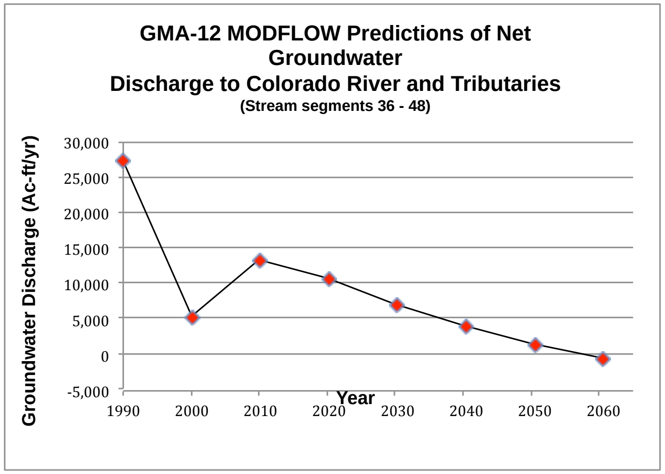
GMA-12 DFCs
GW-SW Considerations

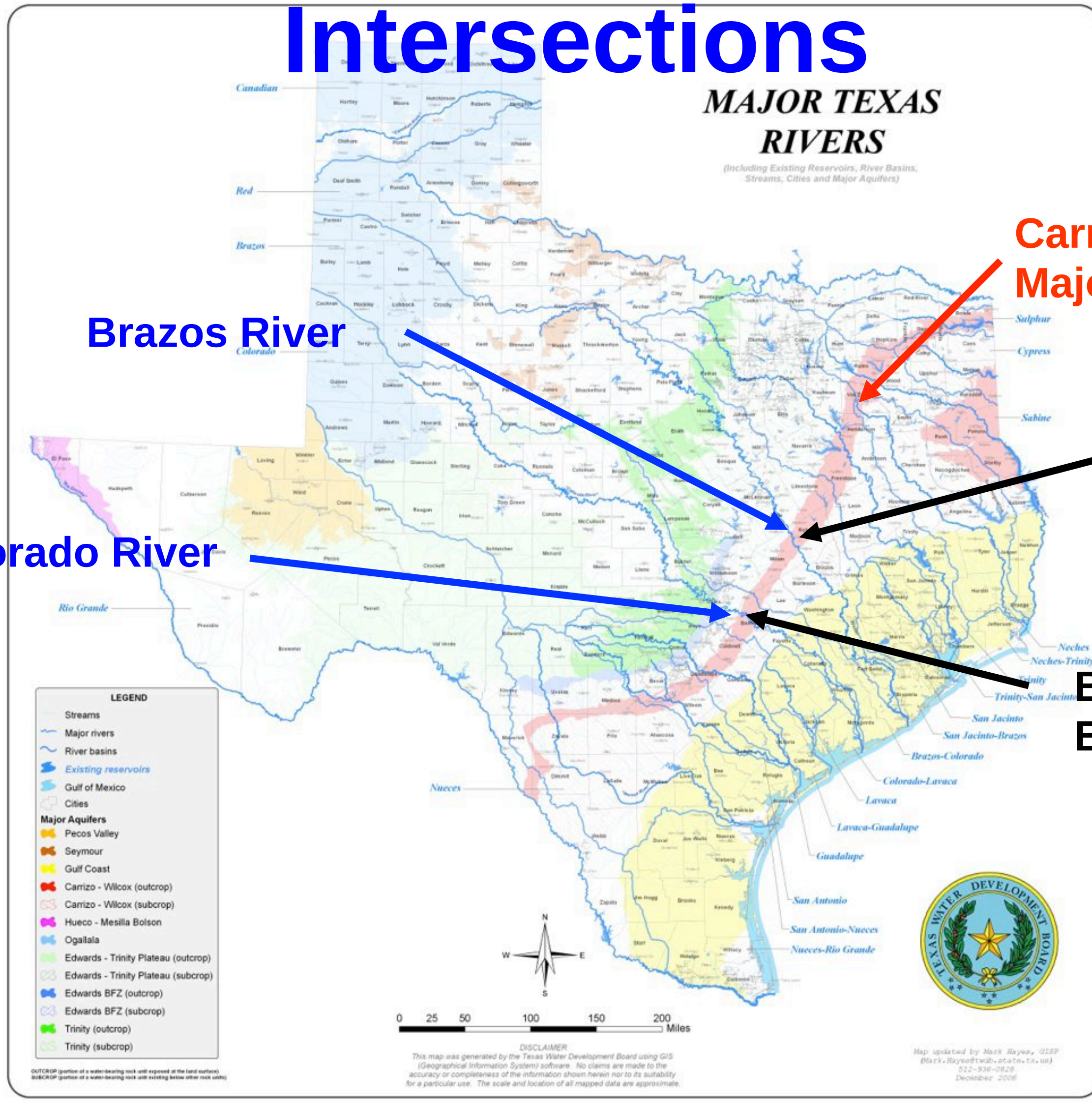


Presented to
GMA-12
June 27, 2014, Milano, Texas

Environmental Stewardship
A Sustainable Ecosphere
TM

Environmental-Stewardship.org

Ground & Surface Water Intersections



Carrizo-Wilcox Major Aquifer

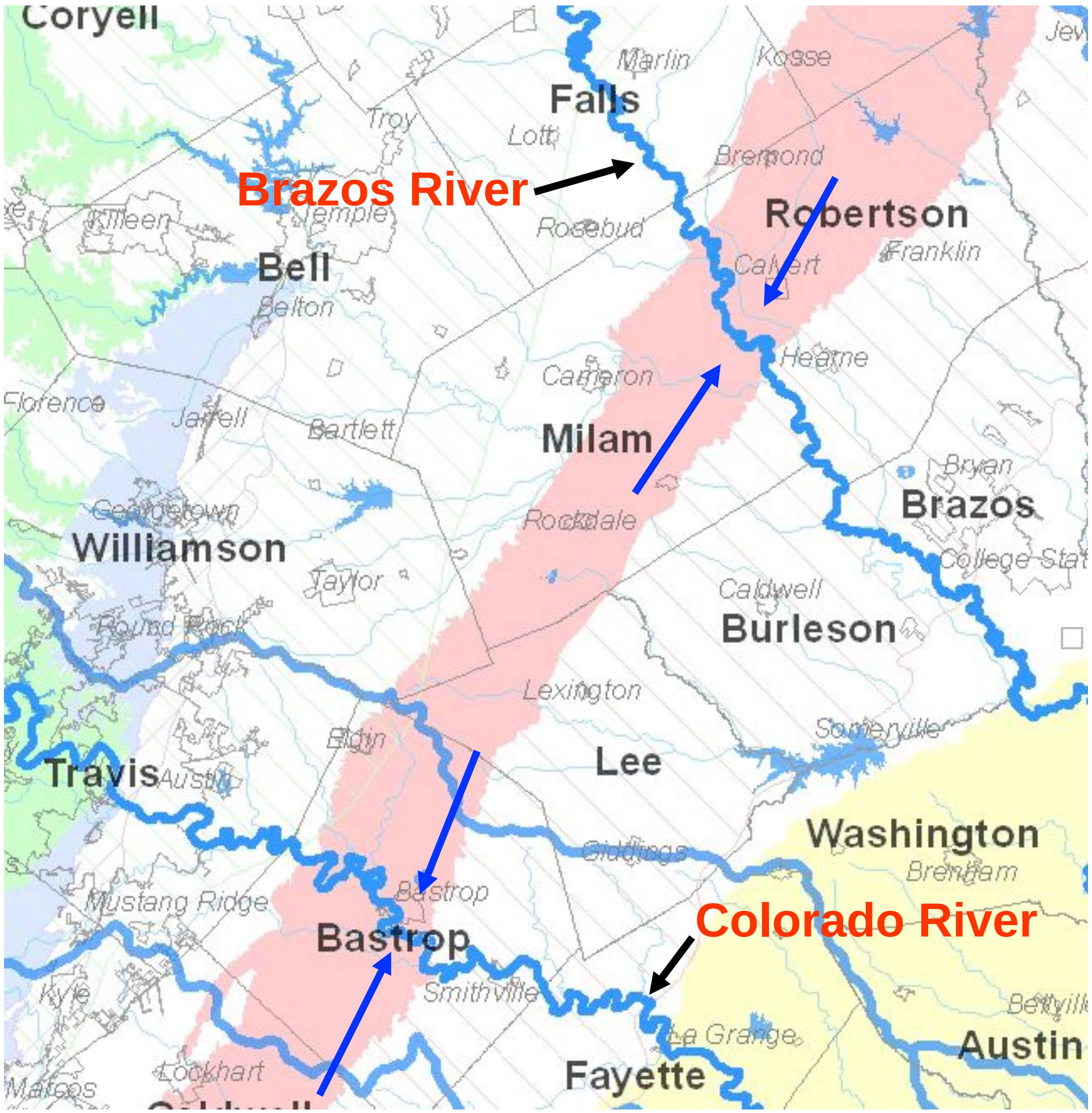
Brazos River

Milam/ Robertson Counties

Colorado River

Bastrop, TX Bastrop County

Currently the Carrizo-Wilcox Charges the Rivers



Charge to Aquifer
(Recharge)

Charge to River
(base-flow)

Under Current Conditions the Carrizo-Wilcox Aquifer Charges Water into the Colorado and Brazos Rivers (Base-flow)

Currently "Gaining" Rivers

Colorado Gaining River

The Colorado River is a "gaining" river as it crosses the Carrizo-Wilcox and other aquifers in Bastrop County.

	Gain/Loss (cubic feet per second)	
TWDB/LCRA 1989 Study **(Exhibit N2)**	+62 cfs	45,000 ac-ft/yr
LCRA 2005 STUDY (Attachment J)		
Austin-Bastrop	-9 cfs	
Bastrop-Smithville	+59 cfs	Net +50 cfs
LCRA 2008 STUDY (Attachment K)		***About 25,000 ac-ft/yr***
Utley-Bastrop (Bob Bryant)	+34.5 cfs	
Bastrop-Smithville	-4.5 cfs	Net +30 cfs
USGS 1918 estimate (Attachment L)		
Carrizo-Wilcox (Utley-Smithville)		Net +36 cfs
Carrizo-Wilcox GAM (Attachment L)		
Baseflow increase:	**32,400 ac-ft/year;**	
GAM calibrated to:	**26,100 ac-ft/year; 36 cfs**	

Brazos Gaining River

- **The Brazos River is a "gaining" river as it crosses the Carrizo-Wilcox and other aquifers in Brazos, Burleson, Milam, and Robertson counties.**
  - **USGS 2002 report 02-068** **(Exhibit 1)**
    - tabulated data on 366 known streamflow gain-loss studies conducted by the USGS in Texas
    - 47 were on the Carrizo-Wilcox aquifer
    - Prepared in cooperation with the TWDB
  - **USGS Scientific Investigation report 2007-5286** **(Exhibit 2)**
    - "Streamflow Gain and Loss of the Brazos River, McLenna County to Fort Bend County, Texas"
    - The gain-loss relationship of the Brazos River was established in this 2006 study
    - Prepared in cooperation with the TWDB

Brazos Gaining River

The Brazos River is a “gaining” river as it crosses the Carrizo-Wilcox and other aquifers in Brazos, Burleson, Milam and Robertson Counties.

			Gain/Loss (cubic feet per second)	
USGS Investigation 2007-5286 STUDY				
(Exhibit 2 - Figure 11 and Table 8)			August	
	B6	Carrizo-Wilcox	**+194 cfs**	
	B9	Carrizo-Wilcox	+39 cfs	
	B12	Queen City/Sparta	-64 cfs	
	B13	Queen City/Sparta	**+134 cfs**	
	B14	Queen City/Sparta	-88 cfs	
	B15	Yegua-Jackson	**+73 cfs**	
	B16	Yegua-Jackson	+79 cfs	**Net ~ 367 cfs** **265,700 ac-ft/yr**

Bold font indicates gain or loss that is greater than potential measurement error for that particular reach.

