Environmental Stewardship
A Sustainable Ecosphere

June 24, 2009

Groundwater Management Area 12
Groundwater Conservation Districts (5)
Boards of Directors
c/o P.O. Box 92
Milano, Texas 76556

Re: Protection of Rivers, Streams, and Springs through Desired Future Conditions

Dear Boards of Directors:

Environmental Stewardship fully embraces the desired future conditions (DFC) process established by HB 1763 and believes this is one of the most important steps in establishing a water management plan that provides for our future water needs while protecting the water and other natural resources of the region. We are at a critical juncture in the State planning process where it is the duty and responsibility of Groundwater Management Districts, Groundwater Management Areas, and the Texas Water Development Board to accurately estimate the amount of groundwater available in the future so regional planning groups like the Lower Colorado and Brazos Regional Water Planning Groups (Regions K and G respectively) can accurately plan to meet water demands.

A gross over-estimation of the groundwater available at this juncture will cause crisis in future years if the amount of groundwater expected is not available without causing damage to the surface water resources of the region. It will be very difficult for our cities and communities to find other sources of water if they have already installed infrastructure and made contracts for groundwater that is not really available. If, as the models predict, pumping in the Carrizo-Wilcox and related aquifers start damaging base flows to the Colorado and Brazos rivers, and the streams, creeks and springs in our region, Groundwater Districts will be hard pressed to take corrective actions unless they have included the protection of these very valuable natural resources in the desired future conditions of the aquifers that contribute water to these surface features.

By including river and stream base-flows and spring flows in the planning at this juncture more accurate estimates can be made on the amount of groundwater that can be made available without damaging these resources. Regions K and G will then have more reliable groundwater estimates to use in their current and future planning processes and will not be caught short at some time in the future.

Therefore, our request is three-fold:

1) protect the rivers, streams and spring that depend on groundwater,
2) provide our water planners with the best estimates possible in order to avert crisis in the future, and
3) **that GMA-12 request that TWDB (or any other entity running GAM(s)) provide quantitative information on the impact on surface waters for any GAM runs that model the DFC of the aquifers of GMA-12 and that such results be reported in a duly announced public hearing where unlimited public comments are allowed.**

The appendices to this letter demonstrate that:

A. there is adequate quantitative data on the Colorado River to include it in the DFC's,
B. over-pumping threatens the groundwater-surface water relationship,
C. groundwater models make adequate provision for rivers, streams and springs to include in DFC's,
D. flow measurement technology exists to quantitatively monitor river & spring flows, and
E. groundwater management areas have a duty to protect surface water resources.

Therefore,

GMA-12 has a duty and obligation to include rivers, streams and springs in the DFC's.

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SUMMARY

Based on these findings and the statutes of the Texas Constitution and Texas Water Code, Groundwater Management Area 12 has a duty and responsibility to take actions in setting the desired future conditions of the groundwater resources in a manner that protects the rivers, streams and springs of the GMA-12 counties. As described in Robert Mace's April 9, 2009 letter (Attachment 1) TWDB rules require them to consider, among other things, "the environmental impacts including, but not limited to, impacts to spring flow or other interactions between groundwater and surface water" in relation to any petition to the TWDB challenging the reasonableness of an adopted desired future condition. It would seem appropriate for the GMA-12 Districts to likewise consider these same environmental impacts in setting the desired future conditions for the groundwater resources.

Environmental Stewardship, on behalf of these natural resources, request that the GMA-12 Board of Directors take such actions as are necessary to protect base flows to the Colorado and Brazos rivers, streams and springs in the counties by including them in the desired future conditions of the area.

Respectfully submitted,
Environmental Stewardship

Steve Box
Executive Director

Environmental Stewardship is a charitable nonprofit organization whose purposes are to meet current and future needs of the environment and its inhabitants by protecting and enhancing the earth's natural resources; to restore and sustain ecological services using scientific information; and to encourage public stewardship through environmental education and outreach. We are a Texas nonprofit 501(c) (3) public charity headquartered in Bastrop, Texas. For more information visit our website http://Environmental-Stewardship.org/ .

April 9, 2009

Laura B. Marbury, P.G.
Texas Water Project Director
Environmental Defense Fund
44 East Avenue
Austin, Texas 78701

Re: TWDB's role in the desired future condition adoption process

Dear Ms. Marbury:

In your letter dated March 30, 2009, you asked several questions concerning the adoption of desired future conditions and the Texas Water Development Board's (TWDB) role in the process. Below are your specific questions (in italics) and our responses.

Please explain at what point(s), if any, in the GMA process does the TWDB evaluate the GMA adopted Desired Future Conditions and resulting Managed Available Groundwater numbers? What criteria are used in the evaluation?

After groundwater conservation districts have adopted their desired future conditions, they are required to submit them to the TWDB. Once received, we ensure that an administratively complete submission has been provided (TAC §356.31–356.35). We also evaluate whether or not the adopted desired future conditions are physically possible, both individually and collectively. If these requirements are met, then we calculate the managed available groundwater amounts and provide drafts of these amounts to the groundwater conservation districts for review. Our board has requested that staff bring them draft managed available groundwater amounts for review before the final amounts are provided to the districts and the regional water planning groups; however, our board does not have approval authority over the amounts or the associated desired future conditions.

