EDWARDS AQUIFER
AUTHORITY

RECEIVED
SEP 02 2010
TWDB

August 24, 2010

Mr. J. Kevin Ward, Executive Administrator
Texas Water Development Board
P O Box 13231
Austin, TX 78711-3231

Dear Mr. Ward:

As Coordinator for Groundwater Management Area (GMA) 10, I want to inform you that GMA 10 has formally adopted Desired Future Condition (DFC) for the fresh and saline zones of the Edwards Aquifer in the northern subdivision of GMA 10 and for Edwards Aquifer within Kinney County in the western subdivision of GMA 10.

After reviewing information packets for the fresh and saline portions of the Edwards Aquifer in the northern portion of GMA 10, all groundwater conservation district (GCD) representatives in attendance, eight of the nine members of the Joint Coordinating Committee of GMA 10, voted unanimously on August 4, 2010, to adopt scenarios for the fresh and saline zones of the Edwards Aquifer in the northern subdivision of GMA 10 as follows:

Freshwater Zone

1. Springflow of Barton Springs during average recharge conditions shall be no less than 49.7 cubic feet per second (cfs) averaged over an 84-month (seven-year) period; and

2. During extreme drought conditions, including those as severe as a recurrence of the 1950's drought of record, springflow of Barton Springs shall be no less than 6.5 cubic feet per second (cfs), averaged on a monthly basis.

Saline Zone

Well drawdown at the saline-freshwater interface (the so-called Edwards "Bad Water Line") in the Northern Subdivision of GMA 10 that averages no more than 5 feet <u>and</u> does not exceed a maximum of 25 feet at any one point on the interface.

Enclosed, please find the following items related to the DFC adoption for the record:

- Copies of posted meeting notices for the August 4, 2010 meeting (Exhibit A);
- Minutes of the August 4, 2010 meeting (Exhibit B);
- Resolution Nos. 2010-02 and 2010-06 with signatures of all attending GCD representatives (Exhibit C);
- Copies of the information packets that served as the basis for the DFC adoption by GMA 10 (Additional Backup for Agenda Item 6 and Additional Backup for Agenda Item 8 – Exhibit D); and

- Additional material, including a spreadsheet showing projected springflow based on different pumping scenarios, a discussion paper on DFC establishment, a research paper on response by the Plethodontid Salamander to declining Dissolved Oxygen, a correlation graph of Dissolved Oxygen vs. springflow at Barton springs and *"Gam Run 09-019"* (Exhibit E).

Additionally, posted notices, maps and approved minutes for a May 17, 2010, meeting at which a decision was made to subdivide GMA 10 into three subdivisions with respect to the Edwards Aquifer are attached (Exhibit F).

Finally, after reviewing information in GAM Task 10-027, all groundwater conservation district (GCD) representatives in attendance, eight of the nine members of the Joint Coordinating Committee of GMA 10, voted unanimously on August 4, 2010, to adopt a Desired Future Condition for the Edwards Aquifer in Kinney County of the western subdivision of GMA 10 of maintaining a water level in Index Well No. 70-38-902 at or above an elevation of 1,184 feet above mean sea level.

Also find enclosed the following items related to the DFC adoption for the record:

- Resolution No. 2010-08 with signatures of all attending GCD representatives (Exhibit G); and
- A copy of GAM Task 10-027 for Kinney County (Exhibit H);

If there are any additional submission requirements necessary, please contact me at:

Edwards Aquifer Authority
1615 N. St. Mary's
San Antonio, TX 78215
Office phone (210) 222-2204
E-mail: rillgner@edwardsaquifer.org

Respectfully,

Rick Illgner

Rick Illgner
Governmental Affairs Officer
Edwards Aquifer Authority

RI/em

Enclosures

EDWARDS AQUIFER
AUTHORITY

Exhibit A

Posted notices for

August 4, 2010 GMA 10

meeting

Groundwater Management Area #10 Joint Planning Meeting

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

NOTICE OF OPEN MEETINGS

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

LT1-86-14063-1

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of July 19, 2010 Minutes.
5. Discussion and action related to readopting a DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
6. Discussion and action related to readopting a DFC for the Saline Edwards Aquifer in the Northern Subdivision of GMA 10.
7. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and the establishment of Trinity DFCs.
8. Discussion and possible action related to establishing DFCs for the Leona Gravel, Buda, Austin Chalk and Related Aquifers in Uvalde County.
9. Discussion and possible action related to designating and establishing DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
10. Discussion of compliance monitoring activities for adopted DFCs within each district.
11. Meeting schedule post September 2010.
12. Adjournment of morning meeting.

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 12:30 pm at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

LT2-0-0-1

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Came to hand and posted on a Bulletin Board in the Courthouse, ________ County, Texas, on this, the____ day of July, 2010 at _________ .m.

______________________________, Deputy Clerk

____________ County, TEXAS

Groundwater Management Area #10 Joint Planning Meeting

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

NOTICE OF OPEN MEETINGS

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of July 19, 2010 Minutes.
5. Discussion and action related to readopting a DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
6. Discussion and action related to readopting a DFC for the Saline Edwards Aquifer in the Northern Subdivision of GMA 10.
7. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and the establishment of Trinity DFCs.
8. Discussion and possible action related to establishing DFCs for the Leona Gravel, Buda, Austin Chalk and Related Aquifers in Uvalde County.
9. Discussion and possible action related to designating and establishing DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
10. Discussion of compliance monitoring activities for adopted DFCs within each district.
11. Meeting schedule post September 2010.
12. Adjournment of morning meeting.

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 12:30 pm at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Came to hand and posted on a Bulletin Board in the Courthouse, Kinney County, Texas, on this, the 29 day of July, 2010 at 3:45p .m.

Dora Elia Sandoval Co. Clerk. Ruela Ramón, Deputy Clerk

Kinney County, TEXAS

NOTICE OF OPEN MEETINGS

Groundwater Management Area #10 Joint Planning Meetings

Wednesday, August 4, 2010, at 11:30 a.m.

Notice is given that an open meeting of Groundwater Conservation Districts that are located within the State of Texas Groundwater Management Area #10, with one or more members of the Board of Directors and/or its designated representative and/or staff of the **Barton Springs Edwards Aquifer Conservation District** in attendance, for purposes of discussing and/or conducting joint planning concerning desired future conditions, in compliance with Texas Water Code, Chapter 36.108. This meeting will be held on **Wednesday, August 4, 2010, at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.**

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of July 19, 2010 Minutes.
5. Discussion and action related to readopting a DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
6. Discussion and action related to readopting a DFC for the Saline Edwards Aquifer in the Northern Subdivision of GMA 10.
7. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and the establishment of Trinity DFCs.
8. Discussion and possible action related to establishing DFCs for the Leona Gravel, Buda, Austin Chalk and Related Aquifers in Uvalde County.
9. Discussion and possible action related to designating and establishing DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
10. Discussion of compliance monitoring activities for adopted DFCs within each district.
11. Meeting schedule post-September 2010.
12. Adjournment of morning meeting.

Wednesday, August 4, 2010, at 12:30 p.m.

Notice is given that an open meeting of Groundwater Conservation Districts that are located within the State of Texas Groundwater Management Area #10, with one or more members of the Board of Directors and/or its designated representative and/or staff of the **Barton Springs Edwards Aquifer Conservation District** in attendance, for purposes of discussing and/or conducting joint planning concerning desired future conditions, in compliance with Texas Water Code, Chapter 36.108. This meeting will be held on **Wednesday, August 4, 2010 at 12:30 pm at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.**

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Came to hand and posted on a Bulletin Board in the Courthouse, Travis County, Texas, on this, the 29 day of July, 2010 at 4:17 P.m.

Michael P. Gonzales, Deputy Clerk
MICHAEL P. GONZALES Travis County, TEXAS

SEAL OF COUNTY COURT TRAVIS COUNTY, TEXAS

Please note:

The Barton Springs/Edwards Aquifer Conservation District is committed to compliance with the Americans with Disabilities Act (ADA). Reasonable accommodations and equal opportunity for effective communications will be provided upon request. Please contact the District office at 512-282-8441 at least 24 hours in advance if accommodation is needed.

FILED AND RECORDED
OFFICIAL PUBLIC RECORDS
Dana DeBeauvoir

Jul 29, 2010 04:17 PM 201080294
GONZALESM: $3.00
Dana DeBeauvoir, County Clerk
Travis County TEXAS

Groundwater Management Area #10 Joint Planning Meeting

Accepted for Filing in: Hays County On: Jul 29,2010 at 03:20P By: Rose Robinson

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

NOTICE OF OPEN MEETINGS

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of July 19, 2010 Minutes.
5. Discussion and action related to readopting a DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
6. Discussion and action related to readopting a DFC for the Saline Edwards Aquifer in the Northern Subdivision of GMA 10.
7. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and the establishment of Trinity DFCs.
8. Discussion and possible action related to establishing DFCs for the Leona Gravel, Buda, Austin Chalk and Related Aquifers in Uvalde County.
9. Discussion and possible action related to designating and establishing DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
10. Discussion of compliance monitoring activities for adopted DFCs within each district.
11. Meeting schedule post September 2010.
12. Adjournment of morning meeting.

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 12:30 pm at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Came to hand and posted on a Bulletin Board in the Courthouse, HAYS County, Texas, on this, the 29th day of July, 2010 at 3:20 P.m.

[signature], Deputy Clerk

HAYS County, TEXAS

Groundwater Management Area #10 Joint Planning Meeting

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222-9869

NOTICE OF OPEN MEETINGS

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

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1. Call to Order.
2. Public Comment.
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7. Discussion and possible action related to the designation of relevant aquifers for DFC's related to the Trinity Group, relevant aquifer assessments, and the establishment of Trinity DFC's.
8. Discussion and possible action related to establishing DFC's for the Leona Gravel, Buda, Austin Chalk and Related Aquifers in Uvalde County.
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At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Came to hand and posted on a Bulletin Board in the Courthouse Caldwell County, Texas, on this, the 29 day of July, 2010 at 3:20 p.m.

FILED this 29th day of July 2010 3:20 P M

NINA S. SELLS

COUNTY CLERK, CALDWELL COUNTY, TEXAS

Martha Gil, Deputy Clerk

Caldwell County, TEXAS

Groundwater Management Area #10 Joint Planning Meeting

Accepted for Filing in:
Hays County
On: Jul 30,2010 at 03:07P
By:
Lynn Curry

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

NOTICE OF OPEN MEETINGS

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

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1. Call to Order.
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4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Came to hand and posted on a Bulletin Board in the Courthouse, Hays County, Texas, on this, the 30th day of July, 2010 at 3:07 p.m.

Lynn Curry, Deputy Clerk
Hays County, TEXAS

Groundwater Management Area #10 Joint Planning Meeting

000784

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

NOTICE OF OPEN MEETINGS

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

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5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Came to hand and posted on a Bulletin Board in the Courthouse, ________ County, Texas, on this the ____ day of July, 2010 at ________ .m.

____________________________, Deputy Clerk

______________ County, TEXAS

Trinity Glen Rose Groundwater Conservation District

6335 Camp Bullis Rd. Suite #25 San Antonio, Texas 78257 (210) 698-1155 Fax (210) 698-1159

Groundwater Management Area Joint Planning Meeting
Wednesday, August 4, 2010 11:30 A.M.

Notice is given that one or more members of the Board of Directors and/or their designated representatives and/or Staff of the Trinity Glen Rose Groundwater Conservation District (TGRGCD) will attend a meeting of Groundwater Conservation Districts which are located within the State of Texas Groundwater Management Area #10 for purposes of discussing and/or conducting joint planning in compliance with the requirements of HB 1763, which was passed during the 2005 Texas Legislative Session. This meeting will be held at the **Edwards Aquifer Authority, located at Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215 on August 4, 2010 at 11:30 a.m. for the following purposes:**

Agenda

Kendall County
DARLENE HERRIN
COUNTY CLERK
On: 07/30/2010 7:39AM
By: Harriet F Seidensticker, Deputy

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of July 19, 2010 Minutes.
5. Discussion and action related to readopting a DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
6. Discussion and action related to readopting a DFC for the Saline Edwards Aquifer in the Northern Subdivision of GMA 10.
7. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and the establishment of Trinity DFCs.
8. Discussion and possible action related to establishing DFCs for the Leona Gravel, Buda, Austin Chalk and Related Aquifers in Uvalde County.
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10. Discussion of compliance monitoring activities for adopted DFCs within each district.
11. Meeting schedule post September 2010.
12. Adjournment of morning meeting.

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 12:30 pm at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Posted at the TGRGCD office, TGRGCD Website, Bexar County, Kendall County and Comal County Courthouses, on this, the 29th day of July, 2010.

General Manager, Trinity Glen Rose Groundwater Conservation District

The Trinity Glen Rose Groundwater Conservation District is committed to compliance with the Americans with Disabilities Act (ADA) Reasonable accommodations and equal opportunity for effective communications will be provided upon request. Please contact the District Representative at 210-219-5555 at least 24 hours in advance if accommodation is needed.

Trinity Glen Rose Groundwater Conservation District

6335 Camp Bullis Rd. Suite #25 San Antonio, Texas 78257 (210) 698-1155 Fax (210) 698-1159

Groundwater Management Area Joint Planning Meeting
Wednesday, August 4, 2010 11:30 A.M.

Notice is given that one or more members of the Board of Directors and/or their designated representatives and/or Staff of the Trinity Glen Rose Groundwater Conservation District (TGRGCD) will attend a meeting of Groundwater Conservation Districts which are located within the State of Texas Groundwater Management Area #10 for purposes of discussing and/or conducting joint planning in compliance with the requirements of HB 1763, which was passed during the 2005 Texas Legislative Session. This meeting will be held at the **Edwards Aquifer Authority, located at Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215 on August 4, 2010 at 11:30 a.m. for the following purposes:**

Agenda

LT1-86-14067-1

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of July 19, 2010 Minutes.
5. Discussion and action related to readopting a DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
6. Discussion and action related to readopting a DFC for the Saline Edwards Aquifer in the Northern Subdivision of GMA 10.
7. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and the establishment of Trinity DFCs.
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9. Discussion and possible action related to designating and establishing DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
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11. Meeting schedule post September 2010.
12. Adjournment of morning meeting.

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 12:30 pm at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

LT2-0-0-1

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Doc# 14067 Fees: $2.00
07/30/2010 9:15AM # Pages 1
Filed & Recorded in the Official Public
Records of BEXAR COUNTY
GERARD RICKHOFF COUNTY CLERK

Posted at the TGRGCD office, TGRGCD Website, Bexar County, Kendall County and Comal County Courthouses, on this, the 29th day of July, 2010.

General Manager, Trinity Glen Rose Groundwater Conservation District

The Trinity Glen Rose Groundwater Conservation District is committed to compliance with the Americans with Disabilities Act (ADA). Reasonable accommodations and equal opportunity for effective communications will be provided upon request. Please contact the District Representative at 210-219-5555 at least 24 hours in advance if accommodation is needed.

Trinity Glen Rose Groundwater Conservation District

6335 Camp Bullis Rd. Suite #25 San Antonio, Texas 78257 (210) 698-1155 Fax (210) 698-1159

Groundwater Management Area Joint Planning Meeting

2010 JUL 30 PM 12: 33 **Wednesday, August 4, 2010 11:30 A.M.**

Notice is given that one or more members of the Board of Directors and/or their designated representatives and/or Staff of the Trinity Glen Rose Groundwater Conservation District (TGRGCD) will attend a meeting of Groundwater Conservation Districts which are located within the State of Texas Groundwater Management Area #10 for purposes of discussing and/or conducting joint planning in compliance with the requirements of HB 1763, which was passed during the 2005 Texas Legislative Session. This meeting will be held at the **Edwards Aquifer Authority, located at Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215 on August 4, 2010 at 11:30 a.m. for the following purposes:**

Agenda

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of July 19, 2010 Minutes.
5. Discussion and action related to readopting a DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
6. Discussion and action related to readopting a DFC for the Saline Edwards Aquifer in the Northern Subdivision of GMA 10.
7. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and the establishment of Trinity DFCs.
8. Discussion and possible action related to establishing DFCs for the Leona Gravel, Buda, Austin Chalk and Related Aquifers in Uvalde County.
9. Discussion and possible action related to designating and establishing DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
10. Discussion of compliance monitoring activities for adopted DFCs within each district.
11. Meeting schedule post September 2010.
12. Adjournment of morning meeting.

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 12:30 pm at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Posted at the TGRGCD office, TGRGCD Website, Bexar County, Kendall County and Comal County Courthouses, on this, the 29th day of July, 2010.

General Manager, Trinity Glen Rose Groundwater Conservation District

The Trinity Glen Rose Groundwater Conservation District is committed to compliance with the Americans with Disabilities Act (ADA). Reasonable accommodations and equal opportunity for effective communications will be provided upon request. Please contact the District Representative at 210-219-5555 at least 24 hours in advance if accommodation is needed.

Groundwater Management Area #10 Joint Planning Meeting

NOTICE OF OPEN MEETINGS

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of July 19, 2010 Minutes.
5. Discussion and action related to readopting a DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
6. Discussion and action related to readopting a DFC for the Saline Edwards Aquifer in the Northern Subdivision of GMA 10.
7. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and the establishment of Trinity DFCs.
8. Discussion and possible action related to establishing DFCs for the Leona Gravel, Buda, Austin Chalk and Related Aquifers in Uvalde County.
9. Discussion and possible action related to designating and establishing DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
10. Discussion of compliance monitoring activities for adopted DFCs within each district.
11. Meeting schedule post September 2010.
12. Adjournment of morning meeting.

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 12:30 pm at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

Came to hand and posted on a Bulletin Board in the Courthouse, Medina County, Texas, on this, the 29th day of July, 2010 at p.m.

POSTED IN MY OFFICE
LISA J. WERNETTE

JUL 29 '10 PM 4 40

COUNTY CLERK, MEDINA CO.

Groundwater Management Area #10 Joint Planning Meeting

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

NOTICE OF OPEN MEETINGS

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of July 19, 2010 Minutes.
5. Discussion and action related to readopting a DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
6. Discussion and action related to readopting a DFC for the Saline Edwards Aquifer in the Northern Subdivision of GMA 10.
7. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and the establishment of Trinity DFCs.
8. Discussion and possible action related to establishing DFCs for the Leona Gravel, Buda, Austin Chalk and Related Aquifers in Uvalde County.
9. Discussion and possible action related to designating and establishing DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
10. Discussion of compliance monitoring activities for adopted DFCs within each district.
11. Meeting schedule post September 2010.
12. Adjournment of morning meeting.

As required by Section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Wednesday, August 4, 2010 at 12:30 pm at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Public Comment.
3. Receipt of Posted Notices.
4. Approval of Minutes of the GMA 10 Meeting beginning at 11:30 AM, August 4, 2010.
5. Discussion of other GMA 10 Business.
6. Next Meeting and Discussion Topics.
7. Adjournment of afternoon meeting.

FILED This 30 day of July A.D. 2010 at 11:51 o'clock A M LUCILLE C. HUTCHESON County Clerk, Uvalde County /s/ Grace Hunt

Came to hand and posted on a Bulletin Board in the Courthouse, ________ County, Texas, on this, the____ day of July, 2010 at ________ .m.

__________________________, Deputy Clerk

____________ County, TEXAS

EDWARDS AQUIFER
AUTHORITY

Exhibit B

Minutes from August 4, 2010 GMA 10 meeting

GMA-10 Joint Planning Committee
Meeting Minutes
August 4, 2010 (First Session)

1. **Call to Order.** The meeting was called to order by Committee Coordinator Rick Illgner (EAA) at 11:36 am.

2. **Public Comment.** Roy Cooley from Maverick County addressed the group on his concerns regarding groundwater withdrawals from Kinney County and their subsequent effect on local springs and streams that feed the Rio Grande.

3. **Receipt of Public Notices.** A quorum of eight of the nine GMA-10 GCDs were present: Barton Springs/Edwards Aquifer Conservation District (BSEACD), Plum Creek GCD (PCGCD), Edwards Aquifer Authority (EAA), Medina Co. GCD (MCGCD), Uvalde Co. UWCD (UCUWCD), Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD (KCGCD); Guadalupe County GCD was not present. Posted meeting notices were received from all nine of the GCDs, including Guadalupe County GCD.

4. **Approval of July 19, 2010, Minutes.** George Wissmann moved and Tommy Boehme seconded approving the July 19, 2010, minutes as presented. There were no objections; therefore minutes were approved.

5. **Discussion and action related to adopting a DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.** Kirk Holland moved and Vic Hilderbran seconded adopting Resolution No. 2010-02 adopting a Desired Future Condition for the Fresh Edwards Aquifer in the Northern subdivision of GMA 10. Motion passed unanimously.

6. **Discussion and action related to adopting a DFC for the Saline Edwards Aquifer in the Northern Subdivision of GMA 10.** Kirk Holland moved and Vic Hilderbran seconded adopting Resolution No. 2010-06 adopting a Desired Future Condition for the Saline Edwards Aquifer in the Northern subdivision of GMA 10. Motion passed unanimously.

7. **Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and a schedule for the establishment of Trinity DFCs.** There was considerable discussion and several actions taken regarding the Trinity Aquifer in GMA 10:
   - David Baker moved and Luana Buckner seconded to adopt a Desired Future Condition of zero feet of drawdown for the portion of the Trinity Aquifer within the boundaries of the Hays Trinity GCD. Motion passed unanimously.
   - George Wissmann moved and Luana Buckner seconded to declare the portion of the Trinity Glen Rose GCD within GMA 10 as non-relevant. Motion passed with Plum Creek CD abstaining and all other GCDs voting in favor..
   - Kirk Holland moved and Luana Buckner seconded to adopt Resolution 2010-07 that would provide a Desired Future Condition for the Trinity Aquifer within

GMA 10 outside of the areas of Hays, Bexar, and Uvalde Counties excepted by previous motions that comprised a 25 foot drawdown. Motion passed 6-2, with Uvalde UWCD and Hays Trinity GCD voting nay.

Vic Hildebrand began discussion of a 20 foot drawdown for the Trinity Aquifer in Uvalde County, which led to an extended discussion regarding how to incorporate all of these various actions and proposed DFC's into an appropriate adoption format that was timely and clearly supported. George Wissmann moved and Luana Buckner seconded to suspend actions on Trinity Aquifer DFCs that were previously agreed and DFCs for the minor aquifers in Uvalde County that were previously discussed in this meeting, develop a general Resolution to incorporate the intent of the previous actions and proposed DFCs and present the Resolution at another meeting to consider for adoption. Motion passed unanimously. A final meeting was scheduled for Monday, August 23 at 11:30 in the EAA Conference Center, to be followed by an afternoon meeting to approve the minutes evidencing whatever actions were taken.

8. **Discussion and possible action related to establishing DFCs for the Leona Gravel, Buda, Austin Chalk and Related Aquifers in Uvalde County.** Vic Hilderbran moved to adopt a Desired Future Condition for the Buda, Austin Chalk and Leona Gravel aquifers in Uvalde County that resulted in zero drawdown. There was no second or action, which created the discussion and subsequent action reported in the latter part of agenda Item 7 above.

9. **Discussion and possible action related to designating and establishing DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.** (Note: This item was taken up immediately after the Public Comments at the outset, so that members of the public from Kinney County could conveniently take part in the discussions.) Bill Hutchison of the Texas Water Development Board discussed how a new model had to be developed for Kinney County and reviewed GAM Task 10-027 with GMA 10. Ken Carver moved and Vic Hilderbran seconded adopting Resolution 2010-08 that provided a Desired Future Condition of maintaining a water level in Index Well No. 70-38-902 at or above an elevation of 1,184 feet above mean seal level. Motion passed unanimously.

10. **Discussion of compliance monitoring activities for adopted DFCs within each district.** This item will be discussed at the next meeting.

11. **Meeting schedule post September 2010.** This item will be discussed at the next meeting.

12. **Adjournment of morning meeting.** The meeting was adjourned at approximately 1:43 pm.

EDWARDS AQUIFER
AUTHORITY

Exhibit C

- Resolution # 2010-02
  DFC for fresh Edwards
  Northern subdivision
- Resolution # 2010-06
  DFC for saline Edwards
  Northern subdivision

STATE OF TEXAS	§	
	§	
COUNTIES OF BEXAR,	§	
CALDWELL, COMAL,	§	**RESOLUTION No.**
GUADALUPE, HAYS, KINNEY,	§	**2010-02**
MEDINA, TRAVIS, AND	§	
UVALDE	§	

THE JOINT COORDINATING COMMITTEE OF GROUNDWATER MANAGEMENT AREA 10

RESOLUTION FOR THE ADOPTION OF THE DESIRED FUTURE CONDITION OF THE FRESHWATER EDWARDS AQUIFER IN THE NORTHERN SUBDIVISION OF GROUNDWATER MANAGEMENT AREA 10

WHEREAS, THE JOINT COORDINATING COMMITTEE OF GROUNDWATER MANAGEMENT AREA (GMA) 10 COMPRISES DELEGATES DESIGNATED BY THE FOLLOWING GROUNDWATER CONSERVATION DISTRICTS LOCATED WHOLLY OR PARTIALLY WITHIN GMA 10: BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT, EDWARDS AQUIFER AUTHORITY, GUADALUPE COUNTY GCD, HAYS TRINITY GCD, KINNEY COUNTY GCD, MEDINA COUNTY GCD, PLUM CREEK CD, TRINITY GLEN ROSE GCD, AND UVALDE COUNTY UWCD;

WHEREAS, CHAPTER 36.108 OF THE TEXAS WATER CODE, (JOINT PLANNING IN MANAGEMENT AREA), REQUIRES THAT THE GROUNDWATER CONSERVATION DISTRICTS IN THE GMA ADOPT DESIRED FUTURE CONDITIONS (DFCs) OF ALL RELEVANT AQUIFERS IN THE GMA FOR A FIFTY-YEAR PLANNING PERIOD, NO LATER THAN SEPTEMBER 1, 2010;

WHEREAS, ONE OR MORE OF THE COMMITTEE MEMBERS OF GMA 10 HAVE HELD ONE OR MORE PUBLIC MEETINGS NOTICED AND POSTED IN ACCORDANCE *WITH* STATE LAW, AND HAVE REVIEWED AND DISCUSSED PERTINENT AQUIFER

ASSESSMENTS BY THE TEXAS WATER DEVELOPMENT BOARD (TWDB) AND OTHERS WITH THE PUBLIC AND HAVE RECEIVED INPUT AND COMMENT FROM STAKEHOLDERS WITHIN THAT PART OF GMA 10 THAT USES AND IS AFFECTED BY USERS AND USES OF THE AQUIFER;

WHEREAS, THE FRESHWATER EDWARDS AQUIFER IN THE NORTHERN SUBDIVISION OF GMA 10 (AQUIFER) IS A KARST AQUIFER THAT EXPERIENCES RAPID RECHARGE DURING PERIODS OF HIGH RAINFALL AND RAPID DEPLETION DURING DROUGHT. THE BARTON SPRINGS SEGMENT THAT COMPRISES THE NORTHERN SUBDIVISION OF THE AQUIFER IS ALSO A RELATIVELY SMALL RESERVOIR THAT MAINLY SERVES AS A PUBLIC WATER SUPPLY SOURCE FOR MORE THAN 50,000 PEOPLE BUT ALSO SERVES SIGNIFICANT INDUSTRIAL, COMMERCIAL, RECREATIONAL, AND OTHER USES, INCLUDING PROVIDING THE HABITAT FOR ENDANGERED SPECIES. THESE FACTS, COMBINED WITH THE AVAILABILITY OF ALTERNATIVE WATER SOURCES TO SOME USERS, INDICATE THAT TWO DFC EXPRESSIONS ARE NEEDED:
:

1. AN UPPER OR :"ALL CONDITIONS" DFC, WHICH WILL CORRESPOND TO A LIMIT ON THE AMOUNT AND RATE BY WHICH THE AQUIFER WATER LEVEL MAY BE DRAWN DOWN UNDER EVEN TRANSIENT HIGH-FLOW CONDITIONS, AND
2. A LOWER OR "EXTREME DROUGHT" DFC, WHICH WILL DEFINE THE AQUIFER WATER LEVEL TO BE MAINTAINED IN A RETURN OF A GREAT DROUGHT LIKE THAT OF THE 1950'S;

WHEREAS, THE FACTORS CONSIDERED IN SETTING AN UPPER OR "ALL CONDITIONS" DFC FOR THE AQUIFER INCLUDE:

1. THE ABILITY OF THE AQUIFER TO SUPPLY REGIONAL WATER NEEDS IN TIMES OF ABUNDANCE;
2. THE ABILITY OF GROUNDWATER CONSERVATION DISTRICTS AND OTHERS TO IMPLEMENT AQUIFER STORAGE AND RECOVERY (ASR) PROJECTS DURING HIGH-FLOW CONDITIONS TO INCREASE THE AMOUNT OF WATER HELD IN STORAGE FOR USE DURING DROUGHT;
3. THE ABILITY OF CONDITIONAL PERMITTEES TO REDUCE AND CURTAIL THEIR USAGE OF AQUIFER WATER THROUGH CONSERVATION AND THE SUBSTITUTION OF OTHER WATER SUPPLIES UPON THE RETURN OF DROUGHT CONDITIONS; AND
4. THE AVOIDANCE OF UNREASONABLE ACCELERATION OF MANDATORY WATER CONSERVATION REQUIREMENTS FOR OTHER PERMITTEES.

WHEREAS, THE COMMITTEE EXAMINED THE MODELED RELATIONSHIPS BETWEEN AVERAGE SPRINGFLOWS AND TOTAL AQUIFER WATER WITHDRAWALS, DEVELOPED BY TWDB IN ITS DRAFT REPORT TITLED "GAM RUN 09-019', DATED DECEMBER 9, 2009, AND FURTHER ELABORATED BY AND

DISCUSSED WITH TWDB'S DR. BILL HUTCHISON USING A SPREADSHEET PRESENTATION TITLED "AVESPRINGFLOW_VS_PUMPING", EMAILED ON MAY 26, 2010, AND CONSIDERED A RANGE OF AVERAGE SPRINGFLOWS BETWEEN 46 CFS AND 53 CFS FOR THE UPPER DFC; THE COMMITTEE DETERMINED THAT A SEVEN-YEAR AVERAGE SPRINGFLOW OF 49.7 CFS, CORRESPONDING TO AN AGGREGATE MAXIMUM OF 16 CFS OF TOTAL ANNUAL WITHDRAWALS FROM THE EDWARDS BY ALL USERS, INCLUDING EXEMPT USERS, GOVERNS THE RATE OF ONSET OF DROUGHT CONDITIONS IN THE AQUIFER TO ACCEPTABLE LEVELS WHILE PROVIDING ADDITIONAL SUPPLIES;

WHEREAS, THE FACTORS CONSIDERED IN SETTING A LOWER OR "EXTREME DROUGHT" DFC INCLUDE:

1. THE VULNERABILITY OF SOME EXISTING PUBLIC WATER SUPPLY, DOMESTIC, LIVESTOCK, AND OTHER WELLS TO DEPLETION OF AVAILABLE GROUNDWATER AT LOW AQUIFER WATER LEVELS;
2. THE POTENTIAL FOR PROLONGED HARM OR EVEN RISK OF EXTINCTION TO THE ENDANGERED BARTON SPRINGS SALAMANDERS AND OTHER WILDLIFE SPECIES OF CONCERN IN BARTON SPRINGS DUE TO LOW SPRINGFLOW AND THE ASSOCIATED LOWER DISSOLVED OXYGEN CONCENTRATIONS, ALTHOUGH THAT RISK MIGHT BE MITIGATED BY OTHER MEANS;
3. THE RECREATIONAL NEEDS OF THE MORE THAN 500,000 ANNUAL VISITORS TO BARTON SPRINGS POOL;
4. THE ABILITY AND COSTS OF EXISTING PUBLIC WATER SUPPLY AND OTHER AQUIFER PERMITTEES TO REDUCE THEIR WATER USAGE AND SECURE ALTERNATIVE WATER SUPPLIES IN TIME OF DROUGHT IN ORDER TO MEET MANDATORY REDUCTION REQUIREMENTS; AND
5. THE ECONOMIC IMPACT OF MANDATORY WATER USE REDUCTION OR CURTAILMENT ON AQUIFER USERS, COMMUNITIES, AND INDIVIDUAL PROPERTY RIGHTS.

WHEREAS, THE COMMITTEE EXAMINED THE MODELED RELATIONSHIPS BETWEEN EXTREME DROUGHT SPRINGFLOWS AND WATER WITHDRAWALS, DEVELOPED BOTH BY THE TWDB, IN ITS DRAFT REPORT TITLED "GAM RUN 09-019, DATED DECEMBER 9, 2009" AND BY THE BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT IN ITS 2004 REPORT TITLED "SUSTAINABLE YIELD STUDY", AND CONSIDERED SPRINGFLOWS OF 5, 7, 9, AND 11 CFS THAT WOULD EXIST DURING A RECURRENCE OF THE DROUGHT OF RECORD FOR THE LOWER DFC; THE COMMITTEE DETERMINED THAT 6.5 CFS ACCEPTABLY BALANCES THE PROTECTION OF ALL USES AND USERS OF THE AQUIFER DURING EXTREME DROUGHT;

WHEREAS, THE APPROVAL OF THE DFCs FOR THE AQUIFER WAS DELIBERATED IN A PROPERLY NOTICED AND POSTED MEETING OF THE JOINT COORDINATING COMMITTEE OF GMA 10, WITH AT LEAST TWO-THIRDS OF THE VOTING MEMBERS OF THE COMMITTEE PRESENT:

NOW, THEREFORE, BE IT RESOLVED THAT THE DISTRICT MEMBERS OF GROUNDWATER MANAGEMENT AREA 10 ADOPT THE FOLLOWING AS THE INITIAL DESIRED FUTURE CONDITIONS FOR THE FRESHWATER EDWARDS AQUIFER IN THE GMA-10 NORTHERN SUBDIVISION, AND FURTHER REQUEST THE TWDB TO PROVIDE AN OFFICIAL ESTIMATE OF THE MANAGED AVAILABLE GROUNDWATER, AS DEFINED BY CHAPTER 36 OF THE TEXAS WATER CODE, THAT IS CONSISTENT WITH ACHIEVING EACH OF THESE DFCs:

1. SPRINGFLOW OF BARTON SPRINGS DURING AVERAGE RECHARGE CONDITIONS SHALL BE NO LESS THAN 49.7 CUBIC FEET PER SECOND (CFS) AVERAGED OVER AN 84-MONTH (SEVEN-YEAR) PERIOD; AND

2. DURING EXTREME DROUGHT CONDITIONS, INCLUDING THOSE AS SEVERE AS A RECURRENCE OF THE 1950'S DROUGHT OF RECORD, SPRINGFLOW OF BARTON SPRINGSSHALL BE NO LESS THAN 6.5 CUBIC FEET PER SECOND (CFS), AVERAGED ON A MONTHLY BASIS.

VOTED AND APPROVED THIS, THE____ __th DAY OF _____________, 2010, BY A VOTE OF ___ AYES AND ___ NAYS, CONSTITUTING AT LEAST A TWO-THIRDS MAJORITY OF THE VOTING MEMBERS PRESENT.