Impacts of Pumping

- **Potential impacts of pumping on spring and surface water outflows and of reduced outflows on surface water resources are predicted by groundwater availability models (GAM).**
  - Region K – 2006 Regional Water Plan
  - Hutchison Calibration Data
  - Water Budget extracted from GMA-12 model files

Rice Study

- ▲ Effects of pumping on the Simsboro
  - Proposed pumping of 45,000 ac-ft/yr would create a cone of depression (region of reduced hydraulic heads) that extends to the contact of the Hooper aquifer and the underlying Midway Group. Thus, it would affect both confined and unconfined portions of the aquifers.
  - Where the aquifers are confined, the reduced heads would cause water levels in wells to decline.
  - Where the aquifers are unconfined, the reduced heads would cause dewatering of the affected portions of the aquifers.

(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

Rice Study (continued)

▲ Effects of pumping on other aquifers

- Pumping would induce leakage from the
  - Hooper
  - Calvert Bluff, and
  - Carrizo aquifers.

(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

Rice Study (continued)

Table 1

GAM Predicted Drawdowns in 2060 for Phased-in Forestar Pumping

Aquifer (model Layer)	Maximum drawdown (ft)	Average drawdown throughout LPGCD (ft)	Average Drawdown in Bastrop County (ft)	Average Drawdown in Lee County (ft)
Carrizo (5)	13	6	3	9
Calvert Bluff (6)	78	34	16	53
Simsboro (7)	624	114	41	197
Hooper (8)	112	48	28	74

(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

Rice Study (continued)

- ▲ Effects of pumping on discharges to Colorado River
  - – Comparison to measured historic
    - GAM predictions are inaccurate
    - GAM under-estimated compared to measured in this case

(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

Rice Study (continued)

- ▲ Historic Empirical Measurements

Table 4

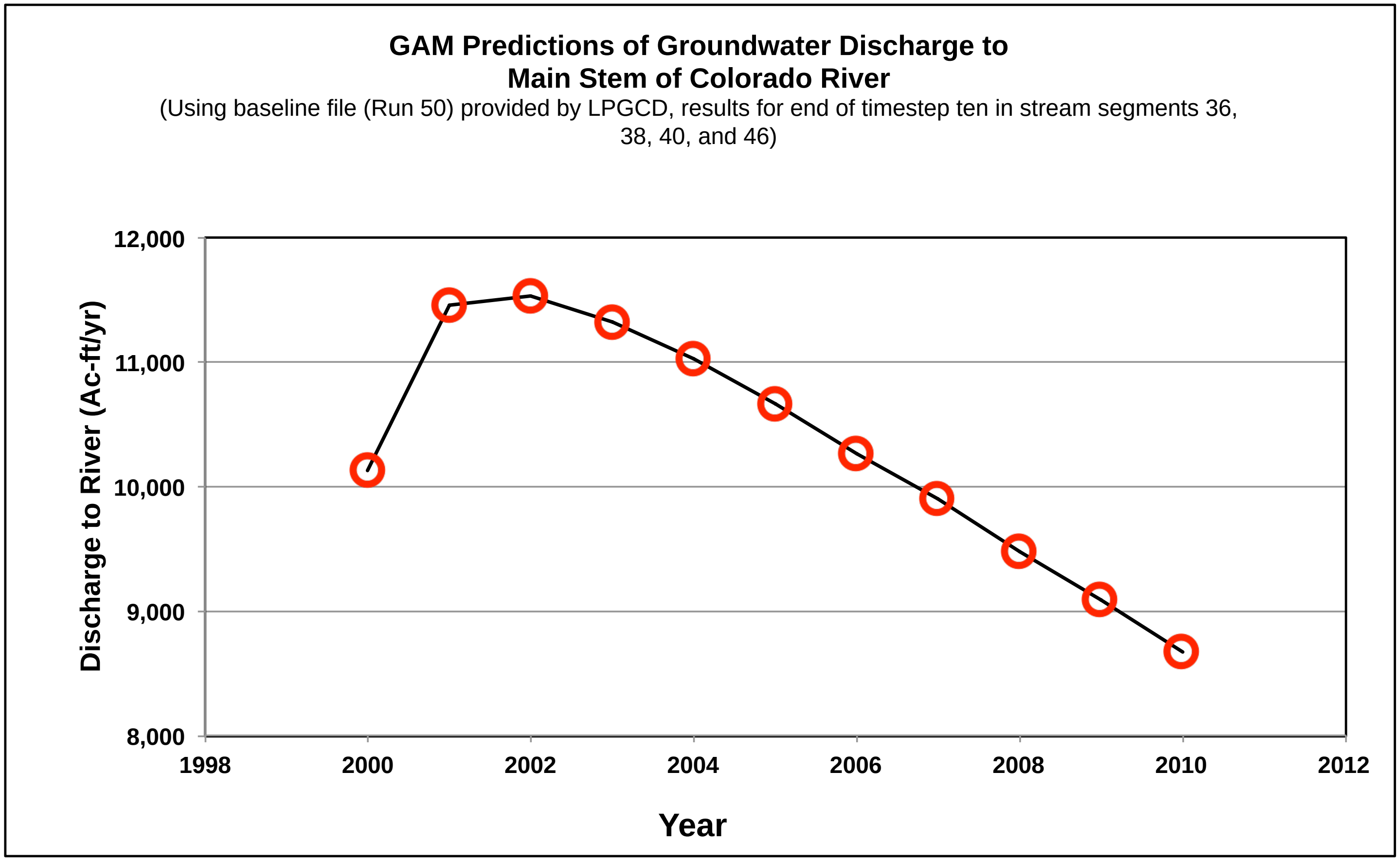
**Measured Groundwater Discharge to the Colorado River
From the Carrizo-Wilcox Aquifer in Bastrop County**

Year	Discharge (cfs)	Discharge (ac-ft/yr)	Remarks
1918	36	26,060	USGS
2005	50	36,200	LCRA
2008	30	21,720	Saunders

(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

Rice Study (continued)

▲ GAM Predictions are inaccurate:



(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

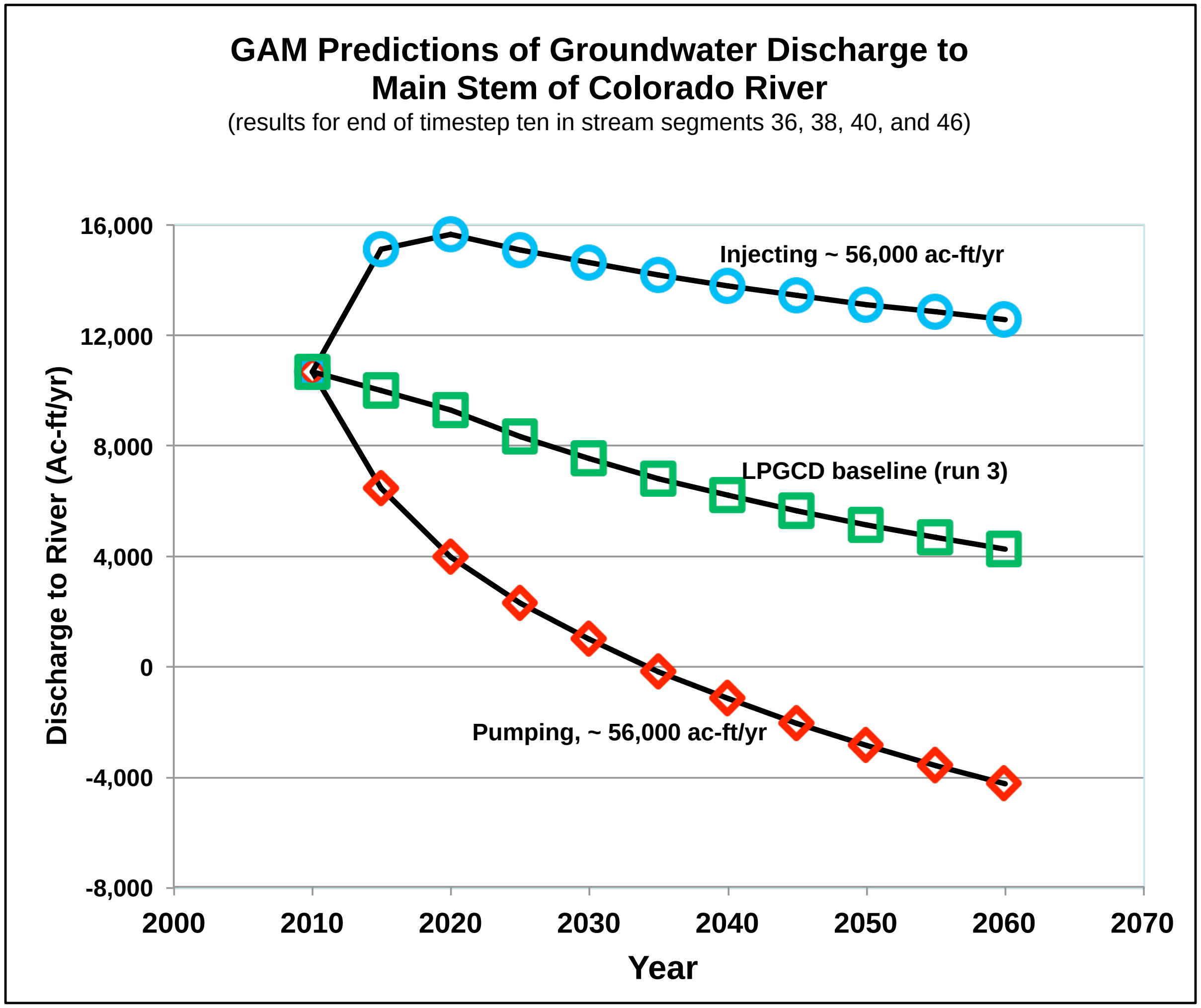
Rice Study (continued)

- Pumping Rates
  - Consistent with expectations
  - Less discharge when pumping rates increased
  - More discharge when water injected at same rate

- Pumping Duration
  - Consistent with expectations
  - Longer pumping times results in less discharge

(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

Rice Study (continued)



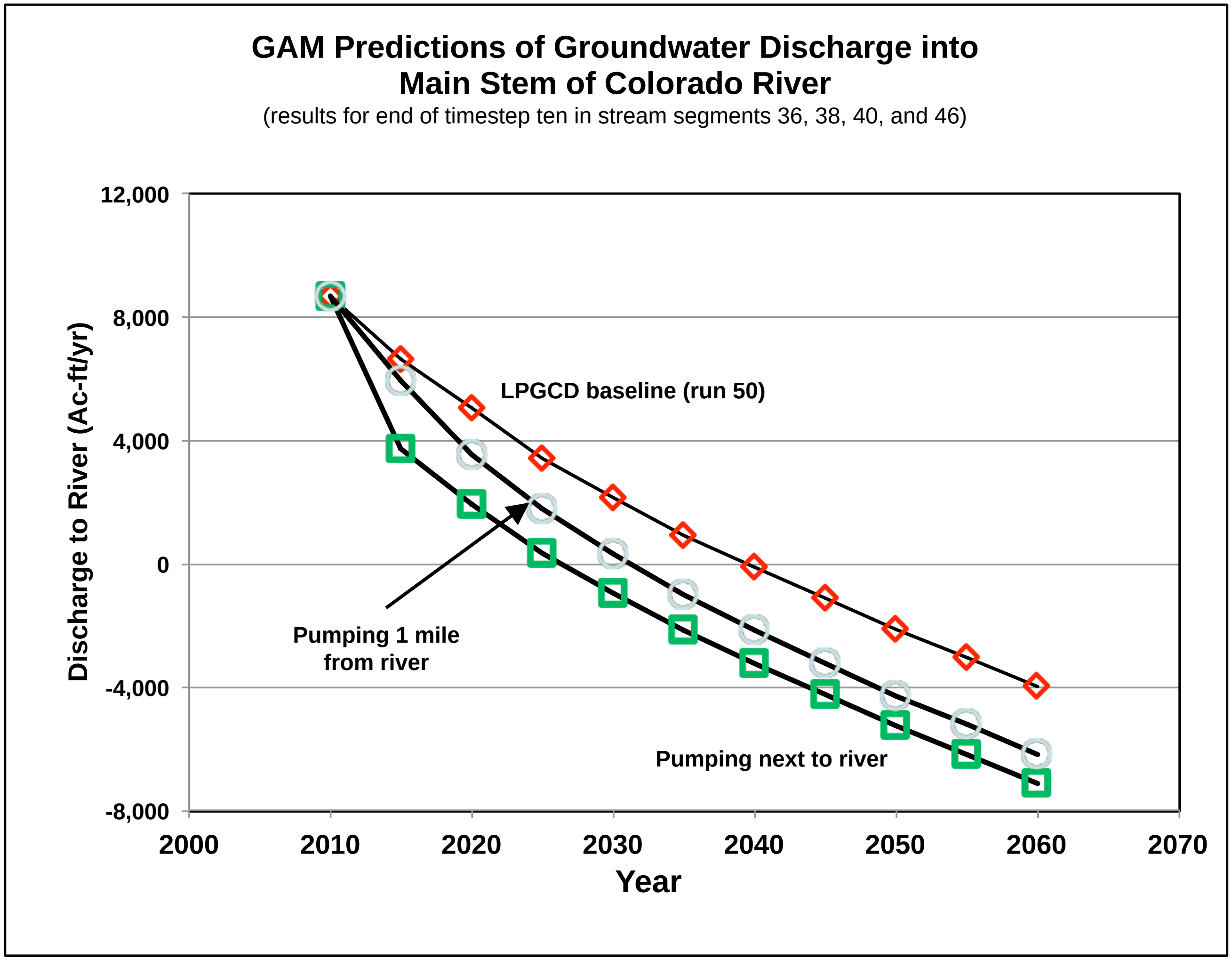
(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

Rice Study (continued)

– Distance of pumping from river
  - Consistent with expectations
  - Less discharge when pumping is adjacent to river
  - More discharge when pumping is a mile from river

(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

Rice Study (continued)



(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

Rice Study (continued)

CONCLUSIONS:

- ▲ GAM reliably predicts trends
  - – Less discharge to river with more pumping
  - – Less discharge to river with longer duration
  - – Less discharge to river when near river
- ▲ GAM does not reliably quantify trends.
  - – Predicted quantity of discharge to river does not agree with empirical data.