If a person with a legally defined interest in groundwater submits a petition to the TWDB challenging the reasonableness of an adopted desired future condition, then our board may review the reasonableness of the desired future condition. As required by our rules (TAC §356.45(i)), our board will consider the following criteria when assessing reasonableness:

(1) whether or not 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;
(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.

Our board may recommend a change to the desired future condition, the districts will then hold a public hearing on the recommended change and then revise the desired future condition based on the board's recommendation and public comment.

Is there a requirement or recommendation by the TWDB for the GMAs to base desired future conditions and the potentially resulting Managed Available Groundwater numbers on the current regional water planning demand projections?

There is no requirement by the TWDB for groundwater conservation districts to base desired future conditions on the current demand projections for regional water planning. However, in our capacity as technical liaisons, we have advised districts to consider regional water planning information, as well as other information, in their evaluations of desired future conditions. We have also recommended that districts communicate and collaborate closely with the regional water planning groups, especially because planning groups can challenge the reasonableness of desired future conditions.

I hope this clarifies our role in the desired future condition process. If you have any additional questions, please do not hesitate to contact me at (512) 936-0861 or Ms. Rima Petrossian of my staff at (512) 936-2420.

Sincerely,

Robert E. Mace, Ph.D., P.G.
Deputy Executive Administrator
Water Science and Conservation

Appendix A – BASE FLOW DATA ON THE LOWER COLORADO RIVER

COLORADO RIVER AND SPRINGS GAIN WATER FROM AQUIFERS

Base flows to the Colorado River - Groundwater Availability Model for the Central Part of the Carrizo-Wilcox Aquifer in Texas, Appendix B "Surface Water–Groundwater Interaction in the Central Carrizo-Wilcox Aquifer"

A copy of Appendix B of the above report is available on the Texas Water Development Board website at: http://www.twdb.state.tx.us/gam/czwx_c/CZWX_c_%20AppendixB_97_Final.pdf

Historical Records – Historical data were reviewed and included in developing the groundwater availability model for the central Carrizo-Wilcox Aquifer ("Groundwater Availability Model for the Central Part of the Carrizo-Wilcox Aquifer in Texas", Appendix B titled "Surface Water–Groundwater Interaction in the Central Carrizo-Wilcox Aquifer"). This document cites a 1918 USGS Low Flow study of the Colorado River from about Utley down to Smithville (river miles 380-425). Base-flow increases across the aquifer outcrop area were estimated to be 36 cfs (26,062 ac-ft/yr). A flow-duration curve generated from the Smithville gage indicated that "even during conditions of extremely low flow, the Colorado River (was) still a gaining reach across the outcrop of the Carrizo-Wilcox aquifer. The flow increase documented in the 1918 study may be compared with the results obtained from the model to estimate the low end of groundwater discharge in the Colorado River across the outcrop (i.e., few, if any, modeled aquifer discharge quantities should be less than this value)."

In this same report, a base-flow separation analysis for the Colorado River from Bastrop to Smithville was conducted using gage records from the years 1960-75 and 1997-2000. These studies estimated increase across that portion of the aquifer at 25,773 ac-ft/yr (35.599 cfs).

LCRA Operations Project – The LCRA is currently conducting studies on the Colorado River to assist in their management of water releases from the highland lakes to meet water rights and environmental flows obligations. These studies include information on the gains/losses of the river as it flows through Bastrop County and may provide some additional quantification the amount of base flow the river gains during the dry period such as has occurred over the last two years. LCRA has indicated that this information will be made public when analysis of the data is completed (expected later this spring).

In a study related to the LCRA Operations Project released in 2006 (TWDB publication 365, Aquifers of the Gulf Coast of Texas, Saunders 2006) the author concluded that "the lower Colorado River is a gaining stream that receives groundwater contributions from major and minor aquifers." Analysis of USGS data contained in the report (Table 19.1), though inconclusive, shows a gain of about 50 cubic feet per second (cfs) in the reaches passing over the Carrizo-Wilcox between Utley and Smithville; about 99 ac-ft/day. Limited field work in 2005 also suggested that the Colorado River has some stream flow gain from groundwater in these reaches; however, since the data were not adjusted for all known gains and losses, the gains cannot be attributed solely to groundwater (Table19.2).

The following tables were created from data included in the study:

From Table 19-1 USGS 1999-2000 Streamflow data.

Reach	Median adjusted gain/loss from groundwater cfs*	ac-ft/day*
Austin-Bastrop	-9	-18
Bastrop-Smithville	59	117
Austin-Smithville	50	99

From Table 19-2 LCRA low flow investigation**

	November 2005 flow measurement		
	Flow	Gain/loss**	
Reach/location	cfs*	cfs*	ac-ft/day*
Utley	332		
Utley-Bastrop	430	98	194
Bastrop-Smithville	382	-48	-95
Utley-Smithville		50	99

* 1 cfs (cubic feet per second) = 1.9835 ac-ft/day

** flows are un-adjusted for all known gains and losses therefore cannot be attributed solely to groundwater

In a follow-up study conducted in November 2008 (Attachment 2) the author concluded: "the total net gain to the Colorado River from the Carrizo-Wilcox aquifer in Bastrop County was estimated to be 30 cfs during the November 2008 low flow event. This compares to the USGS 1918 estimate of 36 cfs, and the LCRA estimate of 50 cfs in November 2005.

