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TO: Board Members

THROUGH: Robert E. Mace, Deputy Executive Administrator, Water Science and Conservation
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FROM: Larry French, Director, Groundwater Resources
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DATE: June 13, 2012

SUBJECT: **Briefing, discussion, and possible action** on appeals of the reasonableness of the Desired Future Conditions adopted by the groundwater conservation districts in Groundwater Management Area 12 for the Sparta, Queen City, Carrizo-Wilcox, Calvert Bluff, Simsboro, Hooper, Yegua-Jackson, and Brazos River Alluvium aquifers

ACTION REQUESTED

Staff recommends that the Board find that the desired future conditions (DFCs) adopted by the groundwater conservation districts (Districts) in Groundwater Management Area 12 (GMA 12) for the Sparta, Queen City, Carrizo-Wilcox, Calvert Bluff, Simsboro, Hooper, Yegua-Jackson, and Brazos River Alluvium aquifers are reasonable based on the analysis set out in this report.

BACKGROUND

This analysis and the attached technical report constitute the staff analysis of petitions filed by legally defined interests in groundwater in GMA 12. These petitions appeal the adoption of the DFC for the Sparta, Queen City, Carrizo-Wilcox, Calvert Bluff, Simsboro, Hooper, Yegua-Jackson, and Brazos River Alluvium aquifers. This analysis discusses whether the DFC is unreasonable based on the evidence in the record.

Legislative History

The 79th Legislature provided that a person with a legally defined interest in the groundwater in a GMA could file a petition with the Texas Water Development Board (TWDB) appealing the approval of a DFC by the districts in that GMA. The Legislature placed the burden on the petitioner to provide evidence that the districts did not establish a reasonable DFC. But the Legislature did not define "reasonable," nor did it provide any guidelines for the TWDB to use in determining whether a DFC is reasonable.[1] The final determination of a DFC is, in fact, the responsibility of the districts in the GMA.[2]

The 82nd Legislature amended the statute to provide a more involved process for groundwater conservation districts to follow in approving a DFC.[3] Districts are now required to prepare a detailed report on the DFC approval process that documents the consideration of certain criteria and the application of a balancing test, and to develop a record of public participation and responses to any public comments. The 82nd Legislature, however, did not change the basic process for an appeal of a DFC to the TWDB.[4] Notwithstanding any findings by the TWDB that a DFC is unreasonable, the final determination of a DFC remains the responsibility of the districts in the GMA.[5]

These revised statutory requirements for adoption of a DFC do not apply, however, to the GMA 12 DFC under consideration, as the DFC was adopted before the changes made by the 82nd Legislature became effective. The determination to review appeals of DFCs under the statute in place at the time of adoption was discussed by the Board on October 19, 2011.

Procedural History
On August 11, 2010, the Districts in GMA 12[6] adopted the following DFCs for the Sparta, Queen City, Carrizo-Wilcox, Calvert Bluff, Simsboro, Hooper, Yegua-Jackson, and Brazos River Alluvium aquifers, pursuant to Texas Water Code § 36.108:

> Average drawdowns that occur between January 2000 and December 2059 for each District and aquifer as indicated in Appendix B to the Resolution Adopted August 11, 2010.

The breakdown of the adopted DFCs appears in Table 1 of Attachment 1 to this analysis.

Administratively complete petitions were submitted by Environmental Stewardship on August 2, 2011, and by End Op, L.P. on August 10, 2011. Petitioner Environmental Stewardship filed its petition to appeal the DFCs "for the Sparta, Queen City, Carrizo-Wilcox, Calvert Bluff, Simsboro, Hooper, Yegua-Jackson, and Brazos River Alluvium aquifers within all areas of" GMA 12.[7] Petitioner End Op challenges the reasonableness of the DFCs for the Sparta, Queen City, Carrizo-Wilcox, Calvert Bluff, Simsboro, and Hooper aquifers as adopted by the Districts in GMA 12.[8]

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[1] *See* Tex. Water Code § 36.108(l)-(n).
[2] *See* Tex. Water Code § 36.108(n).
[3] Acts 2011, S.B. 727 and S.B. 660, 82nd Leg., R.S.
[4] *See* new Tex. Water Code § 36.1083, eff. 9/1/2011.
[5] *See* new Tex. Water Code § 36.1083(d), eff. 9/1/2011 comp. to former Tex Water Code § 36.108(n).
[6] Brazos Valley Groundwater Conservation District, Fayette County Groundwater Conservation District, Lost Pines Groundwater Conservation District, Mid-East Texas Groundwater Conservation District, and Post Oak Savannah Groundwater Conservation District.
[7] Environmental Stewardship Petition, pg. 1.
[8] End Op Petition, pg. 1,

TWDB staff held hearings on the End Op petition on February 29, 2012, in Milano, Texas, and on the Environmental Stewardship petition on March 7, 2012, in Milano, Texas, to take testimony and evidence from the petitioners and the Districts. The record for the End Op petition remained open until March 14, 2012, to receive additional evidence from other interested persons, as required by 31 Tex. Admin. Code § 356.44(f). The record for the Environmental Stewardship petition remained open until March 21, 2012. The TWDB received additional evidence related to the End Op petition from two persons and additional evidence related to the Environmental Stewardship petition from 4 persons, including Neighbors for Neighbors, Texas Rain, and the Lone Star Chapter of the Sierra Club. In addition, the TWDB received statements from 265 individuals expressing support for the Environmental Stewardship petition.

The Arguments

Petition of End Op, L.P.

Petitioner End Op leases groundwater rights covering more than 17,000 acres of land in Lee and Bastrop counties. End Op has filed 14 permit applications with the Lost Pines Groundwater Conservation District that, if granted, would give End Op the right to withdraw up to 56,000 acre feet of groundwater per year from wells wholly within the Simsboro Aquifer in the Lost Pines District.[9]

End Op challenges the reasonableness of the DFCs adopted by GMA 12 on several grounds that will be discussed in detail below. To summarize, End Op finds the DFCs unreasonable because:

> (1) the DFC process did not adequately involve stakeholders and GMA 12 did not present timely and sufficient opportunities for stakeholder review and comment;
>
> (2) the DFCs are based on an average drawdown that is too vague, ambiguous, and inherently arbitrary to be an effective management goal;
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> (3) the method of reverse engineering is arbitrary and has no bearing on the "health" of the aquifer;
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> (4) the DFCs cannot be satisfactorily measured in the field;
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> (5) the DFCs negatively impact private property rights;
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> (6) the DFCs do not allow for a reasonable and prudent development of the State's groundwater resources;
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> (7) the DFCs conflict with the state's policy of encouraging economic development; and
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> (8) adverse socio-economic impacts are reasonably expected to occur as a result of attempting to implement the DFCs as a management goal.

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[9] End Op Pet. pg. 2.

Petition of Environmental Stewardship

Petitioner Environmental Stewardship is a non-profit corporation and the owner of real property located in Bastrop County. Environmental Stewardship challenges the DFCs as “unreasonable” because:

(1) over-pumping will result that will unreasonably threaten the groundwater-surface water relationship;

(2) the DFCs pose significant risks to the Colorado River and its tributaries;

(3) the DFCs do not consider quantitative impacts to numerous springs in the region;

(4) available flow measurement technology was not considered or employed to monitor the impacts of the DFCs;

(5) unreasonably harmful socio-economic impacts will be experienced due to over-pumping that will result from the DFCs; and

(6) the DFCs do not consider citizens’ expressed desire to have the rivers, streams, and springs protected.[10]

Analysis of Issues Raised

Attachment 1 is a report of staff’s technical analysis of certain issues raised by the petitions. Reference to that report will be made as appropriate throughout this discussion.

Both Petitioners challenge the DFCs based on a perceived failure to follow proper procedures, inappropriate methodology including modeling assumptions, and failure to adopt evidence presented to the Districts during meetings of the GMA. Any or all of these criticisms may be valid but none of them, in the context of these hearings and the evidence presented, warrants a determination that the adopted DFCs are unreasonable.

TWDB rules provide that the Board shall base any recommended revisions to the desired future conditions only on evidence in the hearing record.[11] In addition, the Board is to consider the following criteria when determining whether a desired future condition is reasonable:

(1) the adopted desired future conditions are physically possible and the consideration given groundwater use;

(2) the socio-economic impacts reasonably expected to occur;

(3) the environmental impacts including, but not limited to, impacts to spring flow or other interaction between groundwater and surface water;

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[10] WVWA Pet. pg. 2-3.
[11] 31 TAC § 356.45(c).

(4) the state's policy and legislative directives;

(5) the impact on private property rights;

(6) the reasonable and prudent development of the state's groundwater resources; and

(7) any other information relevant to the specific desired future condition.[12]

Consequently, this analysis will be organized around the criteria listed above. Arguments from the Petitioners and from the Districts will be presented, followed by staff's analysis.

1. The DFC is physically possible.

End Op

End Op asserts that the DFCs are unreasonable because they are vague, ambiguous, arbitrary, and physically not measurable.[13] End Op describes the process used to develop the DFCs as taking preset amounts of pumping in preset areas instead of looking at overall groundwater availability and saying "how much can this aquifer produce."[14] Starting with a desired maximum production based on current production means that the modeled available groundwater (MAG) value simply reflects existing pumping in existing pumping locations.[15] Because of the nature and location of many of the wells, monitoring will not adequately reflect impacts on the aquifers as a whole.[16]

The Districts

The Districts respond that drawdown is something that can be reliably measured.[17] The Districts stated that, after considering suggestions to use aquifer storage instead of drawdown values for developing the DFCs, the Districts decided to use changes in water levels "as the primary metric for monitoring changes in the aquifer system and for developing DFCs."[18] The choice, according to the Districts, was based on three factors: 1) water level change is an independent variable that can be directly measured, 2) water storage cannot be directly measured and must be calculated based on assumptions that include water level change, and 3) water level change is a metric that is readily understood among stakeholders.[19] In addition, average water-level decline is the method used to define DFCs in 12 of the 16 groundwater management areas in the state.[20]

Environmental Stewardship

[12] *Id.*
[13] End Op Hearing Trans., pg. 21.
[14] End Op Hearing Trans., pg. 30, 33.
[15] End Op Hearing Trans., Power Point presentation.
[16] End Op Hearing Trans., Power Point presentation.
[17] End Op Hearing Trans., pg. 53-54.
[18] End Op Hearing, Dist. Exh. C, para. 10.
[19] *Id.*
[20] End Op Hearing Trans., pg. 68.

Environmental Stewardship argues that the DFCs are not physically possible because they are incompatible with requirements for surface water flows—appropriated water rights that will be impaired and environmental flows that must be preserved.[21]

Environmental Stewardship contends that the Districts in GMA 12 failed to consider "each geographic area overlying an aquifer . . . within the boundaries of the management area"[22] by failing to recognize the geological and ecological differences in the conditions of the river alluvium and the piney wood forest regions.[23] Thus, the DFCs are not based on significant differences in groundwater-surface water relationships, nor on biological or ecological considerations.[24]

The Districts

The Districts counter that uses or conditions of an aquifer within the management area that differ substantially from one geographic area to another were taken into account when the Districts established multiple drawdown DFCs within each district and within different geographic areas.[25]

The Districts testified that they considered requests to use stream and springflows as bases for the DFCs, but did not do so because they found that the data and the science that reasonable experts in the field rely upon was not sufficient to provide a workable, measurable approach.

The Districts also stress that water-level measurements are a direct assessment tool for aquifer response to groundwater withdrawals.[26] The adopted DFCs are also based on the average water level drawdown in individual districts within the GMA, not merely on one average drawdown over the entire GMA.

Staff

The parties agree with the observation of Environmental Stewardship that the rivers both gain and lose water as they pass through the areas bounded by GMA 12 and that the relationships between groundwater and surface water need to be better understood.[27] Testimony on the impact of the DFCs on surface waters was conflicting and inconclusive, however. A number of factors affect instream flows and outflows from the Colorado and Brazos rivers and technical work remains to be done to better monitor, analyze, and manage that interaction. In fact, the Districts are explicitly required to consider this issue in the next round of joint planning.[28] But the issue at hand is whether the DFCs are reasonable as expressions of the desired future conditions of the aquifers. The Districts testified that they sought to evaluate the long-term use of water from the aquifers as a water supply to help meet the needs for water within the GMA.[29] Analysis of

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[21] Env. Stewardship Hearing Trans., pg. 11.
[22] Tex. Water Code § 36.108(d)(2).
[23] Env. Stewardship Hearing Trans., pg. 40.
[24] Env. Stewardship Hearing Trans., pg. 40.
[25] Env. Stewardship Hearing Trans., pg. 70
[26] End Op Hearing Trans. pg. 68-70.
[27] Env. Stewardship Hearing Trans., pg. 41.
[28] Tex. Water Code § 36.108(d)(4).
[29] Env. Stewardship Hearing Trans., pg. 79.

drawdowns and their impact on groundwater resources and uses provides a reasonable basis for describing the aquifers and making management decisions.

2. Consider socio-economic impacts that are reasonably expected to occur.

End Op

End Op asserts that the DFC is not reasonable because, by prescribing the amount of production to determine the DFCs, the Districts created an artificial shortage of water that restricts development of new jobs, businesses, and tax base for GMA 12 and the state.[30]

The Districts

The Districts respond that a major impact they considered is what would happen if the Districts did not meet the groundwater needs projected in the state and regional planning numbers. The adopted DFCs, they contend, are consistent with those numbers.[31]

Environmental Stewardship

Environmental Stewardship states that a potential exists for problems in regional water planning associated with water management strategies that exceed the MAG value estimated from the DFCs. Based on analysis by the Bureau of Economic Geology, economic impact values associated with water deficits in major economic sectors for the region were estimated to be in the range of $256 million by 2060.[32] In other words, DFCs that allow overdrafts on the aquifers would create future shortages that would negatively impact certain socio-economic sectors.

The Districts

The Districts state that a number of assumptions are made in the estimates of socio-economic impact presented by Environmental Stewardship. All the demand shortfalls in the estimates were assumed to be met with groundwater, while certain demands are currently met entirely with surface water. Thus, the socio-economic impact is overstated and not realistic.

Staff

End Op does not develop its claims in its hearing testimony or exhibits. Thus, it is difficult to identify and assess the potential socio-economic impacts that End Op claims. Testimony by the Districts point to problems with the data provided by Environmental Stewardship—specifically the fact that the analysis Environmental Stewardship relies on does not differentiate between impacts related to groundwater and impacts related to surface water uses. Thus, staff did not find compelling evidence to support potential socio-economic impacts that would render the DFCs unreasonable.

3. Consider environmental impacts including but, not limited to, impacts to spring flow or other interaction between groundwater and surface water.

End Op

[30] End Op Pet., pg. 4; End Op Hearing Trans., pg. 16-17.
[31] End Op. Hearing Trans., pg. 78.
[32] Env. Stewardship Pet. pg. 12.

End Op does not raise any environmental concerns.