(New Exhibit N1-2014 – Forestar's Proposal to Pump Groundwater from the Simsboro Aquifer, George Rice, December 14, 2013)

Communicating Sands

- Impacts of pumping on other aquifers have significant implications for shallow surface wells, streams, springs and surface features that depend on shallow groundwater to survive and thrive.
- The literature indicates the sand aquifers of the Carrizo-Wilcox Group communicate and are not isolated.

Communicating Sands

- ▲ TWDB and LCRA developed a digital model of the Carrizo-Wilcox Aquifer within the Colorado River basin (primarily Bastrop and Fayette counties) published in 1989. **(Exhibit N2)**
- ▲ Key Findings:
  - – "The sand units yield most of the water and are <u>interconnected</u>, at least regionally, causing the entire system to act <u>as a leaky artesian system.</u>"

(New Exhibit N2-2014: A Digital Model of the Carrizo-Wilcox Aquifer within the Colorado River Basin of Texas: TWDB Report LP-208, January 1989.

Communicating Sands

- ▲Key Findings (continued):
  - "The aquifer is essentially full and currently loses water through interformational flow to the overlying Younger Rocks, flow to the Colorado River where it crosses the outcrop, and rejected recharge in lower-lying portions of the outcrop area."
  - "The aquifer model which was constructed … works well to predict regional trends within the aquifer, and can be used for regional planning."

(New Exhibit N2-2014: A Digital Model of the Carrizo-Wilcox Aquifer within the Colorado River Basin of Texas: TWDB Report LP-208, January 1989.

Communicating Sands

- Key Findings (continued):
  - "… study of water level maps indicates that the Colorado River and its major tributaries appear to be receiving a major portion of the natural discharge from the Carrizo-Wilcox aquifer."
  - "… a significant component of ground-water flow in the Carrizo-Wilcox within the study area is toward the Colorado River."

(New Exhibit N2-2014: A Digital Model of the Carrizo-Wilcox Aquifer within the Colorado River Basin of Texas: TWDB Report LP-208, January 1989.

Communicating Sands

- Key Findings (continued):
  - Using 1985 pumping, "… about 65,000 acre-feet is rejected through natural discharge in the outcrop area through seeps and springs, and about 45,000 acre-feet flows to the Colorado River in the outcrop." **(Exhibit N2)**
  - "… in these simulations, discharge to the Colorado River correspondingly decreased incrementally with each increase in pumpage." **(Exhibit N2)**

(New Exhibit N2-2014: A Digital Model of the Carrizo-Wilcox Aquifer within the Colorado River Basin of Texas: TWDB Report LP-208, January 1989.

Communicating Sands

- ▲ Other Reference to communicating sands:
  - "In this report, the Carrizo Sand and the Wilcox Group are considered as a unit because they are hydrologically connected." **(Exhibit N3)**

(New Exhibit N3-2014: Ground-water Resources of Bastrop County, Texas. TWDB Report 109, Third printing, November 1981.)

Communicating Sands

- Other Reference to communicating sands:
  - "Because the sands of the Wilcox Group are hyraulically connected with the Carrizo Sand, the term "Carrizo-Wilcox aquifer" is often used." **(Exhibit N4)**
  - The aquifer consists of hydrologically connected interbedded sands, clays, slits and discontinuous lignite beds of the Wilcox Group and overlaying the massive sands of the Carrizo." **(Exhibit N4)**

(New Exhibit N4-2014: Phase I Evaluation Carrizo-Wilcox Aquifer West-Central Study Area Trans-Texas Water Program Draft. LBG-Guyton Associates. January 1994, Published in Volume 2, May 1994.

Communicating Sands

- Other Reference to communicating sands:
  - "Vertical leakage to and from the more important Carrizo and Simsboro sands of the Carrizo-Wilcox aquifer is through confining beds (aquitards)" **(Exhibit N4)**
  - "The expectation that there will be drawdown in the outcrop raises the issue as to what the magnitude of the hydrologic and environmental impact will be." **(Exhibit N4)**

(New Exhibit N4-2014: Phase I Evaluation Carrizo-Wilcox Aquifer West-Central Study Area Trans-Texas Water Program Draft. LBG-Guyton Associates. January 1994, Published in Volume 2, May 1994.

Communicating Sands

- Other Reference to communicating sands:
  - "… analysis indicate that significant quantities of water could enter the Carrizo (and Simsboro in Bastrop County only) as leakage from the hydraulically connected sands and clays of the Wilcox because of the pumpage-imposed vertical hydraulic gradients" **(Exhibit N4)**

(New Exhibit N4-2014: Phase I Evaluation Carrizo-Wilcox Aquifer West-Central Study Area Trans-Texas Water Program Draft. LBG-Guyton Associates. January 1994, Published in Volume 2, May 1994.

Communicating Sands

- ▲ Other Reference to communicating sands:
  - "Because of the presence of <u>relatively poor quality water</u> in a least some portions of the Wilcox, this interformational leakage may not have a desirable effect on the Carrizo and Simsboro Sands." **(Exhibit N4)**

(New Exhibit N4-2014: Phase I Evaluation Carrizo-Wilcox Aquifer West-Central Study Area Trans-Texas Water Program Draft. LBG-Guyton Associates. January 1994, Published in Volume 2, May 1994.

Communicating Sands

- ▲ Other Reference to communicating sands:
  - "Three data sets on hydraulic properties were used [in the model]. One data set included interpreted results of field tests conducted near the Sandow Mine in Milam County according to standard hydrological techniques."
  - "A second set of filed-tested results was compiled from literature and the TWDB Internet site."
  - The third data set, provided by Mr. David Thorkildsen, was used in his previous model of the Carrizo-Wilcox Aquifer."
  - Accordingly, all data on hydraulic conductivity were pooled together.

(Attachment S: Groundwater Availability in the Carrizo-Wilcox Aquifer in Central Texas – Numerical Simulations of 2000 through 2050 Withdrawal Projections. Alan R. Dutton. Bureau of Economic Geology Report of Investigations No. 256.)

Communicating Sands

- Based on sound science and the data used to build the GAM used by GMA-12 it is reasonable to conclude that:
  - Water <u>does move between the aquifers</u> of the Carrizo-Wilcox formation on a regional basis.
  - The GAM <u>reasonably estimates the water movement</u> vertically between aquifers.
  - Pumping in the Simsboro Aquifer <u>will induce leakage</u> from the Carrizo, Calvert Bluff and Hooper formations into the Simsboro.

Region K Water Plan

1.2.4.2 Threats Due to Water Quantity Issues

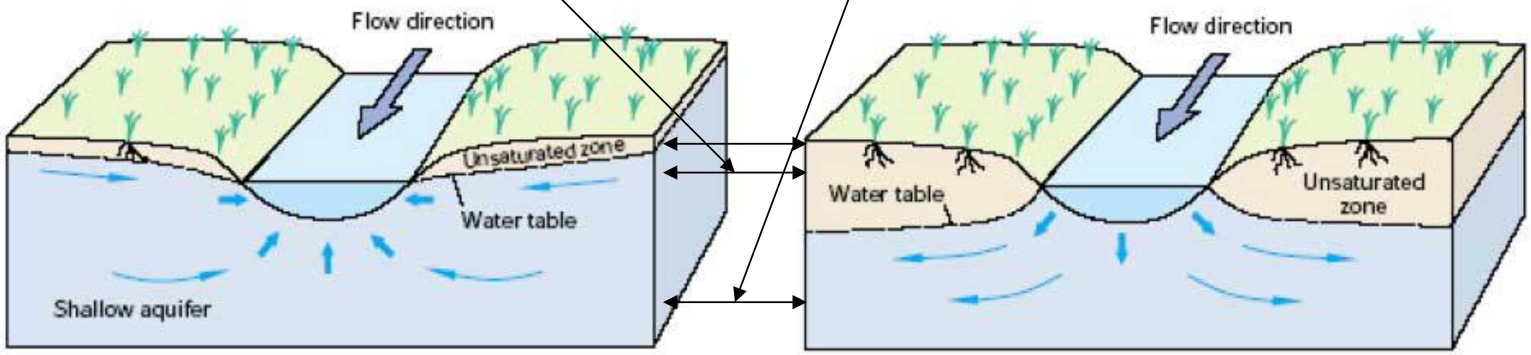
- **The relationships that currently exist between surface and groundwater may also change. "Simulations indicate that the Colorado River, which currently gains water from the Carrizo-Wilcox aquifer, may begin to lose water to the aquifer by the year 2050". (page 1-44)**
  - **Estimated 38 cfs decrease in outflow to river**
  - **27,500 ac-ft/yr decrease with 188,700 ac-ft/yr pumping (scenario 5) (Attachment P)**
  - **DFC estimates 215-285,000 ac-ft/yr pumping**

2006 Lower Colorado Regional Water Plan/2007 State Water Plan
(Attachments P-T)

Groundwater-Surface Water Relationship (Base-Flows)

Original desired drawdown in outcrop area = 50 ft.

Adopted DFC drawdown = 237 ft.



