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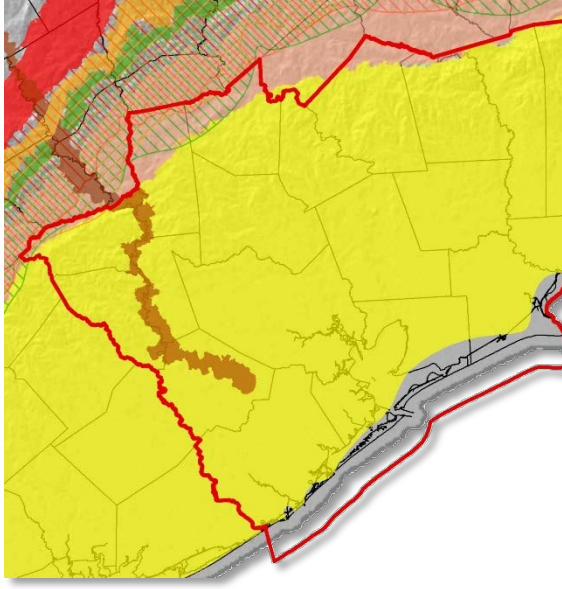

Review of Proposed Desired Future Conditions and Statutory Criteria from TWC 36.108(d)(1)-(9)

GROUNDWATER MANAGEMENT AREA 14

June 24, 2015

Project Status

- Overview
  - Northern Gulf Coast (NGC) GAM
  - Results of NGC GAM Run 2 and Proposed Desired Future Conditions (DFCs)
  - Consideration of Factors

Project Status

- Consideration of factors presented in TWC 36.108(d)(1)-(9)

Factor	04/13	05/13	06/13	09/13	04/14	06/14	09/14	11/14	06/15
Aquifer Uses and Conditions				●					●
Water Supply Needs and Strategies				●					●
Hydrological Conditions						●			●
Other Environmental Impacts						●			●
Impacts on Subsidence						●			●
Socioeconomic Impacts							●		●
Impacts on Private Property							●		●
Feasibility of Achieving DFC								●	●
Other Relevant Factors				○		○	○	○	○

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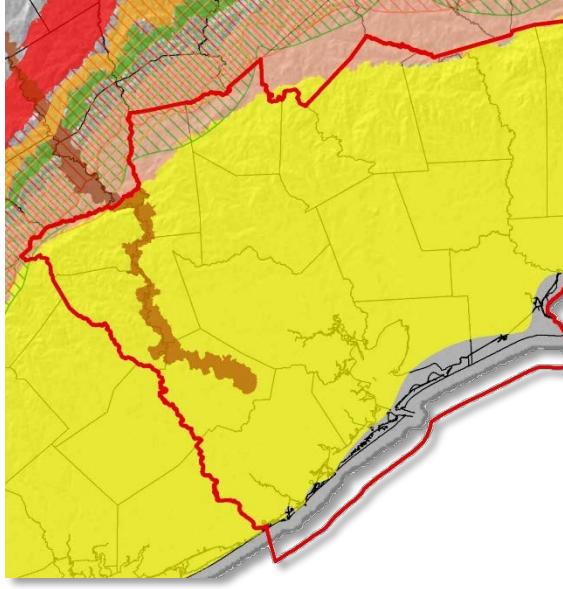

Northern Gulf Coast (NGC) GAM

Model Update Summary

June 24, 2015

NGC GAM

- GAM Development
  - Current model based on Houston Area Groundwater Model (HAGM)
  - Designed for MODFLOW-2000
  - Simulation of flow, heads, drawdown, and land subsidence at a regional scale for:
    - Chicot Aquifer
    - Evangeline Aquifer
    - Burkeville Confining Unit
    - Jasper Aquifer

NGC GAM

- TWDB Review and Approval
  - Technical analysis
  - Comment period and response by TWDB
  - Approved by TWDB February 18, 2014

We conclude that the Houston Area Groundwater Model is better than the Groundwater Availability Model for the northern part of the Gulf Coast Aquifer System to use for joint planning in Groundwater Management Area 14 because of the extension of the modeling period, implementation of land surface subsidence in all four layers, and because of the better comparison with a set of TWDB water level data from throughout the model area for the Chicot Aquifer, Evangeline Aquifer, and Burkeville confining unit.

TWDB GAM Task 13-043

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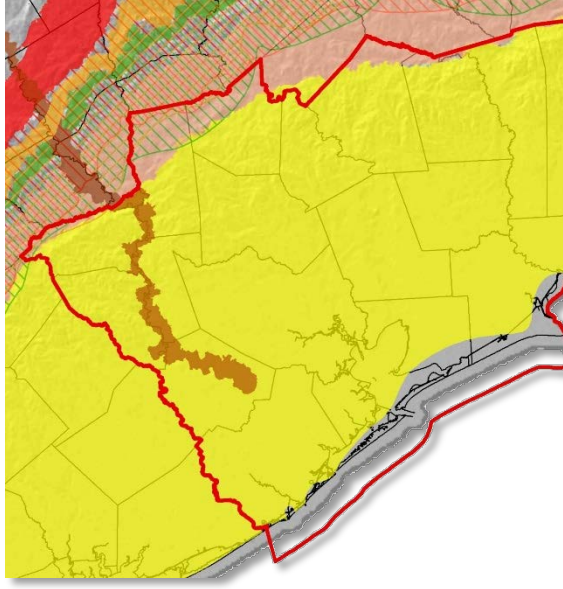


NGC GAM Run and Proposed Desired Future Conditions

Model Process and Results

June 24, 2015

NGC GAM Run and Proposed Desired Future Conditions

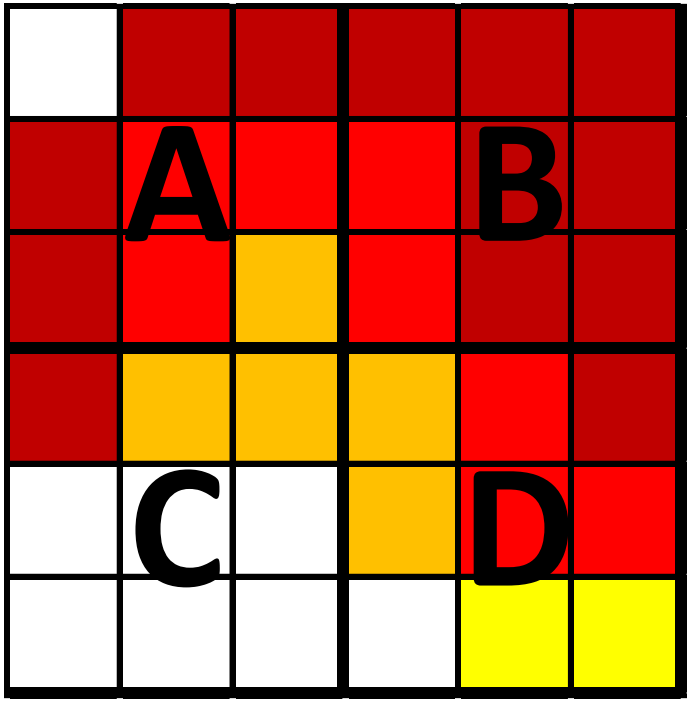
- Model Execution History
  - Revised model run
    - Presented June 24, 2014
    - Based on 2010 model run, district management plans, and district input
  - June 24, 2014 model run used for subsequent analysis and consideration

NGC GAM Run and Proposed Desired Future Conditions

- Model Results
  - Presented by layer
  - Presented by county
  - Variations from 2010 DFCs
    - Updates to historical dataset
    - Revisions through model calibration
    - Extended simulation period

NGC GAM Run and Proposed Desired Future Conditions

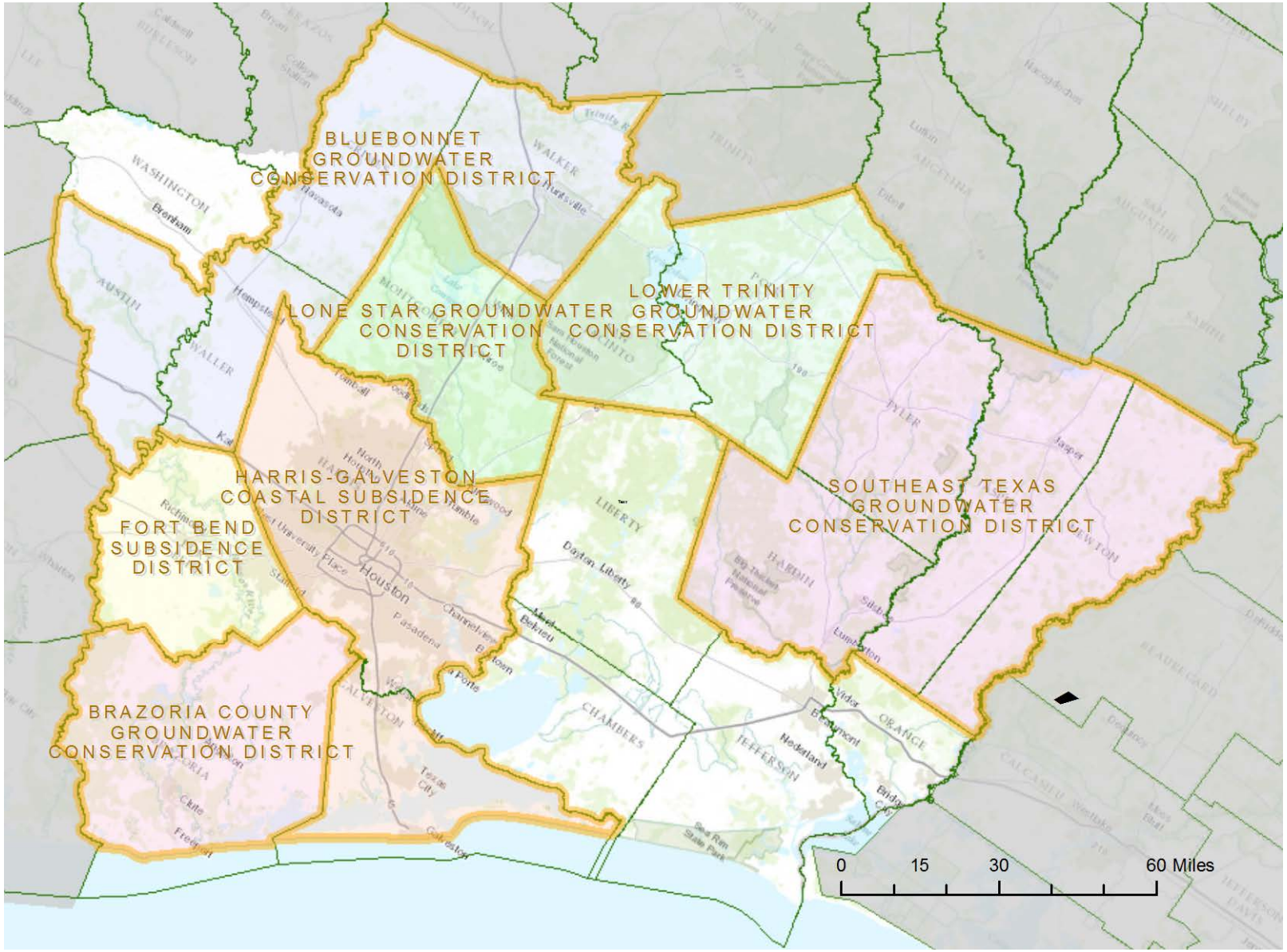
- Understanding Drawdown Results



16.9	18.9
13.3	11.9

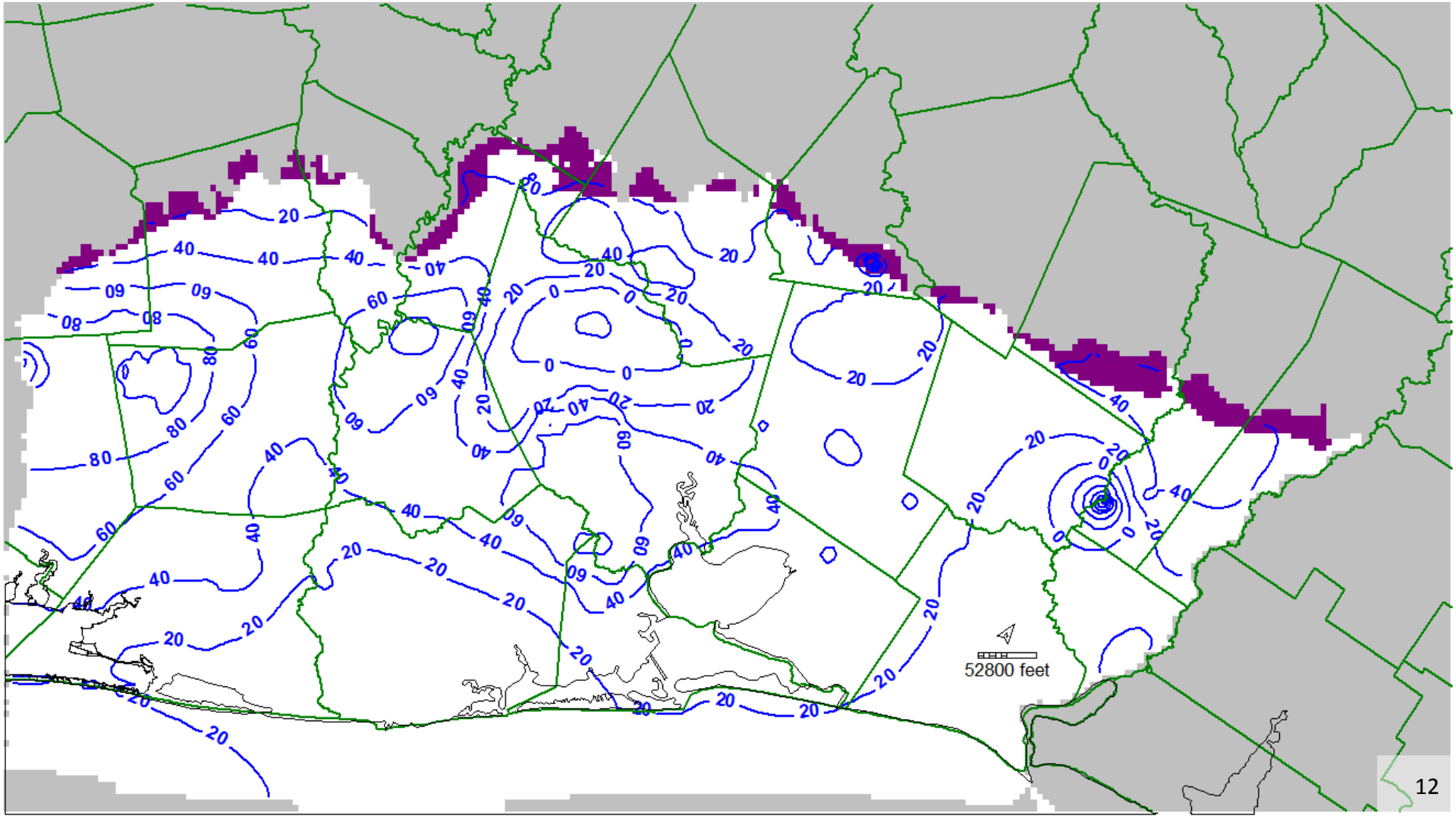
5 ft. of drawdown
10 ft. of drawdown
15 ft. of drawdown
20 ft. of drawdown

NGC GAM Run and Proposed Desired Future Conditions



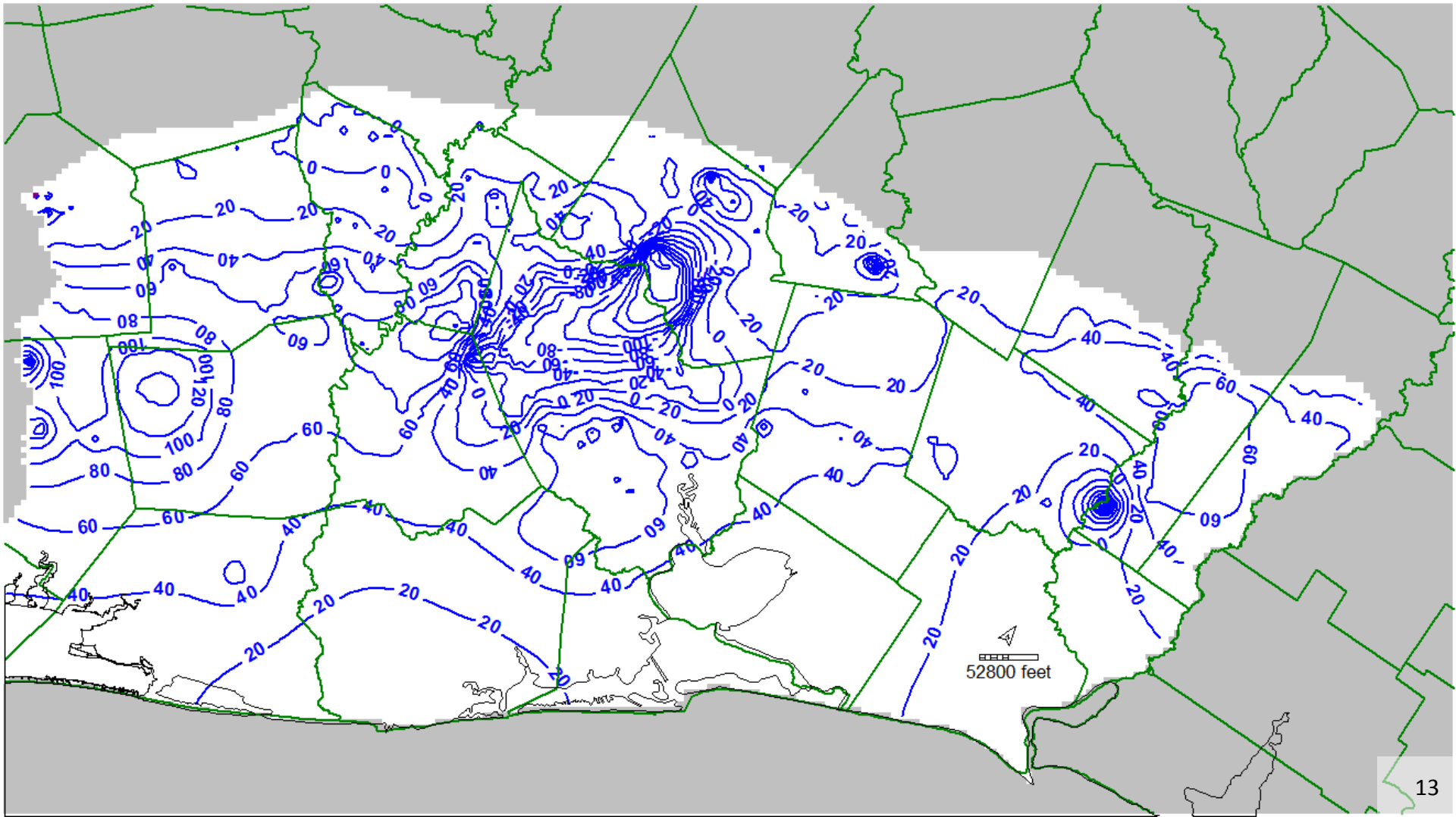
NGC GAM Run and Proposed Desired Future Conditions

- Model Results (2014/06) – Chicot



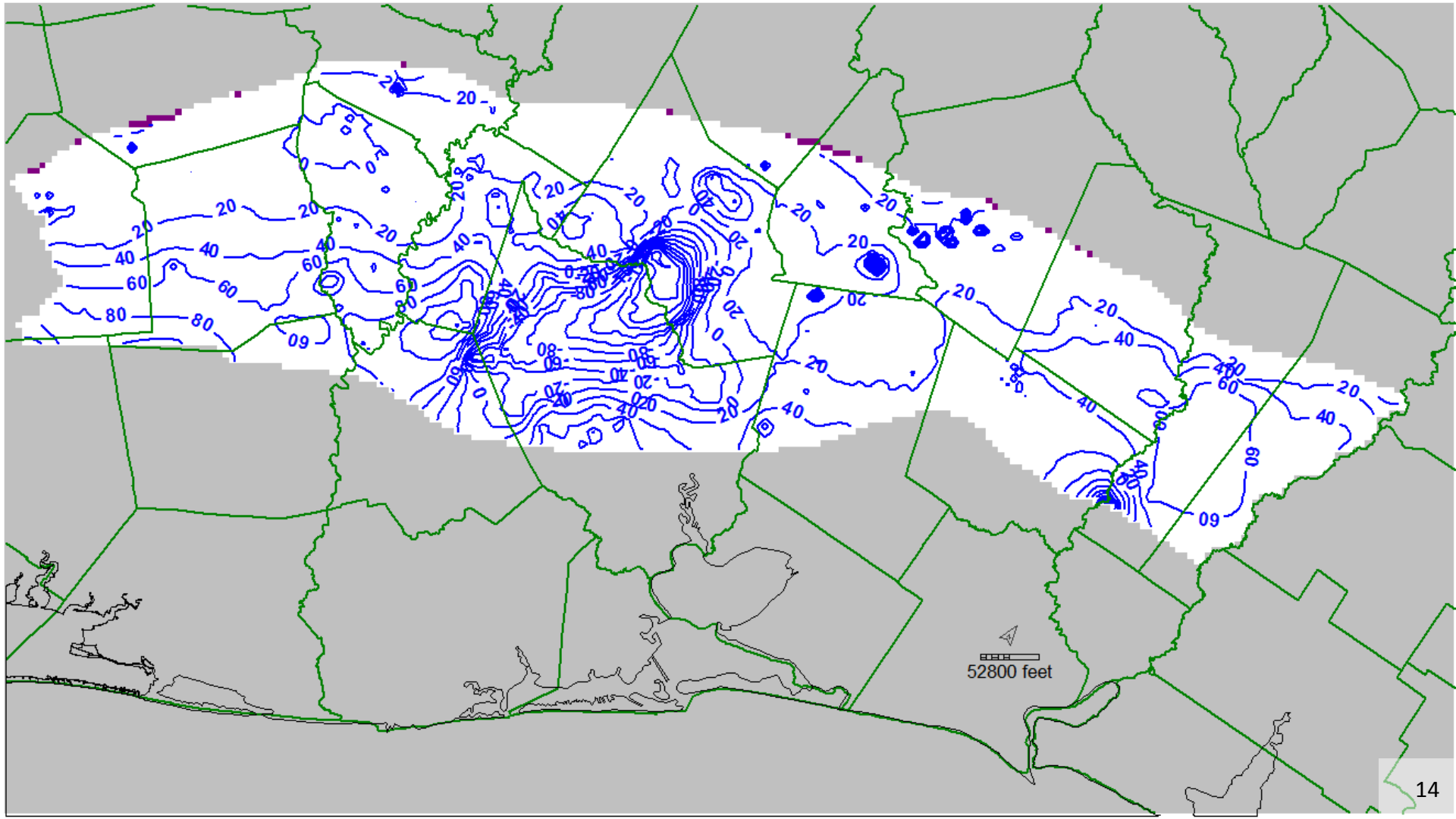
NGC GAM Run and Proposed Desired Future Conditions

