Proposed Desired Future Condition(s) for Aquifer(s) in GMA 12

Environmental Stewardship

Comments on Environmental Impact Presentation

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Proposed Desired Future Condition(s)

Please be as detailed as possible in describing your proposed DFC. Include the quantifiable value and a description of the method for measuring or calculating the value. Attach additional pages as needed.

Aquifer	Proposed DFC and Measuring/Calculating Method

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Consideration of Proposed Desired Future Condition(s)

The Texas Water code requires that the GMA develop DFCs that "provide a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence in the management area." In the space below, or on additional attached pages, please provide your considerations with regard to the nine items that must be considered, per the Texas Water Code, for the proposed DFC(s).

Consideration 1 – "Aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another:"

Consideration 2 – "The water supply needs and water management strategies included in the state water plan:"

See ES comments dated August 6, 2015

Consideration 3 – "Hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge:"

See ES Comments dated May 15, June 18, and August 6, 2015.

Consideration 4 – "Other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water:"

Environmental Stewardship (ES) greatly appreciates the information compiled by the Consultants and presented by Steve Young on August 13, 2015. The following comments are provided regarding the presentation.

First, ES wishes to acknowledge that the GMA-12 Carrizo-Wilcox, Queen City, and Sparta GAM does not appear to be a sufficient tool to fully model and predict, on a quantitative basis, the impacts of modeled pumping on surface waters (rivers and streams) and springs (drains) at the level needed and requires improvements. ES is also very pleased that Post Oak Savannah and Brazos Valley GCDs, LCRA and BRA have agreed to fund improvements in the groundwater-surface water capabilities of the model in the upcoming improvements in the faults and updating of data funded by the Texas Water Development Board. We appreciate that Lost Pines GCD is providing an in-kind contribution to this work. ES and INTERA have, this week, presented a request for funding to the Colorado-Lavaca Basin and Bay Area Stakeholder Committee (CL BBASC) to provide an additional $60,000 from its Cycle 2 funding to make further improvements to the GAM to make the river and stream simulations even more robust by reducing grid sizes around rivers and streams to 0.25 square mile where appropriate. We are hopeful that these improvements will enable the model to be used in localized modeling, monitoring, and conjunctive management of the rivers and aquifer systems in GMA-12.

Overall, ES asserts that the relationship between groundwater pumping and the impact of that pumping on the rivers and streams (outflow to surface water), springs (drains), and on the lowering of water tables and dewatering of regions of the aquifer will have significant, and, in some cases, perhaps unacceptable, impacts on the ecology and biological life in the rivers, streams and springs, and on terrestrial life at or near the land surface. These same impacts will also be experienced by human inhabitants in the form of reduced capacity or dry wells, less productive terrestrial landscape, reduced economic value of land, and increased economic costs as the ecological services provided by both groundwater and surface waters are lost and necessarily replaced in order to maintain a quality lifestyle in the region. Finally, we believe that these impacts are important considerations in determining the amount of water that is available for development from the aquifers in balancing conservation and development.

For these reasons we urge the GMA-12 member districts to value the understanding of these relationships and give thoughtful considerations to the implications of the trend data that can be derived from modeling and the evidence of impacts from monitoring. It is not adequate to this consideration to say that *we don't have adequate tools, so we are not going to take serious, and act on, trends that warn of future dangers*. To the contrary, it is incumbent upon us to use the best science we have available and common sense to estimate the potential impacts from the trends that are evident, and act accordingly. An appropriate action is to improve the tools, as is being done with the GMA-12 GAM improvement project, and to defer serious changes in the adopted desired future conditions until we have better information available from monitoring and the improved tools to predict impacts.

GMA-12 GAM Development Reports

One published reports discuss the development, calibration, and verification, predictions and limitations of the GMA-12 groundwater availability model (GAM) for the central part of the Carrizo-Wilcox Aquifer[1] major aquifer. GAMs are also available for the Queen City and Sparta Aquifers[2] and Yegau-Jackson[3] minor aquifers. A GAM is being developed for the Brazos River Alluvium minor aquifer. For purposes of this discussion I will concentrate on the Carrizo-Wilcox report since, as noted in the abstract, *during the past 2 decades about 90 percent of the water pumped from the aquifer was from the Simsboro and Carrizo formations*, and those same formations are targeted for yet additional major development.