Thus, the potential ground water contribution of flow to the Colorado River from the Carrizo-Wilcox aquifer may be significant, particularly when compared to more well-known sources such as Barton Springs in Austin, which was flowing at 19 cfs during the field investigation in November 2008. Such contributions to the base flow from these sources can be important during critical low-flow conditions.

Although ground water flow in sand aquifers is generally considered to be slow and steady, it is possible that ground water contributions to the lower Colorado River may be variable from one time period to another. However, a study of ground water – surface water interaction prepared as part of development of the Central Carrizo-Wilcox groundwater availability model (GAM) indicated that base-flow rates of rivers crossing the aquifer outcrop have not decreased over time, and seasonal variability in base flow for perennial streams may not fluctuate significantly (Dutton, et al., 2003). In addition, flow from bedrock aquifers through the alluvium to the river is a complicated system and deserves more understanding. As demands on ground water resources increase with future growth in the Central Texas region, ground water – surface water interactions may need to be periodically monitored to assess water availability in the decades to come".

Many undocumented springs flowing during current drought

There are many documented and undocumented springs in Bastrop and Lee Counties that have continued to flow throughout the last two droughts. These springs are important to the citizens and should serve as indicators (canaries) of the condition of our aquifers by ensuring that they are documented and monitored in a quantitative manner. Texas Parks and Wildlife Department has an ongoing program to help locate, document, and monitor springs throughout the State. Springs are an integral part of the groundwater-surface water interaction (see TPWD comments in other sections of this letter). Many springs provide base-flows to the creeks and streams in the GMA-12 counties.

Appendix B – OVER-PUMPING THREATENS GROUNDWATER-SURFACE WATER RELATIONSHIP

Lower Colorado Region Water Planning Group (Region K) – Region K recognized that one of the threats to the Colorado River is over-pumping of groundwater. The 2006 Region K Water Plan states: "The Carrizo-Wilcox aquifer's primary water quantity concern is the water-level declines anticipated through the year 2060 due to increased pumping." "The TWDB co-sponsored a study of the Central Texas portion of the Carrizo-Wilcox aquifer using a computer model to assess the availability of groundwater in the area." "The simulated water-level declines in the Carrizo-Wilcox aquifer mainly reflect a pressure reduction within the aquifer's artesian zone. Some dewatering takes place in the center of certain pumping areas. In addition, simulations indicate that drawdown within the confined portion of the aquifer will significantly increase the movement of groundwater out of the shallow, unconfined portions to the deeper artesian portions of the aquifer. **The relationships that currently exist between surface and groundwater may also change. Simulations indicate that the Colorado River, which currently gains water from the Carrizo-Wilcox aquifer, may begin to lose water to the aquifer by the year 2050.**" (Section 1.2.4.2 Threats Due to Water Quantity Issues, page 1-44; emphasis added).

Texas Parks and Wildlife Department -- TPWD has expressed its concerns about the potential impacts of groundwater use on springs and base flows to rivers and streams. In a presentation to the GMA-12 on May 10, 2007, the TPWD estimated that the Carrizo-Wilcox, Queen City and Sparta Aquifers in GMA-12 region will contribute 128 cfs (93,000 acre-feet per year) less flow to surface water bodies in 2060 as compared to 2002 (2007 estimate) with the then projected pumping rates (more recent estimates are136 cfs; 98,460 ac-ft/yr). Based on this estimate the TPWD urged GMA-12 to include stream flow in the GMA-12's desired future conditions metric and to 1) consider impacts to surface water during DFC deliberations, 2) include quantitative impacts to surface water in DFC definitions, and 3) improve the GAMs in their representation of Groundwater/Surface water interaction.

TPWD proposed that stream flow be used as a DFC metric because 1) stream-flows have a direct impact on the environment, 2) surface water rights have been authorized contingent on the historical stream-flow record, and 3) stream-flows are a highly visible characteristic of the Texas landscape. TPWD further emphasized the importance of springs because they support unique aquatic environments, including rare species, serve as a barometer of local aquifer conditions (canaries), are relatively inexpensive means of monitoring groundwater, and provide important base-flows to rivers. Base-flows, he emphasized, are dependent on aquifer discharge, are important component of natural flow regime, and support habitats during dry periods.

This information was reiterated in a presentation to the GMA-12 at a public hearing on October 30, 2008 by Environmental Stewardship.