- Model Results (2014/06) – Evangeline



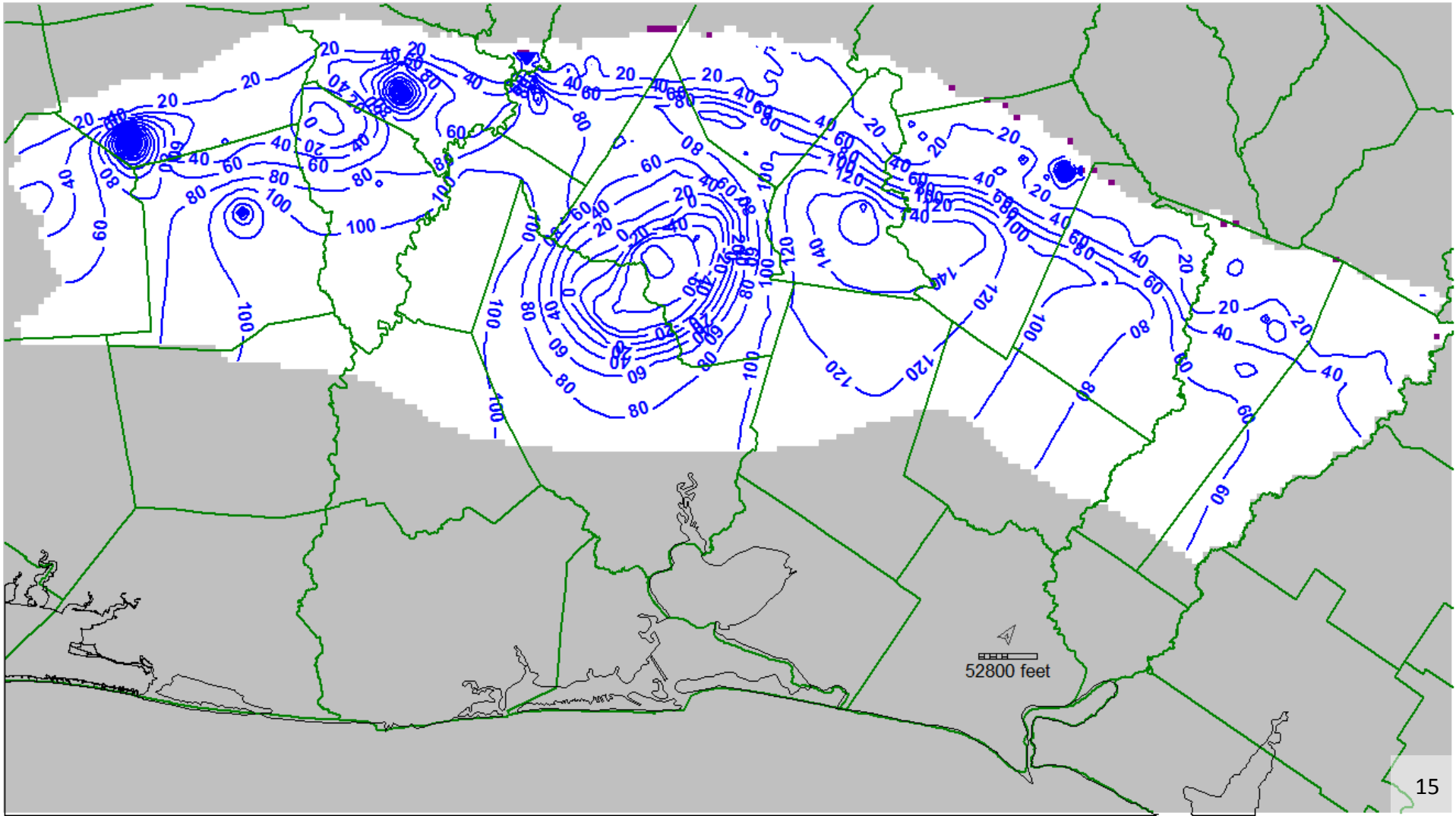
NGC GAM Run and Proposed Desired Future Conditions

- Model Results (2014/06) – Burkeville Confining Unit



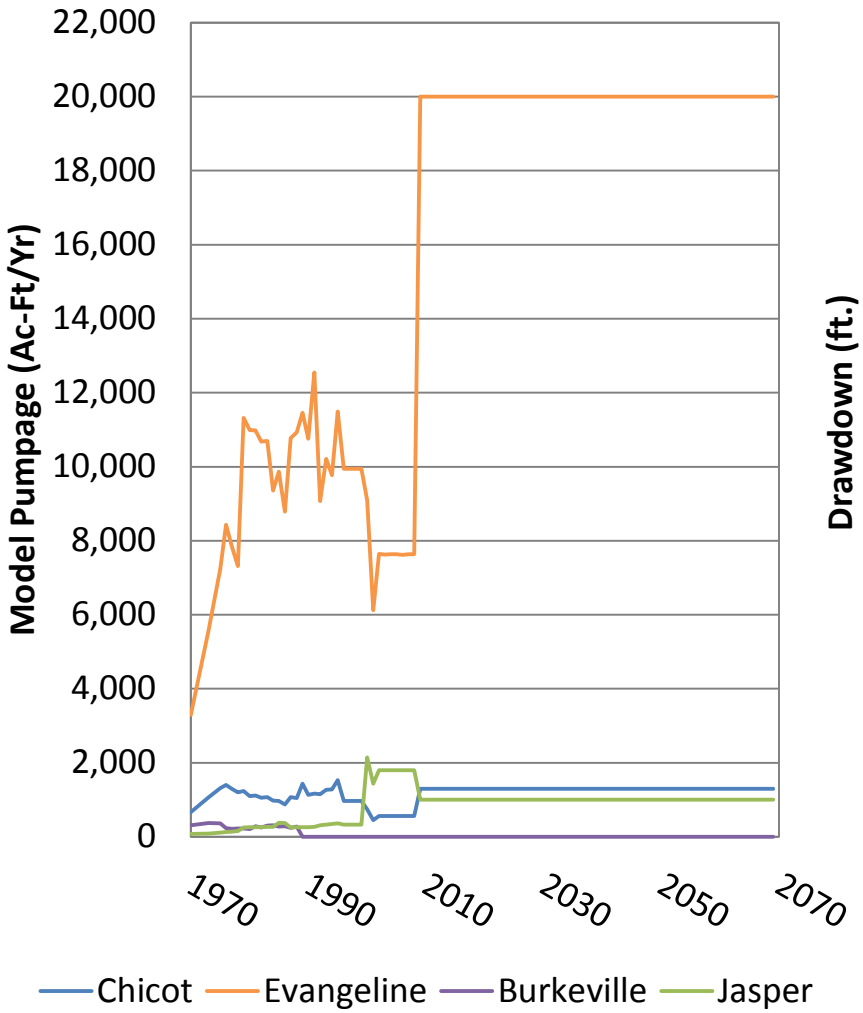
NGC GAM Run and Proposed Desired Future Conditions

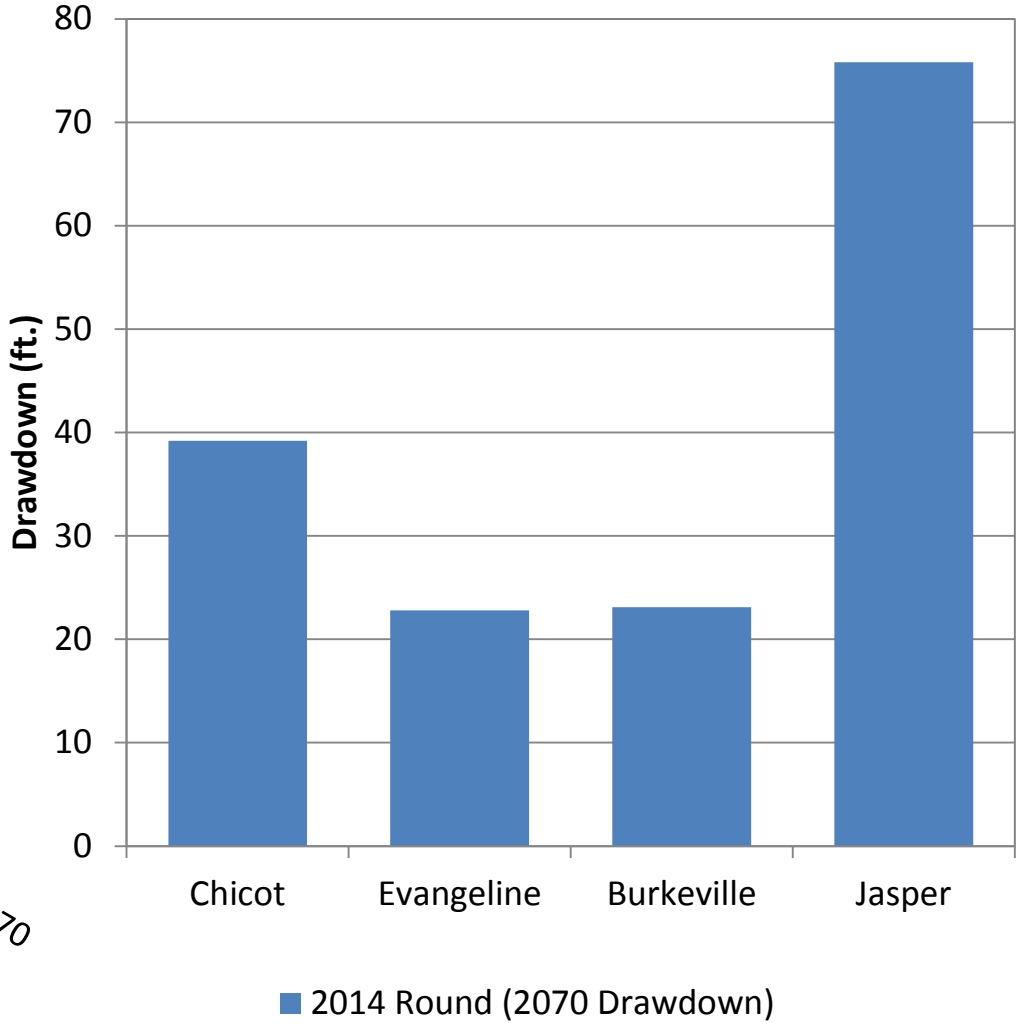
- Model Results (2014/06) – Jasper



NGC GAM Run and Proposed Desired Future Conditions

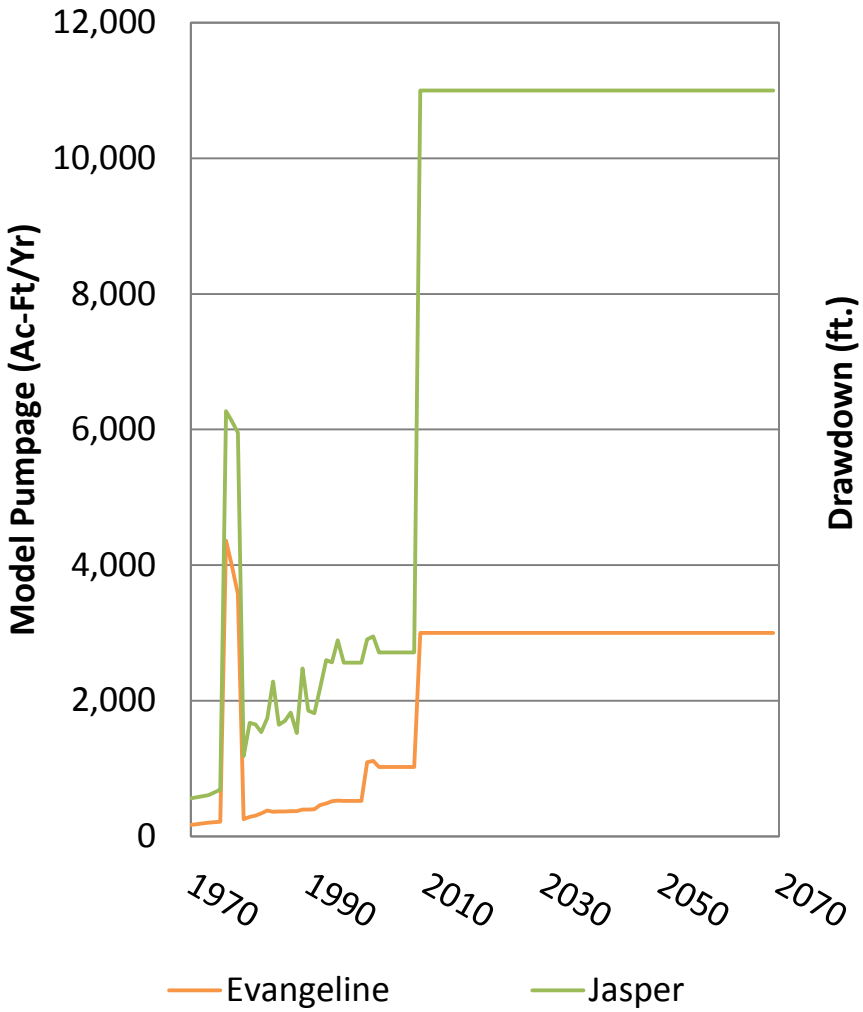
- Model Results – Austin County (BGCD)

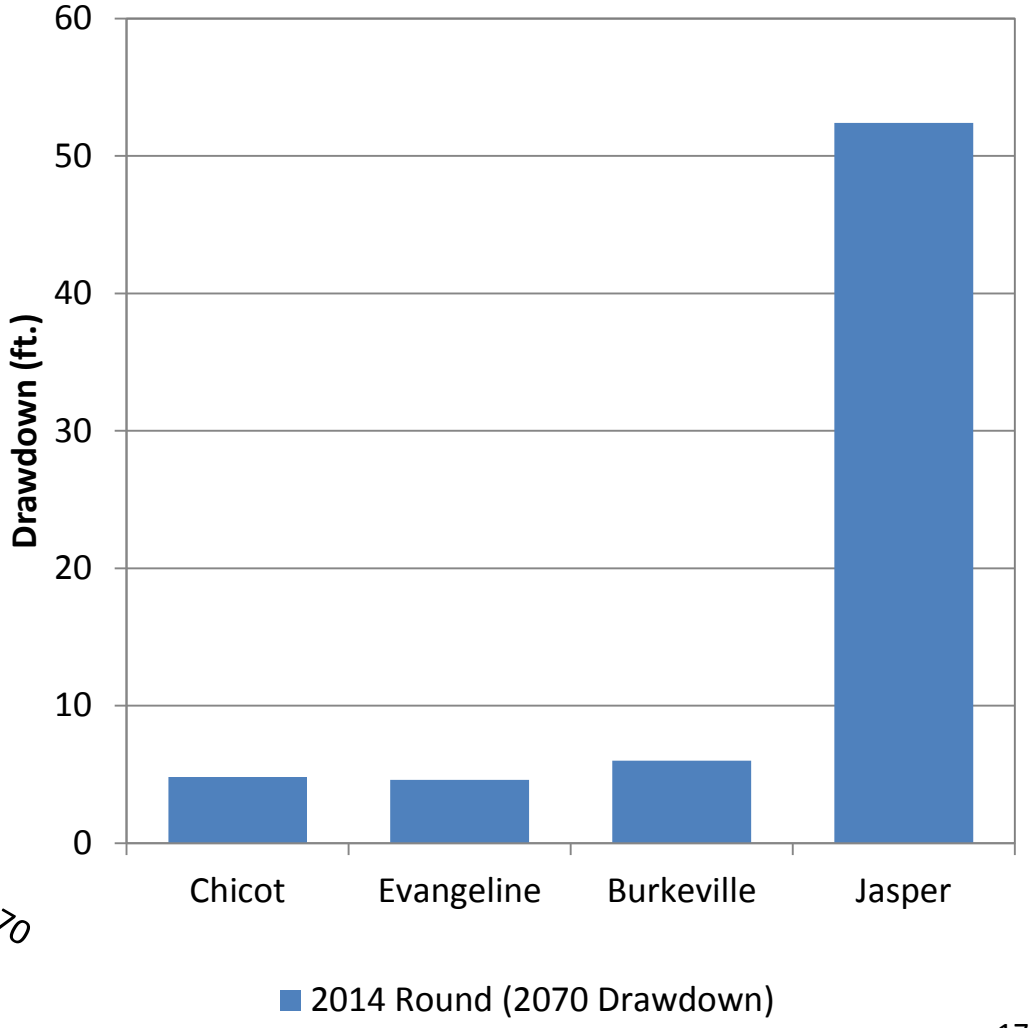




NGC GAM Run and Proposed Desired Future Conditions

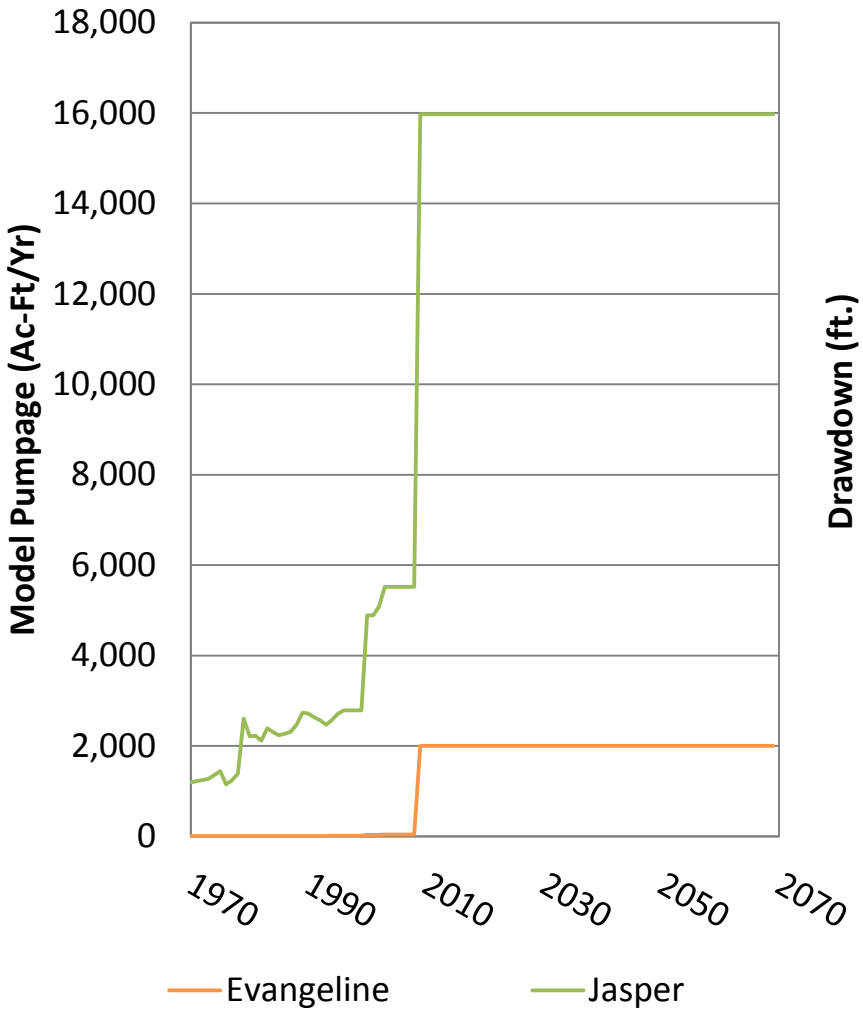
- Model Results – Grimes County (BGCD)