NOTE: *italics* are used in this section to indicate text quoted from the report.

It is noteworthy that the authors indicate *a steady-state model representing "predevelopment" (no pumping) conditions was calibrated against water levels measured prior to 1950 and historical low-flow measurements in streams*, and that *uncertainty in calibrated water levels is less than or equal to 10 percent of the range of water-level measurements*.

At the time the model was calibrated and tested, the authors expected *total pumping from the Carrizo-Wilcox aquifer in the study area to increase from 194,000 acre-feet per year in 2000 to over 360,00 acre-feet per year in 2050*. Current GMA-12 estimates are for pumping to increase to 314,146 acre-feet for the Carrizo-Wilcox and 340,130 acre-feet per year for all aquifers[4] by 2070.

Overall, the authors conclude in the abstract that the *simulated decline of water level related to groundwater pumping will occur mainly through a decrease in artesian storage*. However, ES analysis[5] of the water budgets presented in the April 14 presentation on PS4 run seems to indicate that pumped water comes primarily from 1st) a reduction in outflows to rivers and streams, 2nd) from vertical leakage from other aquifers, 3rd) from lateral leakage from other districts, and lastly) from storage.

The authors also conclude in the abstract that the model also suggests that *the major rivers will continue to receive groundwater discharge even with increased pumping and under drought conditions*. They go further in section 4.6 - Interactions of Surface Water and Groundwater - to opine that *most of the discharge is probably from the Simsboro and Carrizo aquifers, and less is from the Hooper and Calvert Bluff aquitards. Estimates of natural groundwater discharge, therefore, require analysis of the flow of these surface waters* (Colorado, Brazos, and Trinity Rivers) [page 92]. In all four studies (available to the authors in developing the GAM, *surface-*

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[1] Dutton, Alan R., Bob Harden, Jean-Philippe Nicot, and David O'Rourke. February 2003. Groundwater Availability Model for the Central Part of the Carrizo-Wilcox Aquifer in Texas. Final Technical Report.
[2] Kelly, Van A., Neil E. Deeds, Dennis G. Fryar, and Jean-Philippe Nicot. October 2004. Groundwater Availability Model for the Queen City and Sparta Aquifers. Final Report.
[3] Deeds, Neil E., Tingting Yan, Abhishek Singh, Toya L. Jones, Van A. Kelley, Paul R. Knox, and Steven C. Young. March 2010. Groundwater Availability Model for the Yegua-Jackson Aquifer. Final Report
[4] Consultants Presentation. April 14, 2015. Update of Preliminary Modeling Results. Presentation on PS4 Model Run, Slide 25.
[5] Environmental Stewardship. June 18, 2015. Comments on Hydrological Conditions Presentation.

water flow increased downstream as the stream crossed the aquifer outcrop, indicating gaining conditions at the time the studies were performed [page 93]. The 1918 Colorado River study, according to the authors, indicated *that even during conditions of extremely low flow, the Colorado River has been a gaining reach across the outcrop of the Carrizo-Wilcox aquifer [page 95].*

The authors tested the model to determine how well it represented groundwater-surface water interaction. *Three sets of calibration targets were developed for evaluating how well the model represents interactions of surface water and groundwater [page 146]. Steady-state calibration sets the initial balance between the amount of water entering the aquifer as recharge and the amount leaving the aquifer in the outcrop as either base-flow discharge to rivers and streams or groundwater ED [Page 178]. With the calibration of parameters for recharge rate, discharge to rivers and streams, ET, and hydrological properties, no model cells can dry during the steady state simulation. Overall the model does a good job in matching predevelopment water levels, considering the sparse data. The root mean square error (RMSE) is 19 ft for the Carrizo aquifer and 25 ft for the Simsboro aquife [page179]. The RMSE values are 9.6 and 16.6 percent, respectively,of the range in water level among the observation wells. Table 12 shows the estimated simulated base flow to the 21 streams and the 5 river basins included in this study. The model generally underpredicts the estimated base flow of the major streams. Simulated base flow is 48 and 61 percent of estimated base flow of for the Colorado and Brazos rivers, respectively. Simulation results better match estimated base flow for smaller streams. Most reaches are gaining: stream losses simulated for a set of model cells are bypically less than 15 percent of the stream gains. The Simsboro and Carrizo aquifers are the main contributors to base flow. The Hooper and Calvert Bluff aquitards contribute little to steam flow in comparison. [page 187].*