TPWD Public Comments at GMA-12 March 1, 2007 meeting: According to the minutes of the meeting that took place earlier in the year, "Dan Opdyke of Texas Parks and Wildlife stated that TP&W is interested in the process of determining DFCs by the GMAs and encouraged GMA 12 to consider in stream flows and the impacts that groundwater resources have on base flows of surface water by contributing water to the surface water. **Mr. Opdyke also stated that TP&W has years of data that could be useful in this process**."

GROUNDWATER AVAILABILITY MODELS (GAM) -- Adequately quantify groundwater-surface water relationship

It appears that there is adequate science and technology available to use the historical and developing data on the groundwater – surface water relationship of the Colorado River and the Carrizo-Wilcox aquifer to merit quantitative inclusion in the desired future conditions. As demonstrated in the information following, the Carrizo-Wilcox GAM has been developed and calibrated to base-flow data on the Colorado River and several streams within the region. The LSWP model and the monitoring program demonstrate that the science and technology are available and in use on the Colorado River to model and monitor the groundwater – surface water interactions. **This same science and technology should be employed to protect the Carrizo-Wilcox Aquifer and the Colorado and Brazos rivers from over-pumping in our region.**

Carrizo-Wilcox GAM 2003 Based on the data reviewed in developing the Central Carrizo-Wilcox GAM (see Historical Records above) the model was calibrated and verified to the historical period of 1980-2000. Table B-4 in the study shows the calibration targets of the Colorado River, Middle Yegual Creek, and the East Yegual Creek; gives the layer, row and column of the target cells for the river and creeks; and gives the estimated base-flow increase across the outcrop. The Colorado River base flow increase was adjusted from 32,400 ac-ft/year to 26,100 ac-ft/year to correspond to the 1918 USGS study cited above.

Table 6 gives calibration targets for the Colorado River, Big Sandy Creek, Middle Yegua Creek, and East Yegua Creek; all found within Bastrop and Lee Counties. **It is clear that the GAM for the central part of the Carrizo-Wilcox has been calibrated to include base flows for the Colorado River and three tributaries in Bastrop and Lee counties. It is expected that GAM analysis of various pumping regimes in these counties would have corresponding impacts on the values of the cells that represent these surface water features and therefore could be used to predict the impact of these regimes on these surface water features. GMA-12 should request that these analyses be included in any GAM runs conducted to evaluate the impact of the collective DFC for the management area.**

It appears that there are "target cells" that represent input/output flows from the GAM to specific surface water features like the Colorado River (cell layer 1, row 39, column 85), therefore:

1. Any GAM run should produce a value in each cell that represents the flow of water in/out of that cell (in ac-ft/yr).

2. From the Appendix it appears that the low-flow conditions for the Colorado River cell was based on the 1918 low flow study which was 36 cfs (26,062 ac-ft/yr). It appears that "median" is set at 32,700 ac-ft/yr. The "minimum" and "maximum" flow increases across the outcrop are likewise based on the same conditions

3. The Queen City/Sparta GAM, which replaced the Carrizo-Wilcox GAM, is likely set at the same levels based on the same data (unless there has been "adjustments").

LCRA-SAWS LSWP Groundwater Model

Though most groundwater availability models (GAM) are weak in representing the groundwater – surface water relationships, the LCRA SAWS Water Project (LSWP) Groundwater Flow Model for the Chicot and Evangeline Aquifers in Colorado, Wharton, and Matagorda Counties was developed to simulate the groundwater – surface water interaction of the these aquifers with the Colorado River (Available on the LCRA-SAWS website). The study included the task to "develop and calibrate a groundwater model capable of simulating the impacts of the LSWP's pumping activities on drawdown, land subsidence, groundwater availability estimates, and changes in surface water-groundwater interactions".

The following paragraph from the report describes the conceptual context of the model: "All of the interaction between groundwater and the rest of the hydrological cycle occurs in the shallow groundwater system. These interactions include recharge, evapotranspiration, and exchange of water between surface water and groundwater. Many regional groundwater models for the Texas Gulf Coast such as the Groundwater Availability Models (GAMs) (Kasmarek and Robinson, 2004; Chowdhury and others, 2002) do not have sufficient vertical discretization to model a shallow aquifer system. **Based on the groundwater system described by Young and Kelley (2006), a groundwater model should explicitly represent a shallow flow system to provide a reasonable representation of the vertical hydraulic gradients and the interaction between groundwater and surface water.**"

The LSWP model developed used six calibration targets to represent the base flows for the Colorado, West Lavaca, East Lavaca, Brazos-Colorado East, and Colorado Lavaca river basins. All of the calibration targets were estimated by base flow separation of river gauge data for the years cited, except for the Colorado which was obtained from the LCRA study (Saunders, 2006) performed from 2005 to 2006 cited elsewhere in this letter. The authors of the model reported that "the model provides excellent matches to the field data."

The model has been used to predict changes in the groundwater contribution to base-flow in the Colorado River from projected pumping rates over the 80 year life of the LCRA-SAWS project (unpublished report).