SIGNED ________________________________
Kirk Holland — Barton Springs/Edwards Aquifer Conservation District

SIGNED ________________________________
Luana Buckner — Edwards Aquifer Authority

SIGNED ________________________________
Ron Naumann — Guadalupe County GCD

SIGNED ________________________________
David Baker — Hays Trinity GCD

SIGNED ________________________________
~~Stan Metcalfe~~ KEN CARVER — Kinney County GCD

SIGNED ________________________________
Tommy Boehme — Medina County GCD

SIGNED ________________________________
Daniel Meyer — Plum Creek Conservation District

SIGNED ________________________________
George Wissmann — Trinity Glen Rose GCD

SIGNED ________________________________
Vic Hilderbran — Uvalde County UWCD

STATE OF TEXAS	§	
	§	
COUNTIES OF BEXAR,	§	
CALDWELL, COMAL,	§	**RESOLUTION No.**
GUADALUPE, HAYS, KINNEY,	§	**2010-06**
MEDINA, TRAVIS, AND	§	
UVALDE	§	

THE JOINT COORDINATING COMMITTEE OF GROUNDWATER MANAGEMENT AREA 10

RESOLUTION FOR THE ADOPTION OF THE DESIRED FUTURE CONDITION OF THE SALINE EDWARDS AQUIFER IN THE NORTHERN SUBDIVISION OF GROUNDWATER MANAGEMENT AREA 10

WHEREAS, THE JOINT COORDINATING COMMITTEE OF GROUNDWATER MANAGEMENT AREA (GMA) 10 COMPRISES DELEGATES DESIGNATED BY THE FOLLOWING GROUNDWATER CONSERVATION DISTRICTS LOCATED WHOLLY OR PARTIALLY WITHIN GMA 10: BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT, EDWARDS AQUIFER AUTHORITY, GUADALUPE COUNTY GCD, HAYS TRINITY GCD, KINNEY COUNTY GCD, MEDINA COUNTY GCD, PLUM CREEK CD, TRINITY GLEN ROSE GCD, AND UVALDE COUNTY UWCD;

WHEREAS, CHAPTER 36.108 OF THE TEXAS WATER CODE, (JOINT PLANNING IN MANAGEMENT AREA), REQUIRES THAT THE GROUNDWATER CONSERVATION DISTRICTS IN THE GMA ADOPT DESIRED FUTURE CONDITIONS (DFCs) OF ALL RELEVANT AQUIFERS IN THE GMA FOR A FIFTY-YEAR PLANNING PERIOD, NO LATER THAN SEPTEMBER 1, 2010;

WHEREAS, ONE OR MORE OF THE COMMITTEE MEMBERS OF GMA 10 HAVE HELD ONE OR MORE PUBLIC MEETINGS NOTICED AND POSTED IN ACCORDANCE WITH STATE LAW, AND HAVE REVIEWED AND DISCUSSED PERTINENT AQUIFER ASSESSMENTS BY THE TEXAS WATER DEVELOPMENT BOARD (TWDB) AND OTHERS WITH THE PUBLIC AND HAVE RECEIVED INPUT AND COMMENT FROM STAKEHOLDERS WITHIN THAT PART OF GMA 10 THAT MIGHT USE, AND WOULD BE POTENTIALLY AFFECTED BY USERS AND USES OF, THE SALINE EDWARDS AQUIFER (AQUIFER);

WHEREAS, THE SALINE EDWARDS AQUIFER IN GMA 10 IS A KARST AQUIFER THAT LIKELY HAS SIGNIFICANT VARIATIONS IN AQUIFER LEVELS OVER RELATIVELY SHORT TIME SPANS; HAS LARGELY UNKNOWN HYDROGEOLOGIC CHARACTERISTICS AND AQUIFER PROPERTIES, INCLUDING INTERFORMATIONAL RECHARGE AMOUNTS; IS LIKELY LOCALLY VARIABLE IN SALINITY AND IN THE AMOUNT OF WATER THAT IS YIELDED TO WELLS; IS PRESENT IN GMA 10 ONLY IN THE SUBCROP PART OF THE AQUIFER UNDER CONFINED HYDROLOGIC CONDITIONS; IS NOT KNOWN TO BE CURRENTLY USED AS A WATER SUPPLY IN APPRECIABLE AMOUNTS; IS LIKELY HYDROLOGICALLY CONNECTED TO THE FRESHWATER EDWARDS AQUIFER IN SOME COMPLEX, POORLY KNOWN WAY, BUT LIKELY INCLUDING SOME INTERCONNECTION WITH OTHER AQUIFERS ACROSS FAULTS;

WHEREAS, THE FACTORS CONSIDERED IN SETTING A DFC FOR THIS AQUIFER INCLUDE:

1. THE UNCERTAINTY OF THE VOLUME AND RATE OF PRODUCTION THAT CAN BE ACHIEVED BY A SALINE PRODUCTION WELL AS PART OF A DESALINATION FACILITY, AND THEREFORE UNCERTAINTY AS TO ITS ABILITY OR TIMING TO SERVE AS A SIGNIFICANT REGIONAL GROUNDWATER RESOURCE.
2. THE FULLY SUBSCRIBED STATUS OF THE FIRM-YIELD OF THE ADJACENT FRESHWATER EDWARDS AQUIFER, WHICH RESTRICTS USE OF THIS HIGHER QUALITY, MORE ACCESSIBLE GROUNDWATER MOSTLY TO EXEMPTS, CREATING A NEED FOR ALTERNATIVE WATER SOURCES.
3. THE RELATIVELY LARGE EXPENSE IN DEVELOPING THIS AQUIFER IN GMA 10 AS A WATER SOURCE, ESPECIALLY IN LIGHT OF SOME INSTITUTIONAL OBSTACLES, UNCERTAINTIES ABOUT CONCENTRATE DISPOSAL, AND OTHER RISKS AND CHALLENGES.
4. THE RELATIVELY LARGE AMOUNT OF DRAWDOWN APPARENTLY AVAILABLE BETWEEN THE DROUGHT-PERIOD POTENTIOMETRIC SURFACE OF THIS AQUIFER AND THE TOP OF THE AQUIFER WHERE DE-WATERING WOULD OCCUR.
5. THE EXCEEDINGLY SPARSE DATA CONCERNING HYDROGEOLOGIC CONDITIONS AND AQUIFER PERFORMANCE IN MOST OF GMA 10.
6. THE CONCERN ABOUT PROTECTING THE FRESHWATER EDWARDS FROM SIGNIFICANT ADVERSE EFFECTS AS THE BRACKISH GROUNDWATER RESOURCE IS DEVELOPED.
7. THE LACK OF AN OFFICIAL GAM FOR THE AQUIFER IN GMA 10;
8. BECAUSE THE STATUTORY PUMPING LIMITS APPLICABLE TO EAA DO NOT DISTINGUISH BETWEEN FRESHWATER AND SALINE EDWARDS GROUNDWATER, EAA DOES NOT DESIRE THAT ANY ADDITIONAL PUMPING LIMITATIONS FROM A SALINE EDWARDS MAG BE ESTABLISHED IN ITS JURISDICTION.

WHEREAS, THE COMMITTEE DOES NOT YET HAVE AN AQUIFER ASSESSMENT FOR THIS AQUIFER BY TWDB, AND ANTICIPATES THAT ANY AQUIFER ASSESSMENT THAT MIGHT BE FURNISHED TIMELY TO THE DFC DEADLINE WOULD LIKELY BE NECESSARILY RUDIMENTARY. NEVERTHELESS THE COMMITTEE PREFERS TO ESTABLISH AT LEAST A NOMINAL, EVEN PLACE-HOLDER DFC FOR THE AQUIFER IN THIS FIRST ROUND OF JOINT REGIONAL PLANNING, WHICH WOULD PROVIDE A MAG AND A BASIS FOR FURTHER SALINE WATER RESOURCE PLANNING AND DEVELOPMENT WHILE PROTECTING THE ADJACENT FRESHWATER RESOURCE. THE COMMITTEE REPRESENTATIVES EXAMINED GEOPHYSICAL TRANSECTS PRODUCED BY USGS AND SAN ANTONIO WATER SYSTEMS AND OTHER RECONNAISSANCE LEVEL STUDIES OF THE SALINE ZONE IN THE VICINITY OF THE INTERFACE WITH THE FRESHWATER AQUIFER, AND CONSIDERED THE RELATIONSHIP OF AND NATURAL VARIATIONS IN THE POTENTIOMETRIC SURFACES BETWEEN THE AQUIFERS WITH TIME. THE COMMITTEE REPRESENTATIVES DETERMINED THAT A NOMINALLY SMALL AMOUNT OF AVERAGE DRAWDOWN ALONG THE INTERFACE IN THE NORTHERN SUBDIVISION OF GMA 10, AND A RELATIVELY SMALL MAXIMUM DRAWDOWN AT ANY ONE POINT ON THAT INTERFACE WOULD PROVIDE A REASONABLE INITIAL DFC, TO BE REFINED AS MORE INFORMATION BECOMES AVAILABLE. SUCH A DFC WOULD BE CONSERVATIVE IN THAT IT WOULD PREVENT ADVERSE IMPACTS TO OTHER RESOURCES WHILE PROVIDING A MEANS TO EVALAUTE AND PROMOTE THE DEVELOPMENT OF THE SALINE EDWARDS AS A NEW WATER SOURCE THAT IS LESS DROUGHT PRONE THAN OTHER SURFACE AND GROUNDWATER RESOURCES IN THE AREA, AND A MECHANISM TO REGULATE IT APPROPRIATELY;

WHEREAS, THE APPROVAL OF THE DFCs FOR THE AQUIFER WAS DELIBERATED IN A PROPERLY NOTICED AND POSTED MEETING OF THE JOINT COORDINATING COMMITTEE OF GMA 10, WITH AT LEAST TWO-THIRDS OF THE VOTING MEMBERS OF THE COMMITTEE PRESENT:

NOW, THEREFORE, BE IT RESOLVED THAT THE DISTRICT MEMBERS OF GROUNDWATER MANAGEMENT AREA 10 ADOPT THE FOLLOWING AS THE INITIAL DESIRED FUTURE CONDITION FOR THE SALINE EDWARDS AQUIFER IN THE NORTHERN SUBDIVISION OF GMA-10, AND FURTHER REQUEST THE TWDB TO PROVIDE AN OFFICIAL ESTIMATE OF THE MANAGED AVAILABLE GROUNDWATER, AS DEFINED BY CHAPTER 36 OF THE TEXAS WATER CODE, THAT IS CONSISTENT WITH ACHIEVING THIS DFC:

> WELL DRAWDOWN AT THE SALINE-FRESHWATER INTERFACE (THE SO-CALLED EDWARDS "BAD WATER LINE") IN THE NORTHERN SUBDIVISION OF GMA 10 THAT AVERAGES NO MORE THAN 5 FEET AND DOES NOT EXCEED A MAXIMUM OF 25 FEET AT ANY ONE POINT ON THE INTERFACE.

VOTED AND APPROVED THIS, THE____ __th DAY OF ____________, 2010, BY A VOTE OF ___ AYES AND ___ NAYS, CONSTITUTING AT LEAST A TWO-THIRDS MAJORITY OF THE VOTING MEMBERS PRESENT.

SIGNED ______________________
Kirk Holland — Barton Springs/Edwards Aquifer Conservation District

SIGNED ______________________
Luana Buckner — Edwards Aquifer Authority

SIGNED ______________________
Ron Naumann — Guadalupe County GCD

SIGNED ______________________
David Baker — Hays Trinity GCD

SIGNED ______________________
~~Stan Metcalf~~ Ken CARVER — Kinney County GCD

SIGNED ______________________
Thomas Boehme — Medina County GCD

SIGNED ______________________
Daniel Meyer — Plum Creek Conservation District

SIGNED ______________________
George Wissmann — Trinity Glen Rose GCD

SIGNED ______________________
Vic Hilderbran — Uvalde County UWCD

EDWARDS AQUIFER
AUTHORITY

Exhibit D

Reference material for DFC's in the Northern subdivision

Additional Backup

Agenda Item 6
Northern Subdivision, Edwards Aquifer DFCs

Supplemental Info for Draft Resolution 2010-2

MOTION ON DESIRED FUTURE CONDITIONS OF THE FRESHWATER EDWARDS AQUIFER IN THE NORTHERN SUBDIVISION OF GMA 10

The Board of Directors of the Barton Springs/Edwards Aquifer Conservation District (BSEACD) adopts the following resolution as its recommendation to all of the groundwater conservation districts within Groundwater Management Area 10 (GMA-10) of the expression of the "desired future condition" (DFC) for the Northern Subdivision of the freshwater Edwards Aquifer, as required by Texas Water Code Sec. 36.108(d) and Texas Water Development Board (TWDB) regulations.

WHEREAS,

A. The DFC is intended to be the realistic goal or target set by the districts within the GMA for groundwater conditions 50 years from now. But the "managed available groundwater" (MAG) amount that will be calculated in accordance with the DFC will be issued to each district by the TWDB within one year after the submission of the DFC, and the districts will be obligated to issue permits totaling up to that amount, provided they satisfy other district requirements. So the DFC must be calibrated with an eye on both near-term outcomes and long-term goals. That is, the desired condition must be achievable relatively soon after the MAG is issued and also achievable and still desirable in 50 years.

B. The freshwater Edwards Aquifer is a karst aquifer that experiences rapid recharge during periods of high rainfall and rapid depletion during drought. The Barton Springs segment that comprises the Northern Subdivision of the aquifer is also a relatively small reservoir that mainly serves as a public water supply source for more than 50,000 people but also serves significant industrial, commercial, recreational, and other uses, including providing the habitat for endangered species. These facts, combined with the availability of alternative water sources to some users, suggest that two types or levels of DFC are needed: an upper or "all conditions" DFC that will set a limit on the amount by which the aquifer water level may be drawn down under even transient high-flow conditions, and a lower or "extreme drought" DFC that will define the aquifer water level to be maintained in a return of a great drought like that of the 1950's. Permits for the amount of groundwater between those two levels should be available only on a conditional basis, subject to reduction and total curtailment when drought returns. The regulatory and drought management programs of the district must provide for pumpage reductions and curtailments that achieve those outcomes.

C. Springflow at the natural outlet of Barton Springs is the best overall indicator of conditions in the Northern Subdivision of the freshwater Edwards Aquifer, especially during the critical low-flow conditions. So the "extreme drought" DFC for the aquifer is best expressed in terms of the amount of springflow that is to be maintained. Under low-flow conditions, there is an approximate one-to-one relationship between the amount of water withdrawn from the aquifer by wells and the amount of springflow. That is, each measure of water that is withdrawn results in an equal measure of reduction in springflow. The "all conditions" DFC relates to the amount of water in storage in the aquifer above the level of Barton Springs and is best expressed as the maintenance of an all-time average springflow over a suitably long time period...

D. The factors to be considered in setting an upper or "all conditions" DFC for the aquifer include the following:

1. The ability of the aquifer to supply regional water needs in times of abundance;
2. The ability of groundwater conservation districts and others to implement aquifer storage and retrieval (ASR) projects during high-flow conditions to increase the amount of water held in storage for use during drought;
3. The ability of conditional permittees to reduce and curtail their usage of aquifer water through conservation and the substitution of other water supplies upon the return of drought conditions; and
4. The avoidance of unreasonable acceleration of mandatory water conservation requirements for other permittees.

E. After considering these factors, the Board concludes that an initial upper or "all conditions" DFC that is defined as maintaining a minimum average springflow of 49.7 cfs over a running seven-year period, which corresponds to 16 cfs of total pumped withdrawals from the Edwards from all users, including exempt users, under any and all aquifer conditions will enable the aquifer to continue to play an important role in supplying regional water needs, will allow the districts and others in GMA 10 to conduct pilots and implement ASR projects if deemed feasible, will provide reasonable assurance that conditional permittees will be able to reduce and curtail their usage upon the return of drought, and will not unreasonably accelerate mandatory water conservation requirements for other permittees.

F. The factors to be considered in setting a lower or "extreme drought" DFC include the following:

1. The vulnerability of some existing public water supply, domestic, livestock, and other wells to depletion of available groundwater at low aquifer water levels;
2. The potential for prolonged harm or even risk of extinction to the endangered Barton Springs salamanders and other wildlife species of concern in Barton Springs due to low springflow and the associated lower dissolved oxygen concentrations, although that risk might be mitigated by other means;
3. The recreational needs of the more than 500,000 annual visitors to Barton Springs Pool;
4. The ability and costs of existing public water supply and other aquifer permittees to reduce their water usage and secure alternative water

supplies in time of drought in order to meet mandatory reduction requirements; and

5. The economic impact of mandatory water use reduction or curtailment on aquifer users, communities, and individual property rights.

G. After considering these factors, the Board concludes that an initial lower or "extreme drought" DFC that is defined as Barton Springs flow averaging no less than 6.5 cubic feet per second (cfs) on a monthly basis during a recurrence of drought-of-record conditions will not unduly endanger vulnerable wells, will not likely create jeopardy for survival and recovery of the endangered species that the district has a duty to protect under the federal Endangered Species Act and BSEACD's approved Management Plan; will not prevent the recreational use of Barton Springs Pool; will be achievable through aggressive conservation, substitution of alternative water supplies, and retirement or reservation of existing permitted uses; and will not cause intolerable economic impacts due to mandatory water use reduction or curtailment.

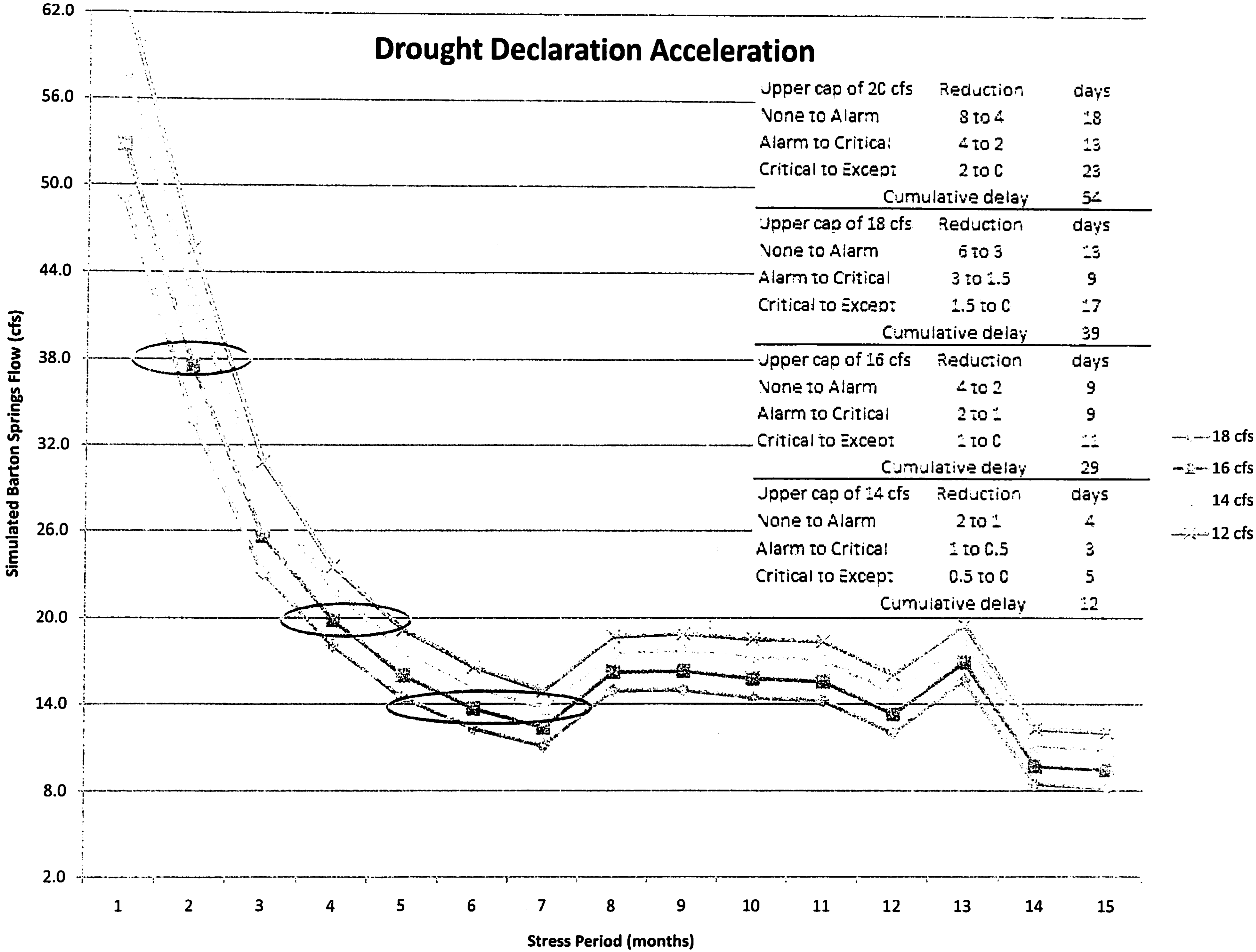
H. The Board recognizes that the limitations on water withdrawals implied by the recommended DFCs, especially the limitations during extreme drought conditions, may cause considerable inconvenience and may lead to some unintended consequences to the human users of the aquifer, yet these DFCs do not presently eliminate, only substantially reduce the risk to the endangered wildlife that depends on the flow of Barton Springs. The Board believes that the proposed DFCs fairly balance the inconvenience, losses, and risks of the resulting groundwater management program with the necessity to fulfill the obligation of the District to protect and conserve the aquifer so that its uses can be passed undiminished to succeeding generations. However, it is the intent of BSEACD to modify the DFCs and how they are achieved to be even more protective of aquifer levels and springflows in future rounds of joint regional groundwater planning, as more effective water conservation methods and increased alternative water supplies, such as reclaimed water, desalinated brackish groundwater, surface water through extended distribution networks, and harvested rainwater become more available. These additional sources of water are either not currently available or are of limited availability. It may be several years or more before these additional sources of water are available in significant enough quantities to alleviate demand on the freshwater Edwards, thereby reducing the inconveniences, losses, and risk. BSEACD is already working to bring about these additional sources of water and will continue these efforts until the inconveniences, losses, and risks are significantly reduced. Our 50-year goal, not currently achievable, is to enable historic consumers to achieve sufficient conservation and access adequate alternative water supplies during an extreme drought to meet their health and safety needs while allowing springflow to be maintained at or above the low of the 1950s drought. In addition, the risk to the survival of the endangered salamanders during low-flow episodes may also be proven to be amenable to mitigation by technical means in the future, such as subsurface aeration or water recirculation, which may temper the ecological consequences of extreme drought conditions.

THEREFORE,

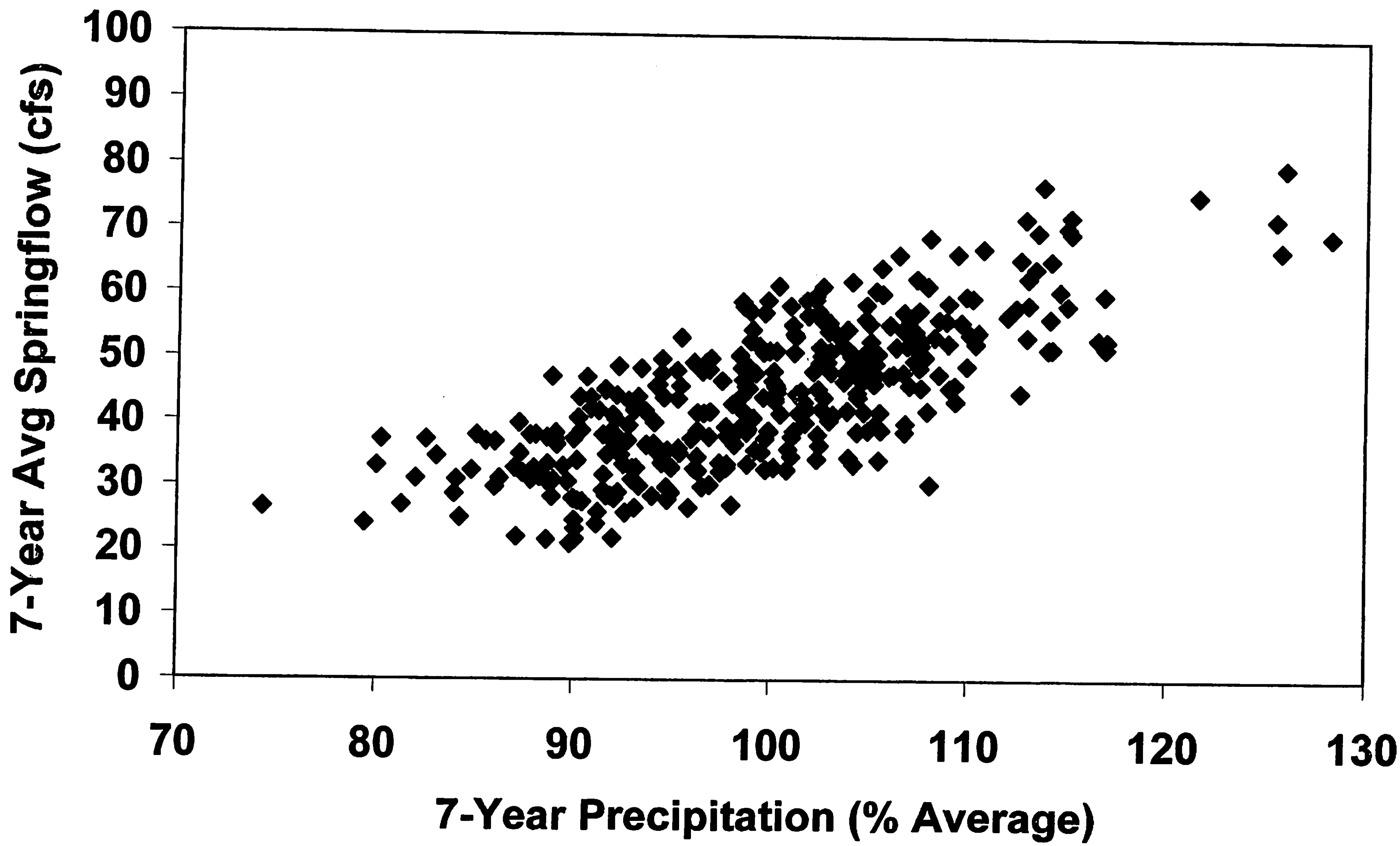
The Board of Directors of the BSEACD recommends that GMA 10 submit to the TWDB the following initial expressions of the DFC for the freshwater Edwards Aquifer in the Northern Subdivision of GMA 10:

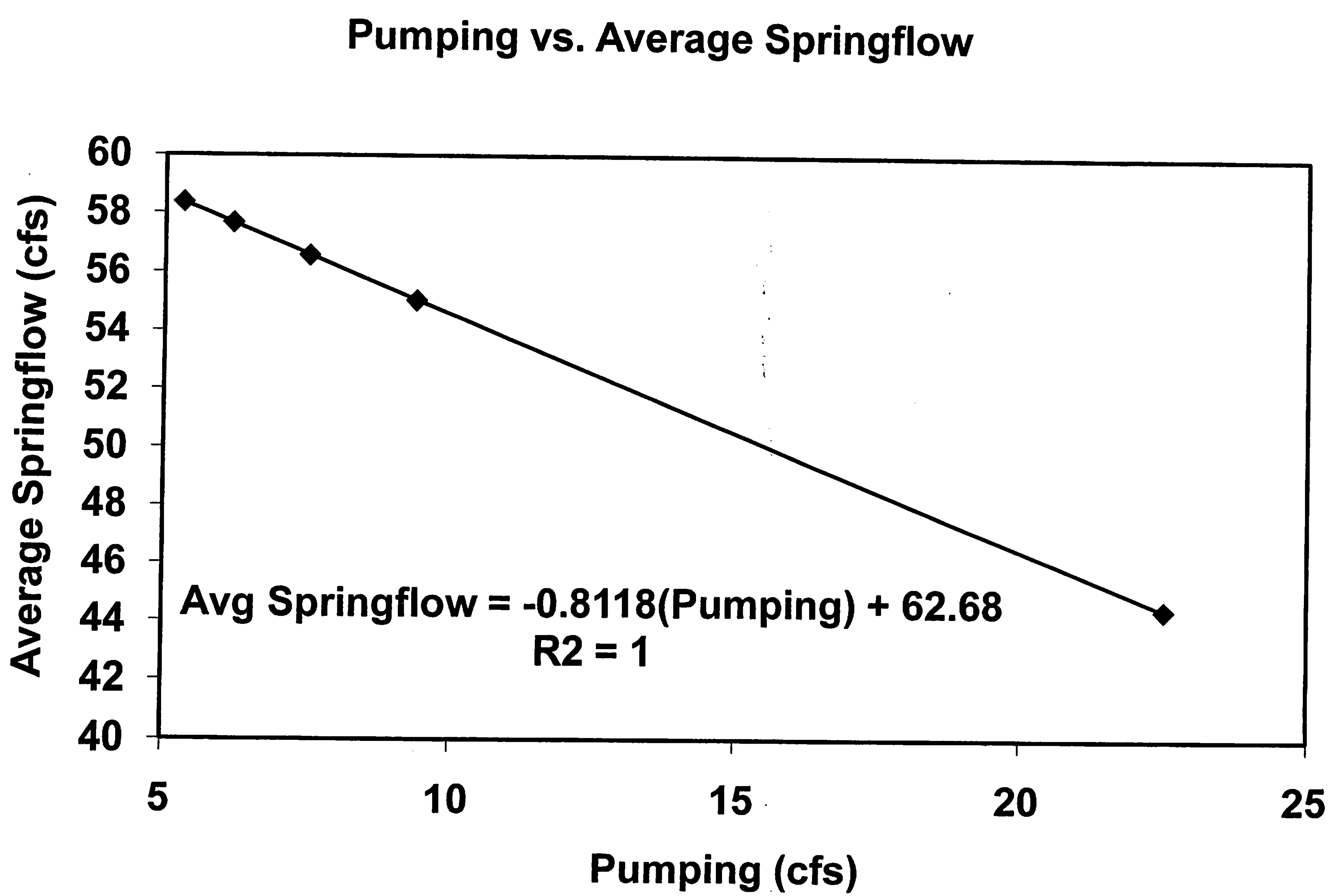
1. Springflow of Barton Springs during average recharge conditions shall be no less than 49.7 cfs averaged over an 84-month (seven-year) period, which is intended to correspond to an aggregate maximum of 16 cfs of total annual withdrawals from the Edwards by all users, including exempt users, in order to govern the rate of onset of drought conditions in the aquifer to acceptable levels; and

2. During extreme drought conditions, including those as severe as a recurrence of the Drought of Record, springflow of Barton Springs shall be no less than 6.5 cubic feet per second (cfs), averaged on a monthly basis.


Drought Declaration Acceleration
Upper cap of 20 cfs Reduction days
None to Alarm 8 to 4 18
Alarm to Critical 4 to 2 13
Critical to Except 2 to 0 23
Cumulative delay 54
Upper cap of 18 cfs Reduction days
None to Alarm 6 to 3 13
Alarm to Critical 3 to 1.5 9
Critical to Except 1.5 to 0 17
Cumulative delay 39
Upper cap of 16 cfs Reduction days
None to Alarm 4 to 2 9
Alarm to Critical 2 to 1 9
Critical to Except 1 to 0 11
Cumulative delay 29
Upper cap of 14 cfs Reduction days
None to Alarm 2 to 1 4
Alarm to Critical 1 to 0.5 3
Critical to Except 0.5 to 0 5
Cumulative delay 12
18 cfs
16 cfs
14 cfs
12 cfs
Simulated Barton Springs Flow (cfs)
62.0
56.0
50.0
44.0
38.0
32.0
26.0
20.0
14.0
8.0
2.0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Stress Period (months)

Pumping = 22.53 cfs (16,311 AF/yr)




Pumping vs. Average Springflow
Average Springflow (cfs)
60
58
56
54
52
50
48
46
44
42
40
Avg Springflow = -0.8118(Pumping) + 62.68
R2 = 1
5
10
15
20
25
Pumping (cfs)

Additional Backup

Agenda Item 8
DFC for Saline Edwards Aquifer

Supplemental Info for Draft Resolution 2010-6

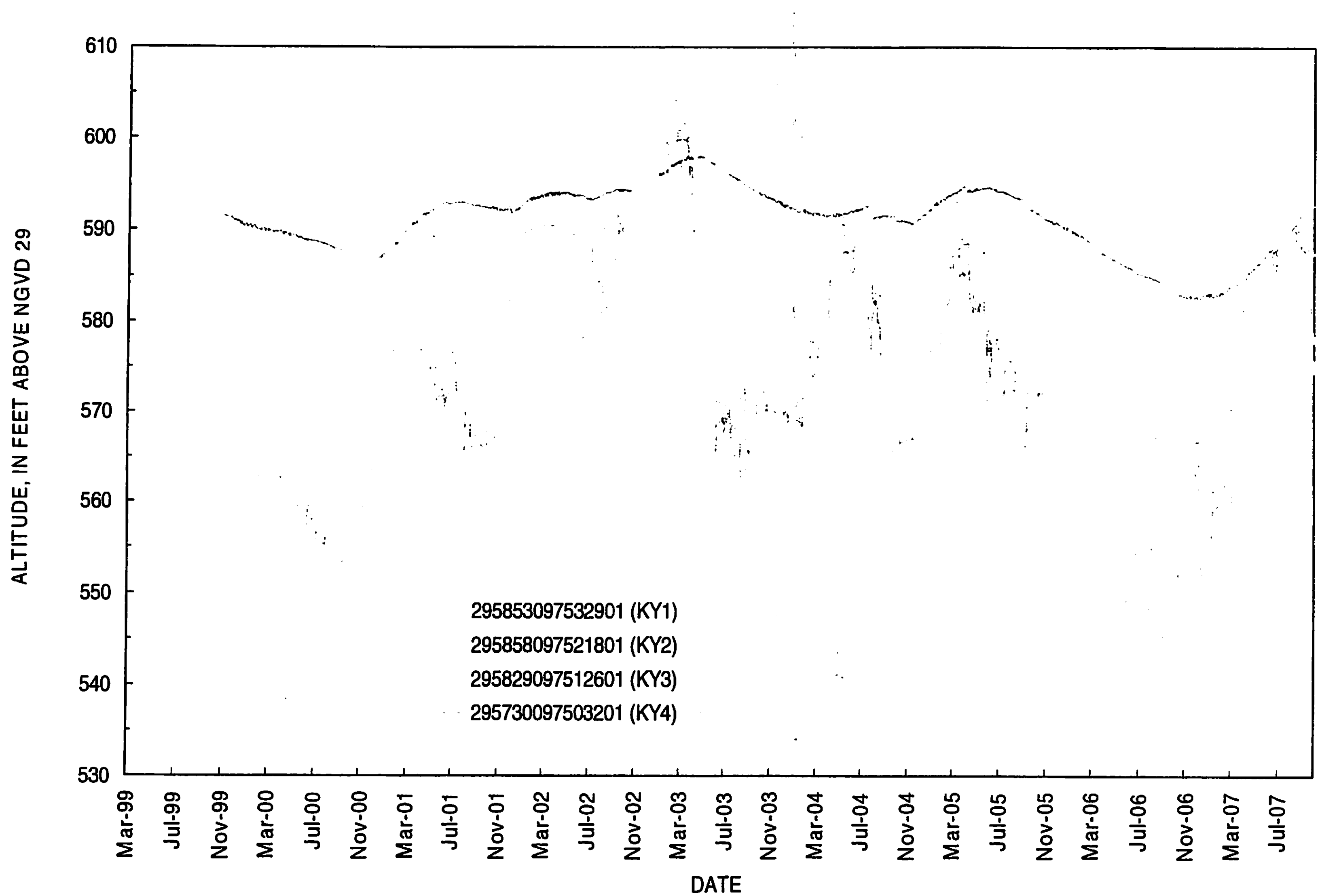


Figure 11. Daily mean equivalent freshwater heads in Kyle transect wells in the San Antonio segment of the Edwards aquifer, south-central Texas, 1999-2007.

EDWARDS AQUIFER
AUTHORITY

Exhibit E

Additional supporting material for DFC's on Edwards in the Northern subdivision

Pumping (AF/yr)	3847	4469	5437	6796
Pumping (cfs)	5.31	6.17	7.51	9.39
Average	58.38	57.68	56.57	55.05
Scenario	Springflow (cfs)	Springflow (cfs)	Springflow (cfs)	Springflow (cfs)
1	84.84	84.14	83.03	81.5
2	89.56	88.86	87.75	86.23
3	81.03	80.33	79.22	77.7
4	62.56	61.86	60.75	59.22
5	61	60.3	59.19	57.67
6	67.72	67.02	65.91	64.39
7	65.87	65.17	64.06	62.54
8	69.22	68.52	67.41	65.89
9	64.92	64.22	63.11	61.59
10	72.1	71.4	70.28	68.76
11	80.15	79.45	78.34	76.81
12	70.6	69.9	68.79	67.27
13	71.01	70.31	69.2	67.68
14	55.98	55.28	54.16	52.64
15	62.38	61.68	60.57	59.04
16	64.22	63.52	62.41	60.89
17	65.04	64.34	63.23	61.71
18	64.6	63.9	62.79	61.27
19	61.42	60.72	59.61	58.09
20	69.99	69.29	68.18	66.66
21	65.47	64.77	63.66	62.14
22	55.72	55.02	53.91	52.39
23	55.53	54.83	53.72	52.2
24	64.38	63.68	62.57	61.05
25	65.62	64.92	63.81	62.28
26	57.82	57.11	56	54.48
27	63.8	63.1	61.99	60.46
28	68.34	67.64	66.53	65.01
29	72.92	72.22	71.11	69.58
30	78.12	77.42	76.31	74.78
31	65.55	64.85	63.74	62.22
32	68.49	67.79	66.68	65.16
33	75.13	74.43	73.32	71.8
34	67.31	66.61	65.5	63.98
35	68.43	67.73	66.62	65.1
36	71.16	70.46	69.35	67.83
37	59.99	59.29	58.18	56.65
38	57.84	57.14	56.03	54.51
39	59.55	58.85	57.74	56.22
40	49.72	49.02	47.91	46.39
41	61.91	61.21	60.1	58.58
42	69.53	68.83	67.72	66.19
43	79.29	78.59	77.48	75.96
44	81.17	80.47	79.36	77.83
45	83.8	83.1	81.99	80.47
46	78.05	77.35	76.24	74.71
47	71.44	70.74	69.63	68.11

48	66.66	65.96	64.85	63.33
49	52.7	52	50.89	49.37
50	51.61	50.91	49.8	48.28
51	51.09	50.39	49.28	47.75
52	44.76	44.06	42.95	41.43
53	50.76	50.06	48.95	47.43
54	55.29	54.59	53.47	51.95
55	42.96	42.26	41.15	39.62
56	42.27	41.57	40.46	38.94
57	46.34	45.64	44.53	43.01
58	55.66	54.96	53.85	52.33
59	62.21	61.51	60.4	58.88
60	47.43	46.73	45.61	44.09
61	46.97	46.27	45.16	43.64
62	48.47	47.77	46.66	45.13
63	51.16	50.46	49.35	47.83
64	40.98	40.28	39.16	37.64
65	40.6	39.9	38.78	37.26
66	51.77	51.07	49.96	48.44
67	57.64	56.94	55.83	54.31
68	70.09	69.39	68.28	66.76
69	74.51	73.81	72.7	71.18
70	84.42	83.72	82.6	81.08
71	93.96	93.26	92.15	90.63
72	83.22	82.52	81.41	79.88
73	73.88	73.18	72.07	70.55
74	69.84	69.14	68.03	66.5
75	64.93	64.23	63.12	61.6
76	65.14	64.44	63.33	61.81
77	46.55	45.85	44.74	43.22
78	46.67	45.97	44.86	43.33
79	48.91	48.21	47.1	45.58
80	46.75	46.05	44.94	43.42
81	50.04	49.34	48.23	46.71
82	58.79	58.09	56.98	55.46
83	64.39	63.69	62.58	61.05
84	72.75	72.05	70.94	69.42
85	74.52	73.82	72.71	71.18
86	70.6	69.9	68.78	67.26
87	75.95	75.25	74.14	72.62
88	79.43	78.73	77.62	76.09
89	72.55	71.85	70.74	69.22
90	71.98	71.28	70.17	68.65
91	67.36	66.66	65.55	64.03
92	75.22	74.52	73.41	71.88
93	66.98	66.28	65.17	63.65
94	58.6	57.9	56.79	55.27
95	61.5	60.8	59.69	58.17
96	69.11	68.41	67.3	65.78
97	72.3	71.6	70.49	68.97
98	71.16	70.46	69.35	67.83
99	66.66	65.96	64.85	63.32