Rate of discharge to streams simulated for the transient model period is similar to the steady state, average base-flow rate. Simulated rate of base-flow discharge fluctuates with annual rates of recharge; there is also a trend of decreasing base-flow rate through time. This simulated decrease in base flow most likely reflects a simulated decline in water levels in the aquifer outcrop attributed to increase pumpage. It should be note, however, that base-flow estimates show no long-term trend [page 220].

According to the authors, *the purpose of developing the GAM model of the central part of the Carrizo-Wilcox aquifer is to provide a tool for evaluating changes in water level and stream flow for various expected or proposed changes in pumping rates and other activities impacting groundwater [page 234].*

Section 10.2 Water Budget: *ET and base-flow discharge to streams are predicted to generally decrease as predicted water levels decline in the outcrop. Stream loss is approximately 21 percent of the stream gains; rivers and streams overall remain as gaining streams through 2050. Comparison of the simulated 2050 water levels with average versus drought-of-record recharge shows that recharge, ET and stream gains are reduced during the predicted drought. The model predicts a further reduction in base flow in all streams with increased pumping through 2050. Base flow, however, is a small fraction of total stream flow. Histrical data show no reduction in base flow [pages 260-261].*

Environmental Stewardship points out that, though base-flow is a small fraction of total stream flow during normal conditions, base-flow is a significant contributor to total stream flow during drought conditions as will be demonstrated in the following section. ES further points out that the authors of the report and developers of the model, were adequately confident in the model to make trend predictions and, in some cases, provide quantification of their estimates. We see no reason why the same cannot be accomplished with the current modeling being done by the GMA-12 consultants.

Remarks on Presentation

Slide 8 – These are the environmental impacts of concern, including low water table impacts on vegetation and terrestrial organisms. In Bastrop County this include the Lost Pines Forest and the Houston Toad that depends on a moist sandy subsurface for survival. So there is this endangered species as well as the plant species mentioned by another stakeholder.

Slide 10 – This slide shows a hydrograph where monitoring well and river gage data are overlaid on the same graph. In this way gaining and losing conditions are identified. Lost Pines and Fayette County GCDs should seek to get some wells associated with Colorado River gages and the Wilbarger Creek gages to monitor this relationship.

Slide 13 – This is an example from normal flow conditions. The same data would show a much different picture if the graph were created for the long low-flow conditions experienced in this drought. The following hydrographs are for the Colorado River Bastrop Gage for the period of 2011-13.

Figure 1 is a hydrograph of the three year drought period from January 2011 through December 2013 when the region experienced some of the most sever drought conditions in decades. The distinguishing feature of this figure is that in-stream flows benefitted from the irrigation releases for down-stream rice farming during the spring, summer and early fall of 2011. Irrigation water was curtailed during the 2012 and 2013 irrigation seasons. Note however that there was very little flow from rainfall during the 2011 period. Lacking irrigation flows, flow in the river for the summer and fall would likely have dropped into the 120 cfs critical environmental flow range during that period.

Figure 2 is a hydrograph of the month of September, 2013 when the flow was trending toward the critical in-stream flow minimum. Fortunately, the region received significant rainfall starting in mid-September and river flow rebounded.

A hydrograph separation on the three year period represented in Figure 1, with irrigation releases removed, would likely reveal a very good estimate of actual groundwater outflows to the river from the Carrizo-Wilcox Aquifer group. During this period the bank storage for the river had likely been exhausted and the river was relying on the minimum flows passing through the Austin gage at Longhorn Dam, City of Austin return flows, and groundwater base flows. Environmental Stewardship attempted to fund a USGS gain-loss study from Utley bridge to Matagorda Bay during that same period in order to provide current period groundwater outflow estimates for purposes of calibrating GAM and WAM models.