A monitoring program has been set up in four locations along the Colorado River at Eagle Lake, Wharton, Bay City and Wadsworth. Shallow wells (<100 ft) have been located near river gages in these locations to provide additional data to demonstrate Colorado is a gaining stream and to demonstrate large differences in hydraulic head in shallow and deep aquifer. A description of the conceptual model and details regarding location of monitoring wells are available in "Groundwater Monitoring network and Proposed Hydrogeologic Field Work to Support On-going Assessments of the LSWP Impacts on Drawdown – Final" at the LCRA website under "Well Monitoring and Future Field Work Technical Memorandum (January 2006):
http://www.lcra.org/library/media/public/docs/lswp/findings/monitoring_report_final.pdf

Appendix C – FLOW MEASUREMENT TECHNOLOGY

Adequate to quantify river and stream base-flows.

The science and technology available for river and stream gain/loss studies has improved steadily over the last 10-20 years. Acoustic Doppler Current Profiling (ADCP) is now an accepted practice that is used throughout the world and in Texas. The U.S. Geological Survey (USGS), Texas Commission on Environmental Quality (TCEQ), Texas Parks and Wildlife Department (TPWD), Texas Water Development Board (TWDB) Lower Colorado River Authority (LCRA), Guadalupe-Blanco River Authority (GBRA) and the Edwards Aquifer Authority (EAA) are among the many agencies using ADCP technology to measure river, stream and spring flows in Texas. Below are but a few citations:

1. U.S. Stream Flow Measurement and Data Dissemination Improve, EOS, Vol. 85, No. 20, 18 May 2004
2. Evaluation of Acoustic Doppler Velocity Meters to Quantify Flow From Comal Springs and San Marcos Springs, Texas, USGS Scientific Investigations Report 2008–5083 in cooperation with the Edwards Aquifer Authority
3. Jacob's Well Continuous Water Quality and Stream Flow and Monitoring Project Plan, Texas Commission on Environmental Quality, USGS Project Number 8653D2R.
4. LSWP Groundwater for Agriculture during Drought Low Flow Gain-Loss Study (Saunders 2006)
5. Analysis of Stream flow Data in Tidal Streams of the Texas Coast (This report has been edited to only include Texas mid-coast streams) Submitted to the Texas Parks and Wildlife Department for the Use Attainability Assessment Project. Texas Water Development Board Surface Water Resources Division Bays and Estuaries Unit
6. Comprehensive Annual Financial Report Fiscal Year Ended August 31, 2002, Guadalupe-Blanco River Authority (GBRA).

Appendix D – DUTY TO PROTECT SURFACE WATER RESOURCES

The powers and duties of GMA-12 reflect the collective powers and duties of the Groundwater Conservation Districts within GMA-12 as follows:

The Texas Constitution provides for the creation of "conservation districts" and the Texas Water Code establishes the purpose, powers and duties of Groundwater Conservation Districts (GCD). The purpose of a GCD includes (but is not limited to) providing for the conservation, preservation, protection, recharging, and prevention of waste of groundwater, and of groundwater reservoirs or their subdivisions. The powers and duties include (but are not limited to) the responsibility to develop a comprehensive management plan which addresses the management goals of (among other goals):

1) **conjunctive surface water management issues**,
2) natural resource issues, and
3) in a quantitative manner the desired future conditions of the groundwater resources.

In the management plan the District is instructed by statue to include estimates of the following (among other things):

1) the managed available groundwater in the district based on the desired future condition established under Section 36.108;
2) **for each aquifer, the annual volume of water that discharges from the aquifer to springs and any surface water bodies, including lakes, streams, and rivers;**
3) the annual volume of flow into and out of the district within each aquifer and between aquifers in the district, if a groundwater availability model is available;
4) **the projected surface water supply in the district according to the most recently adopted state water plan; and**

Though not explicitly stated within the Texas Water Code, **groundwater conservation districts have duties to evaluate the potential impact of groundwater withdrawals on existing permit holders and surface waters within their jurisdiction.** By logical extension, it is reasonable that GCDs would exercise the same level of diligence by considering the impact of their overall groundwater withdrawal and management plans.

Pursuant to Sec. 36.113 (d) of the Texas Water Code, GCD's have a responsibility to evaluate permits to determine if proposed use of water unreasonably affects existing groundwater and surface water resources or existing permit holders. Likewise it would seem incumbent upon GCD's to consider these factors relative to the overall withdrawal of water within their jurisdiction. **GCD's have a duty to show that it has adequately evaluated the impact of the proposed desired future conditions on the existing permit holders, spring-flows and base flows to the surface waters of the region before adopting such desired future conditions that might significantly alter current conditions.**

Pursuant to Sec. 36.113 (e) of the Texas Water Code, GCD's have a duty to impose more restrictive permit conditions as are reasonably necessary to protect existing users.

Pursuant to Sec. 36.122 (f) of the Texas Water Code, GCD's have a duty to show that it has adequately reviewed the potential for transferring groundwater out of the district including:

(1) the availability of water in the district and proposed receiving area during the period for which transfer is anticipated **in conjunction with the surface water impacts**, and

(2) the projected effect of the proposed transfer on aquifer conditions, depletion, subsidence, or effects on existing permit holders or other groundwater users within the District **in conjunction with the surface water impacts**.