100	55.59	54.89	53.78	52.26
101	51.48	50.78	49.67	48.14
102	43.78	43.08	41.97	40.44
103	38.1	37.4	36.29	34.77
104	45.04	44.34	43.23	41.71
105	51.82	51.12	50.01	48.49
106	62.59	61.89	60.78	59.26
107	59.21	58.51	57.4	55.87
108	61.98	61.28	60.17	58.65
109	72.96	72.26	71.15	69.63
110	66.14	65.44	64.33	62.81
111	61.77	61.07	59.96	58.43
112	58.81	58.11	57	55.48
113	59.73	59.02	57.91	56.39
114	65.09	64.39	63.28	61.76
115	64.33	63.63	62.52	61
116	61.94	61.24	60.13	58.61
117	63.44	62.74	61.63	60.11
118	69.94	69.24	68.13	66.6
119	66.06	65.36	64.25	62.72
120	59.8	59.1	57.99	56.46
121	57.84	57.14	56.03	54.51
122	59.55	58.85	57.74	56.22
123	57.53	56.83	55.72	54.2
124	55.92	55.22	54.11	52.59
125	50.35	49.65	48.54	47.02
126	51.9	51.2	50.09	48.56
127	46.8	46.1	44.99	43.46
128	39.76	39.06	37.95	36.43
129	45.94	45.24	44.12	42.6
130	53.17	52.47	51.36	49.84
131	58.61	57.91	56.8	55.27
132	61.83	61.13	60.02	58.49
133	55.34	54.64	53.53	52
134	58.05	57.35	56.24	54.72
135	67.16	66.46	65.35	63.83
136	52.47	51.77	50.66	49.14
137	51.13	50.43	49.31	47.79
138	42.67	41.97	40.86	39.34
139	51.14	50.44	49.32	47.8
140	59.77	59.07	57.96	56.44
141	58.38	57.68	56.57	55.04
142	55.3	54.61	53.49	51.97
143	63.93	63.23	62.12	60.59
144	76.41	75.71	74.6	73.08
145	86.2	85.5	84.39	82.87
146	85.9	85.2	84.09	82.56
147	83.51	82.81	81.7	80.18
148	80.33	79.63	78.52	77
149	74.05	73.35	72.24	70.72
150	75.29	74.59	73.48	71.95
151	69.58	68.88	67.77	66.25

152	66.83	66.13	65.02	63.5
153	48.48	47.79	46.67	45.15
154	47.54	46.84	45.73	44.21
155	49.55	48.85	47.74	46.22
156	52.85	52.15	51.04	49.52
157	46.86	46.16	45.05	43.53
158	46.15	45.45	44.34	42.82
159	51.29	50.59	49.48	47.96
160	53.82	53.12	52.01	50.49
161	55.55	54.85	53.74	52.22
162	61.76	61.06	59.95	58.43
163	59.79	59.09	57.98	56.46
164	59.31	58.61	57.5	55.97
165	66.4	65.7	64.59	63.06
166	72.4	71.7	70.59	69.07
167	73.42	72.72	71.6	70.08
168	69.41	68.71	67.6	66.08
169	68.46	67.76	66.65	65.13
170	61.64	60.94	59.83	58.31
171	60.55	59.85	58.74	57.22
172	55.62	54.92	53.81	52.29
173	59.07	58.37	57.26	55.73
174	60.89	60.19	59.08	57.56
175	53.83	53.13	52.02	50.5
176	57.75	57.05	55.94	54.42
177	59.55	58.85	57.74	56.22
178	57.65	56.95	55.84	54.32
179	57.75	57.05	55.94	54.41
180	57.26	56.56	55.45	53.93
181	59.31	58.61	57.5	55.98
182	60.4	59.7	58.59	57.06
183	52.35	51.65	50.54	49.01
184	51.75	51.05	49.94	48.42
185	54.53	53.83	52.72	51.19
186	49.28	48.58	47.46	45.94
187	48.5	47.81	46.69	45.17
188	42.05	41.35	40.24	38.72
189	46.74	46.04	44.92	43.4
190	44.65	43.95	42.84	41.31
191	51.86	51.16	50.05	48.52
192	50.32	49.62	48.51	46.98
193	48.76	48.06	46.95	45.43
194	43.24	42.54	41.43	39.9
195	41.67	40.97	39.86	38.34
196	44.84	44.14	43.03	41.51
197	49.47	48.77	47.66	46.13
198	51.65	50.95	49.84	48.32
199	60.44	59.74	58.63	57.11
200	63.27	62.57	61.46	59.94
201	71.17	70.47	69.36	67.84
202	72.99	72.29	71.18	69.66
203	64.9	64.2	63.09	61.57

204	57.03	56.33	55.22	53.7
205	54.46	53.76	52.65	51.12
206	54.26	53.56	52.45	50.93
207	53.34	52.64	51.53	50
208	44.57	43.87	42.75	41.23
209	48.77	48.07	46.96	45.44
210	45.62	44.92	43.81	42.29
211	47.33	46.63	45.52	44
212	42.42	41.72	40.61	39.09
213	43.85	43.15	42.04	40.52
214	47.59	46.88	45.77	44.25
215	52.46	51.76	50.65	49.13
216	63.64	62.94	61.83	60.31
217	66.75	66.05	64.94	63.42
218	72.26	71.56	70.45	68.93
219	67.03	66.32	65.21	63.69
220	71.98	71.28	70.17	68.65
221	65.61	64.91	63.8	62.28
222	62.9	62.2	61.09	59.57
223	58.65	57.95	56.84	55.31
224	64.72	64.02	62.91	61.39
225	67.72	67.02	65.91	64.38
226	66.3	65.6	64.49	62.97
227	68.04	67.34	66.22	64.7
228	73.7	73	71.89	70.37
229	70.18	69.48	68.37	66.85
230	70.03	69.33	68.22	66.7
231	66.04	65.34	64.23	62.7
232	67.35	66.65	65.54	64.01
233	65.97	65.27	64.16	62.64
234	55.19	54.49	53.38	51.86
235	46.7	46	44.89	43.36
236	42.95	42.25	41.14	39.62
237	42.02	41.32	40.21	38.69
238	38.01	37.31	36.2	34.68
239	35.58	34.88	33.77	32.24
240	39.05	38.35	37.24	35.72
241	41.49	40.79	39.68	38.16
242	37.24	36.54	35.43	33.91
243	38.6	37.9	36.79	35.27
244	39.82	39.12	38	36.48
245	34.95	34.25	33.14	31.62
246	42.43	41.73	40.62	39.1
247	46.62	45.91	44.8	43.28
248	53.61	52.91	51.8	50.28
249	52.76	52.06	50.95	49.43
250	58.04	57.34	56.23	54.71
251	62.92	62.22	61.11	59.58
252	63.16	62.46	61.35	59.83
253	61.5	60.8	59.69	58.17
254	55.93	55.23	54.12	52.6
255	63.22	62.52	61.41	59.89

256	67.62	66.92	65.81	64.29
257	61.25	60.55	59.44	57.91
258	63.26	62.56	61.45	59.93
259	61.52	60.82	59.71	58.18
260	61.93	61.23	60.12	58.6
261	57.4	56.7	55.59	54.07
262	55.76	55.06	53.95	52.43
263	52.77	52.07	50.96	49.44
264	49.49	48.79	47.68	46.15
265	45.39	44.69	43.58	42.06
266	51.45	50.75	49.64	48.11
267	62.93	62.23	61.12	59.6
268	68.15	67.44	66.33	64.81
269	73.66	72.96	71.85	70.33
270	82.82	82.12	81.01	79.49
271	91.03	90.33	89.22	87.7
272	85.87	85.17	84.06	82.54
273	76.54	75.84	74.73	73.2
274	68.17	67.47	66.36	64.83
275	57.86	57.16	56.05	54.53
276	52.5	51.8	50.69	49.17
277	51.99	51.29	50.18	48.66
278	48.13	47.43	46.32	44.8
279	53.45	52.75	51.63	50.11
280	44.34	43.64	42.53	41.01
281	47.46	46.76	45.65	44.12
282	55.13	54.43	53.32	51.8
283	57.26	56.56	55.45	53.93
284	53.77	53.07	51.96	50.43
285	52.5	51.8	50.69	49.17
286	52.53	51.83	50.72	49.2
287	49.79	49.09	47.98	46.46
288	50.95	50.25	49.14	47.62
289	41.06	40.36	39.25	37.73
290	35.66	34.96	33.85	32.33
291	35.97	35.27	34.16	32.63
292	40.55	39.85	38.74	37.22
293	47.32	46.62	45.51	43.99
294	51.32	50.62	49.51	47.99
295	48.23	47.53	46.42	44.9
296	47.43	46.73	45.62	44.1
297	51.6	50.9	49.79	48.27
298	46.92	46.22	45.11	43.59
299	49.06	48.36	47.25	45.73
300	43.77	43.07	41.96	40.44
301	41.93	41.23	40.12	38.6
302	45.05	44.35	43.24	41.71
303	44.91	44.21	43.1	41.58
304	47.01	46.31	45.2	43.68
305	50.86	50.16	49.04	47.52
306	53.69	52.99	51.88	50.35
307	52.15	51.45	50.34	48.82

308	52.52	51.82	50.71	49.18
309	52.24	51.54	50.43	48.91
310	50.45	49.75	48.64	47.12
311	41.84	41.14	40.03	38.51
312	35.86	35.16	34.05	32.53
313	40.61	39.91	38.8	37.28
314	44.21	43.51	42.4	40.88
315	42.38	41.68	40.57	39.05
316	46.33	45.63	44.52	42.99
317	46.69	45.98	44.87	43.35
318	48.61	47.91	46.8	45.28
319	45	44.3	43.19	41.67
320	43.97	43.27	42.16	40.64
321	52.58	51.88	50.77	49.25
322	50.32	49.62	48.51	46.99
323	59.16	58.46	57.34	55.82
324	60.55	59.85	58.74	57.22
325	65.7	65	63.89	62.37
326	65.8	65.1	63.99	62.47
327	59.42	58.72	57.61	56.09
328	63.4	62.7	61.59	60.07
329	61.22	60.52	59.41	57.89
330	54.23	53.53	52.42	50.89
331	57.22	56.52	55.41	53.89
332	62.47	61.77	60.66	59.14
333	55.49	54.79	53.68	52.16
334	56.74	56.04	54.93	53.41
335	55.33	54.63	53.52	51.99
336	54.97	54.27	53.16	51.64
337	47.87	47.17	46.06	44.54
338	51.19	50.49	49.38	47.86
339	50.49	49.79	48.68	47.16
340	60.39	59.69	58.58	57.06
341	59.78	59.08	57.97	56.45
342	61.66	60.96	59.85	58.33

		Recharge Factor	% Avg	Precip % Avg
16311	AF/yr			
22.53				
44.39	46696.16	1.00	99.98	99.69
Springflow (cfs)				
70.85	68224	1.46	146.00	121.55
75.57	74058	1.59	159.00	125.70
67.04	62618	1.34	134.00	107.53
48.57	46261	0.99	99.00	88.87
47.02	52618	1.13	113.00	101.19
53.74	53766	1.15	115.00	99.39
51.88	58428	1.25	125.00	106.04
55.24	55791	1.19	119.00	99.62
50.94	53756	1.15	115.00	100.98
58.11	56688	1.21	121.00	106.46
66.16	63691	1.36	136.00	111.98
56.61	57187	1.22	122.00	99.67
57.02	54296	1.16	116.00	102.57
41.99	46125	0.99	99.00	93.41
48.39	53896	1.15	115.00	107.80
50.23	51401	1.1	110.00	103.02
51.05	50587	1.08	108.00	104.17
50.62	51426	1.1	110.00	105.33
47.44	52810	1.13	113.00	108.50
56.01	56235	1.2	120.00	114.05
51.49	52144	1.12	112.00	107.96
41.74	41620	0.89	89.00	96.92
41.54	42814	0.92	92.00	98.42
50.4	57726	1.24	124.00	107.33
51.63	53116	1.14	114.00	102.70
43.83	44952	0.96	96.00	94.46
49.81	53559	1.15	115.00	99.04
54.36	55411	1.19	119.00	99.80
58.93	57229	1.23	123.00	105.58
64.13	64885	1.39	139.00	114.25
51.57	52679	1.13	113.00	103.87
54.51	53883	1.15	115.00	102.61
61.15	65455	1.4	140.00	112.97
53.32	54599	1.17	117.00	106.71
54.45	54763	1.17	117.00	106.74
57.17	54557	1.17	117.00	105.25
46	45168	0.97	97.00	93.28
43.86	43844	0.94	94.00	94.20
45.57	48117	1.03	103.00	100.92
35.74	42465	0.91	91.00	96.53
47.92	53393	1.14	114.00	102.97
55.54	62533	1.34	134.00	114.16
65.31	64930	1.39	139.00	110.72
67.18	64423	1.38	138.00	113.47
69.82	65850	1.41	141.00	113.38
64.06	59684	1.28	128.00	107.50
57.46	55256	1.18	118.00	105.07

52.68	55243	1.18	118.00	104.95
38.71	41974	0.9	90.00	92.18
37.63	39088	0.84	84.00	91.92
37.1	36982	0.79	79.00	87.81
30.93	31300	0.67	67.00	85.99
36.78	45347	0.97	97.00	96.60
41.3	44212	0.95	95.00	94.97
28.98	32535	0.7	70.00	88.90
28.29	30334	0.65	65.00	84.81
32.35	38456	0.82	82.00	93.08
41.67	45234	0.97	97.00	96.88
48.22	47862	1.02	102.00	97.78
33.44	37994	0.81	81.00	89.47
32.98	34618	0.74	74.00	83.05
34.48	35641	0.76	76.00	80.25
37.17	37228	0.8	80.00	81.30
26.99	28675	0.61	61.00	74.29
26.61	34283	0.73	73.00	85.06
37.79	47208	1.01	101.00	100.19
43.65	50516	1.08	108.00	104.82
56.1	58402	1.25	125.00	114.62
60.52	59094	1.27	127.00	114.98
70.43	73815	1.58	158.00	125.92
79.97	74790	1.6	160.00	128.23
69.23	66460	1.42	142.00	116.86
59.89	60515	1.3	130.00	108.89
55.85	55305	1.18	118.00	104.82
50.94	49771	1.07	107.00	99.91
51.16	49547	1.06	106.00	100.83
32.57	33572	0.72	72.00	87.98
32.68	33760	0.72	72.00	87.26
34.92	40704	0.87	87.00	93.18
32.77	39729	0.85	85.00	92.16
36.06	41550	0.89	89.00	91.61
44.81	50662	1.08	108.00	102.59
50.4	51278	1.1	110.00	98.52
58.77	59384	1.27	127.00	105.31
60.53	56516	1.21	121.00	101.88
56.61	60601	1.3	130.00	104.10
61.97	66963	1.43	143.00	112.62
65.44	64412	1.38	138.00	108.98
58.57	57644	1.23	123.00	98.62
58	57169	1.22	122.00	101.26
53.38	53191	1.14	114.00	100.36
61.23	59294	1.27	127.00	107.22
53	55741	1.19	119.00	104.40
44.62	49283	1.06	106.00	94.46
47.52	53032	1.14	114.00	101.10
55.13	58675	1.26	126.00	104.84
58.32	56943	1.22	122.00	102.43
57.18	54506	1.17	117.00	98.95
52.67	49106	1.05	105.00	93.63

41.61	45318	0.97	97.00	91.80
37.49	39063	0.84	84.00	85.99
29.79	31285	0.67	67.00	79.43
24.12	31572	0.68	68.00	82.02
31.06	36744	0.79	79.00	87.77
37.84	43148	0.92	92.00	92.26
48.61	51173	1.1	110.00	98.88
45.22	46513	1	100.00	95.24
48	51890	1.11	111.00	101.79
58.98	58691	1.26	126.00	107.27
52.16	52696	1.13	113.00	103.77
47.78	47339	1.01	101.00	101.54
44.83	46792	1	100.00	100.23
45.74	49696	1.06	106.00	100.26
51.1	55800	1.19	119.00	104.12
50.35	52483	1.12	112.00	102.16
47.95	50712	1.09	109.00	102.87
49.45	50720	1.09	109.00	102.59
55.95	55620	1.19	119.00	103.67
52.07	50730	1.09	109.00	100.24
45.81	48279	1.03	103.00	99.62
43.85	47856	1.02	102.00	98.75
45.56	46528	1	100.00	95.28
43.54	43742	0.94	94.00	90.87
41.93	42337	0.91	91.00	89.14
36.37	37335	0.8	80.00	88.06
37.91	42060	0.9	90.00	94.97
32.81	35068	0.75	75.00	92.64
25.78	29210	0.63	63.00	87.39
31.95	42417	0.91	91.00	97.73
39.19	43249	0.93	93.00	100.31
44.62	48581	1.04	104.00	103.07
47.84	46822	1	100.00	98.68
41.35	41464	0.89	89.00	92.18
44.07	47749	1.02	102.00	95.43
53.18	56929	1.22	122.00	104.41
38.48	40459	0.87	87.00	89.10
37.14	37745	0.81	81.00	83.96
28.69	30875	0.66	66.00	82.53
37.15	42075	0.9	90.00	94.28
45.78	50508	1.08	108.00	101.33
44.39	50606	1.08	108.00	101.44
41.32	47135	1.01	101.00	96.96
49.94	55196	1.18	118.00	107.38
62.43	65801	1.41	141.00	115.13
72.21	69654	1.49	149.00	112.87
71.91	75691	1.62	162.00	115.18
69.53	67983	1.46	146.00	109.42
66.34	63194	1.35	135.00	105.64
60.06	59797	1.28	128.00	107.92
61.3	61672	1.32	132.00	109.63
55.6	56164	1.2	120.00	107.58

52.85	50197	1.07	107.00	103.99
34.5	35621	0.76	76.00	94.50
33.55	37835	0.81	81.00	99.22
35.57	37817	0.81	81.00	98.85
38.86	43488	0.93	93.00	97.76
32.88	39563	0.85	85.00	97.45
32.17	35546	0.76	76.00	95.97
37.31	38604	0.83	83.00	101.75
39.84	41010	0.88	88.00	104.74
41.57	46098	0.99	99.00	106.73
47.78	50466	1.08	108.00	109.32
45.8	49900	1.07	107.00	109.07
45.32	49855	1.07	107.00	108.99
52.41	55830	1.2	120.00	113.03
58.41	57271	1.23	123.00	110.19
59.43	57247	1.23	123.00	105.02
55.42	57085	1.22	122.00	103.90
54.48	54380	1.16	116.00	99.22
47.65	48344	1.04	104.00	98.60
46.57	47063	1.01	101.00	91.26
41.63	45253	0.97	97.00	91.59
45.08	46494	1	100.00	90.65
46.91	48705	1.04	104.00	94.10
39.84	42749	0.92	92.00	90.29
43.76	47820	1.02	102.00	95.42
45.56	46520	1	100.00	90.85
43.67	43522	0.93	93.00	94.60
43.76	46360	0.99	99.00	92.79
43.27	47071	1.01	101.00	100.29
45.33	50747	1.09	109.00	103.72
46.41	46488	1	100.00	98.78
38.36	41020	0.88	88.00	97.80
37.77	39140	0.84	84.00	99.11
40.54	42129	0.9	90.00	99.54
35.29	37630	0.81	81.00	96.29
34.52	38507	0.82	82.00	92.08
28.06	32594	0.7	70.00	86.99
32.75	35116	0.75	75.00	88.65
30.66	36031	0.77	77.00	91.49
37.87	41595	0.89	89.00	93.71
36.33	37596	0.81	81.00	92.40
34.78	36122	0.77	77.00	91.51
29.25	31302	0.67	67.00	90.20
27.69	30333	0.65	65.00	88.96
30.85	37382	0.8	80.00	94.76
35.48	42737	0.92	92.00	96.88
37.67	43422	0.93	93.00	97.53
46.45	48718	1.04	104.00	96.09
49.29	50523	1.08	108.00	98.93
57.19	58461	1.25	125.00	102.23
59.01	56155	1.2	120.00	101.20
50.92	52216	1.12	112.00	101.70

43.04	42898	0.92	92.00	90.23
40.47	45308	0.97	97.00	92.13
40.27	42508	0.91	91.00	92.79
39.35	40338	0.86	86.00	89.70
30.58	36166	0.77	77.00	91.69
34.78	36481	0.78	78.00	91.52
31.64	35181	0.75	75.00	88.67
33.35	34548	0.74	74.00	94.02
28.44	35520	0.76	76.00	96.55
29.87	33148	0.71	71.00	97.42
33.6	41597	0.89	89.00	106.83
38.48	44518	0.95	95.00	107.28
49.65	55138	1.18	118.00	117.00
52.77	53884	1.15	115.00	115.00
58.28	57722	1.24	124.00	116.58
53.04	53343	1.14	114.00	112.41
57.99	58501	1.25	125.00	116.96
51.62	51955	1.11	111.00	109.93
48.92	54140	1.16	116.00	112.67
44.66	47571	1.02	102.00	105.43
50.74	54291	1.16	116.00	110.09
53.73	54109	1.16	116.00	110.37
52.32	52104	1.12	112.00	110.50
54.05	56121	1.2	120.00	109.88
59.72	60508	1.3	130.00	114.13
56.2	57505	1.23	123.00	107.04
56.05	55054	1.18	118.00	107.60
52.05	53685	1.15	115.00	108.29
53.36	53500	1.15	115.00	106.92
51.99	49612	1.06	106.00	100.49
41.22	39844	0.85	85.00	92.99
32.72	36689	0.79	79.00	92.26
28.97	32308	0.69	69.00	89.96
28.04	31453	0.67	67.00	91.18
24.03	29394	0.63	63.00	88.63
21.59	25255	0.54	54.00	84.23
25.06	29049	0.62	62.00	90.44
27.5	29501	0.63	63.00	90.08
23.25	29468	0.63	63.00	90.05
24.62	29183	0.62	62.00	91.24
25.83	29043	0.62	62.00	89.83
20.97	28329	0.61	61.00	91.88
28.44	35786	0.77	77.00	99.75
32.63	42207	0.9	90.00	105.31
39.62	41770	0.89	89.00	105.61
38.77	41036	0.88	88.00	98.53
44.05	48346	1.04	104.00	104.76
48.93	49520	1.06	106.00	105.31
49.17	52257	1.12	112.00	108.53
47.52	48069	1.03	103.00	101.83
41.94	45725	0.98	98.00	96.68
49.23	53497	1.15	115.00	103.39

53.64	54279	1.16	116.00	106.00
47.26	48196	1.03	103.00	102.48
49.27	52900	1.13	113.00	106.22
47 53	49959	1.07	107.00	100.14
47.94	47845	1.02	102.00	101.61
43.41	47202	1.01	101.00	103.90
41.78	43552	0.93	93.00	98.39
38.78	39608	0.85	85.00	94.18
35.5	35774	0.77	77.00	88.26
31.41	37559	0.8	80.00	88.64
37.46	45455	0.97	97.00	98.73
48.95	56030	1.2	120.00	102.94
54.16	59688	1.28	128.00	102.23
59.67	62727	1.34	134.00	108.02
68.84	67939	1.45	145.00	113.74
77.05	76925	1.65	165.00	125.44
71.89	66422	1.42	142.00	113.01
62.55	63866	1.37	137.00	107.32
54.18	52722	1.13	113.00	104.43
43.87	43720	0.94	94.00	101.18
38.51	42311	0.91	91.00	102.39
38.01	43487	0.93	93.00	105.53
34.15	37790	0.81	81.00	98.58
39.46	40174	0.86	86.00	108.09
30.36	33655	0.72	72.00	104.25
33.47	35009	0.75	75.00	103.16
41.15	45726	0.98	98.00	109.39
43.27	46144	0.99	99.00	106.84
39.78	41665	0.89	89.00	99.91
38.52	39372	0.84	84.00	99.86
38.55	37882	0.81	81.00	95.33
35.81	36585	0.78	78.00	92.74
36.97	40377	0.86	86.00	98.04
27.08	31127	0.67	67.00	90.10
21.68	26014	0.56	56.00	87.11
21.98	30630	0.66	66.00	93.13
26.56	30796	0.66	66.00	92.54
33.34	39125	0.84	84.00	99.72
37.34	40481	0.87	87.00	102.38
34.24	36238	0.78	78.00	98.83
33.44	36693	0.79	79.00	101.08
37.62	39064	0.84	84.00	100.16
32.93	35524	0.76	76.00	95.38
35.08	36936	0.79	79.00	94.73
29.78	33085	0.71	71.00	90.01
27.95	30893	0.66	66.00	86.22
31.06	33795	0.72	72.00	84.04
30.93	34076	0.73	73.00	80.03
33.02	39323	0.84	84.00	85.52
36.87	41771	0.89	89.00	87.21
39.7	43075	0.92	92.00	89.08
38.16	39233	0.84	84.00	90.38

38.53	41217	0.88	88.00	91.89
38.26	39286	0.84	84.00	94.07
36.47	37298	0.8	80.00	94.79
27.85	30037	0.64	64.00	92.00
21.88	28545	0.61	61.00	95.86
26.63	34127	0.73	73.00	96.92
30.23	32796	0.7	70.00	91.67
28.4	34422	0.74	74.00	96.32
32.34	35675	0.76	76.00	96.15
32.7	37150	0.8	80.00	101.06
34.63	35526	0.76	76.00	92.98
31.01	35933	0.77	77.00	93.35
29.99	37993	0.81	81.00	96.29
38.59	41772	0.89	89.00	102.49
36.34	41672	0.89	89.00	102.39
45.17	50497	1.08	108.00	104.71
46.57	48660	1.04	104.00	102.51
51.71	49961	1.07	107.00	106.37
51.81	55087	1.18	118.00	107.61
45.43	47473	1.02	102.00	104.23
49.41	50822	1.09	109.00	104.40
47.23	49245	1.05	105.00	102.98
40.24	44327	0.95	95.00	100.21
43.24	43934	0.94	94.00	98.54
48.49	51542	1.1	110.00	105.55
41.51	42999	0.92	92.00	98.08
42.76	45230	0.97	97.00	96.29
41.34	43132	0.92	92.00	91.98
40.98	42065	0.9	90.00	90.18
33.89	34963	0.75	75.00	90.01
37.21	41527	0.89	89.00	98.17
36.51	43774	0.94	94.00	100.11
46.41	51857	1.11	111.00	107.05
45.79	47613	1.02	102.00	105.12
47.68	49918	1.07	107.00	108.53

For Discussion by Advisory Committees

A Perspective on What We Know and Don't Know:

Salient Points in Establishing a Desired Future Condition
for the Edwards Aquifer, Northern Subdivision, GMA 10;
and in Preparing a Habitat Conservation Plan
for Endangered Species Protection

Overall Context

1. The programs, rules and regulations of the BSEACD over the past 20+ years have and will continue to limit groundwater pumping of the Barton Springs segment of the Edwards Aquifer -- during both non-drought and especially drought conditions -- especially from what would have otherwise existed as this area developed. Any such regulatory program benefits the aquifer's existing users as well as Barton Springs. The aquifer's users to be protected include both humans and endangered species.

Salamander, Dissolved Oxygen and Springflow Relationships

2. Dissolved oxygen (DO) of water issuing from the springs tends to be lower at lower springflows within the range of flows historically experienced. However, there is essentially no data on DO-springflow relationships in the critically important period below 15 cfs of flow; and no statistically significant extrapolation of this trend is possible. Even for the sparse data available below 20 cfs, the "noise" in the data indicates that the amount of springflow is just one of the factors that influence DO concentrations, and other, unmanageable (by the District) factors may be as or more important with lower flow conditions.

3. The DO vs. flow relationships differ among the various spring outlets and may be caused, at least conjecturally, by several contributing factors:
   - Their flow regimes contain more conduit vs. less conduit
   - Flows may be more turbulent vs. more laminar
   - Ambient physical/chemical conditions (algae, temperature, org. carbon) may influence DO in recharge waters
   - Contact with a subsurface atmosphere may allow re-aeration vs. isolated or confined water that may prevent re-aeration.

4. Based on discussions with a USGS scientist, while many possible factors may be influencing the DO concentrations in the aquifer and in spring discharge, the DO of water in the aquifer feeding the Barton Springs complex may not drop appreciably below 4.0 mg/L under natural low-flow conditions; however, the dataset for making such judgments is limited.

5. The endangered salamander population survived not only the Drought of Record in the 1950s, when daily flows dropped to a minimum of a reported 9.6 cfs (and monthly average flow was 11 cfs), but also other droughts in the historical and pre-historical record that were much more severe.

6. The survivability and ability of the salamander population to recover from temporary reductions in habitat quality are not just about effects on adult salamanders, but also on juveniles, reproduction, prey and predator behavior, etc., in a 'weakest link' situation, although cumulative impacts are almost certainly also important.

7. Other aspects besides the amount of pumping in the aquifer may work in antagonistic fashion to affect salamander habitat quality, including sedimentation, pooling of the spring outlets, and development in the contributing watershed that introduces oxygen-demanding materials, toxics such as pesticides and herbicides, nutrient-rich fertilizers that promote swings in aquatic growth and oxygen demand, and Barton Springs pool-related activity, among other things.

8. The mobility and inaccessibility of a significant number of individual salamanders for actual counts imply that a proxy measure of habitat condition is required for representing and protecting this endangered species population, but there is not a universal proxy that can represent all effects or impacts on their habitats.

9. For purposes of both habitat conservation planning and establishment of Desired Future Conditions as required by law, the overall springflow at the Barton Springs complex is our best, if quite imperfect proxy, at least for now.

10. The University of Texas laboratory study of salamander response to variations in dissolved oxygen and conductivity was completed by Drs. Art Woods and Mary Poteet and peer-evaluated by Dr. Bryan Brooks of Baylor University. They compared metabolic rates between *E.* nana (a surrogate species from San Marcos Springs) and *E. sosorum*. Activity responses of *E. nana* to DO were quantified and assessed. In addition, experiments were performed to determine adult mortality and juvenile growth responses to DO. Further, a "probabilistic ecological hazard assessment" (PEHA) approach was used to relate threshold responses of the salamanders to DO measurements in spring habitats for the first time. The collaborative work by Woods, Poteet and Brooks is currently being published. It represents the most comprehensive understanding of adverse effects of DO on any salamander to date.

11. The HCP Biological Advisory Team (BAT) is reviewing the research by Woods, Poteet, Brooks, data collected by the City of Austin, as well as other research; and is making a series of recommendations for further study to reduce uncertainties associated with the species of concern. Future recommendations for research will be included in their final review documentation. The initial versions of neither the DFC nor HCP will be able to wait until this future research is available.

12. A DO concentration of 4.4 mg/L or above appears to be a level that will not substantially adversely affect the salamander; a prolonged DO concentration of 3.4 mg/L or below appears to be a level that would likely create such stress on the species that it may not survive as a population. It is not known whether "take" is linear between these two endpoints, but laboratory studies suggest it is approximately so for the DO stressor.

13. The behavior of salamanders in the wild and their ability to adjust to low DO stresses, such as moving into micro-environments where water velocities are larger and therefore more oxygen is available to them even if in lower concentration, are conjectural and unknown. Still, the re-appearance of salamanders at the Upper Spring outlet shortly after it started flowing again after two years of no discharge in the most recent drought suggests that this behavior may be an important consideration. The retardation in their re-appearance at the Old Mill Spring outlet in the same time period illustrates that we don't know the factors that govern migration.

14. Even during extreme drought, local rainfall events will occur from time to time and introduce oxygen-replenishing water into the aquifer; the amount of springflow and DO does not behave monotonically during prolonged drought.

Hydrogeological Assessments

15. Very recent geohydrologic studies suggest that during severe droughts, the groundwater divide between the San Antonio segment and the Barton Springs segment dissipates and water from the SA segment bypasses San Marcos Springs and flows into the Barton Springs segment. During the most recent drought, the amount of this water was estimated to be about 5 cfs, which may represent recharge that was not completely accounted for in groundwater modeling of the Barton Springs segment. (Conversely, the effects of flow from the Barton Springs segment to the San Marcos segment during certain non-drought and early-drought conditions may not have been completely accounted for either.)

16. Probabilistic numerical simulation of recharge over a period of rainfall record extending for centuries (using regional tree-ring data), pumping, and resultant springflows that has been conducted recently by the TWDB indicates that a specified amount of pumping from the aquifer may lead to springflows that vary considerably. (Another way of saying this is that any specific springflow may be produced by a range of pumping.) Such variability is accommodated in regulatory planning by the specification of some acceptable probability that a particular spring discharge will be associated with a particular amount of pumpage.

17. The effects of global climate change on Central Texas are predicted to make the weather more extreme, but will likely produce more frequent and persistent La

Niña conditions, leading to hotter and drier overall conditions, which in turn would reduce springflow, other factors equal.

Institutional Considerations

18. The current regulatory program of the District (absent the temporary moratorium, pending establishment of a Desired Future Condition/Managed Available Groundwater limitation) would not restrict the total amount of water being withdrawn under permits during non-drought conditions but would completely curtail new conditional-use water withdrawals during extreme drought; and would require alternative means to address those curtailments. The requirements to demonstrate interruptible-supply/alternative supply demonstration characteristics for these withdrawals are a governor on new users. However, to the extent new conditional users request such permits, and even though the effect of any one such user is small relative to losses from the system due to springflows, in aggregate they tend to increase the rapidity and frequency of all users entering into drought stages, unless there is also some non-drought cap of the conditionally permitted withdrawals from the Edwards instituted. A DFC referenced only to Drought of Record conditions would not constitute such a cap.

19. From an endangered-species protection standpoint, the unknowns and the uncertainties that exist indicate that the District should be relatively conservative (toward the salamander) in establishing its groundwater management program objectives.

20. The current contentious political climate for groundwater management in Texas, surrounding the vested rights of landowners over groundwater in place, the need for more water supplies for the state, the limits on new surface water supplies, and the resistance of powerful private and public influences to regulatory restrictions on pumping for whatever reason, could increasingly limit the statutory authorities of all GCDs in the state in the future, which would reduce the BSEACD's ability to implement an effective groundwater management program.

21. A DFC may be revised each year and must be reviewed by the Groundwater Management Area every five years to consider new information. But any *less restrictive* DFC that may increase the MAG in the future and that becomes the basis for a different regulatory springflow program would comprise a major amendment to the HCP and Section 10(a) Permit, including NEPA review. From this institutional standpoint (only), it is better to go from a regulatory program that is less restrictive (larger MAG) to more restrictive (smaller MAG). However, a less restrictive initial program would likely produce a larger MAG that could be legally accessed for additional (non-conditional) pumping authorizations. Taken together, these considerations suggest that the District will need to live with the selected DFC/MAG as an HCP measure during the term of the Section 10(a) Permit supported by the HCP.

Conservation Physiology of the Plethodontid Salamanders *Eurycea nana* and *E. sosorum*: Response to Declining Dissolved Oxygen

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Eurycea sosorum **and** ***E. nana*** **are plethodontid salamanders endemic to several karst springs in central Texas (USA). Landscapes around these habitats are increasingly urbanized. At the Barton Springs complex, where** ***E. sosorum*** **occurs, average dissolved oxygen (DO) in the main flow is ~6.5 mg L^{-1}. However, DO is quite variable, ranging between 2.4 & 10 mg O_2 L^{-1}, and recent data suggest a positive relationship between DO and spring discharge in Barton Springs Pool, though this relationship may not be as strong under extreme low-flow conditions. Here we examine sensitivity of** ***E. nana*** **and** ***E. sosorum*** **to experimental variation in oxygen availability (DO). A suite of traits was measured on adults: ability to escape simulated predation, spontaneous activity, metabolic rate, and mortality during 28 days of exposure. A separate experiment examined growth of juveniles across levels of DO during 60 days of exposure. Levels of DO below 3.4 mg O_2 L^{-1} appeared to pose a grave threat to salamander survival over a 28-day study, whereas DO above 4.5 mg O_2 L^{-1} gave no observable effects in any experiment. Between these values is a critical range in which salamanders became progressively compromised. An ambient water quality criterion for DO in lentic systems (5 mg O_2 L^{-1}, 24 hour minimum) appears adequate to protect** ***Eurycea.***

Global amphibian declines over the past half century (Houlahan et al., 2000) appear to have stemmed from factors associated with climate change, including increased UV-B exposure, changes in precipitation patterns, and outbreaks of pathogens (Kiesecker et al., 2001). At local scales, declines also stem from habitat degradation or destruction (Blaustein et al., 1994) related to watershed urbanization (Wang et al., 2001; Price et al., 2006; Miller et al., 2007). Because urban land use influences many aspects of streams—flow regime, channel morphology, water quality, and biological community composition (Wang et al., 2001)—it is difficult to identify specific factors, or interactions of factors, that adversely affect populations. But doing so is important: although urbanization may be inevitable, understanding relative risk associated with various stressors will support better conservation decision-making.

Here we focus on dissolved oxygen (DO), which is known to vary spatially and temporally in aquatic systems (Wetzel and Likens 2000). US Environmental Protection Agency has established national ambient water quality criteria (NAWQC) for DO that are intended to protect aquatic life in surface waters. In the central Texas karst system at the Barton Springs complex, DO in the main spring has been measured irregularly since 1969. Since then, mean DO has been ~6.5 mg L^{-1} (Turner, 2004), with discrete measurements ranging between 2.4 and 10 mg L^{-1} (for comparison, air-saturated DO at spring temperature, 20°C, is about 8.5 mg L^{-1}). Moreover, recent data, since 2003, indicate a positive relationship between DO and spring discharge (Turner, 2004). These data suggest that low spring flows, which could stem from either droughts or higher levels of pumping from the aquifer, may subject salamanders to lower DO. Whether current surface water DO NAWQC are appropriate for protecting salamanders in spring-fed ecosystems is unknown.

For salamanders, adequate DO is important for all life stages (Hillman and Withers, 1979). Hypoxia can retard embryonic development (Mills and Barnhart, 1999), slow or arrest juvenile growth (Werner and Glennemeier, 1999; Stevens et al., 2006), and depress adult oxygen consumption (Withers, 1980; Noland and Ultsch, 1981; Booth and Feder, 1991; Crowder et al., 1998; Sheafor et al., 2000). Identifying problematic levels of DO is difficult, however, because effects vary by species, stage, and physiological circumstance. For example, Withers (1980) showed that O_2 consumption (in air) by resting *Plethodon* spp. was unaffected by ambient PO_2 down to approx. 5 kPa. By contrast, exercised salamanders, forced to escape repeatedly, were much more sensitive to ambient PO_2, with rapid declines in O_2 consumption below 14 kPa. In some circumstances, negative effects of hypoxia may be mitigated by physiology and behavior. Known responses include increases in egg capsule conductance (Mills et al., 2001), precocious hatching (Petranka et al., 1982), increases in heart rate and buccal pumping (Sheafor et al., 2000), behavioral hypothermia (Tattersall and Boutilier, 1997), gill hypertrophy and increases in gill perfusion (Bond, 1960), and frequent excursions to the water-air interface for air or 'bobbing' (Wassersug and Seibert, 1975; Crowder et al., 1998).

Unlike other plethodontids, most of which have biphasic or fully terrestrial lifestyles, *Eurycea nana* and *E. sosorum* are obligately aquatic neotenes, with gills retained throughout adulthood (perennibranchiate). Oxygen uptake must therefore occur across the skin or the gills; the dominant route is unknown. Booth and Feder (1991) showed that amphibians using cutaneous respiration in water, including *E. bislineata*, can develop steep oxygen gradients across boundary layers adjacent to the skin; even when ambient DO was high (> 8 mg L^{-1}), DO at the skin surface usually was 1 – 2 mg L^{-1}. In *E. sosorum* and *E. nana*, boundary layers near the skin may be minimized by other factors, including small body size (< 1 g) and association with rapidly-flowing, well-oxygenated spring flows (Sweet, 1982).