Environmental Stewardship

Environmental Stewardship claims that the DFCs are contrary to the legislative directives of Senate Bill 3[33] for the preservation of environmental flows in surface water. Environmental Stewardship contends that increasing production from the aquifers, as the DFCs would allow, impairs the ability to maintain those flows that are legislatively mandated.[34] The result, according to Environmental Stewardship is that the Colorado and Brazos rivers would cease to be "gaining" systems from groundwater discharge from the aquifers.[35] This will have impacts on the ecology of the rivers as well as on the bays and estuaries to which they contribute.[36]

Districts

The Districts respond that many of the streams and springs in the GMA are not related to the regional aquifer system, but to shallow, localized flow systems. These shallow systems will not be impacted by the pumping that is managed through the DFC process.[37] Regarding impacts on the rivers, the Districts testified that stream flows into the Colorado River and other regional rivers cannot be used directly to assess discharge from the aquifers as aquifer contributions are highly variable and are not consistent or reliable.[38] That is, stream flow does not equal aquifer discharge. Other factors influence stream flow and river gains and losses.[39] Therefore, the Districts concluded that the use of stream flow is not appropriate as a specific DFC metric by which to develop management strategies regionally for groundwater production.[40]

Staff

Environmental Stewardship cites provisions of law enacted by Senate Bill 3 regarding protection of the state's rivers, lakes, bays, and estuaries.[41] But Environmental Stewardship does not note the context of the statutory phrases. Water Code Section 11.0235 "encourages voluntary water and land stewardship to benefit the water in the state." Section 11.0235 goes on to provide that the Texas Commission on Environmental Quality (TCEQ) is tasked with considering and providing "for the freshwater inflows and instream flows necessary to maintain the viability of the state's streams, rivers, and bay and estuary systems in the commission's regular granting of permits for the use of state waters."[42] The statute further provides for the creation of an Environmental Flows Advisory Group to study, evaluate options for providing adequate environmental flows, and report to each Legislature regarding, among other matters, the requirements of the riverine, bay, and estuary systems.[43]

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[33] Act of June 16, 2007, 80th Leg., R.S., ch. 1430, 2007 Tex. Gen. Laws 5848.
[34] Env. Stewardship Hearing Trans., pg. 11.
[35] Env. Stewardship Hearing Trans., pg. 14-20.
[36] Env. Stewardship Hearing Trans., pg. 39.
[37] Env. Stewardship Hearing Trans., pg. 89.
[38] Env. Stewardship Hearing Trans., pg. 90.
[39] Env. Stewardship Hearing Trans., pg. 94.
[40] Env. Stewardship Hearing Trans., pg. 93.
[41] Env. Stewardship Hearing Trans. 42, Power Point presentation slide 42, quoting Senate Bill 3, § 1.06, codified at Water Code § 11.0235.
[42] Tex. Water Code § 11.0235(c).
[43] Tex. Water Code § 11.0236.

Senate Bill 3 does not place the responsibilities discussed by Environmental Stewardship on the Districts.[44] Before granting or denying a permit, a district must consider, among other things, whether "the proposed use of water unreasonably affects existing groundwater and surface water resources or existing permit holders."[45] But that requirement is part of the permitting process; there is no explicit requirement in the statutes under which this petition was brought for the Districts to consider impacts on spring flow and other interactions between groundwater and surface water.[46]

All the parties acknowledge the interaction between groundwater and surface water. As noted above under criterion 1, a number of factors affect inflow to and outflow from the Colorado and Brazos rivers and technical work remains to be done to better monitor, analyze, and manage that interaction. The Districts indicated that they are taking steps consistent with suggestions from Environmental Stewardship and its witnesses to address monitoring of those factors, especially groundwater and surface water interaction. Those efforts will become part of the Districts' management plans. In that context, the DFCs represent a policy decision by the Districts to balance conservation with meeting existing and future demands. Thus, the data does not suggest that the DFCs are unreasonable with regard to environmental issues.

4. Consider the state's policy and legislative directives.

End Op

End Op states in its petition that the 2007 State Water Plan estimates water users within regions K and L will need nearly 1,000,000 acre-feet of water supplies by 2060.[47] End Op claims that the DFCs adopted by the Districts in GMA 12 restrict the utilization of a prolific source of water that is ideal for meeting these needs and may adversely affect economic development in these regions.[48]

Districts

The Districts respond that they used available groundwater planning data from the 2006 regional water plans and the 2007 State Water Plan when establishing the DFCs.[49]

Environmental Stewardship

Environmental Stewardship asserts that in examining these DFCs, the TWDB should consider all the water planning policies and legislative directives of the state, including Senate Bill 3, which

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[44] Districts have representation on the basin and bay area stakeholders committee for each river basin appointed by the Environmental Flows Advisory Group. Tex. Water Code § 11.02362(f).
[45] Tex. Water Code § 36.113(d)(2).
[46] Senate Bill 660, 82nd Leg., R.S., 2011, amended § 36.108(d) to add that in establishing desired future conditions districts must consider "environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water."
[47] End Op Pet., pg. 4.
[48] *Id.*
[49] End Op Hearing Trans., pg. 62.

requires that basin and bay systems be protected by providing freshwater instream flows to rivers, bays, and estuaries.[50]

Districts

In the hearing on the Environmental Stewardship petition, the Districts asserted that they incorporated regional water plans for regions C, G, H, and K and state water plan information as well as the requirements of Texas Water Code ch. 36 in their deliberations and decision-making. The Districts state that they take these resources as their primary statutory and policy directives when establishing the DFCs.[51]

Staff

While End Op raises this issue in its petition, it does not produce any evidence in its testimony or exhibits to support the assertion that the Districts failed to consider state policy and legislative directives.

Currently, groundwater conservation districts are the state's preferred method of groundwater management.[52] The state water plan is a guide to state water policy.[53] Surface water in the state is the property of the state and is managed by TCEQ.[54] As Environmental Stewardship notes, Senate Bill 3 established bay and basin area stakeholders committees to recommend state environmental flow standards to TCEQ. The directives in Senate Bill 3 to which Environmental Stewardship refers are addressed to TCEQ, TWDB, and Texas Parks and Wildlife Department, specifically to the development of the Texas Instream Flow Program, not to the Districts. As noted earlier, consideration of the issues raised by Environmental Stewardship were not required of Districts until amendments made in the 2011 legislative session. For purposes of these petitions, the issue is whether the DFCs adopted by the Districts are reasonable, quantitative expressions of the desired future condition of the aquifers. Staff finds that the DFCs are reasonable based on the state policy and legislative directives that guide groundwater management.

5. Consider the impact on private property rights.

End Op

End Op asserts that the DFCs adopted by the Districts in GMA 12 deny landowners, especially in Lee and Bastrop counties including those represented by End Op, the opportunity to exercise their rights to withdraw groundwater from their land.[55]

End Op claims that the DFC process did not provide for stakeholder input. Consequently, the District representatives engineered DFCs that prevent additional production without considering

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[50] Env. Stewardship Hearing Trans., pg. 42.
[51] Env. Stewardship Hearing Trans., pg. 72, 79.
[52] Tex. Water Code § 36.0015.
[53] Tex. Water Code § 16.051.
[54] Tex. Water Code §§ 11.023-11.026.
[55] End Op. Pet., pg. 3.

the groundwater available.[56] By "extrapolating backward" from current demand rather than from an analysis of the aquifer's actual conditions, the Districts have unduly limited the amount of water that may be authorized for production.[57]

Districts

The Districts respond by listing the number of open meetings held, the public comments provided by individuals, agencies, environmental groups, businesses, institutions, and other interests during the DFC process.[58] The Districts claim that the impact on all property rights interests were considered in their process—existing permits and users as well as projected future demands for permits.[59] The result is that the DFCs allow for up to three times the amount of current production in the Lost Pines District over the next 50 years.[60] But that amount, according to the Districts, is balanced with the Lost Pines District's regulations that protect landowners' rights to water in place.[61]

Environmental Stewardship

Environmental Stewardship claims that water withdrawn from the river systems as a result of the DFCs in GMA 12 will take water away from appropriated surface water rights-holders.[62] Environmental Stewardship argues that water that may be permitted for withdrawal from the aquifers under the GMA 12 DFCs but that now feeds the rivers constitutes already appropriated surface water rights and cannot be withdrawn without harming those surface water rights.[63]

Districts

The Districts state that there is a logical and legal disconnect in the argument that withdrawing water from an aquifer—the property of the landowner under chapter 36—may result in a taking from a surface water permit holder. The Districts point out that the Legislature provided for environmental flows in chapter 11 of the Water Code through permitting of surface water rights by TCEQ. Section 11.0235 directs TCEQ to balance "all other public interests" and to provide for freshwater flows to maintain the state's streams in the context of TCEQ's "regular granting of permits for the use of state waters," that is, surface water.[64] The Districts go on to assert that SB 3 does not obligate groundwater conservation districts to set aside groundwater to contribute to state surface water.[65]

Staff

As the Districts note, the Legislature provided one statutory regime for groundwater rights and permitting and another for surface water rights and permitting. But the question of whether the

[56] End Op. Hearing Trans., pg. 13.
[57] *Id.*
[58] End Op. Hearing Trans. pg. 62-65.
[59] End Op Hearing Trans., pg. 53.
[60] End Op Hearing Trans., pg. 78.
[61] *Id.*
[62] Env. Stewardship Hearing Trans., pg. 20.
[63] Env. Stewardship Hearing Trans., Power Point Presentation.
[64] Env. Stewardship Hearing Trans., pg. 110-111.
[65] *Id.*

regulation of one could result in a taking of the other is a question that is outside the scope of consideration in this proceeding.

The Districts also point out that nothing in chapter 11 or chapter 36 authorized or obligated the Districts to provide in their management of the aquifer for groundwater discharge to the rivers. This is true for the statutes that were in place when the DFCs in question were adopted. As noted earlier, Senate Bill 660, 82nd Leg., R.S., 2011, amended § 36.108(d)(4) to add that in establishing desired future conditions districts must consider "environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water." The Districts must take that consideration into account when future DFCs are reviewed.

For purposes of this petition, the issue is whether the DFCs adopted by the Districts are reasonable, quantitative expressions of the desired future condition of the aquifers. Currently, groundwater districts are the state's preferred method of groundwater management.[66] A landowner owns the groundwater below the landowner's land subject to a district's regulation of production as provided by law.[67] The petitioners present no evidence that the DFCs adopted by the Districts have an unreasonable impact on private property rights.

6. Consider the reasonable and prudent development of the state's groundwater resources.

End Op

End Op points to the South Central Texas Regional Water Plans for 2001 and 2006 that indicate 75,000 acre-feet per year of water is available from the Simsboro Aquifer, a highly productive aquifer. End Op claims that the DFCs are unreasonable because they ignore available information and preclude development of available groundwater resources. [68] End Op asserts that no consideration was given to the total available water supply, total recoverable supply, or sustainable yield when the DFCs were established.

Districts

Districts respond that the DFCs as determined permit future growth, providing for reasonably prudent development of the groundwater. The Districts testified that the DFCs accommodate more than 175,000 acre-feet per year of increased pumping by 2060 above 2008 estimated levels for the Carrizo-Wilcox aquifer alone.[69]

Environmental Stewardship

Environmental Stewardship asserts that the DFCs undermine the reasonable and prudent development of the state by undermining the use of adaptive management.

Districts

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[66] Tex. Water Code § 36.0015.
[67] Tex. Water Code § 36.002.
[68] End Op Pet., pg 4. (Note, the Simsboro is part of the Carrizo-Wilcox aquifer system.)
[69] End Op Hearing Trans., pg. 71-72.

The Districts respond that the DFCs balance the need to help meet water demands over time with the need to protect groundwater resources.[70] The Districts state that the adopted DFCs allow the Districts to meet continuing water demand increases, provide some protection for existing users in terms of the available drawdown, and allow for permitting flexibility within the Districts.[71] A significant increase in demand for groundwater in the area is projected over the next 50 years. That reality has to be considered in conjunction with protection of aquifer levels, which, in turn, protect surface water.[72]

Staff

The MAG value based on the DFCs is more than double pumping by existing users by 2060.[73] The numbers reflected in Tables 2 through 9 of Attachment 1 do not suggest unusual constraints on potential pumping or on the Districts' ability to manage specific strategies as they develop. Rather, the MAG value accommodates future development within overall consistency with the 2012 State Water Plan.

Closing

Environmental Stewardship concluded its presentation by listing the "remedies" it sought from the appeal process. In addition to finding the DFCs unreasonable, the "remedies" included:

1. considering the impacts of reduced surface water outflows;
2. preserving the groundwater-surface water relationship;
3. including adaptive management; and
4. setting different DFCs for substantially different geographic areas;

In reviewing the testimony and evidence, staff concludes that the Districts accomplished number 4 by the manner in which they adopted the DFCs for the different aquifers and the different Districts as discussed above under criterion 1. Staff finds the recommendations regarding use of adaptive management instructive for development of management plans. Several of the specific tasks Environmental Stewardship highlighted are apparently already being considered by the Districts. The recommendation, however, while perhaps appropriate for a management plan, is not appropriate for a DFC, as it does not define a quantitative desired future condition of the aquifer.

Suggestions 1 and 2 are linked by the concern with surface water conditions. Senate Bill 3 does not place the responsibilities discussed by Environmental Stewardship on the Districts.[74]

Both End Op and Environmental Stewardship claim that the Districts did not consider important factors such as good science, total available supply, recommendations from environmental groups, and best management practices. In contrast to Petitioners' assertions, the Districts

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[70] Env. Stewardship Hearing Trans., pg. 75.
[71] Env. Stewardship Hearing Trans., pg. 85.
[72] Env. Stewardship Hearing Trans., pg. 104-105.
[73] Attachment 1, Table 2.
[74] Districts have representation on the basin and bay area stakeholders committee for each river basin appointed by the Environmental Flows Advisory Group. Tex. Water Code § 11.02362(f).

presented testimony that issues were discussed, interest groups were heard at numerous open meetings, and recommendations were considered—some are even being acted upon and may become part of the Districts' management plans. The Petitioners' complaints essentially are not that the Districts failed to consider certain matters but that the Districts failed to adopt Petitioners' positions on those matters.

For purposes of this petition, the issue is whether the DFCs adopted by the Districts are reasonable, quantitative expressions of the desired future condition of the aquifers. The Districts offered reasoned justifications for their decisions and the decisions themselves are reasonable.

RECOMMENDATION

Staff recommends that the Board find that the DFCs adopted by the Districts in GMA 12 for the Sparta, Queen City, Carrizo-Wilcox, Calvert Bluff, Simsboro, Hooper, Yegua-Jackson, and Brazos River Alluvium aquifers are reasonable based on the petitions, the testimony and evidence presented at the hearings, and staff's summary and analysis of that evidence. The reasonableness of the DFCs with respect to environmental impacts and the exercise of personal property rights will depend on the way in which the Districts incorporate the MAG value in their management plans and make related decisions regarding permit authorizations and administration.

Attachment(s): Technical Analysis of Petitions

TECHNICAL ANALYSIS OF PETITIONS

CHALLENGING THE REASONABLENESS OF THE DESIRED FUTURE CONDITIONS FOR THE SPARTA, QUEEN CITY, CARRIZO, CALVERT BLUFF, SIMSBORO, HOOPER, YEGUA-JACKSON, AND BRAZOS RIVER ALLUVIUM AQUIFERS IN GROUNDWATER MANAGEMENT AREA 12

Petitioners:
End Op, L.P.
Environmental Stewardship

Prepared by:
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Texas Water Development Board
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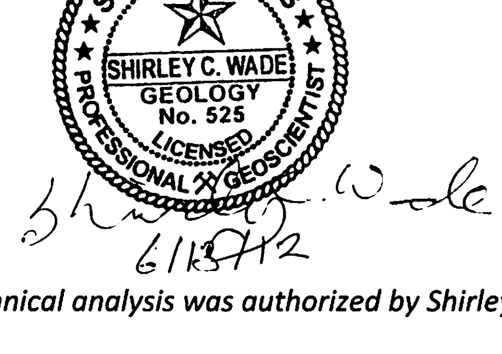
Prepared for:
Texas Water Development Board
June 21, 2012 Board Meeting

June 13, 2012



The seal appearing on this technical analysis was authorized by Shirley C. Wade, P.G. 525 on June 13, 2012.

EXECUTIVE SUMMARY

We have summarized groundwater availability model runs, groundwater/surface water interaction data, and information from the 2012 State Water Plan to provide context to issues raised in two petitions filed by End Op, L.P. and Environmental Stewardship appealing the reasonableness of the desired future conditions (DFCs) for the Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro, Hooper, Yegua-Jackson, and Brazos River Alluvium aquifers. We also performed a series of GAM runs with one petitioner's requested pumping included. We uniformly scaled pumping up and down and plotted drawdown versus total pumping. The run results predict more than 100 feet of additional drawdown in the Simsboro Aquifer in Lost Pines Groundwater Conservation District due to the additional pumping requested by End Op, L.P.

We compared draft modeled available groundwater (MAG) amounts based on the DFCs with state and regional water planning data, water use survey data, and estimates of maximum sustainable pumping. For the Carrizo-Wilcox Aquifer in Groundwater Management Area 12 the groundwater availability in the 2012 State Water Plan exceeds the draft modeled available groundwater by about 50,000 acre-feet per year in 2010 , but by 2060 the draft MAG exceeds the 2012 State Water Plan availability by about 16,000 acre-feet per year. In Lost Pines Groundwater Conservation District the draft Carrizo-Wilcox MAG is less than the 2012 State Water Plan groundwater availability by about 16,000 acre-feet per year in 2010, but by 2060 the MAG is approximately equal to the 2012 State Water Plan groundwater availability. When Region L, located outside of Groundwater Management Area 12, strategies are excluded, the draft Carrizo-Wilcox Aquifer MAG for Lost Pines Groundwater Conservation District is greater than the 2012 State Water Plan Existing Water Supplies plus Recommended Water Management Strategies over the entire 50-year modeling period.