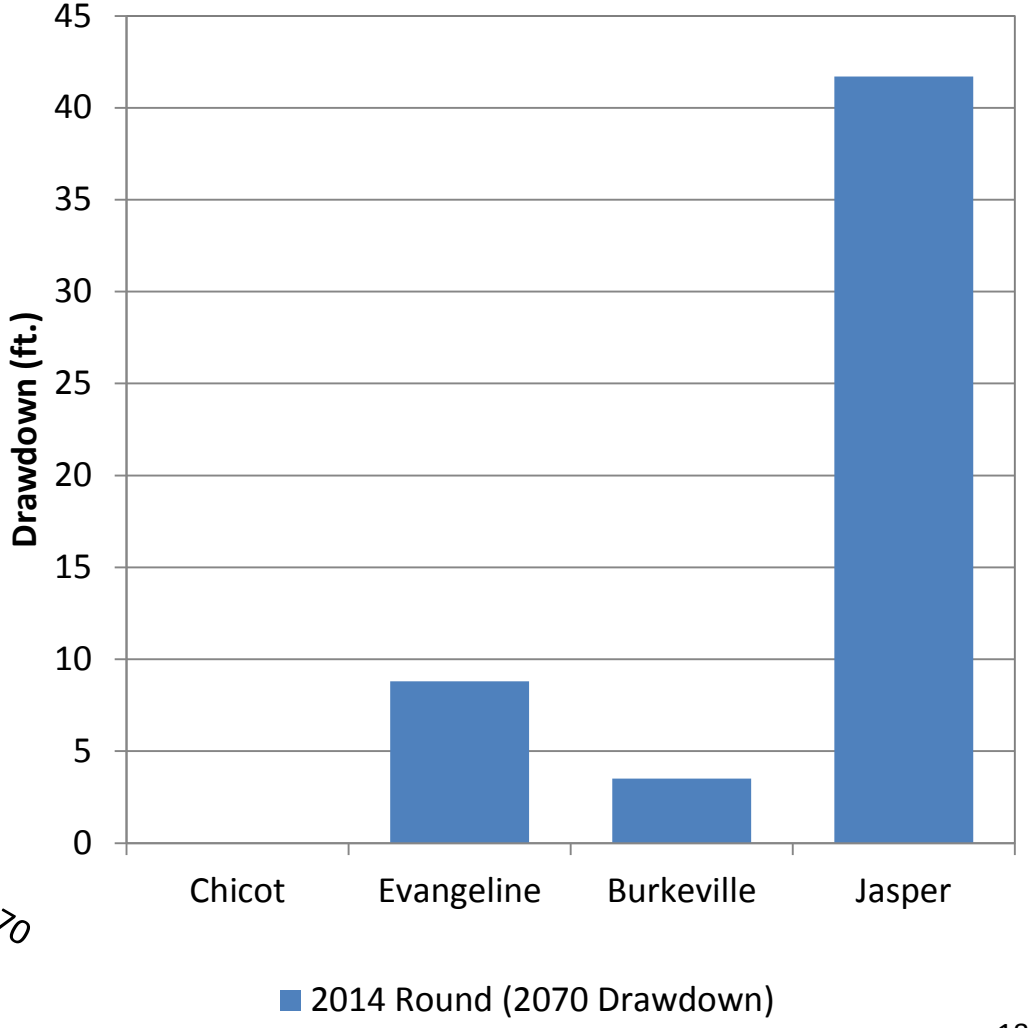




NGC GAM Run and Proposed Desired Future Conditions

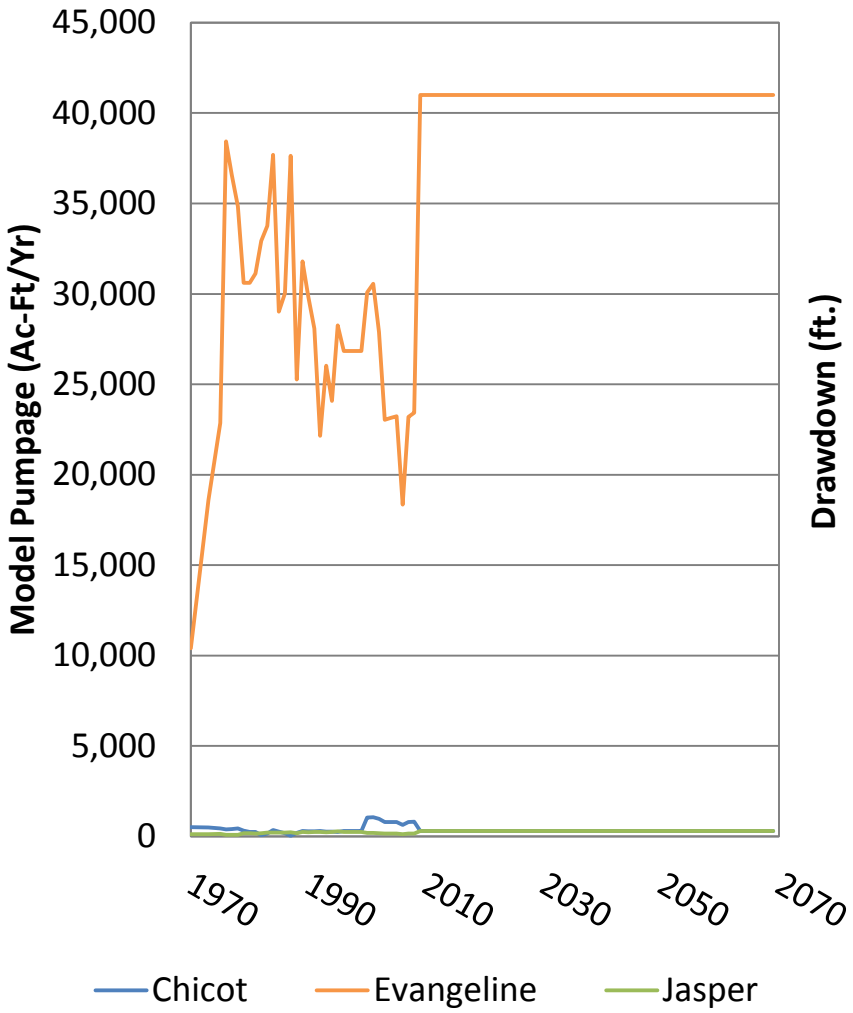
- Model Results – Walker County (BGCD)

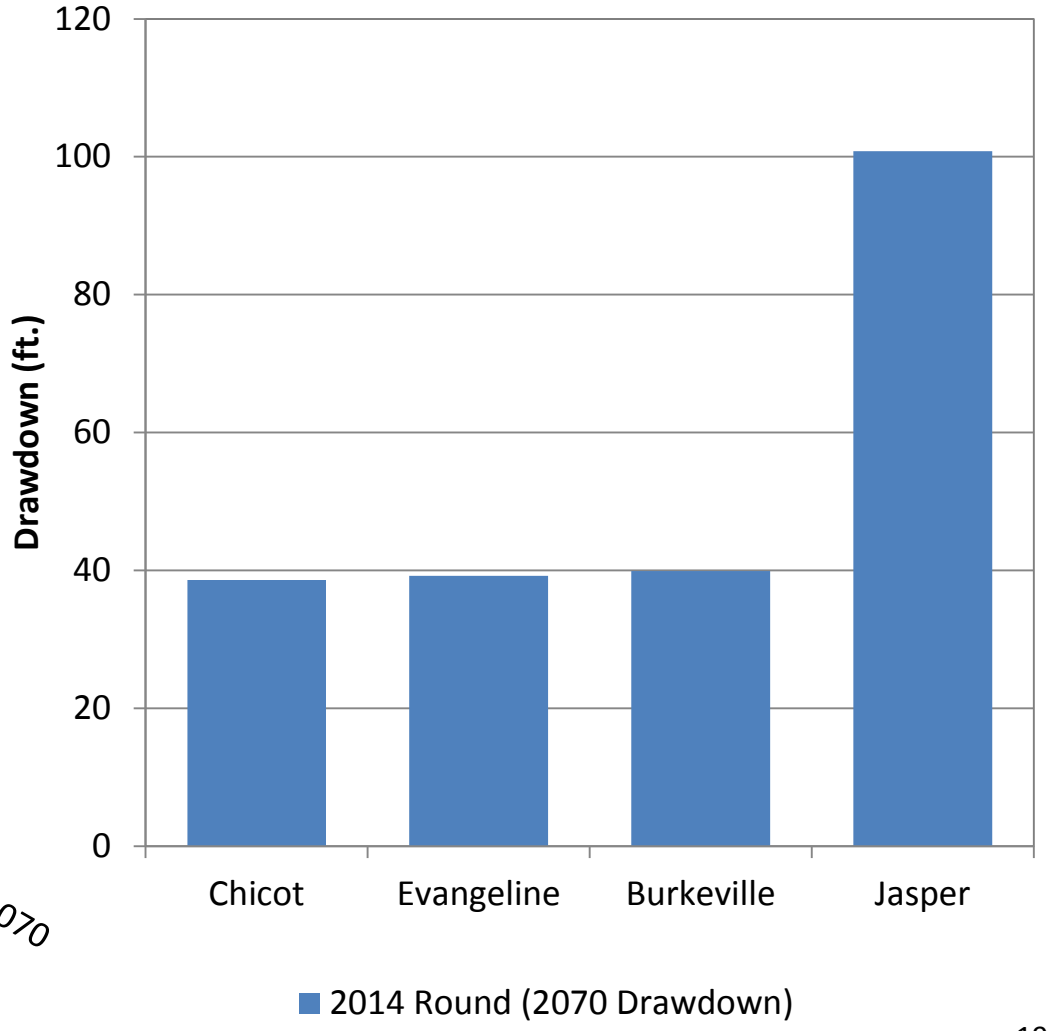




NGC GAM Run and Proposed Desired Future Conditions

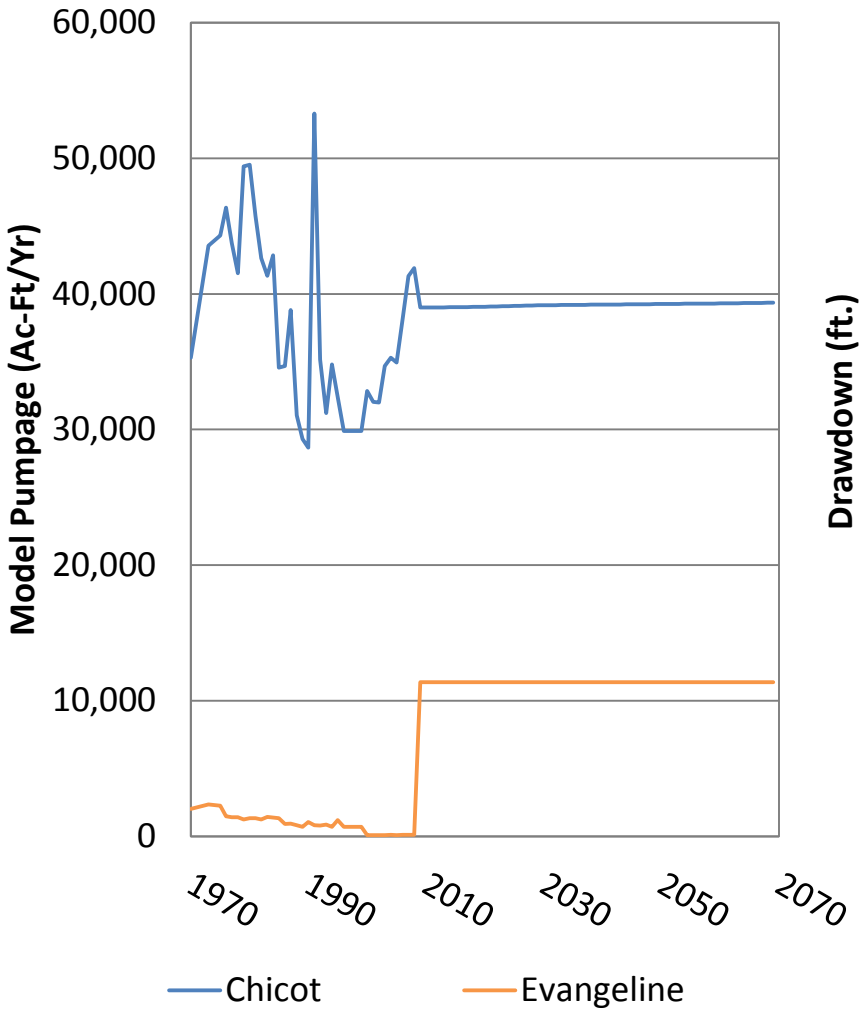
- Model Results – Waller County (BGCD)

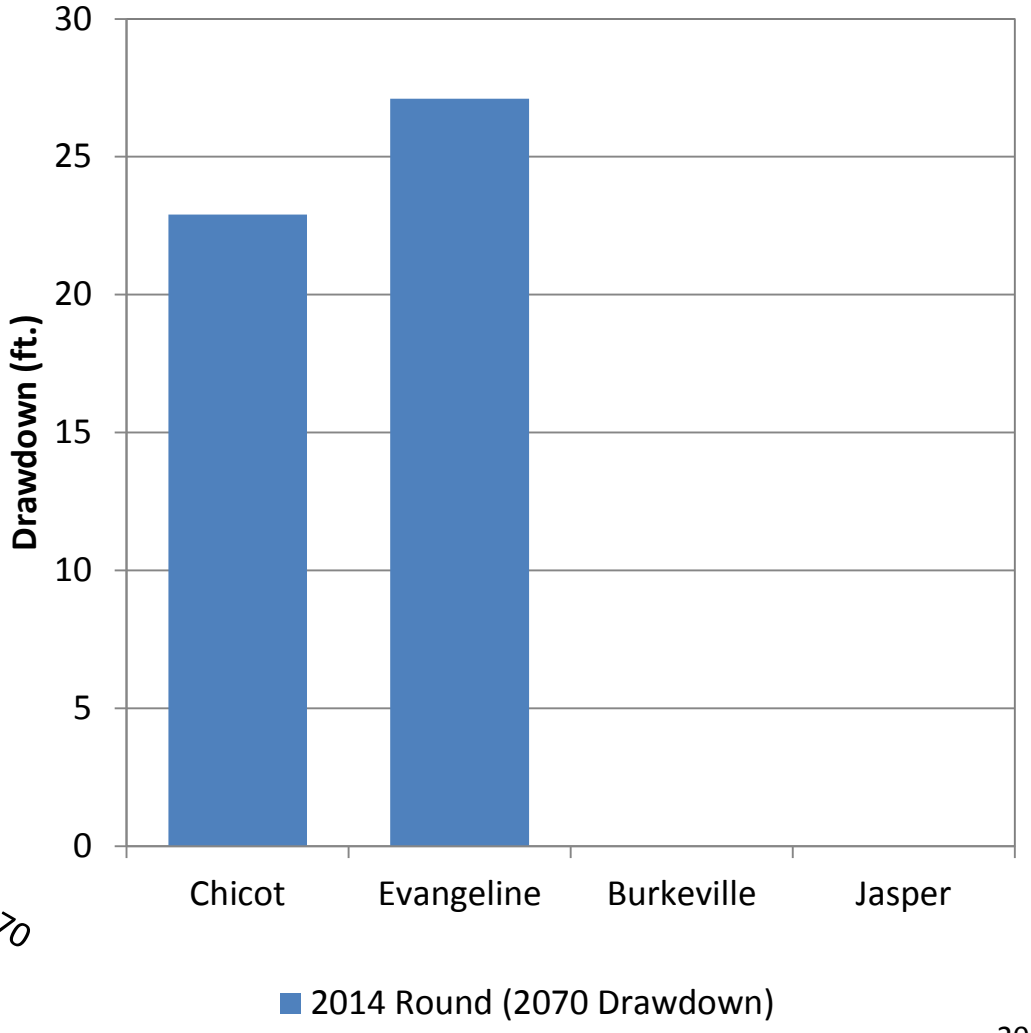




NGC GAM Run and Proposed Desired Future Conditions

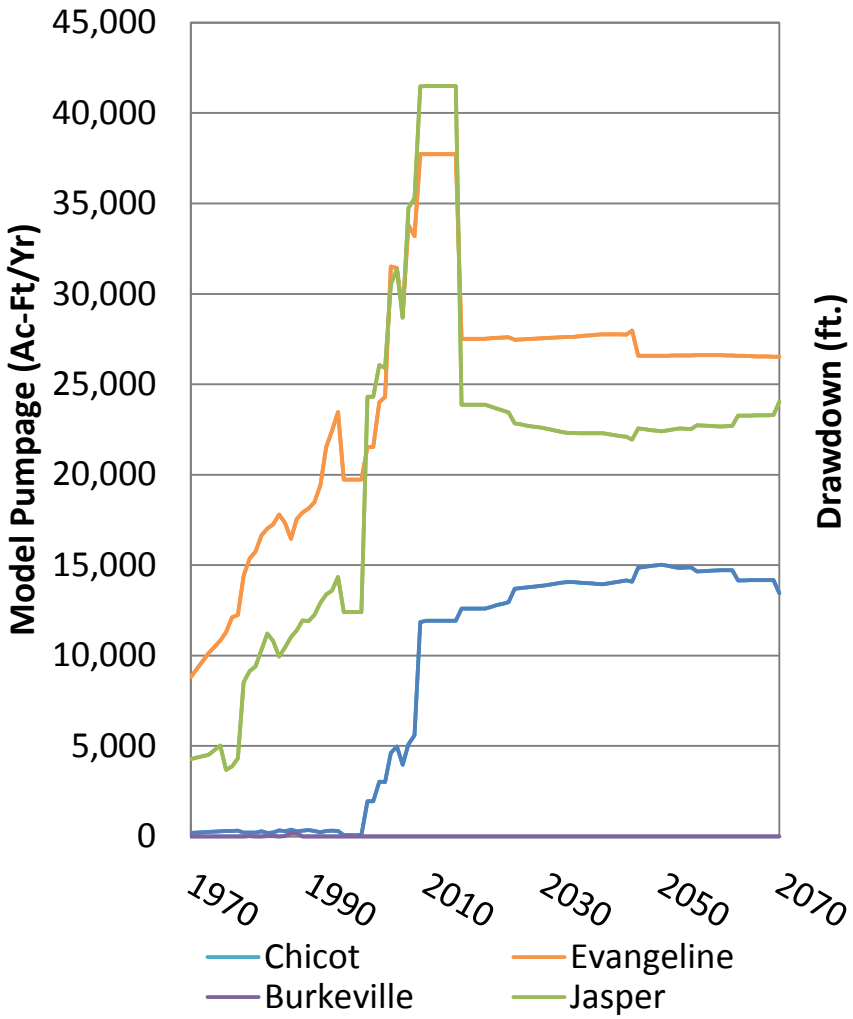
- Model Results – Brazoria County (BCGCD)