Here we examine sensitivity of juvenile and adult *E. nana* and *E. sosorum* to experimental variation in oxygen availability (DO). Using adult salamanders, we imposed short- to long-term variation in ambient PO_2 and quantified (1) escape responses to simulated predation; (2) spontaneous activity; (3) metabolic rates; and (4) mortality. For juvenile salamanders, we measured growth rates during 60 days of exposure to different levels of oxygen. This data set provides the most complete multi-stage description of oxygen's effects for any salamander and suggests levels of DO below which physiology, and likely fitness, is compromised. We subsequently performed a probabilistic ecological hazard assessment to relate salamander response thresholds to DO measurements in spring habitats.

MATERIAL AND METHODS

Animals.---Experiments were carried out between November of 2005 to December of 2006. Adult *Eurycea nana* (SVL 22.1 – 35.1 mm, mean 27.9 mm) (Tupa and Davis, 1976) were collected by hand from rocky substrate below the Spring Lake dam (San Marcos, Texas, USA), placed in aerated coolers, returned to Austin, and separated into four 10-gallon holding aquaria. We collected 20 adult *Eurycea sosorum* (SVL 22.9 – 30.2 mm, mean 26.1 mm) from Eliza Spring during a single collecting trip. Salamanders were collected with the cooperation and supervision of the City of Austin (COA) using the same techniques as those described for *E. nana*.

Salamanders were held in 10 gallon aquaria filled with Eliza Spring water. Each aquarium had multiple pieces of pre-soaked PVC tubing for cover, gravel collected from below the Spring Lake dam, an air stone delivering room air, and a filter unit (AquaClear, with mechanical, chemical, and biological filtering capability, 400 liters h^{-1}). We also controlled water pH using a pH-stat system (Milwaukee Instruments model SMS122, Rocky Mount, NC, USA), which measured pH continuously and, whenever it rose above 7.6, injected CO_2 until pH fell below the set point. pH regulated in this way was quite stable, varying between 7.3 – 7.8 over the course of 15 – 20 min. Salamanders were kept on a 13L:11D light cycle and fed bloodworms every day (Hikari, with multivitamins added, approx. 2 bloodworms per salamander). *E. nana* were used in all experiments; *E. sosorum* were used only in measurements of short-term metabolic rates.

Water collection.---Water was collected from Eliza Spring, part of the Barton Springs complex (includes also Eliza Spring and Old Mill) that supports the highest density of *E.*

sosorum in the wild (pH 7.1 – 7.5, conductivity ~ 600 µS cm^{-1}, temperature = 20°C). Water was pumped into food-grade trashcans, transported to the Univ. Texas campus, and filtered through 0.45-µm PTFE membranes (Pall Life Sciences, TF-450) into storage containers -- two 1136-liter food-grade polyethylene holding tanks. All holding containers were presoaked with tap water for 1 week and allowed to air dry before use. Stored Eliza water was aerated continuously with room air.

Escape response experiment.---We measured escape responses of *Eurycea nana* (N = 8) over 9 levels of dissolved oxygen. Escape response was evaluated as the ability of the animal to flee a stimulus, specifically as the duration (time spent escaping) and vigor (frequency of activity, defined as number of loops and number of undulations) of the response. The loss of righting was scored as an absolute loss of escape response.

Each salamander was placed in a 1.5-L aquarium containing Eliza Spring water (pH = 7.5) and allowed to acclimate for 20 minutes. Subsequently, it was touched or gently grasped with entomology forceps (Bioquip, round-tip featherweight forceps) to simulate predation. The touching was repeated three times. Touches 2 and 3 were done only after the animal remained stationary for 5 seconds. After each set of touches, DO was immediately ramped down and the salamander was given a 20 minute rest period before manipulations recommenced. DO levels were ramped down on the following schedule (mg O_2 L^{-1}): 8, 7, 6, 5.1, 4.1, 3.1, 2.2, 1.1, 0. Experiments continued until oxygen was ramped to 0 mg L^{-1} or the salamander lost its escape response. Once a salamander could not right itself within 60 s, it was immediately removed to a recovery aquarium. Salamanders were videotaped continuously during the experiment. Because salamanders were manipulated for several hours, and DO was always ramped from high to low, we were concerned that any observed effects reflected salamander fatigue rather than effects of DO *per se*. We therefore ran a set of control tests on each salamander two weeks after the DO tests. In the controls, salamanders ($N = 8$) were manipulated in the same way, except that DO (8 mg O_2 L^{-1}) was held constant.

Desired levels of DO were obtained by mixing pure O_2, N_2, and CO_2 and bubbling the resulting stream directly into experimental chambers. Gas flow rates were controlled by mass flow controllers (all by Unit Instruments, Milpitas, CA, models UFC-1100 or 1101A; O_2: 0 – 1 slm or 0 – 500 sccm; N_2: 0 – 1 slm or 0 – 500 sccm; CO_2: 0 – 10 sccm), which were themselves controlled by a separate electronics package (MFC-4, Sable Systems, Las Vegas, NV). Total flows were approx. 500 ml min^{-1}, and CO_2 flows were adjusted to give pH of ~7.5.

Videotapes of salamander responses were scored blind (observer did not know DO). For each salamander, we measured total time of activity following touching, number of body undulations during that time (as a measure of vigor), and number of loops the salamanders swam around the aquarium during that activity.

We analyzed this experiment using linear mixed effects (LMEs) models (S-Plus 2000 rel. 2, Insightful Corporation, Seattle, WA, http://www.tibco.com) that accounted for salamander identity (random effect) and mass (covariate). Using a second LME, we then tested whether the responses of the salamanders differed significantly between DO and control experiments.

Spontaneous activity.---Spontaneous activity of *E. nana* ($N = 8$) was recorded using a modification of Sheafor et al.'s (2000) infrared method. Salamanders were confined individually to custom-built, flow-through glass chambers (1.5 × 9 cm), with water driven through the chambers by small gear pumps (Micropump, Vancouver, WA, USA) at 1 cm s^{-1}. Water was recirculated past salamanders from a reservoir, a design that facilitated easy modification of water characteristics (see below). The entire apparatus, including reservoir, was held underwater in a temperature-controlled water bath (maintained at 20°C). Salamander activity was measured using AD-1 infrared activity detectors (Sable Systems, Las Vegas, NV, USA) with LED emitters and detectors on 70-cm long wires, so that they could be placed directly into the water around the glass chambers. Output voltages from the detectors were sampled once per second onto a computer running Expedata software (Sable Systems, version 2.33).

Individual salamanders were put into chambers, allowed to acclimate for 4 hours in Eliza Spring water (~ 660 μS cm^{-1}), then subjected to DO ramp from 8.9 mg O_2 L^{-1} down to ~ 1.3 mg O_2 L^{-1} over 2.5 hours and back up to 8.9 mg O_2 L^{-1} over the subsequent 2.5 hours. Conductivity, pH, and DO were measured continuously with a YSI 556 handheld multiparameter instrument, which was calibrated regularly against standards.

Activity data were analyzed using log survivorship analysis (Slater and Lester 1982) implemented in S-Plus (v. 6.1). First, each raw voltage trace was filtered so that each logged value was classified either as 'no activity' (0) or 'activity' (1). We did this, rather than using raw voltages directly, because there is no linear relationship between magnitude of voltage spike and instantaneous degree of activity (advice from Sable Systems). Individual voltage measurements were considered 'no activity' if they were < 5 standard deviations from the mean background noise and 'activity' otherwise. Second, we calculated intervals (N) between every sequential activity event, which were then plotted (as log N) on a histogram. In data traces containing distinct bouts of activity, the log plots show a characteristic concave shape, arising from two different event timings. Within bouts, there is a high probability of subsequent activity (short intervals), and thus at the left side of the graph the slope is steep (corresponding to a high probability of subsequent activity). The shallower part of the trace, to the right, corresponds to between-bout times—i.e., the slope is shallow because the probability of a subsequent event is low.

Historically, the 'bout criterion'—the time distinguishing within bout from between bout intervals—has been identified by eye as the point at which the slope changes most rapidly. However, several authors argue for more quantitative methods of estimation. We used Slater and Lester's (1982) method, which they show minimizes the total number of misclassified intervals. They define the optimal bout criterion as:

$$t^{*} = \left(\frac{1}{\lambda_W - \lambda_B}\right)\log\left(\frac{\lambda_W N_W}{\lambda_B N_B}\right) \qquad \text{Eq. 1}$$

where λ_W and λ_B are slopes of the within- and between-bout parts of the log survivorship graph, N_W is number of intervals in the within-bout section, and N_B is number of intervals in the between-bout section. The four parameters were estimated for each individual salamander by fitting a double exponential equation to the log survivorship plot, using a non-linear least squares fitting function in S-Plus. Once the bout criterion was identified for each salamander, its activity vector was filtered again to identify regions that were either within activity bouts or between activity bouts.

Responses were modeled with logistic regression, which is appropriate with binary response variables (e.g., active vs not active). We used both probit and logit links. Fitted coefficients were used to calculate IC_{50}, the level of DO giving activity half the time, as

$$IC_{50} = -a/b \qquad \text{Eq. 2.}$$

where a is the fitted intercept and b the coefficient for DO. The 8 separate estimates of IC_{50} (one per salamander) were then used to calculate mean IC_{50} with 95% CI.

Salamander metabolic rates.---To estimate critical levels of oxygen causing changes in metabolic rate (Booth and Feder, 1991), we measured metabolic rates of *E. nana* (N = 15) and *E. sosorum* (N = 14) over ramped levels of DO. Oxygen consumption was measured using a semi-closed system. In each metabolic chamber, a milled, perforated nylon insert protected the salamander from a stir bar. A second nylon insert was milled with three ports, one for a mini Clark-style oxygen electrode (model 730, Diamond General, Ann Arbor, MI, USA), and one each for water inlet and outlet (1/8 inch stainless steel). Fits on the stainless steel tubing were tight enough that no additional sealants were used; electrodes were sealed with silicone. The 3-port insert was sealed to the glass beaker (100 ml volume) by an O-ring (Buna-N).

Accurate measures of metabolic rate in aquatic systems depends on controlling or measuring several characteristics of the water, including volume, mixing, and biological activity. Water volumes in chambers were measured gravimetrically (47 - 64 ml). Stir bar rotation was set to mix chamber water thoroughly within 10 seconds (measured in preliminary experiments using dye dispersal), and the ports allowed us to flush chambers gently while salamanders were in place. When chambers were closed (no flushing), changes in oxygen were due only to biological activity. Extensive testing showed, first, that chambers were essentially leak-free; and, second, biological oxygen consumption by non-salamander sources (e.g., bacteria) were minimal, as introduction of air-saturated water gave stable, air-saturated electrode readings for several hours. To ensure that this was so in every experiment, we always included one or more blank chambers.

The mini electrodes were connected to a picoammeter (Microsensor, Diamond General) via a 10-channel electrode multiplexer (Diamond General, model 1090A), which allowed us to run up to 8 salamander and two blank chambers during a single run. Signals from the picoammeter were logged onto a computer via an A/D converter (Sable Systems, U12, Las Vegas, NV, USA). Electrode membranes (polyethylene, 1 mil thick) were replaced regularly.

To reduce bacterial growth, all chamber parts were washed thoroughly. Electrodes were calibrated at temperature using N_2-purged and air-saturated water. Salamanders were weighed (Mettler Toledo analytical balance, ± 1 mg) and photographed through a stereo-zoom microscope (Nikon SMZ1500 with DS-5M camera) for later analysis of SVL, then placed one to a chamber (up to 8 salamanders with 2 blank chambers) filled with Eliza Spring water (conductivity ~680 $\mu S\ cm^{-1}$). Chambers were submerged in a temperature-controlled water bath set to 20°C. Salamanders were given ~ 45 minutes to acclimate, and then each chamber was flushed with 5 volumes (~ 250 ml) of air-bubbled Eliza Spring water. Using the electrode multiplexer, we then manually stepped through electrodes, measuring O_2 levels in each chamber for 1 – 2 minutes. Each chamber was sampled generally 5 times in 45 - 60 minutes, during which time oxygen content fell from air-saturated to a minimum of 80% of air saturation (approx. 7.4 mg O_2 L^{-1}). Subsequently, each chamber was flushed with 5 volumes of water at a lower level of DO (equilibrated to gas streams generated by mass-flow controllers, as described above).

We used non-linear mixed-effects models, implemented in S-Plus v. 6.1 (Insightful Corporation, Seattle, WA, USA), to examine relationships between DO and metabolic rate. Visual inspection of the data suggested that metabolic rates fell at lower levels of DO. We therefore chose to fit the 'Biochemical Oxygen Demand' (BOD) model in Bates and Watts (1988),

$$y(x) = \phi_1[1 - \exp(-\exp(\phi_2)x], \qquad \text{Eq. 3}$$

where y is metabolic rate, x is level of DO, ϕ_1 is the asymptote (in our case, the asymptotic metabolic rate) and ϕ_2 describes how sharply the curve transitions from zero to the asymptote. From fitted values of ϕ_2 the IC_{50} (the DO giving a 50% reduction in metabolic rate) can be calculated as

$$IC_{50} = \log 2 / \exp(\phi_2) \qquad \text{Eq. 4}$$

We followed Pinheiro and Bates' (2000) iterative strategy for fitting such models in S-Plus, using the function SSasympOrig (from their Appendix C.3).

28-day oxygen-toxicity test.---To assess long-term lethal levels of DO, we measured mortality of 60 adult *E. nana* in a 28-d oxygen toxicity test (where *low* oxygen was the stressor). Salamanders were housed individually in 2-L aquaria, each equipped with an air stone inside a hydraulic lift tube to drive water circulation. Oxygen levels were F1 maintained by bubbling air from the box head spaces into salamander-containing aquaria. Head spaces in the upper chambers were regulated by a multichannel oxygen regulator (ROXY-8, Sable Systems, Las Vegas, NV, USA). To maintain aquarium temperature, the lower halves of the chambers were plumbed for continual recirculation of chilled water (20°C). Aquarium pH was controlled between 7.0 and 8.0 using the pH-stat system described above.

Individual aquaria were arranged three to a Plexiglas chamber (Fig. 1). Plexiglas chambers in the same oxygen treatment were connected via gas lines, with gas flow between them driven by small fans. Twelve salamanders (pseudo-replicates) were randomly assigned to one of 5 DO exposure treatments, 1.3, 2.4, 3.6, 4.6, and 7.5 mg/L, in individual aquaria. Three aquaria were randomly assigned to a given Plexiglas chamber (replicate) providing an experimental design with 5 treatments and 4 replicates (Plexiglas chambers) with 3 pseudo-replicates per replicate (aquaria). Pseudo-replicates were averaged per replicate to provide 4 values per treatment. During the course of the experiment, there was some mortality from salamander escapes not related to DO level. A total of six escapes and one fungal contaminated salamander resulted in an unbalanced design with N = 10 salamanders in treatments with DO = 3.6 and 4.6 mg/L and N = 9 in the DO = 7.5 mg/L.

60-day juvenile growth experiment.---Juvenile salamanders were obtained from the *Eurycea nana* captive breeding program at the San Marcos National Fish Hatchery, TX. Juveniles were placed in the same set up as described in the 28-d oxygen toxicity experiment, but DO treatments were set to be non-lethal (Table 1). Juveniles were maintained under these conditions for 60 d. During that time, we weighed (mg) and measured snout to vent length (SVL) of each salamander approximately every 5 days. Juveniles were weighed to the nearest 0.01 mg on a Sartorius MC-5 microbalance. To minimize errors from adherent water and evaporation, salamanders were gently blotted with a dry tissue before being transferred to a weigh boat. SVLs were measured from calibrated digital images. Due to limited availability of juveniles from the captive breeding program, we were able to place only 5 salamanders into each treatment at the beginning of the experiment.

Toxicity data analysis.---Specific growth rate (G_W), defined as the rate of change of the logarithm of weight through time, was calculated for the 60 d study:

$$G_W = 100 \cdot (\ln(W_{final} / W_{initial}) / t) \qquad \text{Eq. 5}$$

where $W_{initial}$ is salamander weight at the beginning of the experiment, W_{final} is weight at the end, and t is time (days). These data were modeled using the linear and non-linear equations outlined in Table 2 (Brain et al., 2006). Model fit was based on the coefficient of determination and the p-value for each associated ANOVA. Each model employs an

T2

iterative process by fitting parameters simultaneously. If the convergence criteria (approach to stable parameter values) are not met in a specified number of iterations, the model cannot be fit. Based on the variability and distribution of the data, tolerance criteria may not be met for a given model; thus, multiple models were tested. To optimize the fitting process, we adjusted number of iterations, step sizes, and thresholds of tolerance. Effective or lethal concentrations required to inhibit or kill x percent of the organisms (EC_x or LC_x) were calculated, with x set to 5, 10, 25 and 50. Lowest observable adverse effect level (LOAEL) and no observed adverse effect level (NOAEL) thresholds were determined for the 60 d juvenile growth study using Bonferroni's post hoc test (US EPA, 2002).

Dissolved oxygen distribution.---Data for Barton Springs DO were acquired from the City of Austin, which was originally obtained from the U.S. Geological Survey (Chris Herrington, pers. comm.). This dataset, containing 517 DO observations taken between November, 1969 and April, 2009, was plotted according to published methods (Solomon and Takacs, 2002) as a cumulative frequency distribution, with probability on the y-axis $\log_{10}$ DO on the x-axis (Solomon et al., 2000). Plotting positions (j) were expressed as percentages and calculated from the Weibull formula:

$$j = 100 \cdot i/(n+1) \qquad \text{Eq. 6}$$

where i is the rank and n is the total number of data points in the data set. Linear regressions were performed on the transformed data using SigmaPlot 2000 (SPSS, Chicago, IL. http://www.sigmaplot.com). This approach is similar to one done recently on anoxia thresholds for marine invertebrates (Vaquer-Sunyer and Duarte, 2008).

Toxicity threshold calculations.---Low centiles of 1% and 5% from the DO distribution were interpreted as thresholds of response and used as Toxicological Benchmark Concentrations (TBCs; Hanson and Solomon, 2002). A centile of 1% was selected as a lower TBC since a log-normal cumulative frequency distribution does not contain a zero y-value. A centile of 5% was employed as a TBC, which is similar to the HC_5 derived from a Species Sensitivity Distribution of NOAELs (Wagner and Lokke, 1991; Aldenberg and Slob, 1993; Sijm et al., 2002).

Probabilistic ecological hazard assessment (PEHA).---We performed a PEHA that used the observed DO distribution in Barton Springs, the LC_5, LC_{10}, LC_{25}, LC_{50}, and 60 d NOAEL and LOAEL thresholds calculated for the 60-d chronic study. A PEHA indicates the likelihood that a DO value will be encountered in Barton Springs that is below the indicated threshold for *Eurycea nana*. This calculation was done by modifying equations from Solomon et al. (2002): we substituted a single threshold value for percentage-based exposure values using Microsoft Excel 2003® (Microsoft Corporation, Redmond, WA, USA. http://www.microsoft.com) as follows:

$$P_x = NORMDIST(m_{tox} \cdot \log_{10}(x) + b_{tox}), \qquad \text{Eq. 7}$$

where x is the threshold exposure value. P_x is the probability that a particular DO affects x% of endpoints, NORMDIST returns the standard normal cumulative distribution function, and m_{tox} and b_{tox} are the slope and intercept, respectively, of the probit/log transformed regression line of the exposure data.

RESULTS

Escape response experiment.---In high DO, salamanders responded vigorously to prodding, taking multiple loops around the test aquaria at high speed. This vigor declined F2 significantly at lower levels of DO (loops: $F_{8,36}$ = 2.56, P = 0.026; undulations: $F_{8,36}$ = 2.24, P = 0.047). By the end of the 7th treatment (DO = 2.2 mg O_2 L^{-1}), 3 of the 8 salamanders had lost the ability to right themselves (Fig. 2A). Following the 8th treatment (DO = 1.1 mg O_2 L^{-1}) only two salamanders were able to right themselves. When these were placed into 0 mg O_2 L^{-1}, neither salamander was able to respond. Although activity decreased significantly with decreasing DO, the total time that salamanders were active did not (time: $F_{8,32}$ = 1.60, P = 0.163).

All salamanders retained their escape response for the duration of the control tests (Fig. 2B). Number of undulations declined slightly with duration of the control test, but neither total time of activity nor number of loops around the aquarium changed significantly with test duration ($F_{(time)}$ = 1.72, df = 10, P = 0.07; $F_{(loops)}$ = 1.56, *df*=10, P = 0.12).

Spontaneous activity.---All 8 *E. nana* in the DO ramp had discernable breakpoints that identified activity bouts (see Fig. 3). Mean bout criterion was 1.60 minutes (range 0.82 – 2.56). F3

Salamanders had a clear onset of activity as DO dropped to between 2.7 and 5.5 mg O_2 L^{-1} (Fig. 4A). During the ramp back up, activity ceased at a lower level of DO, approximately 1.8 – 4.1 mg O_2 L^{-1}. Figure 4B summarizes salamander activity during the F4 experiment. For each salamander, we fitted a logistic regression model separately to rising and falling parts of its activity curve, estimated each IC_{50}, then calculated means and 95% CI across the 8 salamanders. Probit and logit links gave virtually identical results, so we present averages of the two techniques. For the rising part of the activity curve (declining DO), the DO at which 50% of salamanders became active was 4.54 mg O_2 L^{-1} (95% CI 4.02 - 5.06). For the falling part of the activity curve (increasing DO), the DO at which 50% of salamanders became inactive was 3.12 mg O_2 L^{-1} (95% CI 2.39 - 3.86). Changes in activity thus exhibited some hysteresis.

Salamander metabolic rates.---Metabolic data were quite variable, both within and between salamanders. Nevertheless, the two species had similar average metabolic rates, F5 and the metabolic rates clearly declined at low levels of DO (Fig. 5A and B), especially below 3 mg O_2 L^{-1}. For both species, we obtained a good fit between the data and the BOD model (Eq. 3).

Estimates of IC_{50} were obtained using Eq. 4. For *E. nana* we estimate IC_{50} = 1.31 T3 mg O_2 L^{-1} and for *E. sosorum* IC_{50} = 1.62 mg O_2 L^{-1} (Table 3). The larger confidence intervals for *E. sosorum* reflect greater variability within its data set. The confidence intervals for both parameters, ϕ_1 and ϕ_2, were broadly overlapping—so we consider species' responses to DO to be statistically indistinguishable. Estimated values for ϕ_1 (metabolic rate under non-limiting oxygen conditions) were 0.052 and 0.043 mg O_2 hr^{-1} for *E. nana* and *E. sosorum*, respectively.

28-day oxygen-toxicity test.---There was a clear logistic relationship between DO and percent mortality (Fig. 6), with mortality falling from high to low between approx. 2 and

F6

4 mg O_2 L^{-1}. Salamander mortality related to DO occurred in the lowest three treatments (1.3, 2.4, and 3.6 mg/L), and all mortality that occurred in the two lowest DO treatments happened within 48 hours of initiating the experiment. No DO related mortalities were observed in either of the two highest treatments (4.6 and 7.5 mg/L). LC_5, LC_{10}, LC_{25}, T4 LC_{50} estimates were calculated for adult mortality data (Table 4) using a three parameter logistic model (r^2 of 0.93; Figure 6) these values were considered thresholds of response for *E. nana* exposed to varying DO concentrations.

60-day juvenile growth experiment.---Although juveniles in the lowest DO (4.4 mg O_2 L^{-1}) had growth rates that were ~30% lower than control salamanders (Table 5), the T5 differences were not significant when analyzed by linear mixed-effects models, perhaps because both the sample sizes and the DO range were small (N = 4 or 5 per treatment). Using a toxicological approach, we determined that the specific growth rate NOAEL was 4.4 mg O_2 L^{-1} ($P > 0.05$; Table 4), the lowest DO examined. Therefore, a lowest observable adverse effect level (LOAEL) was not determined. However, had growth rates in 4.4 mg O_2 L^{-1} been just slightly lower, they would have been significantly different from controls ($P < 0.05$) based on minimum significant difference values. This indicates that the growth NOAEL of 4.4 mg O_2 L^{-1} closely approached a LOAEL for juvenile *E. nana* over a 60-d period. A similar analysis using growth rate for each salamander calculated as the slope of its mass over time gave similar results (no significant effect of DO at $P < 0.05$).

Probabilistic ecological hazard assessment.---The linear regression equations generated from the probability and $\log_{10}$ transformed DO data for Barton Springs, Eliza Spring, and Old Mill sampling locations (Fig. 7) were: $y = 12.5x - 9.8$, $y = 13.2x - 10.1$, and $y = 6.1x - 4.5$, respectively. The probabilities of exceedance, based on these DO distributions at the sampling locations, and calculated using the LC_x estimates generated from the 28-d study with adult *E. nana* thresholds (mortality) and a 60-day NOAEL (specific growth rate), are summarized in Table 4. The exceedance values for Barton Springs and Eliza Spring were similar; however, Old Mill had substantially higher exceedance estimates owing to a flatter slope and lower measured DO values. However, the correlation coefficient (r^2) for the regression line fitted to the Old Mill data was also lower (0.65) than those for Barton Springs and Eliza Spring (0.97 and 0.96, respectively). In addition, inspection of the data (Fig. 7) indicates that the flow-DO relationship at Old Mill was not log-linear. Nonetheless, there were many low DO values, potentially related to low spring flows, compared to the other two sites, causing a shift in the curve and resulting in loss of linearity. Consequently, greater confidence is placed on estimates generated from Barton Springs and Eliza Spring data.

F7

As summarized in Table 4, the probability of toxicological threshold exceedances (proportion of DO values below thresholds) for Old Mill ranged from 11% to 38%. For Barton Springs and Eliza Spring the exceedance estimates were similar, ranging from 0.08 to 5.2% and 0.1 to 6.8%, respectively. Based on the DO data from Barton Springs and Eliza Spring there is a 4.5% and 5.8% chance, respectively, that daily DO concentrations will drop below 4.4 mg O_2 L^{-1} (the 60 d NOAEL) that would adversely affect juvenile *E. nana* specific growth rate, a widely accepted parameter linked to population level stress (Suter, 2007). In Old Mill, there is a 28% chance that DO will drop below 4.4 mg O_2 L^{-1} during daily observations

Toxicological Benchmark Concentrations (TBCs) were calculated for low centiles of 1% and 5% based on the DO distributions for Barton Springs at 4 and 4.5 mg O_2 L^{-1}, for Eliza Spring at 3.9 and 4.4 mg O_2 L^{-1}, and for Old Mill at 2.3 and 2.9 mg L^{-1}, respectively. These values are considered reasonable thresholds of response and indicate that there is ≤1% chance that the DO values will fall below 4, 3.9, and 2.3 mg O_2 L^{-1}, respectively, at Barton Springs, Eliza Spring, and Old Mill, and ≤5% chance that DO will fall below 4.5, 4.4, and 2.9 mg O_2 L^{-1} at the same locations, respectively. It is important to note that this PEHA is driven by probability of discrete and daily average DO values exceeding toxicity thresholds determined from 28-d adult mortality and 60-d juvenile growth studies. Future efforts are needed to determine probabilities of encountering DO exceedances of such thresholds over sustained time periods corresponding to laboratory DO experiments (e.g., 28, 60 d).

DISCUSSION

Although species declines stem from multiple factors, more than 70% of endangered organisms are adversely affected by habitat destruction (Pattee et al., 2003). For these species, management decisions often are supported by analyses of ecological hazard or risk (Suter, 2007), with risk assessed in relation to *populations*. For threatened and endangered species, however, risk may also be assessed in relation to *individuals* (Suter, 2007), as we have done here. Furthermore, some populations may be imperiled enough that detailed physiological or ecological studies simply cannot be done. Historically, this situation has been approached by studying surrogate species instead, and sophisticated models are available for analyzing correlations between the responses of surrogates and threatened or endangered species (Raimondo et al., 2007). In this study, we selected *E. nana* as a surrogate because its genetics and life history are similar to those of *E. sosorum* (Chippindale et al., 2000), it occupies similar karst-fed springs in central Texas, and the two species have similar physiologies. Although a lack of even minimal data on *E. sosorum* prevented us from applying formal correlation analyses (Raimondo et al., 2007), our data on *E. nana* provide significant insight into how *E. sosorum* is likely to respond to different levels of DO.

Physiology has much to offer conservation—by providing mechanistic insight into links between environmental factors and animal performance (Feder, 1983; Ricklefs and Wikelski, 2002; Helmuth et al., 2005). In turn, understanding performance should allow us to develop *prospective* views of how animal populations will change in response to stressors and degradation of habitat quality. In practice, establishing strong links between select physiological measures and population processes can be difficult, for two reasons. First, environmental change may affect multiple aspects of performance (e.g., behavior and physiology), and it may be difficult to identify *a priori* which aspects are most important, though the relationship of sensitivities among endpoints is understood for many chemical and physical stressors (Suter, 2007). Second, most animals have complex life cycles (Werner, 1988), and distinct stages can respond to changing environments in different ways.

We analyzed effects on *Eurycea* salamanders of an environmental factor, dissolved oxygen (DO), that is known (i) to vary substantially in the habitat of interest (the Barton Springs complex) and (ii) to affect other aquatic organisms in profound ways. To assess links between variable DO and salamander population-level processes, we analyzed the effects of DO on fitness-related physiological and behavioral characters (escape responses, spontaneous activity levels, metabolic rates, survival probabilities, and growth rates) across more than one life stage (juveniles and adults). This approach provides data-rich views of salamander biology, while also highlighting further gaps that would have been useful to examine but were not within the scope of the project—e.g., how DO affects *Eurycea* reproduction, egg development, and hatching.

Effects of DO on salamander activity.---Two kinds of behaviors may be important in response to variable DO. The first is the ability to escape predators. Escape involves coordination of separate processes: sensing and recognizing threats, initiating nervous responses, and executing responses using muscles. Low DO may compromise any or all of these. Our escape response experiment, which subjected individual salamanders to falling DO and measured their ability to escape simulated predation (squeezing by forceps), provided only moderate support for this idea: escape performance was not hampered dramatically until quite low levels of DO (≤ 2 mg O_2 L^{-1}). In the wild, moreover, single-burst escape responses may be even less sensitive to DO, as salamanders would not have immediate histories of aerobic activity. These findings suggest that, of measured traits, escape responses were least sensitive to DO. Such a finding makes biological sense—whereas depressed metabolic rates at low DO may be tolerable some of the time, capture by predators is not.

A second, potentially important response to low DO is *mitigation*. In most habitats, salamanders will occur across mosaics of high and low DO (or of other factors, such as water flow rate, that affect O_2 availability). Although sensing and responding to such mosaics may be irrelevant at high average DO levels, it surely becomes more important at low DO. In our experiments, salamanders clearly perceived and responded to low (or falling) DO—the infrared detection system measured onset of activity during falling DO and cessation of activity during subsequent rising DO (Fig. 4). Moreover, altered activity in response to declining DO occurred at higher levels of DO (2.5 – 5 mg $O_2\ L^{-1}$) than did escape response failure ($\leq$ 2 mg $O_2\ L^{-1}$).

We interpret activity as having either of two mitigation functions. The more likely is escape from low DO into higher DO areas (though this was not possible for salamanders in our experiments). In the wild, salamanders in local pockets of low-DO water may find higher-DO water nearby. Rigorously assessing this possibility would require measuring the spatial scale of DO variation in natural habitats (Revsbech and Jorgensen, 1986; Dodds, 1991; Kemp and Dodds, 2001). This interpretation is consistent with patterns of salamander presence and absence in the Barton Springs complex. *E. sosorum* counts decline in Barton Springs when DO falls below 5 mg $O_2\ L^{-1}$ (Turner, 2004). It is likely that salamanders move into the karst system during periods of low DO; however, it is not known whether recolonizing salamanders are the same individuals as those leaving.

A second function of increased activity may be to minimize boundary layers adjacent to skin and gills. Water flow rates in our experiments were, for technical reasons, fairly low (~ 1 cm s^{-1}), likely giving substantial boundary layers. Salamanders may increase oxygen flux to sites of respiratory exchange by disrupting those boundary layers—e.g., by bobbing, flicking their heads, or swimming (Wassersug and Seibert, 1975; Crowder et al., 1998).

Effects of DO on salamander physiology, survival, and growth.---The three traits—respiration rate, 28-d survival probability, and 60-d growth rate—were differentially sensitive to DO. In particular, the metabolic IC_{50} (acute exposure, giving 50% depression of oxygen consumption rate) was low. For *E. nana* it was 1.3 mg O_2 L^{-1} and for *E. sosorum* 1.6 mg O_2 L^{-1}. In the 28-d oxygen toxicity test, the LC_{50} (giving 50% reduction in survival) was higher, 3.4 ± 0.2 mg O_2 L^{-1}. This difference may reflect that particular levels of low DO are worse for salamanders the longer their exposure to it. However, in the 60-d juvenile experiment, we observed no significant effects of low DO on growth rate—with the caveat that sample sizes were small and our range of experimental DO levels did not extend below 4.4 mg O_2 L^{-1}. Future studies should assess growth under lower oxygen levels and after acclimation to various DO concentrations.

Linking dissolved oxygen to population persistence.---This study was motivated by a conservation problem: *E. nana* and *E. sosorum* are threatened and endangered, respectively, and exist only in small sets of springs surrounded by urban areas. Water quantity and quality in the springs vary over time, with flow and DO positively correlated for Barton Springs (City of Austin, 1997). Historically, variation in flow has been driven by weather and climate on the Edwards Plateau, the limestone escarpment that is the source of aquifer water feeding the springs. At present, variation in flow likely is influenced also by human water use (Slade et al., 1985; Smith and Hunt, 2004). Pumping appears to increase the likelihood of low water flows and associated low DO. Unfortunately, there are few available observations of DO concentrations at low flows. For example, only 27 observations of flow below 20 c.f.s. were included in the dataset used for a PEHA in this study (Fig. 7), and the mean DO value associated with these low flows is 4.69 (±0.28) mg O_2 L^{-1} for Barton Springs. Further, there were only 35 DO observations for Barton Springs below 4.5 mg O_2 L^{-1} in the available dataset (Fig. 7), and there was no statistically significant ($P > 0.05$) relationship between these low flow and associated DO values. Less information for Eliza Spring and Old Mill precluded similar evaluations here.

Other factors such as nutrients and oxygen-demanding wastes, which are known to influence DO variability and daily minima, are targeted by regulatory agencies under the US Clean Water Act to protect aquatic life in inland waters (TCEQ 2003). A recently developed water quality protection plan for the Barton Springs segment of the Edwards Aquifer identified a number of factors associated with urbanization that may result in water quality stress to endemic salamanders (Naismith 2005). Compared to groundwater withdrawals, the relative contribution of landscape practices and nutrient enrichment on regulation of diurnal, seasonal and interannual DO dynamics in *Eurycea* habitats is not understood, but likely is significant.

A key question is how salamander populations will fare in different levels of DO. The most severe effect would be large-scale mortality of one or more life stages. For example, adult *E. nana* in the 28-d toxicity test had an LC_{50} of 3.4 mg O_2 L^{-1}. Clearly, DO levels ≤ 3.4 mg O_2 L^{-1} would constitute a grave threat to populations if conditions persisted for 28 d. The probability of such an event is low (Table 4). However, it is worth also considering less severe conditions, as these have substantially higher probabilities of occurring in the Barton Springs complex: the LC_5 and LC_{10} values are likely to be exceeded with probabilities (percentage of DO values below thresholds) of >5.2% and >2.3%, respectively, over short time intervals (discrete sampling). Certainly, exceedance probabilities will be lower for 28-d periods, but how much lower is unknown. Two additional kinds of data would help resolve this issue: (i) more modeling of the probability of long-duration, low-DO events, and (ii) the effects on adults of more natural time courses of DO cycling. For this discussion, an important caveat is that toxicity testing was done on adults only. If other stages—eggs or juveniles—are more sensitive (exhibit higher LC_{50}s), higher levels of DO may still constitute a considerable threat. For example, no data are available to evaluate LC_{50}s for eggs. Although eggs are small, which should relieve boundary layer resistance to oxygen flux, they are also immobile and, especially early in development, may have poorly developed systems for coping with oxygen variability.

The converse is to ask: above what level of DO did we observe *no statistical change* in any of the measured traits? In the growth experiment, there were no observable effects of DO $\geq$ 4.4 mg O_2 L^{-1}, and in the acute experiment there was 10% mortality (LC_{10}; considered equivalent to a NOEC (TenBrook et al. 2009)) at 4.2 mg O_2 L^{-1}. Metabolic rates appeared only slightly depressed in this range. In the escape experiment, all salamanders were able to evade simulated predation at 5 mg O_2 L^{-1}. The spontaneous activity experiment indicated an intermediate sensitivity to DO (IC_{50} of 4.5 mg O_2 L^{-1}).

The DO range between these extremes—of large-scale mortality at 3.4 mg O_2 L^{-1} versus no observable effects at above ~4.4 mg O_2 L^{-1}—is the location of greatest biological interest. It is likely that populations in the Barton Springs complex would fare increasingly poorly in lower DOs persisting for 28 – 60 d periods within this range, but *how* poorly is unknown. Quantitative assessment of these effect thresholds awaits additional, field-oriented studies.

To relate laboratory stressor – response data to ambient DO values in *Eurycea* habitats, we performed a PEHA for three spring-fed systems in the Barton Springs Complex: Barton Springs Pool, Eliza Spring and Old Mill. The PEHA suggests that the 5^{th} centile values of average daily DO (4.5 and 5.8 mg O_2 L^{-1} in Barton Springs Pool and Eliza Spring, respectively) are sufficient to protect juvenile and adult *Eurycea*, as the NOAEL for juvenile growth rates over a 60 d period was 4.4 mg O_2 L^{-1}. However, the likelihood of exceeding ecologically meaningful DO thresholds is much higher in Old Mill (Table 4). These observations suggest that we need a better understanding of the physical, chemical, and biological factors influencing DO below 4.4 mg O_2 L^{-1} in *Eurycea* spring-fed habitats.