Researchers report that the Carrizo-Wilcox Aquifer provides discharge to streams and rivers in Groundwater Management Area 12. The groundwater availability model was calibrated to base-flow data, and the model predicts a decline in discharge to streams over the historical calibration period. However, a base-flow study reported as part of the model development showed no evidence of a decreasing trend with time historically.

SECTION 1: INTRODUCTION

This document is a summary of technical information to provide context to the issues raised in two petitions appealing the reasonableness of the desired future conditions adopted by groundwater conservation districts (Figure 1) within Groundwater Management Area 12 (GMA 12) for the Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro, Hooper (Figure 2), Yegua-Jackson, and Brazos River Alluvium aquifers (Figure 3). This report accompanies the staff evaluation of the issues raised in the petitions filed by End Op, L.P. and Environmental

Stewardship. In this technical report we draw no conclusions about the merits of the issues raised in the petitions.

To help address the technical aspects of the petitions we have summarized the six groundwater availability model runs and tasks performed for GMA 12 (Section 2). We also conducted additional modeling runs as part of this technical analysis to evaluate the effect of one petitioner's proposed pumping (Section 3). In addition, we have compiled groundwater use data from the TWDB Online Water Use Survey (TWDB, 2012) as well as groundwater availability and recommended water management strategies from the 2011 Regional Water Plans (Region C Water Planning Group, 2011; Brazos G Regional Water Planning Group, 2011; Region H Water Planning Group, 2011; and Lower Colorado Regional Water Planning Group, 2011; all part of the 2012 State Water Plan) (Section 4).

To help evaluate concerns raised in the Environmental Stewardship petition about the effects of pumping on natural groundwater discharge, we have summarized some information on groundwater/surface water interaction as well as information on streamflow calibration and implementation and recharge implementation (Section 5) in the groundwater availability model.

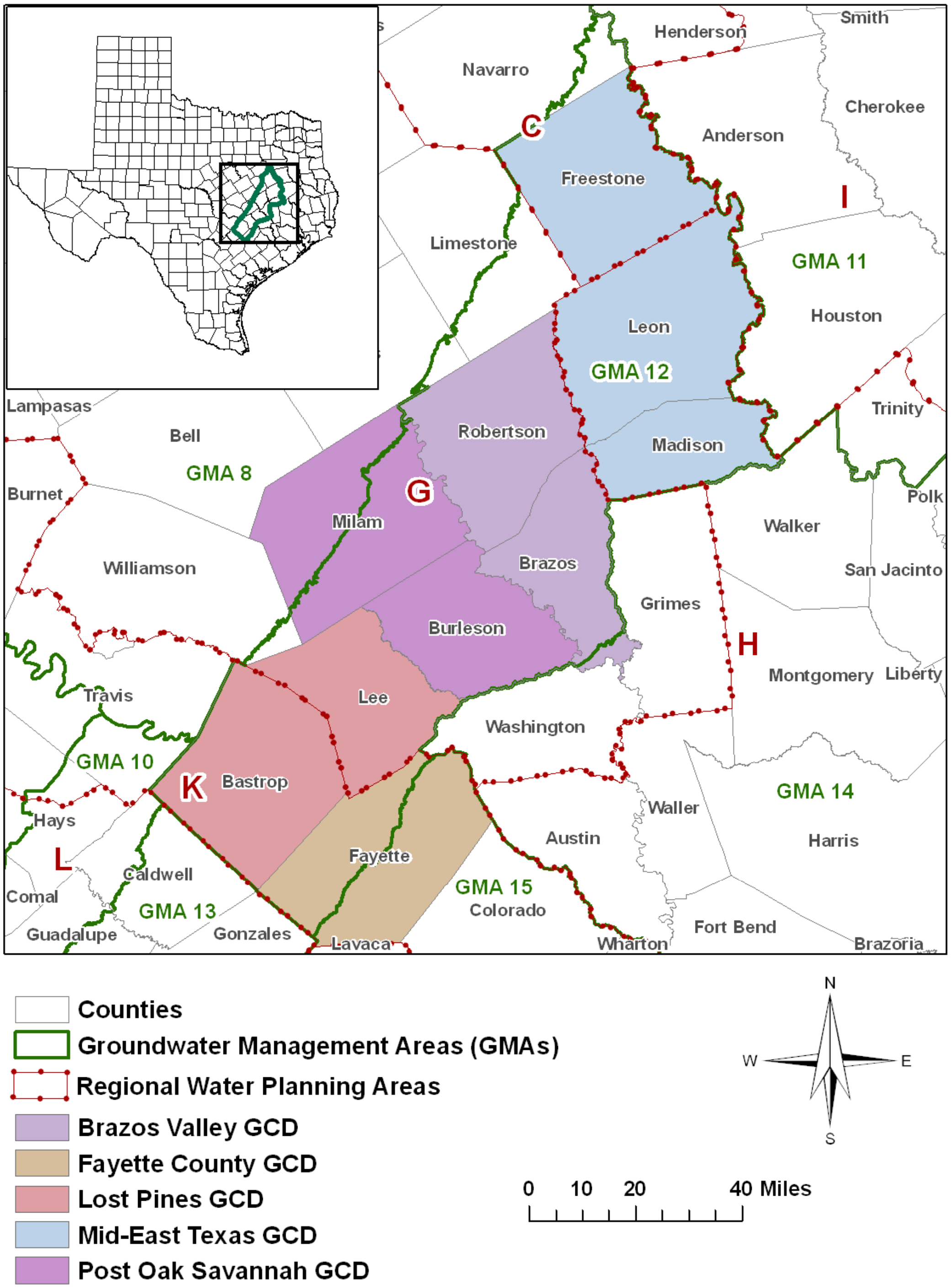


Figure 1. Groundwater conservation districts and Regional Water Planning Areas in Groundwater Management Area 12. (GCD = Groundwater Conservation District).

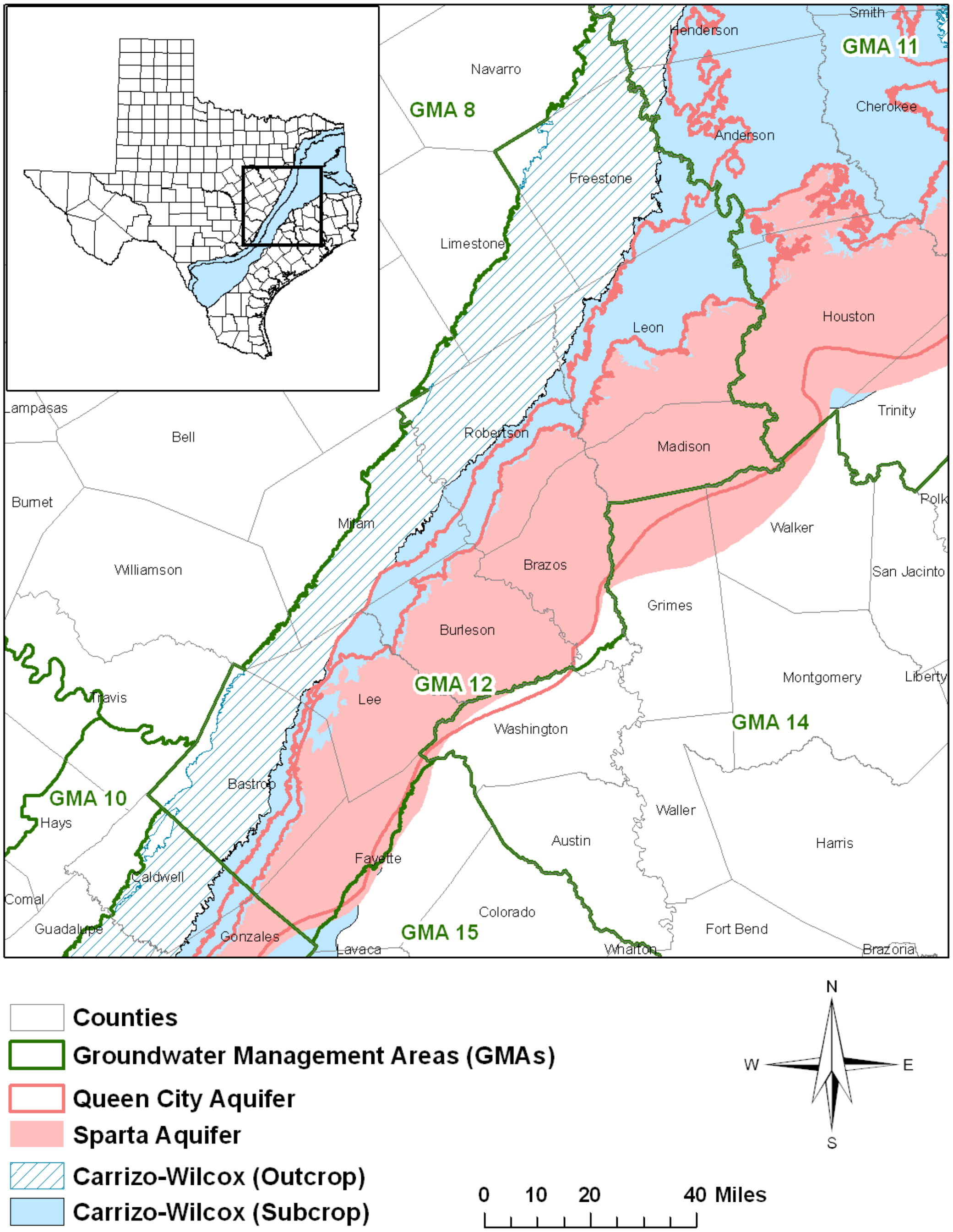


Figure 2. Location of the Carrizo-Wilcox, Queen City, and Sparta Aquifers in Groundwater Management Area 12.

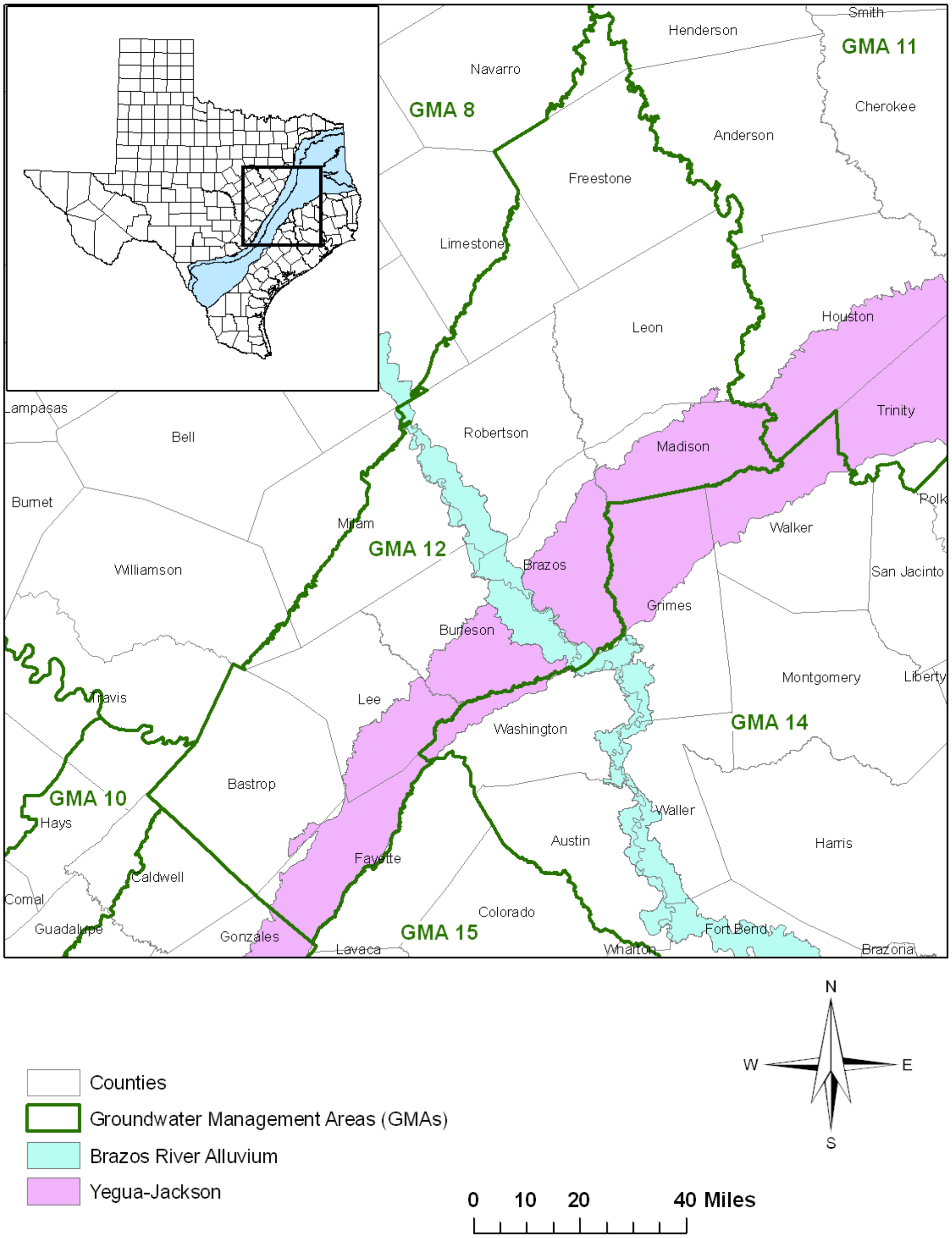


Figure 3. Location of the Brazos River Alluvium and Yegua-Jackson aquifers in Groundwater Management Area 12.

SECTION 2: GROUNDWATER AVAILABILITY MODEL RUNS

Most of the modeling work for GMA 12 to develop their desired future conditions was performed by consultants under contract to the groundwater conservation districts within GMA 12. However, TWDB staff also completed six groundwater availability modeling analysis and task reports for GMA 12.

GAM Task 10-012

Oliver (2010a)

For GAM Task 10-012 we ran the groundwater availability model (GAM) for the Yegua-Jackson Aquifer (Deeds and others, 2010) using pumping based on the 2007 State Water Plan. We also adjusted the “base” pumping up and down to estimate how the aquifer responds to different levels of pumping. The runs were conducted to serve as a source of information for groundwater management areas. In general, the changes in water levels in GMA 12 for the various scenarios ranged from rebounds of less than one foot to declines of just over one foot.

GAM Task 10-024

Wade (2010)

For GAM Task 10-024 we ran the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers using a well file submitted by consultants working for GMA 12. The well file, GMA12_7A.txt, was used by the consultants to develop the desired future conditions (DFCs) for GMA 12. The purpose of this task was to verify that the submitted well file produced the desired future conditions of GMA 12. The well file did not exactly produce the desired future conditions of GMA 12 so pumping was incrementally adjusted to determine whether the desired future conditions were compatible and physically possible. An exact match to the DFCs was not possible so two best fit scenarios were determined with pumping increased 5,000 acre-feet per year and 9,000 acre-feet per year.

GAM Run 10-044, 045, and 046

Oliver (2010b, c, d)

GAM Runs 10-044, 10-045, and 10-046 are draft managed available groundwater reports for the Carrizo-Wilcox, Queen City, and Sparta aquifers, respectively. We ran the model using the model simulation well file, GMA12_7B.wel, submitted by the consultants for GMA 12 and confirmed that the model simulation achieved the desired future conditions adopted by the members of GMA 12. We then extracted pumping estimates from the model output and summarized the amounts by county, regional water planning area, and river basins as well as listing amounts for groundwater conservation districts.

GAM Run 10-060
Oliver (2011)

GAM Run 10-060 is the draft managed available groundwater report for the Yegua-Jackson Aquifer in GMA 12. We ran the groundwater availability model for the Yegua-Jackson Aquifer (Deeds and others, 2010) using a well file provided by the consultants for GMA 12 and confirmed that with minor modifications the well file reproduced the adopted desired future conditions within 5 feet or 5 percent. We then extracted pumping estimates from the model output and summarized the amounts by county, river basin, and regional water planning area as well as by groundwater conservation district.

