January 12, 2011

Dr. Robert Gulley, Program Director
Edwards Aquifer Recovery Implementation Program

Delivered via email

Re: Review of the report "Evaluation of the Proposed Edwards Aquifer Recovery Implementation Program Drought of Record Minimum Flow Regimes in the Comal and San Marcos River Systems" by Thomas Hardy, Kristy Kollaus, and Kristina Tower of the River Systems Institute

Dear Dr. Gulley:

Per your request, attached are comments from members of the Edwards Aquifer Area Expert Science Subcommittee on the report "Evaluation of the Proposed Edwards Aquifer Recovery Implementation Program Drought of Record Minimum Flow Regimes in the Comal and San Marcos River Systems". The report was published by the River Systems Institute on December 28, 2010. I instructed members to email me their comments by the end of the day January 11, 2011, to be included in this review. Because of his involvement with the project, Ed Oborny did not participate as a reviewer of the report in his capacity as a subcommittee member.

Note that this is a compilation of comments from members and in no way infers subcommittee consensus on the report.

Please let me know if you have any questions on this review.

Sincerely,

Robert E. Mace, Ph.D., P.G.
Chair, Edwards Aquifer Area Expert Science Subcommittee

Comments by members of the Edwards Aquifer Area Expert Science Subcommittee on the report "Evaluation of the Proposed Edwards Aquifer Recovery Implementation Program Drought of Record Minimum Flow Regimes in the Comal and San Marcos River Systems" by Thomas Hardy, Kristy Kollaus, and Kristina Tower of the River Systems Institute

Acronyms used in the comments:

AAS = Austin American-Statesman

cfs = cubic feet per second

EARIP = Edwards Aquifer Recovery Implementation Program

F = Fahrenheit

FD = fountain darter

GBRA = Guadalupe-Blanco River Authority

HSC = habitat suitability criteria

HSI = habitat suitability index

LCRA = Lower Colorado River Authority

TWDB = Texas Water Development Board

WSJ = Wall Street Journal

Note that subcommittee members are listed in alphabetical order.

Mr. R.A. Barker, P.G.

From my hydrogeologic perspective (with limited background in aquatic biology), I am unqualified to judge the legitimacy of most biologically oriented aspects of this report. Therefore, rather than focusing on the more technical contents, my review suggests fixes to shortcomings that would appear to affect most any reader's overall understanding of the report and, in particular, its conclusions.

(1) Authors should consider obtaining a thorough editorial review of the manuscript before releasing it formally or to the public.

By eliminating typos and minimizing awkward syntax, the response to such a review would help most any reader (and especially those with limited biological backgrounds) comprehend the more technical aspects of otherwise murky explanations or confusing details.

(2) Although the report provides comprehensive explanations of the assumptions, approach, and associated limitations, the conclusions (Summaries) are relatively vague in places.

For example, could the qualitative expression at top of page 78 regarding “reasonable numbers” of darter populations be stated more specifically and backed up by the relatively quantitative (albeit simulated) results embedded within the report? In other words, what exactly is the meaning of “reasonable” in terms of the relations among observed and simulated variations in darter habitats and the populations that are simulated to result under projected conditions?

(3) Despite influencing major components of the report, the so-called “drought of record” is nowhere defined.

Were everyone in agreement on this issue, this omission might not be a legitimate concern. However, ask 10 people in central Texas to define the impact or length of this major event, and you might get 10 different responses. For example, a quick Google search indicates the following possibilities:

LCRA
Drought of Record: The *decade-long drought that affected Central Texas from the late 1940s through the late 1950s.*

GBRA
The historical greatest known drought for the Guadalupe River Basin, which is referred to as "The Drought of the 1950's" *occurred from 1947-1957*.

TWDB website:
Drought of Record: the period-of-time during recorded history when natural hydrological conditions provided the least amount of water supply. For Texas as a whole, the drought of record is *generally considered to be from about 1950 to 1957*.

AAS (November 3, 2009):
The worst drought on record, a *decade-long dry spell that ended in 1957*.

WSJ (July 28, 2009):
The state's worst drought made the record books for its longevity, spanning *a seven-year period during the 1950s*.

(4) Font sizes used in several key illustrations and tables should be ramped up to at least 10 pts.

As is, without magnification, one would have to possess the vision of a hawk to read some of the finer print associated with information provided in places such figures 2-5 and tables 10 and 11.

(5) Text version of report needs pagination to improve reader's ability to navigate among the various sections and subsections.

