rainy year and then there was a drought. It's like a rollercoaster. In 1952 my father gauged 26 inches in a day on this ranch. Then the next year it rained 13 inches for the year, then 7 inches the year after that. Developers and buyers are from another part of Texas or out of state... and want to put in vanity ponds and fill them with groundwater. They're living against nature.
- (What is the cause?) The bottom line is greed. Money. The Hill Country is a major attraction. People want to live and retire in the Hill Country.
- Developers want to make as much money as they can and then leave. When the drought started they had never developed anything outside of East Texas where it

rains a lot. Their comment was "what do you do when it doesn't rain?" When you've got a population living there on your water supply then how responsible are you? Basically it comes down to fraud. Is that fraud, when you promise people water a central water system and wells. Then what happens? We have no idea what will happen when this population starts to pump water.

- Reporter from San Antonio paper reported on golf courses. Each 18 hole golf course in that area uses enough water for 23,000 residences.

No Action

- You will see all the way up that the Blanco River is drying up. When we overbuild the water supply then we are going to suffer the consequences of it.

- Developers want to make as much money as they can and then leave. When the drought started they had never developed anything outside of East Texas where it rains a lot. Their comment was "what do you do when it doesn't rain?" When you've got a population living there on your water supply then how responsible are you? Basically it comes down to fraud. Is that fraud, when you promise people water a central water system and wells. Then what happens? We have no idea what will happen when this population starts to pump water.

Resources

- We have several aquifers that we have no information about at all. And that information is critical to make decisions for a management plan.

- I just want developers to be honest with people. Say these are the kinds of things you can and cannot do in Blanco. You can't have a water guzzling landscape. You can't have the things you had someplace else.

- The county should encourage people… giving tax incentives for rainwater collection systems.

- The manager and the board need information. They haven't monitored or even registered all the wells. I run into people who don't know that the board can ask them to register their well… I tell them they need articles in the paper, speeches, they need to get out there let people know.

Barriers

- The whole concept of the management plan is based on research. And if you don't have enough monitor wells scattered over the county then you don't have good research.

- We have not had anyone turn us down [for a meter]. Most people don't understand that a well that pumps 25,000 gallons a day or more that it's a

commercial well and needs to have a meter on it. That's an education problem that we have, people understanding the differences in wells.

- We have no idea how many acres it takes to recharge a well.
- Other GCDs have determined possible yield. We don't know. Does it take 10 or 30 acres to recharge a well? We have no idea.
- I'mfor sustainable development, but frankly I have no idea what that means in terms of water supply because we don't have enough research to establish that.
- It comes back to that research base. We can't make any decisions without a solid base of information.
- We are an urban state. We need to realize that.
- The hold-up is in the state level because developers control the legislature too much.

Ideal

- Some people treat water as if it's oil… that's it's something you can make money with. But I think it's like blood, like it's vital.
- I'm for sustainable development, but frankly I have no idea what that means in terms of water supply because we don't have enough research to establish that.
- We want people who move in here to live with nature, not against nature. There is a difference between those two concepts.

Pat Boyle

Interview by Thomas Wiles with Pat Boyle, Developer, Bandera, Texas, November 10, 2006. Coded by Tom Wiles.

Pat Boyle is a real estate agent, a developer, and a life-long resident of Bandera County, Texas. His children and grandchildren live there as well; through them he has a long term interest in the availability of groundwater and quality of the environment. He is concerned with the degradation of water quality and quantity due primarily to irresponsible development and is proud to point out that the land he has developed has had less of an environmental impact then those developed by outsiders. Pat states that we should assure our water quality and quantity through more stringent regulation. He feels that if no action is taken then the people with the most power and money will control access to water. Pat thinks that there are engineered solutions such as aquifer storage and recovery that should be looked into, but ultimately we should strive to be better stewards of our environment.

Problem

- Until a few years ago…there weren't any kind of regulation…people would put out a 55-gallon drum out for a septic…in the older days you could see raw sewage going through there.

- Our water table falling, it's the same old cliché that everybody uses, you keep sticking so many straws in one drink and it's going to go dry.

Cause

- So much of this property up here has been bought and sold by people that are just in here for the fast buck.

- So many people have come in with no tie-in with the community; they came in, cut it up, made their money, and took off.

- There are lots of areas…in different directions out of this town, the water is of very poor quality and the quantity is very bad.

- Until a few years ago…there wasn't any kind of regulations as far as septic systems or water well drilling.

- In some places, with old dried up wells, people would buy them, drill a new well, and run their sewage into the old well.

No Action

- I think…it would be like the old west, whoever had the fastest gun/who had the deepest well was going to get all the water.

Resources

- This county has 500 acre-feet of water from the river… I think they need to build a plant to suck that water from the river and put it back in the aquifer.

- A lot of things would be so much simpler if there were some sort of way to inform people so that they would understand why the regulations need to be put in place.

- If the government would implement some kind of a program to help a farmer or rancher go on to their place and build something to catch water, a certain amount of that will go back into the aquifer and that's going to benefit the county as a whole.

- They need to get a pretty stringent set of guidelines and they need to abide by them.

- I would like to see larger minimum tracts to put a well or septic system.

- I'm a believer if you had a master plan set up with one well, some sort of water system in place…it would be better than everybody being on their own well.

- I think that we need to start being a better steward of our natural resources. We need to implement some changes in the way we do things. Things that used to be par for the course, don't work anymore.

Barriers

- Any kind of restrictions on anything irritates people. Nobody wants to be regulated; they buy a piece of land, they should be able to do what they want to with it.

- People are not conscious of the water tables here, they're not knowledgeable.

- Everybody wants to get some kind of running water system. Most of the developers, when they buy something they buy something that's next to a river or creek or something.

- I'd rather see (larger tracts) but…a lot of people say they couldn't afford that because the price of the Hill Country has dramatically increased over the years.

Ideal

- They need to get a pretty stringent set of guidelines and they need to abide by them…I don't think there should be any variances at all, except in the most extreme situations.

- You've got to put an importance on springs.

Luana Buckner

Interview by Brenner Brown with Luana Buckner, General Manager, Medina County Groundwater Conservation District, Hondo, Texas, October 27, 2006. Coded by Anna Bricker.

Luana Buckner is the Groundwater Manager of the Medina County Groundwater Conservation District in Hondo. Medina County seems to have very few water issues at the moment. There are no wells going dry and no conflicts either with litigation or among agencies. Luana does foresee problems in the future if development continues rapidly or if there is an extended drought. She also sees issues with not having enough information on the aquifers and lack of participation by the public.

Problems

- We're in an extreme drought right now. There has been some rainfall. We have seen some wells in the northern part of the county have some production problems. We haven't seen any wells go dry so far, but the production is declining.

Causes

- The northern part of the county is undergoing some very rapid development. I think the majority of the issues are due to the drought and the slower recharge in the Trinity Aquifer versus some higher production limits.

- (On developer issues) Well, in some cases yes, in other cases they will get their permit, but other than that, they don't communicate well with the district.

- (On environmental group issues) Definitely the recreational-use people in Medina country...the environmental interests aren't as tuned in to the issues. Maybe they are just not as well organized as other places in the Hill Country and Bexar County.

Barriers

- Some of the limitations are the amount of information we actually have on those different portions of the Trinity Aquifer

- (What if development continues?) We really don't have enough information to answer that question, which is one of our problems. But it could put the existing wells at risk, particularly in times of drought.

- One of the biggest issues we are going to have is dealing with public water suppliers and getting them on board with what their future needs are going to be and what's going to be available to them out of the Trinity.

- Little public participation in board meetings.

Ideal

- An ideal situation would be having more information on the aquifer and the different formations of the Trinity Aquifer and, based on that information, having production limits that still allow growth and access while at the same time protecting that water source so it is still available for people to come.

David Dockery

Interview by Caleb Brown with David Dockery, City Administrator, City of Johnson City, Johnson City, Texas, October 27, 2006. Coded by Anna Bricker.

David Dockery is the City Administrator of Johnson City. Mr. Dockery reports that groundwater management, while not an immediate issue, will become a problem in the future. If development continues in his area, he sees that the groundwater resource will be used up. He is aware of the population boom in the Hill Country and states that groundwater over-usage reflects in part high density subdivisions. Mr. Dockery is also of the opinion that it will be extremely difficult to manage groundwater with the current monitoring and data collection levels. It is impossible, he asserts, to manage a resource whose statistics are not known. He hopes that there will be legislation in the future to protect this resource. He would like to see the community only using as much groundwater as the aquifer can recharge. He also hopes to see programs such as rainwater harvesting and desalinization as alternatives to groundwater use. He believes that education will be an asset to getting the community involved in the conservation of this natural resource.

Problem

- The use of groundwater is increasing at such a rate that we are concerned about its long term sustainability.

Cause

- We're getting much larger populations moving to the rural areas where the aquifers are less monitored.

- Development goes unchecked and permits are continually allowed… for unregulated development that occurs outside of the regulatory agencies of TCEQ, and exceptionally high permits being granted to smaller developments… and there are other concerns: we also have large petrol pipelines that go throughout the area. We are worried about possible contamination through the pipelines and large septic fields that are coming with the large developments.

- High density subdivisions may not be suitable for groundwater.

No Action

- Depletion of groundwater to the point that we don't have it for the historic use of our water.

- Without good checks and balances we will begin to mine the aquifers and pull water at a greater rate than the recharge is capable of putting back into our aquifers

- I don't like to be forced any more than anyone else does, but if we don't, there may not be anything to regulate, to keep from contamination for our children.

- Without good water, without water that is suitable for people to drink, we won't be able to live here, there won't be anything here.

Resources

- To make sure that the coming generations are well educated on sustainability- how to be able to maintain the groundwater.

- Groundwater has to be managed at the local level, at the state level and at the national level.

- The more you educate people, the more awareness that there is, the more cooperation that there is.

- Treat waste water to the point that it could become potable water. Water reuse is something that we could utilize.

- Greater education for the residents of this area now so that the groundwater districts would be able to have greater regulatory power.

Barriers

- We don't have the data or inventory to know what is available

- It is impossible to regulate a resource that you do not know the extent of its use or its present quantity.

- We are trying to manage something that we don't even know how much we have. We are trying to manage something that we don't even know how much we use.

Ideal

- Use the amount of groundwater that we can have to recharge our aquifers.

O.J. Erlund

Interview by Leigh Byford and Manami Suga with O.J. Erlund, Hay Farmer, Kerrville, Texas, February 20, 2007. Coded by Manami Suga.

Mr. Erlund, owner of rural water systems in seven counties, currently farms on a small scale.

Problem

- Wells around here do not pump well.
- We are experiencing a decline in the aquifers.

Resources

- Education on conservation would be better than regulation. Public education is important.
- Rate structures set up with allotted fees to provide funding for studies and projects.
- Conservation through education.
- Make use of treated effluent.
- Study… moving water from areas that have a surplus.
- Explore the potential for dams and injection wells.
- GCD should allocate groundwater pumping similar to the method of the Edwards.