Draft Submission June 2009 for the TWDB "Aquifers of the Upper Coastal Plains of Texas" conference to be held in October 2009

Low-Flow Gain-Loss Study of the Colorado River in Bastrop County, Texas

Geoffrey P. Saunders, P.G., C.G.W.P.[1]

Introduction

A field investigation was conducted in November 2008 as a follow-up to previous gain-loss studies of the lower Colorado River in Texas. Previous studies conducted by the Lower Colorado River Authority (LCRA) of surface water – ground water interaction between the Carrizo-Wilcox aquifer and the Colorado River provided valuable information, but the results were inconclusive. A more detailed investigation was conducted by LCRA of gains or losses in river flow upstream and downstream from the outcrops of two productive aquifer units: the Simsboro sand and Carrizo sand formations.

Study Area

The lower Colorado River flows through Bastrop County in a meandering channel within a broad alluvial floodplain (Figure 1). Outcrops of the Simsboro sand and Carrizo sand formations are exposed along the banks of the river and underneath the alluvium associated with the river. The Simsboro sand formation is exposed in a 70-foot cliff at Powell Bend upstream from the town of Bastrop (Figure 2). The Carrizo sand formation underlies the Colorado River between Bastrop and the Colovista County Club measurement site shown on Figure 1. At some locations, small seeps and springs may be found along the banks of the river, but most ground water – surface interaction occurs through the river alluvium.

Previous Studies

Earlier low-flow investigations by the U.S. Geological Survey in 1918 found that the Colorado River gained about 36 cubic feet per second (cfs) across the outcrop of the Carrizo-Wilcox aquifer (TBWE, 1960). A study conducted by LCRA of stream flow hydrographs during low-flow conditions in 1999 found data suggesting a possible gain in river flow between gauging stations at Bastrop and Smithville of 59 cfs based upon the USGS stream gauge readings (Saunders, 2005). A field investigation conducted by LCRA in November 2005 also produced data suggesting a possible net gain in river flow from Utley to Smithville of 50 cfs (Saunders, 2006).

[1] Lower Colorado River Authority

Methodology

This study was conducted according to the methodology for low-flow investigations and gain-loss studies recommended by the U.S. Geological Survey (USGS, 1972 and Slade, et al., 2002). Conditions of steady river flow, dry weather, and minimal tributary inflows, discharges and withdrawals were ideal for a low-flow investigation during an ongoing dry period in late November 2008, thus the field investigation was conducted on November 24 and 25, 2008. Although river flow is continuously monitored at gauging stations at Bastrop and Smithville, for this study, flow measurements were taken at four mainstem locations as well as on any tributaries between Utley and Smithville in which flow was present. Streamflow was measured using acoustic Doppler velocity meters and portable cut-throat flumes. While best efforts were made to maximize the accuracy of stream flow measurements, the estimated error associated with this type of measurement is plus or minus four percent. Furthermore, although flow measurements were not taken continuously for the two-day period of this study, the river was considered to be in a near steady flow condition such that estimates of gains and losses could be calculated. In order to complete the calculations, all known discharges and withdrawals were verified by observation and checking with the operators.

Results

Results of data collection are shown in Table 1. The data is arranged in order from upstream to downstream to indicate relationships.

Table 1. Results of Data Collection, Nov. 24-25, 2008

Mainsteam	Off-Channel	Type	Flow, cfs	Inflow (-) Outflow (+)	Net Gain-Loss, cfs
Colorado River at Utley		river flow	231 cfs		
	Wilbarger Creek	tributary		0 cfs	
	Big Sandy Creek	tributary		-1.5 cfs	
	Sim Gideon pumping station	withdrawal		+30 cfs	
Colorado River at Bob Bryant Park		river flow	237 cfs		(237-231) - 1.5 + 30 = 34.5 cfs
	Piney Creek	tributary		0 cfs	
	City of Bastrop WWTP	discharge		-1 cfs	
	Gills Branch	tributary		0 cfs	
Colorado River at Colovista C.C.		river flow	234 cfs		(234-237) – 1 = -4 cfs
	Colovista C.C. pump	withdrawal		0 cfs	

	Cedar Creek	tributary		-0.5 cfs	
	Alum Creek	tributary		0 cfs	
	Gazley Creek	tributary		0 cfs	
Colorado River at Smithville		river flow	234 cfs	(234-234) – 0.5 = -.5 cfs	
				Net Gain	+30 cfs

River flow measurements at Utley, Bob Bryant Park upstream from Bastrop, Colovista Country Club downstream from Bastrop, and at Smithville were remarkably consistent, ranging between 231 and 237 cfs. There was a relatively large withdrawal of water at Powell Bend to supplement Lake Bastrop (30 cfs) during the field investigation. Tributaries inflows were negligible at Wilbarger Creek (0 cfs), Big Sandy Creek (1.5 cfs), Piney Creek (0 cfs), Gills Branch (0 cfs), Alum Creek (0 cfs), Cedar Creek (0.5 cfs) and Gazley Creek (0 cfs). The City of Bastrop wastewater treatment plant was discharging (1 cfs) during the field investigation.