Dr. Tom Brandt

Page 30 - Temperature modeling – third sentence. I think the following more accurately reflects what the three fountain darter temperature studies reported. Thom may have to reword quite a bit of his fountain darter findings to fit what the actual numbers are.

Laboratory studies have suggested that at 77.0 (F) there is an increased rate of larval mortality for darters; at 80.6 (F) egg production is curtailed, and at 91.4 (F) and 94.6 (F) larval and adult thermal death can be expected.

The three references listed below were used but not cited in Thom's report.

Page 33 - Are all the numbers in Table 9 correct? % flows at 351 do not make sense.

Page 54 - Figures 35, 36, and 37 – some of the legends on the figures can't be read even when viewed at 400%.

Page 57 - Temperatures in "Implications of Temperature on FD" need to be reduced to reflect rewritten sentence on page 30. I also have problems with the statement that reproduction and recruitment had been observed at water temperatures in the high 80s F. The three fountain darter temperature studies have been consistent. Each study narrowed the range to when effects became significant. We found that no eggs were produced at 80.6 F so I think it is unlikely that reproduction and recruitment was occurring at temperatures in the high 80s F. It is possible that reproduction was occurring near a spring seep that remained near 75 F while the surrounding waters had warmed into the upper 80s F.

Page 60 paragraph 2 - "… limiting temperature for cessation of egg production (86 F)…". The temperature for cessation of egg production should be 80.6 F not 86 F. The next two paragraphs need to be rewritten.

Page 62 first 2 lines - " we postulate that these areas would be utilized during late fall..." I disagree with this statement. The area may have the right temperature, but without the right flow and right vegetation, fountain darters probably will not use it. Blieders Creek is an area that at times is the right temperature but other than the area adjacent to Landa Lake it is not utilized by fountain darters.

Figures 50 thru 54 need to have the increase in larval mortality line lowered from 78.8 to 77.0 F. When this is done it affects what is written in the paragraphs (page 72) that refer to the figures. These paragraphs also refer to the egg production curtailment temperature which Thom mistakenly listed as 86 F on page 30 when the temperature is actually 80.6 F.

Brandt, T. M., K. G. Graves, C. S. Berkhouse, T. P. Simon, and B. G. Whiteside. 1993. Laboratory spawning and rearing of the endangered fountain darter. Prog. Fish-Cult. 55:149-156.

Bonner, T. H., T. M. Brandt, J. N. Fries, and B. G. Whiteside. 1998. Effects of temperature on egg production and early life stages of the fountain darter. Trans. Amer. Fish. Soc. 127:971-978.

McDonald, D. L., T. H. Bonner, E. L. Oborny, Jr., and T. M. Brandt. 2007. Effects of fluctuating temperatures and gill parasites on reproduction of the fountain darter, *Etheostoma fonticola*. Journal of Freshwater Ecology 22:311-318.

Dr. Glenn Longley

I have read the report and looked at the appendices and find it to be a valuable addition to our knowledge of the two spring runs. It should be kept in mind that it is only a model and its ability to predict is limited by the information utilized. The latest information about bottom topography after recent floods would improve the information. It is critical to point out that there are numerous conditions sited in the models. If these conditions are not met then the model is less useful. Other than a few misspellings and failure in some areas to use italics on scientific names the document passes muster. Example of misspelling is “toobshoot” in Fig. 2.

Ms. Jackie Poole

Hardy et al. have produced a comprehensive report using available observed species habitat and monitoring data as the basis for modeling a set of minimum flow regimes in the San Marcos and Comal rivers based on the drought of record. The report answered several questions and concerns that I had previously. However, some concerns remain.

<u>Proposed Flow Regime</u>
The report includes an evaluation of the proposed low flow regimes for Comal and San Marcos springs. Based on the modeling results, Hardy et al. indicate the flow regimes being considered provide adequate quantity and quality to protect the listed species during a reoccurrence of the drought of record. However, these low flows have been referred to by some as the “edge of the cliff” for the listed species and the response of the

ecosystems (biotic and abiotic) is relatively uncertain given the lack of data that has been gathered at such low flows.