Gaining river becomes Losing river

Figure B-2: Gaining (Left) and Losing (Right) Streams and Associated Groundwater Flow Direction

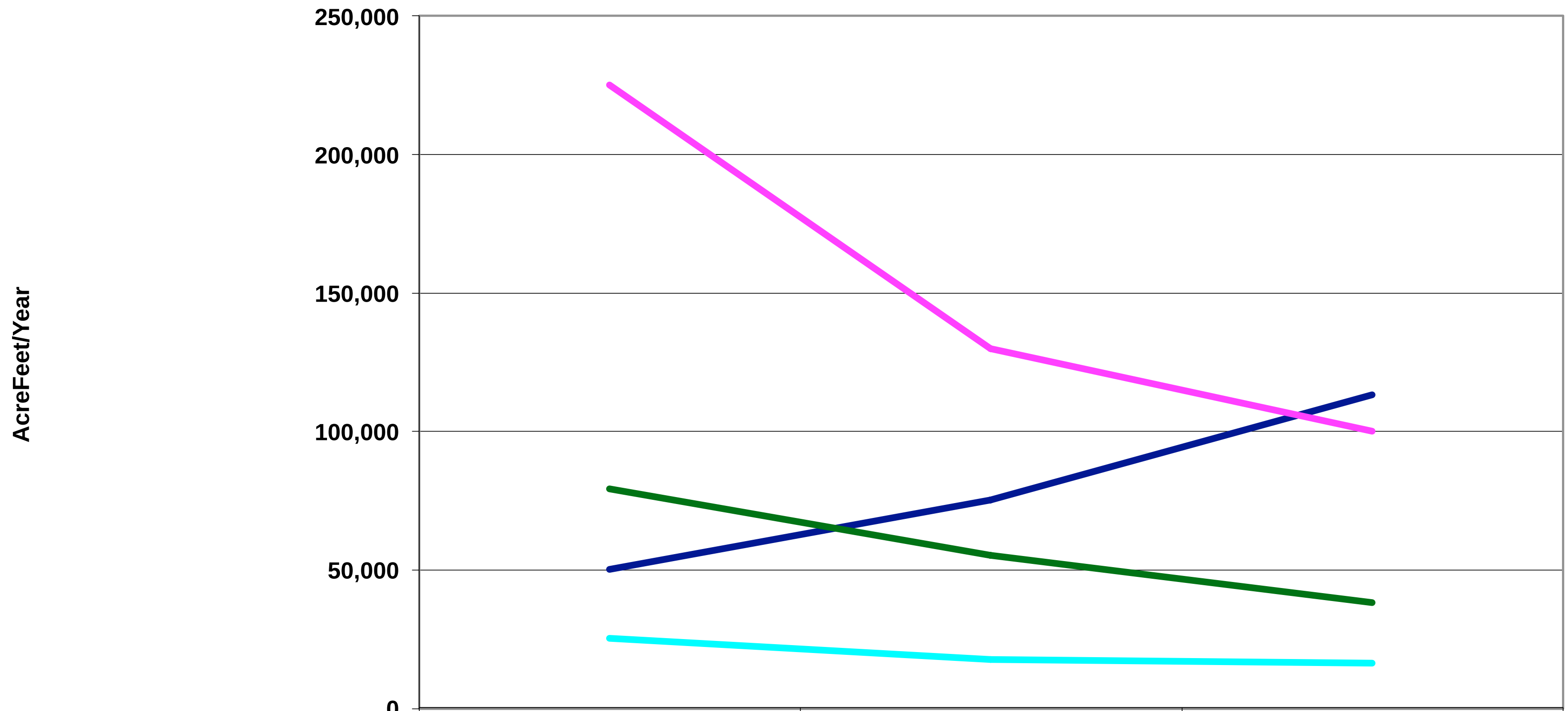
Lost Pines GCD originally set “sustainable” drawdown levels at 50 ft for the outcrop region of the Simsboro formation.

Under pressure from GMA-12, in March 2009 Board meeting the drawdown was increased to 150 ft for the outcrop region of the Simsboro formation.

Under pressure from GMA-12, in August 2010 the Board adopted GMA-12 DFC of 237 ft for the Simsboro Aquifer in LPGCD.

GMA-12 GAM Calibration Results (1980-1999)

(Data from Bill Hutchison Presentation to LPGCD November 18, 2009)



Year	1980	1990	1999
Pumping	50,000	75,000	113,000
Surface Water Outflow	225,000	130,000	100,000
Evapotranspiration Outflow	79,000	55,000	38,000
Springs Outflow	25,000	17,500	16,000

Year

Pumping Surface Water Outflow Evapotranspiration Outflow Springs Outflow

(Attachments X-Y)

Rivers & Creeks in Model

Bold indicates in GMA-12	
San Antonio River	**Brazos River**
Cibolo Creek	**Little Brazos River**
Guadalupe River	Walnut Creek
San Marcos River	Duck Creek
Plum Creek	Steel Creek
Cedar Creek	Navasota River
Colorado River	Big Creek
Big Sandy Creek	Upper Keechi Creek
Middle Yegua Creek	Tehuacana Creek
East Yegua Creek	Trinity River
Little River	+ 9 Lakes/Reservoirs

(Attachment L)

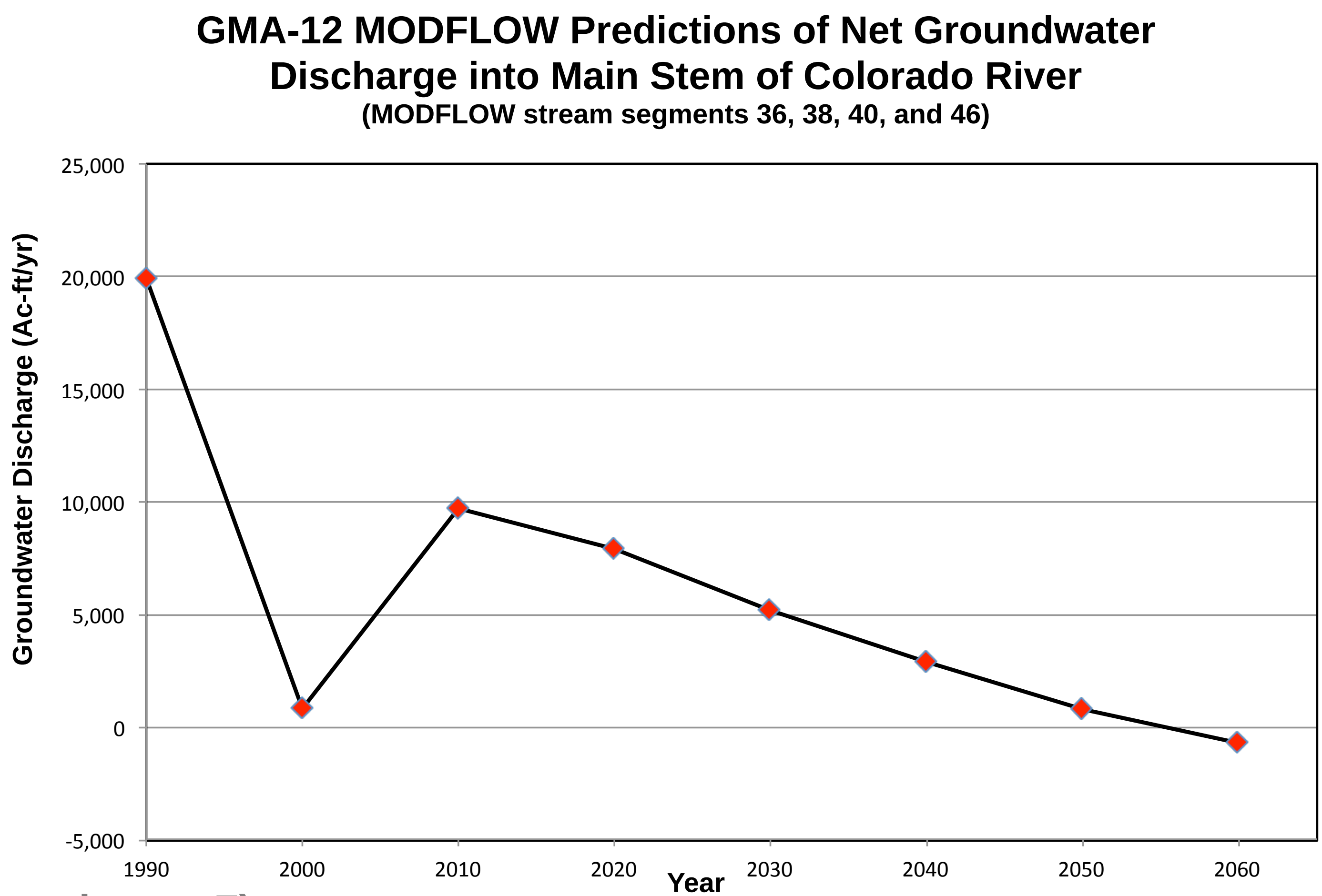
GMA-12 Water Budget

GMA-12 Water Budget 1980-1999 (Hutchinson) and 2010-2060 (DFC Files)

	Hutchinson (AF/yr)			GMA-12 DFC 2010-2060 (AF/yr)					
Component	**1980**	**1990**	**1999/2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
INFLOWS									
Recharge from Precipitation	250,000	325,000	175,000	266,000	266,000	266,000	266,000	266,000	266,000
Cross-formational flow	-700	2,700	4,200	13,900	15,700	18,600	19,900	21,300	22,100
Reservoir Leakage									
Stream Leakage				26,700	28,800	31,800	34,200	36,600	39,300
TOTAL INFLOW	**249,300**	**327,700**	**179,200**	**306,600**	**310,500**	**316,400**	**320,100**	**323,900**	**327,400**
TOTAL INCREASED INFLOW		**78,400**	**-148,500**	**127,400**	**3,900**	**5,900**	**3,700**	**3,800**	**3,500**
OUTFLOWS									
Pumping	49,000	75,000	113,000	215,000	233,000	249,000	259,000	277,000	285,000
Surface Water (Stream leakage)	225,000	130,000	100,000	132,000	122,000	114,000	107,000	103,000	99,400
Colorado River Basin (MODFLOW 2)		*27,300*	*5,410*	*13,400*	*10,700*	*6,970*	*3,960*	*1,360*	*-6,330*
Colorado River (MODFLOW 2)		*19,900*	*7,640*	*9,650*	*7,770*	*5,080*	*2,820*	*734*	*-750*
Colorado River (End Op)				*9,650*	*3,880*	*572*	*-2,820*	*-5,360*	*-7,410*
Evapotranspiration	79,000	55,000	38,000	33,600	31,900	31,400	31,500	32,400	33,100
Springs (Drains)	25,000	17,500	16,000	10,300	8,560	7,170	6,080	5,220	7,530
Cross-formational flow	21,230	19,390	18,030	12,100	10,700	9,260	8,520	7,960	7,530
TOTAL OUTFLOW	**399,230**	**296,890**	**285,030**	**403,000**	**406,160**	**410,830**	**412,100**	**425,580**	**432,560**
TOTAL DECREASE OUTFLOW		**-102,340**	**-11,860**	**117,970**	**3,160**	**4,670**	**1,270**	**13,480**	**6,980**
Storage Change (Calculated)	**-150,930**	**11,420**	**-123,860**						
Storage Change (Hutchinson)	**-140,000**	**30,000**	**-150,000**						
Change in Stream and Spring Outflows									
River Status (Gain/Loss)	***Gaining***	***Gaining***	***Gaining***	***Gaining***	***Gaining***	***Gaining***	***Gaining***	***Gaining***	***Losing***
River Status (Gain/Loss) with EndOp							***Losing***	***Losing***	***Losing***

Exhibit 3

Gaining River ➔Losing River



(Attachment Z)