SECTION 3: GROUNDWATER AVAILABILITY MODEL RUNS WITH END OP, L.P. PUMPING INCLUDED

As part of this petition analysis we ran the GAM for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers with End Op, L.P.'s requested pumping included in northwest Lee and northeast Bastrop counties. Well drilling permit applications supplied with the petition stated that 14 wells in the two counties would supply approximately 56,000 acre-feet per year (approximately 4,000 acre-feet per year each). Well locations were also included in the well drilling permit applications (End Op, L.P., 2007). We added the pumping to the well file used to estimate the desired future conditions and draft modeled available groundwater, GMA12_7b.wel. We summarized model drawdowns by groundwater conservation district (Table 1). With the additional pumping the average drawdown in the Simsboro Aquifer in Lost Pines Groundwater Conservation District increases by more than 100 feet (Table 1).

We also ran the model with the desired future condition pumping plus the End Op pumping scaled by 40 percent, 60 percent, 80 percent, 130 percent, and 160 percent, and we plotted average aquifer drawdown versus total GMA 12 pumping for each aquifer and groundwater conservation district (Figures 4 through 9). The average drawdown in the Lost Pines and Post Oak Savannah groundwater conservation districts is up to 600 feet with pumping scaled by 160 percent (Figure 8).

Table 1. Adopted desired future conditions for Groundwater Management Area 12 and average drawdown for model run with End Op, L.P. pumping included.

Groundwater Conservation District or County	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
Adopted Desired Future Conditions Average Drawdown (feet) 2000 to 2059						
Brazos Valley	15	12	47	106	270	170
Fayette County	60	60	60	NA	NA	NA
Lost Pines	7	13	47	99	237	129
Mid-East Texas	0	0	55	70	115	95
Post Oak Savannah	30	30	65	140	300	180
Model Run with End Op Pumping Average Drawdown (feet) 2000 to 2059						
Brazos Valley	14	12	50	117	289	193
Fayette County	62	59	63	NA	NA	NA
Lost Pines	4	14	51	124	374	174
Mid-East Texas	0	-3	54	71	121	104
Post Oak Savannah	28	29	65	155	339	207

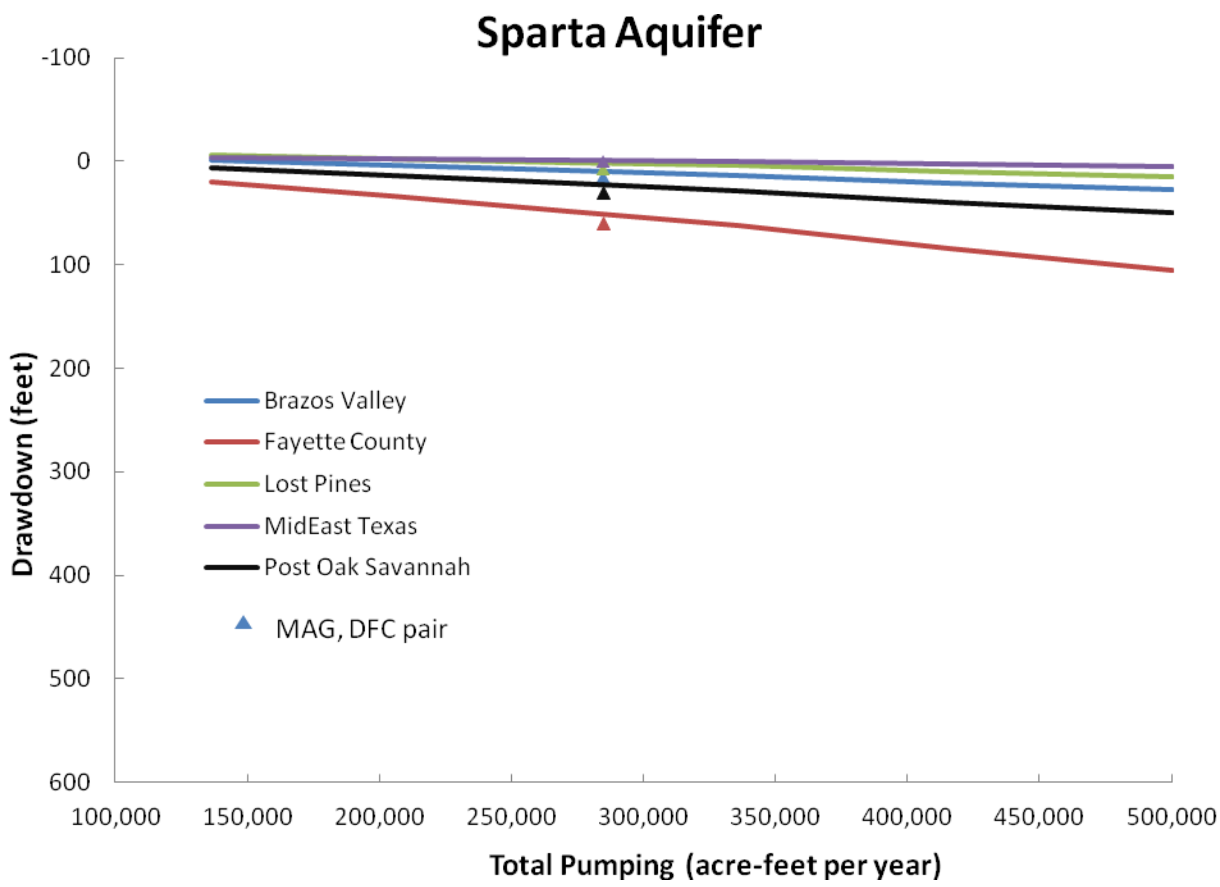


Figure 4. Average drawdown in the Sparta Aquifer in Groundwater Management Area 12 versus Groundwater Management Area 12 pumping for scaled runs with End Op, L.P. pumping. The desired future conditions for various GCDs are shown with the triangles (see Table 1).

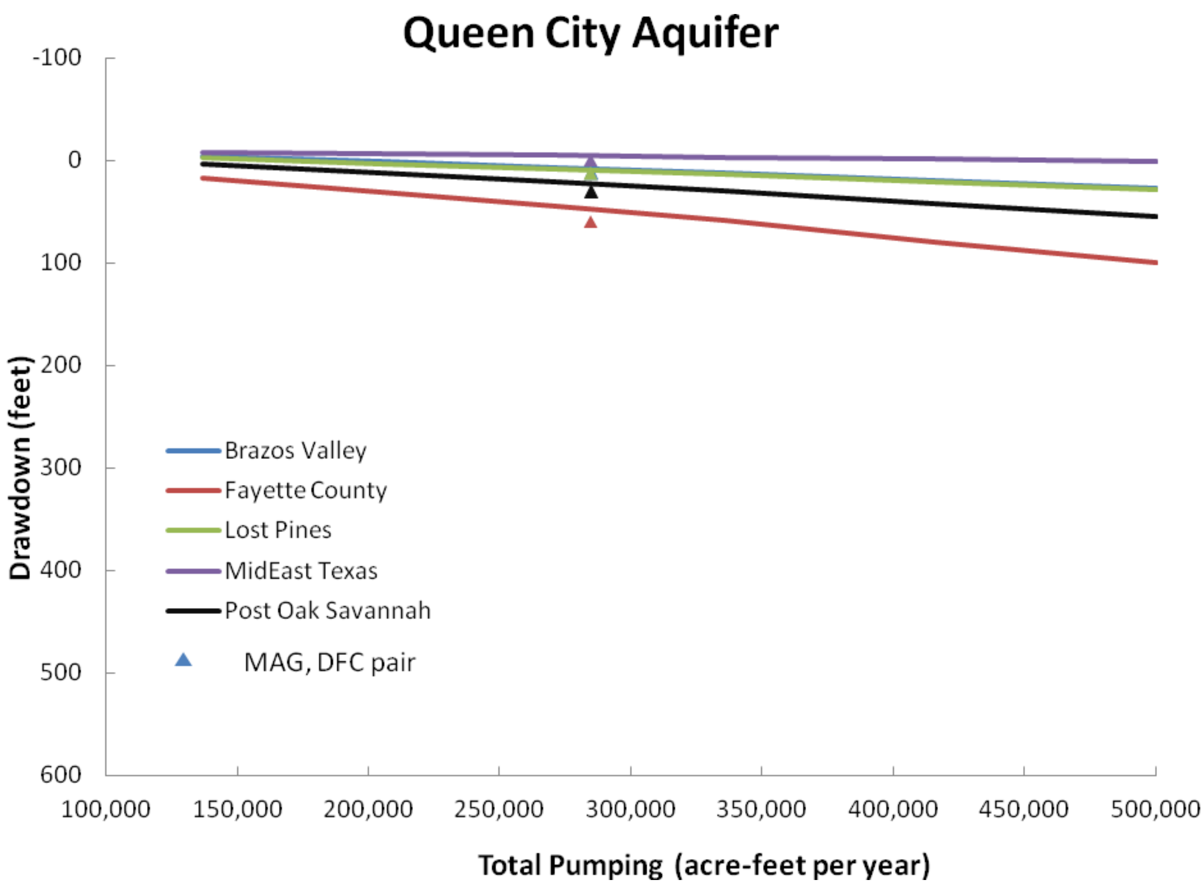


Figure 5.Average drawdown in the Queen City Aquifer in Groundwater Management Area 12 versus Groundwater Management Area 12 pumping for scaled runs with End Op, L.P. pumping. The desired future conditions for various GCDs are shown with the triangles (see Table 1).

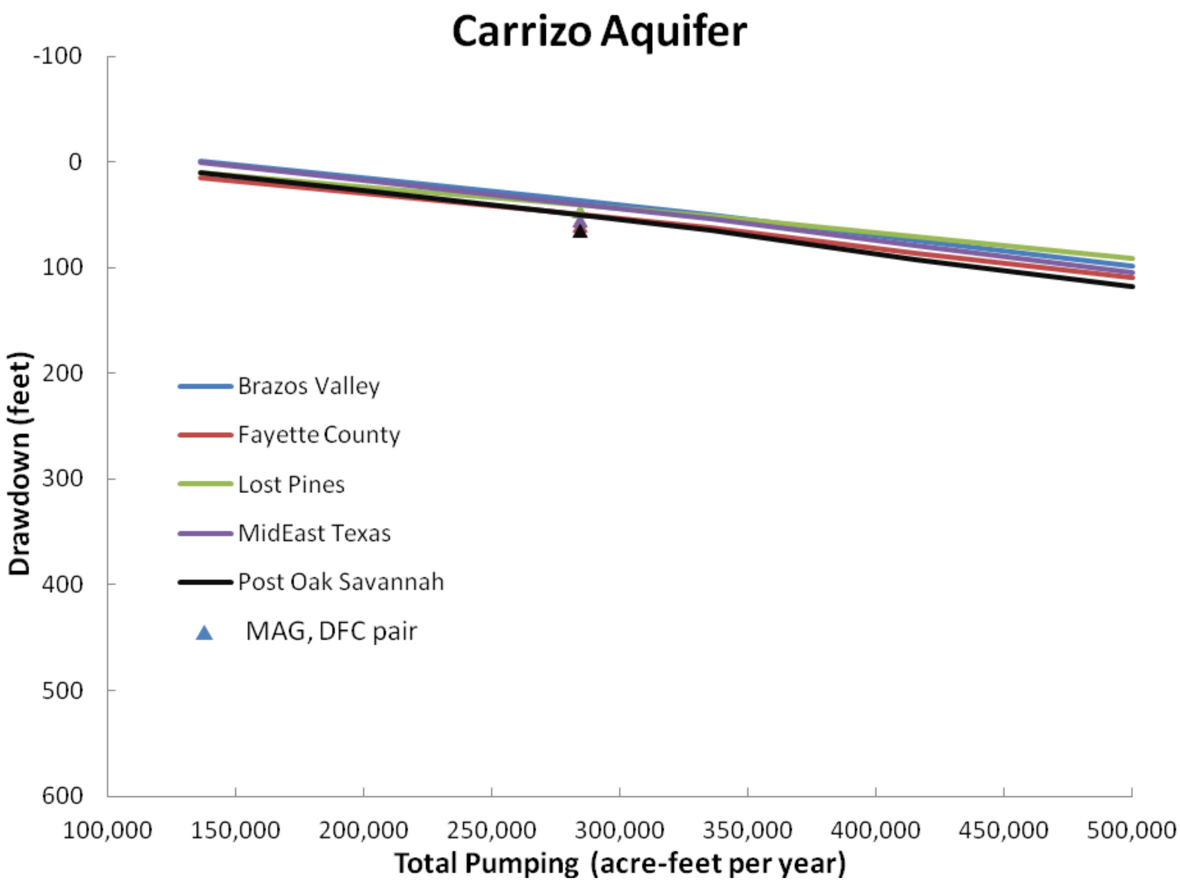


Figure 6.Average drawdown in the Carrizo Aquifer in Groundwater Management Area 12 versus Groundwater Management Area 12 pumping for scaled runs with End Op, L.P. pumping. The desired future conditions for various GCDs are shown with the triangles (see Table 1).

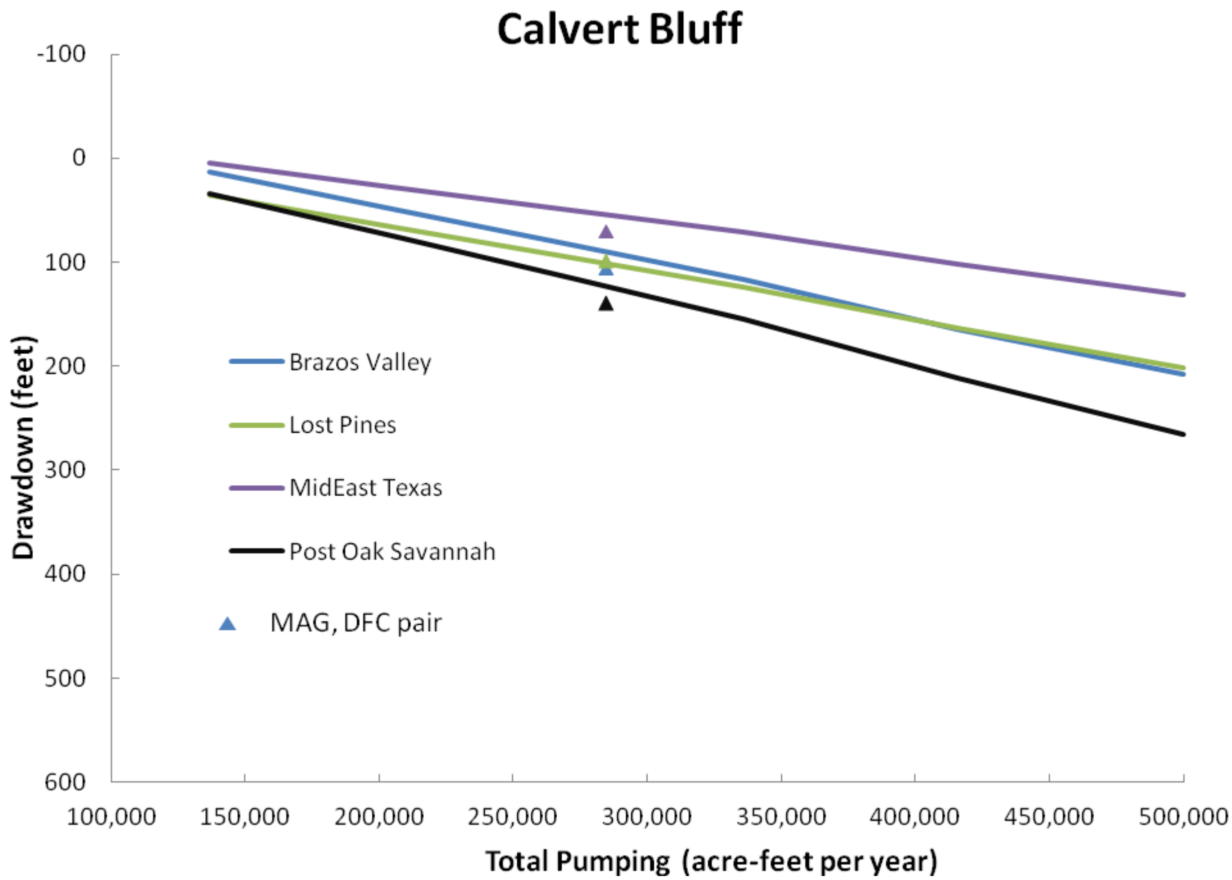


Figure 7. **Average drawdown in the Calvert Bluff Aquifer in Groundwater Management Area 12 versus Groundwater Management Area 12 pumping for scaled runs with End Op, L.P. pumping. The desired future conditions for various GCDs are shown with the triangles (see Table 1).**