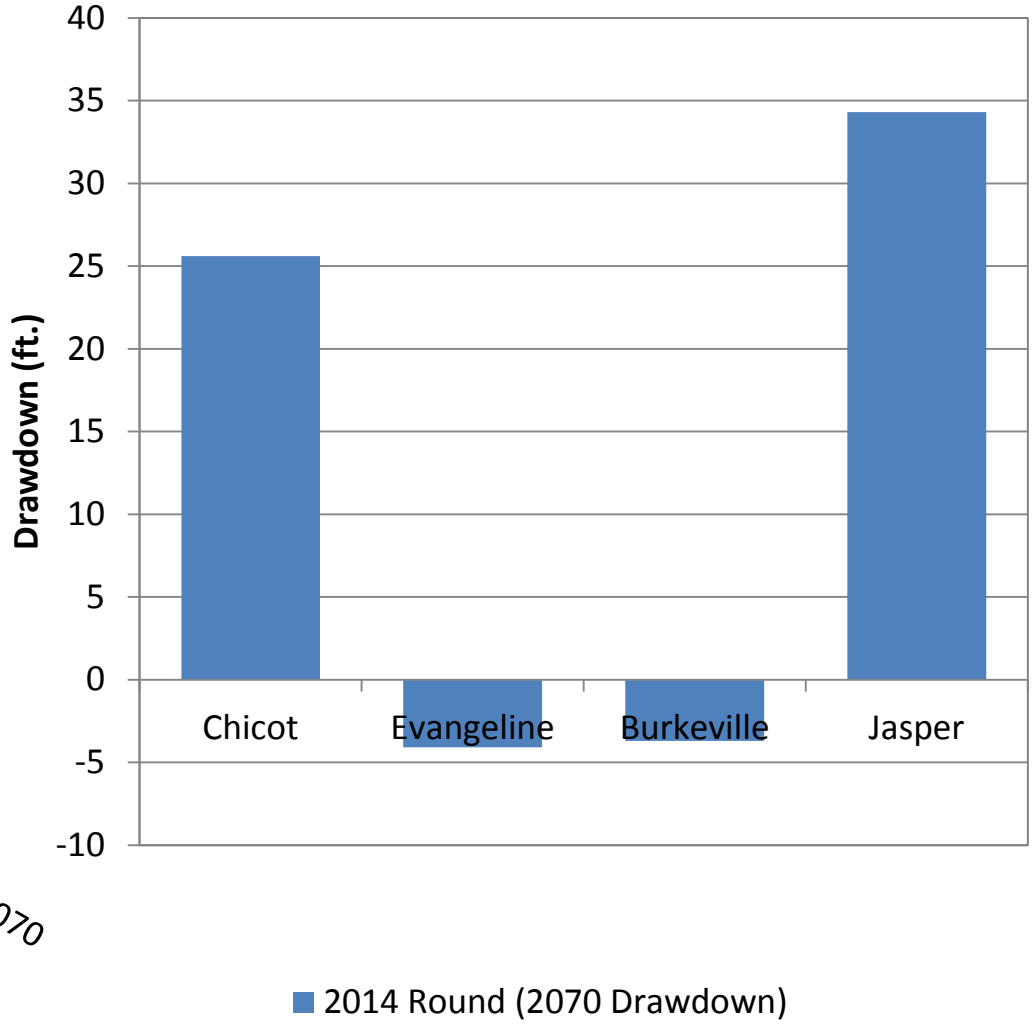




NGC GAM Run and Proposed Desired Future Conditions

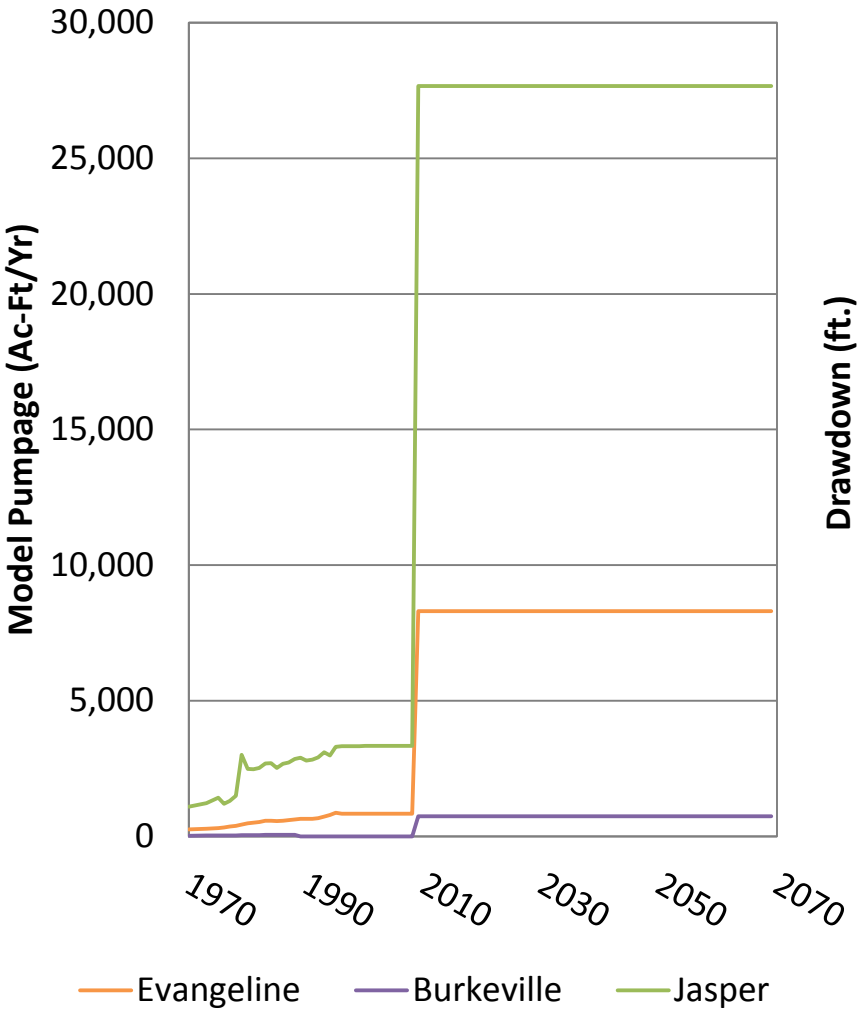
- Model Results – Montgomery County (LSGCD)

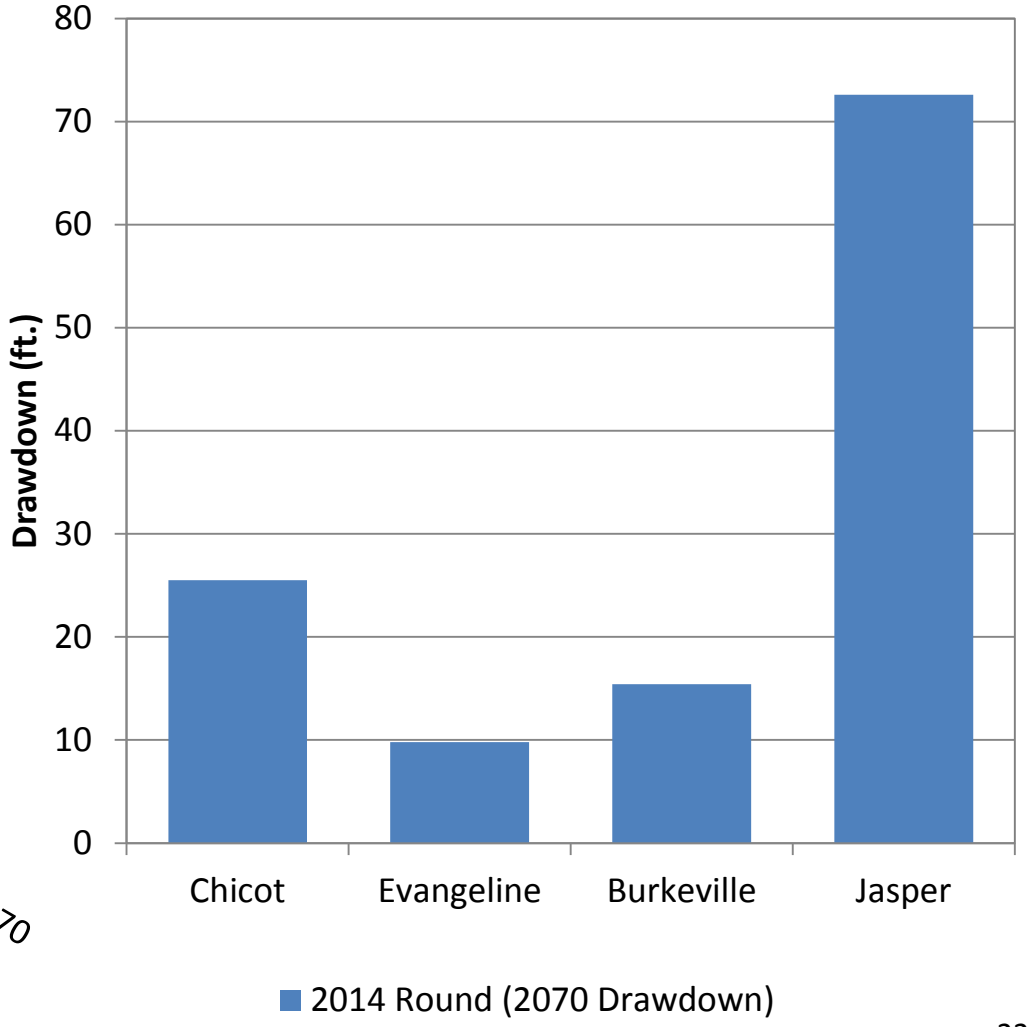




NGC GAM Run and Proposed Desired Future Conditions

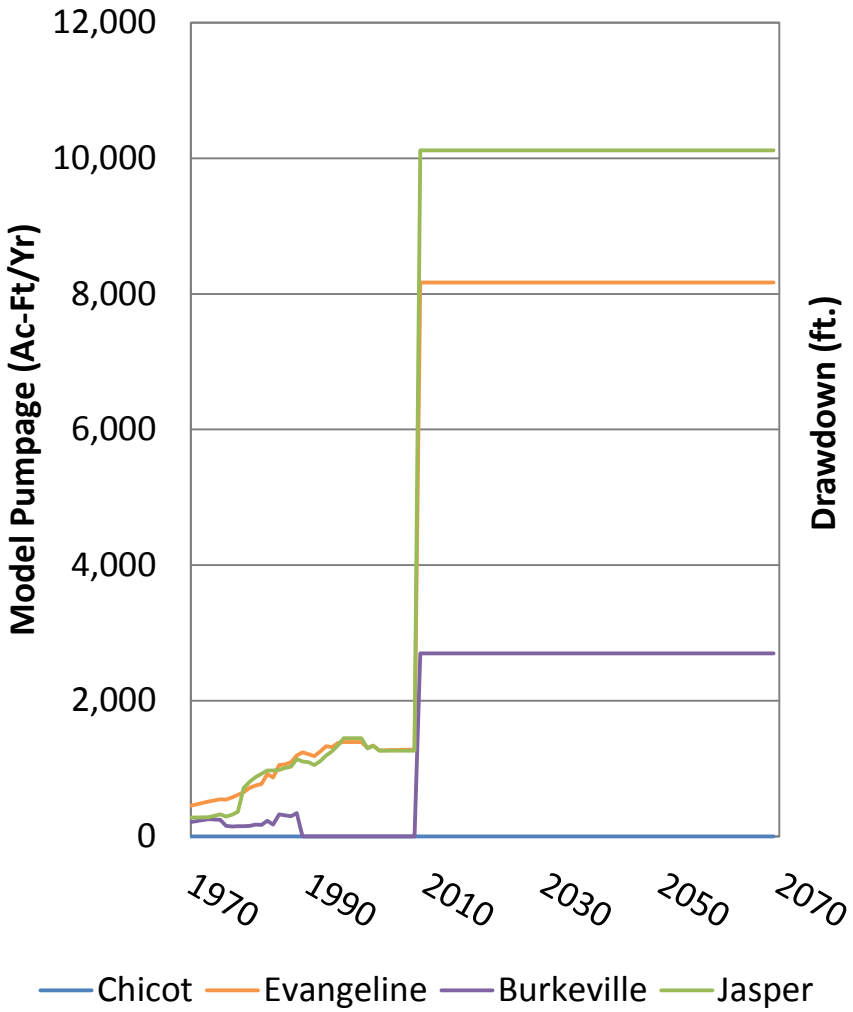
- Model Results – Polk County (LTGCD)

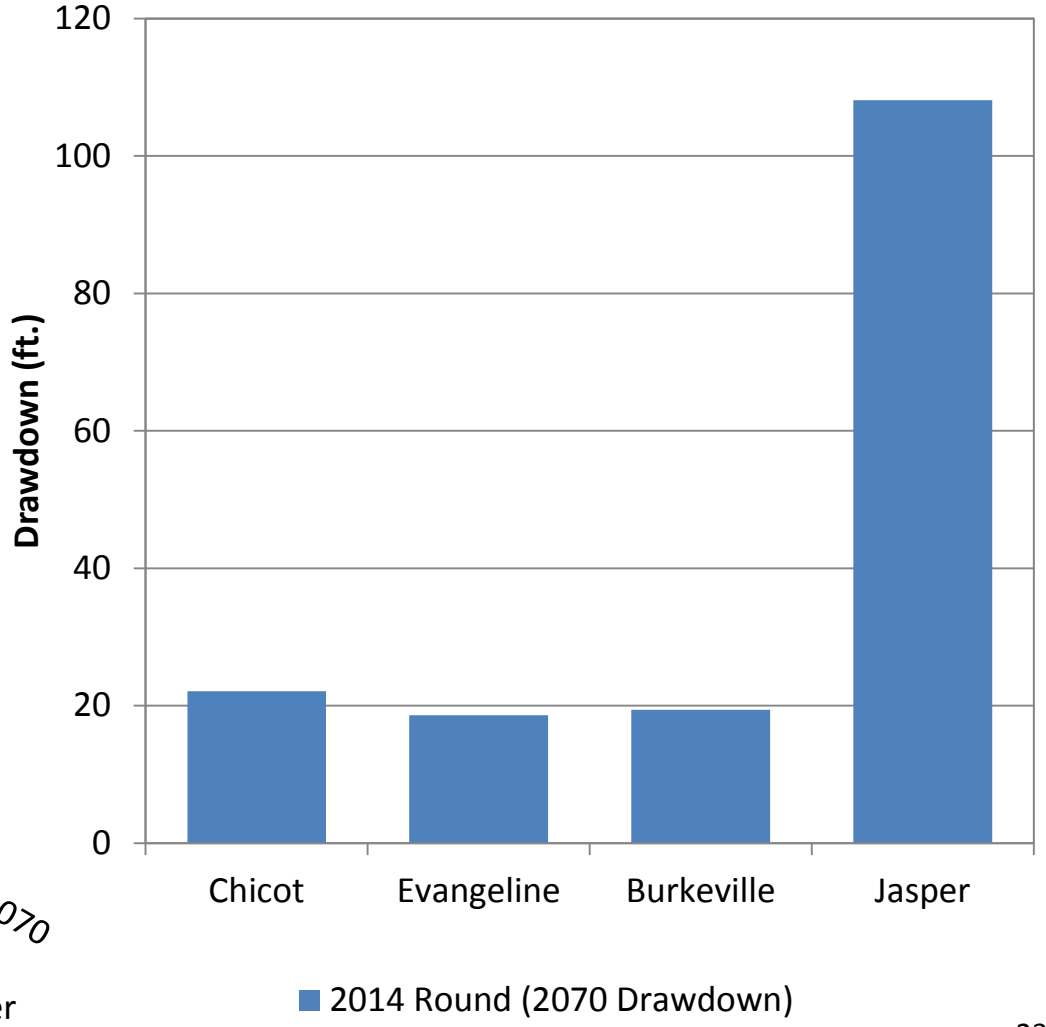




NGC GAM Run and Proposed Desired Future Conditions

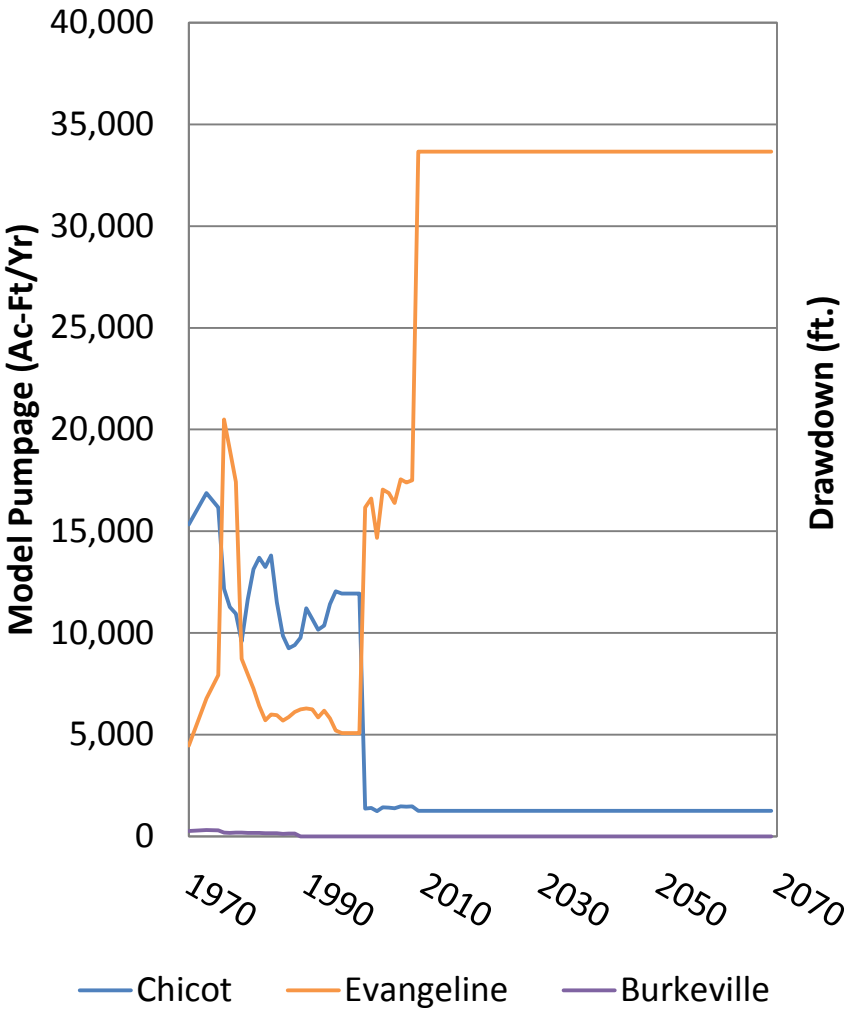
- Model Results – San Jacinto County (LTGCD)

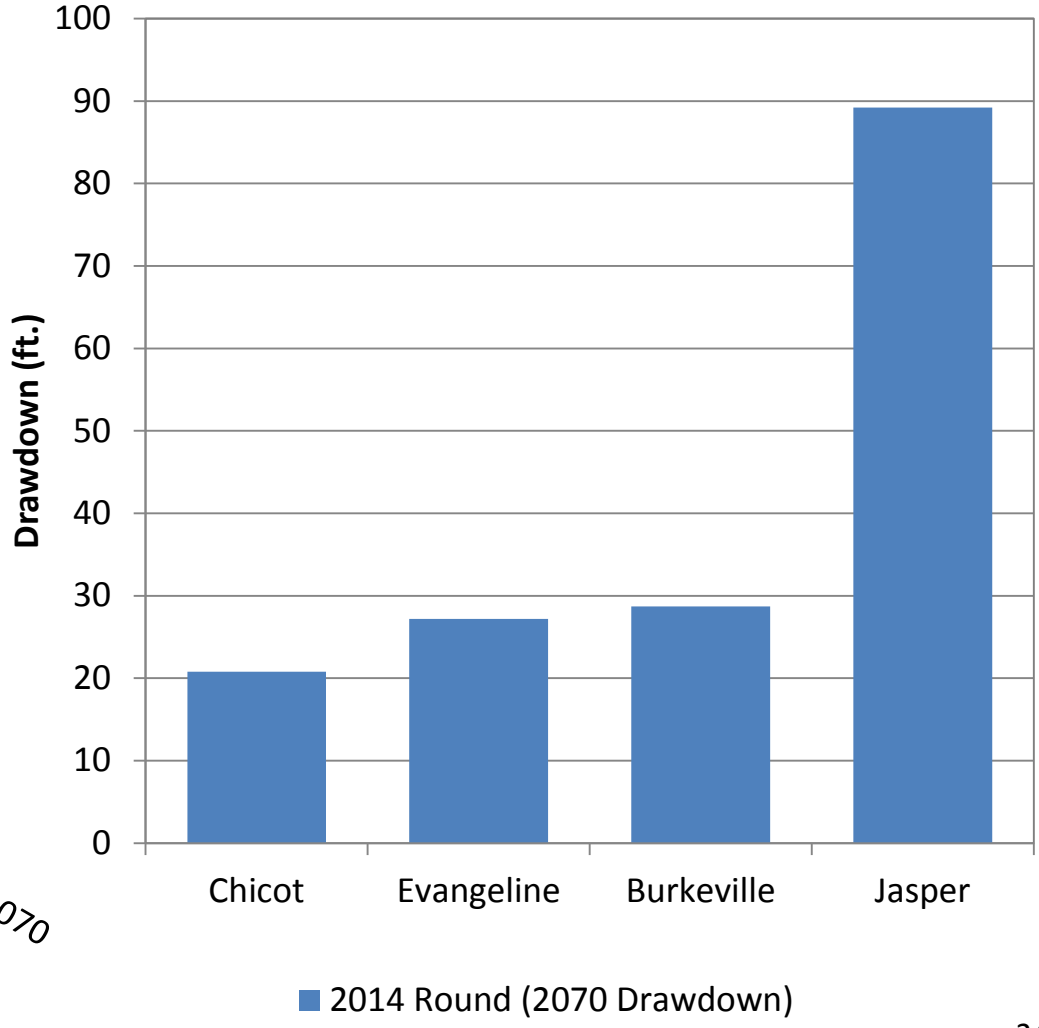




NGC GAM Run and Proposed Desired Future Conditions

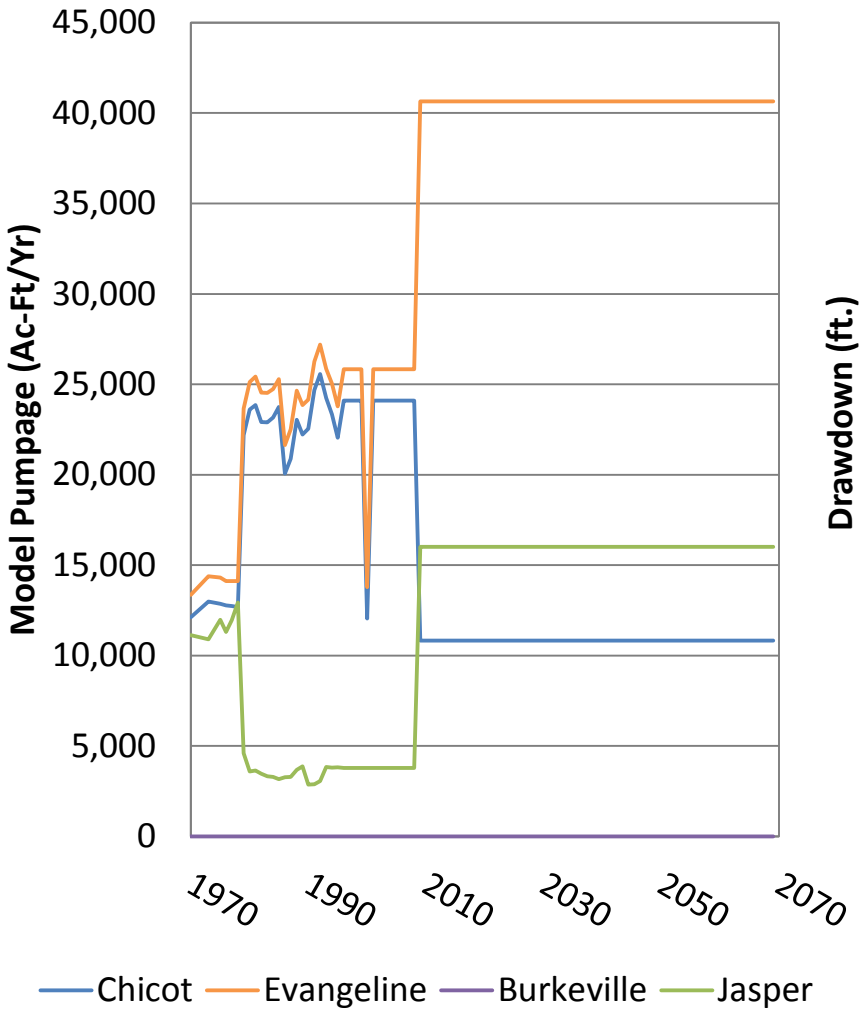
- Model Results – Hardin County (SETGCD)

