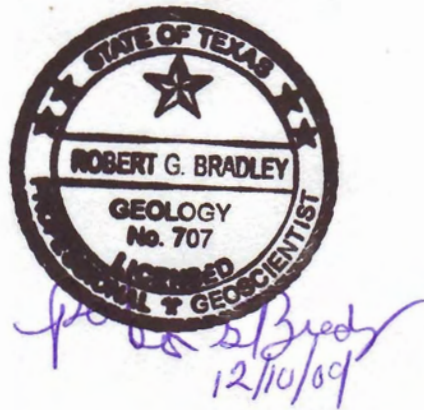


GTA Aquifer Assessment 08-04mag

by Robert G. Bradley, P.G.

Texas Water Development Board
Groundwater Technical Assistance Section
(512) 936-0870



December 10, 2009

REQUESTOR:

Cheryl Maxwell, of the Clearwater Underground Water Conservation District acting on behalf of Groundwater Management Area 8.

DESCRIPTION OF REQUEST:

In a letter dated June 10, 2008, Ms. Cheryl Maxwell provided the Texas Water Development Board (TWDB) with the desired future conditions for the Ellenburger-San Saba, Hickory, and Marble Falls aquifers in Groundwater Management Area 8 and requested that TWDB estimate managed available groundwater values. This aquifer analysis presents the managed available groundwater for the Hickory Aquifer in Groundwater Management Area 8.

DESIRED FUTURE CONDITIONS:

- Burnet County pumping should maintain approximately 100 percent of the saturated thickness after 50 years by using approximately 80 percent of the estimated recharge.
- Brown, Lampasas, Mills, Travis, and Williamson Counties should maintain approximately 90 percent of the available drawdown [saturated thickness] after 50 years.

METHODS:

The desired future condition for Burnet County adds a stipulation of using 80 percent of the estimated recharge (Williams, 2008). Because this is a volume and not a condition of the aquifer, this part of the statement was disregarded in the calculation of the managed available groundwater.

A transient hydrologic budget for the saturated portion of an aquifer is described by Freeze and Cherry (1979, p.365):

$$Q(t) = R(t) - D(t) + \frac{dS}{dt}$$

where: Q(t)= total rate of groundwater withdrawal
R(t)= total rate of groundwater recharge to the basin
D(t)= total rate of groundwater discharge from the basin
 $\frac{dS}{dt}$ = rate of change of storage in the saturated zone of the basin

For this analysis, it is assumed that:

$$R(t) = R(r) + R(e)$$

where: $R(r)$ = rejected recharge for the basin
 $R(e)$ = effective recharge

Effective recharge is the amount of water that enters an aquifer and is available for development (Muller and Price, 1978, p. 5). Rejected recharge is the amount of total (or potential) recharge that discharges from an aquifer because it is over-full and cannot accept more water (Theis, 1940, p.1).

In addition, it is assumed that:

$$R(r) \cong D(t)$$

Therefore, the total rate of groundwater withdrawal equals effective recharge plus the change in storage of the aquifer, or:

$$Q(t) = R(e) + \frac{dS}{dt}$$

County, regional water planning area, river basin, subcrop/outcrop, and groundwater conservation district boundaries subdivided the aquifer into map areas (Figure 1). The areal extent of each aquifer map area was calculated. These areas were used to calculate estimated annual effective recharge.

To determine the volume from storage used, the areas were multiplied by the estimated aquifer specific yield (outcrop) or storage coefficient (subcrop), and then by the drained saturated thickness necessary to maintain the desired future condition. This volume was then divided by 50 years to obtain a yearly volume.

Annual effective recharge to the aquifer was calculated by multiplying each outcrop area by the average precipitation (1971 to 2000) and an estimated effective recharge rate.

Estimated saturated thicknesses were calculated by taking average water-level elevations from TWDB (2009) and USGS (2002) and subtracting the average base of the Hickory sandstone from Standen and Ruggiero (2007) for each map area.

The calculations were completed in a Microsoft Excel worksheet.