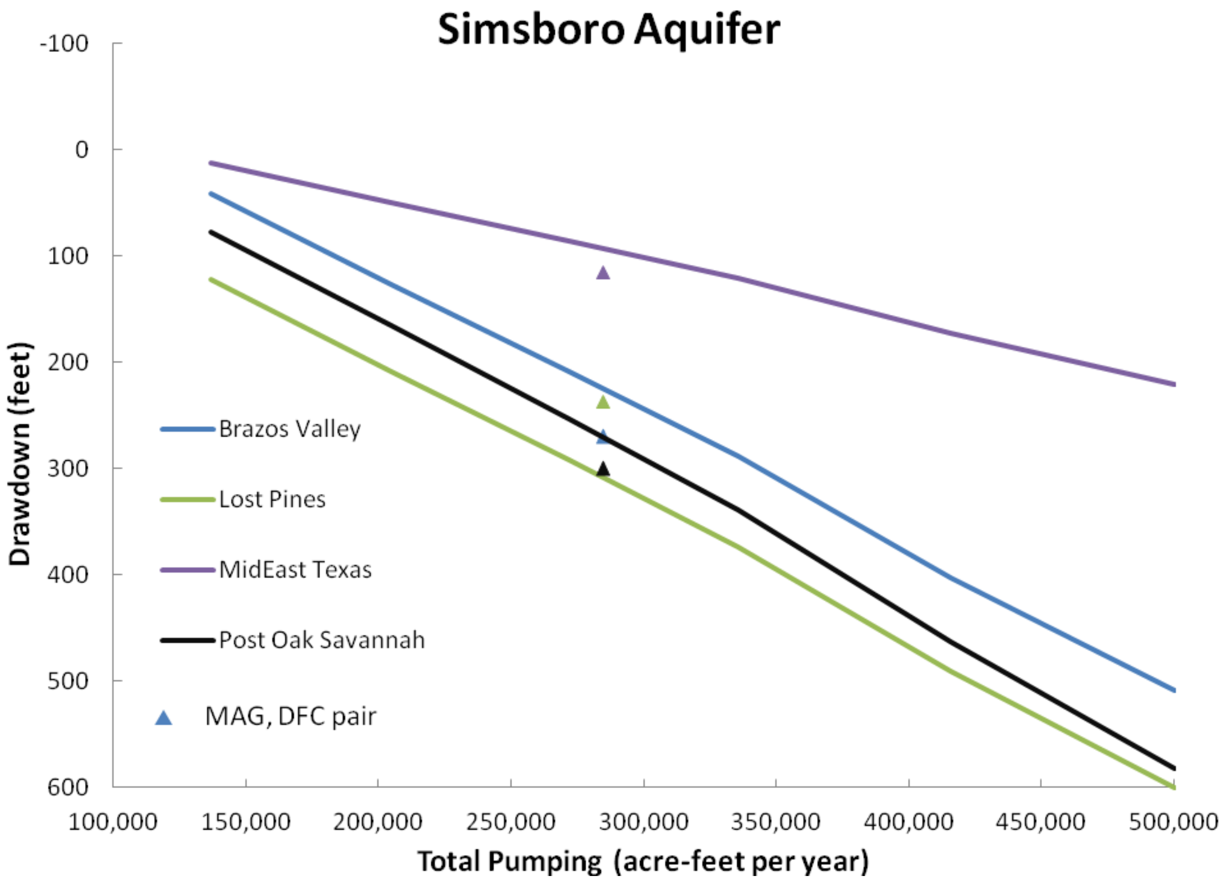


Figure 8. Average drawdown in the Simsboro Aquifer in Groundwater Management Area 12 versus Groundwater Management Area 12 pumping for scaled runs with End Op, L.P. pumping. The desired future conditions for various GCDs are shown with the triangles (see Table 1).

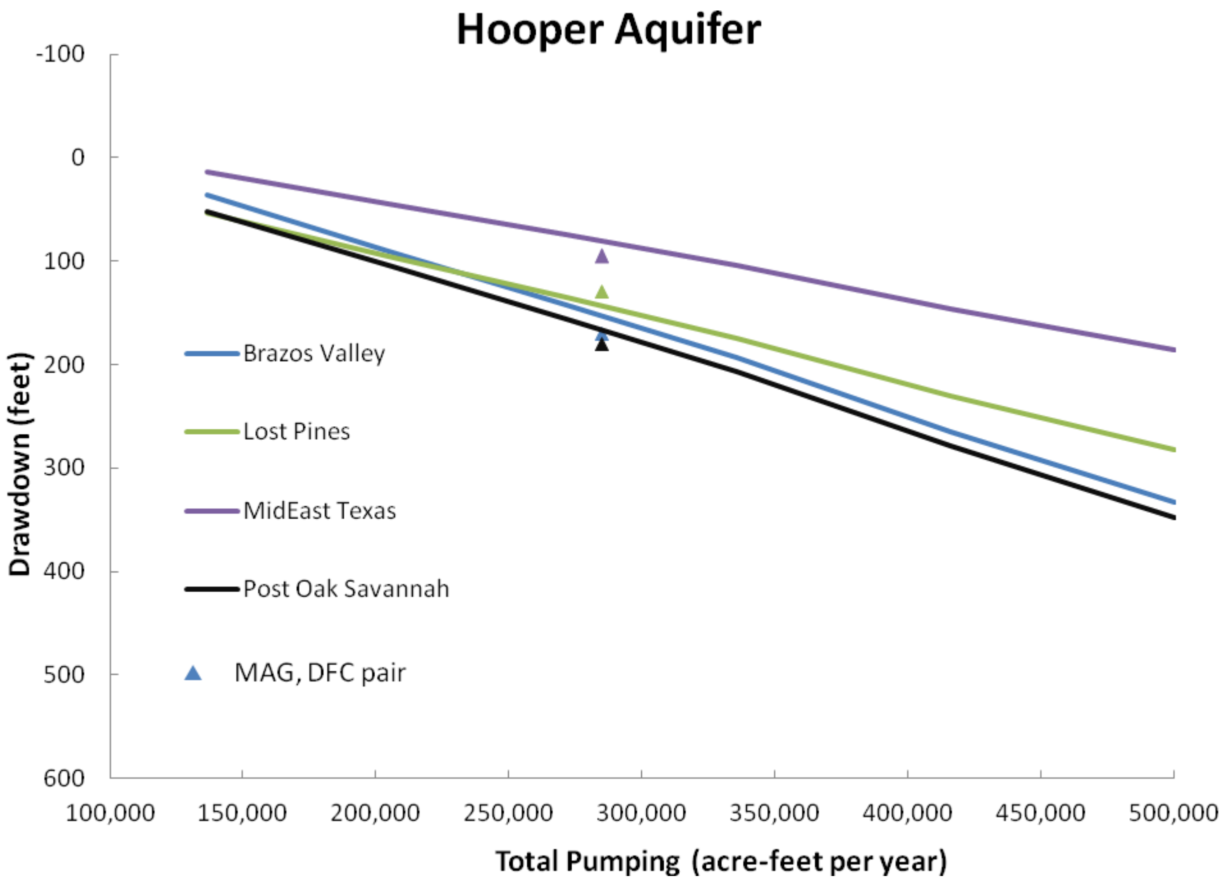


Figure 9. Average drawdown in the Hooper Aquifer in Groundwater Management Area 12 versus Groundwater Management Area 12 pumping for scaled runs with End Op, L.P. pumping. The desired future conditions for various GCDs are shown with the triangles (see Table 1).

SECTION 4: COMPARISON OF DRAFT MODELED AVAILABLE GROUNDWATER WITH STATE WATER PLAN GROUNDWATER AVAILABILITY, AND WATER MANAGEMENT STRATEGIES, FOR THE AQUIFERS IN GROUNDWATER MANAGEMENT AREA 12.

To put the modeled available groundwater volumes for GMA 12 into context we compiled and plotted estimates of historical use, exempt use, groundwater availability from the 2012 State Water plan (TWDB, 2012b) as well as 2012 State Water Plan water management strategy volumes for the Carrizo-Wilcox (Tables 2 and 3; Figures 10 and 11), Queen City (Tables 4 and 5), Sparta (Tables 6 and 7), Yegua-Jackson (Table 8), and Brazos River Alluvium aquifers (Table 9). We compiled both total GMA 12 volumes (Tables 2, 4, 6, 8, and 9) as well as volumes for the Lost Pines Groundwater Conservation District (Tables 3, 5, and 7). In addition, we compiled precipitation recharge, estimated maximum sustainable pumping, and total storage volume from the GAMs for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers and the Yegua-Jackson Aquifer.

Modeled available groundwater amounts divided by groundwater conservation district for each unit of the Carrizo-Wilcox Aquifer are listed in Appendix A (Table A.1, Carrizo; Table A.2, Calvert Bluff; Table A.3, Simsboro, Table A.4, Hooper) .

Historical Groundwater Pumping

The 2003 estimated groundwater pumping (Tables 2 through 9) is from the TWDB Online Water Use Survey data (TWDB, 2012a). We also include water use data from 1980 through 2003 on the comparison charts (Figures 10 and 11).

Estimated Exempt Use

Exempt use is the projected amount of pumping from the aquifer that is exempt from permitting by a groundwater conservation district. Examples of exempt uses include certain domestic and livestock use. Each district may also exempt additional uses as defined by its rules or enabling legislation. TWDB staff developed a standardized method for estimating exempt use for domestic and livestock purposes based on projected changes in population and the distribution of domestic and livestock wells. Because other exempt uses can vary significantly from district to district, estimates of exempt pumping outside domestic and livestock uses were not included in the TWDB estimate (Oliver, 2012).

2012 State Water Plan Groundwater Availability

Groundwater Management Area 12 is located in parts of four regional water planning areas (Figure 1): Region C (Freestone and Navarro counties), Brazos G (Brazos, Burleson, Falls, Lee, Limestone, Milam, Robertson, and Williamson counties), Region H (Leon and Madison counties), and Lower Colorado (K; Bastrop and Fayette counties).

In its 2011 Regional Water Plan (Region C, 2011), Region C assumed groundwater availability for the Carrizo-Wilcox and Queen City aquifers to be the same as in the 2006 Region C Water Plan (Region C, 2006 and 2011).

For the 2011 Brazos G Regional Water Plan (Brazos G Regional Water Planning Group, 2011), Brazos G based estimates of groundwater availability for the Carrizo-Wilcox, Queen City, and Sparta aquifers on pumping information from preliminary groundwater modeling assessments of GMA 12. The GMA 12 modeling assessments included estimates of existing, permitted and likely permitted pumping levels (Brazos G Regional Water Planning Group, 2011). The groundwater availability for the Brazos River Alluvium Aquifer was set equal to the 2006 regional water plan estimates, and the Yegua-Jackson Aquifer availability was calculated from net recharge rate and area of outcrop (Brazos G Regional Water Planning Group, 2006 and 2011).

For its 2011 Regional Water Plan (Region H, 2011), Region H used groundwater availability estimates for the Carrizo-Wilcox, Queen City, and Sparta aquifers from the 2006 Regional Water Plan (Region H, 2006 and 2011).

For its 2011 Regional Water Plan (Lower Colorado Regional Water Planning Group, 2011), the Lower Colorado Regional Water Planning Group used the availability of the Carrizo-Wilcox Aquifer in Bastrop County from the Lost Pines Groundwater Conservation District Groundwater Management Plan. The availability in Fayette County was taken from the Fayette County Groundwater Conservation District Groundwater Management Plan (Lower Colorado Regional Water Planning Group, 2011). Availability for the Queen City, Sparta, and Yegua-Jackson aquifers in Fayette County were based in the Fayette County Groundwater Conservation District Groundwater Management Plan, and for Bastrop County they were based on the 2000 Region K Water Supply Plan (see Lower Colorado Regional Water Planning Group, 2011).

2012 State Water Plan Existing Water Supplies plus Recommended Water Management Strategies

Currently available water supplies are those water supplies that have been permitted or contracted and that have infrastructure in place to transport and treat the water. Some water supplies that are permitted or contracted for use do not yet have the infrastructure in place. Connecting such supplies is considered a water management strategy (see Region C Regional Water Planning Group, 2011). Existing groundwater supplies plus recommended groundwater strategies represents possible future use of groundwater according to the state water plan.

One of the recommended mater management strategies included in GMA 12 in Lost Pines Groundwater Conservation District (Tables 2 and 3; Figures 10 and 11) is an export to the Region L area (South Central Texas Regional Water Planning Group, 2011). The 2011 Region L Regional Water Plan includes recommended water management strategies that would result in overdrafting the groundwater in certain locations (overdrafting is when groundwater supplies plus groundwater water management strategies exceeds the groundwater availability) if all the recommended projects were actually implemented. These projects were recognized as 'overdraft' water management strategies in the Region L plan (South Central Texas Regional Water Planning Group, 2011).

The Region L plan acknowledges that implementing many of the recommended water management strategies will require obtaining additional groundwater permits from groundwater conservation districts. The Region L plan acknowledges that implementation of groundwater projects is uncertain and contingent upon groundwater permits from various groundwater conservation districts (South Central Texas Regional Water Planning Group, 2011).

In the event that one of the associated, recommended water management strategies becomes infeasible (that is, due to failure to obtain groundwater pumping permits) the Region L plan includes backup recommended water management strategies and/or alternative water management strategies that could be substituted to meet the associated identified water needs (South Central Texas Regional Water Planning Group, 2011).

The Region L plan acknowledges that all these recommended projects could only be implemented if an additional quantity of groundwater is determined to be available and is permitted by the associated groundwater conservation districts (South Central Texas Regional Water Planning Group, 2011).

Estimated Recharge from Precipitation

We used the GAMs for the central part of the Carrizo-Wilcox and Queen City and Sparta aquifers (Kelley and others, 2004) and the Yegua-Jackson Aquifer (Deeds and others, 2010) to estimate the average historical (1980 to 1999) recharge from precipitation. Recharge for the Brazos River Alluvium was estimated by multiplying the outcrop area by the average precipitation from 1971 through 2000 and an effective recharge rate of 7.5 percent (Bradley, 2011).

Estimated Maximum Sustainable Pumping

We developed estimates of maximum sustainable pumping using the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers (Kelley and others, 2004) and the Yegua-Jackson Aquifer. We determined the maximum rate of pumping that would result in stable water levels after a long period of time (500 years).The estimate does not account for costs associated with a certain level of pumping or possible impacts of pumping such as reduced water quality and decreased outflow to streams and springs.

Comparison Summary

For the Carrizo-Wilcox Aquifer in GMA 12 the 2012 State Water Plan groundwater availability exceeds the draft modeled available groundwater (MAG) by about 50,000 acre-feet per year in 2010, but by 2060 the draft MAG exceeds the 2012 State Water Plan availability by about 16,000 acre-feet per year (Table 2; Figure 10). For GMA 12 the Carrizo-Wilcox Aquifer draft

MAG is greater than existing water supplies plus recommended water management strategies over the entire 50-year modeling period.

For the Queen City, Sparta, Yegua-Jackson, and Brazos River Alluvium aquifers in GMA 12 the state water plan groundwater availability exceeds the draft modeled available groundwater (MAG) over the entire 50-year modeling period (Tables 4, 6, 8, and 9, respectively).

In the Lost Pines Groundwater Conservation District the Carrizo-Wilcox draft MAG is less than the state water plan groundwater availability by about 16,000 acre-feet per year in 2010, but by 2060 the draft MAG is approximately equal to the state water plan groundwater availability (Table 3; Figure 11). Existing water supplies plus recommended water management strategies are less than the draft MAG in 2010, but exceed the draft MAG by about 40,000 acre-feet per year in 2060. However, when Region L strategies are excluded, the Carrizo-Wilcox Aquifer draft MAG for Lost Pines Groundwater Conservation District is greater than existing water supplies plus recommended water management strategies over the entire 50-year modeling period (Table 3; Figure 11).