Ideal

- As an ideal situation, we can use more water in summer.
- A supply of water that does not exceed demand.

Ron Fieseler

Interview by David Eaton, Marcel Dulay, Leigh Byford and Brenner Brown with Ron Fieseler, General Manager, Blanco-Pedernales Groundwater Conservation District, Austin, Texas, October 10, 2006. Coded by Marcel Dulay.

Ron Fieseler is the General Manager of the Blanco-Pedernales Groundwater Conservation District. Mr. Fieseler feels fortunate that his work found him because of his love for geology and his experience with natural resources. As a youth he explored caves. His education dealt with aquifers and geography and his first job was natural resource mapping. His experience in the Wyoming oil field, broad-based education, and business ventures qualified him for his first groundwater management job with Barton Springs Edwards Aquifer Conservation District that lasted 12 years. He has now been with the Blanco-Pedernales Groundwater Conservation District for five years.

Mr. Fieseler would like the people have a reliable potable source of water that is managed in a way to get people through a long drought comfortably with minimal losses and consequently the district may be seen as a positive resource to the community. If this can be done, the aquifer will be full along with the creeks and people will be happy. Currently, people are angry with the GCD and there is conflict in the region because certain developments have not been stopped, which evolved to unfounded fears that development is going to dry up local wells. He reports that some people believe that the GCD can stop growth, so anger flared when the Rockin' J Ranch application was approved. What people did not realize is that the GCD cannot deny a permit if an applicant follows the rules, and hence the GCD cannot arbitrarily stop growth. He states that some people have a misconception of a GCD's authority and role, and may not understand legal limitations which may have led people to believe that the GCD is not doing its job. Aquifers are sometimes less reliable today than in the past because they are stressed to the point where wells can go dry if one is not careful about pumping. Aquifers can be over-pumped, and there is risk of economic hardship if aquifers are low, especially during drought. The aquifer stress is from high population growth demands, water consuming decorative landscapes, aesthetic ponds, and water transfers. Without the district, good management, and local control, water may be scarce on the land in the future because of high demand; there will be no recourse if someone affects your well. Excessive pumping will affect potable water supplies and there will be limited knowledge of water on the land leading to chaos and uncertainty of the quantity and quality of water.

For Mr. Fieseler, the key to success is to build a structure to get through drought, develop proper regulations, and educate the people so that trust can be built. The structure is based on aquifer knowledge from good science and field data to help manage it better and effectively, which in turns build trust in the district that is vital when the drought plan is put into effect (water use should be flexible in times of plenty). As trust is built, districts gain more access to data, science gets better, management improves, and trust is strengthened—a circular loop effect. The people must understand that high demand resources have to be locally regulated for good management and the aquifer could be protected if people understand water conservation; benefits, limits, and utilization of groundwater; GCD authority; and the need to cut back during drought. Trust is already built in his district because people do believe the GCD is doing a good job and the GCD is already useful directing growth through its rules. It is going to take all the people skills, technical knowledge, and science the GCD can develop to keep this trust. The difficulty lies in that there is never enough data, not enough time, money, and personnel to do the work. It will always be hard to change attitudes, difficult to make science believable, and challenging to make warnings followed. People will always want to drill wells and increase demand, which causes aquifer behavior to change. People may not be able to decide what they want so that any goal will be a complex; moving target hard to restrict under the confines of a law.

Problem

- People are mad at us because we have not stopped a subdivision or a golf course from going forward.

- People don't like that the GCD is not doing something that they thought the GCD could do.

- People that move from the city are used to turning on their water and getting all you want. In the district they now have a well that puts out 5-15 g.p.m… if they let their water run, they may dry up their own well, have pumps burn out, and other problems can occur (this is costly to the homeowner).

- We are in conflict with people because we allowed the Rockin' J Ranch (1,400 quarter-to a third-acre lots) which is building a public water supply and sewage treatment to irrigate a golf course. People don't like the developer, small lots, or golf courses; however, all the aquifer tests show that the pumping will have minimal impact on the wells adjacent to it, but I cannot convince some people that their wells will not dry up.

- The Edwards Aquifer is very prolific and recharges quickly, but because of the tremendous development it can be pumped into a drought in just a few months time if they don't get enough rainfall. They are in stage 4 drought right now, that equals the drought of the '50s that took seven years to get to that point and now they can get that way in one year.

- If you are willing to let the river dry up, it will cause economic hardship on Klepac Greenhouses and Blanco State Park because they rely heavily on the springs. The nursery is the largest business in Blanco County.

- People could come in next to someone and suck the well dry across the fence and the person would have no recourse. That is the case law in Texas right now. Cases have shown that, absent a groundwater district, you have no recourse; if someone dries up your well, tough luck.

Cause

- Some people were in favor of establishing a GCD because they thought they GCD could regulate things, do things, protect water, slow down development, stop growth, prohibit certain things. There is some truth to that and some misconception.

- People raise issues about trying to stop new subdivision and stop growth, but we can't do that.

- Rockin' J Ranch stirred up all the trouble. Rockin' J could have drilled their wells and found no water and they would be mad because it would stop them… but since they found water now everybody is mad at the GCD. People are mad because the GCD could not stop the developer from building a golf course. People felt that it is waste of water, so the GCD should deny the permit because not all people will benefit from it, its just recreation. However, that same argument could be used against the parks, foot ball fields, baseball fields, or other

recreation. Not all people go to those things as well, so we cannot discriminate against any sport.

- There are some misconceptions by some people that we can deny people permits because the district does not like it; we cannot do that.

- If people apply to drill a well and they file an application, they follow all the rules, do not drill within public water supply, [the well] has good quality, does not affect other wells, there is enough water, and [is] used for beneficial purpose, then by law we have to give them that permit.

- People are mad because people don't know that if developers follow rules and if we don't give them the permit they can file a writ of mandamus and force us to comply with our own rules. There are limits that people don't understand and it makes them mad because they see the law working for the developer rather than for them.

- We are following the law and we are trying to do a good job… but we realize our limitations, but they don't.

- People complain that the GCD is not doing what we were put it in place to do; if you voted for this district and expect it to do something that is not legal, then you voted for it for the wrong reason. You misunderstood what our limitations were and what we can and cannot do.

- People select only parts of the rules and complain that the GCD is not abiding by the rule, but they miss the big picture. Rules are designed to encompass the whole picture and it may seem that it misses something but it is tied to something else. People don't grasp that.

- It's a misinterpretation of the codes, because they have read them but don't understand how everything ties together.

- A lot of people want to drill wells to water their yards with well water. People have a high water bill ($300/month) because they irrigate a large city lot or large lot and they have all these plants and shrubs… if they drill a well it will pay for itself in a couple of years.

- People want to build lakes and ponds that are large (10 - 15 acres) and want them kept full with ground water in a county where we are very limited with our groundwater resources. I have to talk to them and let them know that you are not going keep up with the evaporative losses with a well that only pumps 10-15 g.p.m., you are only going to create a mud hole.

- My view is that if my plants in my yard cannot survive a Texas summer than they [should] not be there, but other people don't think that way. They want to have a

green lawn and decorative plants (e.g., palm trees). Everyone has a different view of what is pretty and desirable.

- People are concerned about the water marketing that is going on. There are companies forming to pump water and sell to local cities.

No Action

- You may reach a point in the future where you may have to tell somebody that you can drill a well on your land but you may not have water year around because of the excessive demand in the area.

- If everybody pumps freely, they could affect a public water supply well, depending on how many pumps and how close to the PWS well.

- Water availability is an issue, some places have good water and a lot of it where in other areas you may drill a dry well three out of four times. Without the GCD you would have more uncertainty and unpredictable results. The people who move out and buy land would not have a good a grasp of what is out there; the GCD can help provide information.

- You are going to have growth, but hopefully not without knowledge. Today when you put a subdivision in, you have to do a water availability study; it helps the county and our district know what the limitations are. It helps the developer understand what kind of lots to put in. For example, if there is tremendous amount of water, you can go to smaller lots or else go to larger lots. If it were winner take all, they can drill a well and people would buy lots they would not know the quantity and quality of their water.

- Without local control, you would have chaotic, unpredictable, and unworkable conditions. It would stress the resources and that would be unnecessary.

Resources

- Far more people in Blanco County support us than oppose us. Many people think we are doing well. People ask questions and we answer them and they go away happy.

- Different skills. I have achieved: orderly approach, team effort, worked with diverse group of people in past work experience, and technical expertise. Main skill: dealing with people, issues, concerns.

- Trying to develop that trust is part of my job. I have been somewhat successful. I have had people who voted against the GCD… come up after a year and say, "I may have made a mistake, because you all are doing a pretty good job."

- People see the GCD as the only answer to having any effect on growth, change, and water use in the county.

- Ground water districts are a way to keep a finger on the pulse of the growth. We can't stop it, but we change a little bit by some of our inputs and education (e.g., we change the lot size by the data we provide). We can work cooperatively with county governments to put in place rules and regulation to help direct growth or make so that it fits within the local ambiance.

- Takes people skills and technical skills… some districts hire technical people (e.g., geologist) with consultants and hire a people person, and some districts handle both together; GM is after both.

- Education: a big component of what GCDs do. We not only inform the public, but we educate ourselves. The more science we do, the more data we get, the more effective we are.

- The more data, science, and information we have for our staff, managers, and board to base their management decision on, the more effective we can be and the better we can manage the aquifer, the better we are able to serve, people, answer their questions, inform and educate them on what is occurring.

- When people gain understanding, they will learn to trust and see us as a resource to the county which in turn will provide additional data, and science because we can gain access to water usage, pumping, ability to test wells, etc.

- Field work: register wells, aquifer testing, measure water levels in well to help determine drought conditions.

- Have a provision that if you have public water supply system available to you, then you cannot drill a well.

- A single individual may not get an immediate direct benefit for their tax dollar, but overall we are learning more and more about the aquifer in our counties over time. More people are going to move in, so the more we know about the better we can manage it effectively, rationally, and scientifically, and we will be better off for it.

- When not in drought and when there is plenty of water, you can allow more pumping. You have to have a good drought plan to get through drought, but may relax the regulations when water is plentiful.

- You manage the aquifer for drought conditions, and look far ahead during times of plenty. You prepare for it, you have the data, wells registered, permits, a process in place, management, and this structure in place so that you can get through the drought and low rainfall. Some people see this as meddling or intrusive, but in the long run if it is done in a well organized manner it will get us through drought.

- The management of the aquifer should focus on drought. When there is plenty of water restrictions should be low. When drought occurs, the management structure (permits, practices, rules, plans) in place [can] manage effectively to get everyone through it in a workable and comfortable way.

- It is people management but it is all tied to the management of the resource. We need the good science to make good decisions so that people have trust when you go into drought conditions or other management scenarios.

- Got to have the good science, good management and people that trust the district and believe that it is doing a service to the community.