Although there was no significant increase in river flow between the mainstem measurement sites, the relatively large withdrawal of water at Powell Bend for Lake Bastrop (30 cfs) factors into the analysis. Considering differences in measured river flow, tributary inflows and the withdrawal at Powell Bend, the data suggests a net gain between Utley and Bastrop of 30 cfs. Such a gain would most likely be attributable to ground water contribution to the Colorado River from the Simsboro sand formation.

Downstream from Bastrop, the data indicate no increase in river flow nor any significant withdrawals or discharges. Therefore, there was no apparent gain in river flow attributable to the Carrizo sand formation during the field investigation.

Conclusions

As shown in Table 1, the total net gain to the Colorado River from the Carrizo-Wilcox aquifer in Bastrop County was estimated to be 30 cfs during the November 2008 low flow event. This compares to the USGS 1918 estimate of 36 cfs, and the LCRA estimate of 50 cfs in November 2005.

Thus, the potential ground water contribution of flow to the Colorado River from the Carrizo-Wilcox aquifer may be significant, particularly when compared to more well-known sources such as Barton Springs in Austin, which was flowing at 19 cfs during the field investigation in November 2008. Such contributions to the base flow from these sources can be important during critical low-flow conditions.

Although ground water flow in sand aquifers is generally considered to be slow and steady, it is possible that ground water contributions to the lower Colorado River may be variable from one time period to another. However, a study of ground water – surface water interaction prepared as part of development of the Central Carrizo-Wilcox groundwater availability model (GAM) indicated that base-flow rates of rivers crossing the aquifer outcrop have not decreased over time, and seasonal variability in base flow for perennial streams may not fluctuate significantly (Dutton, et al., 2003). In addition, flow from bedrock aquifers through the alluvium to the river is a complicated system and deserves more understanding. As demands on ground water resources increase with future growth in the Central Texas region, ground water – surface water interactions may need to be periodically monitored to assess water availability in the decades to come.

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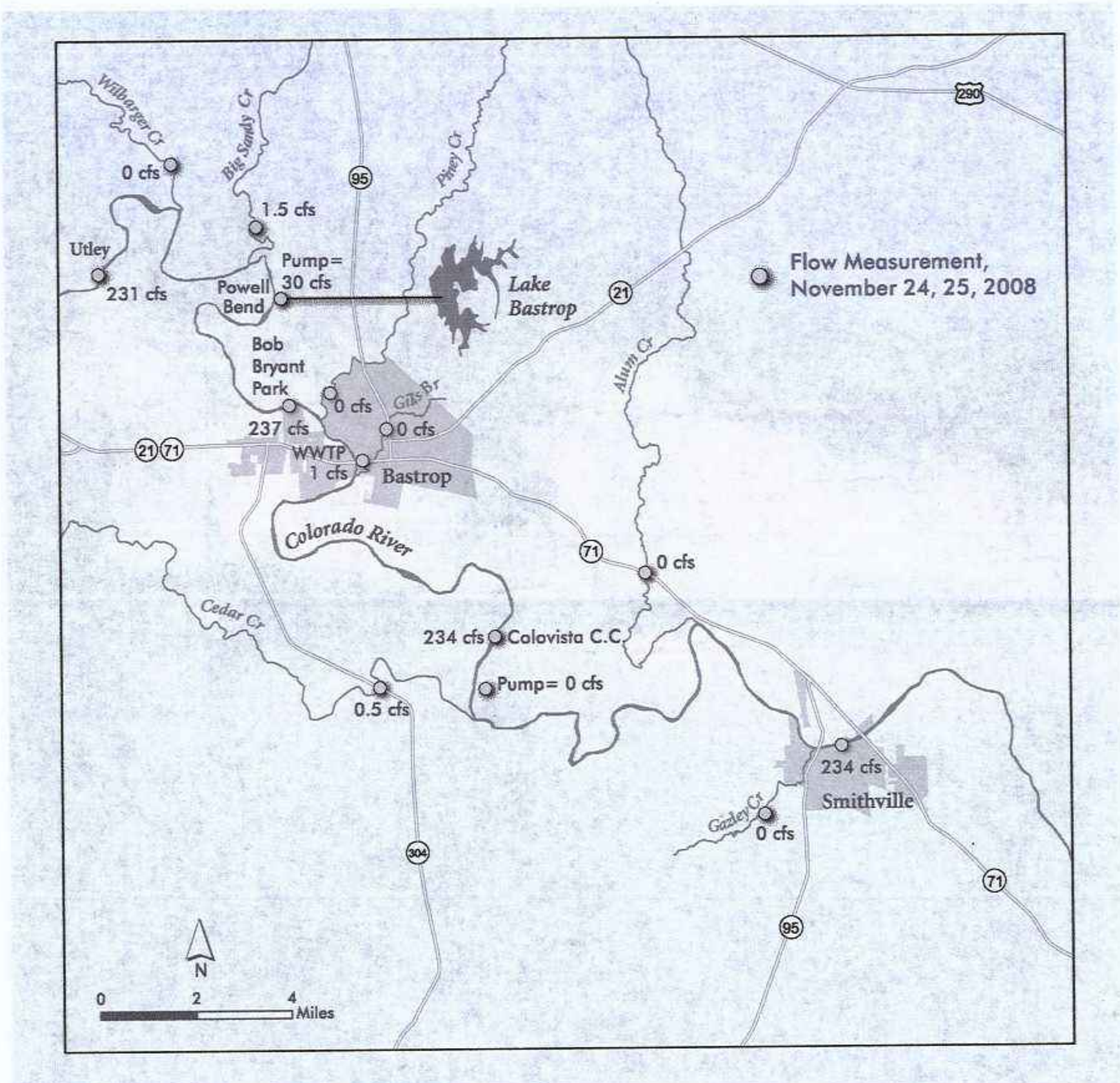