Gaining River ➔ Losing River

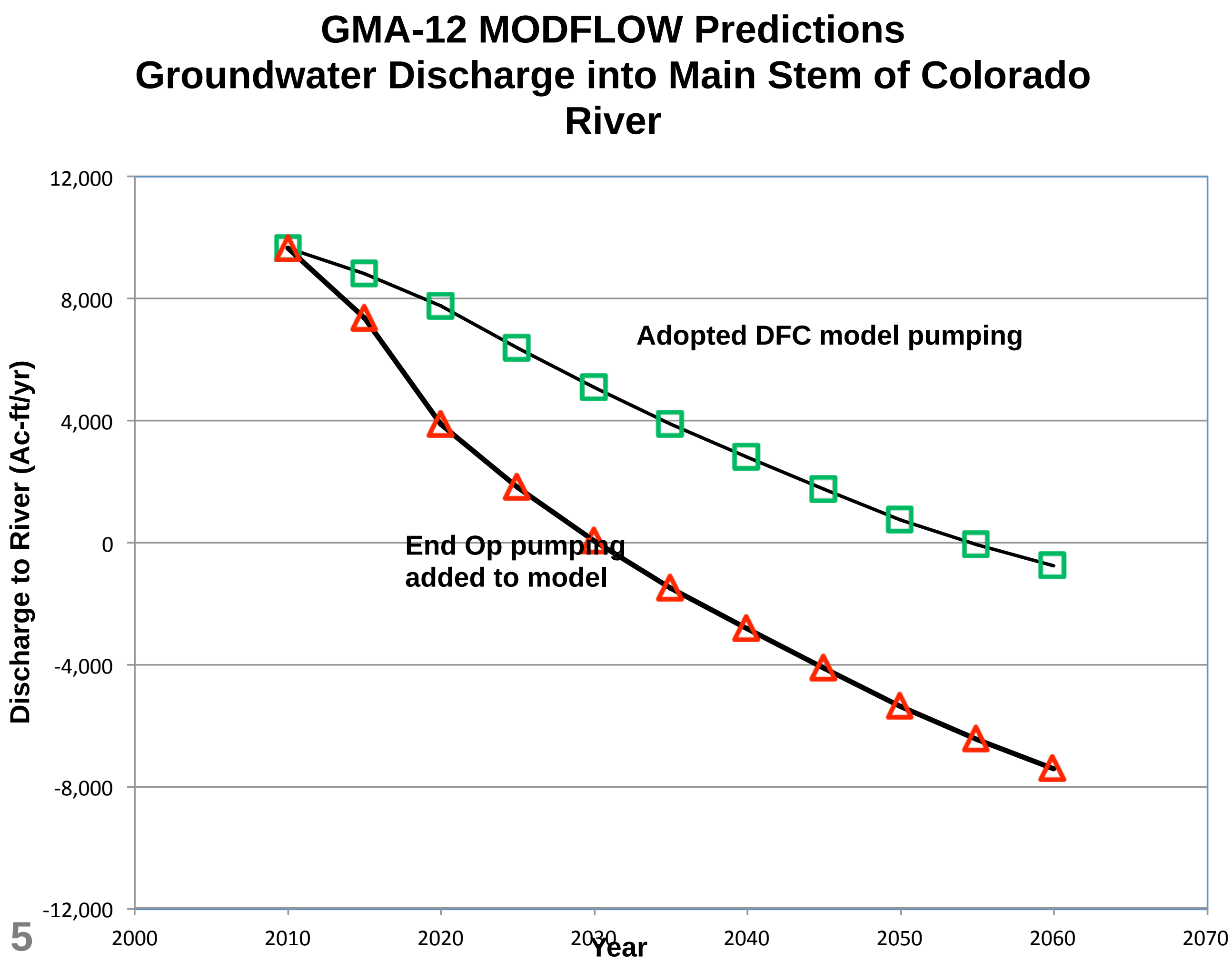


Exhibit 5

Brazos River

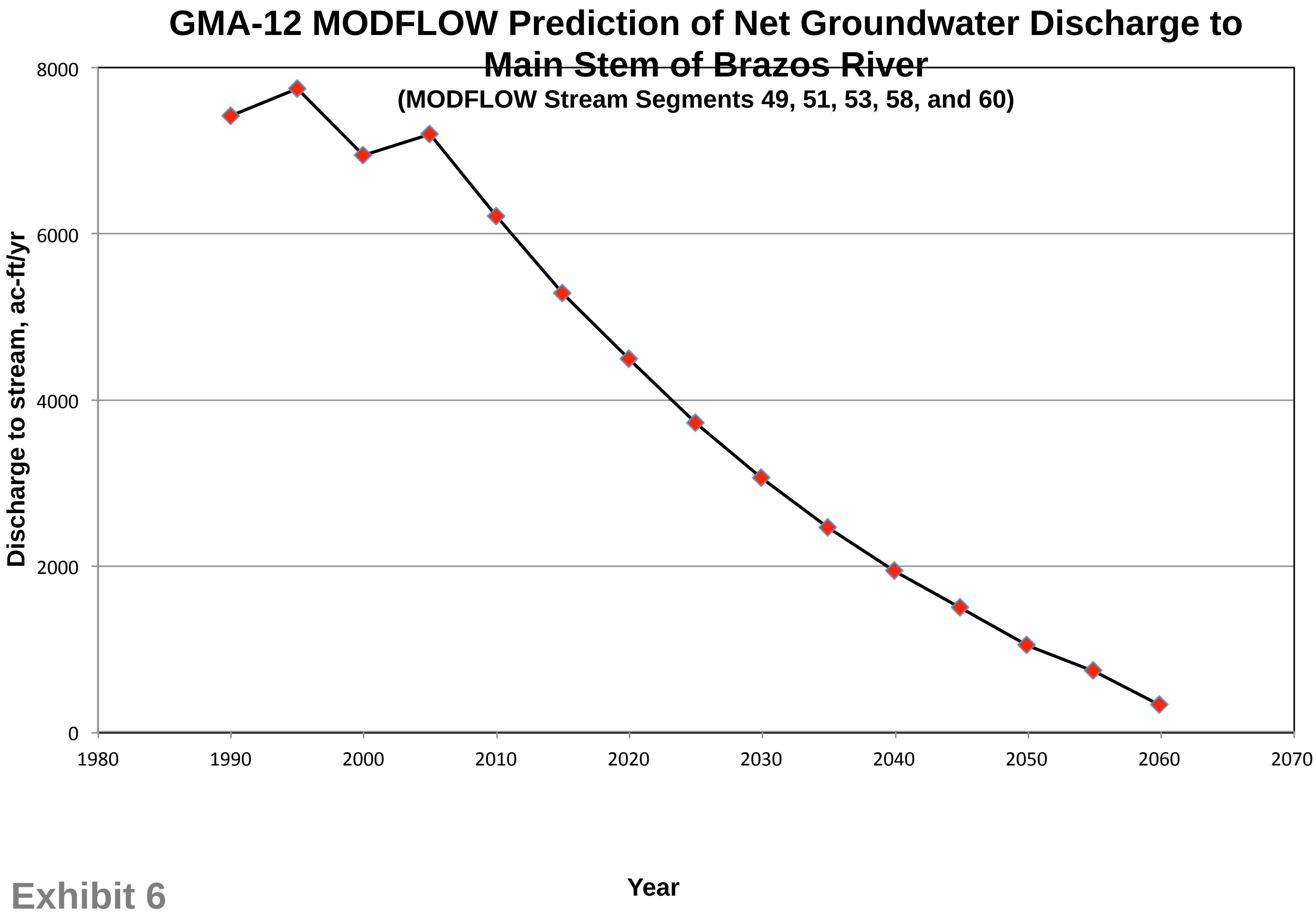


Exhibit 6

GMA-12 & Hutchinson Comparison

- Rice compared the Hutchinson calibration water budget to the GMA-12 DFC water budget.
  - Recharge Comparison
  - Pumping Comparison
  - Outflow to Streams Comparison
  - Outflow to Springs Comparison
  - Evapotranspiration Comparison

Exhibit 4

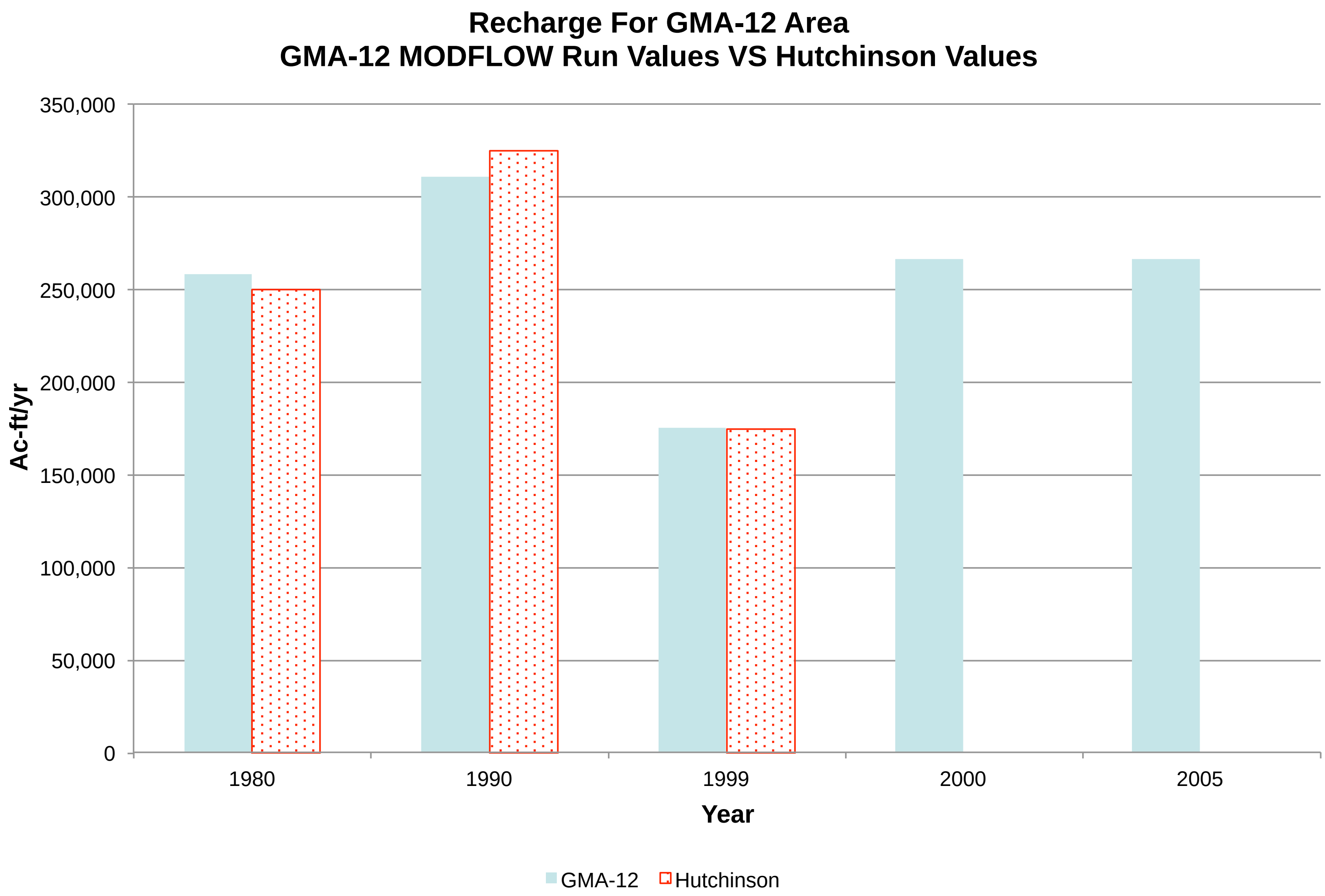
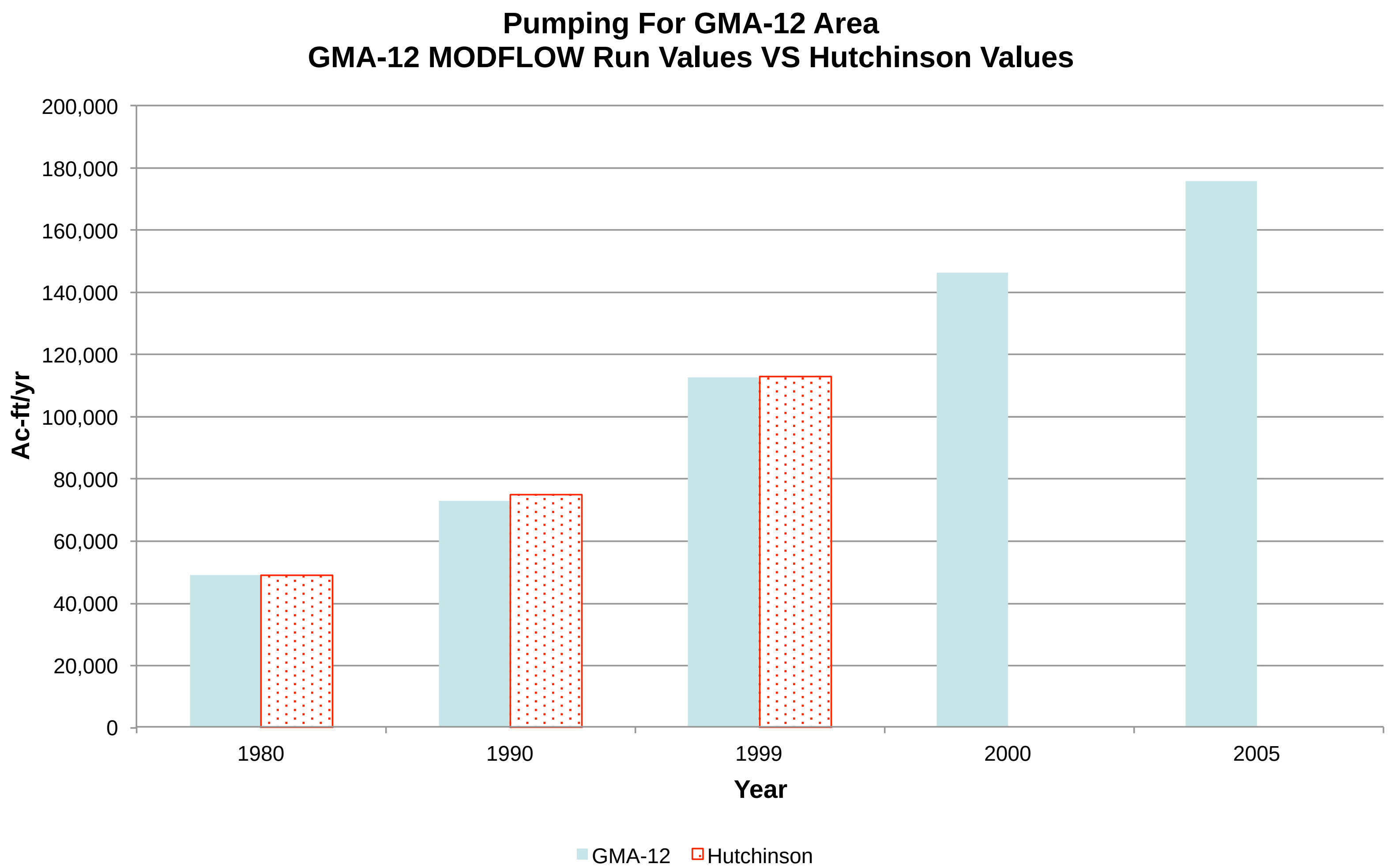
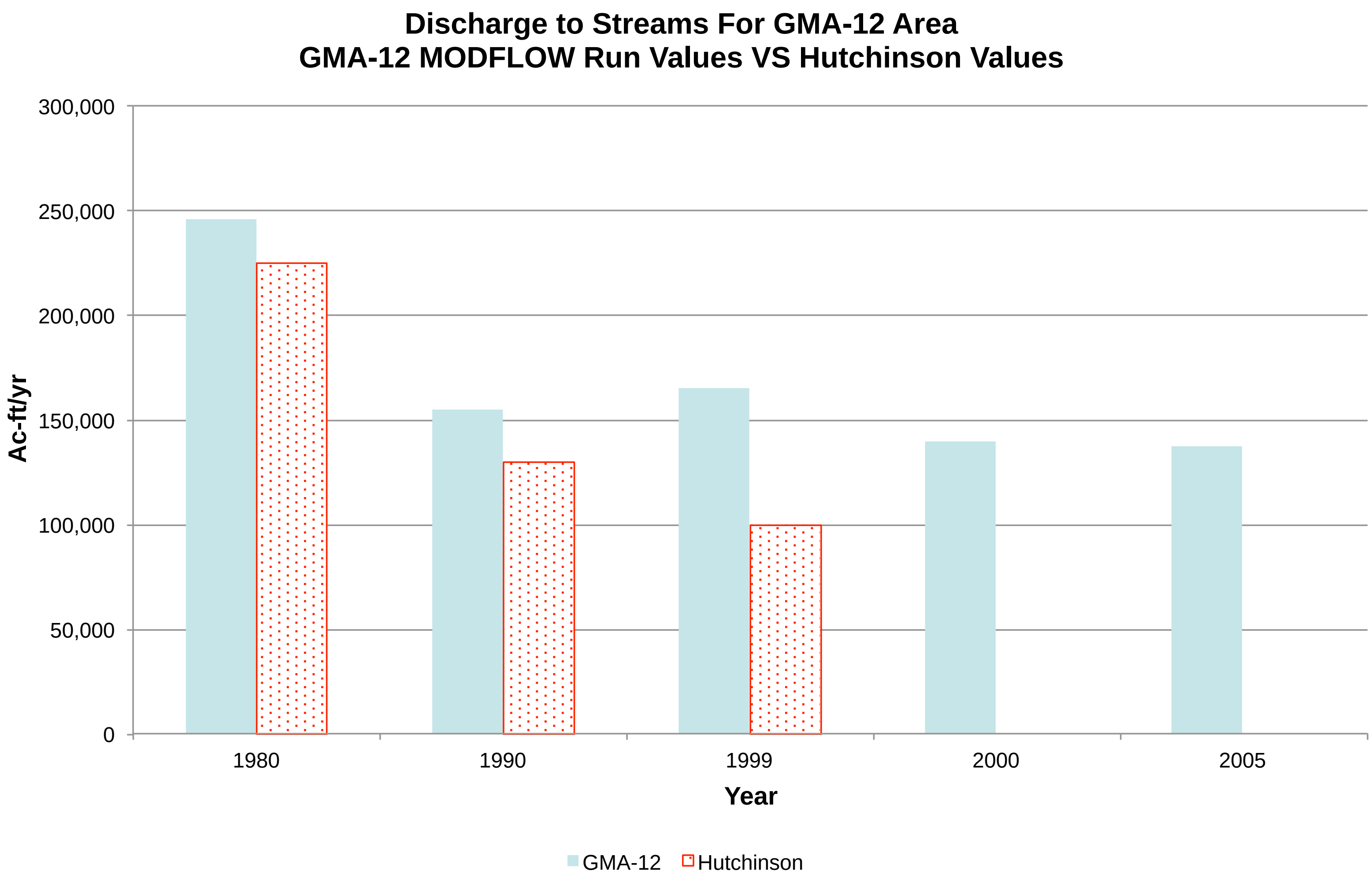