For the Queen City and Sparta aquifers in Lost Pines Groundwater Conservation District the state water plan groundwater availability exceeds the draft MAG over the entire 50-year modeling period (Tables 5 and 7 respectively).

As mentioned above, the 2011 Region L Regional Water Plan includes recommended water management strategies that would result in overdrafting the groundwater in certain locations if all the recommended projects were actually implemented. These projects were recognized as 'overdraft' water management strategies in the Region L plan (South Central Texas Regional Water Planning Group, 2011).

Table 2. Groundwater Management Area 12 (Total Area) Carrizo-Wilcox Aquifer All values in acre-feet per year except where noted.

Decade	2010	2020	2030	2040	2050	2060
Draft Modeled Available Groundwater	195,735	211,278	219,047	233,129	250,069	257,482
2012 State Water Plan Groundwater Availability	242,533	241,958	241,796	241,682	241,658	241,658
TWDB Estimated Exempt Use	10,282	11,049	15,250	15,530	15,707	15,897
2012 State Water Plan Existing Water Supplies plus Recommended Water Management Strategies	156,268	188,355	191,405	217,684	245,161	245,475
2003 Groundwater Pumping	120,580					
Estimated Recharge	157,000					
Estimated Storage Volume (acre-feet)	1,137,000,000					
Estimated Maximum Sustainable Pumping	44,707					

Table 3. Lost Pines Groundwater Conservation District - Carrizo-Wilcox Aquifer All values in acre-feet per year except where noted.

Decade	2010	2020	2030	2040	2050	2060
Draft Modeled Available Groundwater	39,125	44,002	44,068	49,457	54,845	55,878
2012 State Water Plan Groundwater Availability	55,533	55,533	55,533	55,533	55,533	55,533
TWDB Estimated Exempt Use	7,594	8,435	12,707	13,045	13,275	13,501
2012 State Water Plan Existing Water Supplies plus ***all** Recommended Water Management Strategies	30,508	62,295	64,794	75,973	94,699	94,949
2012 State Water Plan Existing Water Supplies plus †**Region G and Region K** Recommended Water Management Strategies	30,508	32,295	34,794	45,973	44,922	45,172
2003 Groundwater Pumping	13,035					
Estimated Recharge	29,387					
Estimated Storage Volume (acre-feet)	228,000,000					
Estimated Maximum Sustainable Pumping	14,277					

*These totals include exports to South Central Texas region L

†These totals include only those strategies for use in Regions G and K

Table 4. Groundwater Management Area 12 (Total Area)-Queen City Aquifer All values in acre-feet per year except where noted.

Decade	2010	2020	2030	2040	2050	2060
Draft Modeled Available Groundwater	3,618	3,697	5,468	3,720	3,708	3,708
2012 State Water Plan Groundwater Availability	13,545	13,545	13,545	13,545	13,545	13,545
TWDB Estimated Exempt Use	2,544	2,832	3,793	3,942	4,061	4,193
2003 Groundwater Pumping	3,101					
Estimated Recharge	49,135					
Estimated Storage Volume (acre-feet)	167,000,000					
Estimated Maximum Sustainable Pumping	1,166					

Table 5.Lost Pines Groundwater Conservation District-Queen City Aquifer All values in acre-feet per year except where noted.

Decade	2010	2020	2030	2040	2050	2060
Draft Modeled Available Groundwater	1,315	1,215	2,880	1,144	1,134	1,133
2012 State Water Plan Groundwater Availability	2,855	2,855	2,855	2,855	2,855	2,855
TWDB Estimated Exempt Use	1,591	1,760	2,624	2,693	2,739	2,784
2003 Groundwater Pumping	1,713					
Estimated Recharge	7,284					
Estimated Storage Volume (acre-feet)	33,000,000					
Estimated Maximum Sustainable Pumping	470					

Table 6. Groundwater Management Area 12 (Total Area)-Sparta Aquifer All values in acre-feet per year except where noted.

Decade	2010	2020	2030	2040	2050	2060
Draft Modeled Available Groundwater	15,311	17,648	24,035	22,387	23,587	23,597
2012 State Water Plan Groundwater Availability	37,128	37,128	37,128	37,128	37,128	37,128
TWDB Estimated Exempt Use	1,819	1,977	2,527	2,616	2,684	2,770
2003 Groundwater Pumping	5,779					
Estimated Recharge	48,433					
Estimated Storage Volume (acre-feet)	82,000,000					
Estimated Maximum Sustainable Pumping	4,165					

Table 7. Lost Pines Groundwater Conservation District-Sparta Aquifer All values in acre-feet per year except where noted.

Decade	2010	2020	2030	2040	2050	2060
Draft Modeled Available Groundwater	2,405	2,236	5,315	1,980	1,885	1,877
2012 State Water Plan Groundwater Availability	5,534	5,534	5,534	5,534	5,534	5,534
TWDB Estimated Exempt Use	1,049	1,143	1,640	1,678	1,704	1,730
2003 Groundwater Pumping	177					
Estimated Recharge	13,733					
Estimated Storage Volume (acre-feet)	13,000,000					
Estimated Maximum Sustainable Pumping	872					

Table 8. Groundwater Management Area 12 (Total Area)-Yegua-Jackson Aquifer All values in acre-feet per year except where noted.

Decade	2010	2020	2030	2040	2050	2060
Draft Modeled Available Groundwater	27,540	27,540	27,540	27,540	27,540	27,540
2012 State Water Plan Groundwater Availability	35,700	35,700	35,700	35,700	35,700	35,700
TWDB Estimated Exempt Use	1,660	1,725	1,812	1,867	1,916	1,998
2003 Groundwater Pumping	NA					
Estimated Recharge	164,497					
Estimated Storage Volume (acre-feet)	109,000,000					
Estimated Maximum Sustainable Pumping	3,687					

Table 9. Groundwater Management Area 12 (Total Area)-Brazos River Alluvium Aquifer All values in acre-feet per year except where noted.

Decade	2010	2020	2030	2040	2050	2060
Draft Modeled Available Groundwater	25,138	25,138	25,138	25,138	25,138	25,138
2012 State Water Plan Groundwater Availability	45,359	45,359	45,359	45,359	45,359	45,359
TWDB Estimated Exempt Use	23	25	26	27	27	27
2003 Groundwater Pumping	29,565					
Estimated Recharge	23,456					
Estimated Storage Volume (acre-feet)	NA					
Estimated Maximum Sustainable Pumping	NA					

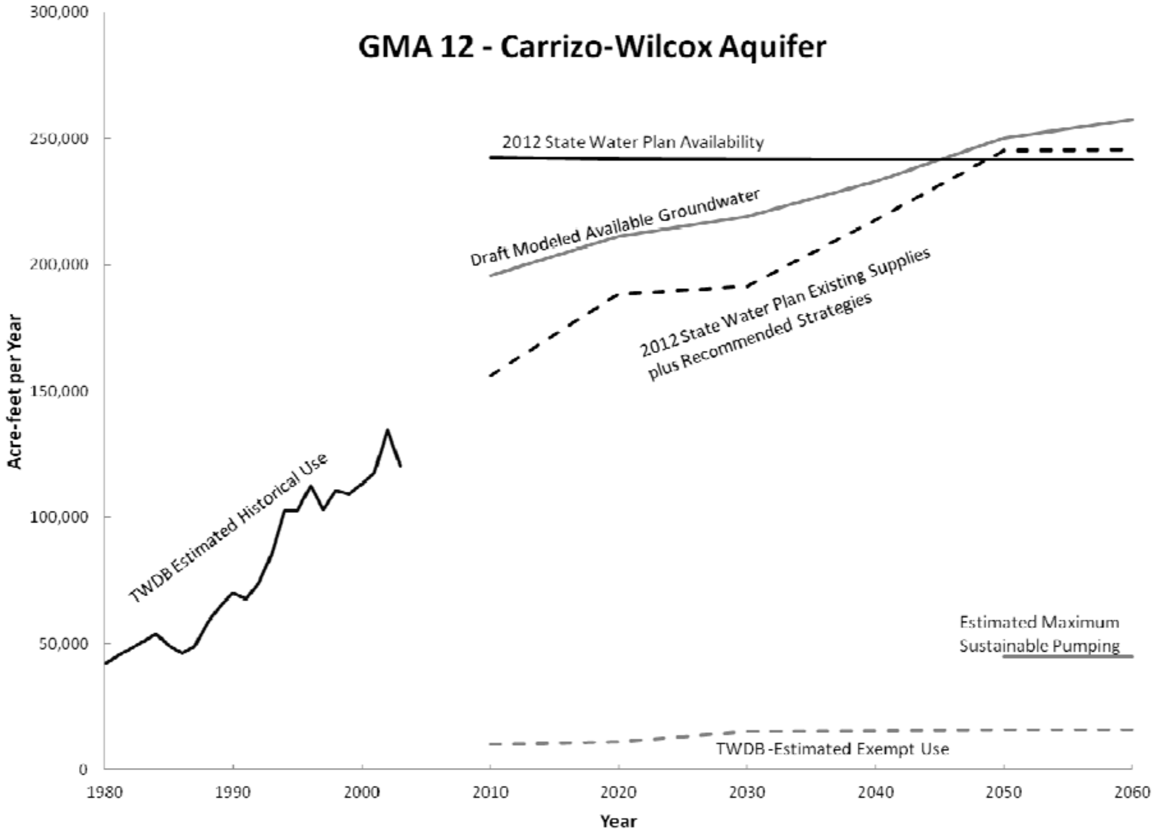


Figure 10. Comparison of various groundwater planning amounts for the Carrizo-Wilcox Aquifer in Groundwater Management Area 12.

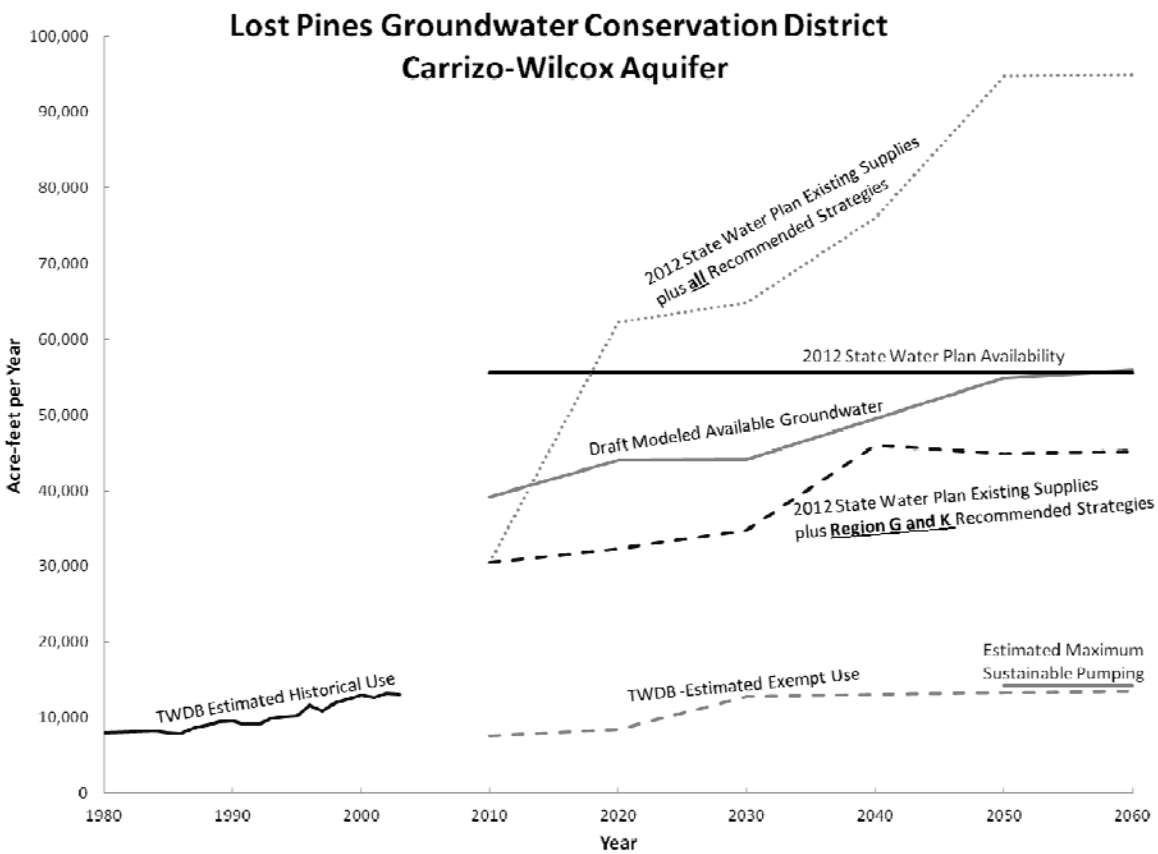


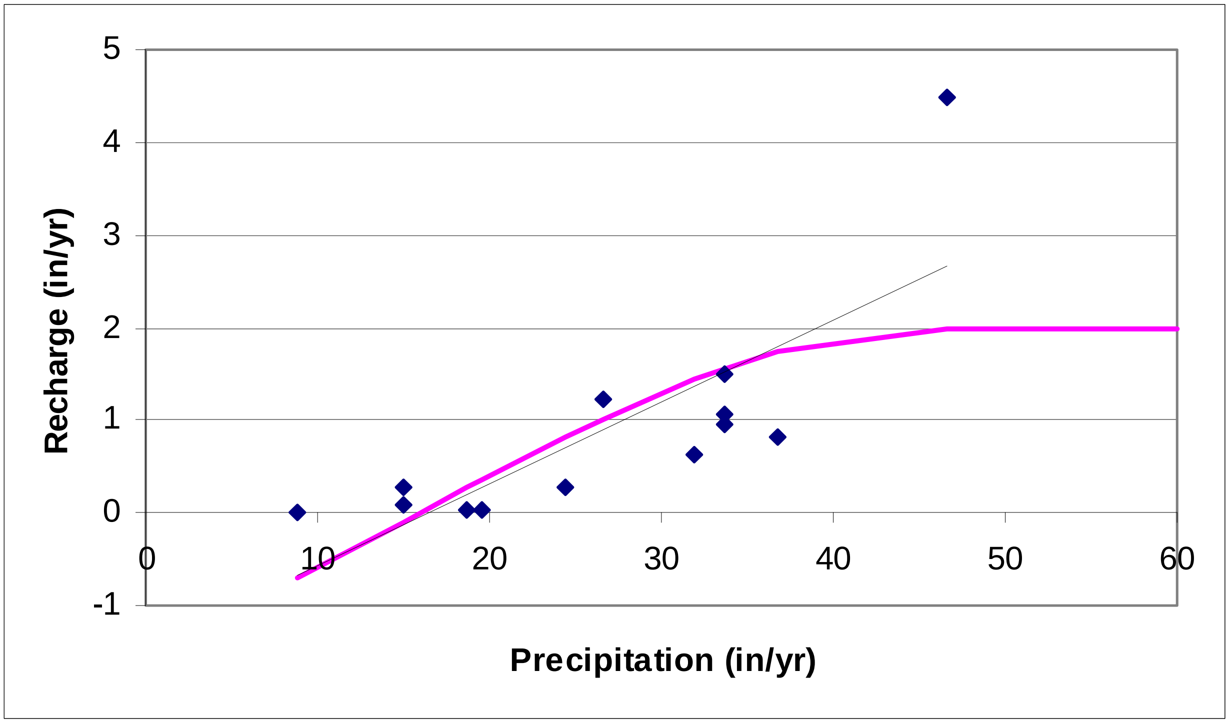
Figure 11. Comparison of various groundwater planning amounts for the Carrizo-Wilcox Aquifer in Lost Pines Groundwater Conservation District.