REQUEST 1: Prepare the hydrographic separation as described above.

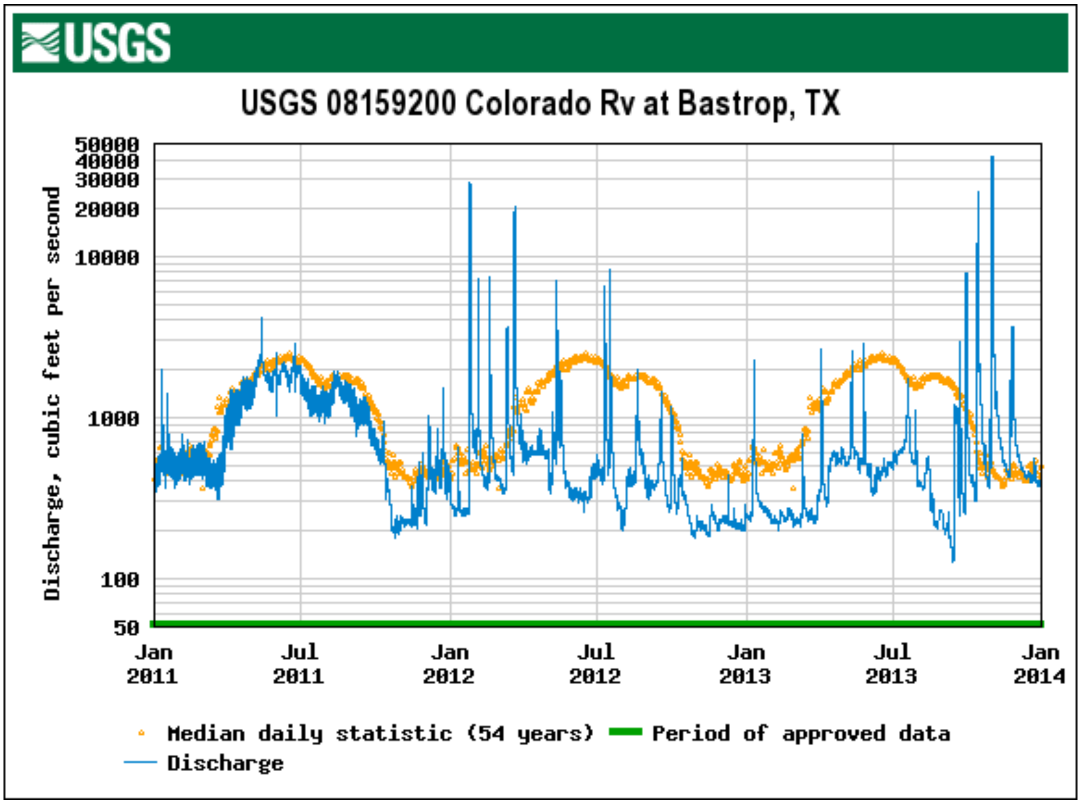

Figure 1. Colorado River at Bastrop gage during drought period Jan.2011 - Dec.2013