During the drought of record, the two lowest daily flows recorded for the San Marcos River were 46 cfs. Two other daily flows were 48 and 49 cfs. From September 1955 to March 1957 flows were between 50 and 80 cfs. Thus, there is no extended period of flows (even six months) at 45 cfs. From late March 1957 flows remained over 100 cfs for almost six years. This would have been sufficient time for recovery although there is at best only limited anecdotal data for any of the species from this time period. The proposed low flow regime involves sustaining low flows (30 cfs for Comal and 45 cfs for San Marcos) for six months and providing a flow pulse of 80 cfs. However, the basis for the 6 month duration of low flow and flow pulses is unclear. While the 45cfs flow rate at San Marcos may be based on modeling (or perhaps the lowest historically recorded flow), the reasoning for the 80 cfs pulse is not as clear. Although the Hardy et al. model indicates that modeled optimal habitat currently occupied by Texas wild-rice starts to decrease between 80 and 90 cfs, the amount of modeled optimal habitat (not just that currently occupied by wild-rice) starts to decrease between 120 and 140 cfs as well as showing a declining trend below 120 cfs (note that Table 15 and Fig. 33 do not agree with Fig. 32 which indicates a break point at 100 cfs rather than 120cfs). If wild-rice is to be reintroduced into more of this available habitat (such as that occupied by hydrilla/hygrophila close to wild-rice), shouldn't the pulse flow match the modeled optimal habitat flow rather than the currently occupied number? Because the timing and duration of both low flows and flow pulses could have a tremendous impact on the listed species, the low flows and flow pulses should be based not only on physical habitat, but also on life history requirements of the listed species.

Additional concerns relating to the proposed flow regime are the use of mean daily flow rates (rather than instantaneous), the lack of a buffer from the "edge of the cliff," and the duration and timing of the low flows. When flow values were discussed previously, there was some question concerning the use of monthly, daily, or instantaneous flow values. Because daily flows have a historic 7-10 percent day to day variation, flows would likely dip below those proposed for some period of time. If the proposed low flows do represent the "edge of the cliff," it seems prudent to incorporate a buffer to ensure flows do not dip below the proposed flow levels, especially given the uncertainties involving the response of the aquatic communities to the low flows. The use of instantaneous flow values or a 7 to 10 percent increase in the proposed low flows may provide an adequate buffer.

<u>Texas Wild Rice</u>
TPWD wild-rice monitoring data from 2009 did show a decrease in overall coverage as well as decreases in almost all sections of the river (including the uppermost segments). However, intensive monitoring of Texas wild-rice from 1989 has shown an overall increase within the San Marcos River, but there are some cautionary notes. Not all areas within the range have remained viable. After the 1998 flood almost all stands below Capes Dam were lost. As of today, the coverage below Capes Dam has not recovered. Thus, although aerial coverage and number of stands have increased, the range has significantly decreased. Also, the current range is more in conflict with recreation. The

section of the river above Rio Vista Dam has more people recreating and more types of recreation that are detrimental to wild-rice such as playing with dogs and wading. The modeled habitat at low flows will be in even greater conflict as water of any depth and velocity becomes scarcer.

It is assumed that wild-rice does not occupy all the optimal habitat because other species, both native and non-native, are occupying the habitat instead. Why does wild-rice not occupy this seemingly suitable habitat? Perhaps the other species are better competitors or colonizers at slightly higher flows. For example, according to the Hardy et al. model, the hydrilla/hygrophila coverage increases slightly from 80 to 100 cfs. Although it could be argued that lower flows would mean less competition for wild-rice, these are not the optimal flows as shown by the modeled optimal habitat.

Why was 75% (or 0.75) chosen as the break point for optimal vs. suboptimal? When Mara Alexander (USFWS) and I worked to determine long-term, six-month, and one-month average flows for Texas wild-rice, we created a histogram based on the frequency of suitable habitat per flow increment that indicated a break point of 0.45 or 45%.

Why Texas wild-rice is not recovering in the section of the river below Capes Dam needs to be determined as it may influence recovery in the upper river segment. The recommendation of Hardy et al. to study turbidity should be broadened from a lab study to include diel turbidity measurements in the river throughout the seasons to determine the diurnal nature, seasonality and scope of the problem.

The section on the “Implications of Flow Regime on Vegetation Dynamics” under fountain darter simulated habitat in the Comal River is also applicable to the San Marcos River and in particular to Texas wild-rice. Because Texas wild-rice is a CO_2 obligate species, the issue of increasing boundary layers with decreasing velocities could be a definite problem for wild-rice. While the plants probably assume an annual habit in order to obtain more CO_2, these annual plants will produce seed and die, thus reducing the amount of aerial coverage. Also, at lowered velocities, the other submerged aquatic plants in the San Marcos (all of which are not CO_2 obligates according to Mara Alexander) could outcompete Texas wild-rice.