- In the future we may need to develop a whole new thought process with our residents about water use. We may need landscape concepts about what makes a pretty landscape; it may shift from high water use landscape to cactus and rocks. It is what we may need to insure a reliable water resource during drought conditions.

- Local control is important. GCDs are firm believers in local control because the state is so large the aquifers differ. By having local control, you have a better grasp of local issues, conditions, hydrology, and geology, thus you have better management.

- I don't like being regulated myself, but I see the need for it if you have enough demand for any resource. Regardless of the resource (e.g., water, land, gas), if you get enough demand you are going to stress those resources and it has to be regulated some way.

- People need to read the laws and rules and really try to understand it.

- Help them become aware of their resources that they rely on, what its limits are, the benefits to them, and how to help protect it. We are all in the resource together and I hope over the years we can have a better understanding of groundwater and its utilization.

- Help them educate themselves (contact, newspapers, word of mouth), provide scientific information (well information, science, measurements, water quality tests), and help them understand the process.

- Help people understand what a GCD can and cannot do: we can regulate well spacing, production, drilling practices and that sort of thing.

- Have to help people in small lot subdivisions (1-25 acres) understand the limitations of their wells.

- Have to repeat and apply our science; some people can be informed and become educated.

- We can all manage to get through a pretty long drought: two to three years way below normal rainfall. We've been in this drought for about 1.5 years. We can get through it if we can help people understand the need to manage the water and cut back usage, and have everyone get through comfortably.

Barriers

- Things change as population grows. Example: in the Barton Springs District: it took seven years to reach stage four drought during the drought of the '50s, but there is so much demand today they can hit that in one year with low rainfall. [As] the aquifer changes over time, so management plans have to change, you can no longer can pump all you want: you got to watch for rain.

- The science needs are very diverse and unlimited; we can create a long list. We cannot get enough data fast enough to satisfy everyone.

- To physically have enough time to do the things we need to do.

- Some people think they know everything about resources: "ain't no aquifer around here but I got a damn good well."

- Unchangeable attitudes: "not in my backyard, shut the gate after I get in."

- We can stop people for drilling wells but it is only under specific circumstances. It is very difficult to tell some one they cannot drill a well on their property if they really want to drill one. There have been only a few times we have stopped someone from drilling a well.

- It's a moving target and it is mixture of science, politics, social and they are all tied together.

- 100 percent of the people will never be informed. There will always be people who don't know about aquifer, science, and testing, so they don't trust us then they are not going to change their mind.

- Where do you draw the line on what the county can support on its groundwater resources? People can't decide what kind of development they want. People can't answer their own questions.

- I have people complain that their wells are sucked dry by a subdivision when it was not even pumping. I have had to tell them it is more likely that it is your neighbor across the street or your pumping habits than the subdivision. They always have their own answers, they are not letting facts stand in their way of their opinion, its not getting in their way. They got it in their minds that it is this subdivision that is going to dry up their well and the Blanco River, despite all the testing data than we have available. It is hard to explain to people when they got their mind set on something even if we can prove it is not the case.

- People put demands on the resource, based on desires, needs, habits, etc., but the resource has limitations, [but] some people may not believe there are limits. You need water to drink, you need water for sanitation, but you don't need water for a waterfall and pond in your back yard. You may want it, you may want green lawns, landscape, etc. Can you really afford it where you are located?

- Problems occur in small lots, so we help people understand some of the limits of their resource out there. Some people take to it and some just ignore us. There is nothing we can do about that. We have to just realize that we are not going to be successful all the time.

- We are bound [by] the Texas Water Code and we have to operate within certain confines of these laws

Ideal

- I live out there and I am on a public water system and I want water to keep coming to my house. I am as selfish as anyone else; I want to have good drinkable water coming out of my faucets, etc., so I want to manage the aquifer so that it continues to happen. It will preserve water resources at houses, subdivisions, county, and elsewhere. We need to manage that water so that it is a reliable year-round source of water.

- I would like to see the aquifer managed in rational, reasonable, and manageable approach to get as many people through drought conditions as possible.

- If we can manage the water so that everybody has a reliable source and get us through a time of low rainfall or pretty serious drought.

- When you have plenty of water in the aquifer, you are likely to have plenty of water on the surface, springs will be flowing and the creeks will be full. Everyone is going to be pretty happy.

- I want the GCD to be a positive resource for Blanco County. I want to have the people in the county see us as a positive government resource in the region.

- My whole goal is to be an asset to the community and county… the bulk of the feed back is positive on that score. That people are glad that we are there, they think that we are doing a good job. Can you do a better job? You can always do a better job, you can always improve. Sometimes that means more money, more personnel, and steps to increase some long term process. It may take a while (2-3 years) before you can move onto something else. Some people understand this, but some people want instant results. If you don't need us you may never know we are there and you may not see a concrete result on your part.

Jack Hollon

Interview by M. D. Anna Bricker, and Tom Wiles with Jack Hollon, Board Member, Hays Trinity Groundwater Conservation District, Austin, Texas, October 17, 2006. Coded by Leigh Byford.

The main problem in this area is wells and springs going dry. The rapid population influx and build-up of homes is the main cause of this problem. Some people moving in to the area are not aware of water regulations and the impact of their actions on the resources. Stewardship of all the land and resources is important to Mr. Hollon. The ideal situation is to have enough water available to sustain future population and economic growth in the area without wells or springs going dry. He has a lot of specific metrics in mind to define sustainable yield. He has a lot of ideas for how best to achieve this ideal. First, the district should take a very active role in educating the people about water regulations, waste, and conservation. Second, citizens or developers should purchase and set aside an area of land to remain open space to allow the aquifer to recharge. Third, developers and local water supply companies should repair their leaky distribution systems to reduce waste and help maintain the level in the aquifer. Finally, the district should educate and encourage the public to use rainwater collection as an alternative water resource. If no action is taken, Mr. Hollon foresees legal battles for the district over permitting. Major aids to the management process are that some people do already have an understanding about the importance of water conservation and want to cooperate with each other to create a good management plan. The low level of legal authority for the GCD is limits its ability to take other actions. His district also needs more scientific data so they can make good decisions in their management plan.

Problem

- Wimberley exists where it is because of Cypress Creek. Settlers built a mill there in the 1840s in the center of the community… ground grain (flour and cornmeal), sawed wood, and had a cotton gin. It was powered by the creek which flows out of Jacob's Well. In 2000 there was a drought and the pumping in that area stopped the well from flowing.

Cause

- Population has been an interest of mine. I see all these things converging here in the Hill Country. There was a questionnaire about where people want to retire. A huge number responded: in the Texas Hill Country. "Carrying capacity" is not being considered.

- Our work so far indicates that we're probably over-pumping the aquifer already. And there is so much growth potential remaining… many platted lots are not yet built on.

- "Vanity ponds" are also a problem; they set a bad example. Evaporative loss is huge.

- Developers platted thousands of lots for Wood Creek North. Some have been built on but there is still huge potential out there and they are selling lots as we speak.

No Action

- They (developers and water supply companies) will be coming to the groundwater district for permits for more wells to supply those homes. That would send us way past our sustainable yield for the aquifer if those permits are granted. The district then would very likely not vote for those permits and we might end up in a legal battle over that.

Resources

- Conservation—that's our ace in the hole. People are finding we can get by on a lot less water: native landscapes rather than St. Augustine lawns. Conservation and living well are compatible goals.

- One source being utilized by a lot of people already, and I think this is very big in our future, that's rainwater harvesting.

- We think we need to be working cooperatively [with other districts and government entities] instead of [in an] adversarial way. The county and the district should work together, for example.

- Legislation to strengthen our district, to make it a really good functioning district, would be my number one priority right now. Then we need to strengthen our outreach to the community on conservation and rainwater.

- There will probably be attempts made fairly soon to bring in other water resources. But I'm not too sanguine about those possibilities. If we have another prolonged drought we'll find that the GBRA and LCRA (possible sources which are already providing some water)… overextended already.

- We are very strong in supporting sustainable development (speaking of HTGCD).

- The groundwater district has taken an active role in discouraging vanity ponds and pumping groundwater into ponds

- I headed up a delegation of the groundwater district and we went to one homeowners association meeting to talk to them about [their manmade lake]. Their attorney was there. We showed them the water code. We showed them that one district purpose was to prevent waste. We showed them the evaporation figures and they shut it down.

- Citizens can be roused to vote for bonds to buy open space property and protect land… or put conservation easements on land so that it doesn't get developed.

- One of the most urgent needs is that water supply companies agree to replace infrastructure to stop loss and waste. They could supply hundreds of homes with the water being lost in their distribution systems. (Essentially, groundwater is being treated as a "free good.")

- One thing the county is looking at, that we are extremely interested in, is having minimum lot sizes that approximate land needed to recharge water for that family. There's no way the recharge on a half acre (or even two acres) will supply the water a family uses from their well; 20 or 30 acres is probably closer to what is needed… less if they supplement with rainwater.

- I'd like to see the county (or region) adopt standards that require new development to have rainwater collection. It works.

Barriers

- Speaking of homeowners (POA) pumping into a large pond: We didn't threaten them with a law suit. We just went out and talked to them. I think that's the best way. Sometimes the way we misuse groundwater is done with good intentions but ignorance of the side effects. They didn't know that it was considered waste in the water code to do what they were doing. The evaporation loss figures did not inform their decision.

- In the GCD we don't have the money right now to do needed science. But we need to do the best possible modeling so that we can find out if our management criteria and numbers are accurate. We're telling people we're oversubscribing the aquifer right now and we think we're pretty accurate. But we are willing to look at that again if we have a better model and more accurate results.

- There is a psychological barrier against going to rainwater that I don't understand. It bothers people. There's something, people get real anxious about the thought that they are at the mercy of the weather, that they are responsible for maintenance. Good information can overcome this.

Ideal

- Stewardship is way high on my list of values. Unless we can stabilize population we are going to destroy a lot of values I hold dear in the Hill Country. We are losing wildlife habitat and crowding out other species. We're putting a lot of pressure on groundwater here that is drying springs and streams. Water makes this place beautiful and special, and is important to riparian areas.

- We're very clear on what we mean by [sustainable development]. We want to use the aquifer efficiently and sustainably. Sustainably means that we want the aquifer high enough to support streams and springs in the area.

- Our water resources are the heart of this Hill County community. We must respect their limits by limiting our numbers and use.

    - The great spring and the Cypress Creek supply recreation for humans and water to wildlife and agriculture..... In our area recreation has huge economic value.

Milan Michalec

Interview by Brenner Brown with Milan Michalec, Board Member, Cow Creek Groundwater Conservation District, Kendall County, November 17, 2006. Coded by Brenner Brown.