Recharge For GMA-12 Area
GMA-12 MODFLOW Run Values VS Hutchinson Values
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Ac-ft/yr
1980
1990
1999
2000
2005
Year
GMA-12
Hutchinson

Exhibit 4



Pumping For GMA-12 Area
GMA-12 MODFLOW Run Values VS Hutchinson Values
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Ac-ft/yr
1980
1990
1999
2000
2005
Year
GMA-12
Hutchinson

Exhibit 4



Discharge to Streams For GMA-12 Area
GMA-12 MODFLOW Run Values VS Hutchinson Values
300,000
250,000
200,000
150,000
100,000
50,000
0
Ac-ft/yr
1980
1990
1999
2000
2005
Year
GMA-12
Hutchinson

Exhibit 4

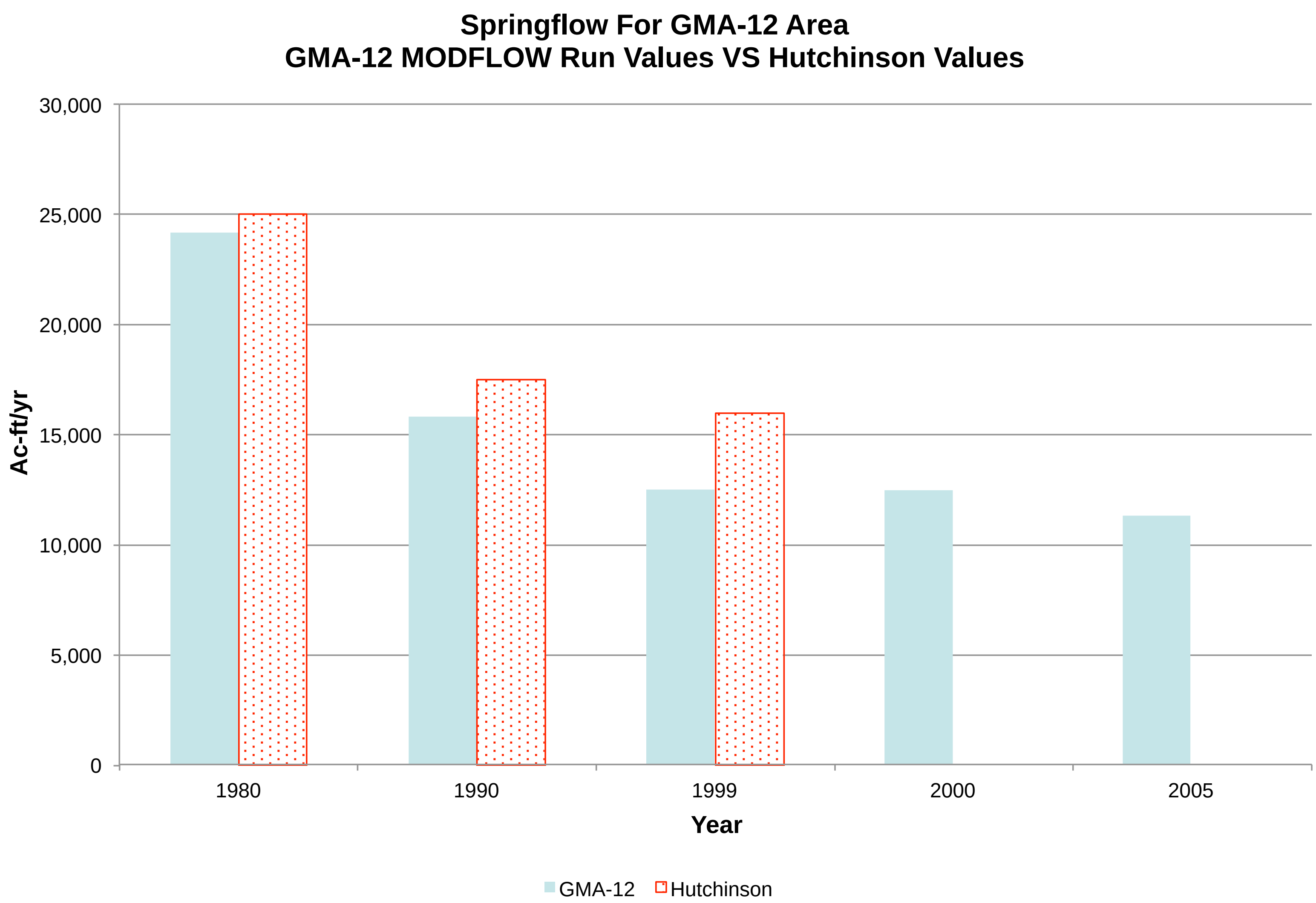
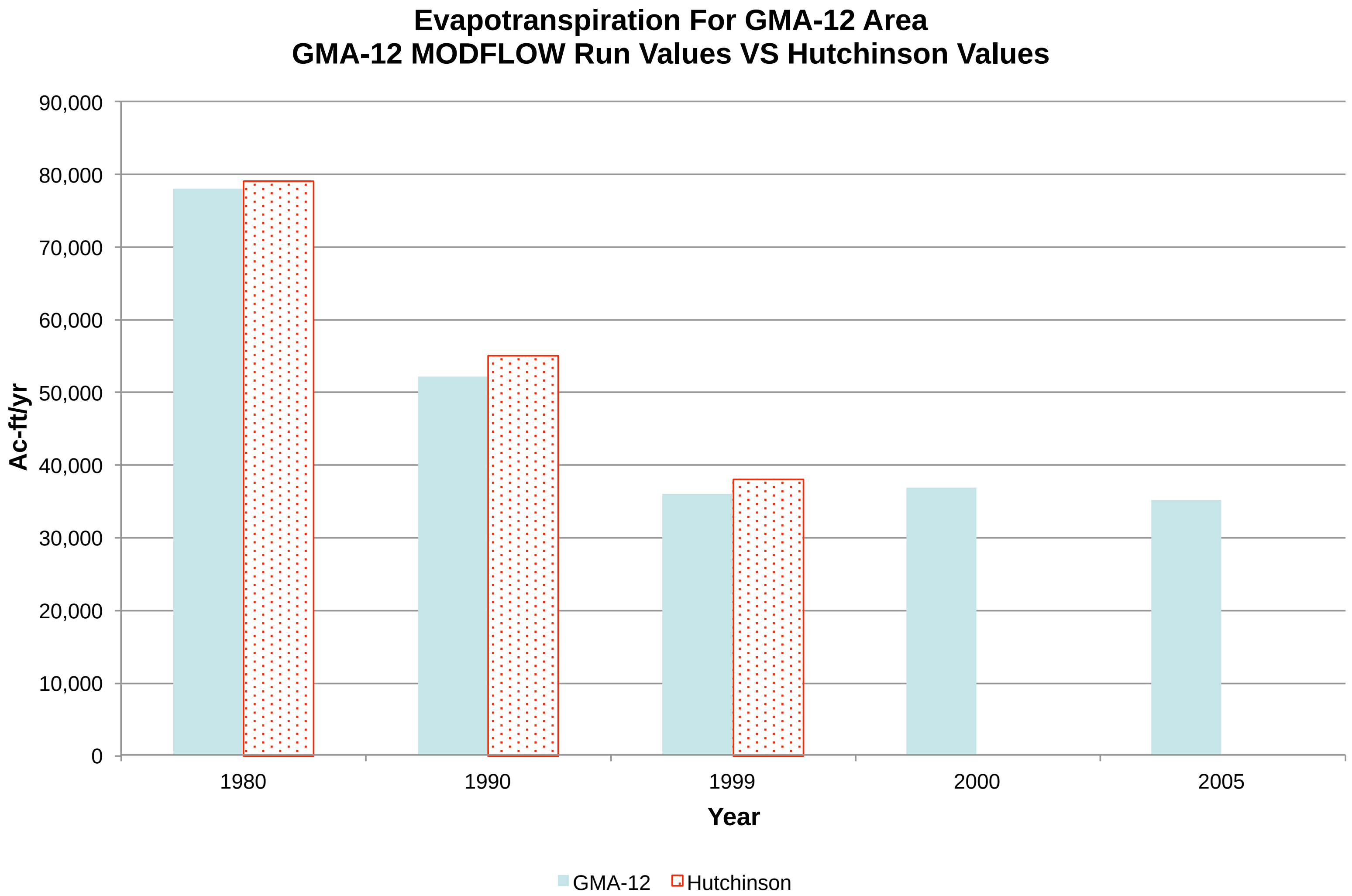