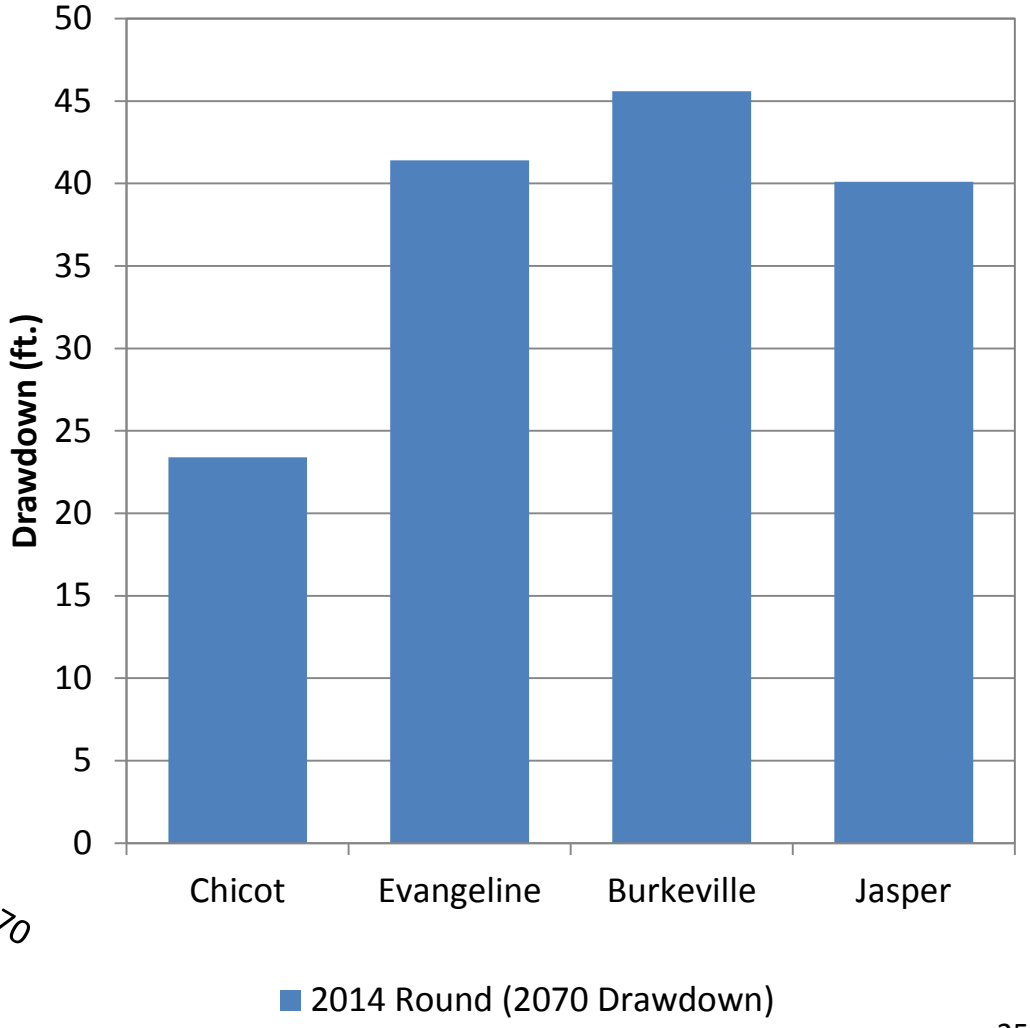




NGC GAM Run and Proposed Desired Future Conditions

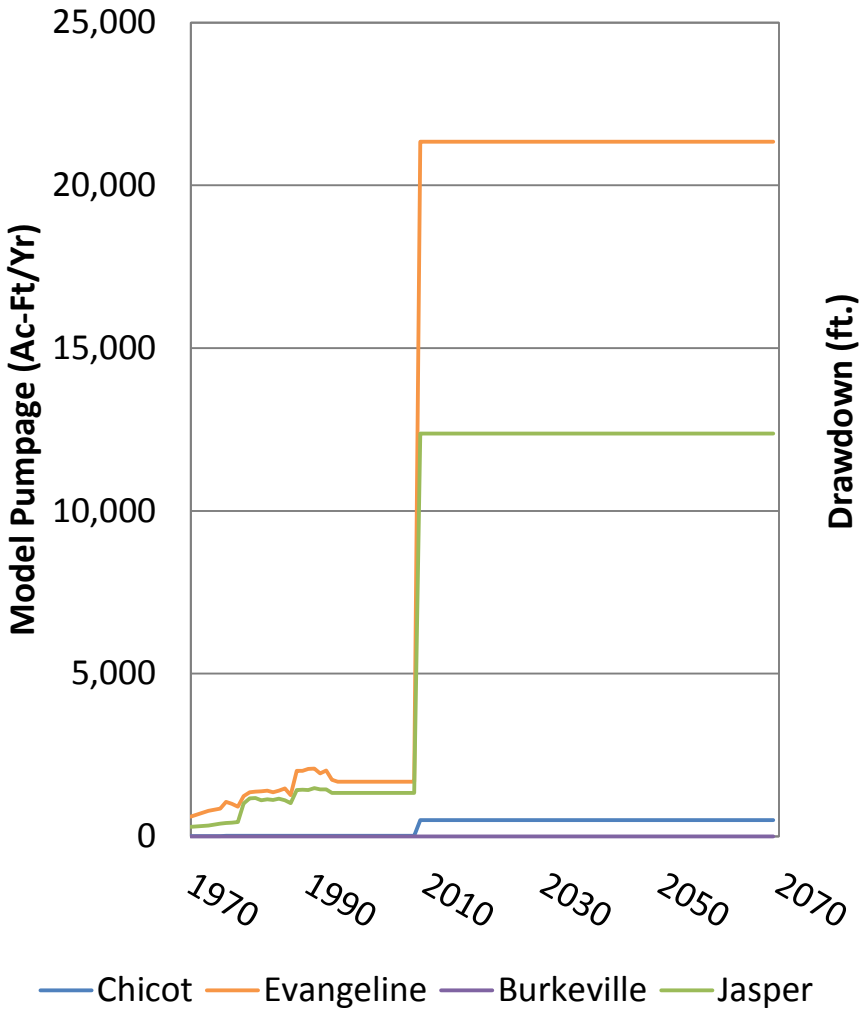
- Model Results – Jasper County (SETGCD)

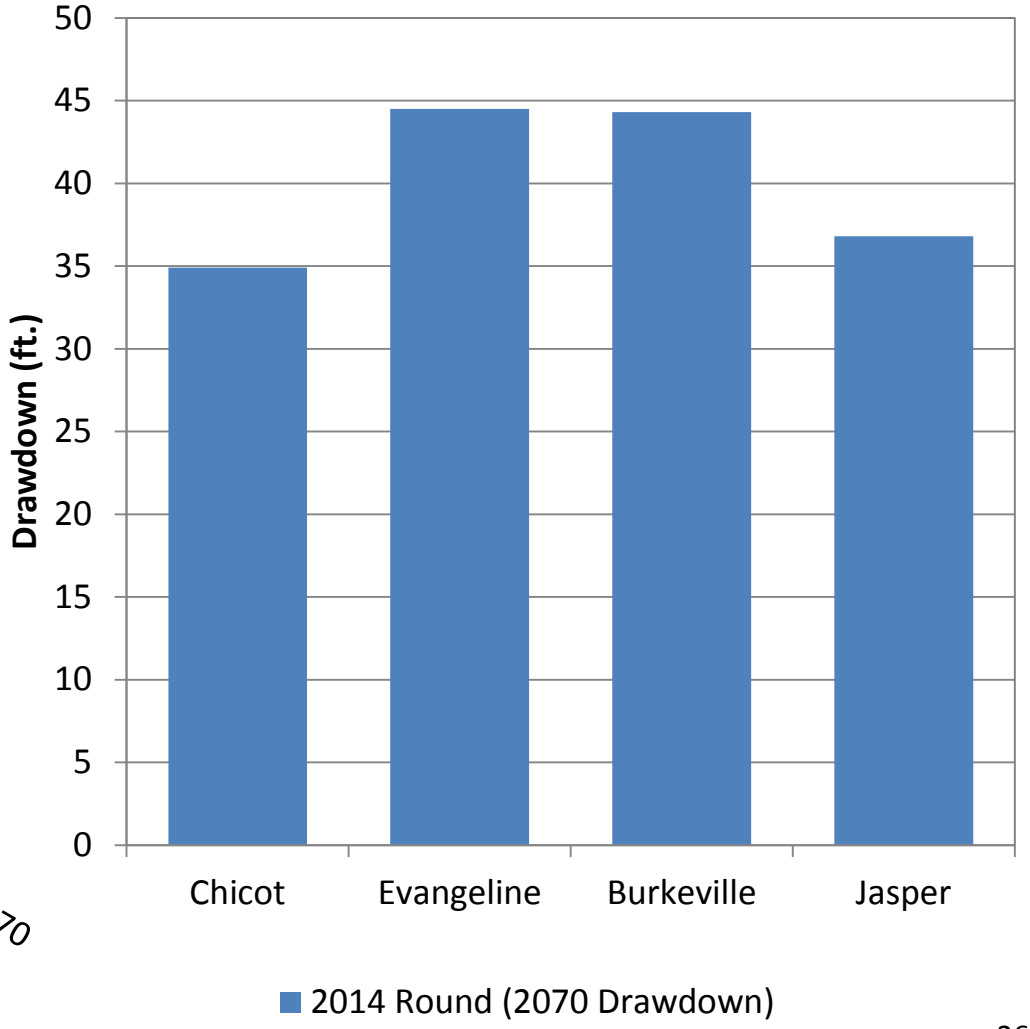




NGC GAM Run and Proposed Desired Future Conditions

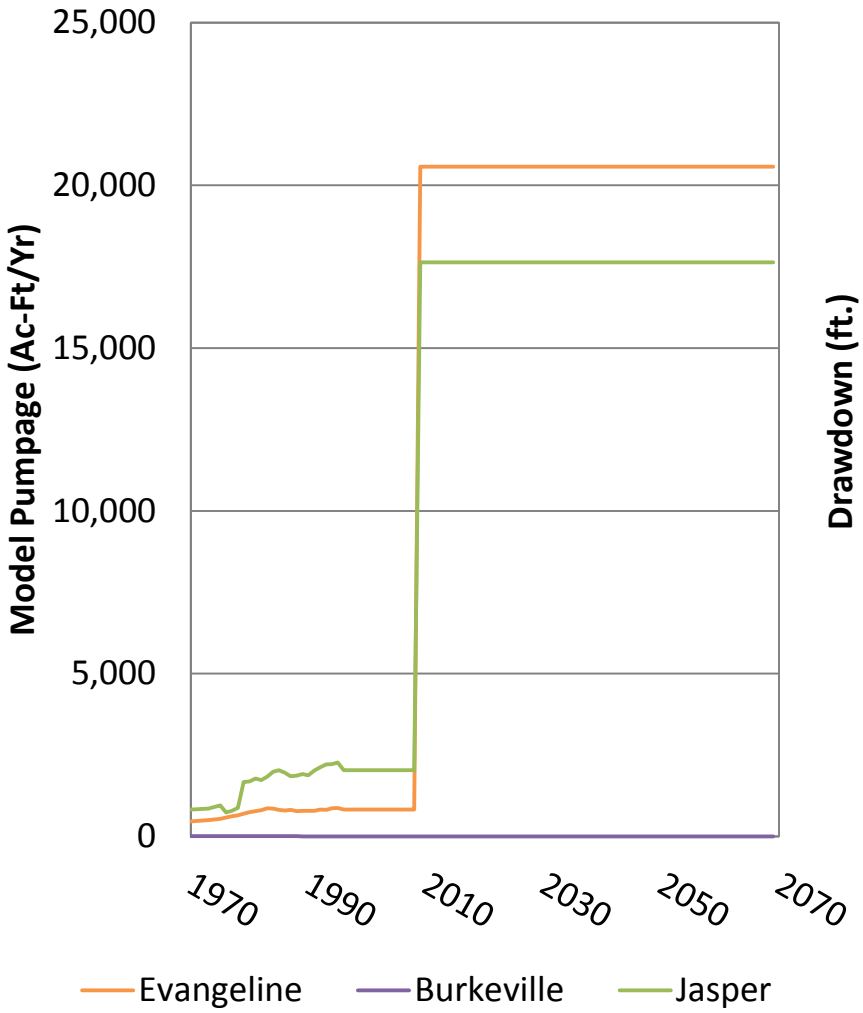
- Model Results – Newton County (SETGCD)

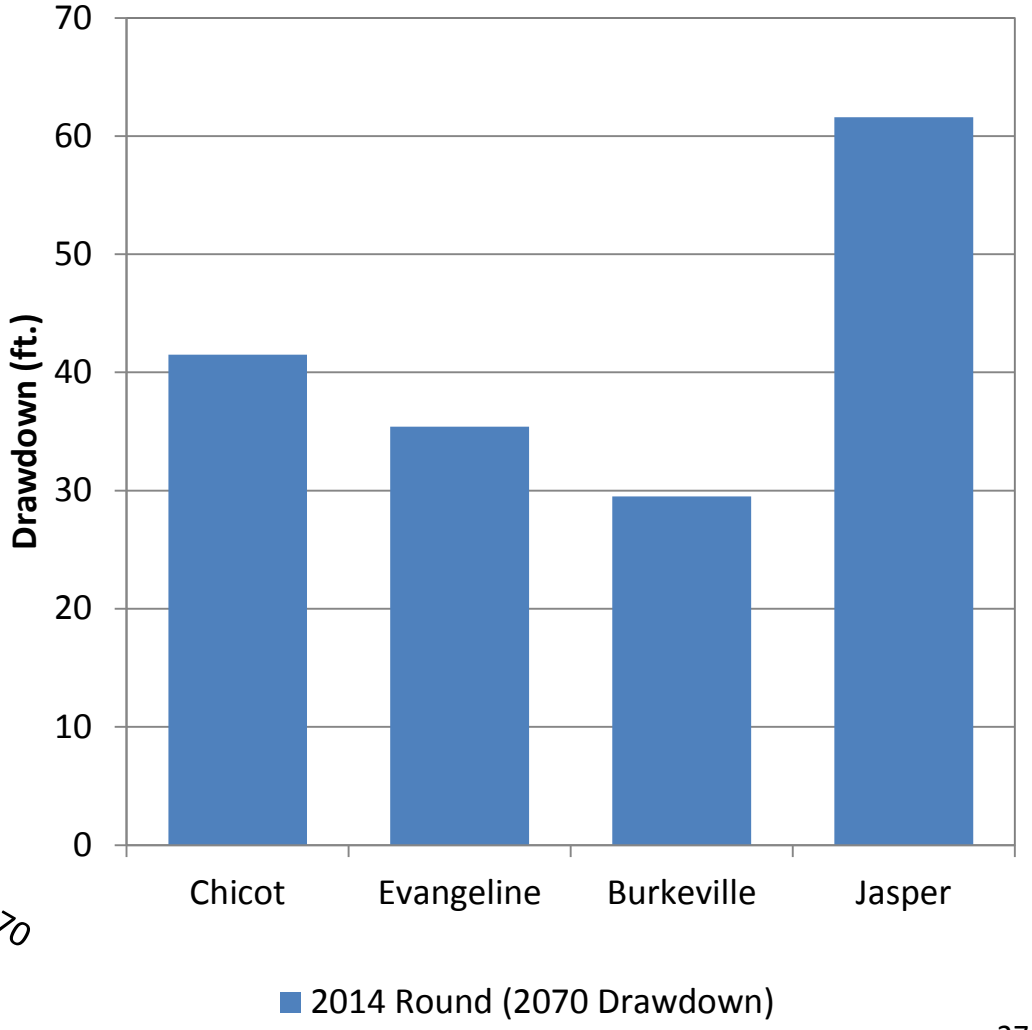




NGC GAM Run and Proposed Desired Future Conditions

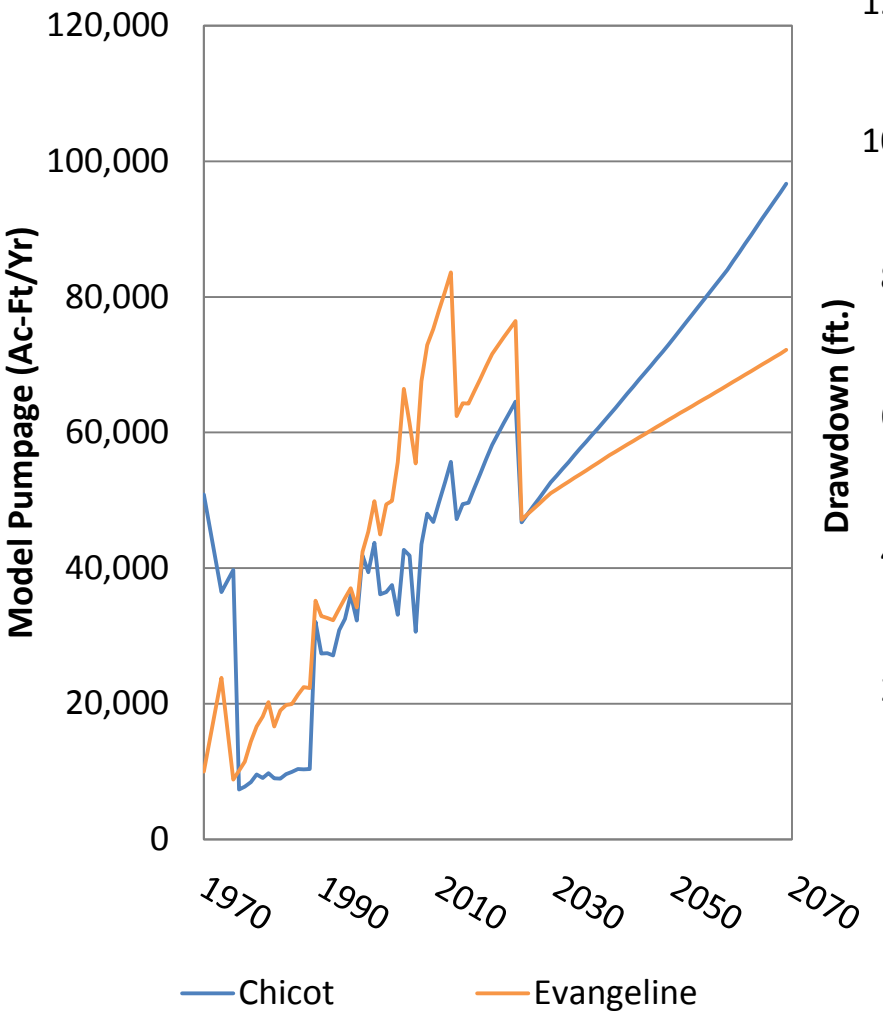
- Model Results – Tyler County (SETGCD)

