Sustainable Yield Studies of the Barton Springs Segment of the Edwards Aquifer

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One commonly used definition of safe yield of an aquifer is "the amount of water which can be withdrawn from it [the aquifer] annually without producing an undesired result" (Todd, 1959). The potential for "undesired results" from excessive pumping of an aquifer is an important concept that the Barton Springs/Edwards Aquifer Conservation District (the District) considers in its role of protecting and enhancing the groundwater resources of the Barton Springs segment of the Edwards Aquifer. The term "sustainable yield" is more commonly used today to acknowledge that there are limits to aquifer pumping that need to be considered in the management of an aquifer to minimize or eliminate undesired results. The District's task has been to determine what those undesired results are and what policies can be developed to avoid them.

The District has reviewed a computer groundwater model developed by the UT Bureau of Economic Geology, the Texas Water Development Board (TWDB), the Lower Colorado River Authority, and the District (Scanlon et al., 2001) as part of the TWDB Groundwater Availability Model (GAM) program. This model was developed as a tool to help evaluate the effects of pumping on the aquifer. The District has conducted extensive reviews and analyses of hydrogeologic data that have been collected by numerous individuals and organizations over many years. A team of scientists from the Austin area has assisted the District in reviewing the model and data.

Through the evaluation process, it has been determined that there are two undesired results that could come about from excessive pumping from the aquifer. Those results are cessation of flow from Barton Springs and low water levels in the aquifer. The consequences of no flow from Barton Springs are that the endangered salamanders that live in the springs are not likely to survive and a valuable recreational resource would be lost for some period of time. Low water levels in the aquifer could lead to problems with water-supply wells that might go dry. Low water levels and low springflow could bring about degradation of water quality that could have a negative impact (undesired results) on the endangered salamanders and on users of the aquifer. There are at least 50,000 people that currently depend on the Barton Springs segment of the Edwards aquifer as their sole source of drinking water.

The transient portion of the GAM model completed in 2001 was calibrated to conditions from 1990 to 1998. After reviewing the results of that model, it was determined that the model could not simulate conditions of the drought of record in the 1950's as well as it could simulate conditions of the 1990s. Therefore, the model was recalibrated using data from the 1950's. To get a better match between simulated and measured heads and simulated and measured springflow, hydraulic conductivity and storage values were modified from the values used in the 2001 GAM. Specific yield was changed from 0.005 to 0.0022, and specific storage was changed from 1.0×10^{-6} to 1.0×10^{-7}. Hydraulic conductivity values in the 2001 GAM range from 1 to 1236 ft/day, with the highest values closest to the springs. The revised hydraulic conductivity values range from 0.3 to 740 ft/day. The amount of pumping estimated for the 1950's of 0.66 cfs (an annualized rate of 478 acre-ft/yr) was also incorporated into the recalibrated model (Brune and Duffin, 1983). The 2001 model indicated that springflow under drought-of-record conditions with no pumping would be 13.7 cfs. The lowest monthly average for measured flow from the springs was 11 cfs in July and August 1956 (Slade et al., 1986). The lowest daily flow measurement ever recorded was 9.6 cubic feet per second (cfs) that occurred on March 29, 1956 (Brune, 2002). Average long-term flow from the springs is about 53 cfs (Scanlon, et al., 2001). Subtracting a pumping rate of 0.66 cfs from 13.7 cfs gives a discrepancy of about 2 cfs between the 2001 GAM simulated results and measured values of springflow. However, the recalibrated model was able to produce a springflow value of 11 cfs, matching the lowest monthly average for measured springflow.

Current permitted and exempt pumpage from the aquifer is estimated to be about 10.8 cfs. This is equivalent to an annualized pumping rate of 7,825 acre-ft/yr. Permitted pumpage is the amount of water that is allowed to be pumped from the permitted water-supply wells. It is estimated that pumping from exempt (non-permitted) wells is less than 10% of permitted pumpage. Actual total pumpage from the aquifer in 2003 is estimated to have been 8.34 cfs or 6,022 acre-ft/yr. The model was run with pumping rates of 0.66, 5, 10, 15, and 19 cfs. At a pumping rate of 0.66 cfs, the model predicts flow at Barton Springs to be 11 cfs, which is the same as the measured monthly average flow **(Figure 1)**. At 5 cfs of pumping, simulated springflow decreases to about 6.5 cfs. At 10 cfs of pumping the model predicts that springflow will be about 1 cfs. At a pumping rate of 15 cfs, simulated springflow will be zero for about 4 months.