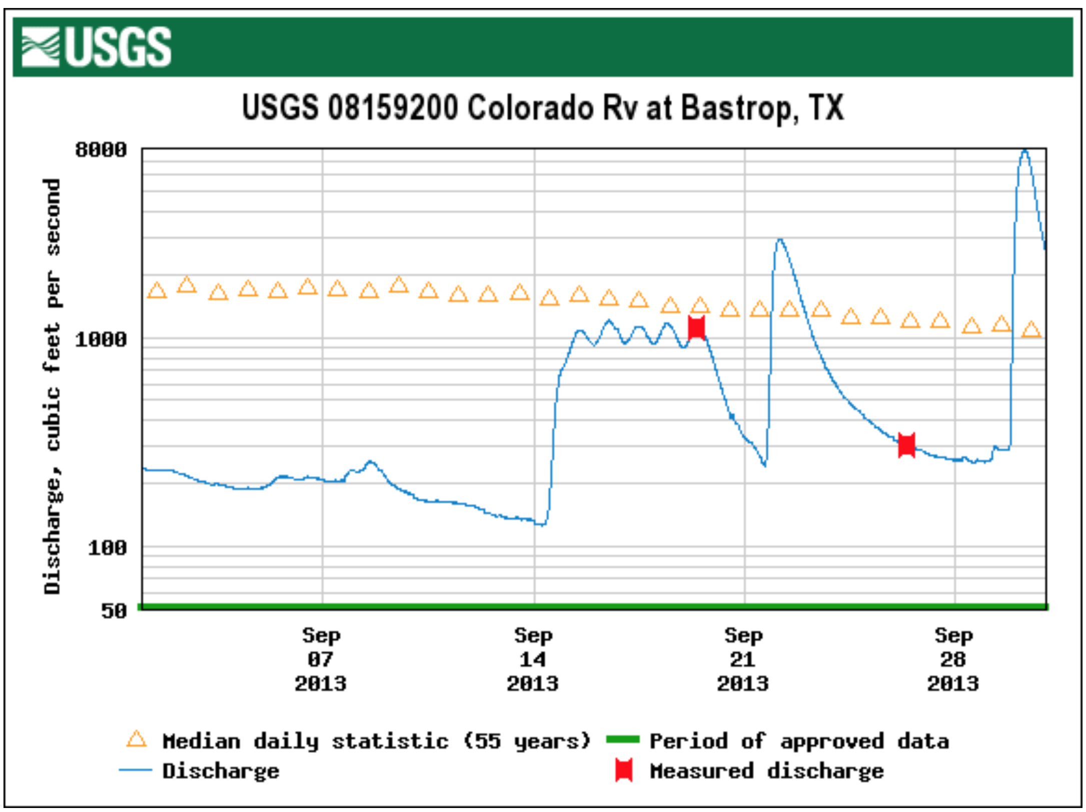

Figure 2. Colorado River at Bastrop gage during drought period Oct. 2012- Sept. 2013

Slide 15 – A hydrograph separation for the low-flow drought period mentioned above would give an indication of contribution of groundwater (outflow) to the river at the Bastrop River and Wilbarger Creek gages.

Slide 17 – Agree. Surface water model is a Water Availability Model (WAM).

Slide 18 – Hydrograph Separation was used to estimate base flow for the Carrizo-Wilcox portion of the GAM.

Slides 19-21 – Groundwater IS a critical component of subsistence and critical flow regimes at the Bastrop gage on the Colorado River. My slide presentation last year (which should be part of this record and available to the Consultants) lays out the importance of Carrizo-Wilcox groundwater outflow in this segment of the river. Critical flow is 120 cfs (in old study) and subsistence flow varies by month in the Environmental Flow Standards (EFS) adopted for the river at this gage. Saunders (2006 and 2009) and Deeds et al (2006) place current and historic outflows at between 30 and 50 cfs and both report negative outflows of (Saunders: -9 cfs; Deeds: -4,347 afy) for the Austin-Bastrop segment of the River. Critical/Subsistence environmental flow standard at the Austin gage is 49 cfs and subject to emergency curtailment. Otherwise, the only flow in the river during drought conditions is primarily from City of Austin, and perhaps City of Pflugerville via Wilbarger Creek, return flows. A significant reduction in groundwater outflows due to pumping could shift this segment of the river from a minor losing segment (estimated at -9 cfs) to a major losing segment if Simsboro pumping were to significantly reduce outflow and/or increase surface water inflows to the aquifer in this segment of the river. Deeds also reports that the Colorado River gains 160,000 ac-ft/yr between Austin and Bay City which is in close agreement with Saunders (2006) report of 217 cfs total gains (157,100 ac-ft/yr) , a significant contribution to Matagorda Bay during drought conditions. Critical Freshwater inflows to Matagorda Bay during drought conditions is set by TCEQ at 14,260 ac-ft/month.

Slide 25 – Points #3 and 4 were met by Saunders (2006, 2009) in both studies. So we may only have a few data sets to use as references for calibration, but they are of good, if not high quality.

