GTA Aquifer Assessment 09-08
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Groundwater Technical Assistance Section
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REQUESTOR:

Janet Adams, General Manager of Jeff Davis County and Presidio County underground water conservation districts, acting on behalf of Groundwater Management Area 4.

DESCRIPTION OF REQUEST:

Ms. Janet Adams provided the Texas Water Development Board (TWDB) with draft desired future conditions for the Capitan Reef Complex, Marathon, Presidio-Redford Bolson, and Rustler aquifers in Groundwater Management Area 4 and requested that TWDB evaluate the draft desired future conditions. This aquifer analysis estimates the annual total pumping to achieve the draft desired future conditions for the Capitan Reef Complex Aquifer in Groundwater Management Area 4.

DRAFT DESIRED FUTURE CONDITIONS:

- Brewster County Groundwater Conservation District (GCD)—on average a 20-foot drawdown over 50 years
- Culberson County GCD—on average a 50-foot drawdown over 50 years
- Jeff Davis County Underground Water Conservation District (UWCD)—on average a 10-foot drawdown over 50 years
- areas outside conservation district boundaries—on average a 20-foot drawdown over 50 years

METHODS:

Due to limited data on the Capitan Reef Complex Aquifer, a simple method of determining groundwater volume based on a uniform water-level decline was used. 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 overfull 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 pumping equals effective recharge plus the change in storage of the aquifer:

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

All of the aquifer within Groundwater Management Area 4 is within the Rio Grande River Basin and the Far West Regional Water Planning Area (Region E). To calculate the total pumping, the aquifer was divided into map areas by county and groundwater conservation district (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 to reach the desired water-level drawdown, the areas were multiplied by the estimated aquifer storage coefficient and 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 distributing existing volumetric recharge estimates evenly across the aquifer areas.

The calculations were completed in a Microsoft Excel worksheet.
PARAMETERS AND ASSUMPTIONS:

- The areas, in acres, for each map area were calculated using the TWDB shapefile for the Capitan Reef Complex Aquifer, projected into the groundwater availability modeling (GAM) projection (Anaya, 2001), within ArcGIS 9.2.
- The Capitan Reef Complex Aquifer is exposed at land surface in the Guadalupe and Apache Mountains in Culberson County and the Glass Mountains in northern Brewster County (Ashworth and Hopkins, 1995).
- The outcrop areas are assumed to be under confined conditions at depth, based on water level data (TWDB, 2008) and from assumptions for

- Estimates of storage coefficient in the Capitan Reef Complex Aquifer range from $1.0 \times 10^{-4}$–$5.0 \times 10^{-2}$ (0.0001–0.05) (Bjorklund and Motts, 1959; Gates and others, 1978; LBG-Guyton Associates, 2003). The storage coefficient was estimated to be $1.0 \times 10^{-3}$ (0.001) for these calculations.

- Effective recharge to the aquifer is estimated to be 12,500 acre-feet per year for the portion of the aquifer in Culberson, Jeff Davis, and Hudspeth counties and 2,100 acre-feet per year in Brewster County. These estimates are based on springflow and surface hydrology, groundwater pumpage and water-level changes, and precipitation estimates (Gates and others, 1978; Muller and Price, 1979; Far West Texas RWPG, 2001; George and others, 2005).

- Significant recharge to the aquifer from surface water bodies, such as ephemeral streambeds, has been observed (Bjorklund and Motts 1959), and likely occurs through fractures and karst features (George and others, 2005). However, because there are no existing estimates of the quantity and distribution of these focused inputs to the aquifer, recharge is assumed to occur evenly across the aerial extent of the aquifer.

- The draft annual total pumping estimates are the sum of the annual effective recharge amount and the annual volume of water depleted from the aquifer based on the draft desired future condition.

- Annual volumes of water taken from storage are calculated by dividing the total volume of depletion, based on the draft desired future condition, by 50 years.

- Water-level declines are estimated to be uniform across the aquifer within map areas.

- It is assumed that the water-level declines do not exceed aquifer thickness.

- Conditions were assumed to be physically possible across the groundwater management area.

**RESULTS:**

The annual effective recharge estimate for the Capitan Reef Complex Aquifer in Groundwater Management Area 4 is 12,500 acre-feet per year for the portion of the aquifer in Culberson, Jeff Davis, and Hudspeth counties and 2,100 acre-feet per year for the portion of the aquifer in Brewster County.

The results (Tables 1 and 2) show the draft annual total pumping estimates for the Capitan Reef Complex Aquifer in Groundwater Management Area 4. Based on the desired future conditions provided, the estimated total pumping volume for
the Capitan Reef Complex Aquifer in Groundwater Management Area 4 is 14,960 acre-feet per year.