In Texas, DO WQC for rivers and lakes are defined as 3 mg L^{-1} and 5 mg L^{-1} minima, respectively, over a 24 hr period (TCEQ 2003). Thus, DO WQC for lentic systems (5 mg O_2 L^{-1}, 24 hr minimum) appears to offer adequate protection to *Eurycea*. But Barton Springs Pool, Eliza Spring and Old Mill are spring-fed surface waters (neither river nor reservoir) with unique physical features known to influence the production - respiration dynamics of ecosystems and, thus, DO (Forbes et al, 2008). Due to data availability and the scope of the present study, we were unable to fully examine whether river DO WQC protect these threatened and endangered salamanders. Further research is needed on how spatial and temporal variation in DO affects *Eurycea* life history and resiliency. Future efforts should determine the influence of urbanization and climate variability on water quality and associated ecological thresholds for *Eurycea* species.

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LITERATURE CITED

Aldenberg, T., and W. Slob. 1993. Confidence limits for hazardous concentrations based on logistically distributed NOEC toxicity data. Ecotoxicology and Environmental Safety 25:48-63.

Bates, D. M., and D. G. Watts. 1988. Nonlinear Regression Analysis and Its Applications. Wiley, New York.

Blaustein, A. R., W. P. Sousa, and D. B. Wake. 1994. Amphibian declines: judging stability, persistence, and susceptibility of populations to local and global extinctions. Conservation Biology 8:60-71.

Bond, A. N. 1960. An analysis of the response of salamander gills to changes in the oxygen concentration of the medium. Developmental Biology 2:1-20.

Booth, D. T., and M. E. Feder. 1991. Formation of hypoxic boundary layers and their biological implications in a skin-breathing aquatic salamander, *Desmognathus quadramaculatus*. Physiological Zoology 64:1307-1321.

Brain, R. A., T. S. Reitsma, L. I. Lissemore, B. J. Bestari, P. K. Sibley, and K. R. Solomon. 2006. Herbicidal effects of statin pharmaceuticals in *Lemna gibba*. Environmental Science & Technology 40:5116-5123.

Chippindale, P. T., A. H. Price, J. J. Wiens, and D. M. Hillis. 2000. Phylogenetic relationship and systematic revision of central Texas hemidactyliine plethodontid salamanders. Herpetological Monographs 14:1-80.

City of Austin. 1997. The Barton Creek Report. Austin, TX, USA.

Crowder, W. C., M. Nie, and G. R. Ultsch. 1998. Oxygen uptake in bullfrog tadpoles (*Rana catesbeiana*). Journal of Experimental Zoology 280:121-134.

Dodds, W. K. 1991. Micro-environmental characteristics of filamentous algal communities in flowing freshwaters. Freshwater Biology 25:199-209.

Feder, M. E. 1983. Integrating the ecology and physiology of plethodontid salamanders. Herpetologica 39:291-310.

Forbes, M. G., R. D. Doyle, J. T. Scott, J. K. Stanley, H. Huang, and B. W. Brooks. 2008. Physical factors control carbon and nitrogen fixation in eight Texas reservoirs. Ecosystems 11: 1181-1197.

Hanson, M. L., and K. R. Solomon. 2002. New technique for estimating thresholds of toxicity in ecological risk assessment. Environmental Science and Technology 36:3257-3264.

Helmuth, B., J. G. Kingsolver, and E. Carrington. 2005. Biophysics, physiological ecology, and climate change: Does mechanism matter? Annual Review of Physiology 67:177–201.

Hillman, S. S., and P. C. Withers. 1979. An analysis of respiratory surface area as a limit to activity metabolism in amphibians. Canadian Journal of Zoology 57:2100-2105.

Houlahan, J. E., C. S. Findlay, B. R. Schmidt, A. H. Meyer, and S. L. Kuzmin. 2000. Quantitative evidence for global amphibian population declines. Nature 404:752-755.

Kemp, M. J., and W. K. Dodds. 2001. Centimeter-scale patterns in dissolved oxygen and nitrification rates in a prairie stream. Journal of the North American Benthological Society 20:347-357.

Kiesecker, J. M., A. R. Blaustein, and L. K. Belden. 2001. Complex causes of amphibian population declines. Nature 410:681-684.

Miller, J. E., G. R. Hess, and C. E. Moorman. 2007. Southern two-lined salamanders in urbanizing watersheds. Urban Ecosystems 10:73-85.

Mills, N. E., and M. C. Barnhart. 1999. Effects of hypoxia on embryonic development in two *Ambystoma* and two *Rana* species. Physiological and Biochemical Zoology 72:179-188.

Mills, N. E., M. C. Barnhart, and R. D. Semlitsch. 2001. Effects of hypoxia on egg capsule conductance in *Ambystoma* (Class Amphibia, Order Caudata). Journal of Experimental Biology 204:3747-3753.

Naismith Engineering, Inc. 2005. Regional Water Quality Protection Plan for the Barton Springs Segment of the Edwards Aquifer and Its Contributing Zone, Vol. I. www.waterqualityplan.org/06-23-05/Final-2005-06-20-VolI.pdf. 254 p.

Noland, R., and G. R. Ultsch. 1981. The roles of temperature and dissolved oxygen in microhabitat selection by the tadpoles of a frog (*Rana pipiens*) and a toad (*Bufo terrestris*). Copeia 1981:645-652.

Parkhurst, B. R., W. J. Warren-Hicks, R. D. Cardwell, J. S. Volosin, T. Etchison, J. B. Butcher, and S. M. Covington. 1996. Aquatic ecological risk assessment: A multi-tiered approach to risk assessment. 91-AER-1. Water Environment Research Foundation, Alexandria, VA, USA.

Pattee, O. H., V. L. Fellows, and D. L. Bounds. 2003. Animal species endangerment: the role of environmental pollution. In: Hoffman, D.J., B.A. Rattner, G.A. Burton, and J. Cairns Jr (Eds.) Handbook of Ecotoxicology. 2nd Ed. Lewis Publishers, Boca Raton, FL. pp. 1237-1251.

Petranka, J. W., J. J. Just, and E. C. Crawford. 1982. Hatching of amphibian embryos: the physiological trigger. Science 217:257-259.

Pinheiro, J. C., and D. M. Bates. 2000. Mixed-Effects Models in S and S-Plus. Springer, New York.

Price, S. J., M. E. Dorcas, A. L. Gallant, R. W. Klaver, and J. D. Willson. 2006. Three decades of urbanization: Estimating the impact of land-cover change on stream salamander populations. Biological Conservation 133:436-441.

Raimondo, S., D.N. Vivian, and M.G. Barron. 2007. Web-based Interspecies Correlation Estimation (Web-ICE) for Acute Toxicity: User Manual. Version 2.0. EPA/600/R-07/071. U.S. Environmental Protection Agency, Office of Research and Development, Gulf Breeze, FL.

Revsbech, N. P., and B. B. Jørgensen. 1986. Micro-electrodes: their use in microbial ecology. Advances in Microbial Ecology 9:293-352.

Ricklefs, R. E., and M.Wikelski. 2002. The physiology/life-history nexus. Trends in Ecology and Evolution 17:462-468.

Sheafor E. A., S. C.Wood, and G. J. Tattersall. 2000. The effects of graded hypoxia on the metabolic rates and buccal activity of a lungless salmander (*Desmognathus fuscus*). Journal of Experimental Biology 203:3785-3793.

Sijm, D. T. H. M., A. P. van Wezel and T. Crommentuijn. 2002. Environmental risk limits in the Netherlands. In: L. Posthuma, G. W. I. Suter and T. P. Traas, Editors, *Species-Sensitivity Distributions in Ecotoxicology*, Boca Raton, FL, USA, pp. 221–253.

Slade, R. M., L. Ruiz, and D. Slagle. 1985. Simulation of the flow system of Barton Springs and associated Edwards Aquifer in the Austin area, Texas. US Geological Survey, Water-Resources Investigations Report 85-4299.

Slater, P. J. B., and N. P. Lester. 1982. Minimising errors in splitting behaviour into bouts. Behaviour 79:153-161.

Smith, B. A., and B. B. Hunt. 2004. Evaluation of sustainable yield of the Barton Springs segment of the Edwards Aquifer, Hays and Travis Counties, Central Texas. Sustainable Yield Final Report, Barton Springs/Edwards Aquifer Conservation District.

Solomon, K. R., J. P. Giesy, and P. Jones. 2000. Probabilistic risk assessment of agrochemicals in the environment. Crop Protection 19:649–655.

Solomon, K. R., and P. Takacs. 2002. Probabilistic risk assessment using species sensitivity distributions. In: L. Posthuma, T. Traas and G. Suter, Editors, *Species Sensitivity Distributions in Risk Assessment*, CRC Press, Boca Raton, FL, USA. 564 pp.

Suter GW II. 2007. Ecological Risk Assessment, 2nd Ed. CRC Publishers, Boca Raton FL. 643 p.

Sweet, S. S. 1982. A distributional analysis of epigean populations of *Eurycea neotenes* in central Texas, with comments on the origin of troglobitic populations. Herpetologica 38:430–444.

Tattersall, G. J., and R. G. Boutilier. 1997. Balancing hypoxia and hypothermia in cold-submerged frogs. Journal of Experimental Biology 200:1031-1038.

TenBrook, P. L., R. S. Tjeerdema, P. Hann, and J. Karkoski. 2009. Methods for deriving pesticide aquatic life criteria. Reviews of Environmental Contamination and Toxicology 199:19-110.

TCEQ. 2003. Guidance for assessing Texas surface and finished drinking water quality data, 2004. Surface Water Quality Monitoring Program, Texas

Tupa, D. D., and W. D. Davis. 1976. Population dynamic of the San Marcos salamander, *Eurycea nana* Bishop. Texas Journal of Science 27:179-195.

Turner, M. E. 2004. Update of Barton Springs water quality data analysis – Austin, Texas. City of Austin, Watershed Protection Development Review. Publication No. SR-00-03.

USEPA. 2002. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms. 4th edition. US Environmental Protection Agency. EPA-821-R-02-013.

USGS. 2007. National Water Information System field / lab water-quality samples for USGS site 08155500, Barton Springs, Austin, TX. http://waterdata.usgs.gov/nwis/nwisman/?site_no=08155500&agency_cd=USGS

Vaquer-Sunyer, R., and C. M. Duarte. 2008. Thresholds of hypoxia for marine biodiversity. Proceedings of the National Academy of Sciences USA 105:15452-15457.

Wagner, C., and H. Lokke. 1991. Estimation of ecotoxicological protection levels from NOEC toxicity data. Water Research 25:1237–1242.

Wake, D. B. 1970. The abundance and diversity of tropical salamanders. American Naturalist 104:211-213.

Wang, L., J. Lyons, P. Kanehl, and R. Bannerman. 2001. Impacts of urbanization on stream habitat and fish across multiple spatial scales. Environmental Management 28:255–266.

Wassersug, R. J., and E. A. Seibert. 1975. Behavioral responses of amphibian larvae to variation in dissolved oxygen. Copeia 1975:86-103.

Werner, E. E., and K. Glennemeier. 1999. The influence of forest canopy cover on breeding pond distributions of several amphibian species. Copeia 1999:1-12.

Wetzel, R. G., and G. E. Likens. 2000. *Limnological Analyses*. Springer.

Withers, P. C. 1980. Oxygen consumption of plethodontid salamanders during rest, activity and recovery. Copeia 1980:781-787.

FIGURE LEGENDS

Fig. 1. Experimental set-up for the 28 day oxygen toxicity experiments. Each of twenty controlled atmosphere boxes held three aquaria (1 salamander per aquarium); only two aquaria are shown in the figure. Controlled aspects of the physical environment included water temperature, pH, dissolved oxygen, and light levels.

Fig. 2. Activity measures as a proxy for escape response across ramped levels of dissolved oxygen. Units for time are seconds. Loops and undulations are numbers of loops around the aquarium and numbers of body undulations respectively. *N* is the number of salamanders remaining for that level of dissolved oxygen.

Fig. 3. Example of the log survivorship analysis of activity for one of the salamanders showing (A) the location of the breakpoint at 0.82 min between activity bouts, fitted by the method of Lester and Slater (1982), and (B) raw voltage trace from infrared activity meter with activity bouts drawn above according to the breakpoint identified in (A).

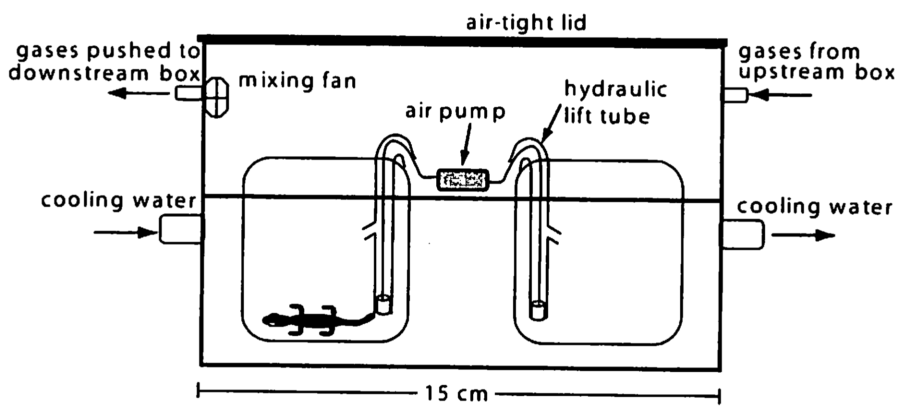
Fig. 4. Spontaneous activity of *Eurycea nana* in response to ramped dissolved oxygen. (A) Raw voltage traces and fitted bouts for each of eight salamanders and a blank chamber superimposed on the trace of dissolved oxygen. (B) Dots are total number of salamanders active (out of 8) and the line is a fitted loess curve (local regression, with smoothing, smoothing parameter = 0.3).

Fig. 5. Metabolic rates of *Eurycea nana* (A) and *E. sosorum* (B) across a range of dissolved oxygen (DO) levels. During experiments, DO was ramped, in steps, from high to low. In most experiments, salamanders were returned to high DO (air-saturated Eliza Spring water) at the end and one more metabolic measurement was taken. Lines represent best fits of the Biological Oxygen Demand model (Eq. 3). See Table 3 for summaries of parameter values and statistical significance.

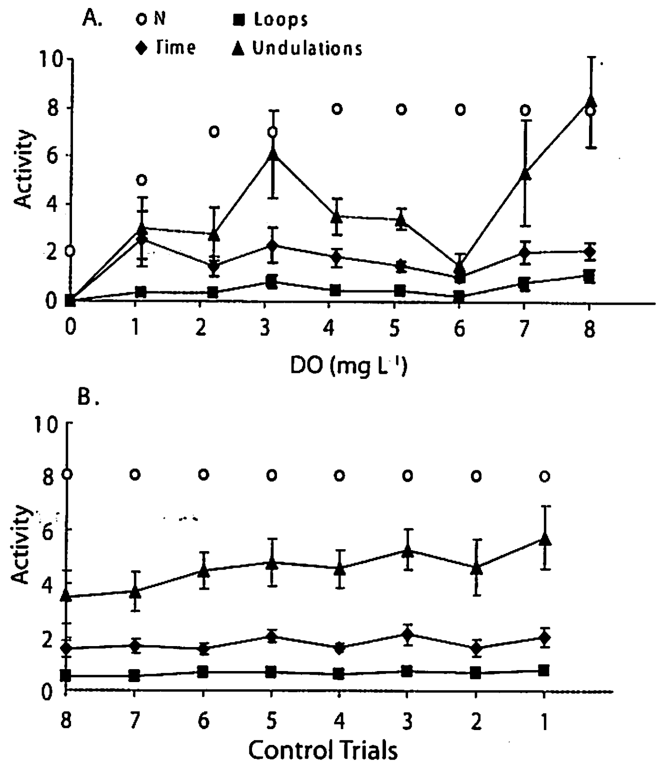
Fig. 6. Percent mortality of *Eurycea nana* exposed to varying dissolved oxygen content. The data were modeled using a 3-parameter logistic model.

Fig. 7. Percentage rank and log-transformed plot for a distribution of discrete dissolved oxygen measurements for Barton Springs ●, Eliza Spring ○, and Old Mill ▼ locations in central Texas, USA. The corresponding correlation coefficients for the regression lines fitted to each sampling site are 0.97, 0.96, and 0.65, respectively. Vertical reference lines represent the LC_{50} (3.4 mg L^{-1}), LC_{25} (3.7 mg L^{-1}), LC_{10} (4.2 mg L^{-1}), LC_5 (4.5 mg L^{-1}), and NOAEL (4.4 mg L^{-1}), respectively, for 28 d adult mortality and 60 d juvenile specific growth rates of *Eurycea nana* exposed to varying dissolved oxygen concentrations.

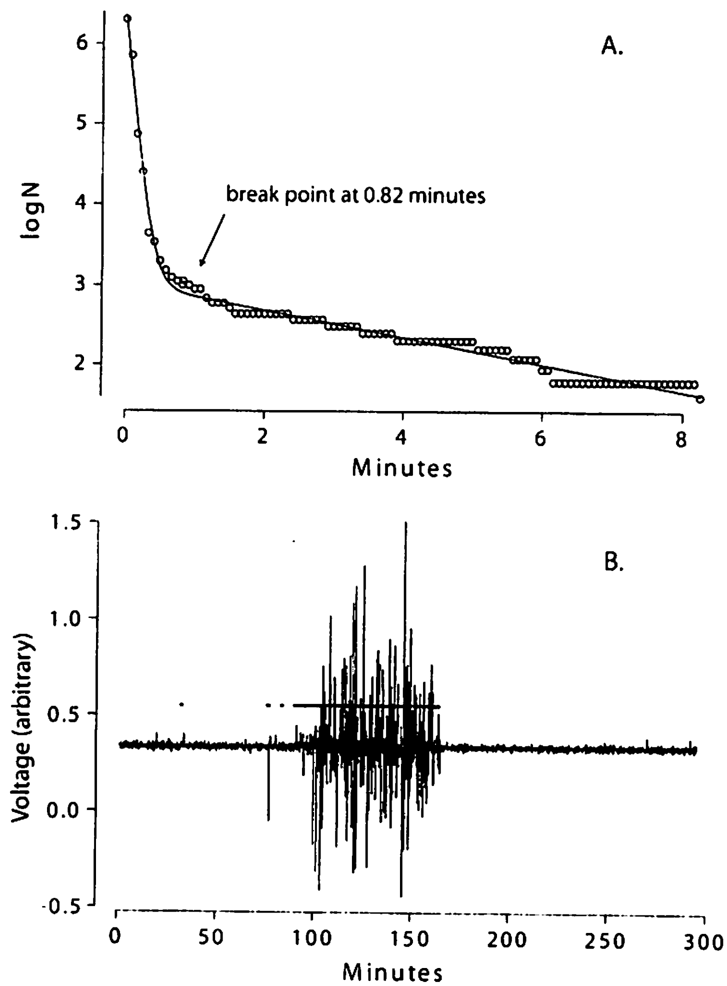
Woods et al. Figure 1



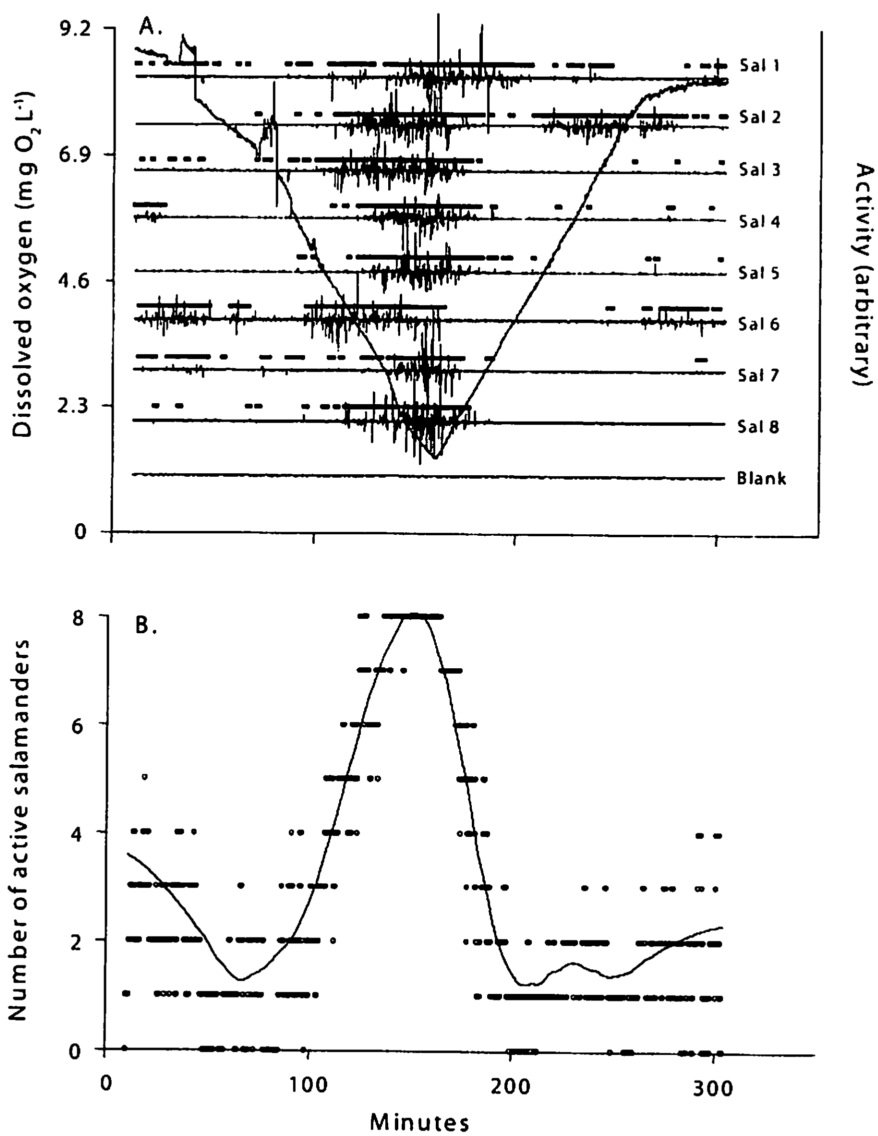
Woods et al. Figure 2



Woods et al. Figure 3



Woods et al. Figure 4.



Woods et al. Figure 5

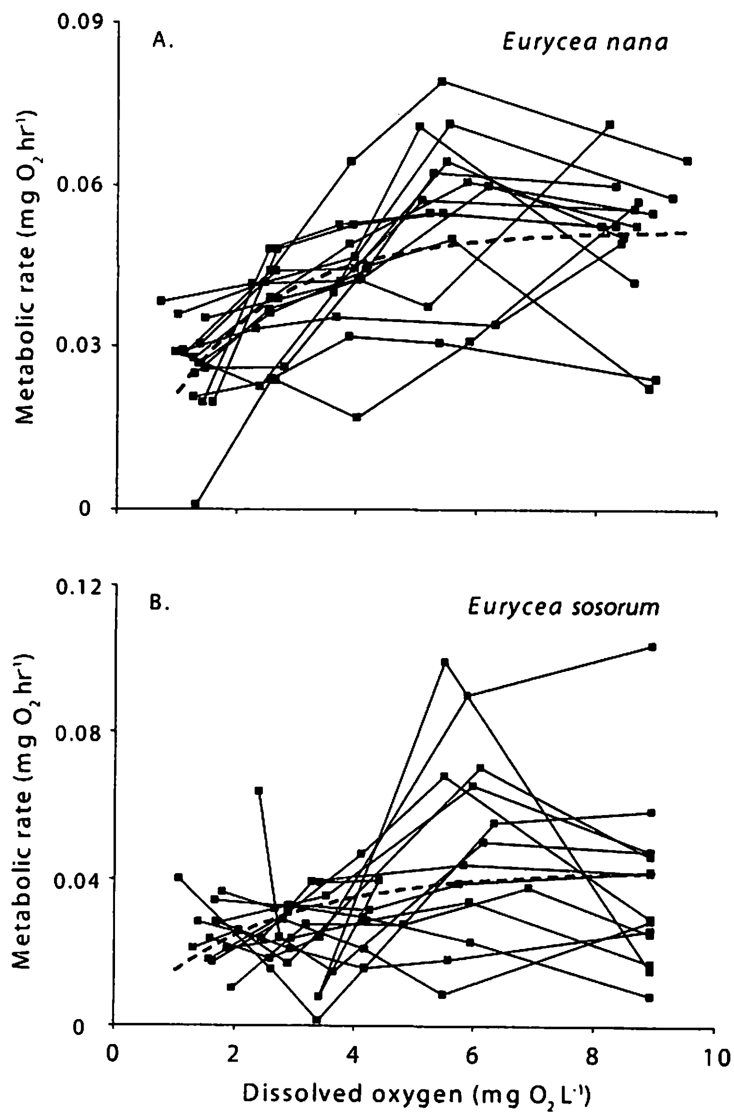


Figure 6.

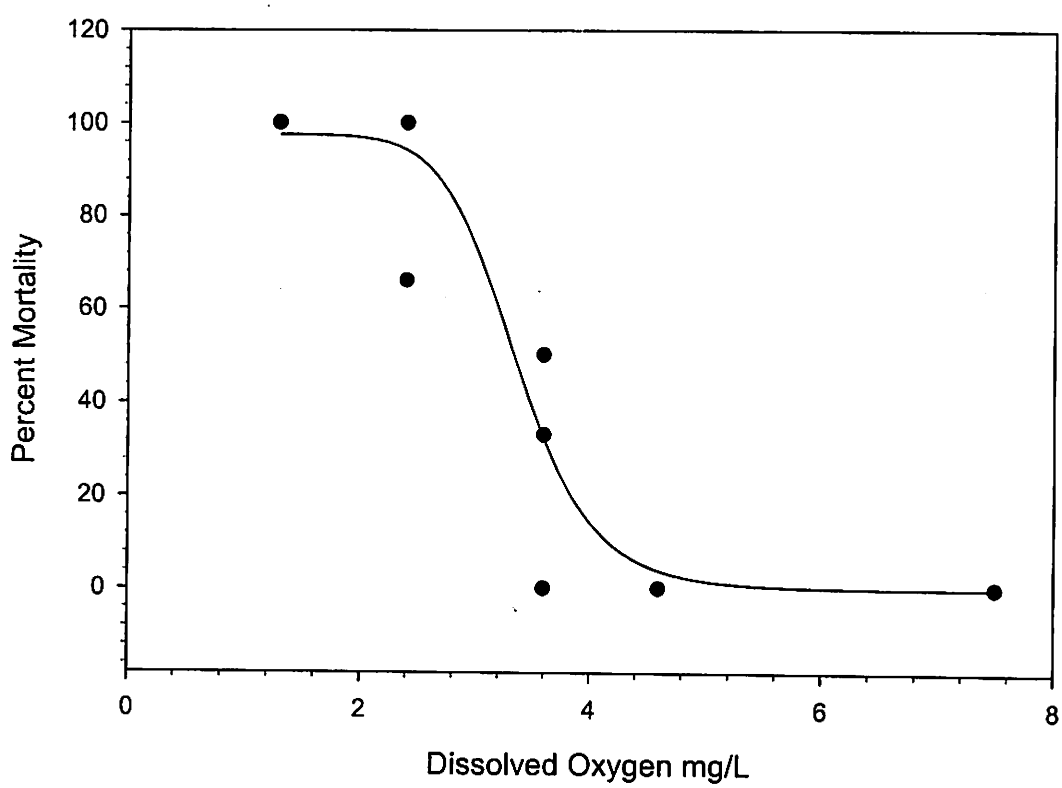
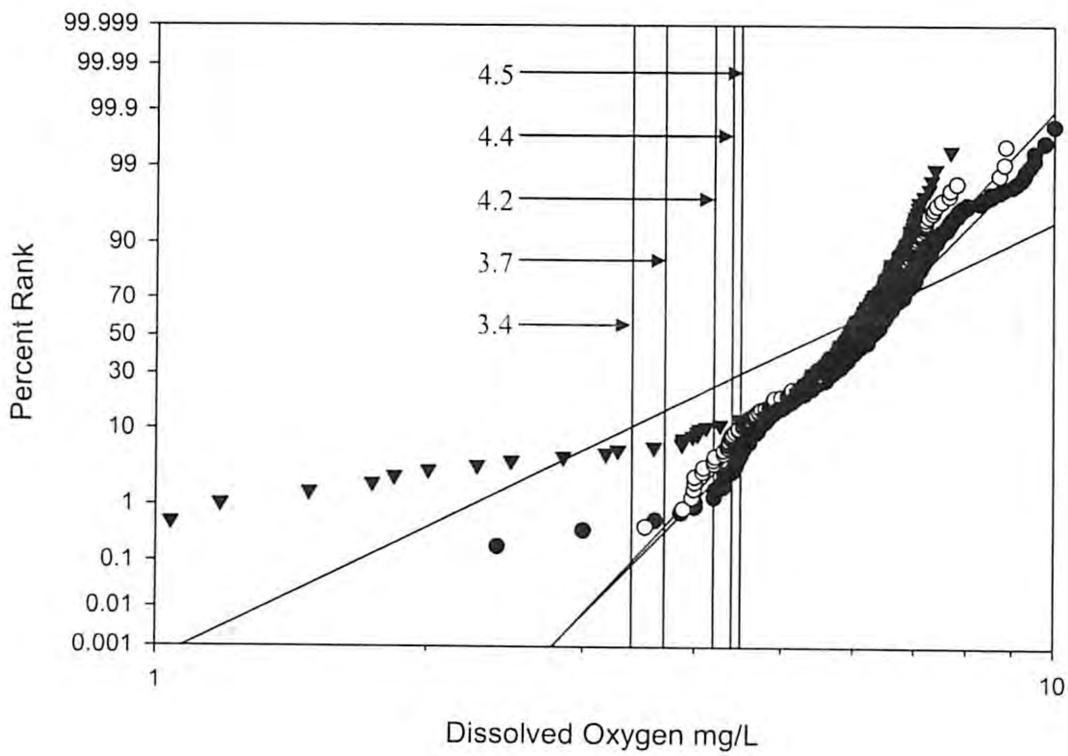

120
100
80
60
40
20
0
Percent Mortality
0
2
4
6
8
Dissolved Oxygen mg/L

Figure 7.



99.999
99.99
99.9
99
90
70
50
30
10
1
0.1
0.01
0.001
Percent Rank
4.5
4.4
4.2
3.7
3.4
1
10
Dissolved Oxygen mg/L

Table 1. Measured Oxygen Levels in the 28-d (Adult Toxicity) and 60-d (Juvenile Growth) Experiments.

Treatment	28-day Mean DO (mg L^{-1})	Std.err.	60-day Mean DO (mg L^{-1})	Std. err.
1	1.7	0.32	4.4	0.28
2	2.8	0.34	5.0	0.36
3	3.1	0.28	5.3	0.18
4	4.6	0.13	6.0	0.31
5	7.3	0.10	8.0	0.52

Table 2. Equations Used to Fit the Concentration-Responses of *Eurycea nana* Exposed to Varying Dissolved Oxygen Levels.

Regression	Equation[a]	Modeling Type
Linear	$y = a+((ap)/LC_x)x)$	Increase
Four Parameter Logistic	$y = y_0 + a/(1+ (x/LC_x)^b)((a/(1 - p)(y_0 + a)-y_0)-1)$	Decrease
Four Parameter Logistic	$y = y_0 + a/(1+ (x/LC_x)^b)((a/(1 + p)(y_0 + a)-y_0)-1)$	Increase
Three Parameter Logistic	$y = a (1 + (p/(1 - p)(x/LC_x)^b))$	Decrease

[a] The variable LC_x is the calculated effective concentration at which proportion *p* of the endpoint is affected and x is the actual concentration (i.e., mg L^{-1}), *y* is the response or change from control of the endpoint modeled, and *a*, *b*, and y_0 are constants

Table 3. Summary of Parameter Values and Statistical Significance from Fitting the Biological Oxygen Demand Model (Eq. 3) to Data on Metabolic Rates as a Function of Dissolved Oxygen Levels (see Fig. 5).

Species	Parameter	Value	95% CI	num DF	den DF	F	P
E. nana	ϕ_1*	0.052	0.045 to 0.058	1	59	251.6	<0.0001
	ϕ_2	-0.64	-0.37 to -0.90	1	59	23.5	<0.0001
	IC_{50}†	1.31	1.01 to 1.70				
E. sosorum	ϕ_1	0.043	0.032 to 0.053	1	55	85.7	<0.0001
	ϕ_2	-0.85	-1.48 to -0.22	1	55	7.03	0.01
	IC_{50}	1.62	0.86 – 3.04				

*units of ϕ_1, the asymptotic metabolic rate, are mg O_2 hr^{-1}

†calculated from Eq. 4; units are mg O_2 L^{-1}

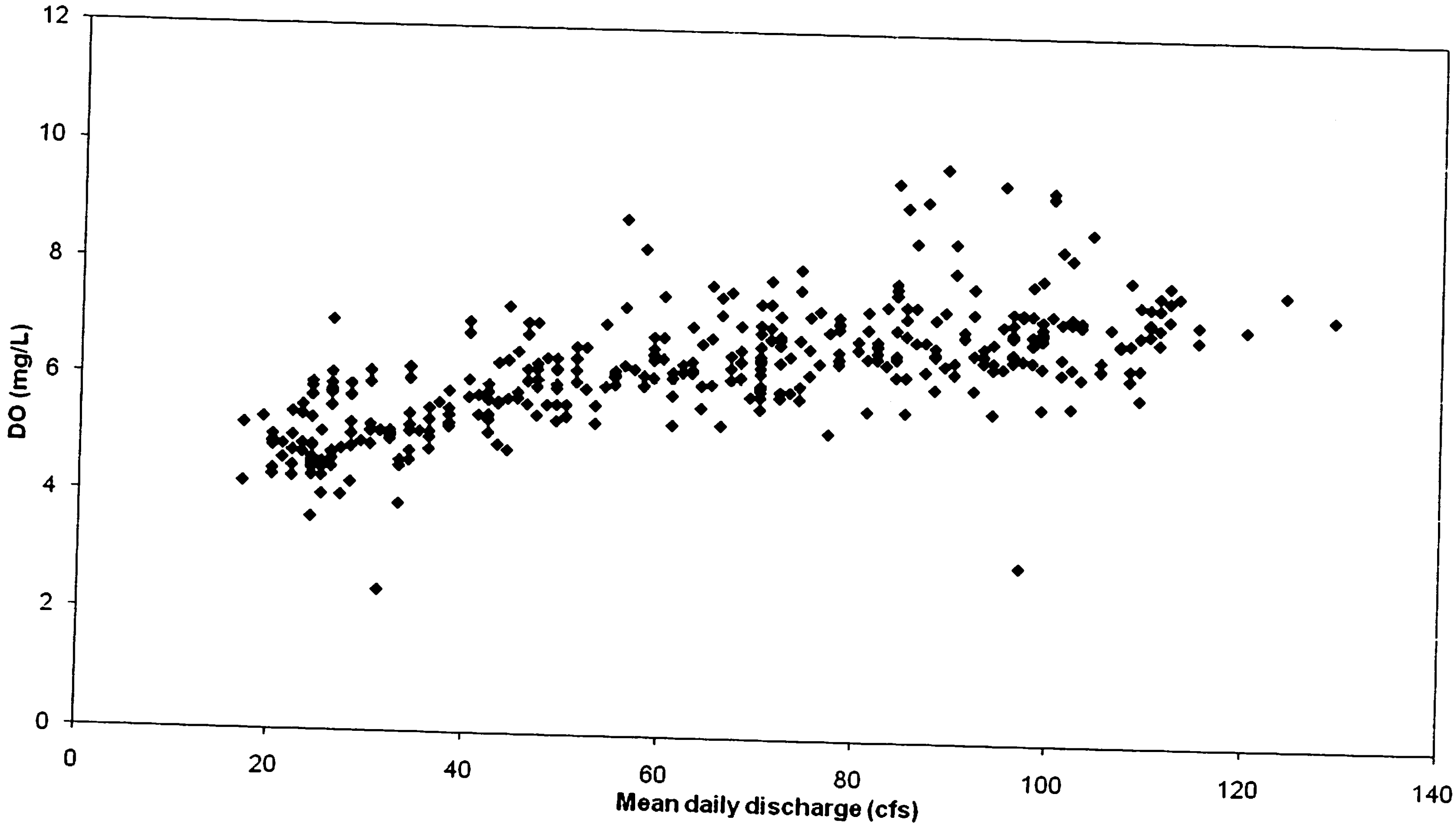
Table 4. Lethal Concentrations (LC_x) of Oxygen Required to Cause Mortality in 5, 10, 25, and 50% of *Eurycea nana* During 28 Days of Exposure and No Observable Adverse Effect Level (NOAEL) for a Chronic 60 Day Exposure. The Probability of Exceedance for Each of the Threshold Values is Provided Based on Calculations Using a Probabilistic Hazard Assessment Model (Equation 2) for Dissolved Oxygen Data From Barton Springs, Eliza Spring, and Old Mill Sites.

					Probability of Exceedance (% of Values Below Threshold)		
Effect	**Type**	**Regression model**	**Value (mg L^{-1})**	**P**	**Barton Springs**	**Eliza Spring**	**Old Mill**
LC_5	Acute	3-parameter logistic	4.5 ± 0.5	<0.0001	5.2	6.8	30
LC_{10}	Acute	3-parameter logistic	4.2 ± 0.3	<0.0001	2.3	3.0	24
LC_{25}	Acute	3-parameter logistic	3.7 ± 0.1	<0.0001	0.4	0.4	15
LC_{50}	Acute	3-parameter logistic	3.4 ± 0.2	<0.0001	0.08	0.1	11
NOAEL	Chronic	Dunnett's Multiple Comparison	4.4	-	4.5	5.8	28

Table 5. Growth rates of juvenile *Eurycea nana* subjected to different experimental levels of DO. Growth rates for individual salamanders were estimated as the slope of mass over time (mg d^{-1}).

DO (mg L^{-1})	N	Growth rate (mg d^{-1})	Standard error of growth rate
4.4	5	0.15	0.04
5.0	4	0.33	0.07
5.3	4	0.26	0.03
6.0	5	0.24	0.05
8.0	3	0.25	0.05

Barton Springs grab DO (all data, storm and non-storm) versus mean daily discharge



GAM Run 09-019

by William R. Hutchison[1], Ph.D., P.E., P.G.
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December 7, 2009

EXECUTIVE SUMMARY:

The existing groundwater availability model for the Barton Springs segment of the Edwards (Balcones Fault Zone) Aquifer (Scanlon and others, 2001) was calibrated based on data from 1989 to 1998. Thus, the calibration did not include the historic drought-of-record that lasted from 1950 through 1956, when the estimated minimum discharges of 11 cubic-feet per second occurred for Barton Springs. Due to the nature of the model run request, it was apparent that the confidence in results from the existing model would be lower than results from a model that had been calibrated during the drought-of-record period. In order to develop results that would be more useful, we recalibrated the existing model for the period January 1943 to December 2004 (Hutchison and Hill, in preparation).