After retiring from the Air Force, Milan Michalec moved to Kendall County. After a long dispute with the Cow Creek Groundwater Conservation District, Mr. Michalec became interested in groundwater. According to Milan two years ago the GCD informed him that they would be managing his water. In an attempt to protect his interests, he challenged the GCD. Through his active battle against the GCD, he realized that to secure groundwater availability for himself and his future, he must not only rely on the GCD but get involved with it as well. Milan sees the GCD as the only protection well owners have over the future availability of groundwater. As a board member of the GCD, Milan is aware of the fact that water levels are dropping and he cites several causes. One of his greatest fears is that Bexar County, which is currently pumping approximately 5,000 acre-feet per day from the aquifer, will put too much of a strain on the aquifer, causing further availability problems. He believes that local management of water through groundwater conservation districts, supported by appropriate state legislation, is the most effective way for the quality and quantity of groundwater to be managed and he points out that as of yet there does not appear to be a cohesive comprehensive state-wide water plan. As an active member of the groundwater planning group for the area Milan is concerned that the efforts that they are putting forth may not help, as past planning efforts did not result in improvement in the state of groundwater in the region. According to Milan the City of Boerne, Kendall County and the Cow Creek GCD have a strong working relationship and can develop more sustainable long-term sustainable plan. Controlled managed growth through local water and building permitting authorities is the key to success in the future.

Problem

- Water availability—you can't change it; the wells are dropping the springs are slowing down… it's just common sense.

Cause

- …with Kendall County being a high growth county… realistically, groundwater is finite… and we are going through the second year of serious drought.

No Action

- Pass a ruling and can't enforce it… what confidence do I have as a landowner… we had this situation with the PGMA and it didn't get any better.

Resources

- Personally, I think it is very important to show the true status of the aquifer. If we are truly over-allocated to our maximum, we should say so…the better we define that, then we can distribute the resource fairly.

Barriers

- The biggest impact is what happens beyond our political boundaries…the hydrology across an entire aquifer is difficult to manage within the borders of the county…there are considerable pressures on the Trinity Aquifer from the Bexar Metropolitan Water District and SAWS...

Ideal

- The object is to maintain the level of sustained growth…limits of, and impact to, available natural resources dictates there are limits to areas that can be grown.

Sandy Pena

Interview by Anne-Mariah Tapp and Manami Suga with Sandy Pena, Environmentalist and HGCD Committeewoman, Kerrville, Texas, February 20, 2007. Coded by Rob Ryland.

Ms. Pena, who self-describes as a retired environmentalist, has resided in Kerr County for over ten years. Her concerns with groundwater began when she moved to Kerrville and was dismayed by the cost of drilling a well along with possible water quality problems within the Trinity Aquifer. She is an advocate for rainwater harvesting and practices it on her own property. She also sits on the Exceptions Committee of the HGCD where she hears requests for exceptions to pumping limits and other groundwater rules.

Ms. Pena believes water is a finite resource and is concerned that increases in water pumping from growth will exceed the area's groundwater resources in the near future. She cites projected population growth along with dry springs and wells, especially in eastern Kerr County, as evidence of approaching groundwater shortages and overuse. She is concerned that water availability for environmental needs such as wildlife, river health, bays and estuaries are not being given sufficient attention.

As an owner and promoter of rainwater harvesting systems, she believes this method holds the key to water-supply and water quality issues in the region and wants the state to

begin implementing the recommendations of the Rainwater Harvesting Committee as soon as possible.

Ms. Pena stated that government regulation of groundwater use is crucial to sustaining the resource, but doubts that there is the political will to do what needs to be done. She recommends that the rule of capture be discarded and for local government agencies to work together and take on greater responsibility for promoting public awareness and everyday water conservation methods, as well as managing the groundwater cooperatively on an aquifer-wide scale.

Problem

- I don't think that our water resources in Kerr County—or in Texas—are sustainable. Water is a finite resource.

- The State of Texas is going to double its population by 2050; Kerr County is going to double its population probably before that. There is just not enough water to sustain that kind of development, in my view, without going to a major commitment to rainwater harvesting as well… so I'm very concerned with there not being enough water.

- There used to be something like 10,000 springs in Texas and the number I heard was that 6,000 of them are no longer flowing. That's a big problem...the droughts that we've had caused the river to go down, caused the aquifer to go down...

- The HGCD hydrologist pointed out some data that they've gathered...as part of an ongoing project which indicated that the eastern side of Kerr County...is in dire need of water. There are wells going dry...they've tested the water in the aquifer and it's about 28,000 years old—which means what? That it's not recharging, that there is probably a finite amount of water down there—they don't know how much. They just know that it's not recharging.

- There is a problem with pesticides and herbicides and other kinds of chemicals used for agriculture that get into the water.

- If the springs continue to dry up—they provide a lot of the water for the Guadalupe River, and the city depends on the river for...all of its drinking water. They have aquifer storage and recovery wells and in times when the river's really flowing, they store water in the ASR wells.

- The bays and the estuaries—which is another problem—that we will lose… the marshes and the lowlands along the beach which are important for wildlife, but they're also important for protecting the land from the fury of hurricanes—as we witnessed so recently in New Orleans.

Cause

- The Rule of Capture...that just simply has to go away....there may have been a time in the old days when population was a lot sparser...but when you're looking at the kind of population explosion we will be experiencing in Texas, it seems to me that it's just...totally unreasonable to continue the Rule of Capture, and most other states have already recognized that.

- We have so many folks moving in from Houston or other parts of the East where rain is so abundant it's not a problem… and they're moving into what they don't realize is a semi-arid area, which is what Kerr County is... People are not accustomed to [drought] and they think that the water's always going to be there for them whenever they turn on the tap or whenever they want to water their yard.

- People talk about the "water wars" and in Texas that's a real problem. There are people buying up water rights and selling them to the highest bidder...and these are aquifer water rights that they are buying up, and so they're literally pulling water out of the aquifer that impinges on the people who are in that area who depend on the same aquifer.

No Action

- That's a very important word—"sustainability." I don't think that our water resources in Kerr County—or in Texas—are sustainable. Water is a finite resource.

- As long as our resources can match the growth, that's fine… I think the day will come pretty soon when [we] will begin to notice that the resources are not meeting the needs. And I'm not sure there's the will on the part of the city or the county to take any major steps to address that, until such time as it becomes so obvious and so—perhaps desperate—a situation that they have to impose some limitations.

Resources

- Over the last eight years or so we've given... 26 presentations to different groups in Kerr County about the joys of rainwater harvesting; about how important it is to think about rainwater as a different resource than just what falls on the ground... but that it can truly provide all the water that you need to live on.

- I don't think the city has done enough to educate the people who live in the city about other things that can be done on a daily basis or a weekly basis; small things that can be done to conserve water.

- I think that the State of Texas ought to adopt every recommendation of the Rainwater Harvesting Committee that was put together by the Texas Water Development Board. There's some very excellent recommendations in there.

- The Rule of Capture...that just simply has to go away....

- One way to address the problems of water shortages is to impose some development standards—some smart growth principles, if you will, so that a developer... has to prove water availability before they can start a development.

- The county needs to take into consideration that massive growth and influx of people is not really what's best for Kerr County.

- Small things can make a large difference if enough people are doing it. For example on our shower we have a flip switch...you can install water meters so you know how much you're watering. You can plant native plants which don't require as much water after they're established. You can plant native grasses like buffalo grass instead of St. Augustine, which takes 62 inches of rain a year. Kerr County averages 31.5 inches of rain in a year.

- I don't think the city has done enough to educate the people who live in the city about other things that can be done on a daily basis or a weekly basis, small things that can be done to conserve water.

- Cedar eradication, and that's something that the state is actually funding in some test plots... I know they're trying some out here... in western Kerr County.

Barriers

- The Rule of Capture

- … I'm not sure there's the will on the part of the city or the county to take any major steps to address that, until such time as it becomes so obvious and so perhaps desperate a situation that they have to impose some limitations.

- There are people buying up water rights and selling them to the highest bidder... and these are aquifer water rights that they are buying up, and so they're literally pulling water out of the aquifer that impinges on the people who are in that area who depend on the same aquifer...

Ideal

- The State of Texas ought to adopt every recommendation of the Rainwater Harvesting Committee that was put together by the Texas Water Development Board.

- Our [rain]water is pure enough that it is the same quality as the water that is used for kidney dialysis. You can't say that about the water that's being drunk, either from the well or from the city. So here again...if you want the best quality of water to drink and to use in your home, there's nothing better than rainwater.

- It takes multi-county management. It takes people talking to each other and coming up with policies that are in the best interests of the aquifer or the river... as a whole, and not just "well let's do this in my county and never mind what's happening [in another county]"—you can't do that with water, because... the aquifers are under all of the land.

Larry Richter

Interview by Leslie Llado with Larry Richter, Realtor, Kerrville, Texas, February 20, 2007. Coded by Robert Ryland.

Mr. Richter is a realtor in Kerrville and a regular attendee at HGCD meetings. He has operated a real estate agency in the Hill Country since 1985 and is a strong supporter of the "smart growth" model. According to Mr. Richter, smart growth is an approach whereby the entire community and all the various interests and local resources are taken into account and economic growth is balanced vis-à-vis conservation of natural resources. He advocates active promotion of conservation education in the schools starting at the elementary level, and believes that management of natural resources begins with individuals in their homes. He advocates "sustainable" economic growth for the Hill Country that must be gauged by the pace and level that local water and other resources can accommodate it.

Mr. Richter says government regulation is right and necessary to achieve this goal, but he does not wish for regulation to be too burdensome to stakeholders. To that end, Mr. Richter supports increased and broad cooperation among all of the various groundwater districts and other government entities that play a part in regulating water use and availability. While he believes that government regulation, such as pumping limits, has an important role to play, this is tempered by a concern that some agencies may be creating rules and regulations without having sufficient scientific data and analysis. He advocates more funding for data gathering and analysis, as well as a "whole aquifer" approach to conservation and management.

Problem

- … In any area that grows too fast, if you don't have the capacity to serve, you're going to posture yourself for a real problem.

Cause

- … In any area that grows too fast, if you don't have the capacity to serve, you're going to posture yourself for a real problem.

No Action

- If you don't start at the very top, where that water basin begins, where that rain runs off to supply natural surface water and groundwater which flows...all the way to the Gulf of Mexico, to keep that balance, then you have broken the weakest link in the chain...then you're going to have a negative result.

Resources

- It's important that all the water districts—surface water, groundwater, municipalities ...all work together, that there should be one common goal of conservation.

- I personally believe that these groundwater districts should begin programs of education and start it in the elementary schools.

- In growth, in any development, when government has certain rules and regulations that that developer has to meet, that's a good thing. I mean, you have to have the sustainability of your natural resources to accommodate what you plan to go forward in building.

- The National Association of Realtors supports the idea of "smart growth," and [included] in that is obviously how you conserve a natural resource...and I'm a strong supporter of that model.

- [That's] where you're going to utilize all your resources...you're going to make sure that everyone is involved, where those decisions made by a groundwater district is one that is supportive of the community...one that the people desire... that's the whole backbone of a democratic government - that you're here as a government entity to serve the needs of the people.