SECTION 5: MODEL RECHARGE AND GROUNDWATER/SURFACE WATER INTERACTION

Implementation of Recharge in the Groundwater Availability Models for the Carrizo-Wilcox, Queen City and Sparta Aquifers

The Carrizo-Wilcox, Queen City and Sparta aquifers GAMs treat the diffuse recharge as a function of precipitation, underlying geologic properties, and topography (Kelley and others, 2004). These relationships were used to relate recharge to precipitation with recharge capped at two inches per year for annual average precipitation rates of greater than 45 inches per year and recharge set equal to zero for annual average of precipitation rates less than 16 inches per year (Figure 12). Model recharge input was estimated from the precipitation relationship (Figure 12) and then scaling factors were applied to account for elevation differences (Figure 13) and underlying geology (Figure 14) (Kelley and others, 2004).

Evapotranspiration rates (Figure 15) and extinction depths (Figure 16) were estimated from the Soil Water Assessment Tool (SWAT, 2000; Kelley and others, 2004). As water levels decline in the model, evapotranspiration discharge decreases which allows more water to travel to the confined portion of the aquifer.



$$R(P)=\begin{cases} C_1\left(1.5\dfrac{P-O}{A}-0.5\left(\dfrac{P-O}{A}\right)^3\right) & (P-O)<A \\ C_1 & (P-O)\geq A \end{cases}$$

Figure 12. Recharge as a function of precipitation (From Kelley and others, 2004; after Scanlon et al., 2003). R = recharge, p = precipitation, A = 30 in/year, C_1 = 2 in/year, o = 16 in/year

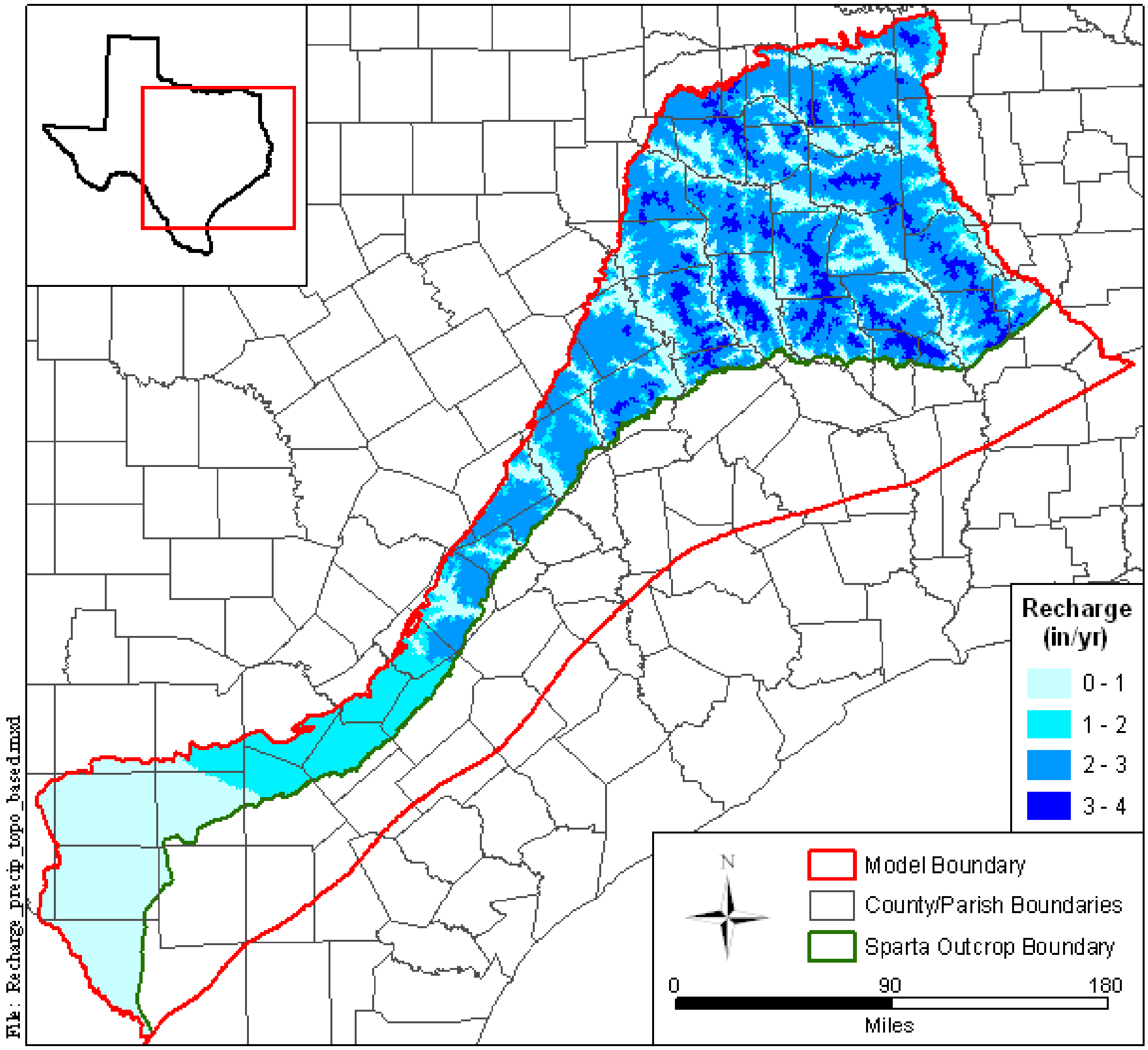


Figure 13. Recharge distribution based upon precipitation and topography (from Kelley and others, 2004).

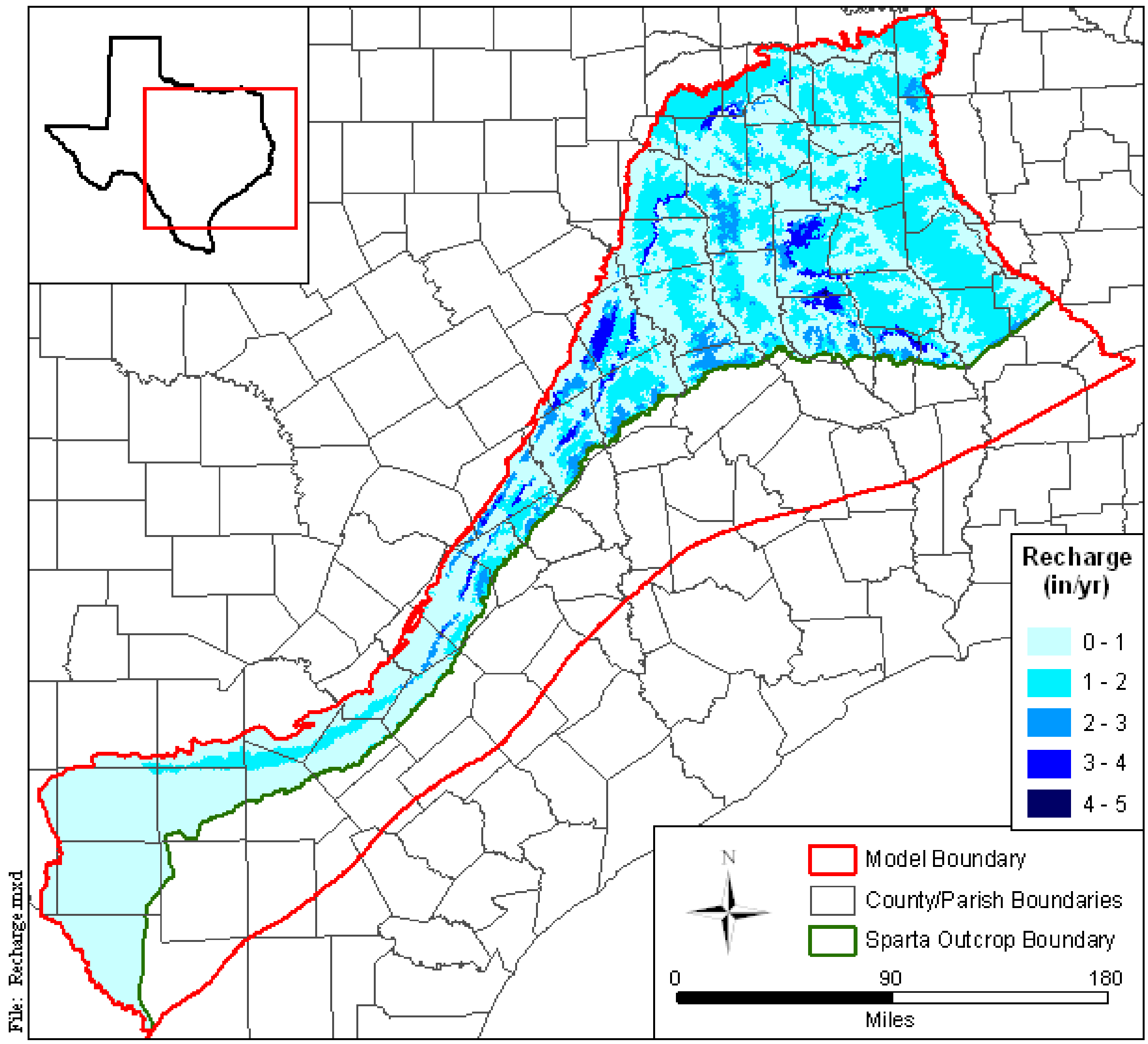


Figure 14. Calibrated recharge estimate based upon precipitation, topography, and geology (from Kelley and others, 2004).

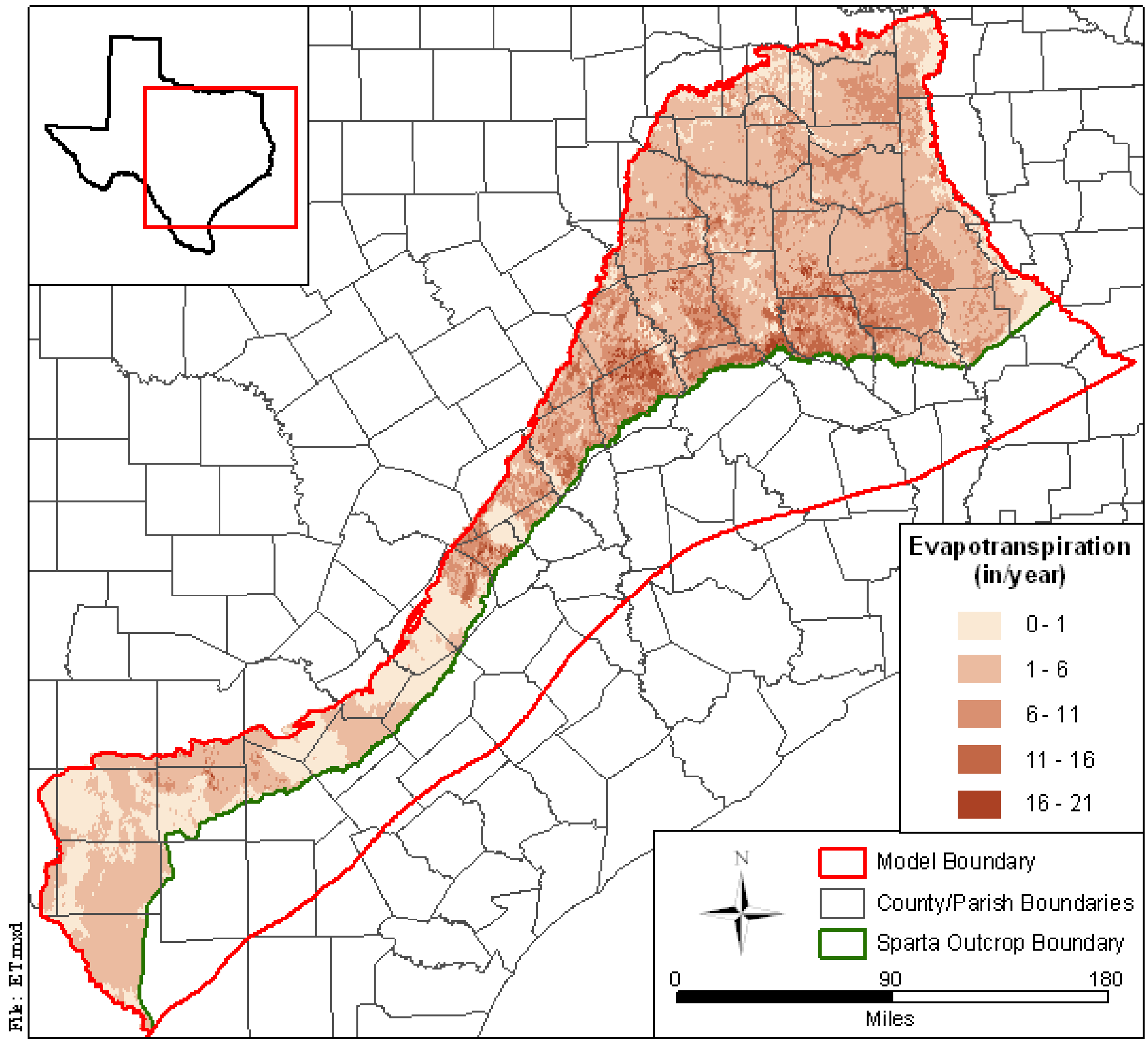


Figure 15. Average evapotranspiration maximum estimated by SWAT (from Kelley and others, 2004).

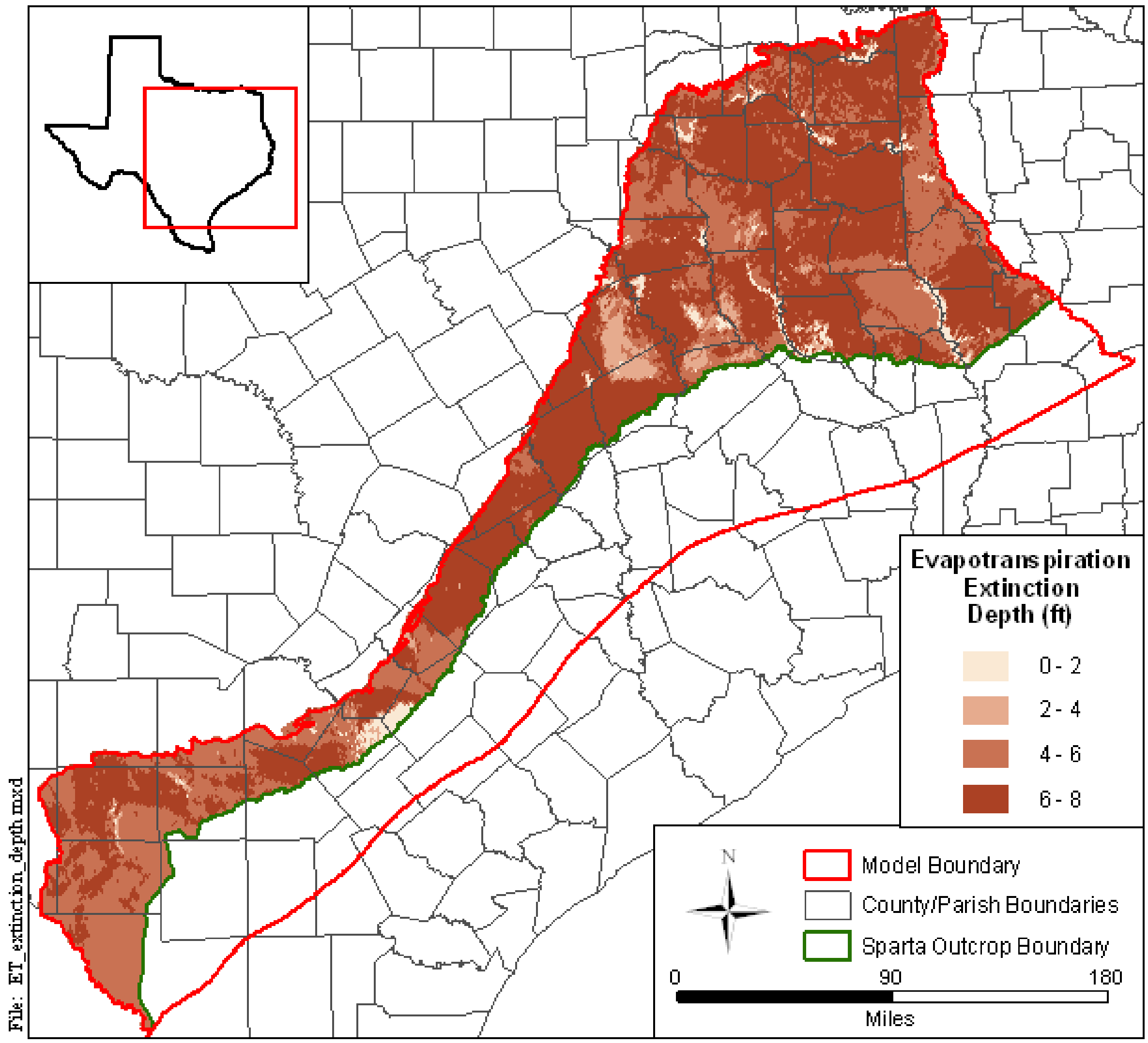


Figure 16. Evapotranspiration extinction depth estimated by SWAT (from Kelley and others, 2004).