I fully agree with Hardy et al. that unless certain mitigation (considerable planting of Texas wild-rice and proven, enforced recreation control) is in place, that the species cannot survive at such low flows. All mitigation should begin immediately as to ascertain its effectiveness. If Texas wild-rice cannot be reintroduced as quickly or easily as needed to help the species through low flows, or if recreation cannot be adequately controlled to protect the species, then minimum flow recommendations should be consistent with those previously proposed by the EARIP Science Subcommittee.

<u>Fountain Darter</u>

The fountain darter Habitat Suitability Criteria (HSC) for depth was modified to indicate no limitation on depth because fountain darters have been observed in the deepest parts of Landa and Spring lakes. Hardy et al. noted that previous curves showed declining suitability at higher depths which was attributed to gear bias. Thus, the fountain darter depth HSC shows 100 percent optimal habitat at depths greater than about 2.3 feet based on the observation of individuals in the deepest parts of the lakes. Species are often found in habitats that do not represent the optimal conditions for a variety of biotic and abiotic factors. While fountain darters are often observed in the deepest parts of the lakes, this does not necessarily mean it is optimal habitat but that it is suitable to some degree. Rather than basing the depth HSC on observation and past sampling methods, more comprehensive sampling is necessary to achieve a more realistic HSC. It should be kept in mind that these deep habitat areas are for the most part artificial, resulting from channel modification and dams. Although this type of habitat exists today and is occupied by the fountain darter, should habitats that were historically atypical be included when calculating optimal habitat?

Hardy et al. identify vegetation as an important component for the physical habitat of the fountain darter. The modeling results in the San Marcos River indicate that over the proposed flow regime range that physical habitat for the fountain darter is reduced by about 10 percent. However, as noted by Hardy et al., the analysis assumes a fixed vegetation composition and spatial distribution as mapped in 2009. It seems highly unlikely that the vegetation composition and distribution would remain the same, especially in light of the proposed oscillating flow regime. Hardy et al. point out that the response of aquatic plants to changes in velocity and other factors is very complex and varies greatly across species. Because the species of aquatic vegetation that inhabit the San Marcos River are known to have differing habitat profiles or preferences, it is most likely that each species will respond differently (i.e. some increasing and others decreasing in coverage) and that the composition and distribution of vegetation will change from that mapped in 2009. Furthermore, fountain darters are known to have higher densities in certain vegetation types as compared to others, so changes in the composition and distribution of vegetation could have significant impacts on the fountain darter population.

<u>Comal Springs riffle beetle</u>

Hardy et al. identify the response of the aquatic vegetation to sustained lower flows within lower Landa Lake and the potential for springflows from the western shoreline “short-circuiting” down the new channel as the greatest areas of uncertainty in evaluating the proposed minimum flows. These uncertainties, and others, ultimately stem from the fact that little to no data exists on the response of the ecosystem (biotic or abiotic) to flows as low as those proposed (i.e. 30 cfs). This emphasizes the need for more hydrogeologic research, more information on the life history of the listed species, long-term monitoring, and adaptive management that is responsive to issues as they arise.

I am still concerned about the populations of riffle beetles in Spring Runs 1-3. Recent genetic work suggests that the population of Comal Springs riffle beetles in the springs runs have gone through a genetic bottleneck as compared to the population in Landa Lake and that little to no gene exchange occurs between the populations. The apparent genetic bottleneck is likely the result of many factors including the limited dispersal capability of riffles beetles and the drought of the 1950s. However, it may have been exacerbated by more recent, less intense droughts that resulted in low flows or the cessation of flow in the spring runs during the 1966, 1984, 1989, 1990, and 1996 droughts. How many more times the population in the spring runs could go through such drought and remain a viable population is not known. While the population of riffle beetles in the spring runs is apparently less genetically diverse and likely smaller in size as compared to the population in Landa Lake, the spring run habitats still represent a significant portion of the Comal Springs riffle beetle's limited range. A basic principle of conservation biology is to avoid range contraction and the proposed flow regime clearly allows the spring run habitats to dry for extended periods of time.

Hardy et al. state that "…at a total Comal River discharge of about 60 cfs…the lower extent of Spring Run 3 becomes inundated and approximately 1/3 of the lower spring run is inundated at a discharge of 80 cfs" and suggests additional subsurface springflows occur over this discharge range that are likely to benefit the Comal Springs riffle beetle. Given the limited knowledge of the life history of the Comal Springs riffle beetle (i.e., lifespan, time spent in various life stages, most vulnerable life stages, dispersal ability, etc), it is unclear if any benefit will be derived from flow pulses of 80 cfs, especially given that the lower spring run habitat will have been dry for several months preceding the flow pulse.