- Groundwater districts should begin programs of education and start it in the elementary schools.

- If we go about these GAMS correctly, then we're building a basis that can be shared with the neighboring water district...with that region...with the TWDB, so we have a total assessment that correlates.

Barriers

- If we don't have the correct scientific data, then we're guessing. And this is one of my big issues with these groundwater districts: why are you passing or mandating rules when you don't have complete information? If we go about these GAMS correctly, then we're building a basis that can be shared with the neighboring water district...with that region...with the TWDB, so we have a total assessment that correlates, so that information has to be correct.

Ideal

- In any area, one has to be very thorough in their approach to growth and it's how you grow. I'm one that certainly favors growth, but then I also know that there's a certain way you need to go about it...the National Association of Realtors supports the idea of "smart growth" and [included] in that is obviously how you conserve a natural resource...and I'm a strong supporter of that model.

- It's important that all the water districts—surface water, groundwater, municipalities ....all work together, that there should be one common goal of conservation.

Clovis Riley

Interview by Manami Suga and Leslie Llado with Clovis Riley, Edmonds Drilling Company, Kerrville, Texas, February 20, 2007. Coded by Robert Ryland.

Mr. Riley is the owner of Edmonds Drilling Company and a resident of the area. He spent over 20 years in the oil drilling industry before "retiring" and moving into the water well drilling business. His company drills water wells for a variety of domestic, agricultural, and industrial users.

Mr. Riley's concerns with regard to groundwater in the region derive mainly from his profession. He believes some drillers do not perform their services with the utmost care and can be less than thorough in their work. His experience tells him that "cutting corners" with respect to materials and methods can lead to higher maintenance costs for end users and cause water quality problems resulting from ruptured and leaky well casings, which allow "bad water" in some upper water-bearing formations to contaminate the Trinity Aquifer. Mr. Riley sees a need for better regulation within the drilling industry in order to minimize these problems and may also make it easier for more conscientious drillers like himself to compete on a more level playing field with other firms.

Mr. Riley is concerned that water quality may be affected by older wells of questionable integrity in the same way, and understands that funding to rectify this problem by plugging old wells may be in short supply. His experience with seasonal water use cycles prompts him to keep concerns about recharge and dropping water levels in perspective. Mr. Riley states that water conservation tools such as new appliances will eventually help reduce per capita use and help availability in the long run.

Problem

- One area I think they need to spend a little more time on and that's protecting the quality of water. When you're out drilling you run across areas that are actually

contaminated, because of old wells drilled years ago, and the casing is eaten up in them...and allows… bad water to get in with the old water [in lower aquifers].

- This last year or so when we had a pretty good drought, we saw some effects of it, especially the... Edwards Aquifer here… a lot of those shallow wells just dried up.

- [Government] needs to watch over the drilling end of it more than they do. That may sound funny coming from somebody that drills, but what happens is, we do everything by the book... [but] if you've got competitors that cut corners, you're not bidding apples to apples when you go out there. It costs me more to drill a well than it does some others, so... if they'd make all of us stand by the same rules, then I could compete with anybody... if you don't get a good cement job and end up with bad water and have to drill another well, then it's not very cheap... probably ought to be a little closer watch on the drilling end of it to make sure—especially for the quality of water.

- A lot of these old wells just need to be plugged... that takes manpower to do that. Most of these districts don't have the funds and so forth to hire enough people to get all that done.

Cause

- This last year or so when we had a pretty good drought, we saw some effects of it, especially the... Edwards Aquifer here—a lot of those wells just dried up; this is shallow wells...we noticed in drilling...when you drill into the Trinity—let's just for an example say you hit the top of the water at 400 foot, and that Middle Trinity runs about a hundred foot thick so you drill into it a hundred foot. But your water will rise—used to—to about a hundred foot before you hit it [pressure head], and then during this drought we noticed it'd... rise about 50 foot. So that tells you something right there.

- I believe that when we saw a drop in the water level, I think it was due to the fact everything's so dry people were just using more water. Once we got some rains, and people quit using so much water, then the aquifer started coming back up, because it's been recharged from snow and so forth from up north. So... in this area in particular I don't think there's a real danger of running out of water.

No Action

- You could have that drop [in aquifer levels] if you don't start conserving now. Because the more people move in the more strain they're putting on it... it's not like it's going to be like this 20 years from now because there's going to be twice that many people in Kerrville Texas 20 years from now.

Resources

- There's a lot of things nowadays—there's appliances in the homes.... they got them where they use less water now... it don't sound like much, but if every household does that, that's a lot of savings... when every household saves 25 percent washing dishes it's going add up to a lot of water... plus shower heads, and everything else...

- [Government] needs to watch over the drilling end of it more than they do. That may sound funny coming from somebody that drills, but what happens is, we do everything by the book... [but] if you've got competitors that cut corners, you're not bidding apples to apples when you go out there. It costs me more to drill a well than it does some others, so... if they'd make all of us stand by the same rules, then I could compete with anybody... if you don't get a good cement job and end up with bad water and have to drill another well, then it's not very cheap... probably ought to be a little closer watch on the drilling end of it to make sure—especially for the quality of water.

Barriers

- A lot of these old wells just need to be plugged... that takes manpower to do that. Most of these districts don't have the funds and so forth to hire enough people to get all that done.

Col. Lee Roper (ret.)

Interview by Caleb Brown with Lee Roper, Developer, Canyon Lake, Texas, November 4, 2006. Coded by Leigh Byford.

Colonel Lee Roper (ret.) has developed housing subdivisions in the Hill Country. He believes that there is not enough water naturally occurring in the area and there are legal and/or financial limits to routing alternative sources of water to homes. It is difficult for the GCDs to manage water effectively because they are many entities instead of one that are trying to control the water. Districts are not consistent in their management plans or data and they do not always cooperate with each other. Cooperation is an important aid to the management process. Mr. Roper agrees that everyone should be good stewards of the land and conserve water. His ideal situation is for homes not to rely on groundwater at all, or for those that do to have centralized management and distribution systems. The solutions are to find alternative water sources to import to this area and to control water resources at the state level rather than the local level. He believes that the market can be a tool to encourage water conservation. If people have to pay the true cost of their water they won't use as much. He acknowledges that some people do not understand the true cost of their water when it comes out of the tap. As a developer Mr. Roper is content to comply with the law and thinks laws should be clearer and stricter in regards to water

regulation. If no action is taken, the consequences will be a slow down in growth in the area, implying perhaps economic problems for developers and other business.

Problem

- Water is critical in the Hill Country. When I first came here people said in a few years all this land will be fully developed. And I said no it won't. Well why not? Because there's not adequate water.

- You're probably going to ask me "do we have enough water?" And I think you know that the answer is we don't. We're going to have to import water.

Cause

- The rate of development is governed pretty well by the economy. If there is no demand for the lots, development will slow down. The demand is high now because a lot of people from other parts of Texas want to be in the Hill Country. And there's an influx of people from other states, California, Washington, areas up north.

- (What are the causes of the growth in this area?) The climate for one thing and the [cheaper] cost of living.

No action

- (What will happen if good water management fails?) The negative consequences are that growth will have to slow down if we don't have adequate water to take care of the people.

Resources

- You're probably going to ask me "do we have enough water?" And I think you know that the answer is we don't. We're going to have to import water.

- … There will come a time when we are going to have to find additional water to bring in to this area. And it's out there, but it's going to take some expensive pipe lines to get it here.

- You talk all you want about conservation, but you have water rates, and everything else is conversation. And that's how you get people to conserve is with rates... We do have accelerated rates. If you use excessive water you will pay more per gallon for it than someone who conserves water. That seems to be the best way. If you charge people a higher rater for excessive use then they'll use less.

Barriers

- A woman called me to say "you shouldn't be charging us for water." I said why not? "Water comes from God and it should be free." And I said you have just answered why I have so many of my problems. You're right, it is free. We don't charge you for the water, we charge you for treating it and transporting it. If you want free water you get a rain barrel and it will be free.

- The big problem with these underground water districts throughout the State of Texas is that they are confined to a particular county or geographical area that they represent, and the water is not restricted to those areas.

- The problem really is that here we have a good district that is very cooperative to work with. But if they were like this throughout the state people wouldn't have a problem. It needs to be set up in such a way that it is consistent throughout the state. And I have heard of districts that are not easy to work with.

Resources

- Ron Fieseler knows what he's doing and is very cooperative. He does what is necessary, implementing rules and regulations, but he is at the same time cooperative with people like us.

- Water has got to be used conservatively. We can't have any area that wastes water. You've got to be a good steward of the land, including the water.

- (What are other aids in this process?) My best aid is my attorney. He is former chairman of state water commission. He does all my water work. He does it with TCEQ. He's been in this business for years. He probably is one of the best authorities on water law in Texas. I don't do anything without him.

Ideal

- Less than 1 percent of our development does not have central water. We believe that it is better to have two holes in the ground for 275 homes than 275 holes. Because if you have a well on each tract it is harder to conserve water and it is much more likely to get contaminated.

- Our objective is to get area away from total reliance on groundwater and start using surface water and nobody was doing that before.

- Our goal is to do what TECQ requires because they are the state agency that governs us, which we operate under. We endeavor to keep them happy, because if we don't, we don't get a CCN, a certificate of convenience and necessity, which allows us to provide water in an area.

- I think underground water should be controlled like rivers and basins in Texas with river authorities like LCRA or GBRA, where you are not restricted to a county or a geographical area.

- I think [groundwater] should primarily be [controlled] at the state level like river authorities. They could generate their own revenue too like GBRA.

- It should be on a greater level of control so that everybody who needs the water gets the water.

- Water has got to be used conservatively. We can't have any area that wastes water. You've got to be a good steward of the land, including the water.

- Yes, it's a high priority that we leave this land better than when we came on it. If you looked at our projects over the last years you'd agree. We try to leave the vegetation as much as we can. We take out cedar, but try to leave natural vegetation and encourage our owners not to put in fancy lawns but to leave the land in its natural state.

John Schwope

Interview by Leigh Byford with John Schwope, Owners, H.W. Schwope and Sons Water Well Drilling, Boerne, Texas, November 14, 2006. Coded by Tom Wiles.

John Schwope is the owner of a well drilling business in Boerne, Texas. He has over thirty years of experience drilling in the surrounding area and has extensive knowledge of the aquifers and rock formations in the area. John believes that there has been a decrease in available water resources due primarily to drought and, to a lesser degree, to development. He feels that resistance to permitting is the primary obstacle to groundwater management and that only through cooperation will lasting solutions be put into place.

Problem

- I just talked to guy whose dirt tanks have dried up… and he's having to haul two loads of water a day to his cattle.

- We've had some problems… with the Lower Glen Rose drying up.

- We've had a lot of wells pump down this summer… we've only had one that went dry enough… that we had to drill it deeper.

Cause

- There's not enough volume, like there is in the Edwards, to irrigate with.