PARAMETERS AND ASSUMPTIONS:

- An average saturated thickness for each map area is used to make volume calculations (Table 2).
- The areas for each area were calculated from the TWDB shapefile for the Hickory Aquifer, projected into the groundwater availability modeling (GAM) projection (Anaya, 2001).
- The downdip limit of the Hickory Aquifer is delineated at the 3,000 TDS isoline (Ashworth and Flores, 1991, 9.p.14).
- Areas, in acres, were calculated within ArcGIS 9.2.
- Average annual precipitation was used to calculate annual average effective recharge volumes.
- The average annual precipitation (1971-2000) for the aquifer map area (Table 1) was determined from the Texas Climatic Atlas (Narasimhan and others, 2008).
- Annual effective recharge from precipitation is estimated to be 10 percent of annual precipitation (Preston, 1996) and is only applied to outcrop areas.
- The managed available groundwater volume estimates are the sum of the annual effective recharge amount and the annual volume of water depleted from the aquifer based on the desired future condition.
- Annual managed available groundwater volumes are calculated by dividing the total volume by 50 years.
- Specific yield of the aquifer is estimated as 0.10 (USGS, 2002; Mason, 1961) and the storage coefficient is estimated as 0.0001 (Bluntzer, 1992; LBG-Guyton Associates, 2003).
- Outcrop areas are calculated as unconfined areas of the aquifer and subcrop areas are calculated as confined areas of the aquifer.
- Conditions were assumed to be physically possible across the groundwater management area.

Table 1. Estimated total annual effective recharge volume for the Hickory Aquifer by map areas (See Figure 1).

GMA	Aquifer	County	GCD	Map area	Areal extent (acres)	Average annual precipitation (inches)	Average annual precipitation (feet)	Effective recharge rate (percent)	Estimated annual effective recharge (ac-ft/yr)
8	Hickory	Burnet	Central Texas GCD	6	8,590	30	2.5	10	2,148
Total									2,148

GMA = groundwater management area GCD= groundwater conservation district ac-ft/yr = acre-feet per year
 The formula for this table is: areal extent (acres) * estimated average annual precipitation (feet) * effective recharge rate = estimated annual effective recharge (ac-ft/yr).

RESULTS:

The annual effective recharge estimate for the Hickory Aquifer in Groundwater Management Area 8 is 2,148 acre-feet per year.

The results (Table 2) show the managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8. This results in an estimated annual total volume of 2,346 acre-feet per year.

Therefore, based on the assessment of the adopted desired future conditions:

- Fox Crossing Water District has a total of 36 acre feet of managed available groundwater;
- Saratoga Underground Water Conservation District has a total of 113 acre feet of managed available groundwater, and;
- Central Texas Groundwater Conservation District has 2,148 acre-feet per of managed available groundwater:

In addition, the areas not covered by groundwater conservation districts have:

- Brown County has a total of 12 acre feet of managed available groundwater;
- Travis County has a total of 22 acre-feet of managed available groundwater, and;
- Williamson County has 15 acre-feet of managed available groundwater.

LIMITATIONS:

Additional data are needed to create improved estimates; these estimates are a fundamental interpretation of the requested conditions. This analysis assumes homogeneous and isotropic aquifers; however, conditions for the Hickory Aquifer may not behave in a uniform manner. The analysis further assumes that precipitation is the only source of aquifer recharge and that lateral inflow to the aquifer is equal to lateral outflow from the aquifer, and that future pumping will not alter this balance.

Note that estimates of managed available groundwater are based on the best available scientific tools that can be used to develop managed available groundwater and that these estimates can be a function of assumptions made on the magnitude and distribution of pumping in the aquifer. Therefore, it is important for groundwater conservation districts to monitor whether or not they are achieving their desired future conditions and to work with the TWDB to refine managed available groundwater given the reality of how the aquifer responds to the actual magnitude and distribution of pumping now and in the future.