As springflows within the spring runs diminish, it seems most likely the remaining riffle beetles will either retreat into the spring orifices, if possible, or drift into Landa Lake. According to Chad Norris (TPWD), those individuals that drift into Landa Lake seem unlikely to survive given the habitat conditions present at the mouth of the spring runs (i.e. depositional habitat with deep, fine sediments and abundant vegetation) and the limited dispersal ability of most riffle beetles, potentially leaving those that survive in subterranean habitats to recolonize the spring runs. The extent of suitable subterranean habitat available to the riffle beetle is not known, but it is likely limited, which may have been a contributing factor in the genetic bottleneck that reportedly occurred in the spring run population. Assuming the population of riffle beetles is able to endure short-term drying of the spring runs, it is possible that the proposed pattern of drying the spring run habitat for months at a time followed by a flow pulse for months will have a negative impact on the Comal Springs riffle beetle population by repeatedly enticing individuals from the remaining population to recolonize a habitat that will ultimately dry again, further reducing the remaining population size.

A review of the literature on closely related riffle beetles (thanks to Chad Norris for bringing this to my attention) indicates life cycles take from six months to five years to complete, with varying amounts of time spent in each life history stage (i.e. egg, larvae, pupae, and adult) and critical periods for survival in the life cycle varied for each species. Such information is needed for the Comal Springs riffle beetle to better assess the impacts of the volume and timing of the proposed flow regime on riffle beetle populations, especially the population in the spring runs. It may be that providing supplemental flows during certain life history stages is more beneficial to riffle beetles than several months at 30 cfs and several months at 80 cfs. Again, these uncertainties underscore the importance of continued monitoring and adaptive management to protect the listed species.

Also of concern is the lack of information on the contribution of the individual springs within Landa Lake and along the western shoreline. It appears that an assumption has been made that most, if not all, of these springs will continue to flow during low flow periods because the orifices remain submerged in Landa Lake, which may be incorrect as no quantitative data has been gathered at such low flows. It is possible the springs along the western shoreline are merely inundated due to the control structures on the Lake and not because they are flowing, especially at total discharges as low as 30 cfs.

It is also unclear if the water that inundates the spring runs at a flow pulse of 80 cfs is derived from springs within the spring runs, along the western shoreline, or from Landa Lake. The distinction is important for at least two reasons: the quality of the water and the source area of the water. Comal Springs riffle beetles are known to inhabit areas in and around spring orifices, so it seems unlikely that Landa Lake water inundating the lower spring run would provide suitable habitat. If the water is derived from springs, the distinction between the western shoreline springs and the spring run orifices is important because they are reportedly fed by separate flow paths (Guyton and Associates 2004).

<u>Miscellaneous</u>
On Figure 35, the numbers on the bars indicating benchmark flows are incorrect except for the bars indicating 90 and 45 cfs. From left to right, the bar marked 70 should be 80, the bar marked 65 should be 75, and the bar marked 75 should be 85. The dots beneath the 75 bars are at 80cfs to indicate the 80 cfs pulses.
Figures showing only depth for the modeled flows would be informative in illustrating connectivity of habitat, especially of concern for the fountain darter in the San Marcos River.

Dr. Shirley Wade, P.G.

I am not qualified to evaluate the biological aspects of the study, but the physical part of the modeling study is thorough and well documented. However, I suggest the following clarifications:

<u>Background:</u> Please discuss the proposed target flow regimes in more detail and cite the source of those proposed flow regimes. It isn't clear in the report exactly what the flow rates are and what they are based on. Are they from the Bio West March 31, 2010 memorandum?

<u>Habitat suitability Criteria (HSC):</u> Please increase the font on the axes labels for figures 6 through 9.

<u>Habitat suitability Criteria (HSC):</u> Please explain habitat suitability criteria values on the plots. Should those axis labels actually be HSI? How are these quantified?

Table 8: Please change the font to the same type as the main text. It is difficult to read as it is.

Temperature Modeling: Please provide a citation for and a brief description of the Qual2E code.

Table 10: The font is too small to read.

Figures 41 through 45: Text does not explain why each plot has multiple lines. What conditions differ between the lines.

Summary: I suggest again explicitly describing the proposed flow target regimes and citing the source.