- We've had a drought this last summer…we haven't had any heavy runoff rains that cause Ciebolo Creek to run (and recharge the aquifer).

- Around Boerne here on the north side of town we have high well density of wells and large capacity wells for subdivisions…that have lowered water levels…for years we've had the pumps set and never had a problem.

- I've noticed the value of the land has jumped up so high that land is being developed in smaller tracts.

Resources

- We don't have a local radio station or television station so it's just the newspapers.

- If we had a four or five inch rain tomorrow, things would be looking great again.

- It's a different world… [once] you bought a piece of land and you owned the water that could come out of it…but if the water isn't there then what are you going to do? So you have to work together...

Barriers

- It's the same deal like back during the Civil War… people came in here fighting mad about the $25 dollar fee (a $25 fee per year per well to fund the GCD) saying they weren't going to pay it.

- The subdivision requires so much landscaping according to how much you spent on your house… we had one customer that was going to wait to start his grass and the homeowners association came in and told him he had a month to get his grass started.

Bob Spears

Interview by Manami Suga and Rob Ryland with Bob Spears, Retired Geologist, Kerrville, Texas, February 20, 2007. Coded by Robert Ryland.

Mr. Spears is a retired petroleum geologist and landowner residing in Kerr County. He spent almost 30 years working for oil companies in the southwestern and midwestern United States. Currently he volunteers his time to the local GCD helping collect and assess data from monitoring wells in the area and is a regular attendee at GCD public meetings. Mr. Spears believes that the first task before the district is to create a map of the area aquifer and its properties, particularly with respect to effective porosity, which he believes is in need of more and better data. It makes more sense to him that any pumping limitations should be determined and distributed according to aquifer mapping, rather than by roads and political boundaries. Mr. Spears is skeptical of the impulse

toward more rules and regulations and believes that natural market forces will resolve potential problems with water availability and the attendant land use and conservation issues. He also states that some regulations on pumping can help sustain water availability and allow those market forces to work gradually.

Problem

- You have to make the right maps to determine the amount [of water]… And you have to determine what the porosity is to a certain extent, which we so far haven't really nailed down. A lot of people estimate it at 25 percent; some may go to 35 percent, some may go to 20, which makes a great deal of difference. But you have to start off with an effective porosity map.

- For instance, just recently the board passed some pumping limitations on the Trinity Aquifer…and the divisions of those pumping limits were based on highways—surface features—Instead of subsurface features. They're not based on geological data whatsoever...well, partially geological data, but erroneously used in conjunction with the subsurface data…which I felt was a very poor situation.

- We're not overproducing the water from the Trinity...at the present time.

Cause

- Recently the board passed some pumping limitations on the Trinity Aquifer, and the divisions of those pumping limits were based on highways—surface features—instead of subsurface features. They're not based on geological data whatsoever... well, partially geological data, but erroneously used in conjunction with the surface data…. which I felt was a very poor situation.

- The Trinity could not sustain a huge explosion of population or therefore you'd have to put a lot more rules and regulations on them.

No Action

- If you have a permitted well that produces a lot of water... like a gravel company...where he washes the gravel and uses lots of water—if he uses more water than what he should… well he'll pull that reservoir down, and therefore it'd be impossible for him to produce that water to wash his gravel. See, so it'll reach an economic limit...he'll either have to move or drill another well or [obtain] an outside source of water.

- Kerr County does not have any problems with water [availability]...even at the projected population of 80,000 people. Now a million people. No. We can't handle that. We can't ship it to somebody else; we need to retain it in the county because the increase in population is just occurring every year here. But our

projected data indicate in 2060 that we're going to have plenty of water... if the projections are correct.

- Well the consequences would be naturally economic—slowing of growth because if people can't have water, well naturally they won't move in here or industry won't go because they don't have the water. But the main consequence is that they'll have to go to another accumulation of water, like surface water... to offset it... if we get an explosion of population.

- I think... economics will take care of a lot of things.

- They [neighbors of big producers] will just have to lower their pump and get what they can get—which is enough for domestic situations.

Resources

- I would think [there is] some way that if Kerrville-Center Point-Hunt-Ingram area grows larger—more people—well then we could acquire some of those 2,000 feet of UGRA rights, which they're trying to get to be permanent instead of expiring in 2010.

- The board is doing...a good job, and it's a lot better than it has been....Five years ago it was practically useless. Now it's using available geological data which they didn't use before—they were just pulling things out of the air...

- Everybody is a conservationist to an extent. It's just a matter of how much... emphasis they put on the conservation. If it comes to more people... and the same amount of water naturally they're going to have to conserve more and be more aware of the situation.

- ...but the UGRA has some too [water rights to the Guadalupe River]. I would think [there is] some way that if Kerrville-Center Point-Hunt-Ingram area grows larger—more people—well then we could acquire some of those 2,000 feet of UGRA rights, which they're trying to get to be permanent instead of expiring in 2010.

- The first thing you have to do is determine approximately how much [water] you have in there, which is sort of hard to do.

- If we could [run] porosity logs in the monitor wells instead of the receptivity logs, well we could calculate the porosity, or give us some basis for the porosity, where right now we don' any basis for the porosity except for the...physical inspection of [rocks], then you're just guessing...

- Pumping limitations will help alleviate some of the situations but it causes a lot of problems.

- Economically that'll change you from a big water user to a small water user. You don't need any rules and regulations. But time-wise, you need rules and regulations on the big producers to lengthen that time.

Barriers

- The first thing you have to do is determine approximately how much [water] you have in there, which is sort of hard to do.
- We're not overproducing the water from the Trinity... at the present time.
- They're using geological data... just not using it to the utmost.

Ideal

- My ideal? Well naturally [to] always have a full aquifer, but that depends on rainfall in another county... and we always have to have conjunctive use, naturally, with the river running through the area.
- I think... economics will take care of a lot of things.

Dr. Fred Stevens

Interview by Leigh Byford with Dr. Fred Stevens, Professor of Biology, Schreiner University, Kerrville, Texas, February 20, 2007. Coded by Leslie Llado.

Fred Stevens is a biologist living in Kerrville. He thinks that people should concentrate on responsible growth and that it is possible for groundwater conditions to improve despite growth. Traditional land and water use practices can be altered and present resources can more than accommodate the population increase. He acknowledges that there are occasional problems with the water level in the river, which can get low at times, and water quality in some areas. He attributes these problems to the fact that the population density has increased in recent years, which increased water usage. The use of natural landscaping could improve groundwater conditions and could be encouraged via price restructuring and incentives for landowners. He argues that some water practices, particularly the Right of Capture, are outdated and need to be revised for responsible growth to occur. The people of the Kerrville area are intelligent and adaptable, which will make it easier to restructure the way groundwater is used; at the same time, they are individualistic, which can make decision making difficult. The district is open to change because it is in their best interest to preserve the Hill Country resources.

Problem

- The river is marginal for canoeing anyway, although its sufficient most of the time, and any drop in the level would change… so it wouldn't be sufficient.

- There's a need for some land use changes that would help with water quality.

Cause

- The population density in the area has increased and is predicted to probably double again in the next few decades.

No Action

- The river is marginal for canoeing anyway, although its sufficient most of the time, and any drop in the level would change… so it wouldn't be sufficient.

Resources

- A lot of people in this area are quite adaptable when they have to be, and they also are intelligent, so when they learn that something works better than the way they've always been, they're more likely to accept that kind of change.

- The influence of the district is a potentially great resource. For one thing, they think it stands to protect the resource and save it for the people that are residing in the area. I think therefore it's in the actual… interest… for them to improve the resource.

- A lot of our water use is for landscaping, which I think is an easy thing to avoid.

- A progressive water rate, at least by the City (of Kerrville), was instituted at one point but that didn't last long. It was fairly rapidly repealed because some constituents objected. But I think that that is one thing that has to be considered again.

- Education, I don't think is enough, I'm pretty sure it's not. I think one should combine that with incentives, price restructuring, maybe some positive incentives for re-landscaping.

- By altering land use practices you can reduce runoff and increase infiltration. Of course if you increase infiltration you increase recharge of aquifers.

- They need some sort of incentives for land owners to accommodate and plan for land use. That's going to help water quality as well.

- Some geologists spoke of directly increasing recharge by strategically located recharge wells. Of course if you do that you want to make sure the water's clean that's going down there, so that's tied in with land use again.

- We have to break out of the idea that growth means sacrifice, in a literal sense. In other words, I think we can have growth, and that we can improve, for example, that flow in springs could be increased at the same time.

- Traditional land practices and water use practices frankly could be improved so much and we could more than accommodate the population pressure.

- When we were very sparsely populated [the Rule of Capture] worked, but that's no longer true and I don't see how that could continue.

Barriers

- It's presented as all people need water. Well yes they do, they need water to drink and for hygiene and so on. But such a large percent of water use isn't used for those purposes, and they don't see that.

- The culture of this area is one of individualism and independence and so that sometimes can be a barrier because they are naturally skeptical about being told what they should be doing.

- (Referring to groundwater/data) I would want to know how they're coming along about the aquifer, as far as where recharge is and where the critical areas are.

Ideal

- We can have growth, and springs could be increased at the same time.

- Traditional land practices and water use practices could be improved so much to more than accommodate the population pressure.

- I think we could see improved spring flow from where it is now, and yet have enough water to support significant growth.

Dan Troxell

Interview by Mariah Tapp with Dr. Dan Troxell, Superintendent of KISD Schools, Kerrville, Texas, February 20, 2007. Coded by Manami Suga.

Dr. Troxell points some problems regarding groundwater in Texas, and makes some recommendations to achieve an ideal situation. He reports three problems: low water flow, lack of a good river system in Kerr County, and population growth. He warns that drought could occur and people would be harmed by insufficient groundwater if the State of Texas does not take measures against it. Dr. Troxell emphasizes the necessity of public education regarding water conservation and a comprehensive plan for groundwater management.

Problem

- We have three problems now: low water flow; it does not have a good river system in Kerr County, and large population growth.

- Despite this we do not have enough water; population is growing.

- Tourism has a very heavy impact on [the] water resource.

No Action

- If there is no action, and the drought occurs simultaneously with population growth, the aquifer would be harmed.

Resources

- Major research institutions have the background and the best information. If each institution cooperates with each other, it would have a large influence.

- In addition, cooperating with the university is also very important. Recommendations from UGRA and the board are also important.

- Since policy is very important, the city, municipal, and government interests should work together.

- To achieve an ideal situation, we have three main actions:

- First, we should consider how we manage groundwater. There are two standpoints: the personal standpoint and the business standpoint. From the personal standpoint, we should manage water that is used by individuals or families such as drinking water or to wash something. From business standpoint, we should manage water that is used by the public such as in schools. Moreover, conservation is very important. It is important to use water conservatively.

- Second, the government should choose the right time that it intervenes—how we use water, and how we conserve water.

- Finally, education is important. The goal would be high quality education.