Springflow For GMA-12 Area
GMA-12 MODFLOW Run Values VS Hutchinson Values
30,000
25,000
20,000
15,000
10,000
5,000
0
Ac-ft/yr
1980
1990
1999
2000
2005
Year
GMA-12
Hutchinson

Exhibit 4



Evapotranspiration For GMA-12 Area
GMA-12 MODFLOW Run Values VS Hutchinson Values
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Ac-ft/yr
1980
1990
1999
2000
2005
Year
GMA-12
Hutchinson

Exhibit 4

Others Requested

- Requested that GMA-12 include surface waters in DFC:
  - Texas Parks and Wildlife Department – 2007-08
    (Attachments E, F & H)
  - Environmental Stewardship – 2008-11
    - Presentation to GMA-12, October 30, 2008 **(Attachments G, T, AA, CC)**
  - Texas Water Project - 2008
    - National Wildlife Federation
    - Sierra Club
    - Environmental Defense Fund
    (Attachment I)

TEXAS PARKS & WILDLIFE

A Groundwater Perspective on Surface Water Resources for GMA12

Dan Opdyke, PhD, PE
Water Resources Branch

(Attachment F)

May 10, 2007

TPWD Proposed DFC Metric: Streamflows

▲Streamflows are gauged in many locations and often have a long period of record.

- Streamflows have a direct impact on the environment.
- Surface water rights have been authorized contingent on the historical streamflow record
- Streamflows are a highly visible characteristic of the Texas landscape

(Attachment F)

Opdyke to GMA-12, May 10, 2007

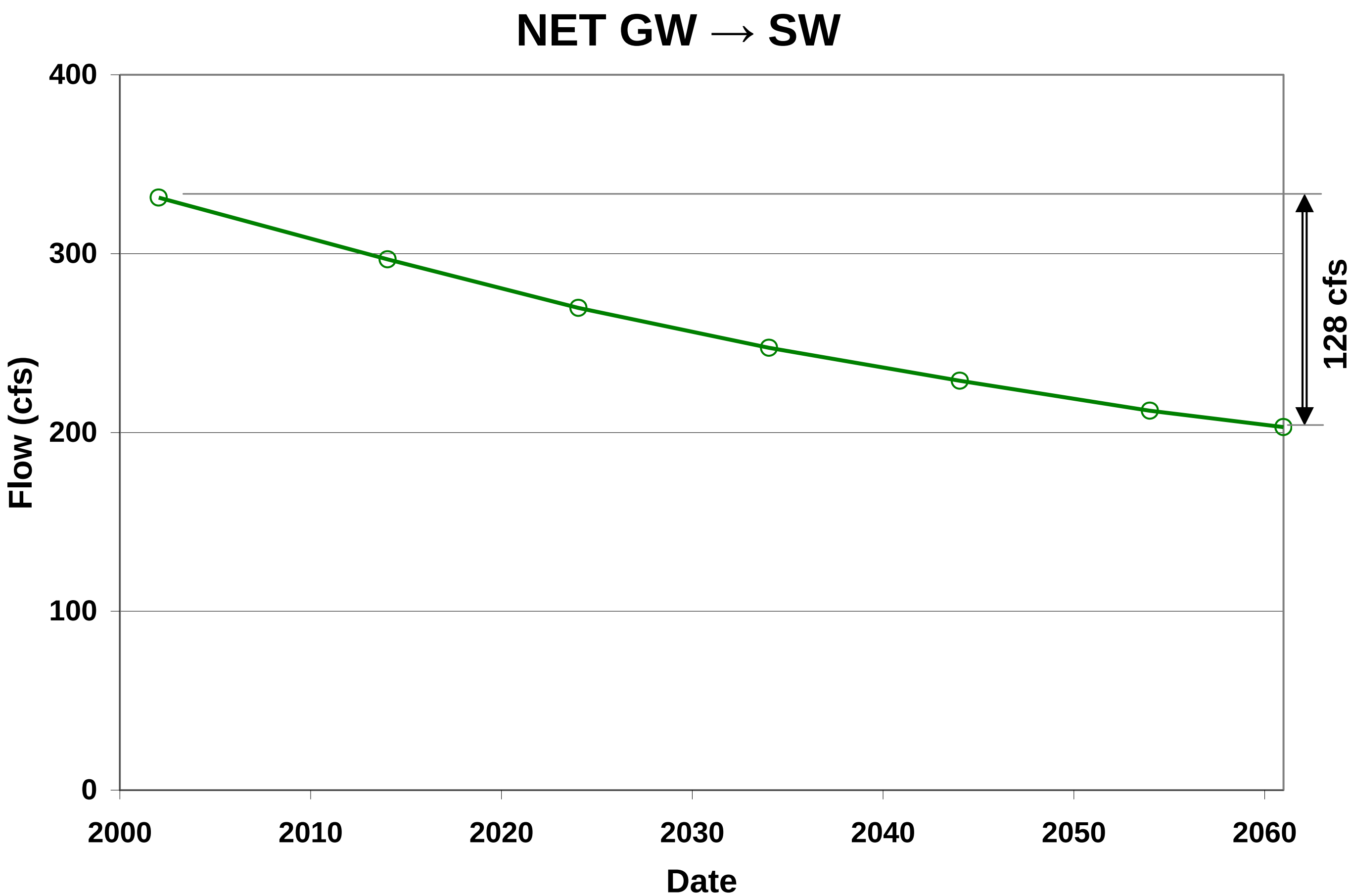
Importance of Springs and Baseflows

- **Springs**
  - Support unique aquatic environments, including rare species
  - Serve as a barometer of local aquifer conditions
  - Relatively inexpensive means of monitoring groundwater
  - Provide important baseflows to rivers

- **Baseflows**
  - Dependent on aquifer discharge
  - Important component of natural flow regime
  - Support habitats during dry periods

(Attachment F: **Opdyke to GMA-12, May 10, 2007)**

GMA-12 Groundwater Contribution to Surface Water (GW →SW)



(Attachment F: **Opdyke to GMA-12, May 10, 2007**

GMA-12 Groundwater Contribution to Surface Water (GW → SW)

- TPWD estimated that the Carrizo-Wilcox, Queen City and Sparta Aquifers in GMA-12 region will contribute 128 cfs less flow to surface water bodies in 2060 as compared to 2002 (2007 estimate)
- 128 cfs ≈ 93,000 ac-ft/yr
- Latest estimate is 136 cfs (per Opdyke, 2008)
  = 98,500 ac-ft/yr

Attachment F: **Opdyke to GMA-12, May 10, 2007**

TPWD Recommendations (in order of increasing difficulty)

- ▲Consider impacts to surface water during DFC deliberations
- ▲Include quantitative impacts to surface water in DFC definitions
- ▲Improve the GAMs in their representation of Groundwater/Surface water interaction

Geographic Regions

- The DFCs should evaluate conditions and impacts on rivers, creeks, springs and other terrestrial surface water resources in the riverine/alluvial and the pinewood forest geographic regions of the management area, especially during drought or extreme drought conditions.
  - Regions that differ substantially from the other regions in the management area

    TWC Section 36.108(d)
  - Rely on outflows from the aquifers

Riverine/Alluvial Geographic Regions

- Colorado & Brazos river alluvial regions
  - **Gain water from spring and surface water outflows from the aquifers**
  - **Provide habitat for the State threatened blue sucker fish (*Cycleptus elongatus)* (Exhibit 12)**
  - **Are substantially different from the non-riverine/non-alluvial geographic regions within the management area**
    - **(Exhibit 13 – Geologic Atlas of Texas – Austin, Alluvium)**
  - **Warrant special protection**

Riverine/Alluvial Geographic Regions

- Colorado River has a groundwater-surface water relationship with following aquifers in Bastrop and Fayette counties:
  - Carrizo-Wilcox group
  - Queen City
  - Sparta
  - Yegua-Jackson
  - Colorado River Alluvium
- Brazos River has a groundwater-surface water relationship with the following aquifers in Burleson, Milam, Robertson and Brazos counties:
  - Carrizo-Wilcox group
  - Queen City
  - Sparta
  - Yegua-Jackson
  - Brazos River Alluvium

Lost Pines Geographic Region

- **The soils of the loblolly pines (*Pinus taeda)* region gain moisture from the aquifers**
  - **Depend on water outflows to the surface for moist soil (Exhibit 14)**
  - **Provide habitat to the federally endangered Houston Toad (*Bufo houstonensis)* (Exhibits 14-19)**
  - **Differs substantially from the non-pinewood forest regions of the management area**
    - Carrizo Sands (Ec)
    - Reklaw Formation (Er)
    - Queen City Sands (Eqc)
    - Weches Formation (Ew)

(Exhibit 16
Geologic Atlas TX – Austin)

  - **Warrant Special Protection**

Consider impact on Environmental Flows

- ▲ Decreased flow to the Colorado River and inflows to Matagorda Bay are in direct conflict with the environmental flow policies of Texas.

- ▲ Environmental Flow Policies (Senate Bill 3)
  - Require instream flows for rivers and streams
  - Require freshwater inflows to the bays and estuaries
  - Especially during drought or extreme drought conditions

Environmental Flows

The Texas State Legislature recognized the value of Texas surface waters by enacting Senate Bill 3

- SECTION 1.06. (b) **Maintaining the biological soundness of the state's rivers, lakes, bays, and estuaries is of great importance to the public's economic health and general well-being.** The legislature encourages voluntary water and land stewardship to benefit the water in the state.

  (c) The legislature has expressly required the commission while balancing all other public interests to consider and, to the extent practicable, **provide for the freshwater inflows and instream flows necessary to maintain the viability of the state's streams, rivers, and bay and estuary systems** in the commission's regular granting of permits for the use of state waters

- "Environmental flow regime" means a schedule of flow quantities that reflects seasonal and yearly fluctuations that typically would vary geographically, by specific location in a watershed, and that are shown to be **adequate to support a sound ecological environment and to maintain the productivity, extent, and persistence of key aquatic habitats in and along the affected water bodies.**

- **Established the Colorado and Lavaca Basins and Matagorda and Lavaca Bays Area Stakeholder Committee (CL BBASC) that completed its recommendations report in September 2011.**

Passed by 80th Session of the Texas State Legislature
Signed into Law June 16, 2007

Environmental Flows (freshwater inflows) for Matagorda Bay

Recommended freshwater inflow regime for Matagorda Bay

	Flow Volumes (acre-feet)			Achievement Guideline†
Threshold	Maintain 15,000 acre-feet per month			100%
Regime:	**Spring**	**Fall**	**Intervening**	
MBHE 1	114,000	81,000	105,000	90%*
MBHE 2	168,700	119,900	155,400	75%*
MBHE 3	246,200	175,000	226,800	60%*
MBHE 4	433,200	307,800	399,000	35%*

†Achievement guidelines refer to the amount of time that the flow volumes should be met or exceeded.

*Based on historical frequency of occurrence.

- Table does not include Long-Term targets.
- 15,000 ac-ft/month is an inflow of about 249 cfs from the Colorado River measured at Bay City, TX.

Exhibits 7: Colorado Lavaca Basin and Bay Area Stakeholder Committee (CL BBASC) Report, September 1, 2011, required by Senate Bill 3.
Exhibit 20: CL Expert Science Team (CL BBEST), **Exhibit 21:** LSWP Matagorda Bay Health Evaluation

Environmental Flows (instream flows) for Colorado River at Bastrop

Colorado River at Bastrop, USGS Gage 08159200,

Recommended Environmental Flow Regime*

Flow	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Subsistence (cfs)	208	274	274	184	275	202	137	123	123	127	180	186
Base – Dry (cfs)	313	317	274	287	579	418	347	194	236	245	283	311
Base – Average (cfs)	433	497	497	635	824	733	610	381	423	433	424	450

* Above does not include pulse flows, channel maintenance and overbank recommendations.