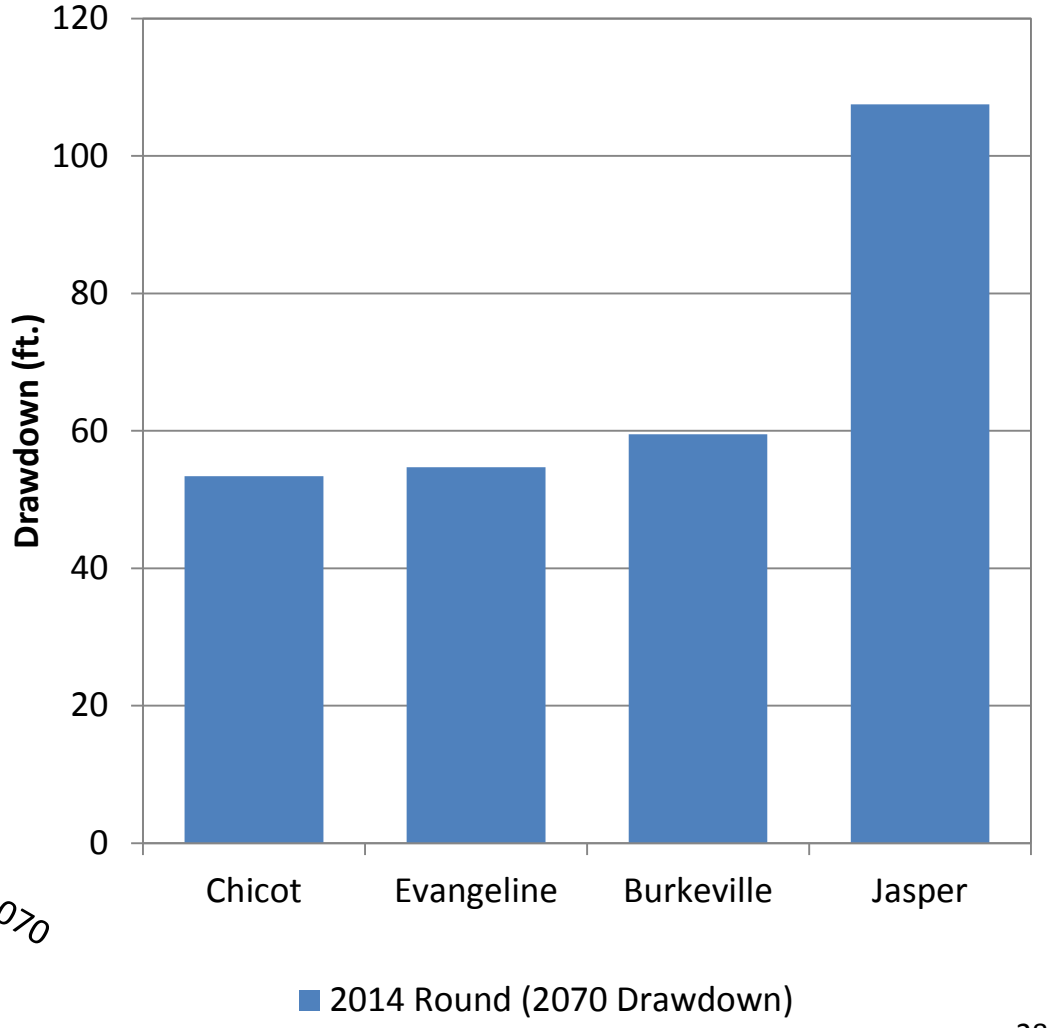




NGC GAM Run and Proposed Desired Future Conditions

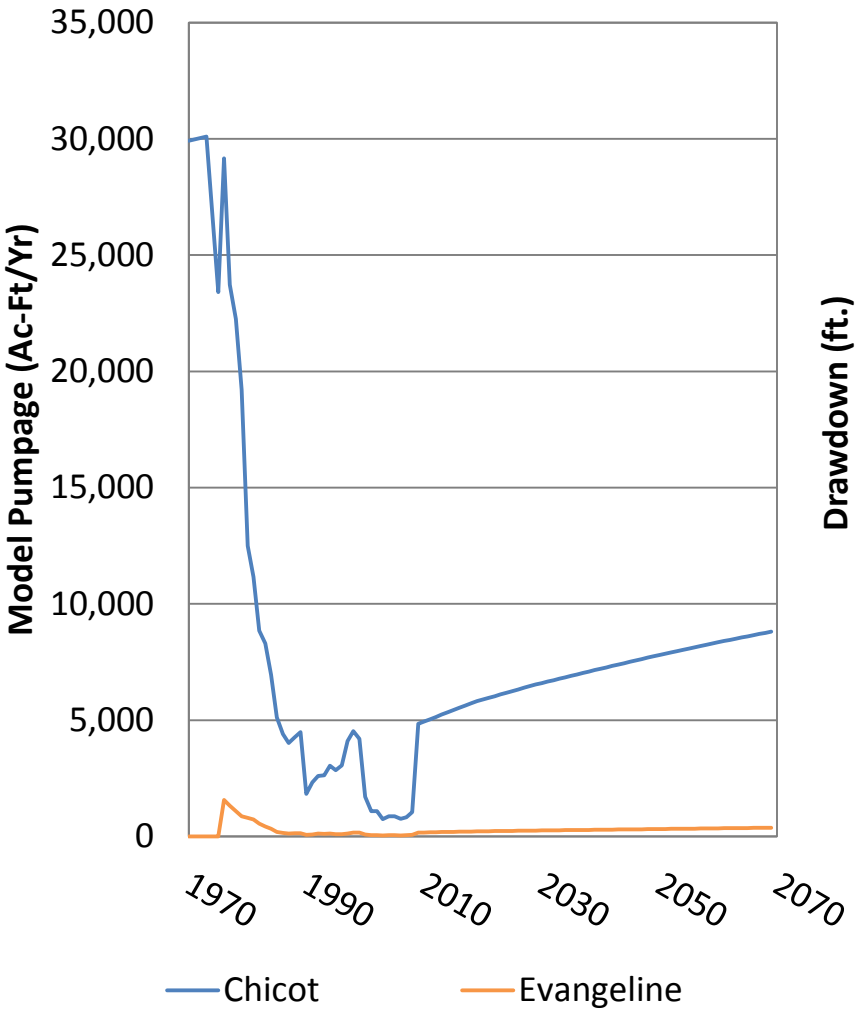
- Model Results – Fort Bend County (FBSD)

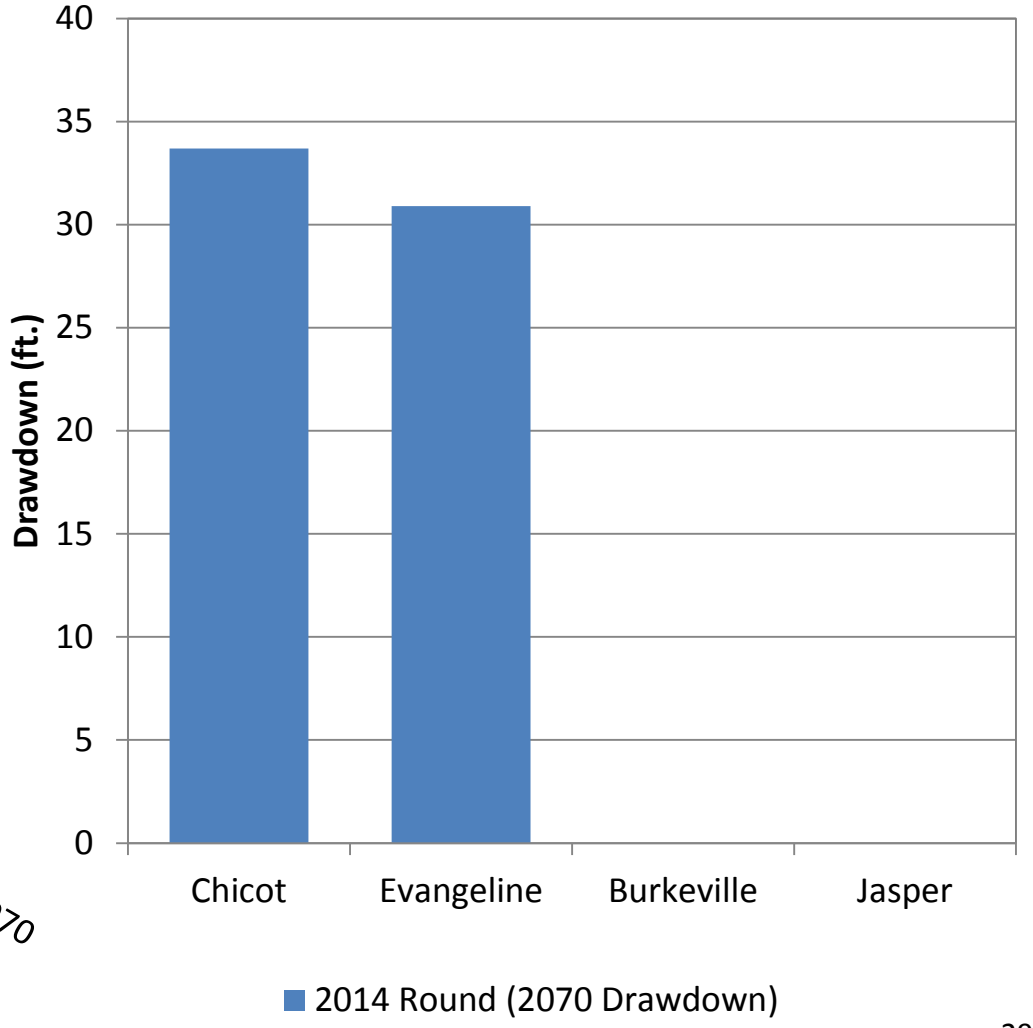




NGC GAM Run and Proposed Desired Future Conditions

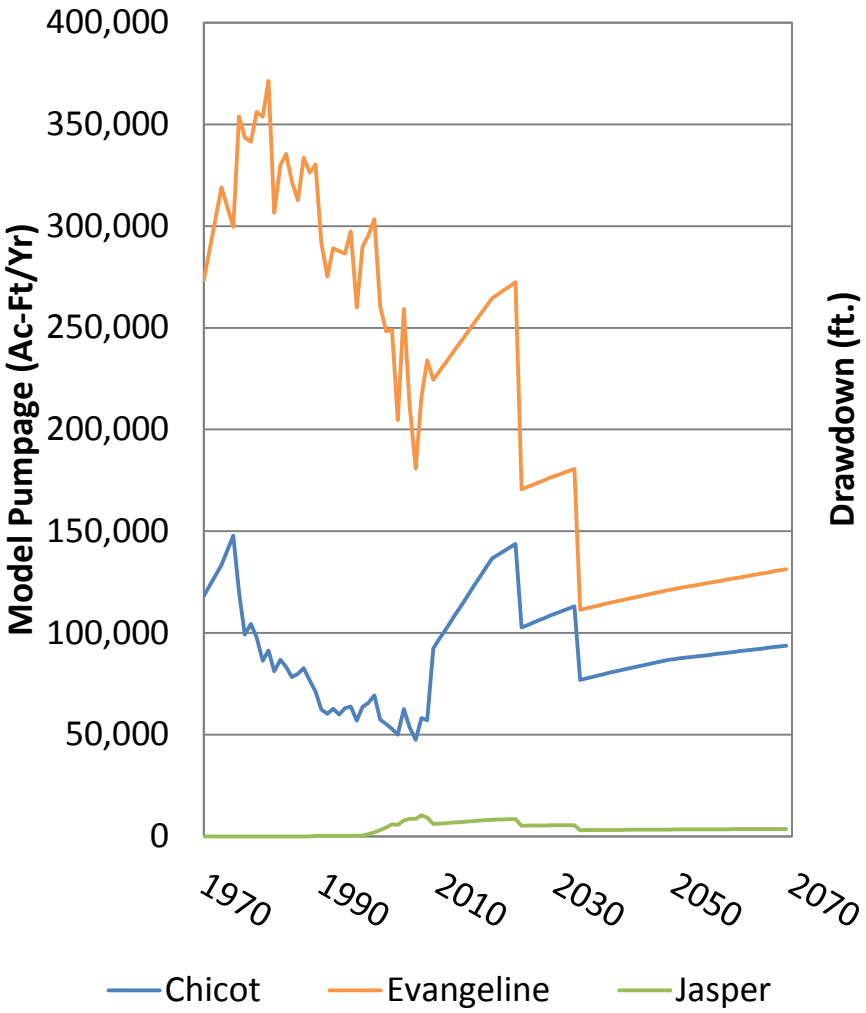
- Model Results – Galveston County (HGSD)

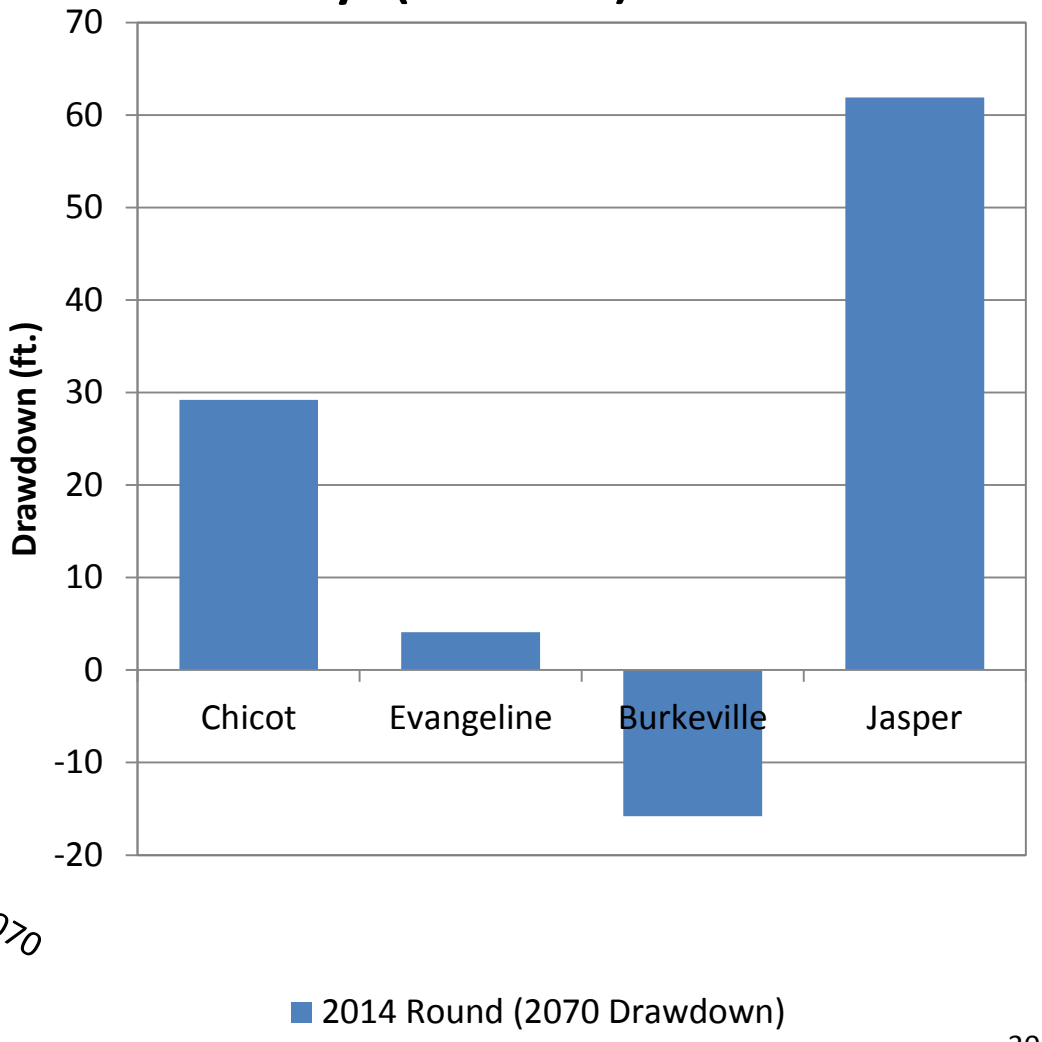




NGC GAM Run and Proposed Desired Future Conditions

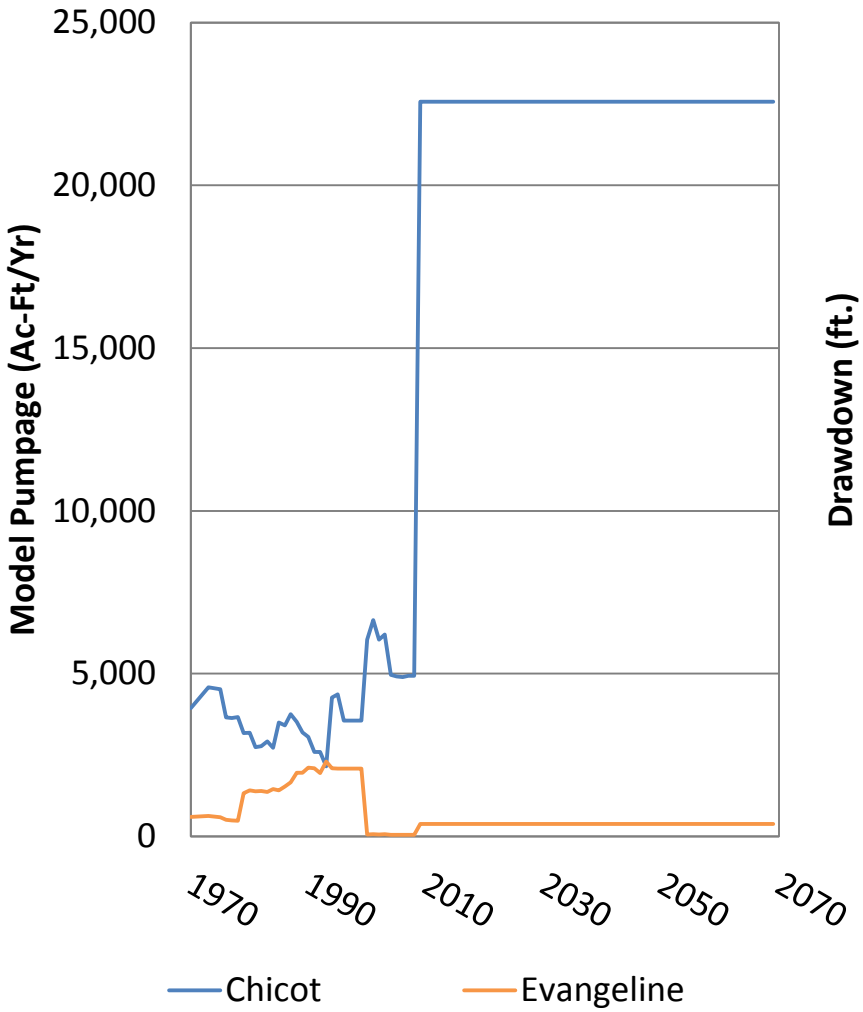
- Model Results – Harris County (HGSD)