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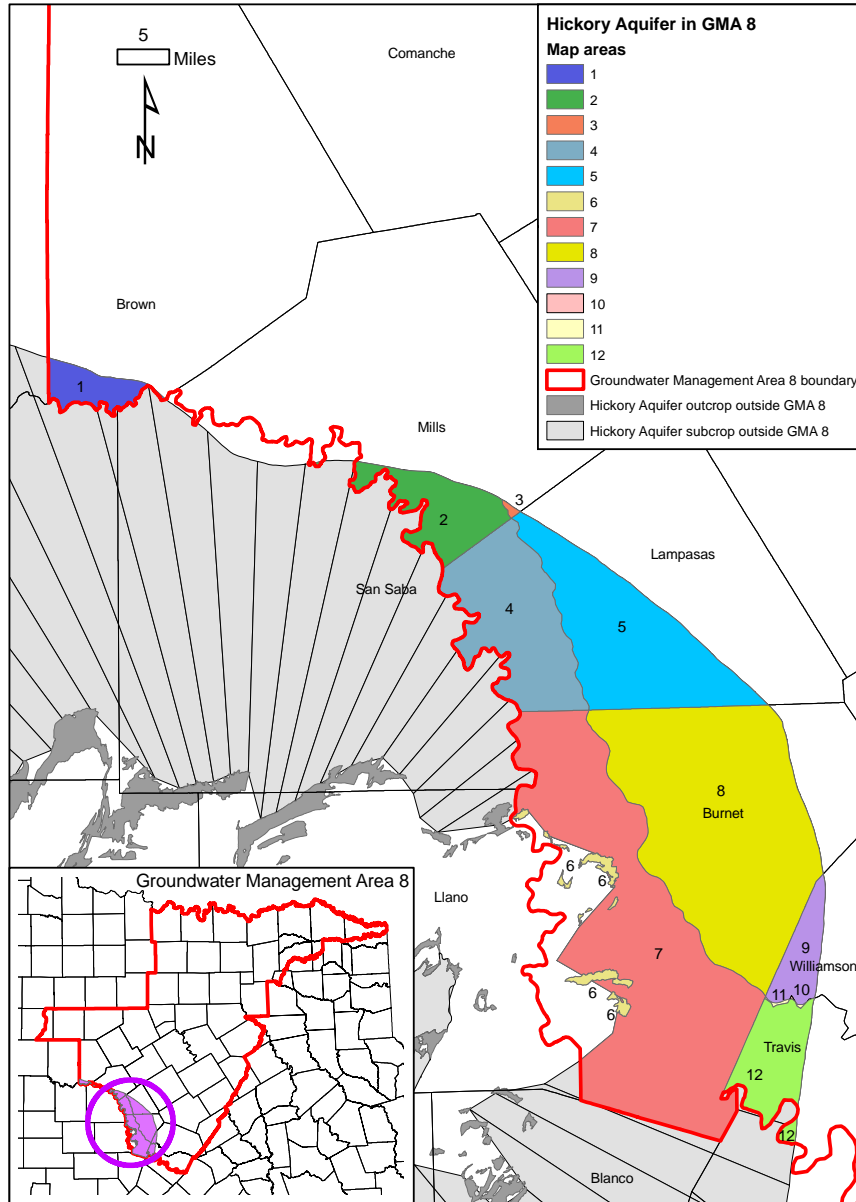


Figure 1. Map areas for estimating managed available groundwater for the Hickory Aquifer in Groundwater Management Area 8. * See Table 3 for a description of map areas based on county, regional water planning area, river basin, groundwater conservation district, and subcrop/outcrop boundaries.

Table 2. Estimates of managed available groundwater for the Hickory Aquifer summarized by map areas (see Figure 1).

GMA	Aquifer	County	GCD	Map area	Storage coefficient	Areal extent (acres)	Estimated saturated thickness (feet)	Desired future percent of saturated thickness	Desired future saturated thickness (feet)	Saturated thickness drained (feet)	Estimated total volume (acre-feet)	Estimated annual volume from storage (acre-feet)	Estimated annual effective recharge ¹ (ac-ft/yr)	Estimated annual total volume (ac-ft/yr)
8	Hickory	Brown Mills	n/a	10.0001	18,941	3,100	90%	2,790	310	587	12	0	12	
				20.0001	43,763	4,000	90%	3,600	400	1,751	35	0	35	
		Lampasas	Saratoga UWCD	30.0001	781	4,100	90%	3,690	410	32	1	0	1	
				40.0001	94,223	2,500	90%	2,250	250	2,356	47	0	47	
		Burnet	Central Texas GCD	50.0001	117,870	2,800	90%	2,520	280	3,300	66	0	66	
				60.1	8,590	500	100%	500	0	0	2,148	0	2,148	
		Travis	n/a	70.0001	269,096	1,500	100%	1,500	0	0	0	0	0	
				80.0001	243,277	2,600	100%	2,600	0	0	0	0	0	
		Williamson	n/a	100.0001	63	3,100	90%	2,790	310	2	0	0	0	
				120.0001	41,568	2,700	90%	2,430	270	1,122	22	0	22	
		Total	Total	90.0001	22,320	3,300	90%	2,970	330	737	15	0	15	
110.0001	522			3,000	90%	2,700	300	16	0	0	0			
Total												9,902	2,148	2,346

GMA = groundwater management area UWCD = underground water conservation district GCD= groundwater conservation district ac-ft/yr = acre-feet per year

1 - This is the estimated total annual effective recharge volume for the Hickory Aquifer by map areas as shown in Table 1.