For the drought reoccurrence simulations, we ran a suite of model scenarios to evaluate simulated discharges during drought conditions at Barton Springs. Our suite consisted of 15 scenarios that involved using 3 different starting head conditions (low-, intermediate-, and high-flow conditions described in the Methods section) and 5 pumping datasets with annual averages of 3,847; 4,469; 5,437; 6,796; and 16,311 acre-feet per year. The purpose for these scenarios was to evaluate the effect of starting heads or flow conditions going into a 7-year drought and pumpage quantities on simulated discharges. Each of these scenarios included 342 7-year simulations extending from 1648 through 1995 for a total of 28,728 months.

Results for the drought reoccurrence simulations indicate that simulated discharges for Barton Springs at or below 11 cubic-feet per second, which are equivalent to the estimated minimum discharges during the 1950 to 1956 drought-of-record, occurred at a relative frequency of 5 percent using starting heads at low-flow conditions and an annual average pumpage of 6,796 acre-feet per year with the 2002 well spatial distribution. The 2002 well spatial distribution is assumed to be comparable to current groundwater withdrawal rates. Discharges from Barton Springs at or below 9 cubic-feet per second occurred at a relative frequency of 4 percent, followed by 2 percent or less for 7, 5, and 3 cubic-feet per second. The relative frequency for simulating discharges at or below 11 cubic-feet per second decreases to 0 percent using an annual average pumpage of 6,796 acre-feet per year with starting heads at intermediate- or high-flow conditions.

Simulated discharges from Barton Springs at or below 11 cubic-feet per second for 3 or more consecutive months, which may be critical to biological needs, occurred at a relative frequency of 3 percent using starting heads at low-flow conditions with an annual average pumpage of 6,796 acre-feet per year with the 2002 well spatial distribution. Discharges at or below 9 cubic-feet per second for 3 or more consecutive months occurred at a relative frequency of 2 percent, using those same starting head conditions, pumpage quantities and distributions, followed by 1 percent or less for 7, 5, and 3 cubic-feet per second. The relative frequency for simulating discharges at or below 11 cubic-feet per second for 3 or more consecutive months decreases to 0 percent using an annual average pumpage of 6,796 acre-feet per year with starting heads at intermediate- or high-flow conditions.

Simulated discharges from Barton Springs were most sensitive to changes in starting head conditions using 4 out of the 5 pumping datasets, specifically, those with annual averages of 3,847; 4,469; 5,437; and 6,796 acre-feet per year. The exception to this was the pumping dataset with an annual average pumpage of 16,311 acre-feet per year. Simulated discharges were less sensitive to starting head conditions and more sensitive to pumping using this well dataset.

REQUESTOR:

Mr. Rick Illgner (of the Edwards Aquifer Authority) on behalf of Groundwater Management Area 10.

DESCRIPTION OF REQUEST:

Mr. Illgner requested a model run with monthly average discharges from Barton Springs of 11, 9, 7, 5, and 3 cubic-feet per second during a drought-of-record reoccurrence using a groundwater flow model calibrated to the 1950 through 1956 drought-of-record.

METHODS:

The existing groundwater availability model for the Barton Springs segment of the Edwards (Balcones Fault Zone) Aquifer (Scanlon and others, 2001) was calibrated based on data from 1989 to 1998. Thus, the calibration did not include the historic drought-of-record that lasted from 1950 through 1956, when the estimated minimum discharges of 11 cubic-feet per second occurred at Barton Springs. Due to the nature of the model run request, it was apparent that the confidence in results from the existing model would be lower than results from a model that had been calibrated during the drought-of-record period. In order to develop results that would be more useful, we recalibrated the existing model for the period January 1943 to December 2004 (Hutchison and Hill, in preparation). The recalibrated model consists of 745 monthly stress periods. The first stress period is set to steady-state conditions with the remaining 744 monthly stress periods set to transient conditions. The model was calibrated using 152 target wells from the Texas Water Development Board groundwater database and estimated/measured springflows provided by the Barton Springs/Edwards Aquifer Conservation District. Simulated discharges at Barton Springs using the recalibrated model satisfactorily simulate the minimum estimated discharges of 11 cubic-feet per second that occurred during the historic drought-of-record in July and August of 1956 (Figure 1).

The run request included alternative springflow conditions under a drought-of-record reoccurrence. In summary, the request sought the amount of pumping that would result in a specified springflow under drought-of-record conditions. In order to fill the request and put the various scenarios in historical context, we held most parameters from the recalibrated model constant (MODFLOW-2000 Discretization, Layer-Property Flow, Drain, and Horizontal Flow Barrier packages), and generated multiple MODFLOW-2000 Basic, Well, and Recharge packages, as described below, for the simulations.

Our suite of simulations consisted of a 3 by 5 matrix (15 scenarios) with three different starting head conditions using low-, intermediate-, and high-flow conditions, and five annual average pumping datasets with quantities of 3,847; 4,469; 5,437; 6,796; and 16,311 acre-feet per year. Each of the scenarios included 342 7-year simulations extending from 1648 through 1995 based on a tree-ring dataset from Cleaveland (2006). Every 7-year simulation consisted of 84 monthly stress periods. The purpose for these scenarios was to evaluate the effect of starting heads or flow conditions at the start of a drought and pumpage on simulated discharges.

We extracted simulated heads for February 1957 from the recalibrated model as the low-flow starting head conditions for the drought-of-record reoccurrence simulations. Simulated heads for June 1992 were selected as the starting heads for high-flow conditions, and January 2004 simulated heads were selected for our intermediate-flow starting heads.

We extracted groundwater withdrawal quantities and their distributions for 1982, 1987, and 2002 from the recalibrated model's well package. We then applied a factor of 1.25 and 3 to the 2002 dataset to achieve 2 additional well datasets. We extracted 1982 and 1987 from the recalibrated model's well package because the annual average pumpage quantities for these years are lower than the 2002 pumpage quantities in the recalibrated model, but are relatively higher than pumpage quantities in the recalibrated model for the early to mid-1990's (Figure 2). We applied the 1.25 factor to the 2002 dataset because groundwater withdrawals in the recalibrated model for that year are 9 percent lower than the estimates provided by the Barton Springs/Edwards Aquifer Conservation District. The larger factor (3) was applied to the 2002 dataset to account for potential increases of groundwater withdrawals. The well package with quantities of 6,796 acre-feet per year are assumed to be the closest to current groundwater withdrawal rates.

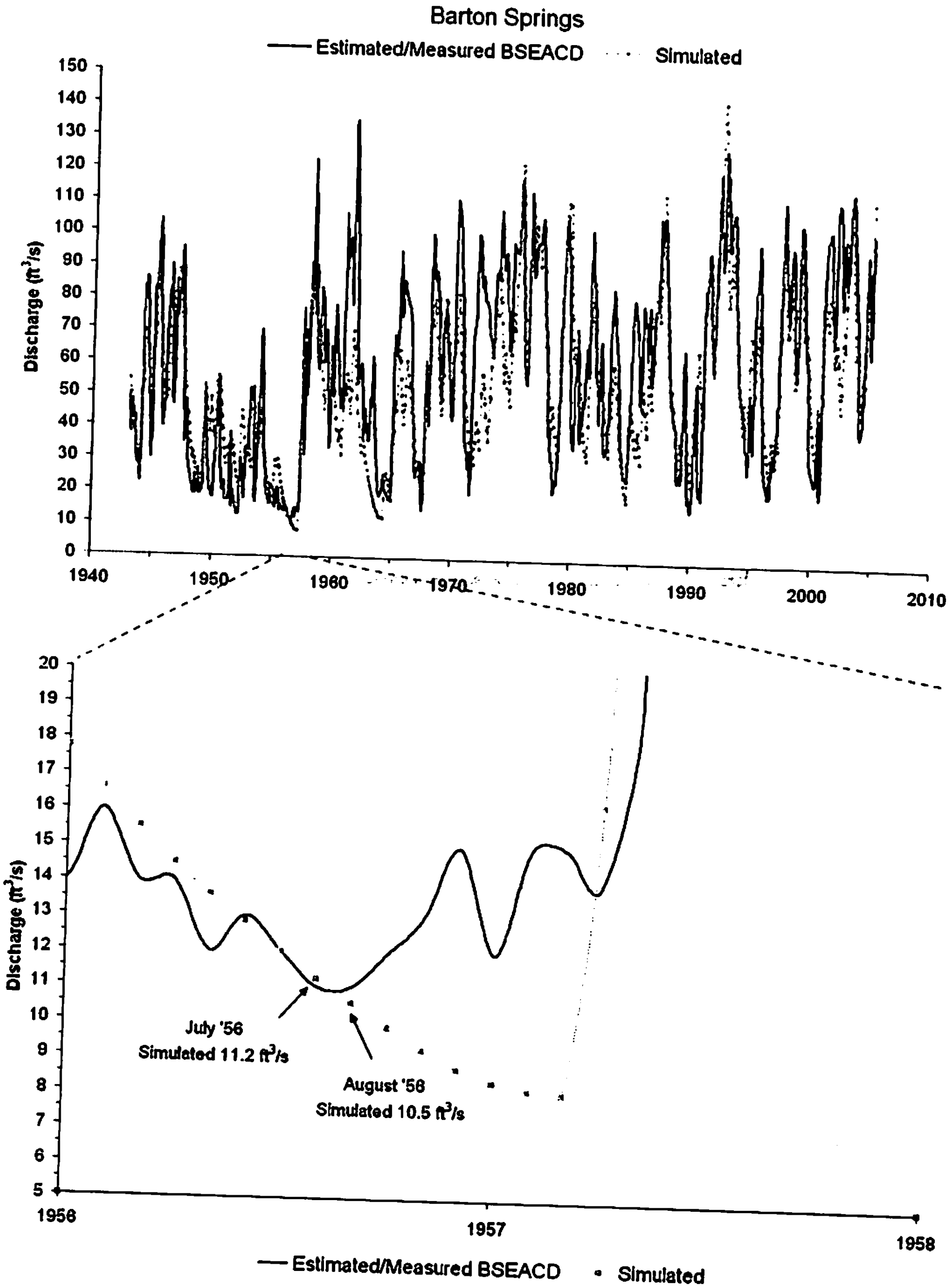


Figure 1. **Estimated/measured discharges at Barton Springs versus simulated discharges from January 1943 to December 2004 using the recalibrated model (top). Bottom plot rescaled to highlight simulated discharges during the historic drought-of-record when the estimated minimum discharges of 11 cubic-feet per second occurred in July and August of 1956.**

We estimated monthly rainfall as follows: first, we took the percentage of reconstructed annual rainfall for a given year relative to the average reconstructed values for 1648 through 1995 based on the composite of 6 post oak tree-ring chronologies for South Central Texas (Cleaveland, 2006). For example, if the annual average reconstructed rainfall for 1648 is 12.9 inches and the average annual reconstructed rainfall for 1648 through 1995 is 15.4 inches per year, then the percent of rainfall for 1648 is 84 percent. Secondly, we created a lookup table with the rainfall values used in the recalibrated model which extends from January 1943 through December 2004. If the annual average rainfall percentage for a given year in the recalibrated model matched the percentage for a given year based on the reconstructed value using the tree-ring record, then the regression relationship developed for the precipitation indices for each recharge zone in the recalibrated model was used to generate a monthly rainfall rate that would be used for the drought-of-record reoccurrence simulations. The recharge zones roughly correlate to the various sub-watersheds that occur where the Edwards (Balcones Fault Zone) Aquifer is exposed at land surface. If an exact match was not identified, then the next closest match was selected and adjusted, or scaled to match the percentage based on the reconstructed values using the tree-ring record.

MODEL DESCRIPTION:

We used the recalibrated model for the Barton Springs segment of the Edwards (Balcones Fault Zone) Aquifer (Hutchison and Hill, in preparation):

- the model consists of one layer representing the Edwards (Balcones Fault Zone) Aquifer. The first stress period of the model is set to steady-state conditions with the remaining 744 monthly stress periods set to transient conditions,
- the calibrated time frame for the model extends from January 1943 through December 2004, including the historic 7-year drought-of-record that lasted from 1950 through 1956,
- simulated discharges at Barton Springs using the transient model satisfactorily match the minimum estimated discharges of 11 cubic-feet per second that occurred in July and August of 1956,
- the absolute residual mean for 152 target wells is 31 feet, and the standard deviation divided by the range is 0.096,
- additional information regarding the recalibrated transient model will be provided in a separate model report (Hutchison and Hill, in preparation),
- we used the MODFLOW-2000 (Harbaugh and others, 2000) groundwater flow simulator with the Geometric Multigrid (GMG) solver (Wilson and Naff, 2004) for model calibration and for the drought reoccurrence simulations requested by Groundwater Management Area 10,

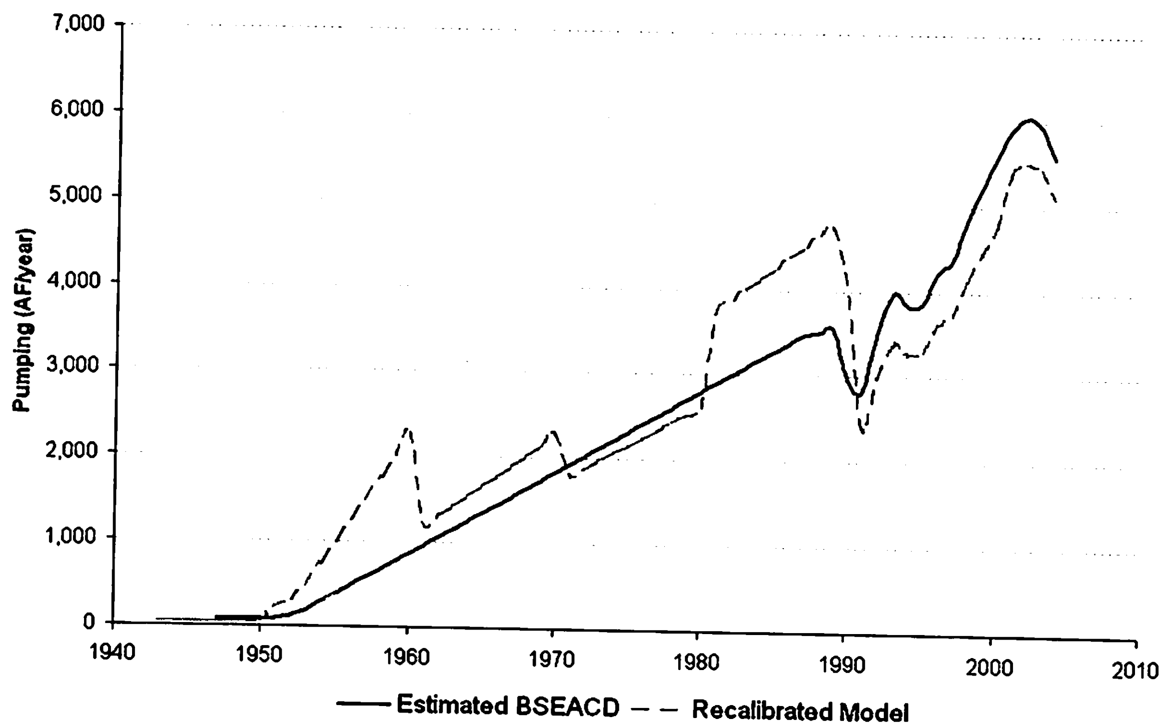


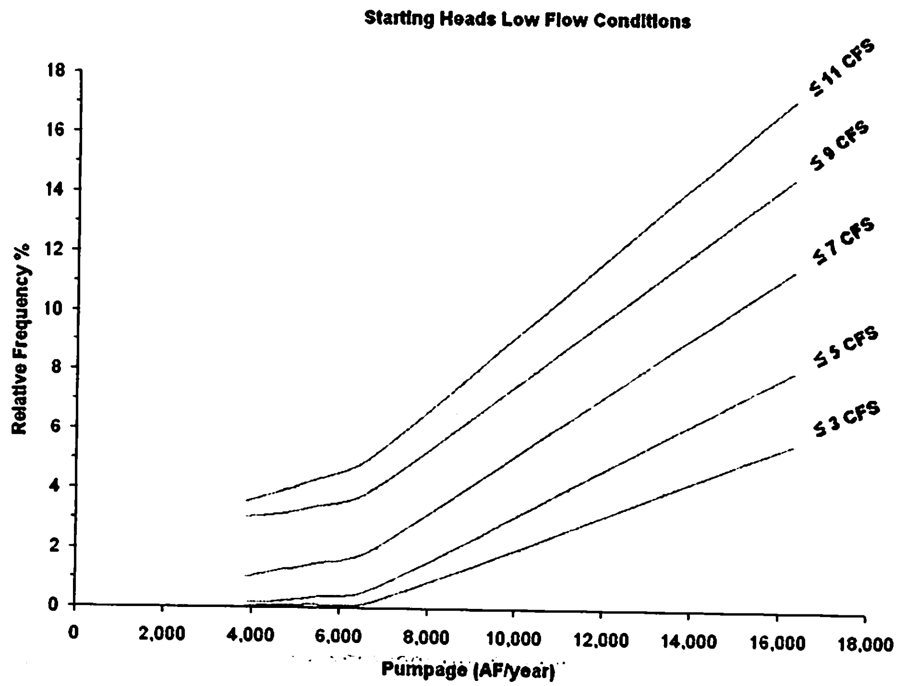
Figure 2. **Plot of annual average pumping estimates provided by Barton Springs/Edwards Aquifer Conservation District versus annual average pumpage in the recalibrated model. During the simulated historic drought-of-record, pumpage quantities in the recalibrated model are generally higher than pumpage estimates provided by the Barton Springs/Edwards Aquifer Conservation District by a factor of 2.6. During the 1980's, the pumpage quantities in the recalibrated model are generally higher than pumpage estimates provided by the Barton Springs/Edwards Aquifer Conservation District by a factor of 1.3 (Hutchison and Hill, in preparation).**

RESULTS:

Figure 3 show the curves for the relative frequency of monthly simulated discharges at or below 11, 9, 7, 5, and 3 cubic-feet per second for each of the starting head conditions (low-, intermediate-, and high-flow conditions) using annual average groundwater withdrawal quantities of 3,847; 4,469; 5,437; 6,796; and 16,311 acre-feet per year. Results from the suite of drought reoccurrence simulations indicate that simulated discharges at or below 11 cubic-feet per second, which are equivalent to the estimated minimum discharges during the 1950 to1956 drought-of-record, occurred at a relative frequency of 5 percent with an annual average pumpage of 6,796 acre-feet per year using the 2002 well spatial distribution and starting heads at low-flow conditions. Discharges at or below 9 cubic-feet per second occurred at a relative frequency of 4 percent, using those same starting heads, pumpage quantities and distributions, followed by 2 percent or less for 7, 5, and 3 cubic-feet per second. However, using an annual average pumpage of 16,311 acre-feet per year with the 2002 well spatial distribution and starting heads at low-flow conditions, increased the relative frequency of simulated discharges at or below 11 cubic-feet per second to 17 percent. The relative frequency for simulating discharges at or below 11 cubic-feet per second decreases to 0 percent using an annual average pumpage of 6,796 acre-feet per year with starting heads at intermediate- or high-flow conditions. Relative frequencies of simulating discharges at or below 11, 9, 7, 5, and 3 cubic-feet per second for each of the starting head conditions and well datasets are summarized in Table 1. Plots of simulated discharges (at and below 15 cubic-feet per second) versus annual average pumping with starting heads at low-, intermediate-, and high-flow conditions are shown in Figure 4. Note the dataset with the highest pumping quantities (16, 311 acre-feet per year) simulates a cessation of flow regardless of the starting head conditions.

Because the duration of low discharge events are critical to biological needs, curves for the relative frequency of simulated discharges for 3 or more consecutive months at or below 11, 9, 7, 5, and 3 cubic-feet per second are shown in Figure 5 for each of the starting head conditions (low-, intermediate-, and high-flow conditions) using annual average groundwater withdrawal quantities of 3,847; 4,469; 5,437; 6,796; and 16,311 acre-feet per year. Results indicate that these longer duration low discharge events typically occur less frequently than the shorter duration (month) low discharge events previously discussed. For example, simulated discharges at or below 11 cubic-feet per second for 3 or more consecutive months occurred at a relative frequency of 3 percent using starting heads at low-flow conditions with an annual average pumpage of 6,796 acre-feet per year with the 2002 well spatial distribution. Discharges at or below 9 cubic-feet per second for 3 or more consecutive months occurred at a relative frequency of 2 percent, using those same starting head conditions, pumpage quantities and distributions, followed by 1 percent or less for 7, 5, and 3 cubic-feet per second. The relative frequency of simulated discharges at or below 11 cubic-feet per second for 3 or more consecutive months using the dataset with an annual average pumpage of 16,311 acre-feet per year with the 2002 well spatial distribution is 12 percent. The relative frequency for simulating discharges, for 3 or more consecutive months, at or below 11 cubic-feet per second decreases to 0 percent using an annual average pumpage of 6,796 acre-feet per year using starting heads at intermediate- or high-flow conditions. Relative frequencies of simulating discharges for 3 or more consecutive months at or below 11, 9, 7, 5, and 3 cubic-feet per second for each of the starting head conditions and well datasets are summarized in Table 2.

For the drought reoccurrence simulations, the effects of going into a 7-year drought with starting heads at low- and high-flow conditions, and with each of the 5 well datasets shows that simulated discharges are more sensitive to starting head conditions for 4 out of the 5 well datasets (Figure 6). However, simulated discharges become more sensitive to groundwater withdrawals when using the dataset with the highest annual average pumping of 16,311 acre-feet per year.



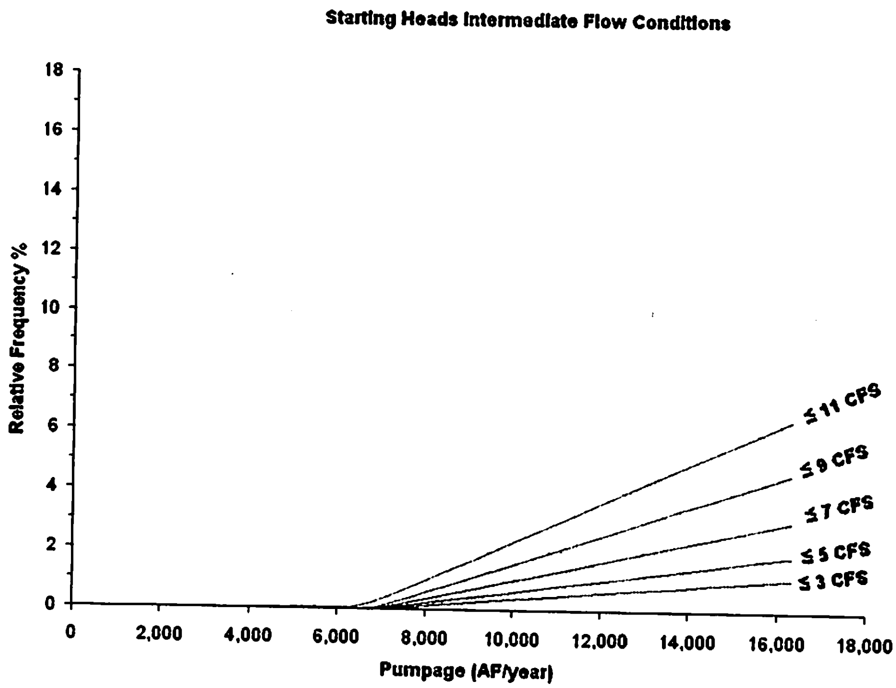


Figure 3. Curves for annual average pumpage (acre-feet per year) versus the relative frequency (percent) for 11, 9, 7, 5, and 3 cubic-feet per second with starting heads at low-flow conditions (top) and intermediate-flow conditions (bottom).

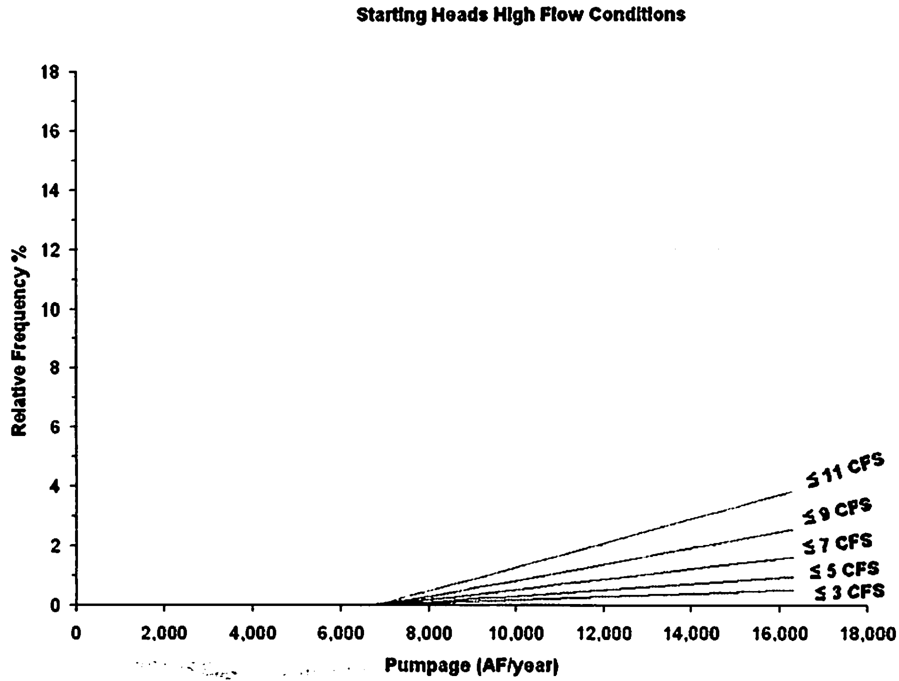


Figure 3 (continued). Curves for annual average pumpage (acre-feet per year) versus the relative frequency (percent) of simulated discharges at or below 11, 9, 7, 5, and 3 cubic-feet per second with starting heads at high-flow conditions.

Table 1. **Summary of starting head conditions, annual average pumpage, frequency of months simulated at or below 11 cubic-feet per second, and the relative frequency (percent) of months simulated at or below 11 cubic-feet per second. Total number of months simulated was 28,728.**

Starting heads	Annual average pumpage (acre-feet per year)	Frequency of months simulated at 11 cubic-feet per second or lower	Relative frequency (percent) of months at 11 cubic-feet per second or lower
Low	3,847	1,026	4
	4,469	1,099	4
	5,437	1,245	4
	6,796	1,491	5
	16,311	4,930	17
Intermediate	3,847	0	0
	4,469	4	0
	5,437	18	0
	6,796	70	0
	16,311	1,857	6
High	3,847	0	0
	4,469	0	0
	5,437	1	0
	6,796	10	0
	16,311	1,102	4

Table 1 (continued). Summary of starting head conditions, annual average pumpage, frequency of months simulated at or below 9 cubic-feet per second, and the relative frequency (percent) of months simulated at or below 9 cubic-feet per second. Total number of months simulated was 28,728.

Starting heads	Annual average pumpage (acre-feet per year)	Frequency of months simulated at 9 cubic-feet per second or lower	Relative frequency (percent) of months at 9 cubic-feet per second or lower
Low	3,847	869	3
	4,469	906	3
	5,437	983	3
	6,796	1,157	4
	16,311	4,181	15
Intermediate	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	13	0
	16,311	1,328	5
High	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	736	3

Table 1 (continued). Summary of starting head conditions, annual average pumpage, frequency of months simulated at or below 7 cubic-feet per second, and the relative frequency (percent) of months simulated at or below 7 cubic-feet per second. Total number of months simulated was 28,728.

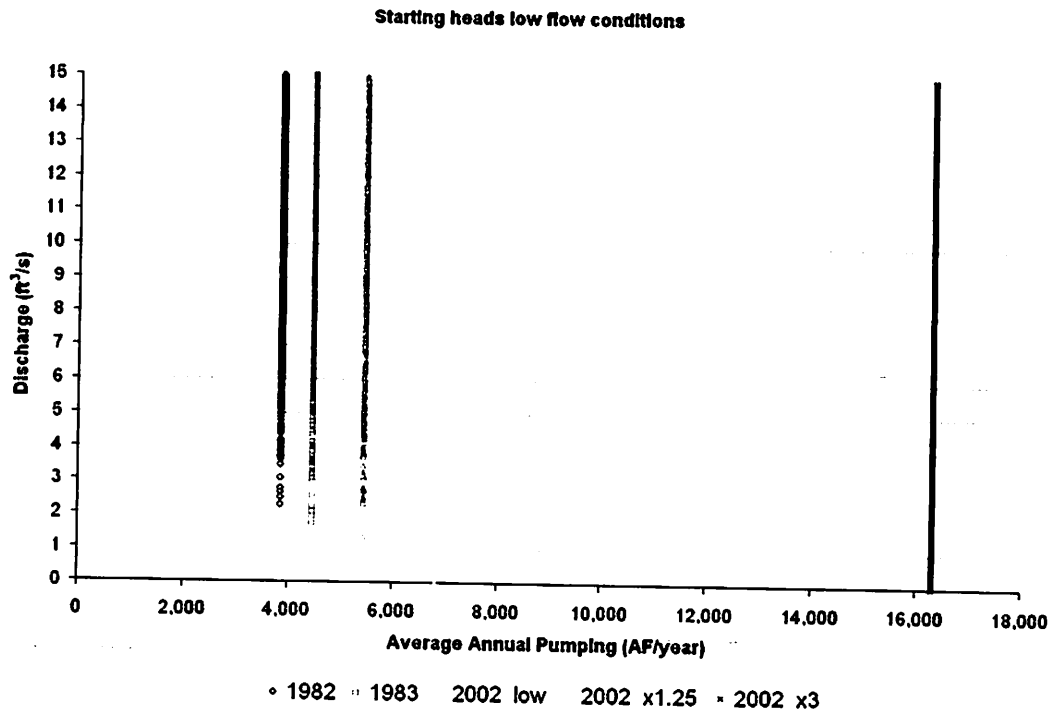
Starting heads	Annual average pumpage (acre-feet per year)	Frequency of months simulated at 7 cubic-feet per second or lower	Relative frequency (percent) of months at 7 cubic-feet per second or lower
Low	3,847	294	1
	4,469	356	1
	5,437	438	2
	6,796	582	2
	16,311	3,292	11
Intermediate	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	870	3
High	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	470	2

Table 1 (continued). Summary of starting head conditions, annual average pumpage, frequency of months simulated at or below 5 cubic-feet per second, and the relative frequency (percent) of months simulated at or below 5 cubic-feet per second. Total number of months simulated was 28,728.

Starting heads	Annual average pumpage (acre-feet per year)	Frequency of months simulated at 5 cubic-feet per second or lower	Relative frequency (percent) of months at 5 cubic-feet per second or lower
Low	3,847	49	0
	4,469	62	0
	5,437	109	0
	6,796	200	1
	16,311	2,308	8
Intermediate	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	539	2
High	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	278	1

Table 1 (continued). Summary of starting head conditions, annual average pumpage, frequency of months simulated at or below 3 cubic-feet per second, and the relative frequency (percent) of months simulated at or below 3 cubic-feet per second. Total number of months simulated was 28,728.

Starting heads	Annual average pumpage (acre-feet per year)	Frequency of months simulated at 3 cubic-feet per second or lower	Relative frequency (percent) of months at 3 cubic-feet per second or lower
Low	3,847	6	0
	4,469	15	0
	5,437	30	0
	6,796	66	0
	16,311	1,605	6
Intermediate	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	316	1
High	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	153	1



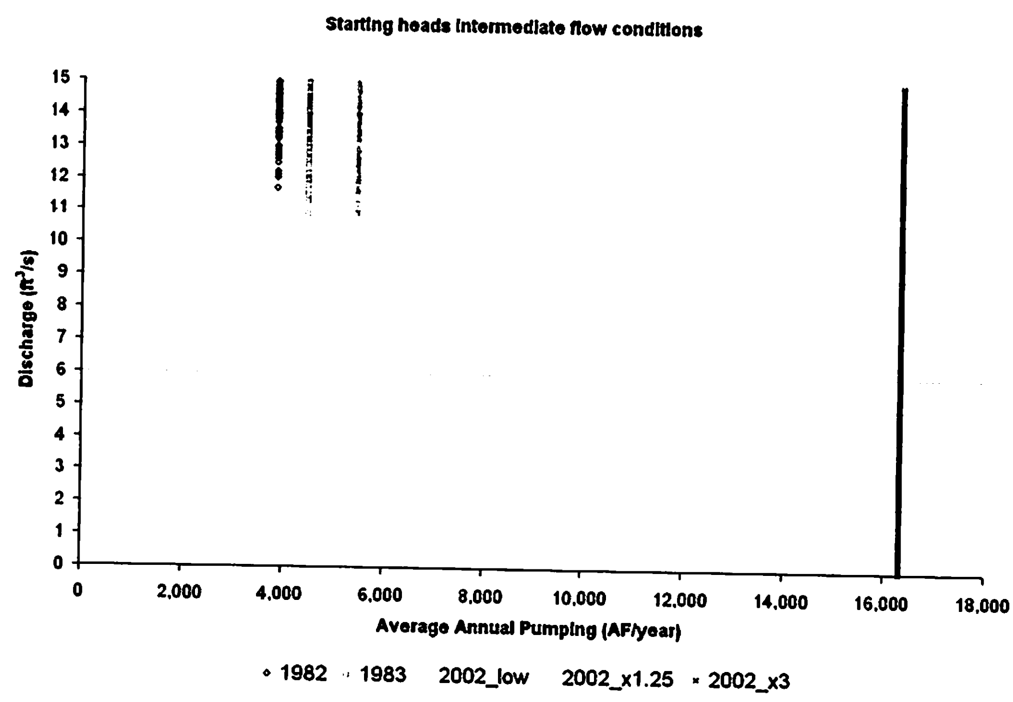


Figure 4. **Plot of simulated discharges at 15 cubic-feet per second or below versus pumpage with starting heads at low-flow conditions (top) and intermediate-flow conditions (bottom).**

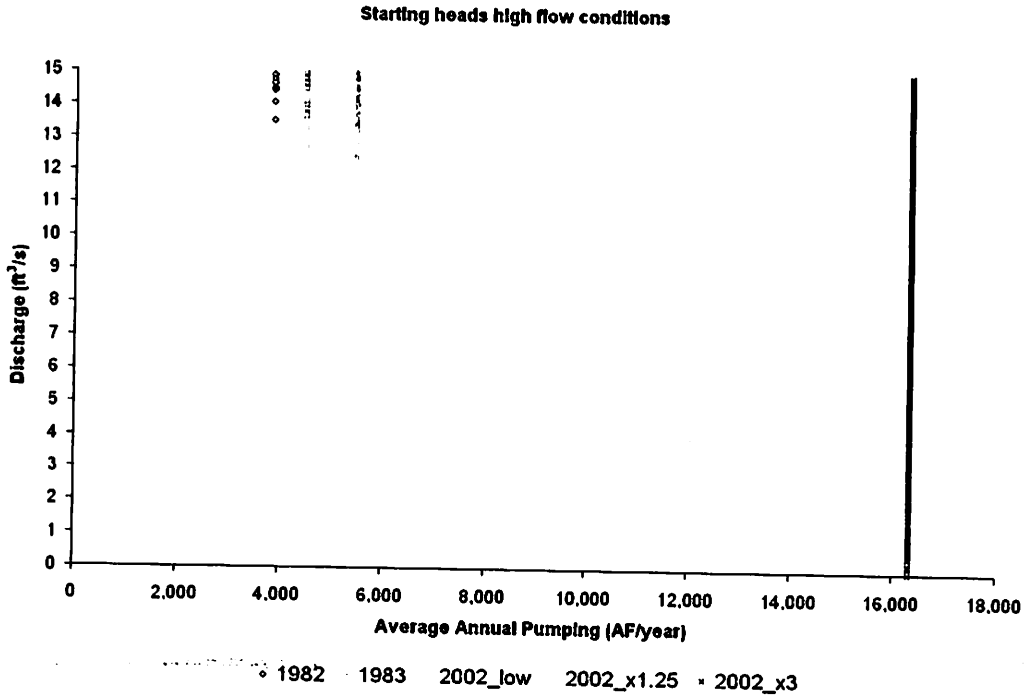


Figure 4 continued. Plot of simulated discharges at 15 cubic-feet per second or below versus pumpage with starting heads at high-flow conditions

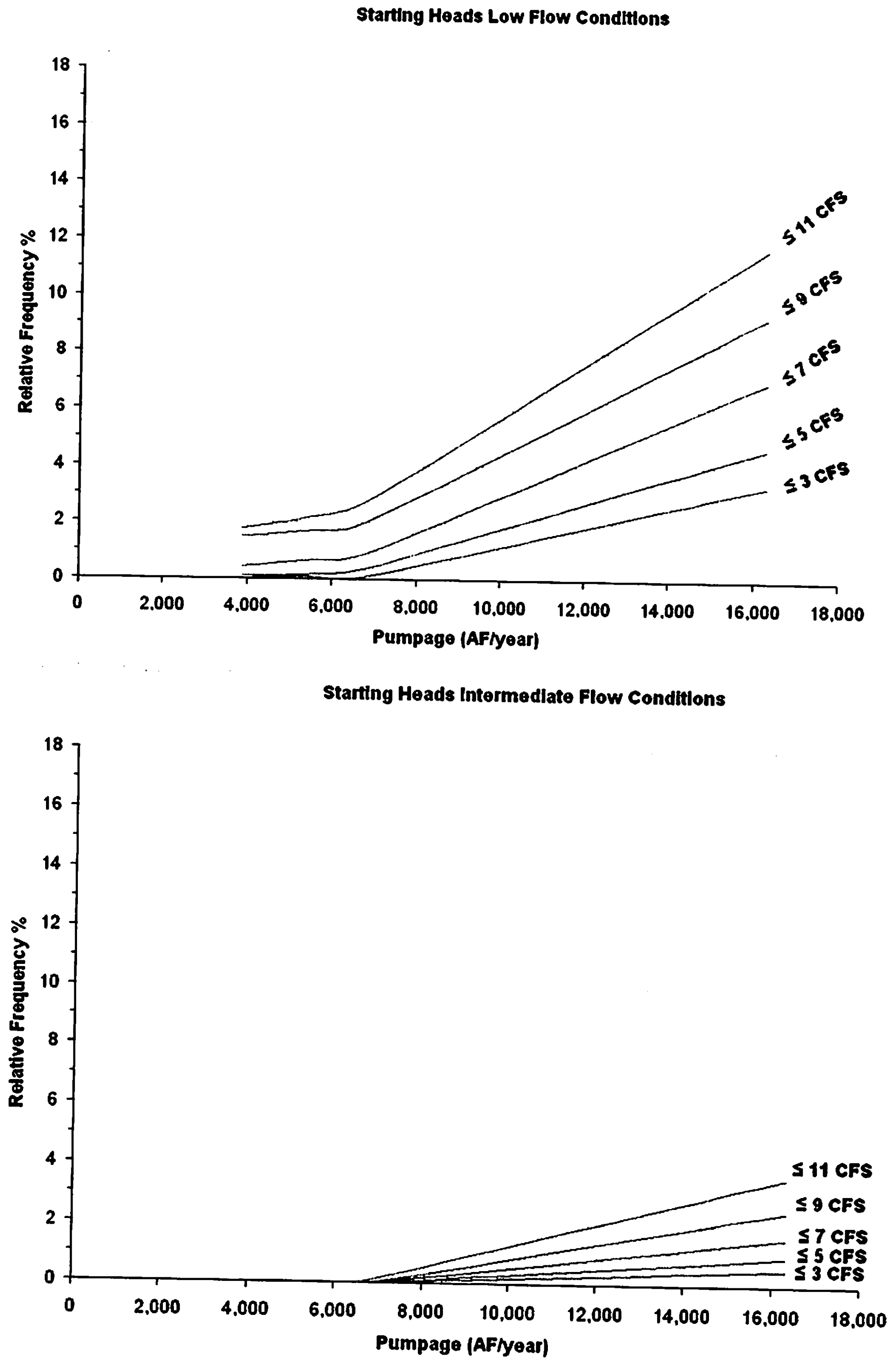


Figure 5. Curves for annual average pumpage (acre-feet per year) versus the relative frequency (percent) of simulated discharges for 3 or more consecutive months at or below 11, 9, 7, 5, and 3 cubic-feet per second with starting heads at low-flow conditions (top) and intermediate-flow conditions (bottom).