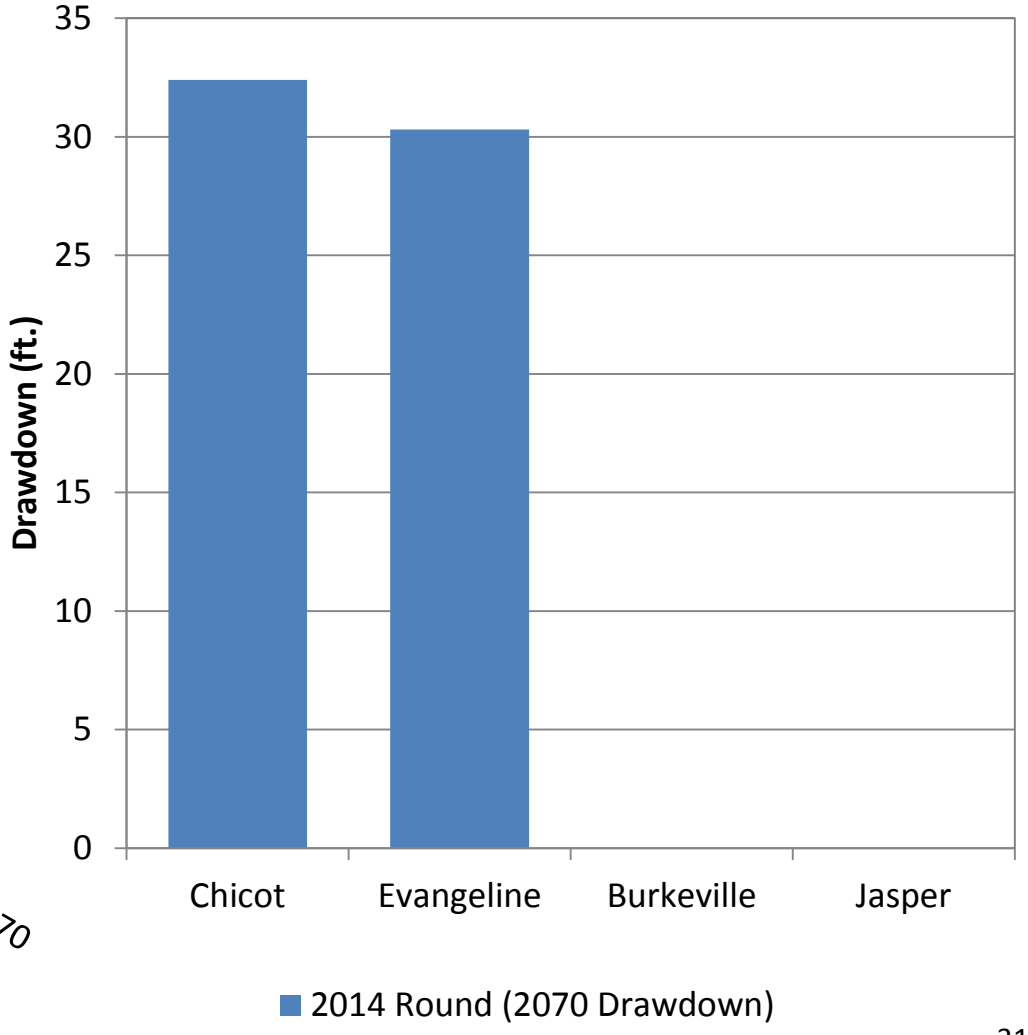




NGC GAM Run and Proposed Desired Future Conditions

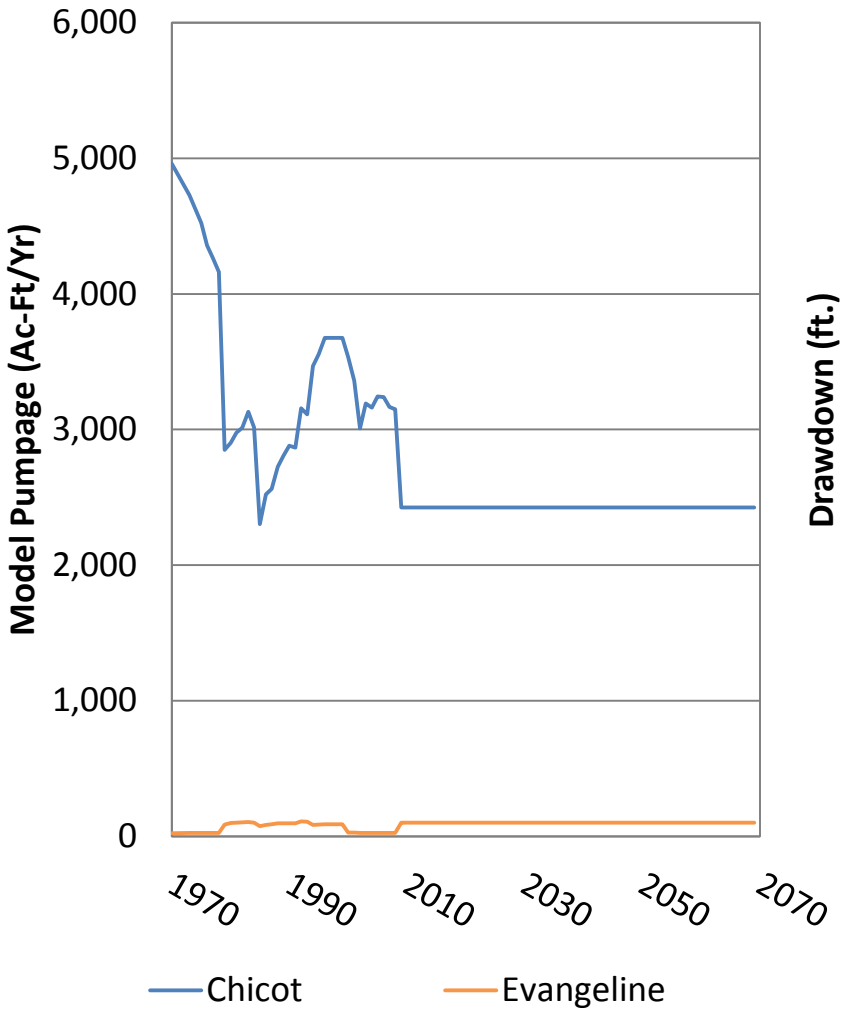
- Model Results – Chambers County

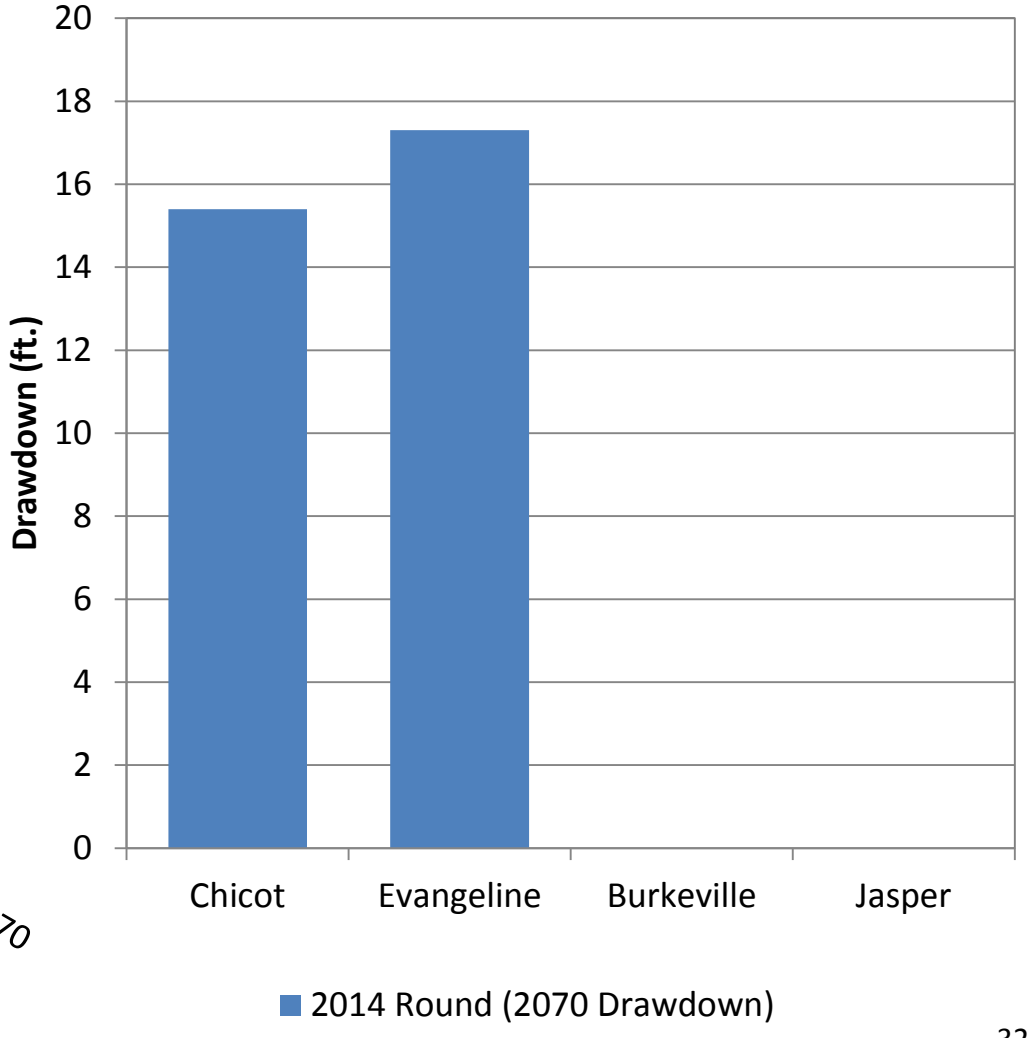




NGC GAM Run and Proposed Desired Future Conditions

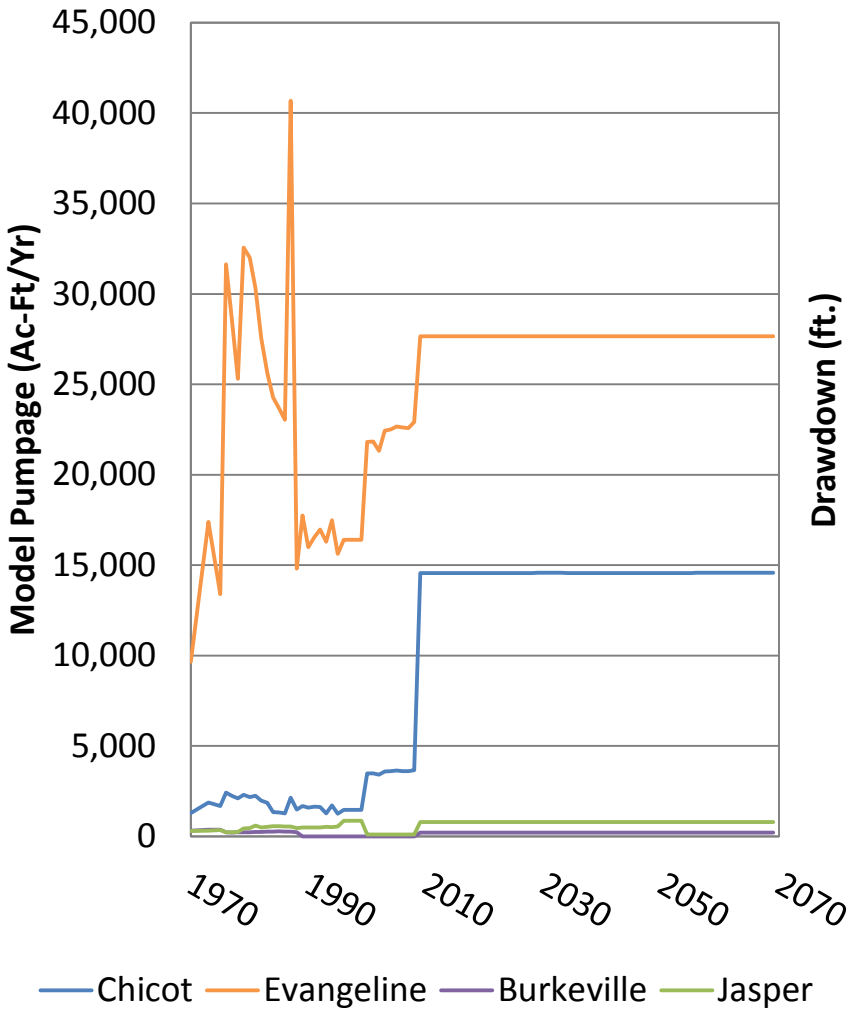
- Model Results – Jefferson County

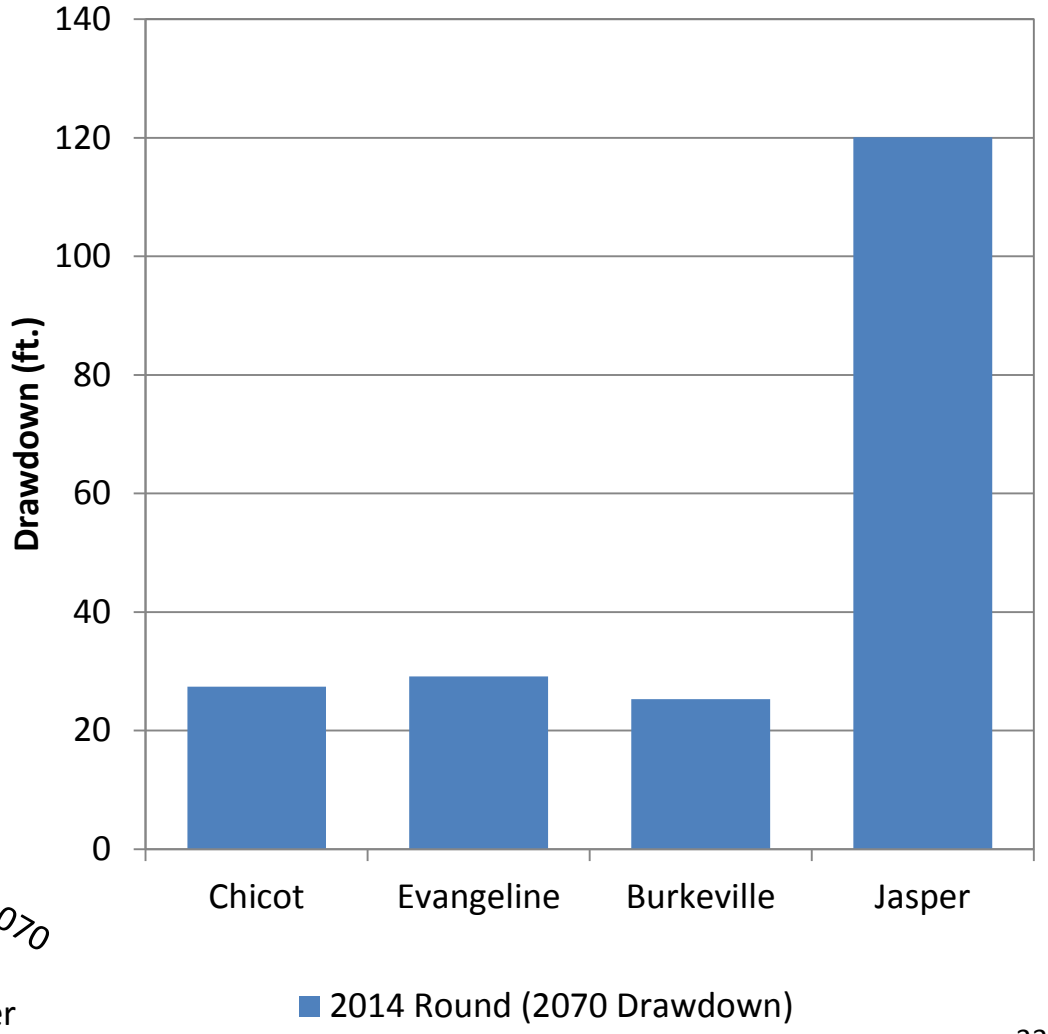




NGC GAM Run and Proposed Desired Future Conditions

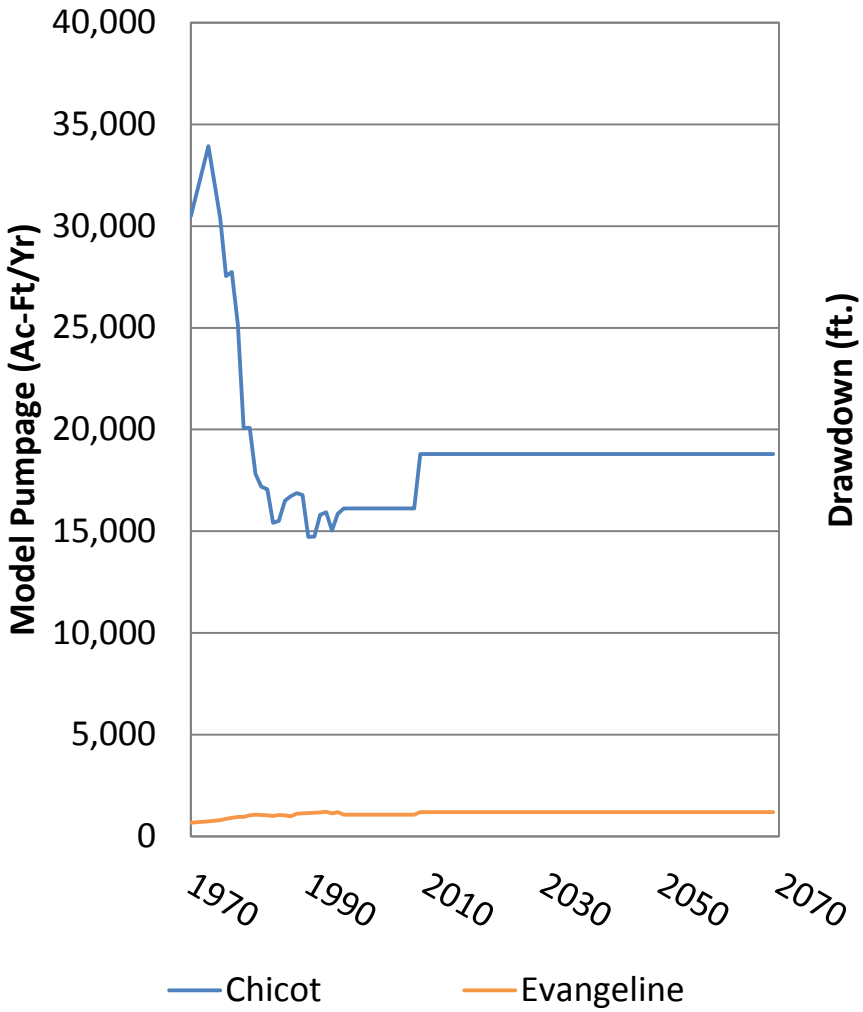
- Model Results – Liberty County

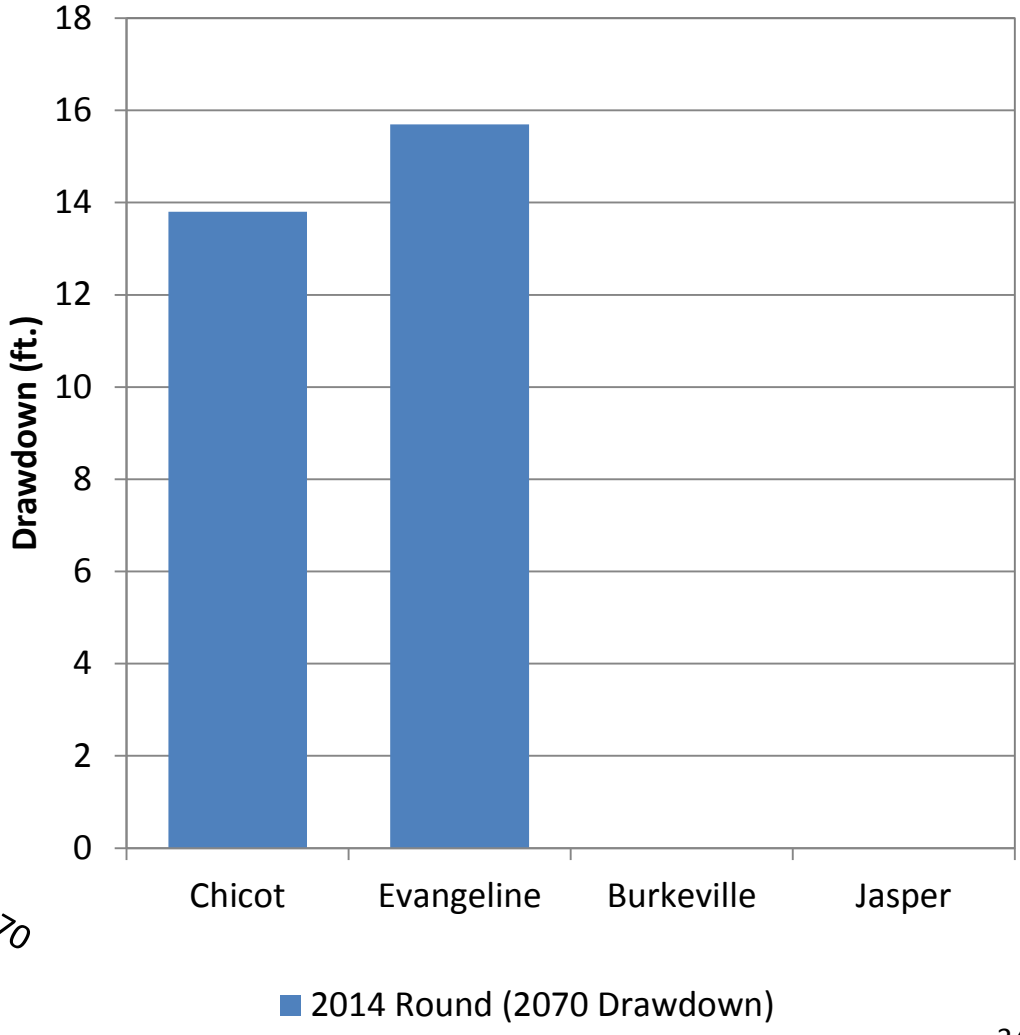




NGC GAM Run and Proposed Desired Future Conditions

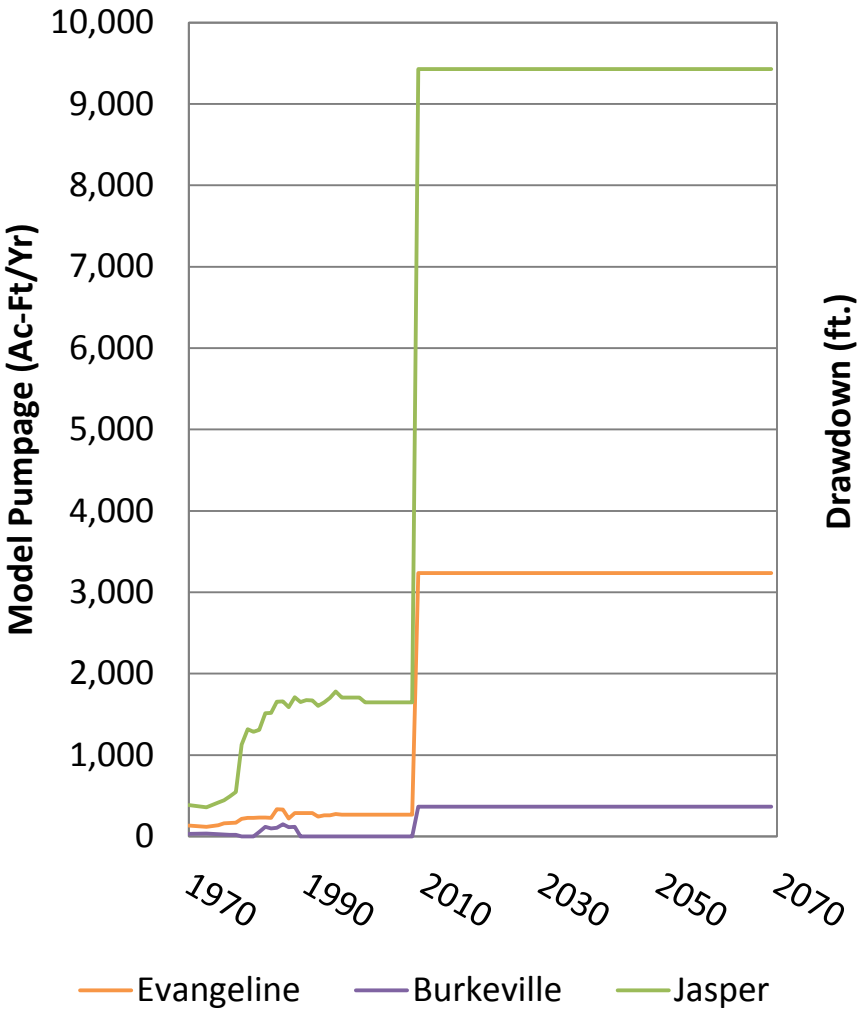
- Model Results – Orange County

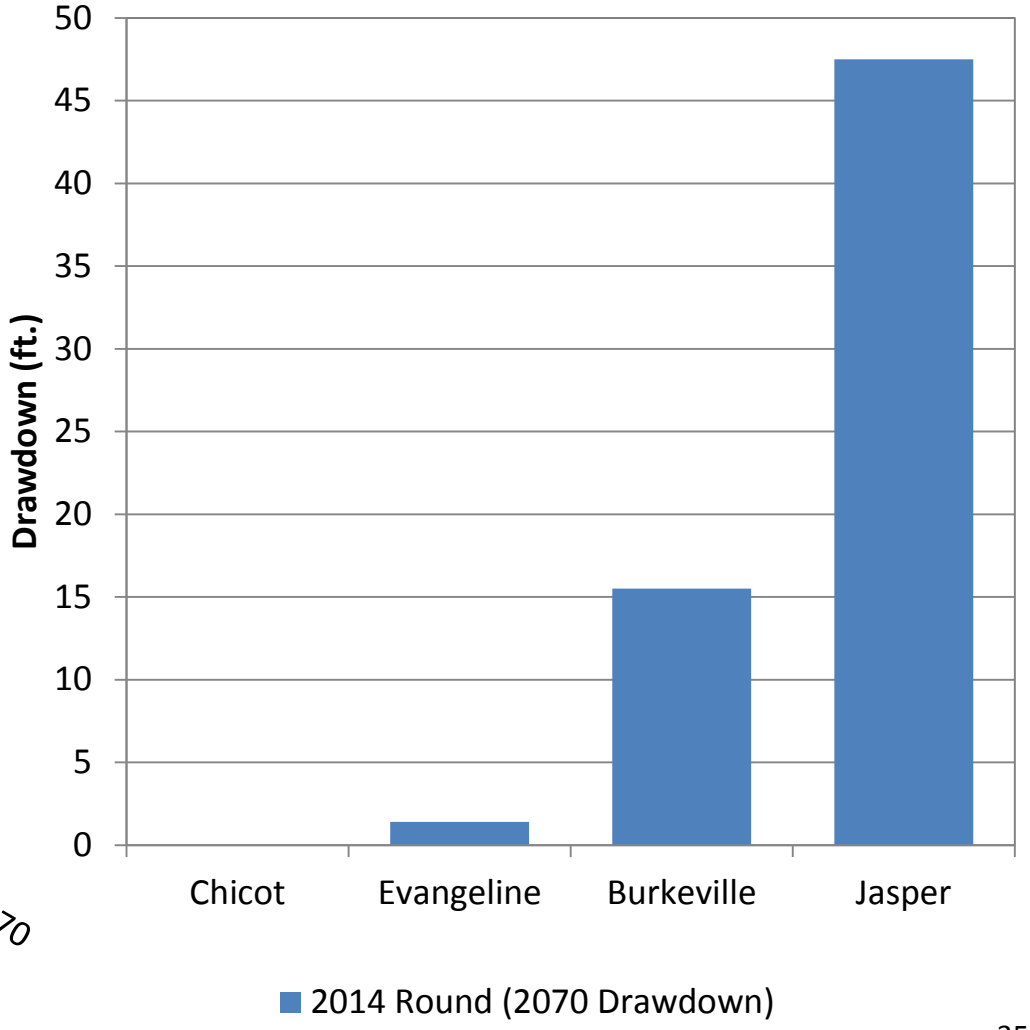




NGC GAM Run and Proposed Desired Future Conditions

- Model Results – Washington County



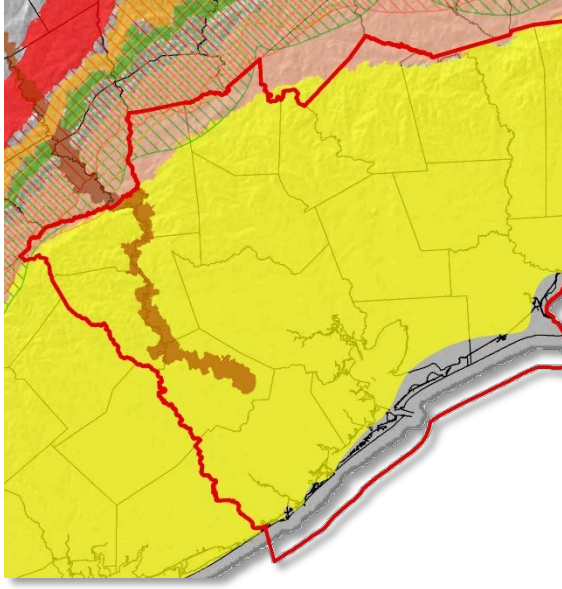


NGC GAM Run and Proposed Desired Future Conditions

- Development of DFC Statement