The formulas for this table are: storage coefficient * areal extent * saturated thickness drained = estimated total volume.

Estimated total volume/50 = estimated annual volume from storage. Then estimated annual volume from storage + estimated annual effective recharge =

estimated annual total volume.

Table 3. Estimates of managed available groundwater for water level declines of 5 feet in the Hickory Aquifer (see Figure 1).

Map Key	Aquifer	County	RWPA	River Basin	GCD	GMA	GeoArea	Year	Outcrop/subcrop	MAG (acre-feet per year)
1	Hickory	Brown	F	Colorado	n/a	8	n/a	n/a	Subcrop	12
2	Hickory	Mills	K	Colorado	Fox Crossing Water District	8	n/a	n/a	Subcrop	35
3	Hickory	Mills	K	Brazos	Fox Crossing Water District	8	n/a	n/a	Subcrop	1
4	Hickory	Lampasas	G	Colorado	Saratoga UWCD	8	n/a	n/a	Subcrop	47
5	Hickory	Lampasas	G	Brazos	Saratoga UWCD	8	n/a	n/a	Subcrop	66
6	Hickory	Burnet	K	Colorado	Central Texas GCD	8	n/a	n/a	Outcrop	2,148
7	Hickory	Burnet	K	Colorado	Central Texas GCD	8	n/a	n/a	Subcrop	0
8	Hickory	Burnet	K	Brazos	Central Texas GCD	8	n/a	n/a	Subcrop	0
9	Hickory	Williamson	G	Brazos	n/a	8	n/a	n/a	Subcrop	15
10	Hickory	Travis	K	Brazos	n/a	8	n/a	n/a	Subcrop	0
11	Hickory	Williamson	G	Colorado	n/a	8	n/a	n/a	Subcrop	0
12	Hickory	Travis	K	Colorado	n/a	8	n/a	n/a	Subcrop	22

RWPA = regional water planning area
 GMA = groundwater management area
 GeoArea = Geographic areas defined by unique desired future conditions as specified by a groundwater management area.
 MAG = Managed available groundwater in units of acre-feet per year.

GCD = groundwater conservation district
 UWCD = underground water conservation district

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December 10, 2009

Ms. Cheryl Maxwell, General Manager
Clearwater Underground Water Conservation District
P.O. Box 729
Belton, TX 76513

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Ms. Maxwell:

The Texas Water Code, Section 36.108, Subsection (o), states that the Texas Water Development Board's executive administrator shall provide each district and regional water planning group located wholly or partly within a groundwater management area with the managed available groundwater in the management area based upon the desired future condition of the groundwater resource. This letter and the attached report (GTA Aquifer Assessment 08-04mag) are in response to this directive.

As noted in your letter dated June 9, 2008, the desired future condition submitted for the Hickory Aquifer in Groundwater Management Area 8 was as follows:

- Burnet County pumping should maintain approximately 100 percent of the saturated thickness after 50 years by using approximately 80 percent of the estimated recharge.
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Managed available groundwater is defined in the Texas Water Code as the amount of water that may be permitted by a district for beneficial use in accordance with the desired future condition of the aquifer, as determined under Texas Water Code, Section 36.108. For various planning purposes, the managed available groundwater estimates have been reported at the combined aquifer, county, river basin, regional water planning area, groundwater management area, groundwater conservation district (if applicable), subdivision of an aquifer (if designated), geologic strata (if designated), and geographic area (if designated) level.

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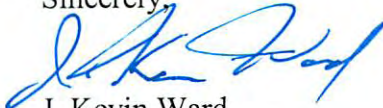
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Ms. Cheryl Maxwell
December 10, 2009
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We understand that groundwater conservation districts have options on how to distribute managed available groundwater in a groundwater management area; therefore, we encourage open communication and coordination between groundwater conservation districts, regional water planning groups, and the TWDB to ensure that managed available groundwater reported in regional water plans and groundwater management plans are not in conflict. In addition, please note that estimates of managed available groundwater are based on the best available scientific tools that can be currently used to develop managed available groundwater and that these estimates may be based on assumptions made on the magnitude and distribution of pumping in the aquifer. Therefore, it is important for groundwater conservation districts to monitor whether their management of pumping is achieving their desired future conditions. Districts are encouraged to continue work with the TWDB to better define available groundwater as additional new data could help better assess responses of the aquifer to actual pumpage values and their distribution now and in the future.