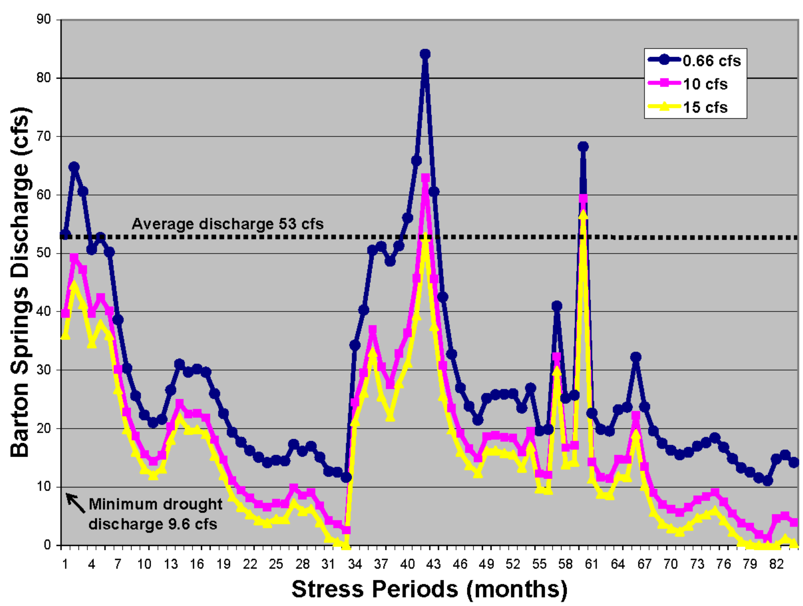

Figure 1. Simulated springflow values in cubic feet per second (cfs) during drought-of-record conditions and pumping rates of 0.66, 10, and 15 cfs. This figure shows predictions of the computer model over a 7-year period similar to the drought of record of the 1950's.

Simulated head values in the 2001 model were considerably lower than values measured in wells at the worst of the drought in September 1956. Of 10 wells from which measurements were taken, average simulated values are about 70 ft lower than measured values, with the largest discrepancy of 145 ft. By modifying storage and hydraulic conductivity values in the recalibrated model, simulated values agreed better with measured values from 1956. The root mean square error (RMS) was reduced from 25% of head change across the modeled area to 6%.

The recalibrated GAM was able to duplicate known aquifer conditions of the 1950's by matching the monthly average springflow of 11 cfs, and by giving a reasonable match for water levels in the aquifer. The model was then used to predict springflow and water levels under drought-of-record conditions and at various rates of pumping from the aquifer.

Simulated drawdown in the southeast portion of the aquifer due to pumping at a rate of 10 cfs (7,240 acre-ft/yr) is up to 150 ft below simulated water levels under drought-of-record conditions and 0.66 cfs of pumping. At a pumping rate of 15 cfs (10,860 acre-ft/yr) the amount of drawdown is simulated to be up to 200 ft. At a pumping rate of 19 cfs (13,755 acre-ft/yr) the amount of drawdown is simulated to be as much as 240 ft in the southeast portion of the aquifer **(Figure 2).**

An evaluation of water levels throughout the aquifer under drought-of-record conditions and high rates of pumping indicates that low water levels could impact many wells. Some of these wells are located in the western portion of the District where the geologic units that make up the Edwards Aquifer are thin and the saturated thickness of the aquifer is low, even during periods of average water levels. Other wells could be impacted because they do not penetrate a sufficient amount of the aquifer to yield water under low water level conditions.

To minimize these potential negative impacts, or undesired results, a limit on pumping from the aquifer of 10 cfs has been set in the District Management Plan that would apply only for periods of severe drought, similar to the drought of the 1950's. A higher pumping limit may be required for pumping during average aquifer conditions so that during a severe drought the lower limit could be met by conservation measures taken by the users and as alternative sources of water become available. Additional studies are planned by the District to continue evaluating potential impacts to the aquifer due to current and futures rates of pumping. Revisions to the pumping limit may be made as we increase our understanding of the aquifer and the consequences of its use.