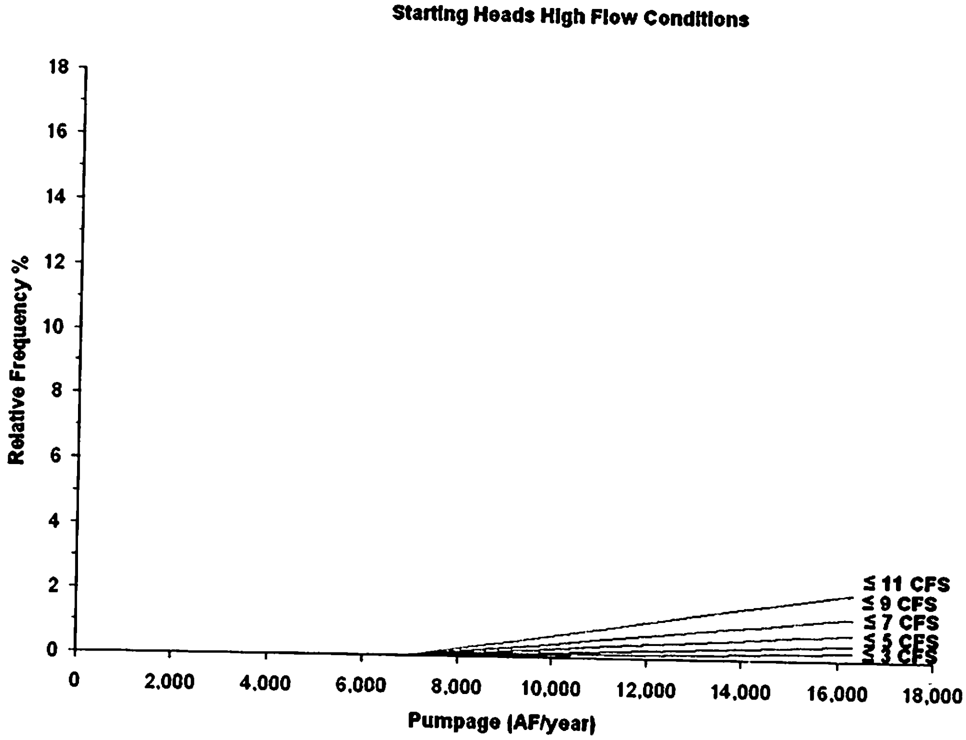


Figure 5 continued. Curves for annual average pumpage (acre-feet per year) versus the relative frequency (percent) of simulated discharges for 3 or more consecutive months at or below 11, 9, 7, 5, and 3 cubic-feet per second with starting heads at high-flow conditions.

Table 2. **Summary of starting head conditions, annual average pumpage, frequency of 3 or more consecutive months simulated at or below 11 cubic-feet per second, and the relative frequency (percent) of months simulated at or below 11 cubic-feet per second. Total number of months simulated is 28,728.**

Starting heads	Annual average pumpage (acre-feet per year)	Frequency of 3 or more consecutive months simulated at 11 cubic-feet per second or lower	Relative frequency (percent) of 3 or more consecutive months at 11 cubic-feet per second or lower
Low	3,847	511	2
	4,469	545	2
	5,437	625	2
	6,796	786	3
	16,311	3,342	12
Intermediate	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	25	0
	16,311	1,041	4
High	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	600	2

Table 2 (continued). Summary of starting head conditions, annual average pumpage, frequency of 3 or more consecutive months simulated at or below 9 cubic-feet per second, and the relative frequency (percent) of months simulated at or below 9 cubic-feet per second. Total number of months simulated is 28,728.

Starting heads	Annual average pumpage (acre-feet per year)	Frequency of 3 or more consecutive months simulated at 9 cubic-feet per second or lower	Relative frequency (percent) of 3 or more consecutive months at 9 cubic-feet per second or lower
Low	3,847	422	1
	4,469	447	2
	5,437	489	2
	6,796	574	2
	16,311	2,659	9
Intermediate	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	711	2
High	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	378	1

Table 2 (continued). Summary of starting head conditions, annual average pumpage, frequency of 3 or more consecutive months simulated at or below 7 cubic-feet per second, and the relative frequency (percent) of months simulated at or below 7 cubic-feet per second. Total number of months simulated is 28,728.

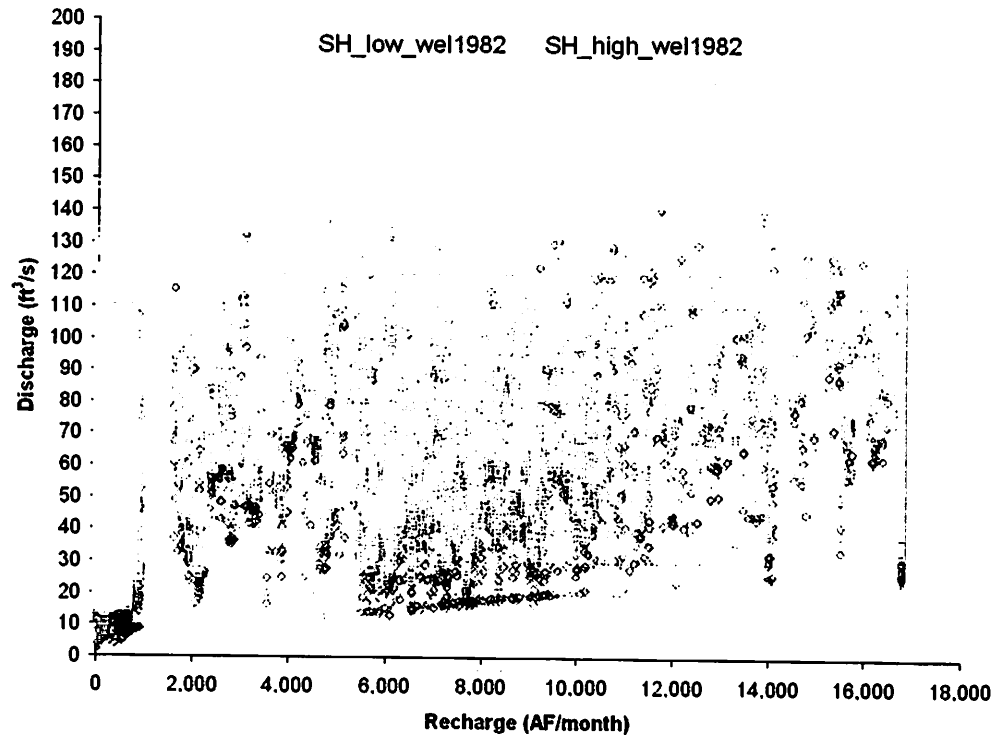
Starting heads	Annual average pumpage (acre-feet per year)	Frequency of 3 or more consecutive months simulated at 7 cubic-feet per second or lower	Relative frequency (percent) of 3 or more consecutive months at 7 cubic-feet per second or lower
Low	3,847	123	0
	4,469	149	1
	5,437	193	1
	6,796	262	1
	16,311	2,006	7
Intermediate	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	453	2
High	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	237	1

Table 2 (continued). Summary of starting head conditions, annual average pumpage, frequency of 3 or more consecutive months simulated at or below 5 cubic-feet per second, and the relative frequency (percent) of months simulated at or below 5 cubic-feet per second. The total number of months simulated is 28,728.

Starting heads	Annual average pumpage (acre-feet per year)	Frequency of 3 or more consecutive months simulated at 5 cubic-feet per second or lower	Relative frequency (percent) of 3 or more consecutive months at 5 cubic-feet per second or lower
Low	3,847	27	0
	4,469	34	0
	5,437	52	0
	6,796	109	0
	16,311	1,328	5
Intermediate	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	277	1
High	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	140	0

Table 2 (continued). Summary of starting head conditions, annual average pumpage, frequency of 3 or more consecutive months simulated at or below 3 cubic-feet per second, and the relative frequency (percent) of months simulated at or below 3 cubic-feet per second. The total number of months simulated is 28,728.

Starting heads	Annual average pumpage (acre-feet per year)	Frequency of 3 or more consecutive months simulated at 3 cubic-feet per second or lower	Relative frequency (percent) of 3 or more consecutive months at 3 cubic-feet per second or lower
Low	3,847	4	0
	4,469	5	0
	5,437	18	0
	6,796	31	0
	16,311	955	3
Intermediate	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	160	1
High	3,847	0	0
	4,469	0	0
	5,437	0	0
	6,796	0	0
	16,311	69	0



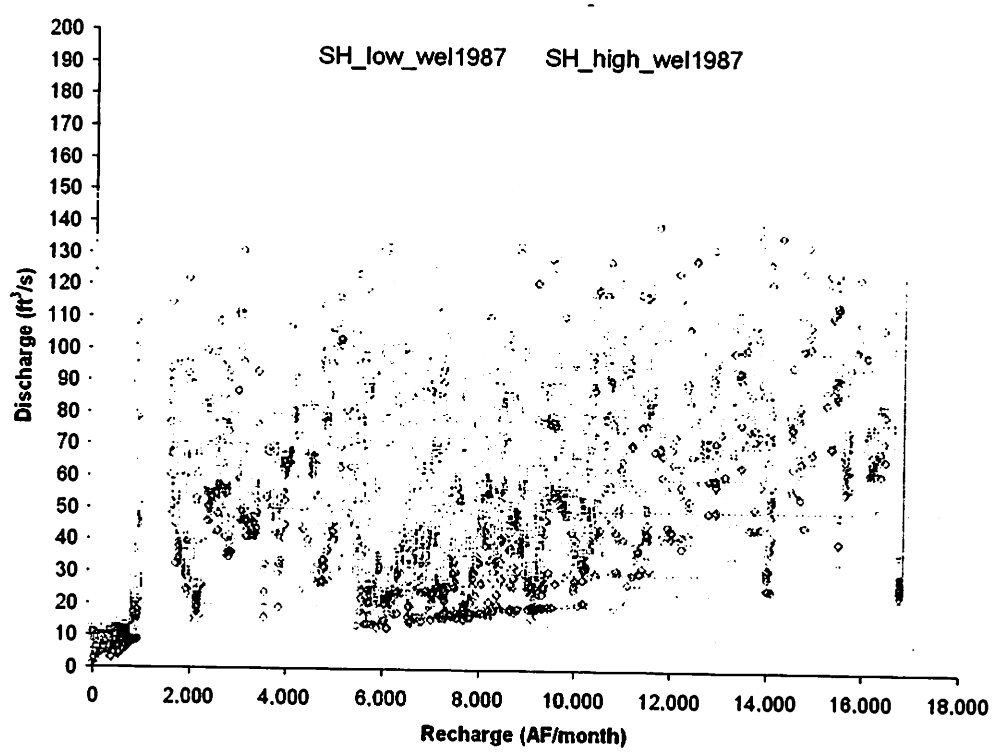
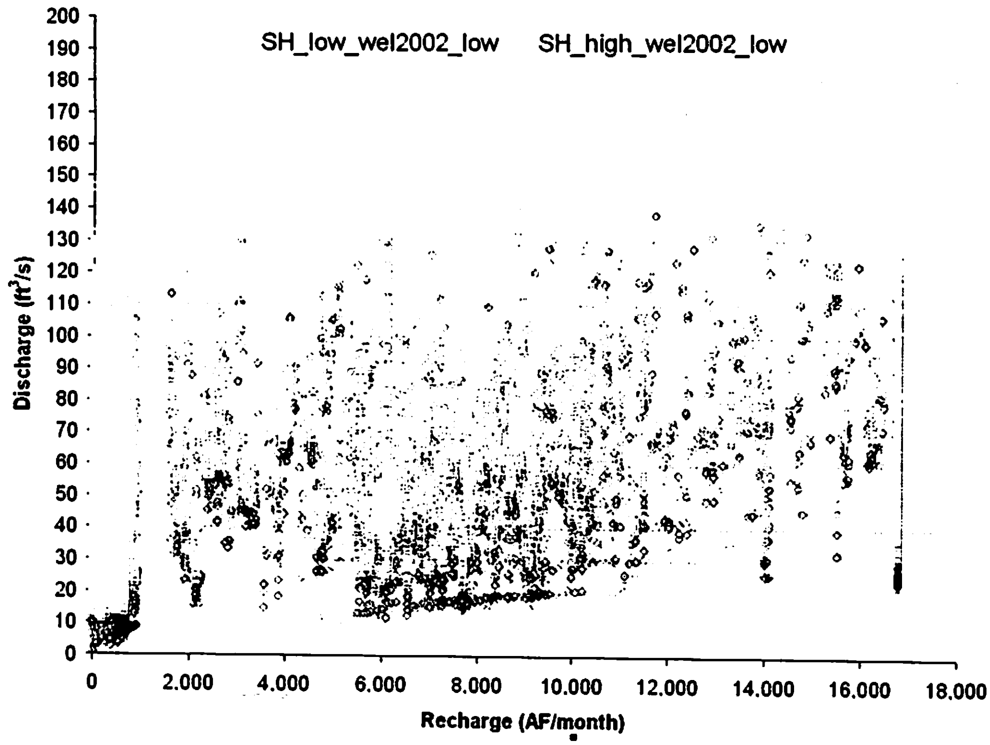


Figure 6. **Plots of recharge versus simulated discharges for starting heads at low- and high-flow conditions with the 1982 (3,847 acre-feet) and 1987 (4,469 acre-feet) pumpage quantities.**



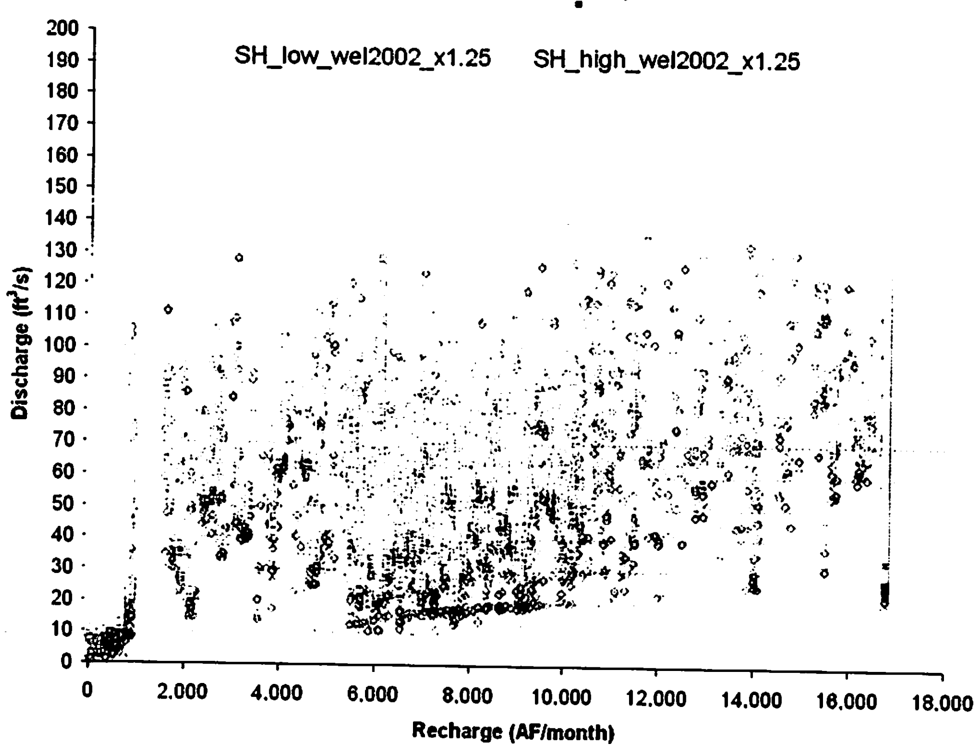


Figure 6 continued. Plots of recharge versus simulated discharges for starting heads at low- and high-flow conditions with the 2002 low (5,437 acre-feet) and 2002 low pumpage quantities multiplied by a factor of 1.25 (6,796 acre-feet).

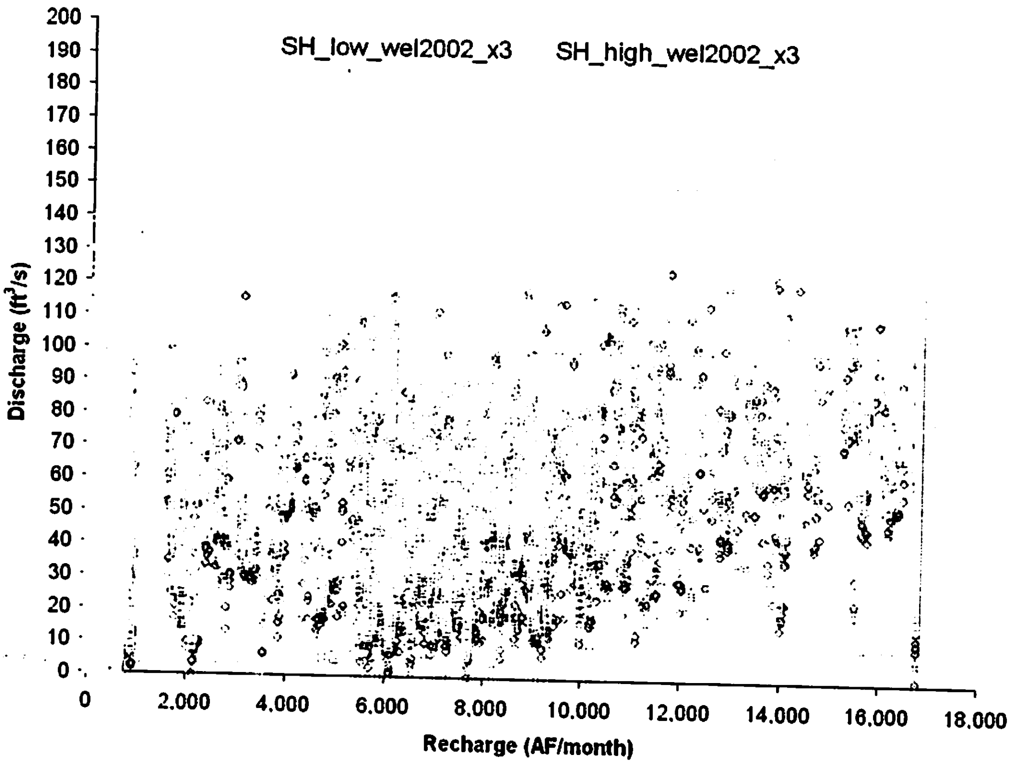


Figure 6 continued. Plots of recharge versus simulated discharges for starting heads at low- and high-flow conditions with the 2002 low pumpage quantities multiplied by a factor of 3 (16,311 acre-feet). Note that using these relatively higher pumpage quantities result in lower simulated discharges even when using starting heads at high-flow conditions.

CONCLUSIONS:

Based on the results from our analyses, significant increases from current annual average pumpage quantities would likely increase the relative frequency (percent) of low discharge events during a drought-of-record reoccurrence regardless of the flow conditions at the start of a drought. Also, the simulated results presented in our analyses will likely differ if point or non-domestic groundwater withdrawal quantities increase appreciably near the head springs due to capture (Bredehoeft and Durbin, 2009).

REFERENCES:

Bredehoeft, J. and Durbin, T., 2009, Ground water development-the time to full capture problem: *Ground Water*, vol. 47, no. 4, p. 506-514.

Cleaveland, M.K., 2006, Extended chronology of drought in the San Antonio area, revised report: University of Arkansas, 29 p. http://www.gbra.org/Documents/Reports/TreeRingStudy.pdf

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model-user guide to modularization concepts and the ground-water flow process: U.S. Geological Survey Open-File Report 00-92, 121 p.

Hutchison, W.R. and Hill, M.E., in preparation, Recalibration of the Edwards (Barton Springs segment) model: Texas Water Development Board.

Scanlon, B.R., Mace, R.E., Smith, B., Hovorka, S., Dutton, A.R., and Reedy, R., 2001, Groundwater availability of the Barton Springs segment of the Edwards aquifer, Texas: Numerical simulations through 2050: Bureau of Economic Geology, 36 p.

Wilson, J.D. and Naff, R.L., 2004, The U.S. Geological Survey modular ground-water model-GMG linear equation solver package documentation: U.S. Geological Survey Open-File Report 2004-1261, 47 p.

EDWARDS AQUIFER
AUTHORITY

Exhibit F

Minutes, Notices & supporting material for May 17, 2010 meeting & vote to subdivide GMA 10

GMA-10 Joint Planning Committee
Meeting Minutes
May 17, 2010

1. **Call to Order.** The meeting was called to order by Committee Coordinator Rick Illgner at 11:30 am.

2. **Designation of meeting Secretary.** Rick Illgner agreed to be the Secretary for the meeting.

3. **Public Comment.** There was no public comment.

4. **Receipt of Posted Notices.** A quorum of eight of the nine GMA-10 GCDs were present: Barton Springs/Edwards Aquifer Conservation District (BSEACD), Plum Creek GCD (PCGCD), Edwards Aquifer Authority (EAA), Medina Co. GCD (MCGCD), Uvalde Co. UWCD (UCUWCD), Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD (KCGCD): Guadalupe County GCD was not present. Posted meeting notices were received from all nine of the GCDs, including Guadalupe County GCD.

5. **Approval of April 19, 2010, Minutes.** Luana Buckner (Medina Co. GCD) moved and Kirk Holland (BSEACD) seconded approving the April 19, 2010, minutes as presented. There were no objections; therefore minutes were approved.

6. **Discussion and possible action related to establishing standard terminology for the various stages of a specific DFC of GMA 10.** Kirk Holland reviewed the DFC adoption flow chart that was discussed at the April 19, 2010 meeting specifically for the purpose of developing standard terminology during the process as follows:
   - A Trial DFC – for GCD board consideration
   - B Preliminary DFC – set by GCD board for public input
   - C Recommended DFC – recommended by the GCD board to the GMA
   - D Proposed DFC – approved by the GMA for "preliminary final MAG"
   - E Adopted DFC – final GMA-approved DFC

   Bill Hutchison commented that each of the steps may not be required in all situations and provided a few examples.

   Bill Hutchison summarized a TWDB MEMO dated May 12, 2010, regarding consideration of exempt use in the DFC process. Generally, the TWDB will convert a DFC into a "total pumping" number that will be presented to the TWDB board on May 20, 2010.

7. **Discussion and possible action concerning the Initially Prepared Plans of the regional water planning groups for Regions K and L, with respect to identified needs and responsive water management strategies.** Regional water planning PowerPoint presentations were made by Steve Raabe (San Antonio River Authority) and Jennifer Walker made presentations on demands and water management strategies that effect groundwater use for Region L and Region K respectively

8. **Discussion and possible action related to establishing a Preliminary DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.** Kirk Holland discussed the development of DFCs by the BSEACD. The BSEACD is using springflow discharge at Barton springs as the DFC measure and is considering a range of 5 – 10 cfs for the drought of record (DOR). Modeling indicates that current pumping is approximately 11 cfs and with drought restrictions in place would provide about 5 cfs during a repeat of the DOR and 5 cfs may not pass the "Jeopardy" test with the U S Fish & Wildlife Service for the Habitat Conservation Plan that is under development. A DFC of 10 cfs would basically cut off all pumping during a DOR. Kirk anticipates a DFC between 5 and 10 cfs that could present management challenges to the district at low flows.

   The BSEACD is considering an upper cap of 14 – 20 cfs that would be a function of water in storage in the aquifer to limit the total pumping amount which will be problematic during a drought. The BSEACD will hold a hearing on May 27.

   Kirk Holland asked the TWDB for input on having two DFCs. Bill Hutchison responded that the DFC for water in storage is an important consideration and, while it is possible to have two DFCs, it is important that they do not conflict with one another. As an example, selecting an upper DFC of 20 cfs would probably be inconsistent with a 10 cfs DFC for the DOR. Therefore, BSEACD might consider expressing a DFC as an average springflow and a minimum springflow during the DOR. Kirk said he would get with the TWDB after the GMA 10 meeting to discuss the matter further.

9. **Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and a schedule for the establishment of Trinity DFCs.** The BSEACD has worked with the Hays – Trinity GCD and would like DFCs for the upper, middle and lower Trinity and there might be parts of GMA 10 where the GMAM 10 boundaries are well-defined. It was mentioned that having a map of the areas where there is Trinity within GMA 10 would be helpful and the TWDB indicated they would try to have one for the next meeting. There is recognition that the DFC decisions of GMA 9 will affect the Trinity in GMA 10; therefore, it is a good idea to wait for the aquifer assessment to make decisions.

10. **Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Saline Edwards, relevant aquifer assessments, and a schedule for the establishment of Saline Edwards DFC(s).** Kirk Holland said the BSEACD does not know a lot about the saline zone in the Edwards and is waiting on the TWDB on some information. The Bill Hutchison and Kirk Holland discussed DFC and assessment options.

11. **Discussion and possible action related to the adoption of the DFC for the Leona Gravel and Related Aquifers in Medina County.** Luana Buckner indicated that the Medina County GCD asked the TWDB to perform an aquifer assessment of the Leona Gravel in Medina County *'GTA Aquifer Assessment 09-01"*. In the assessment, declines of 15', 25' and 35' over a 50-year period were considered. After consideration, the Medina County GCD selected a 15' decline which yields a MAG of 22,110 acre-feet. Motion was made by Tommy Boehme and seconded by Luana Buckner that GMA 10 adopts a Desired Future Condition for the Leona Gravel in Medina County of 15' in 50 years. The motion passed unanimously.

12. **Discussion and possible action related to the adoption of the DFC for the Leona Gravel and Related Aquifers in Uvalde County.** Vic Hilderbran stated that the Uvalde County aquifer assessment is not complete, but should be finished soon. Although no decisions for a DFC have been made, the district has decided to use the J-27 monitoring well as a DFC measuring index. Public hearings will scheduled after the district receives the completed aquifer assessment and then the board will take a vote a few days later and he expects to have a recommendation for GMA 10 within a month.

13. **Discussion and possible action related to designating and establishing Preliminary DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.** The TWDB made a presentation to the Kinney County GCD on May 13 on an aquifer assessment and is continuing to work with the district. A work shop is scheduled for June 4 at which a DFC decision could be made.

14. **Discussion and possible action concerning the schedule and location of upcoming public hearings on Preliminary Recommended DFCs that are planned by member GCDs.** Kirk Holland reiterated that BSEACD will be holding a hearing on May 27. Luana Buckner indicated the Medina County GCD should have something on the Trinity by the next GMA 10 meeting

15. **Next Meeting and Discussion Topics.** The next meeting will be on Monday, June 14 from 11:30 2:00 at the EAA Conference Center. The agenda be distributed two weeks in advance (May 31) and that each GCD send the EAA a copy of their posted notice one week before the meeting (June 7) to avoid posting problems.

16. **Adjournment**. The meeting was adjourned at approximately 2:20 pm.

GMA-10 Joint Planning Committee
Meeting Minutes
April 19, 2010

1. **Call to Order.** The meeting was called to order by Committee Coordinator Rick Illgner (EAA) at 11:30 am.

2. **Designation of meeting Secretary.** Rick Illgner agreed to serve as the Secretary for the meeting.

3. **Public Comment.** George Wissman (Manager of the Trinity Glen Rose GCD in northern Bexar County), reported that he had only recently learned that a very small parcel of the Trinity Glen Rose GCD is in GMA 10. The Texas Water Development Board promised to add the district to the official listing of GCDs in GMA 10 on their web site. He asked that the small portion of the Trinity Glen Rose GCD be considered a non-relevant aquifer for GMA 10 (see discussion on Agenda item 8 below).

4. **Receipt of Posted Notices.** A quorum of eight of the nine GMA-10 GCDs were present: Barton Springs/Edwards Aquifer Conservation District (BSEACD), Plum Creek GCD (PCGCD), Edwards Aquifer Authority (EAA), Medina Co. GCD (MCGCD), Uvalde Co. UWCD (UCUWCD), Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD (KCGCD); Guadalupe County GCD was not present. Posted meeting notices were received from the seven attending GCDs: Hays Trinity GCD forgot to bring their notice to the meeting; however, turned it in later. The Trinity Glen Rose GCD and the Guadalupe County GCD did not post (see discussion for Agenda item 9). During the discussion on posting, the Bill Hutchison stated that an official DFC vote requires all GCDs within a GMA to properly post notices.

5. **Approval of January 19, 2010, Minutes.** Luana Buckner (Medina Co. GCD) moved and Kirk Holland (BSEACD) seconded approving the January 19, 2010, minutes as presented. There were no objections; therefore minutes were approved.

6. **Determination and possible action to subdivide GMA 10 into three defined geographic zones for establishing Desired Future Conditions (DFCs): Northern, Central and Western Subdivisions.** Kirk Holland reviewed maps of the three proposed GMA 10 subdivisions. The basis for the three subdivisions is primarily hydrologic; however, it also has a political factor in that they are also GCD boundaries. The proposed boundaries are as follows:
   - Northern Subdivision – north of the boundary between the BSEACD and the EAA. GCDS in this area include BSEACD, Hays Trinity GCD and the PCGCD.
   - Central Subdivision - south of the boundary between the BSEACD and the EAA and east of the Kinney County/Uvalde County line.
   - Western Subdivision - west of the Kinney County/Uvalde County line.

   Discussion – this subdivision will result in three separate DFCs/MAGs for the Edwards Aquifer. A potential issue of making this subdivision is a small portion of the saline Edwards Aquifer within the Central Subdivision that is also within the BSEACD service area. The BSEACD might want to develop a DFC for the saline portion of the Edwards Aquifer within their jurisdiction while the EAA permitted amount (their MAG) established by the Legislature does not distinguish between fresh and saline Edwards and some of the issued permits are from saline wells.

Motion was made by Kirk Holland and seconded by Luana Buckner to subdivide GMA 10 into three defined geographic zones for establishing Desired Future Conditions (DFCs) for the Edwards Aquifer; Northern, Central and Western Subdivisions. Motion passed unanimously.

7. **Discussion and possible action related to defining required public participation and input in establishing DFCs.** Kirk Holland reviewed a DFC adoption flowchart that he prepared. Representatives from the Medina, Uvalde and Kinney county GCDs discussed their plans and activities for DFC adoption. No interest was expressed by GMA 10 members to have GMA-sponsored hearings at this time.

8. **Discussion of developing a DFC for the Trinity Aquifer(s) as a relevant aquifer or aquifers within GMA 10, including its outcrop and subcrop areas in the various subdivisions.** The Hays Trinity GCD prefers to treat the outcrop and subcrop areas of the Trinity Aquifer in GMA 10 and use the same DFC as the Trinity for GMA 9. Bill Hutchison stated that GMA 10 doesn't have to use the same subdivisions for the Trinity Aquifer that were established for the Edwards Aquifer because it has different hydrology. The BSEACD, Hays Trinity, Trinity Glen Rose, Medina and Uvalde GCDs will all have Trinity DFCs.

   Rick Illgner voiced concern about setting a DFC/MAG for the Trinity Aquifer within GMA 10 where there are no GCDs for regulation. Bill Hutchison responded that for areas without a GCD, there will be an assumption of a certain amount of pumping. If that pumping is incorrect, and pumping increases, the GMA might have to consider a new DFC. Kirk Holland said that BSEACD had an assessment of the middle and lower Trinity that resulted in a MAG of approximately 2,000 acre-feet/ year (they do not permit wells in the upper Trinity because of the direct contact with the Edwards.

   Kirk Holland moved and Doug Wierman seconded to request the TWDB conduct an assessment for the subcrop of the Trinity (upper, middle and lower) to a water quality of 3,000 mg/l total dissolved solids along the entire GMA 10 boundary. Motion passed unanimously. After the vote, all GCDs were asked to provide information on their Trinity wells to the TWDB to assist with the assessment.

9. **Discussion and possible action to adopt a DFC for the Leona gravel aquifer in Medina County.** Luana Buckner discussed "GTA Aquifer Assessment 09-01" for the Leona Aquifer in Medina County. The DFC recommended by the Medina County GCD is an average aquifer decline of 15' in 50 years which would result in a MAG of 22,110 acre-feet per year.

   Tommy Boehme moved and Kirk Holland seconded that GMA 10set a DFC of 15' decline over 50 years for the Leona Aquifer in Medina County. Motion passed unanimously. (It should be noted that official adoption of the DFC is dependent on a meeting notice posting by the

Guadalupe County GCD. Rick Illgner contacted the Guadalupe County GCD the following day and learned that the district did not post notice).

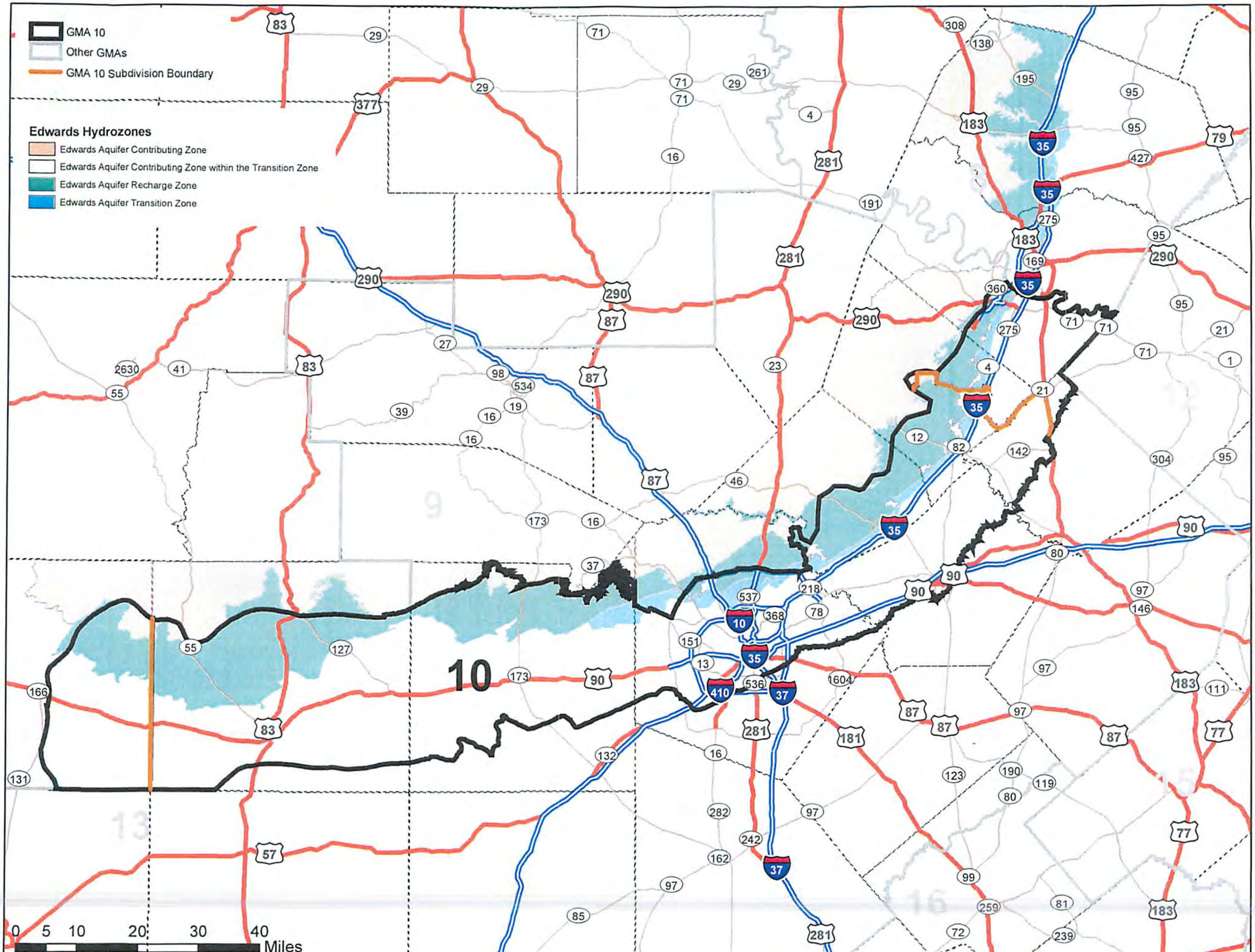
10. **Discussion of DFC status for the Leona aquifer in Uvalde County.** Vic Hilderbran reported that the Uvalde County UWCD has contracted with Southwest Research Inc. to conduct aquifer assessments in Uvalde County and should have results by the end of April. Following a presentation to the board, the district will hold public hearings on the results.