Sincerely,



J. Kevin Ward
Executive Administrator

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c w/att.: Cary Betz, Texas Commission of Environmental Quality, Water Supply Division
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December 10, 2009

Mr. Richard Bowers, General Manager
Central Texas Groundwater Conservation District
P.O. Box 870
Burnet, TX 78611

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Mr.  Bowers:

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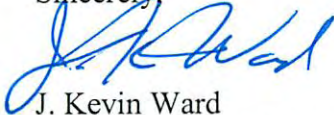
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December 10, 2009

Mr. Rodney Carlisle, Board President
Fox Crossing Water District
P.O. Box 926
Goldthwaite, TX 76844

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Mr. Carlisle:

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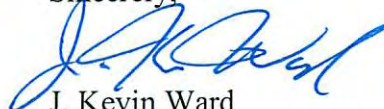
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December 10, 2009

Mr. Joe Cooper, General Manager
Middle Trinity Groundwater Conservation District
150 North Harbin Drive, Suite 434
Stephenville, TX 76401

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

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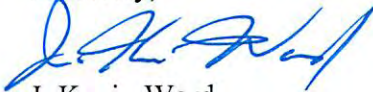
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Mr. Joe Cooper
December 10, 2009
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Sincerely,



J. Kevin Ward
Executive Administrator

Attachment: GTA Aquifer Assessment 08-04mag

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Joe M. Crutcher, *Member*

December 10, 2009

Mr. Eddy Daniel, Board President
North Texas Groundwater Conservation District
114 McKinney Street
Farmersville, TX 75442

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Mr. Daniel:

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Mr. Eddy Daniel
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December 10, 2009

Mr. Mark Mendez, District Agent
Northern Trinity Groundwater Conservation District
100 E. Weatherford Street, Suite 404
Fort Worth, TX 76196

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Mr. Mendez:

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Mr. Mark Mendez
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December 10, 2009

Mr. Gary Westbrook, General Manager
Post Oak Savannah Groundwater Conservation District
P.O. Box 92
Milano, TX 76556

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Mr. Westbrook:

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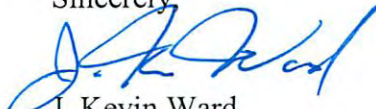
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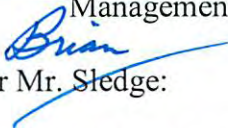
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December 10, 2009

Mr. Brian Sledge, Attorney
Prairielands Groundwater Conservation District
816 Congress Avenue, Suite 1900
Austin, TX 78701

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8


Dear Mr. Sledge:

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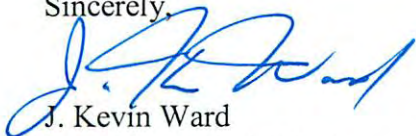
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Mr. Brian Sledge
December 10, 2009
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December 10, 2009

The Honorable Eileen Cox, Fannin County Judge
Red River Groundwater Conservation District
101 E. Rayburn Drive, Suite 101
Bonham, TX 75418

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Judge Cox:

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December 10, 2009

Mr. Randy McGuire, Board President
Saratoga Underground Water Conservation District
P.O. Box 231
Lampasas, TX 76550

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Mr. McGuire:

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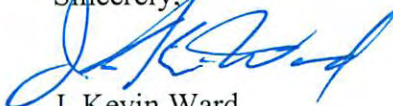
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J. Kevin Ward
Executive Administrator

Attachment: GTA Aquifer Assessment 08-04mag

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Mr. Randy McGuire
December 10, 2009
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Joe M. Crutcher, *Member*

December 10, 2009

Ms. Tricia Law, General Manager
Southern Trinity Groundwater Conservation District
P.O. Box 2205
Waco, TX 76703

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Ms. Law:

The Texas Water Code, Section 36.108, Subsection (o), states that Texas Water Development Board's executive administrator shall provide each district and regional water planning group located wholly or partly within a groundwater management area with the managed available groundwater in the management area based upon the desired future condition of the groundwater resource. This letter and the attached report (GTA Aquifer Assessment 08-04mag) are in response to this directive.