Figure 1. Low-flow measurements in the reach of the Colorado River from Utley to Smithville, Bastrop County, Texas, November 24-25, 2008 (LCRA graphic).

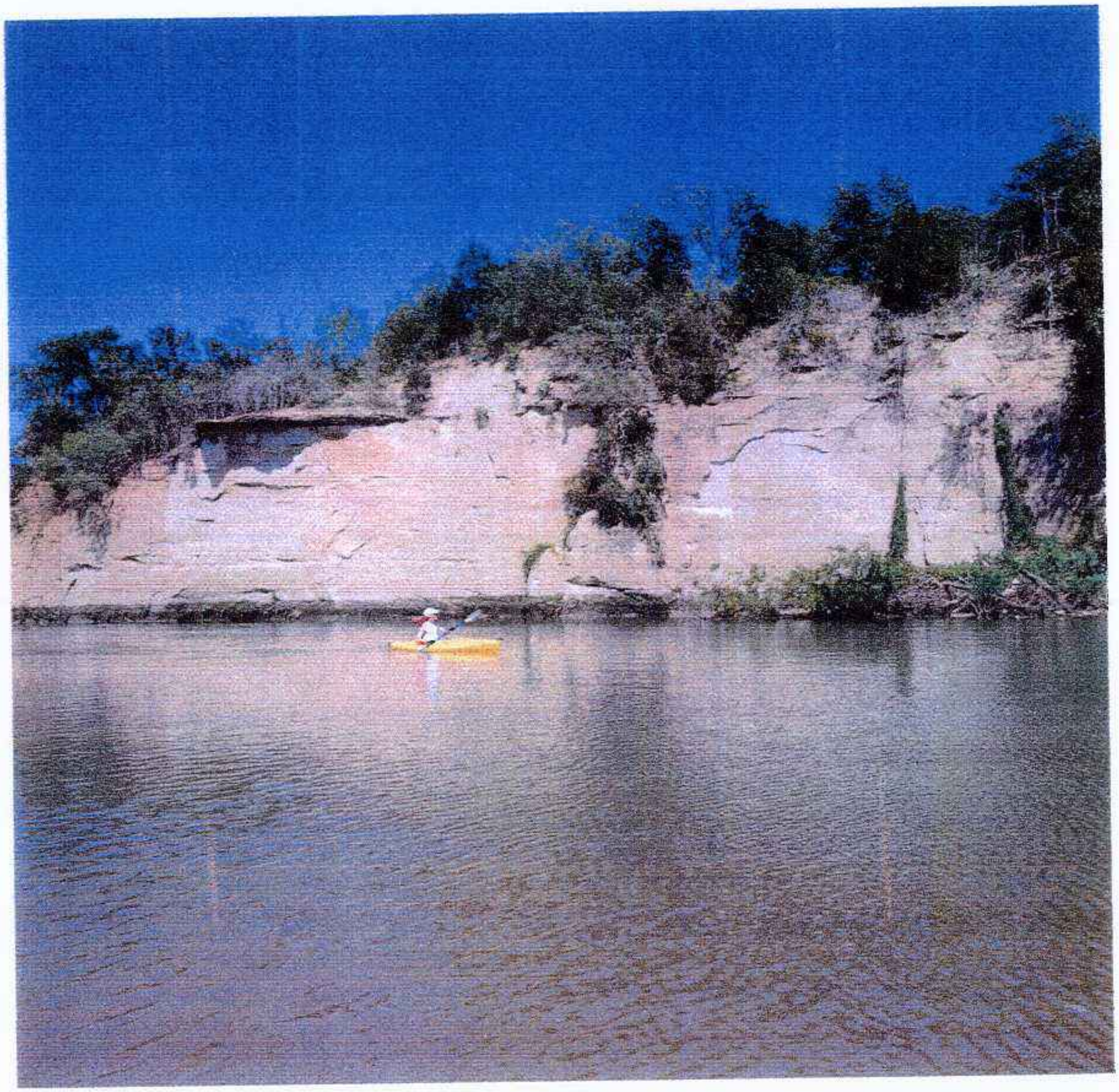

Figure 2. Outcrop of the Simsboro sand formation along the Colorado River at Powell Bend, Bastrop County, Texas (LCRA photo).