Exhibits 7: Colorado Lavaca Basin and Bay Area Stakeholder Committee (CL BBASC) Report, September 1, 2011, required by Senate Bill 3, **Exhibit 20:** CL Expert Science Team (CL BBEST), **Exhibit 12:** LSWP Instream Flows Report

Scenario for Colorado River

- **Colorado River flow @ Bastrop could be non-compliant for 8 of 12 months (66%)**
  - Without groundwater outflows (36 cfs)
  - Without an emergency declaration
  - Bastrop flow could be reduced to less than subsistence levels
- **Colorado River flow @ Bastrop could be non-compliant for 12 of 12 months (100%)**
  - Due to an Emergency Declaration
- **Colorado River at Bastrop is partially dependent on groundwater outflows**

Exhibit 25: (calculations for above scenario)

Scenario for Colorado River

- **Flows managed according to LCRA's Water Management Plan** **(Exhibits 23 & 24)**
- **Conditions on January 1, 2012**
  - Highland Lake Storage ~ 740,000 ac-ft
  - Colorado River low flow @ Bastrop 283 cfs
  - Subsistence flow required at Bastrop = 123-202 cfs
- **IF Extreme Drought Continues (and it has)**
  - Highland Lake Storage drops below 600,000 ac-ft
  - Interruptible water cut off
    - Almost all irrigation has been cut off
    - Minimum irrigation flow in the river this spring
  - Firm water could be curtailed
    - Reduced return flow

Environmental Flow during Drought Conditions

Critical Flow - life support during drought

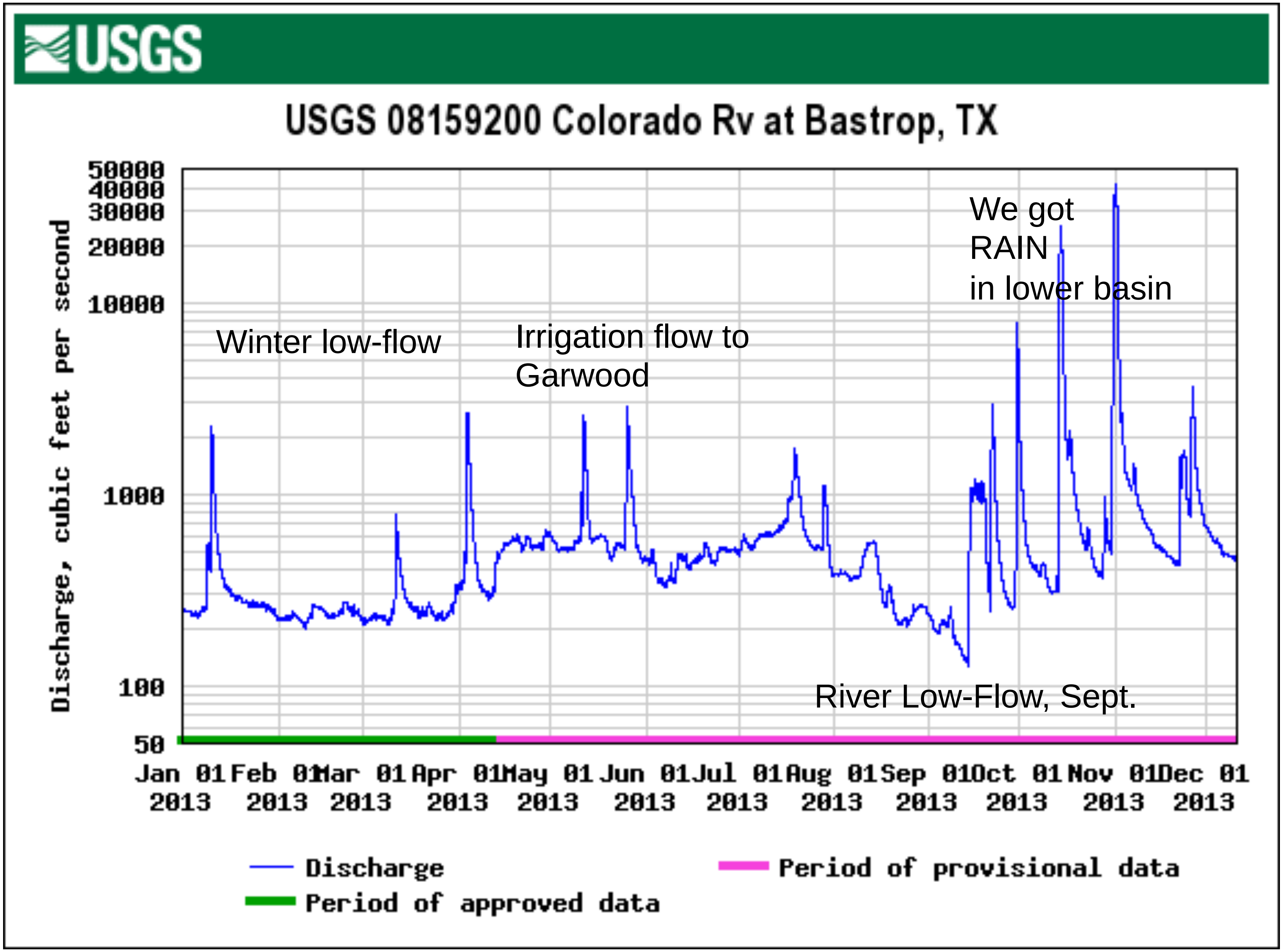
River and Bay On Life Support for the last three years

Instream Flows for the Rivers

- Bastrop Gage
  - Minimum flow standard: 120 cfs (123-202 cfs)
  - Low flow (Sept, 2013): 170 cfs **(Includes CoA return-flow)**
  - Groundwater contribution: ~36 cfs **(30% of minimum flow)**
    - Approximately 25,000 – 35,000 acre-feet per year.

Freshwater Inflows for the Bays

- Matagorda Bay 14,500 acre-feet/month


USGS
USGS 08159200 Colorado Rv at Bastrop, TX
Discharge, cubic feet per second
50000
40000
30000
20000
10000
1000
100
50
Winter low-flow
Irrigation flow to Garwood
We got RAIN in lower basin
River Low-Flow, Sept.
Jan 01 2013
Feb 01 2013
Mar 01 2013
Apr 01 2013
May 01 2013
Jun 01 2013
Jul 01 2013
Aug 01 2013
Sep 01 2013
Oct 01 2013
Nov 01 2013
Dec 01 2013
Discharge
Period of approved data
Period of provisional data

Environmental Impacts

- Aquifer outflows of GMA-12 contribute significant environmental flows to the Colorado and Brazos rivers; especially in times of drought.
- Significant environmental impacts are projected from the desired future conditions of GMA-12 by the groundwater availability model as outflows decline and/or reverse.
- GAM runs for major pumping predict induced leakage from other aquifers into the pumped aquifer lowering water levels in wells and dewatering some unconfined areas.

Environmental Impacts

(Continued)

- Impacts of dewatering terrestrial and surface water features in the pinewood forest and Colorado River alluvium geological regions need to be considered in the DFC.
- Projected environmental impacts conflict with the environmental flow policies of the State of Texas and could result in non-compliance during extreme drought.

ES Requests

- **GMA-12 DFC process include:**
  - **Consider impacts of reduced surface water outflows on**
    - Environment, springs and streams
    - Property rights and private wells
  - **Preserve groundwater-surface water relationship**
    - Protect Environmental Flows & State Policies
  - **Adaptive Management Recommendations**
    - Inform decisions and policies
    - Optimize conjunctive management
    - Avoid necessity of undoing harm
  - **Set different DFCs for substantially different geographic areas**

ES Requests

Adaptive Management by GMA and GCDs

- ▲ GCDs install <u>monitoring projects</u> to provide empirical data to detect change in the groundwater-surface water relationship in the areas of concern.
  - – Develop and implement <u>in cooperation with the river authorities, USGS</u>, and, to the extent necessary, the regional water planning groups in the management area.
- ▲ GCDs establish <u>triggers linked to specific actions</u> to mitigate and limit any potential damage to the rivers, streams, springs and aquifers of the region (adaptive management).

Adaptive Management

- Adaptive management is the State's preferred method of managing new and changing regulatory processes.
  - Empirical data informs/calibrates models
  - Monitoring guides decision making
  - Science guides public policy
- Data are needed to
  - Improve the models
  - Sustainably protect the resources
  - Optimize conjunctive management

Monitoring Tools Exist

- **Adequate tools and monitoring methodologies exist to detect and respond to changes in the groundwater-surface water relationships that can be employed to avoid negative impacts while optimizing the conjunctive use of both resources.**
  - Gain/Loss studies on rivers and streams (LCRA/USGS – Attachments J & K)
  - Well and surface water gage relationships (LCRA-SAWS Project – Exhibits 26-29)
  - GCD monitoring wells

Monitoring Tools Exist

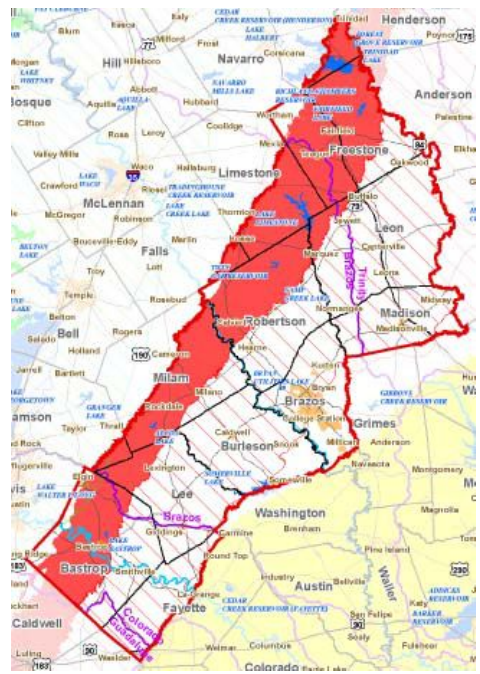
- LCRA-SAWS Water Project
  - Shallow Monitoring Well Installation Wharton and Matagorda Counties, Texas **(Exhibit 26)**
  - Monitoring Data Report from April 2006 to December 2007 for the LSWP Shallow Wells Installed in Wharton and Matagorda Counties, Texas **(Exhibit 27)**
  - A Site Conceptual Model to Support the Development of a Detailed Groundwater Model for Colorado, Wharton and Matagorda Counties. **(Exhibit 28)**
  - Development of the LCRB Groundwater Flow Model for the Chicot and Evangeline Aquifers in Colorado, Wharton, and Matagorda Counties **(Exhibit 29)**
  - LCRA-SAWS LSWP Project Study Archives: http://www.lcra.org/water/lswp/groundwater.html

Monitoring Tools Exist

- ▲ USGS Partnership Projects
  - – San Antonio River (Exhibit 30)
    - – River flow model interface with GAM
    - – Recharge model data available for GAM
    - – Evapotranspiration model available for GAM
    - – Provide input data to Carrizo-Wilcox, Queen City, Sparta GAMS
  - – Ogallala Aquifer (Exhibit 31)
    - – Water Budget Methods & Importance to good management
    - – Major Geologic Units
    - – Water availability and sustainability (Lost Pines GCD)
    - – Soil-Water-Balance Models (Loblolly pines)
  - – Guadalupe River (Exhibit 32)

It's GMA-12's Responsibility to the Citizens of our Region

- **To establish Desired Future Conditions** (DFC) for the aquifers in our region that protect the groundwater, surface water, and environmental resource of the area.
- **DFC's that:**
  - **Protect**
    - **the Aquifers**
    - **rivers & streams**
    - **Springs**
    - **Surface features (Trees, etc.)**
  - **Balance**
    - **Pumping and**
    - **Recharge**
  - **Provide needs of**
    - **Local Counties**
    - **Export where possible**



References

- “Attachments” are to Original Petition
- “Exhibits” are to Hearing Documents
- “New Exhibits” are provided
- See ES Website Page: http://www.environstewardship.org/2012/04/21/groundwater-management-area-12-environmental-stewardships-petition-appealing-desired-future-conditions/#more-506

Environmental Stewardship

A Sustainable Ecosphere

Environmental-Stewardship.org

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