Groundwater Availability Model and Groundwater/Surface Water Interaction

A base-flow study was conducted by the consultants developing the GAM for the central portion of the Carrizo-Wilcox Aquifer (Dutton and others, 2003; O'Rourke and Choffel, 2003), a predecessor of the GAM for the central part of the Carrizo-Wilcox, Queen City, and Sparta Aquifers (Kelley and others, 2004). Results of this study were also used as targets to calibrate the current model (see HDR targets on Figures 17 and 18). The base-flow study noted that although it has been suggested that recent groundwater development would result in less groundwater discharge compared with historical times, the unit values calculated from the base-flow analysis showed no evidence of a decreasing trend with time (Dutton and others,2003; O'Rourke and Choffel, 2003).

Saunders (2009) conducted a low-flow gain-loss study of the Colorado River and estimated a total net gain to the Colorado River from the Carrizo-Wilcox Aquifer in Bastrop County of 30 cubic feet per second. This estimate compared well with a U.S. Geological Survey estimate of 36 cubic feet per second from 1918 and an LCRA estimate of 50 cubic feet per second in 2005 (Saunders, 2009). Saunders (2009) also noted that flow from bedrock aquifers through the alluvium to the river is a complicated system and requires further data and analysis.

The GAMs use the MODFLOW streamflow routing package to model aquifer interaction with major streams and rivers for the Carrizo-Wilcox, Queen City and Sparta Aquifers. A surface-water elevation is assigned to a stream or reservoir cell and this elevation is compared with the model calculated head in the aquifer. Flow between the stream and the aquifer are determined by the head gradient and stream-bed conductance values (Dutton and others, 2003; O'Rourke and Choffel, 2003).

As part of the model calibration, two sets of gain/loss data were compared to the model results for the transient calibration period. Dutton and others (2003) included a WAM based analysis and the HDR targets (O'Rourke and Choffel, 2003) were from hydrograph separation studies discussed above. For the Colorado and Brazos rivers the model slightly under-predicts HDR estimates (O'Rourke and Choffel, 2003) of stream gain/loss for 1989 and 1996 (Figures 17 and 18). The net flow from the aquifers to the streams simulated by the GAM through the transient calibration period declines by approximately 50,000 acre-feet per year during the calibration period (Figure 19; Hutchison, 2009).

Although a GAM provides a first-order approach to coupling surface water to groundwater, which is adequate for the regional scale modeling, the model does not provide a rigorous solution to surface water modeling in the region and should not be used as a surface water modeling tool in isolation (Kelley and others, 2004).

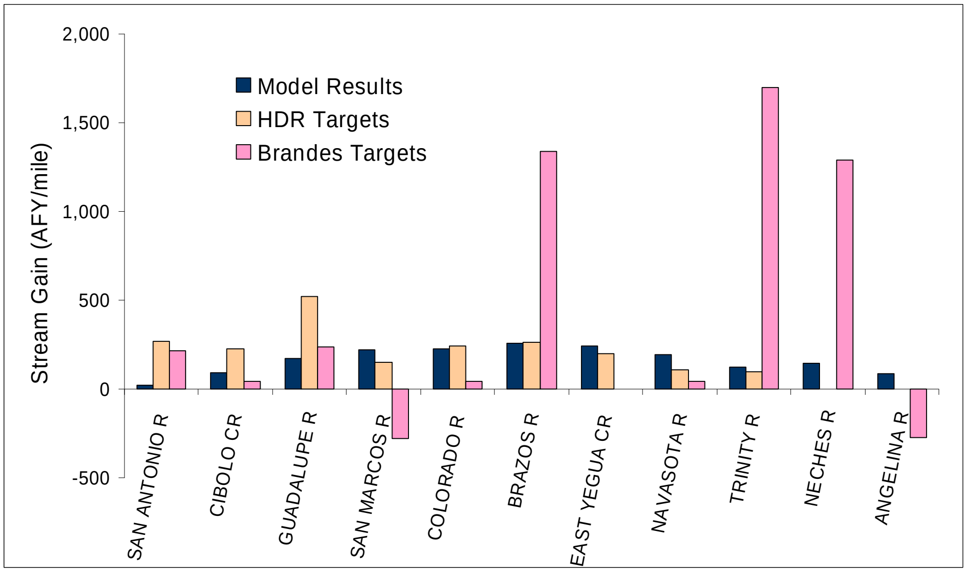


Figure 17. Comparison of 1989 transient model stream gain/loss to measured gain/loss (from Kelley and others, 2004).

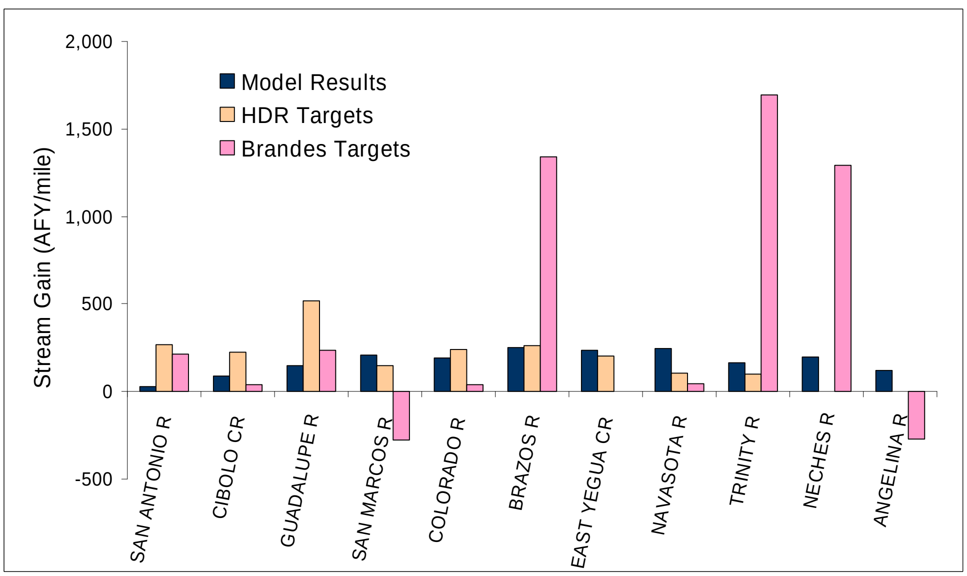


Figure 18. Comparison of 1996 transient model stream gain/loss to measured gain/loss (from Kelley and others, 2004).

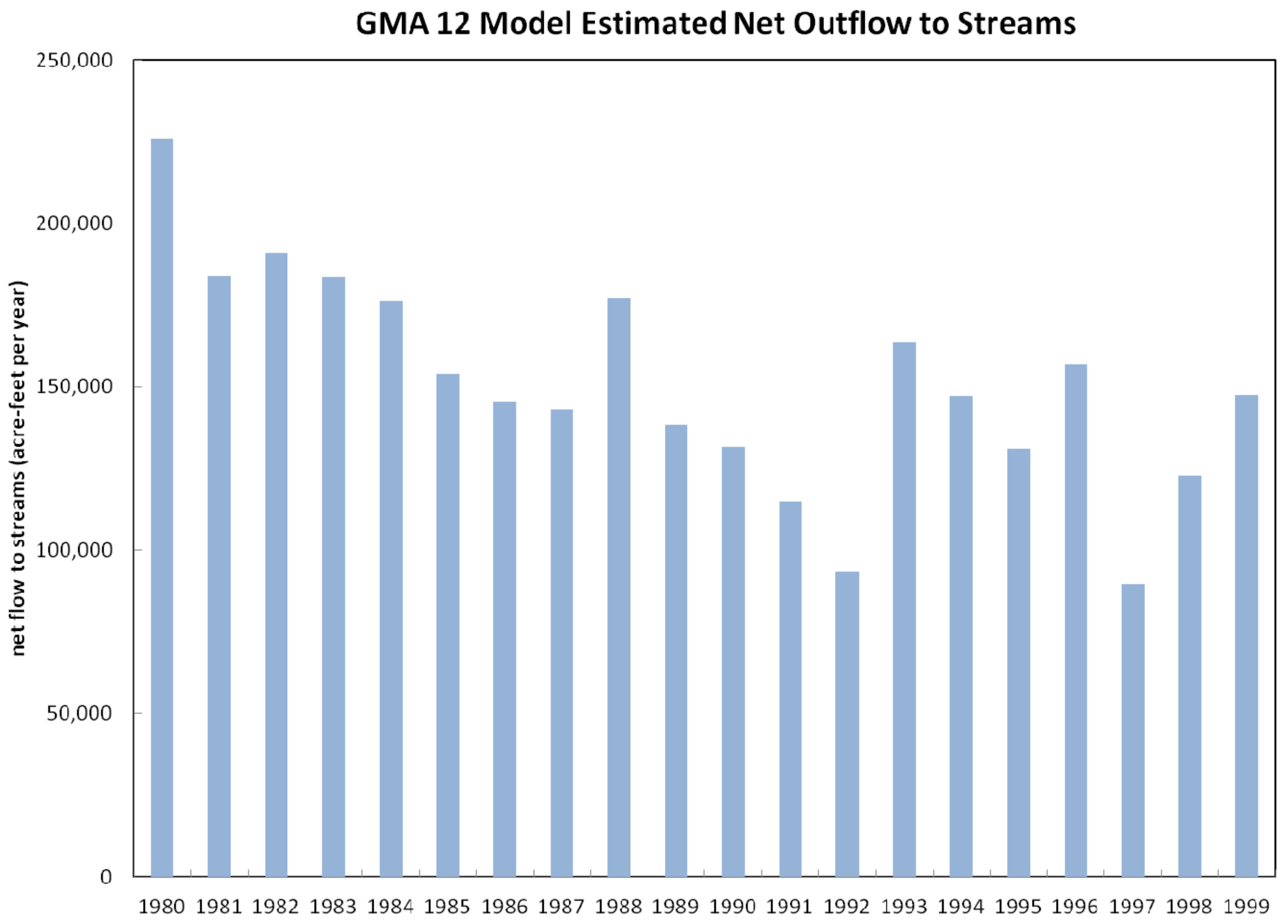


Figure 19. Net flow to streams in Groundwater Management Area 12 simulated by groundwater availability model during calibration period of 1980-1999 (Hutchison, 2009).

SECTION 6: MODEL PARAMETERS, ASSUMPTIONS, and LIMITATIONS

We used version 2.02 of the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers for this analysis. See Dutton and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. We used version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer. See Deeds and others (2010) for assumptions and limitations of the groundwater availability model for the Yegua-Jackson Aquifer.

The groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers includes eight layers, which generally correspond to (from top to bottom) the Sparta Aquifer, the Weches Formation, the Queen City Aquifer, the Reklaw Formation, the Carrizo Aquifer, the Wilcox Group (Calvert Bluff Formation, Simsboro Aquifer, and Hooper Formation). The groundwater availability model for the Yegua-Jackson includes five layers representing the Yegua-Jackson Aquifer and the overlying Catahoula unit.

The root mean squared error (a measure of the difference between simulated and measured water levels during model calibration) in the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers is 22 feet for the Sparta Aquifer, 27 feet for the Queen City Aquifer, 36 feet for the Carrizo Aquifer, and 31 feet for the Simsboro Aquifer for the calibration period (1980 through 1989) and 24, 33, 32, and 43 feet for the same aquifers, respectively, in the verification period (1990 through 1999) (Kelley and others, 2004).

The mean absolute errors (a measure of the difference between simulated and measured water levels during model calibration) for the Jackson Group (combined upper and lower Jackson units), Upper Yegua, and Lower Yegua portions of the aquifer for the historical-calibration period of the model are 31, 24, and 25 feet, respectively. These represent 1, 6, and 6 percent of the hydraulic head drop across each model area, respectively (Deeds and others, 2010).

Groundwater in the Carrizo-Wilcox, Queen City, and Sparta aquifers ranges from fresh to brackish in composition (Kelley and others, 2004). Groundwater with total dissolved solids of less than 1,000 milligrams per liter are considered fresh and total dissolved solids of 1,000 to 10,000 milligrams per liter are considered brackish.

The groundwater models used in completing this analysis are the best available scientific tools that can be used to meet the stated objective(s). To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and streamflow are specific to a particular historic time period.

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

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Appendix A

Modeled Available Groundwater Divided by Groundwater Conservation District for each unit of the Carrizo-Wilcox Aquifer

Table A.1 Draft modeled available groundwater for the Carrizo Unit of the Carrizo-Wilcox Aquifer in Groundwater Management Area 12.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Brazos Valley GCD	4,985	5,428	5,425	5,453	5,493	5,496
Fayette County GCD	1,000	1,000	1,000	1,000	1,000	1,000
Lost Pines GCD	6,610	7,618	8,358	9,263	11,800	12,052
Mid-East Texas GCD	11,755	11,336	11,185	11,121	11,092	11,088
Post Oak Savannah GCD	4,025	4,706	5,177	6,118	6,353	7,059
Total (excluding non-district areas)	**28,375**	**30,088**	**31,145**	**32,955**	**35,738**	**36,695**
No District	-	-	-	-	-	-
Total (including non-district areas)	**28,375**	**30,088**	**31,145**	**32,955**	**35,738**	**36,695**

Table A.2 Draft modeled available groundwater for the Calvert Bluff Unit of the Carrizo-Wilcox Aquifer in Groundwater Management Area 12.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Brazos Valley GCD	1,777	1,762	1,756	1,756	1,755	1,755
Fayette County GCD	0	0	0	0	0	0
Lost Pines GCD	1,785	2,226	2,633	3,183	3,912	3,985
Mid-East Texas GCD	3,405	3,565	3,681	3,788	3,901	3,912
Post Oak Savannah GCD	502	1,038	1,038	1,038	1,038	1,038
Total (excluding non-district areas)	**7,469**	**8,591**	**9,108**	**9,765**	**10,606**	**10,690**
No District	215	218	223	228	235	235
Total (including non-district areas)	**7,684**	**8,809**	**9,331**	**9,993**	**10,841**	**10,925**

Table A.3 Draft modeled available groundwater for the Simsboro Unit of the Carrizo-Wilcox Aquifer in Groundwater Management Area 12.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Brazos Valley GCD	71,725	76,761	83,163	88,133	92,988	96,185
Fayette County GCD	0	0	0	0	0	0
Lost Pines GCD	29,556	32,731	31,362	34,916	36,544	37,249
Mid-East Texas GCD	6,664	6,933	7,040	7,120	7,165	7,170
Post Oak Savannah GCD	36,507	38,468	37,899	40,041	46,027	48,501
Total (excluding non-district areas)	**144,452**	**154,893**	**159,464**	**170,210**	**182,724**	**189,105**
No District	9,797	9,852	9,950	10,093	10,339	10,339
Total (including non-district areas)	**154,249**	**164,745**	**169,414**	**180,303**	**193,063**	**199,444**

Table A.4 Draft modeled available groundwater for the Hooper Unit of the Carrizo-Wilcox Aquifer in Groundwater Management Area 12.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Brazos Valley GCD	324	319	317	317	316	316
Fayette County GCD	0	0	0	0	0	0
Lost Pines GCD	1,174	1,427	1,715	2,095	2,589	2,592
Mid-East Texas GCD	834	805	826	832	828	827
Post Oak Savannah GCD	899	2,960	4,139	4,433	4,433	4,422
Total (excluding non-district areas)	**3,231**	**5,511**	**6,997**	**7,677**	**8,166**	**8,157**
No District	2,196	2,125	2,160	2,201	2,261	2,261
Total (including non-district areas)	**5,427**	**7,636**	**9,157**	**9,878**	**10,427**	**10,418**