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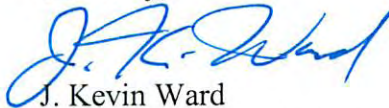
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Ms. Tricia Law
December 10, 2009
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Joe M. Crutcher, *Member*

December 10, 2009

Mr. Mike Massey, Board President
Upper Trinity Groundwater Conservation District
P.O. Box 1786
Granbury, TX 76048

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear  Mr. Massey:

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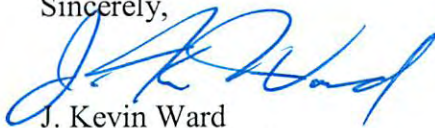
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Mr. Mike Massey
December 10, 2009
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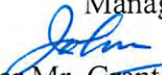
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Executive Administrator

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Joe M. Crutcher, *Member*

December 10, 2009

Mr. John Grant, Region F Chairman
Colorado River Municipal Water District
P.O. Box 869
Big Spring, TX 79721

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8


Dear Mr. Grant:

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Mr. John Grant
December 10, 2009
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Thomas Weir Labatt III, *Member*
Joe M. Crutcher, *Member*

December 10, 2009

The Honorable Dale Spurgin, Region G Chairman
Jones County Judge
P.O. Box 148
Anson, TX 79501

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Judge Spurgin:

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The Honorable Dale Spurgin
December 10, 2009
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December 10, 2009

Mr. John Burke, Region K Chairman
Aqua Water Supply Corporation
P.O. Drawer P
Bastrop, TX 78602

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Mr. Burke:

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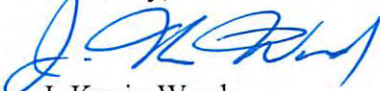
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Mr. John Burke
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December 10, 2009

Mr. Curtis Campbell, Region B Chairman
Red River Authority of Texas
P.O. Box 240
Wichita Falls, TX 76307

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8


Dear Mr. Campbell:

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Joe M. Crutcher, *Member*

December 10, 2009

Mr. James Parks, Region C Chairman
North Texas Municipal Water District
P.O. Box 2408
Wylie, TX 75098

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8


Dear Mr. Parks:

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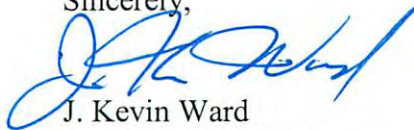
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Mr. James Parks
December 10, 2009
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Sincerely,



J. Kevin Ward
Executive Administrator

Attachment: GTA Aquifer Assessment 08-04mag

c w/att.: Cary Betz, Texas Commission of Environmental Quality, Water Supply Division
Kelly Mills, Texas Commission of Environmental Quality, Groundwater Planning and Assessment Division
Robert E. Mace, Ph.D., P.G., Deputy Executive Administrator, TWDB, Water Science and Conservation
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December 10, 2009

Mr. Richard LeTourneau, Region D Chairman
Regional Water Planning Group D
P.O. Box 12071
Longview, TX 75607

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear Mr.  LeTourneau:

The Texas Water Code, Section 36.108, Subsection (o), states that Texas Water Development Board's executive administrator shall provide each district and regional water planning group located wholly or partly within a groundwater management area with the managed available groundwater in the management area based upon the desired future condition of the groundwater resource. This letter and the attached report (GTA Aquifer Assessment 08-04mag) are in response to this directive.

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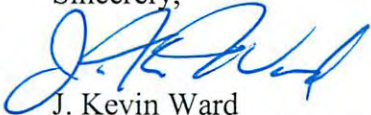
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Mr. Richard LeTourneau
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December 10, 2009

Mr. Phil Ford, General Manager
Brazos River Authority
P.O. Box 7555
Waco, TX 76714

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8


Dear Mr. Ford:

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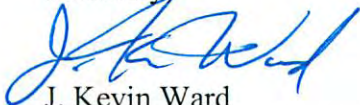
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December 10, 2009

Mr. Thomas G. Mason, General Manager
Lower Colorado River Authority
P.O. Box 220
Austin, TX 78767

Re: Managed available groundwater estimates for the Hickory Aquifer in Groundwater Management Area 8

Dear  Mr. Mason:

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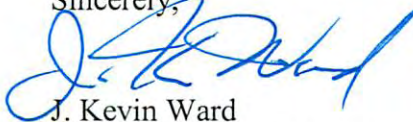
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