Specifically,

- Brewster County GCD has a total of 2,129 acre-feet of annual total pumping;
- Culberson County GCD has a total of 7,580 acre-feet of annual total pumping;
- the area of Culberson County outside of Culberson County GCD has 4,083 acre-feet of annual total pumping;
- Hudspeth County (outside of the GCD) has 825 acre-feet of annual total pumping; and
- Jeff Davis UWCD has a total of 343 acre-feet of annual total pumping.
Table 1. Estimates of draft annual total pumping for the Capitan Reef Complex Aquifer summarized by map areas (see Figure 1).

<table>
<thead>
<tr>
<th>GMA</th>
<th>Aquifer (confined)</th>
<th>County</th>
<th>GCD</th>
<th>Map area</th>
<th>Storage coefficient</th>
<th>Areal extent (acres)</th>
<th>Desired total aquifer drawdown (feet)</th>
<th>Estimated total volume from storage (acre-feet)</th>
<th>Estimated annual volume from storage (acre-feet)</th>
<th>Estimated annual effective recharge (ac-ft/yr)</th>
<th>Estimated annual total volume (ac-ft/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Capitan</td>
<td>Brewster</td>
<td>Brewster</td>
<td>1</td>
<td>0.001</td>
<td>72,731</td>
<td>20</td>
<td>1,455</td>
<td>29</td>
<td>2,100</td>
<td>2,129</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Culberson</td>
<td>Culberson</td>
<td>2</td>
<td>0.001</td>
<td>259,695</td>
<td>50</td>
<td>12,985</td>
<td>260</td>
<td>7,320</td>
<td>7,580</td>
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<tr>
<td></td>
<td></td>
<td>Culberson</td>
<td>none</td>
<td>3</td>
<td>0.001</td>
<td>142,853</td>
<td>20</td>
<td>2,857</td>
<td>57</td>
<td>4,026</td>
<td>4,083</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hudspeth</td>
<td>none</td>
<td>4</td>
<td>0.001</td>
<td>28,862</td>
<td>20</td>
<td>577</td>
<td>12</td>
<td>813</td>
<td>825</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jeff Davis</td>
<td>Jeff Davis</td>
<td>5</td>
<td>0.001</td>
<td>12,100</td>
<td>10</td>
<td>121</td>
<td>2</td>
<td>341</td>
<td>343</td>
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<tr>
<td></td>
<td>Total</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17,995</td>
<td>360</td>
<td>14,600</td>
<td>14,960</td>
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</tbody>
</table>

GMA = groundwater management area; GCD = groundwater conservation district; ac-ft/yr = acre-feet per year.
The formulas in this table are: storage coefficient * areal extent * desired total aquifer drawdown = estimated total volume from storage
estimated total volume from storage/50 = estimated annual volume from storage
estimated annual volume from storage + estimated annual effective recharge = estimated annual total volume

Table 2. Summary of estimated annual total pumping for the Capitan Reef Complex Aquifer in Groundwater Management Area 4.

<table>
<thead>
<tr>
<th>Map key</th>
<th>Aquifer</th>
<th>County</th>
<th>RWPA</th>
<th>River basin</th>
<th>GCD</th>
<th>GMA</th>
<th>GeoArea</th>
<th>Year</th>
<th>Total Pumping (acre-feet per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Capitan</td>
<td>Brewster</td>
<td>E</td>
<td>Rio Grande</td>
<td>Brewster County GCD</td>
<td>4</td>
<td>n/a</td>
<td>n/a</td>
<td>2,129</td>
</tr>
<tr>
<td>2</td>
<td>Capitan</td>
<td>Culberson</td>
<td>E</td>
<td>Rio Grande</td>
<td>Culberson County GCD</td>
<td>4</td>
<td>n/a</td>
<td>n/a</td>
<td>7,580</td>
</tr>
<tr>
<td>3</td>
<td>Capitan</td>
<td>Culberson</td>
<td>E</td>
<td>Rio Grande</td>
<td>none</td>
<td>4</td>
<td>n/a</td>
<td>n/a</td>
<td>4,083</td>
</tr>
<tr>
<td>4</td>
<td>Capitan</td>
<td>Hudspeth</td>
<td>E</td>
<td>Rio Grande</td>
<td>none</td>
<td>4</td>
<td>n/a</td>
<td>n/a</td>
<td>825</td>
</tr>
<tr>
<td>5</td>
<td>Capitan</td>
<td>Jeff Davis</td>
<td>E</td>
<td>Rio Grande</td>
<td>Jeff Davis County UWCD</td>
<td>4</td>
<td>n/a</td>
<td>n/a</td>
<td>343</td>
</tr>
</tbody>
</table>

RWPA = regional water planning area, GCD = groundwater conservation district, UWCD = underground water conservation district, GMA = groundwater management area, GeoArea = geographic areas defined by unique desired future conditions as specified by a groundwater management area.
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 Capitan Reef Complex Aquifer may not behave in a uniform manner. The analysis further assumes that lateral inflow to the aquifer is equal to lateral outflow from the aquifer and that future pumping will not alter this balance.

REFERENCES:


Far West Texas RWPG (Regional Water Planning Group), 2001, Far west Texas regional water plan: Far West Texas Regional Water Planning Group, variously paginated.