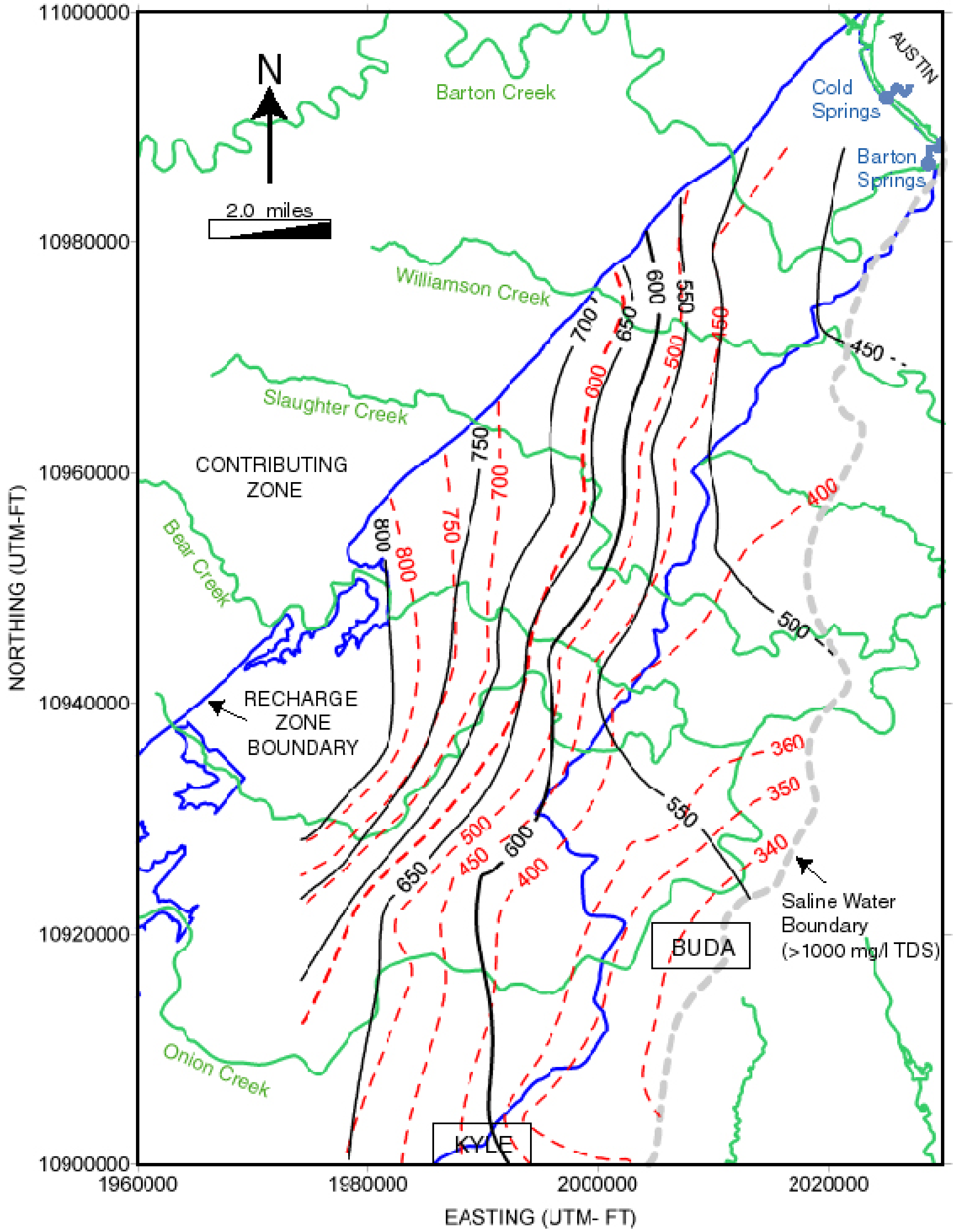

Figure 2. Simulated potentiometric surface during average flow conditions (solid black line) compared to simulated potentiometric surface during drought-of-record conditions with 19 cfs of pumping (dashed red line).

References

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