Slide 30 – ES has provided a list of springs identified along the Colorado River between Utley Bridge and Tahitian Village. We can also provide maps of these segments with significant springs marked. Most of the springs in these segments have continued to flow during drought conditions. ES provided INTERA with location and flow measurements on Bastrop Spring, in Bastrop, TX that show that this spring has maintained a constant flow for many years.

Slide 40 – Grid cell construction options. This slide is referenced in later discussions.

Slide 43 – Point #4 seems to indicate that a 300 ft thickness (depth) is an important benchmark.

Slides 46-47 – ES agrees that the 1975-2000 data are somewhat questionable and hopes that this will be cleared up in the GMA-12 GAM improvement project.

Slides 48-50 – ES believes these slides and the associated maps are very important to understanding and estimating trends in the data. If these data were overlain on the Geologic Atlas of Texas, Austin Sheet, then the relationship to the specific aquifer outcrops would become evident and the location on the river and stream segments would be more meaningful. Likewise, if the individual cells can be identified and characterized with respect to the conditions in Slide 40, some additional judgement could be made on the relevance of each cell, and troublesome cells could be eliminated to see if a trend emerges.

ES REQUEST 2: Provide maps with 1) this data overlaid on the Geologic Atlas of Texas – Austin Sheet, 2) identify the location of each cell relative to rivers and streams, 3) characterized relative to the conditions indicated in slide 40, and 4) remove troublesome cells from the map to see if meaningful trends become more evident.

Slides 51-53 – ES agrees that these provide justification for the GMA-12 GAM improvements.

Slide 54 – Point #5. Saunders (2006, 2009) provides data that is few in number but good or high quality for use in model development and determining the significance of trends.

Slide 62 – Will GMA-12 GAM improvements impact on the reliability of drains/spring predictions? Likely will help around rivers but not elsewhere since cell sizes may not be adjusted in these portions of the model.

Slide 65 – Agree with characterization of Brazos River study use as “caution” and LCRA (Saunders) studies as use with “care”.

Slide 66 – Point #2 implies that River Authorities are currently also managing in-stream flows that take into consideration groundwater base flows. LCRA can clarify, but it is my understanding from working on the water management plan (WMP) and through discussions with Saunders and others regarding the gain-loss studies that the only “management” use of information on groundwater base flows (outflows to surface) are to help manage releases from the Highland Lakes to down-river customers so that gains and losses are accounted for in the release and water is more efficiently delivered. The WMP currently does not attempt to predict the impact of changes in groundwater base flows in the WAM model used. The exception is that there is some consideration given to the use of pumped groundwater in the Lost Pines Power Plant operation vis-à-vis the use of river water, and likewise at one down-stream rice irrigation operation. For the most part, conjunctive management of groundwater and surface water is limited.

Point #3 is true, especially during drought conditions. Because of the importance of maintaining water in the lakes associated with these river systems, and the susceptibility of such supplies for environmental flows during drought conditions as a result of emergency curtailments, the existing groundwater flow into streams needs to be carefully protected. These are, especially during drought conditions, high value environmental flows, thus the defining terms “critical” and “subsistence”.

Point #4 is true, however, any significant spring or base flow is likely captured in gain/loss studies. In other parts of the region away from rivers and streams, the environmental concern is related to water table declines and the impact on surface animals and vegetation.

Consideration 5 – "The impact on subsidence:" ________________________________

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Consideration 6 – "Socioeconomic impacts reasonably expected to occur:" ______

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Consideration 7 – "The impact on the interests and rights in private property, including ownership and the rights of management area landowners and their lessees and assigns in groundwater:"

SEE ES Comments date August 6, 2015.

Consideration 8 – "The feasibility of achieving the desired future condition:" ____

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Consideration 9 – "Any other information relevant to the specific desired future conditions:" ____

SEE ES comments dated May 15, 2015 as follows:

Environmental Stewardship respectfully requests that other documents provided to GMA-12 prior to this "form" be included in the record and be considered in your deliberations regarding the current review of the desired future conditions.

Specifically citing:

ES presentation on June 27, 2014 which included a PowerPoint presentation, list of references, and copies of selected documents, all of which were provided to GMA-12.

ES letter and attachments dated March 27, 2015.