11. **Discussion of the status of the DFCs applicable to the aquifers of Kinney County in the Western Subdivision of GMA-10.** Bill Hutchison stated that the TWDB has combined two models and now have a model that covers the entire county and even considers springflow. The TWDB will assist Kinney County GCD with its interactions with GMA 7 and GMA 10. The TWDB will make a presentation to the Kinney County GCD on May 13 and a hearing will be held after the board presentation (hopefully by the end of May). Stan Metcalf reported the district may have to change its rules.

12. **Discussion of other miscellaneous topics related to establishing Desired Future Conditions.** Kirk Holland referred back to the DFC flow chart that was discussed in Item 7 above and indicated that the BSEACD is concurrently working on a Habitat Conservation Plan (HCP); however, it appears that the district will have an Edwards Aquifer DFC before their HCP is complete.

13. **Next Meeting and Discussion Topics.** The next meeting will be on Monday, May 17 from 11:30 2:00 at the EAA Conference Center. The group requested that the agenda be distributed two weeks in advance (May 3) and that each GCD send the EAA a copy of their posted notice one week before the meeting (May 10) to avoid posting problems. It was suggested that representatives from Region K and Region L attend the meeting to give presentations on groundwater needs in their respective regional water planning group.

14. **Adjournment.** The meeting was adjourned at approximately 1:48 pm.


GMA 10
Other GMAs
GMA 10 Subdivision Boundary
Edwards Hydrozones
Edwards Aquifer Contributing Zone
Edwards Aquifer Contributing Zone within the Transition Zone
Edwards Aquifer Recharge Zone
Edwards Aquifer Transition Zone
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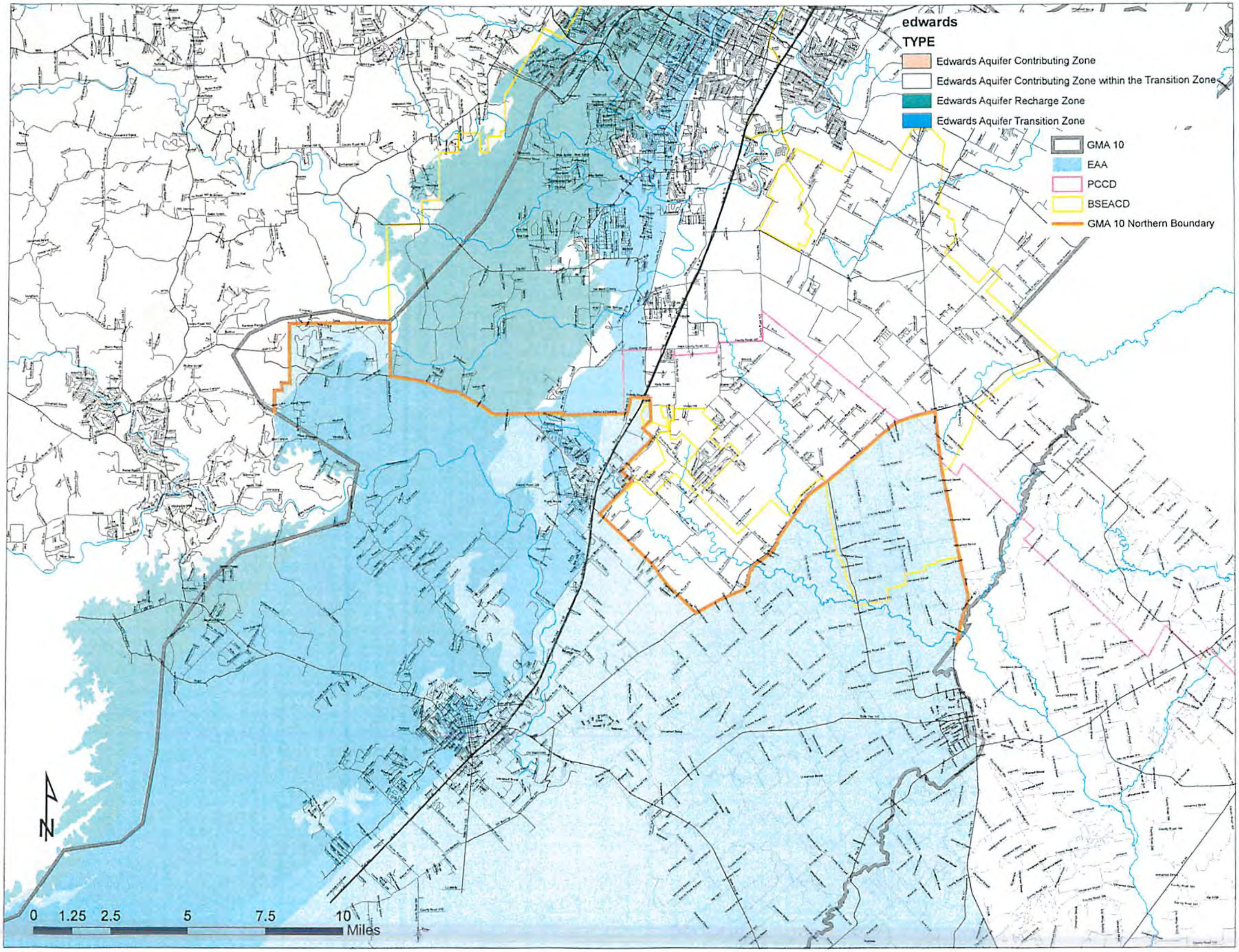
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Edwards Aquifer Contributing Zone
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Edwards Aquifer Recharge Zone
Edwards Aquifer Transition Zone
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BSEACD
GMA 10 Northern Boundary
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Groundwater Management Area #10 Joint Planning Meeting

NOTICE OF OPEN MEETING

As required by section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Monday, May 17, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Designation of meeting Secretary.
3. Public Comment.
4. Receipt of Posted Notices.
5. Approval of April 19, 2010 Minutes.
6. Discussion and possible action related to establishing standard terminology for the various stages of a specific DFC of GMA 10.
7. Presentation, discussion and possible action concerning the Initially Prepared Plans of the regional water planning groups for Regions K and L, with respect to identified needs and responsive water management strategies.
8. Discussion and possible action related to establishing a Preliminary DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
9. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and a schedule for the establishment of Trinity DFCs.
10. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Saline Edwards, relevant aquifer assessments, and a schedule for the establishment of Saline Edwards DFC(s)..
11. Discussion and possible action related to the adoption of the DFC for the Leona Gravel and Related Aquifers in Medina County.
12. Discussion and possible action related to establishing a Preliminary DFC for the Leona Gravel and Related Aquifers in Uvalde County.
13. Discussion and possible action related to designating and establishing Preliminary DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
14. Discussion and possible action concerning the schedule and location of upcoming public hearings on Preliminary Recommended DFCs that are planned by member GCDs.
15. Next Meeting and Discussion Topics.
16. Adjournment

FILED
6 day of MAY A.D. 2010.
11:45 o'clock A M
E.C. HUTCHERSON
Clerk, Uvalde County, Texas
/S/ Brooke Garner
Deputy

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

Groundwater Management Area #10 Joint Planning Meeting

NOTICE OF OPEN MEETING

As required by section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Monday, May 17, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

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10. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Saline Edwards, relevant aquifer assessments, and a schedule for the establishment of Saline Edwards DFC(s)..
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12. Discussion and possible action related to establishing a Preliminary DFC for the Leona Gravel and Related Aquifers in Uvalde County.
13. Discussion and possible action related to designating and establishing Preliminary DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
14. Discussion and possible action concerning the schedule and location of upcoming public hearings on Preliminary Recommended DFCs that are planned by member GCDs.
15. Next Meeting and Discussion Topics.
16. Adjournment

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222-9869

Accepted for Filing in:
Hays County
On: May 03,2010 at 01:47P
By,
Alisha Herzog

Groundwater Management Area #10 Joint Planning Meeting

NOTICE OF OPEN MEETING

As required by section 36.108(c), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Monday, May 17, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Designation of meeting Secretary.
3. Public Comment.
4. Receipt of Posted Notices.
5. Approval of April 19, 2010 Minutes.
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7. Presentation, discussion and possible action concerning the Initially Prepared Plans of the regional water planning groups for Regions K and L, with respect to identified needs and responsive water management strategies.
8. Discussion and possible action related to establishing a Preliminary DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
9. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and a schedule for the establishment of Trinity DFCs.
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14. Discussion and possible action concerning the schedule and location of upcoming public hearings on Preliminary Recommended DFCs that are planned by member GCDs.
15. Next Meeting and Discussion Topics.
16. Adjournment

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222-9869

6335 Camp Bulls Rd. Suite 17
San Antonio, TX 78257
Phone 210.698.1155
Fax 210.698.1159

Trinity Glen Rose Groundwater Conservation District

Fax

To:	Rick Illner	**From:**	George Wissmann
Fax:	210.222.9748	**Pages:**	4
Phone:	210.222.2204	**Date:**	5/10/2010
Re:	Deposit	**CC:**	

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

● **Comments:**

Rick, Enclosed are copies of the meeting postings for TGRGCD.

George
(210) 698-1155

Trinity Glen Rose Groundwater Conservation District

6335 Camp Bullis Rd. Suite #25 San Antonio, Texas 78257 (210) 698-1155 Fax (210) 698-1159

Groundwater Management Area Joint Planning Meeting
Monday, May 17, 2010 11:30 A.M.

Notice is given that one or more members of the Board of Directors and/or their designated representatives and/or Staff of the Trinity Glen Rose Groundwater Conservation District (TGRGCD) will attend a meeting of Groundwater Conservation Districts which are located within the State of Texas Groundwater Management Area #10 for purposes of discussing and/or conducting joint planning in compliance with the requirements of HB 1763, which was passed during the 2005 Texas Legislative Session. This meeting will be held at the **Edwards Aquifer Authority, located at Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215 on Monday, May 17, 2010 at 11:30 a.m. for the following purposes:**

Agenda

Kendall County
DARLENE HERRIN
COUNTY CLERK
On: 05/06/2010 1:11PM
By: Harriet P Saidensticker, Deputy

1. Call to Order.
2. Designation of meeting Secretary.
3. Public Comment.
4. Receipt of Posted Notices.
5. Approval of April 19, 2010 Minutes.
6. Discussion and possible action related to establishing standard technology for various stages of a specific DFC of GMA 10.
7. Presentation, discussion and possible action concerning the Initially Prepared Plans of the regional water planning groups for Regions K and L, with respect to identified needs and responsive water management strategies.
8. Discussion and possible action related to establishing a Preliminary DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
9. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and a schedule for the establishment of Trinity DFCs.
10. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Saline Edwards, relevant aquifer assessments, and a schedule for the establishment of Saline Edwards DFC(s)..
11. Discussion and possible action related to the adoption of the DFC for the Leona Gravel and Related Aquifers in Medina County.
12. Discussion and possible action related to establishing a Preliminary DFC for the Leona Gravel and Related Aquifers in Uvalde County.
13. Discussion and possible action related to designating and establishing Preliminary DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
14. Discussion and possible action concerning the schedule and location of upcoming public hearings on Preliminary Recommended DFCs that are planned by member GCDs.
15. Next Meeting and Discussion Topics.
16. Adjournment

Posted at the TGRGCD office, TGRGCD Website, Bexar County, Kendall County and Comal County Courthouses, on this, the 6th day of May, 2010.

[signature] 5-6-10

General Manager, Trinity Glen Rose Groundwater Conservation District

The Trinity Glen Rose Groundwater Conservation District is committed to compliance with the Americans with Disabilities Act (ADA). Reasonable accommodations and equal opportunity for effective communications will be provided upon request. Please contact the District Representative at 210-219-5555 at least 24 hours in advance if accommodation is needed.

Trinity Glen Rose Groundwater Conservation District

6335 Camp Bullis Rd. Suite #25 San Antonio, Texas 78257 (210) 698-1155 Fax (210) 698-1159

Groundwater Management Area Joint Planning Meeting
Monday, May 17, 2010 11:30 A.M.

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Agenda

1. Call to Order.
2. Designation of meeting Secretary.
3. Public Comment.
4. Receipt of Posted Notices.
5. Approval of April 19, 2010 Minutes.
6. Discussion and possible action related to establishing standard terminology for the various stages of a specific DFC of GMA 10.
7. Presentation, discussion and possible action concerning the Initially Prepared Plans of the regional water planning groups for Regions K and L, with respect to identified needs and responsive water management strategies.
8. Discussion and possible action related to establishing a Preliminary DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
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12. Discussion and possible action related to establishing a Preliminary DFC for the Leona Gravel and Related Aquifers in Uvalde County.
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14. Discussion and possible action concerning the schedule and location of upcoming public hearings on Preliminary Recommended DFCs that are planned by member GCDs.
15. Next Meeting and Discussion Topics.
16. Adjournment

Posted at the TGRGCD office, TGRGCD Website, Bexar County, Kendall County and Comal County Courthouses, on this, the 6th day of May, 2010.

[signature] 5-6-10

General Manager, Trinity Glen Rose Groundwater Conservation District

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Trinity Glen Rose Groundwater Conservation District

6335 Camp Bulls Rd. Suite #25 San Antonio, Texas 78257 (210) 698-1155 Fax (210) 698-1159

Groundwater Management Area Joint Planning Meeting
Monday, May 17, 2010 11:30 A.M.

Notice is given that one or more members of the Board of Directors and/or their designated representatives and/or Staff of the Trinity Glen Rose Groundwater Conservation District (TGRGCD) will attend a meeting of Groundwater Conservation Districts which are located within the State of Texas Groundwater Management Area #10 for purposes of discussing and/or conducting joint planning in compliance with the requirements of HB 1763, which was passed during the 2005 Texas Legislative Session. This meeting will be held at the **Edwards Aquifer Authority, located at Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215 on Monday, May 17, 2010 at 11:30 a.m. for the following purposes:**

Agenda

LT1-88-13688-1

1. Call to Order.
2. Designation of meeting Secretary.
3. Public Comment.
4. Receipt of Posted Notices.
5. Approval of April 19, 2010 Minutes.
6. Discussion and possible action related to establishing standard terminology for the various stages of a specific DFC of GMA 10.
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8. Discussion and possible action related to establishing a Preliminary DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
9. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and a schedule for the establishment of Trinity DFCs.
10. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Saline Edwards, relevant aquifer assessments, and a schedule for the establishment of Saline Edwards DFC(s).

Groundwater Management Area #10 Joint Planning Meeting

NOTICE OF OPEN MEETING

As required by section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, **Medina County GCD**, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on **Monday, May 17, 2010 at 11:30 am** at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Designation of meeting Secretary.
3. Public Comment.
4. Receipt of Posted Notices.
5. Approval of April 19, 2010 Minutes.
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7. Presentation, discussion and possible action concerning the Initially Prepared Plans of the regional water planning groups for Regions K and L, with respect to identified needs and responsive water management strategies.
8. Discussion and possible action related to establishing a Preliminary DFC for the Edwards Aquifer in the Northern Subdivision of GMA-10.
9. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Trinity Group, relevant aquifer assessments, and a schedule for the establishment of Trinity DFCs.
10. Discussion and possible action related to the designation of relevant aquifers for DFCs related to the Saline Edwards, relevant aquifer assessments, and a schedule for the establishment of Saline Edwards DFC(s)..
11. **Discussion and possible action related to the adoption of the DFC for the Leona Gravel and Related Aquifers in Medina County.**
12. Discussion and possible action related to establishing a Preliminary DFC for the Leona Gravel and Related Aquifers in Uvalde County.
13. Discussion and possible action related to designating and establishing Preliminary DFC(s) for the relevant aquifers in the Western Subdivision of GMA-10 and in Kinney County.
14. Discussion and possible action concerning the schedule and location of upcoming public hearings on Preliminary Recommended DFCs that are planned by member GCDs.
15. Next Meeting and Discussion Topics.
16. Adjournment

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

NOT ... was ... PARED

Groundwater Management Area #10 Joint Planning Meeting

NOTICE OF OPEN MEETING

As required by section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, **Medina County GCD**, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on **Monday, May 17, 2010 at 11:30 am** at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

At this meeting, the following business may be considered and recommended for Joint Planning Committee action:

1. Call to Order.
2. Designation of meeting Secretary.
3. Public Comment.
4. Receipt of Posted Notices.
5. Approval of April 19, 2010 Minutes.
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15. Next Meeting and Discussion Topics.
16. Adjournment

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

POSTED IN MY OFFICE
LISA J. WERNETTE

MAY 06 '10 PM -3 49

COUNTY CLERK, MEDINA CO.

Hays Trinity
Groundwater
Conservation
District

Accepted for Filing in:
Hays County
On: May 04,2010 at 02:17P
By,
Rose Robinson

Groundwater Management Area #10 Joint Planning Meeting

Date: Monday, May 17, 2010
Time: 11:30 am
Place: Conference Center of the Edwards Aquifer Authority
Located at: 1615 N. St. Mary's, San Antonio, TX 78215

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Adjourn

The Board of Directors of the Hays Trinity Conservation District reserves the right to go into Executive Session at any time during the course of this meeting to discuss any of the matters listed on this agenda, as authorized by the Texas Open Meetings Act, Chapter 551, Government Code. No final action or decision will be made in Executive Session.

The Hays Trinity Groundwater Conservation District is committed to compliance with the Americans with Disabilities Act (ADA). Reasonable accommodations and equal opportunity for effective communications will be provided upon request. Please contact the District office at 512-858-9253 at least 24 hours in advance if accommodation is needed.

This notice has been posted on a bulletin board at a place convenient to the public in the Hays County Courthouse and outside the main entrance to the District offices not less than three (3) days prior to the scheduled meeting in accordance with the provisions of the Texas Open Meetings Act, Chapter 551, Government Code.

Posted by. Dana H. Carmean

Center Lake Business Park: 14101 Hwy 290 W. Bldg.100. Ste. #212, Austin, Texas 78737
Mail: P. O. Box 1648 Dripping Springs, TX 78620
E-mail: manager@haysgroundwater.com Phone: 512-858-9253 Fax: 512-858-2384 website: haysgroundwater.com

Groundwater Management Area #10 Joint Planning Meeting

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Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

Groundwater Management Area #10 Joint Planning Meeting

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Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

NOTICE OF OPEN MEETINGS

Groundwater Management Area #10 Joint Planning Meeting

Monday, May 17, 2010 at 11:30 a.m.

Notice is given that an open meeting of Groundwater Conservation Districts that are located within the State of Texas Groundwater Management Area #10, with one or more members of the Board of Directors and/or its designated representative and/or staff of the **Barton Springs Edwards Aquifer Conservation District** in attendance, for purposes of discussing and/or conducting joint planning concerning desired future conditions, in compliance with Texas Water Code, Chapter 36.108. This meeting will be held on **Monday, May 17, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.**

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Came to hand and posted on a Bulletin Board in the Courthouse, Travis County, Texas, on this, the 6th day of May, 2010 at 1:50 p.m.

LAURA FERGUSON, Deputy Clerk
Travis County, TEXAS

Groundwater Management Area #10 Joint Planning Meeting

NOTICE OF OPEN MEETING

LT1-86-13665-1

As required by section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 10 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 10: Edwards Aquifer Authority, Guadalupe County GCD, Medina County GCD, Uvalde County UWCD, Plum Creek CD, Barton Springs Edwards Aquifer CD, Hays Trinity GCD, Trinity Glen Rose GCD and Kinney County GCD will be held on Monday, May 17, 2010 at 11:30 am at the Conference Center of the Edwards Aquifer Authority, 1615 N. St. Mary's, San Antonio, TX 78215.

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LT2-0-0-1

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Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222 -9869

Kinney County Groundwater Conservation District

P.O. Box 369
502 South Ellen Street, Suite B
Brackettville, Texas 78832-0369
(830) 563-9699
Fax (830) 563-9606

FAX NUMBER TRANSMITTED TO: 210 - 222 - 9869

To: Rick Illgner

From: Kinney County Groundwater Conservation District

Date: 5-5-10

Documents: DMA Agenda posting for May 17th Mtg.

Number of Pages (Including cover sheet): 2

Comments:

If you do not receive all pages, please telephone the District office (830) 563-9699.

Groundwater Management Area #10 Joint Planning Meeting

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No. ______
Filed on 5 day of May 20 10
At 10:00 o'clock A M.
Dora Elia Sandoval
County District Clerk
Kinney County, Texas
By Terminal Garcia Deputy

Edwards Aquifer Authority

Phone (210) 222-2204 Fax (210) 222-9969

EDWARDS AQUIFER
AUTHORITY

Exhibit G

Resolution # 2010-08

for Kinney Co.

RESOLUTION No. 2010-08
RESOLUTION FOR THE ADOPTION OF THE DESIRED FUTURE CONDITION OF THE EDWARDS AQUIFER IN KINNEY COUNTY WITHIN GROUNDWATER MANAGEMENT AREA 10

WHEREAS; GROUNDWATER MANAGEMENT AREA (GMA) 10 IS COMPRISED OF DELEGATES FROM THE FOLLOWING GROUNDWATER CONSERVATION DISTRICTS LOCATED WHOLLY OR PARTIALLY WITHIN GMA 10: BARTON SPRINGS EDWARDS AQUIFER CONSERVATION DISTRICT, EDWARDS AQUIFER AUTHORITY, GUADALUPE COUNTY GCD, HAYS TRINITY GCD, KINNEY COUNTY GCD, MEDINA COUNTY GCD, PLUM CREEK CD, TRINITY GLEN ROSE GCD, AND UVALDE COUNTY UWCD;

WHEREAS; CHAPTER 36.108 OF THE TEXAS WATER CODE, (JOINT PLANNING IN MANAGEMENT AREA), REQUIRES THAT THE GROUNDWATER CONSERVATION DISTRICTS IN THE GMA ADOPT DESIRED FUTURE CONDITIONS OF ALL RELEVANT AQUIFERS IN THE GMA FOR A FIFTY YEAR HORIZON, NO LATER THAN SEPTEMBER 1, 2010;

WHEREAS; THE COMMITTEE MEMBERS OF GMA 10 HAVE HELD PUBLIC MEETINGS NOTICED AND POSTED IN ACCORDANCE WITH STATE LAW, AND HAVE REVIEWED AND DISCUSSED GROUNDWATER AVAILABILITY MODEL (GAM) RUNS WITH INPUT AND COMMENT FROM STAKEHOLDERS WITHIN GMA 10;

WHEREAS; THE GAM RUNS FOR KINNEY COUNTY BY THE TEXAS WATER DEVELOPMENT BOARD WERE NOT WELL SUITED. THE TEXAS WATER DEVELOPMENT BOARD DEVELOPED A GROUNDWATER FLOW MODEL SPECIFIC TO KINNEY COUNTY.

NOW, THEREFORE, BE IT RESOLVED THAT, THE DISTRICT MEMBERS OF GROUNDWATER MANAGEMENT AREA 10, ADOPT THE SCENARIO FOR KINNEY COUNTY THAT THE DFC SHALL BE THAT THE WATER LEVEL IN WELL NUMBER 70-38-902 SHALL NOT FALL BELOW 1184 FEET MSL.

VOTED AND APPROVED THIS, THE 4 th DAY OF August, 2010, BY A VOTE OF 8 AYES AND 0 NAYS, CONSTITUTING AT LEAST A TWO-THIRDS MAJORITY OF THE VOTING MEMBERS PRESENT.

SIGNED ______________________________
Kirk Holland — Barton Springs/Edwards Aquifer Conservation District

SIGNED ______________________________
Luana Buckner — Edwards Aquifer Authority

SIGNED ______________________________
Ron Naumann — Guadalupe County GCD

SIGNED ______________________________
David Baker — Hays Trinity GCD

SIGNED ______________________________
~~Stan Metcalf~~ KEN CARVER — Kinney County GCD

SIGNED ______________________________
Thomas Boehme — Medina County GCD

SIGNED ______________________________
Daniel Meyer — Plum Creek Conservation District

SIGNED ______________________________
George Wissmann — Trinity Glen Rose GCD

SIGNED ______________________________
Vic Hilderbran — Uvalde County UWCD

EDWARDS AQUIFER
AUTHORITY

Exhibit H
GAM Task 10-027
for Kinney Co.

GAM Task 10-027

by William R. Hutchison, Ph.D, P.E., P.G.
Texas Water Development Board
Groundwater Resources Division
(512) 463-5067
August 2, 2010

This document is released for the purpose of interim review under the authority of William R. Hutchison, P.E. 96287, P.G. 286 on August 2, 2010

EXECUTIVE SUMMARY

This GAM Task summarizes the results of seven pumping scenarios using the recently completed groundwater flow model of the Kinney County area. The seven pumping scenarios represent pumping that is higher and lower than historic pumping in order to evaluate changes in spring flow in Las Moras Springs and estimate minimum groundwater elevation in the monitor well that is used by the Edwards Aquifer Authority. The spring flow and minimum groundwater elevation have been adopted by the Kinney County Groundwater Conservation District as their desired future conditions of the aquifer system underlying Kinney County. Based on this analysis, average spring flow in Las Moras Springs will be 23.9 cubic feet per second and median spring flow in Las Moras Springs will be 24.4 cubic feet per second if pumping is about 77,000 acre-feet per year in Kinney County. Minimum groundwater elevation in the monitoring well will be 1,162 feet above mean sea level under this scenario.

ORIGIN OF TASK:

The Kinney County Groundwater District requested assistance in developing desired future conditions for their aquifer system. As a result of this request, TWDB staff developed a groundwater flow model of all the aquifers in Kinney County and surrounding areas. This model is documented in Hutchison and others (2010). This task report summarizes the results of seven scenarios that were presented at the Kinney County Groundwater Conservation District Board meeting of July 27, 2010.

DESCRIPTION OF TASK:

Based on the results of the calibration of the groundwater flow model of Kinney County, historic groundwater pumping from 1950 to 2005 has ranged from about 51,000 acre-feet per year to about 77,000 acre-feet per year (Hutchison and others 2010). In general, pumping increases result in reduced spring flow, and reduced pumping result in increased spring flow. The objective of the simulations run for this task was to quantify the change in spring flow under various scenarios of constant pumping. The information from these simulations has been used by the Kinney County Groundwater Conservation District in establishing the desired future conditions of their aquifer system as part of the joint planning process in Groundwater Management Areas 7 and 10. In order to facilitate comparison with historic spring flows, all simulations were run with the recharge and river conditions equivalent to the model's historic period (1950 to 2005).

METHODS:

Seven pumping scenarios were developed for this task, each with constant pumping. The base case assumed 77,000 acre-feet per year of pumping, which is equivalent to the highest year of pumping based on the calibrated model for the period 1950 to 2005. Two scenarios included reduced pumping and four scenarios included increased pumping as follows:

Scenario	Kinney County pumping (acre-feet per year)
1	38,000
2	57,000
3	77,000
4	96,000
5	115,000
6	134,000
7	153,000

The scenarios consisted of running the model for 56 years, using recharge and river conditions from 1950 to 2005 in order to facilitate comparison with the historic spring flows.

PARAMETERS AND ASSUMPTIONS:

- The recently developed groundwater flow model of the Kinney County area (Hutchison and others, 2010) was used for these simulations (version 1.01).

- The model has four layers: layer 1 represents the Carrizo-Wilcox and associated aquifers, layer 2 represents the upper Cretaceous formations that yield groundwater, layer 3 represents the Edwards (Balcones Fault Zone) Aquifer and the Edwards Group of the Edward-Trinity (Plateau) Aquifer, and layer 4 represents the Trinity Aquifer, including the Trinity portion of the Edwards-Trinity (Plateau) Aquifer..

- As further detailed in the model report (Hutchison and others, 2010), model calibration statistics for the entire model domain for groundwater elevation and spring flow are summarized below. Note that groundwater elevation data are expressed in feet above mean sea level (ft), and spring flows are expressed in cubic feet per second (cfs):

Statistic	Groundwater elevation	Spring flow
Number of measurements	1,824	432
Average residual	7.8 ft	-1.2 cfs
Standard deviation	53 ft	10 cfs
Range of measurements	1581 ft	223 cfs
Standard deviation divided by range	0.03	0.04

- Seven different pumping scenarios were used as described above

- Each simulation consisted of 57 annual stress periods. All model input files were identical to the calibration period in each scenario except for the pumping file, as noted above.

- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

RESULTS:

Spring flow

The results of the simulation include estimating spring flow changes under alternative pumping scenarios. A summary of the results expressed as average spring flow for the three major springs in Kinney County (Las Moras, Mud, and Pinto) as a function of pumping in Kinney County are presented in Figure 1.

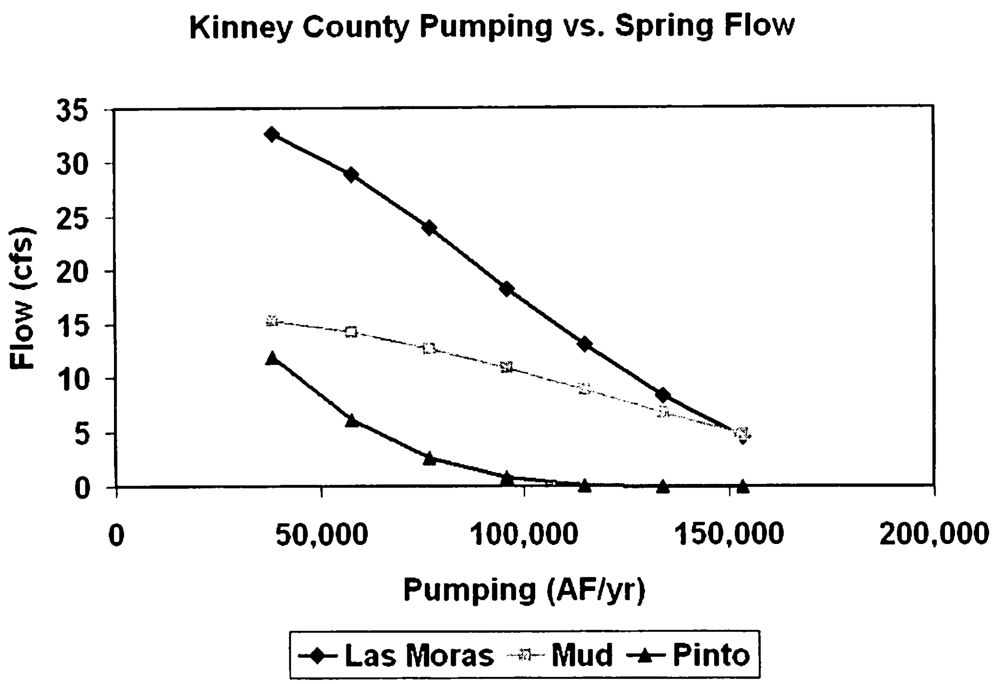

Figure 1. Kinney County pumping versus spring flow for seven pumping scenarios.

Note that as a result of input received from the Kinney County Groundwater Conservation District Board of Directors, Las Moras Springs is the only spring for which a desired future condition will be set due to monitoring constraints. The frequency of various flows in Las Moras Springs that are a result of changes in recharge conditions are presented in Table 1.

Table 1. Las Moras Spring Flow Frequency under Seven Alternative Pumping Scenarios
Pumping Totals for Kinney County Only. Frequency Expressed as Percent Occurrence for 56 Year Simulations

Las Moras Spring Flow (cfs)	Scenario 1 (Pumping = 38,000 AF/yr)	Scenario 2 (Pumping = 57,500 AF/yr)	Scenario 3 (Pumping = 77,000 AF/yr)	Scenario 4 (Pumping = 96,000 AF/yr)	Scenario 5 (Pumping = 115,000 AF/yr)	Scenario 6 (Pumping = 134,000 AF/yr)	Scenario 7 (Pumping = 153,000 AF/yr)
0	0	0	0	13	25	45	59
0 to 5	0	0	5	9	14	9	16
5 to 10	0	2	13	9	9	13	5
10 to 15	0	11	7	13	7	9	7
15 to 20	11	9	18	11	18	9	4
20 to 25	13	18	9	14	7	5	2
25 to 30	20	13	16	9	7	4	5
30 to 35	18	20	11	11	5	5	2
35 to 40	16	9	11	7	5	2	0
40 to 45	11	14	7	5	2	0	0
> 50	13	5	4	0	0	0	0

Because the average spring flow and median spring flow of Scenario 3 were adopted as the desired future condition for the aquifer system located in the portion of Kinney County in Groundwater Management Area 7, a graphical summary of Scenario 3 for Las Moras Springs is presented in Figure 2. Note that the average flow and the median flow fall into the group that would occur about 9 percent of the time (20 to 25 cfs). A spring flow between 15 and 20 cfs (slightly below the adopted desired future condition) would occur 18 percent of the time, and flow between 25 and 30 cfs (slightly above the adopted desired future condition) would occur about 16 percent of the time. Thus, Las Moras spring flow would be between 15 and 30 cfs about 43 percent of the time. Note that because the model was run on annual stress periods, these spring flows are representative of the end-of-the calendar year conditions. Thus, for comparative purposes, flows collected in December and January should be used to track with the desired future condition.

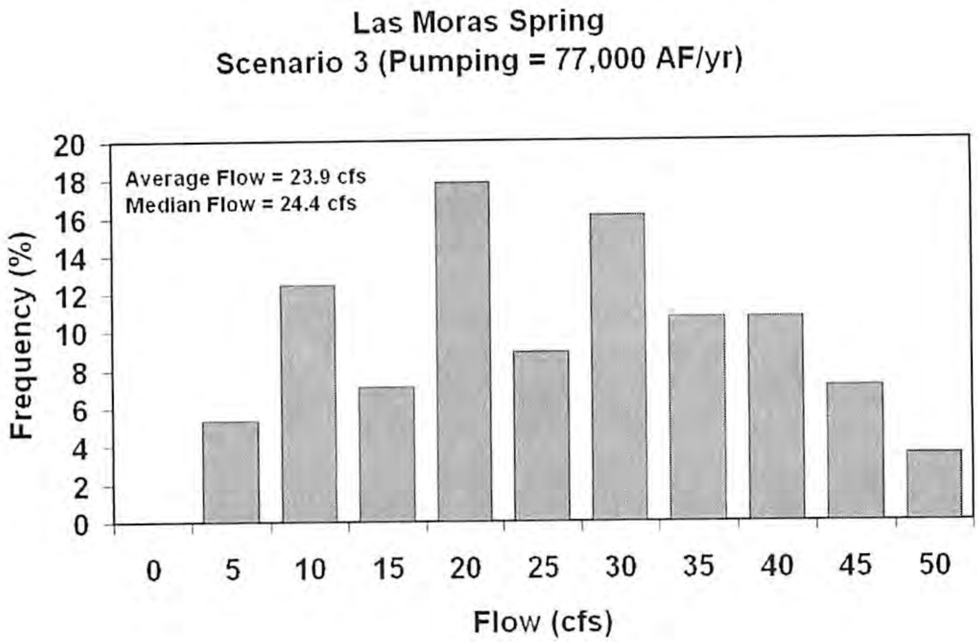

Figure 2. Las Moras Springs flow frequency for Scenario 3.

Groundwater elevations

Groundwater elevation changes due to pumping were evaluated for the monitoring well used by the Edwards Aquifer Authority (Well No. 70-38-902). This well was constructed in 1973 by the Texas Water Development Board. Measured groundwater elevations are presented in Figure 3.

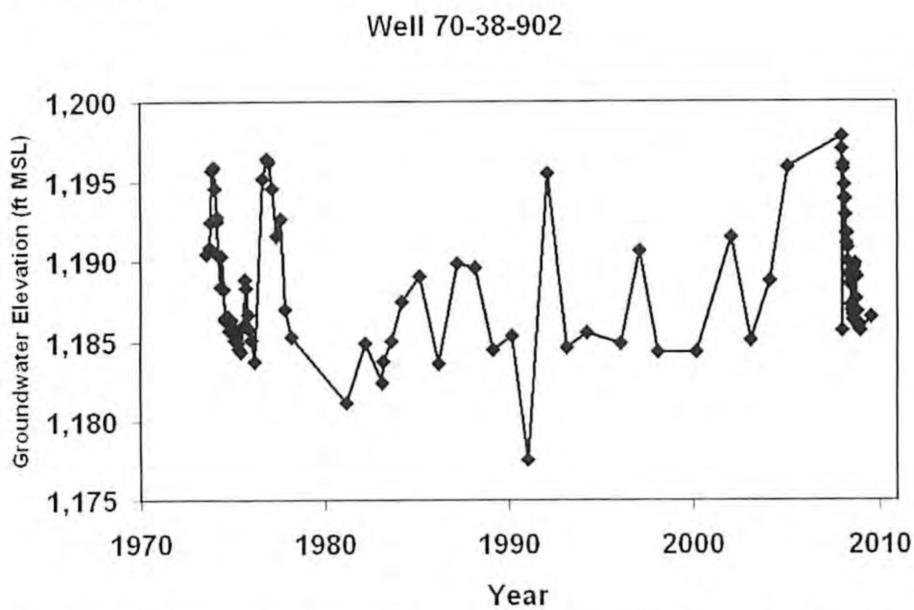

Figure 3. Groundwater elevation measurements in Well 70-38-902

Note that the minimum groundwater elevation is 1177.6 feet above mean level, which was measured in January of 1991. The monitoring well has a limited record of data as compared to the calibration period of the model. Moreover, some of the highest levels of groundwater pumping in Kinney County predate the existence of the monitoring well.

Because the Kinney County Groundwater Conservation District Board of Directors has expressed an interest in establishing a minimum groundwater elevation in this well as desired future condition for the Groundwater Management Area 10 portion of Kinney County, an analysis of simulated groundwater levels at the site of this well was completed. Based on this analysis, the minimum groundwater elevation for the period 1950 to 2005 for each pumping scenario is summarized in Table 2.

Table 2. Simulated minimum groundwater elevations in Well 70-38-902

Scenario	Kinney County Pumping (AF/yr)	Minimum Groundwater Elevation in Well 70-38-902 (ft MSL)
1	38,000	1,167
2	57,000	1,165
3	77,000	1,162
4	96,000	1,158
5	115,000	1,152
6	134,000	1,141
7	153,000	1,135

Based on this analysis, and because the Kinney County Groundwater Conservation District has adopted a desired future condition that is consistent with Scenario 3, the appropriate minimum groundwater elevation for Well 70-38-902 to be used as a desired future condition for Groundwater Management Area 10 is 1,162 feet above mean sea level.

REFERENCES:

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model-user guide to modularization concepts and the ground-water flow process: U.S. Geological Survey Open-File Report 00-92, 121 p.

Hutchison, William R., Shi, Jerry, and Jigmond, Marius, 2010 (in review), Evaluation of Groundwater Flow in Kinney County Using a MODFLOW-2000 Model. Texas Water Development Board Unpublished Report.