Barriers

- There are four barriers to achieve an ideal situation: lack of education; people do not realize [the] water issue; each institution does not cooperate with each other well; and [any] comprehensive plan does not involve [the] Upper Guadalupe River Authority.

Ideal

- As an ideal situation, we should make a comprehensive plan. The comprehensive plan should work toward a specific goal. The goal could be measurable, for example, the access to water we need. In addition, we are going to have levels of success.

Micah Voulgaris

Interview by Anna Bricker and Leigh Byford with Micah Voulgaris, General Manager, Cow Creek Groundwater Conservation District, Boerne, Texas, November 3, 2006. Coded by Caleb Brown.

Micah Voulgaris is the Operations Manager of the Cow Creek Water Conservation District. His major concerns involve people taking too much water and not realizing how much they are taking. He reports that the water is going to run out in Kendall County if people do not practice greater conservation and stop using so much water. To him, it's everyone's responsibility to manage the water as a valuable resource.

Problem

- Our biggest problem right now is that we have such a low sustainable yield.
- Do we set aside half of this water for all the wells are already out there, that we know are there? Or, do we give [water] to all the people asking for permits?

Cause

- There's property rights. You can't tell someone who had a lot before we had our rules come out "no [water]" So they're all going to get a well someday.
- There's just constant growth. There's a non-stop growth rate out here.

No action

- We'll have water shortages. You know it's not like a rolling blackout where the water is going to turn-off for a couple hours and then turn back on.
- If something isn't done, you would have a major economic problem; you'd have a major everything… without water everybody moves out.
- … once the water runs out, what would happen? You don't build houses anymore, you move out of houses.

Resources

- Education changes people's point of view.
- I think the most important thing we can do is education.
- When we say no more well permits, then it's almost guaranteed that someone is going to fight it.
- Now we have a six acre rule. You have to have a six acre density. If you are going to put in a new subdivision, you have at least a six acre density. We took

the whole area of our county, we figured up recharge, we figured up rainfall, and we said if everybody in Kendall County had six acre tract, you'd give them 100 gallons per acre per day.

Barriers

- People who say, "Well, you're just telling me I can't drill another well." They don't care about 50-year planning cycles and sustainable levels of the aquifer; they want a well and they want water on their property. It's a hard sale.

- You have all this water that we don't have any authority over. If you're dumping it on the ground, we really don't have the authority to say anything about it—it's surface water. That's really one issue the legislature is going to have to address.

- I need to find some way to talk to people before we buy property, and that's impossible to do.

- If we could stop all irrigation on all grass in the summer, then we wouldn't have water problems either.

Ideal

- (What's the ideal?) The sustainable yield of our whole county.

- Surface water and ground water have to be managed together… there has to be some kind of connect there.

Bob Waller

Interview by Leslie Llado and Annie Bricker with Bob Waller, Executive Committee Member of the Kerrville Economic Development Foundation, Kerrville, Texas, February 20, 2007. Coded by Leslie Llado.

Bob Waller is a banker residing in Kerr County. He hopes that citizens of the Hill Country, whether their water is supplied by the city or by private wells, can have adequate water without having to be restricted. His primary concern is adequacy; if there is a water resource problem there may be less people moving in and current residents might move out of the area. If there are less people, the economy and businesses in the area would suffer.

The City of Kerrville has good rapport with their local and congressional representatives and can rely on them for help with new groundwater policies. Preferably, the new policies would allow the level of groundwater to stay the same or increase; it would be detrimental to have policies that were ingrained with bureaucracy and heavy cost. However, it can be difficult to monitor water use, especially in rural areas. People need to focus on water conservation, from their daily hygiene activities to using natural yard

landscaping. If people don't change, they could eventually have their home water use restricted.

Problem

- The primary concern is adequacy and are we going to have water.
- It doesn't take much of a dry period to put Kerr County into water restrictions.
- Another concern… that we've had the last couple of years: drought type conditions. We've had water restrictions and from an economic development perspective, a business perspective… that's the thing that prospective businesses are going to look at.
- A lot of the new people moving in are living outside of areas where the water is treated, they're on a water system or they're on a well. So I think the more wells you have, the more challenge it is to the aquifers.

Cause

- A lot of new people are moving in.

No Action

- At some point, if people don't change, then they won't be able to use, maybe, a sprinkler system. You'd be watering your yard totally with a hose.
- If you don't come up with something to provide for adequate water supplies, you could have problems, not only on the business side but you could have problems even with people having water in their homes.

Resources

- We have good rapport with our congressional representatives, both on the state and the national level, and we don't hesitate to use that.
- We would start at the local level to try to see what we could do dealing with the city and the county, but the next level would be we would go straight to our state representatives and state senators.
- If we were able to put in place regulations or compliance parameters that would allow our water levels to stay the same or increase, that would be positive. If they put things in place that were ingrained with bureaucracy and heavy cost and really not addressing the water issue, that would be a failure.
- We need to train people to be less wasteful...

- I hope that we could get to a point where we have either some kind of reservoirs created, better education to the public on not wasting water, from something as simple as brushing your teeth and shaving to bathing to washing cars to watering yards. When you get into developments, I think you're going to need more natural type landscaping as opposed to things that require a lot of water.

- We have good rapport with our congressional representatives, both on the state and the national level, and we don't hesitate to use that.

- We would start at the local level to try to see what we could do dealing with the city and the county, but the next level would be we would go straight to our state representatives and state senators.

Barriers

- In a municipality, I think the restrictions are more stringent, they can be controlled, and they can drive by and see you using the water. When you're in a more rural system, then you have a lot more challenge to see what people are using the water for.

- You can set all the restrictions you want, but to keep people in compliance with that, I think the first challenge you've got is convincing the people through strict enforcement.

Ideal

- For people on wells to have adequate water without having to be restricted.

Ed Warren

Interview by Leslie Llado and Rob Ryland with Ed Warren, Concerned Citizen, Kerrville, Texas, February 20, 2007. Coded by Leslie Llado.

Ed Warren is a retired geologist residing in Kerr County. He hopes that the aquifer can be sustained with natural recharge and aquifer mining can be prevented, while still supporting growth in the area. It is important to find out how much water is available in the aquifer to make sure that there is enough water to support people who currently live in the area as well as new people who are moving in. Mr. Warren stated that the Groundwater Availability Model method is a good way to assess the groundwater conditions and many of the area's landowners have supplied well data for the GAM. However, more data are necessary to create an effective GAM and it can be difficult to get necessary data. The modelers may not need to include so many levels in their model; it would help to have the Hill Country model in sync with the TWDB model. The politics, economy, and science of the area need to coincide if the groundwater situation is going to be handled effectively.

Problem

- We want to be able to know how much water we [have], so when people move here, they can move with the certainty that they're going to be supplied with water.

Cause

- I think that the attraction of the Hill Country, even though the environment is great, if you don't have water to supply people with, you're going to have people not coming here. The tax rate, the tax base, is going to be the same amount of money, but to be drawn from less people.

Resources

- This information has been volunteered by landowners such as myself and a lot of other people. (Regarding well information)

- The GAM method, maybe not with so many levels, is the better way to attack it.

- The approach that they're (the GCD) using right now with the GAMs… I think is a good approach. I think they're doing too many levels, and our TWDB does maybe three or four, depending on where they are. For simplicity's sake, to have those two bureaucracies be in tune would be a help.

- Another thing that would be a help would be for the politics of the area to be in concert with the science of the area… to be able to not throw darts at each other.

- Another thing that would be is the finance groups, different financial groups, real estate, etc, to be aware of what's happening because they make their money bringing people in.

- We want to be able to know how much water we got so when people move here, they can move with the certainty that they're going to be supplied with water.

- It's not just the science of it, it's not just the politics of it, and it's not just the economy of it. It's the living with it, and learning about it.

Barriers

- Other problems are knowing how to prepare a GAM and having enough control to complete a GAM, because of all the details needed to prepare… all of the data that are included a GAM.

- Not only is the district faced with drilling these monitor wells in a pattern that will cover the county… they're faced with finding out how many wells out of which aquifer are producing and the daily rate each producing.

- A lot of people, I don't know whether they don't take the time to consider the problem or what.

- We need more data, and the gathering of data takes time.

- I find that there's not a whole lot of cooperation in the bureaucracies.

Ideal

- I'd like to think that we had enough management, with all bureaucracies in tune, to not mine the aquifer like they're doing in North Texas. To be able to sustain with recharge what we feel, to be able to employ aquifer storage and recovery wells for the storing of water, to a certain extent, to satisfy the projected growth of the area.

Bryant Williams

Interview by Mariah Tapp and Rob Ryland with Bryant Williams, Concerned Citizen, Kerrville, Texas, February 20, 2007. Coded by Leigh Byford.

Mr. Williams believes there can be a balance of people and water in the Hill Country and that there can be more of both. According to Mr. Williams, there are two main aspects to groundwater that must come together to have that balance: the scientific data and the political management. Local political entities need to work together so that roles are clear and consistent. They also need to review the existing science and supporting new science. If these two elements do not come together and a balance is not found, there is potential for individual wells to go dry, hurting particular consumers. If the resource is not managed well in the long-term, there is a possibility of running out of water for everyone. Mr. Williams is concerned about political leadership making decisions with the current level of science. There could be a lot of flaws in existing data. The science must be continually updated as things change and we learn more. In his opinion, there is currently a lack of adequate funding for the scope of science necessary to make a good desired future condition (DFC) decision. Another barrier to sufficient management is the real estate industry's reluctance to address the issue, to listen to the science, or to express the issue to their clients. The GCD's efforts at educating the public have been beneficial so far and these efforts should continue.

Problem

- We have plenty of water… plenty more than people think we have. But we don't understand where it is. I think we've got room for a lot more people then.

No Action

- There is a good opportunity for certain parts of the county to be without groundwater. There are brown areas in this county already.

- If we don't understand why and we continue to overpopulate brown areas there is going to be no groundwater… Growth is healthy for the county, but growth has got to be managed.

Resources

- I think we've come a long way in the last two years. We're very fortunate to have Feather Wilson doing our model. He's very knowledgeable about the Trinity, which is very important. If you have somebody working on the model who doesn't understand the container you're in big trouble. We probably should have started ten years ago, but at that time I don't think people had the foresight to see the need for a model.

- It has to be clear who has the authority over the groundwater. There should be no doubt about that.

- There is a very definite need for stronger coordination and cooperation of political units present in the county.

- [District managers and board members, and other government representatives] also have to understand what the model is. They are not scientists. They need to understand it is a proven process. You need to have the data to make it work.

- I think over the last two years they have done a real good job of educating the public. More newspaper articles, more town hall meetings, workshops... The public is starting to understand how important this work is.

- If [the Blanco County] model is different, there's a reason why—their aquifer is different. You have to build the model to fit your problem. You can't universally dictate what the model looks like because it doesn't take into consideration the problems that you have within your local area.

- How do we do that? We keep building the model. The model is evergreen. You continue to build the model. The more data you get, the more you understand it, the more you know the weak points and the positive points.

- You need to fund operations that will get you additional data. In other words, more monitoring wells.

- The people that are buying property should have a full understanding of the groundwater potential in the area that they are going to purchase. That ought to be real estate law. Full disclosure of the groundwater situation before I go buy a hundred acres.

- It's the findings from a substantial grid of monitor wells. They have a good start at that, but they have a ways to go. When you start to see failings in the monitor wells then the aquifer is failing.

Barriers

- I don't think we're water short but I don't think we understand how much water we have got. You have to continue to build the model, keep funding monitor wells... so you can continue to change the model and upgrade.

- There is a barrier in the area of funding of geophysical data.

- The other barrier is funding for the geosciences. It has to be long-range funding. That is very important. And it may need more than one man.

- Reluctance—that's another barrier. There are some real estate people that are reluctant to support this model and what it can do for us because it is going to put restrictions on where they want to sell real estate.

Ideal

- I think there are two phases to it: the management phase, or the political phase, and the scientific phase.

- The management side of it: you need a local group like Headwaters that has some teeth, that has authority to do what they need to do, to get the best benefit out of the model they have.

- You've got county, city, and UGRA people. All these management groups have got to do a better job of getting on the same track and going in the same direction. That doesn't always happen.

- It has to be clear who has the authority over the groundwater. There should be no doubt about that.

- We want that aquifer to be there and be useful for people in this county 50 years from now.

- It would be a balance of population and water.

Gene Williams

Interview by Thomas Wiles with Gene Williams, General District Manager, Headwaters Groundwater Conservation District, Kerrville, Texas, November 3, 2006. Coded by Tom Wiles.

Gene Williams is the manager of the Headwaters Groundwater Conservation District (HGCD). He held a groundwater technician position prior to his promotion to manager and has been a resident of Kerr County for six years. Mr. Williams recognizes that there is a domestic threat to groundwater availability: people are already being forced to drill their wells deeper and springs are drying up. The cause of the problems is a combination of drought and limited supply, growing population, and sale of groundwater. He foresees a potential threat in the sale of groundwater out of the county; he states that the potential sale of groundwater resources and transfer out of the county is what prompted the creation of the HGCD. If no action is taken, Mr. Williams argues that market forces will dictate that the richest and most powerful will have control of the water. Ideally, he would like to see the aquifer used in a sustainable manner that ensures each citizen has water and that springs flow and aquifer levels are maintained. He sees the resistance to regulation as the primary obstacle and believes that conservation education is the key to realizing the ideal outcome in Kerr County.

Problem

- They're saying there are going to be water shortages and water declines [in Kerr County].
- We've seen pretty good drops in well levels and wells have gone dry. People have had to drill deeper or abandon what they had and drill new wells.
- We've seen…low river flow and creeks and springs have dried up.

Cause

- The fact that the amount of water is not going to increase means were going to have to share what's available.
- A lot of the older citizens wanted the GCD formed to protect the water in Kerr County from leaving the county.
- We've been experiencing a drought since 2005 and this summer has really taken a toll on the aquifer.
- We've seen low river flow… in turn, the river master shut the City of Kerrville off river water, which forced the city to use its groundwater wells significantly, for the first time.

No Action

- If the citizens don't cooperate and agree to quit wasting water…you could have people run out of water.
- I think over a period of time you'd see water transported out to the county by pipeline…the people with the most power, the most money, and the most land would control the water.

Actions

- The fact that the amount of water is not going to increase means that we're going to have to learn to share what we have.
- The district has to allow water out of the county but it can be regulated by the district through pumping limits and export fees.
- Working on things like databases, where everyone's using the same data base and sharing whatever data anybody wants to share between all the districts.
- Conservation education should be the main goal of where we're heading.

Resources

- Kerr County has already been labeled as a priority management area.
- The district has to allow the transfer of water out of the county but it can be regulated by the district through pumping limits and export fees.
- We have construction standards that require you to complete the well in a certain way…which is a water quality issue to protect the water.
- There are programs that are available to us so that we can begin in elementary schools; they have a WET program they call it. Of course these things take money and time.
- The years before they put that (surface water plant) in, the water levels were definitely on decline.
- A lot of the county commissioner's vision is to incorporate more surface water use in the county.

Barriers

- If the citizens in the county don't cooperate and agree to quit wasting water…you could have people run out of water I guess.
- The district is in the process of permitting wells…that's a big challenge.
- Some of the rules like waste rules (vanity ponds)…I think the water districts don't have the full means to enforce.
- What I've experienced is most people don't want to permit their well.
- From the other side, the drillers and pump installers, they don't care to have to abide by the regulation. Maybe it's the paperwork more than anything else.

- I sense a little bit of concern that the (GMA 9) will take away some local control.
- But not only did the state mandate it (the GMA process), they didn't fund it.
- You see a lot of people have had the use of this water for years with no regulation…you're trying to go in and regulate people doing something they've been doing.

Ideal

- Each citizen has water to use in the future.
- I guess the best outcome is going to be to try to reach a point of well usage as compared to recharge…what you're taking out is being recharged.

Anonymous Stakeholders

The statements below reflect the opinions of stakeholders who prefer to remain anonymous.

Problem

- Point and non-point pollution. That is more particularly to surface water, but it's all one system.
- This past summer some of their wells went dry and the city supplied some of these people who had no water at all.
- In certain areas they had to dig deeper than they had originally done because the supply that helped, that they used at first was no longer available at that level.
- Developing some sort of unified use of water permit limits.
- Irrigation and keeping peoples' yards green.
- Public water supply basically. There are a lot of other wholesale users: golf courses, irrigators. Public water supply is probably the most vital for a groundwater source in the Trinity. There are probably 4 or 5 major utilities drawing water from that source, so they pre-empt all the other users.
- Groundwater and availability are critical issues here.
- Not enough water.

Cause

- Failing septic fields; that's one of the reasons the Upper Guadalupe River Authority and the county and the city have gotten together putting in connections to the city sewer systems, in particularly areas south of the river, Camp Meeting Creek, which runs through there, had started to become polluted with failing septic fields...

- A problem is animal waste from land being washed into the river, and from there it would find its way into the aquifers.

- These wells were drilled when the county was more sparsely populated and they worked then, but they just don't work now. They have to find another deeper source; it's directly related to population, I believe.

- Supply and demand.

- Demand on the aquifer, demand on groundwater and surface water irrigation.

No-Action

- If the district didn't exist, there would be some isolated problems out there.

- If they continued on the path they are on now, they'll use the water until nothing comes out of the spigot.

Resources

- I would like to see the groundwater districts have more power than they do for enforcement, for instance pumping limits.

- Headwaters Board is doing an excellent job now. They're very committed and they work together very well now, which has not always been true in the past.

- In the future we might even treat effluent to be used as a water source.

- I would like to see the groundwater districts have more power than they do for enforcement, for instance pumping limits.

- You certainly start with peoples' needs first, and peoples' needs as a necessary for life beverage comes first, and then things after that… recreation is an important avenue of economic development for this area, since it is so pretty.

- The county, how they can do it, is land use, if they had particularly more power to limit the number of residences and where they're located [such as a] particular drainage area or watershed area that perhaps would affect an aquifer by overuse.

- I think that you would have a plan of sustainability; it may not always do that, but I think you need one...

- Some kind of a model has to be put in place that can be varied enough to take care of how the different areas are, how they are recharged, how quickly they are recharged, how many people, how many folks they can support, etc. That really smarts of quite a bit of regulation, which will be a problem.

- Of course we need more science, but the district is looking into that through their monitor wells.

- There will be more of those (ASR wells) in the future, and that's good because it prevents us from having to use groundwater; we can use that first, that stored water first.

- We're the beneficiary of a very comprehensive education (program).

- We're fairly fortunate here in Northern Bexar County where, I would say, 70 percent of our boundaries are served by public water utilities.

- When I said education, I meant we need more education. Not that we have a specific program yet. I've utilized information from the TWDB; they have some educational information that I've taken advantage and have forwarded out to our consumers. I meant we really need to focus on education and educating the district members… about conservation.

- We really have to monitor the whole Trinity and the Northern Bexar County area for the impacts that one individual pumping will have on another.

- Long-term, we want to use data to update our management plan and to forecast for what the actual available water... help the state… update their models.

- Education.

- Go to the schools and talk to the kids about conserving water and planning for the future.

- Find a way to educate people who don't read the newspaper and don't go to public meetings to plant drought resistant grass and lawns.

Barriers

- The conservation district also needs, as I believe, more enforcement power for pumping limits… so that we can conserve what we have.

- We currently don't have any well spacing regulations, as far as how close wells can be placed.

- The different groundwater districts will have a hard time being uniform if they don't communicate often.

- Droughts make things happen and floods make things happen; during the normal course of the year when everything is going fine nobody wants or needs to do anything with water.

Ideal

- It would be good for developers and cities to have a unified allowance of water and good communication with the regulators so that they're all talking together to find some good ways to deal with these permitting issues.

- Long-term, we want to use data to update our management plan and to forecast… the actual available water... help the state… update their models.

- When I said education, I meant we need more education. Not that we have a specific program yet. I've utilized information from the TWDB; they have some educational information that… have forwarded out to our consumers. I meant we really need to focus on education and educating the district members out there utilizing wells about conservation.

- I think it remains to be seen what the GAM will do because we are really just getting started.

- The desired future condition is to have sufficient water... to have sufficient water and everybody lives happily ever after.

- You certainly start with people's needs first, and people's needs as a necessary for life beverage comes first, and then things after that… Recreation is an important avenue of economic development for this area, since it is so pretty.

- My ideal district would be where… the public was well informed and where they all took a conservationist viewpoint to the water that was available.

Appendix 9.
Available Online GIS Resources

Texas Water Development Board WIID:

http://wiid.twdb.state.tx.us/index_explain.asp

Texas Natural Resource Information System:

http://www.tnris.state.tx.us/

Geospatial One Stop:

http://www.geodata.gov/

National Atlas of the United States:

http://www.nationalatlas.gov/atlasftp.html

U.S. Geological Survey:

http://water.usgs.gov/maps.html

http://seamless.usgs.gov/

http://nhd.usgs.gov/data.html

http://water.usgs.gov/usa/nwis/

State Soil Database:

http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/

County Soil Database:

http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/

National Climate Data Center:

http://www.ncdc.noaa.gov/

Appendix 10.
Sample Interview Questions

1. In your opinion what would be the ideal situation for groundwater users in this region?

2. Are there any problems with groundwater today or risks in the future?

3. What are the causes of these problems?

4. What will happen if these problems are not addressed?

5. What actions are necessary to avoid or address these problems?

6. What resources can we rely on that may help us address the problems?

7. Are there factors that are barriers to progress or success?

8. How would you tell whether your efforts will succeed or fail?

9. What do you think an agreement on groundwater in this area would look like?

10. Who else should we be talking to?