  - Based on results of NGC GAM Run presented June 24, 2014
  - General language for the representation of groundwater management in HGSD, FBSD
  - Added subsidence conditions for BGCD
    - Maximum subsidence from 1890 through 2070 (entire model period)

Mullican
and Associates

FREESE AND NICHOLS



Supporting Materials

AQUIFER USES AND CONDITIONS

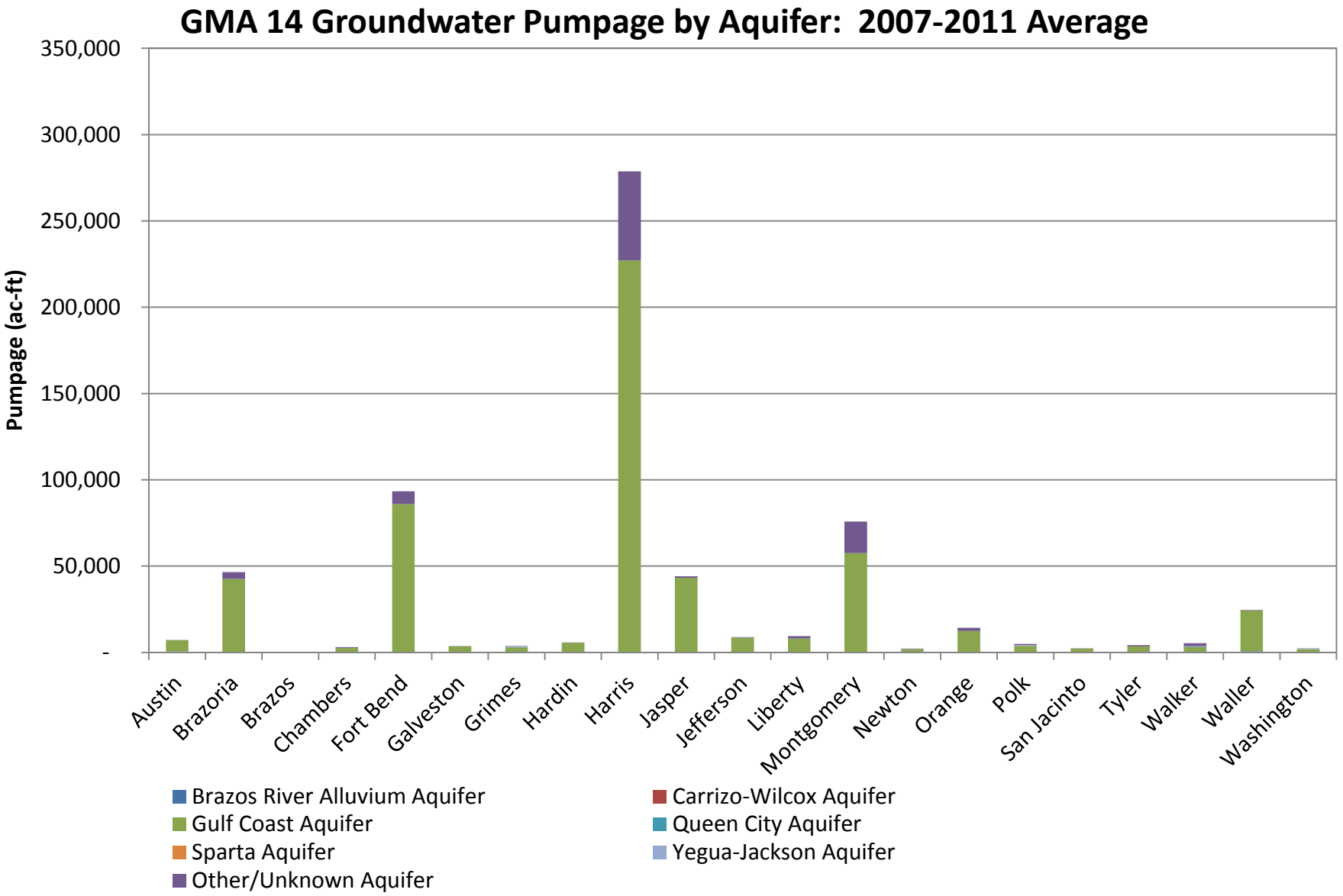
June 24, 2105

Supporting Materials
Aquifer Uses and Conditions

- Aquifer Uses and Conditions
  - *"*aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another*;"*
    TWC 36.108 (d) (1)
  - Water use data from TWDB – Water Use Survey
  - Year 2000 to 2011
  - Summarized by county, aquifer, and use

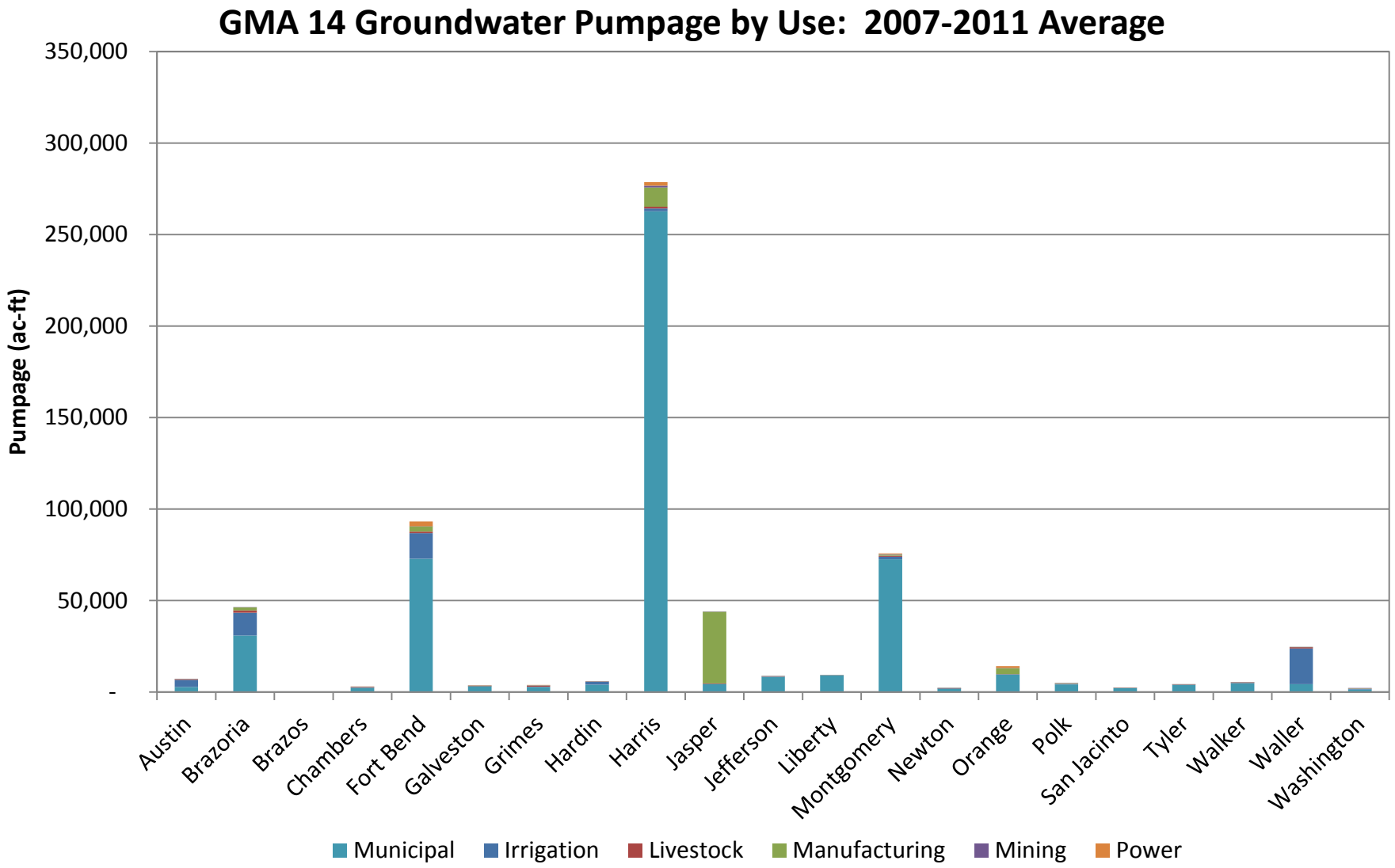
Supporting Materials

Aquifer Uses and Conditions



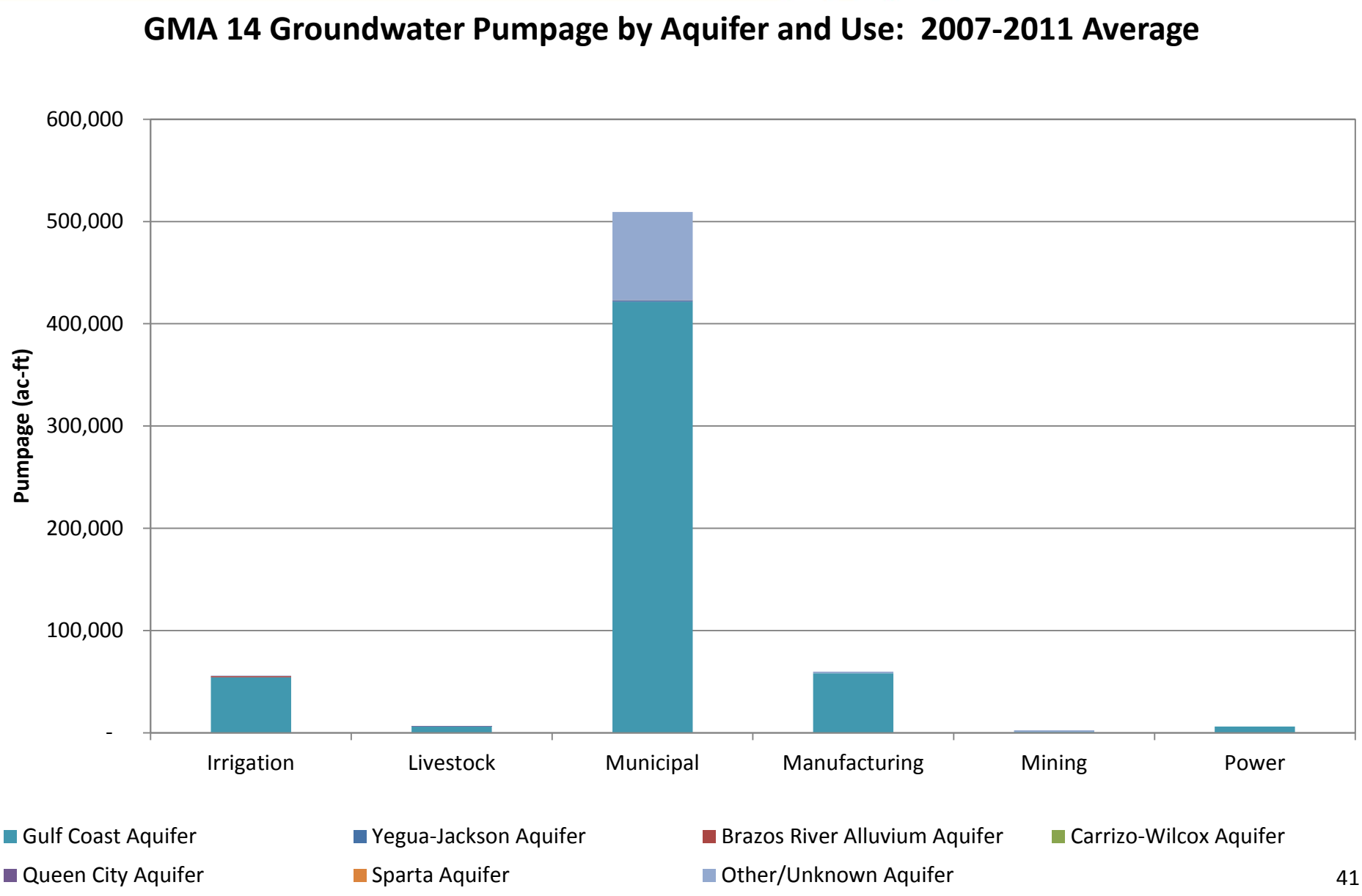
Supporting Materials

Aquifer Uses and Conditions



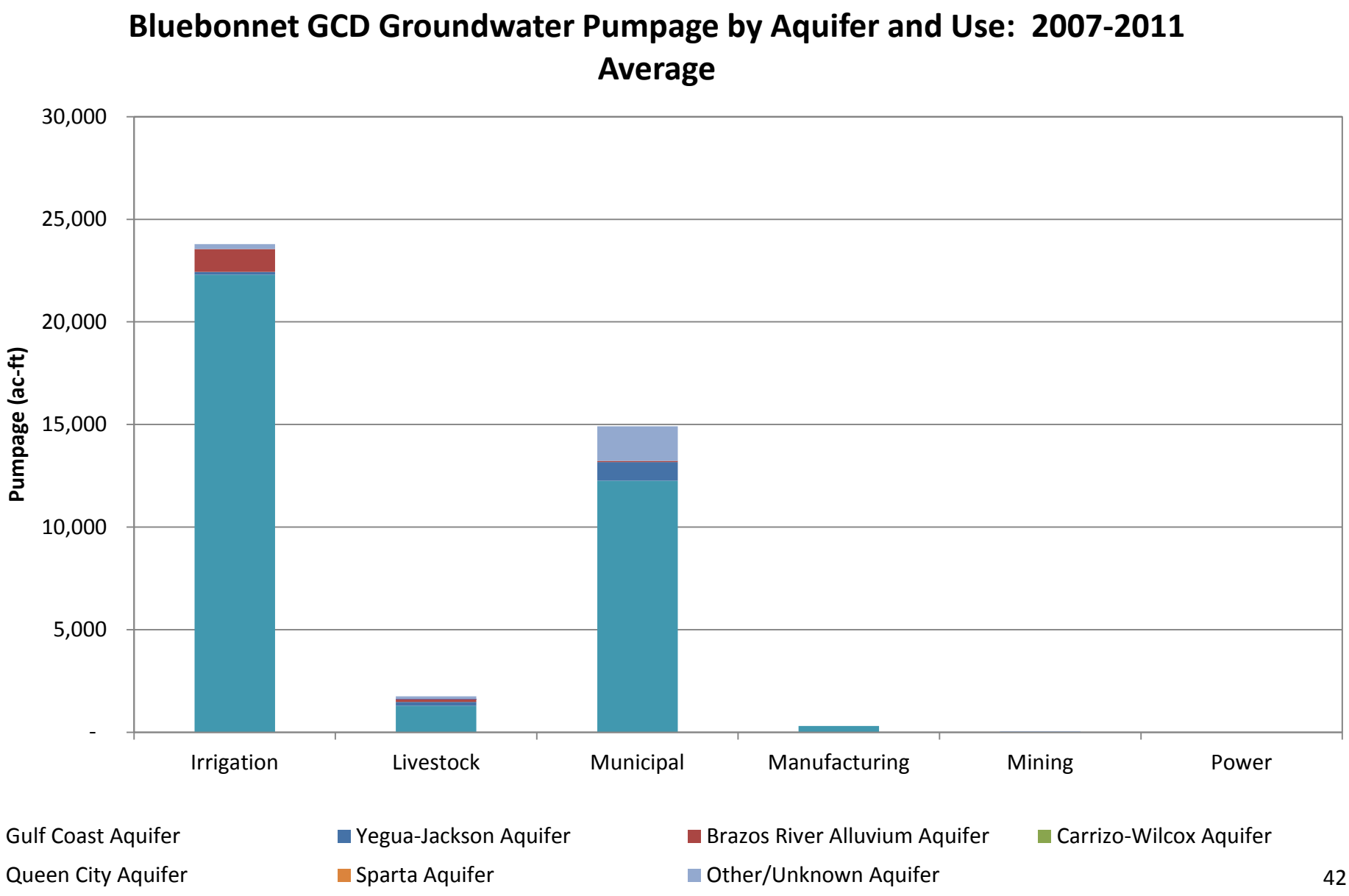
Supporting Materials

Aquifer Uses and Conditions



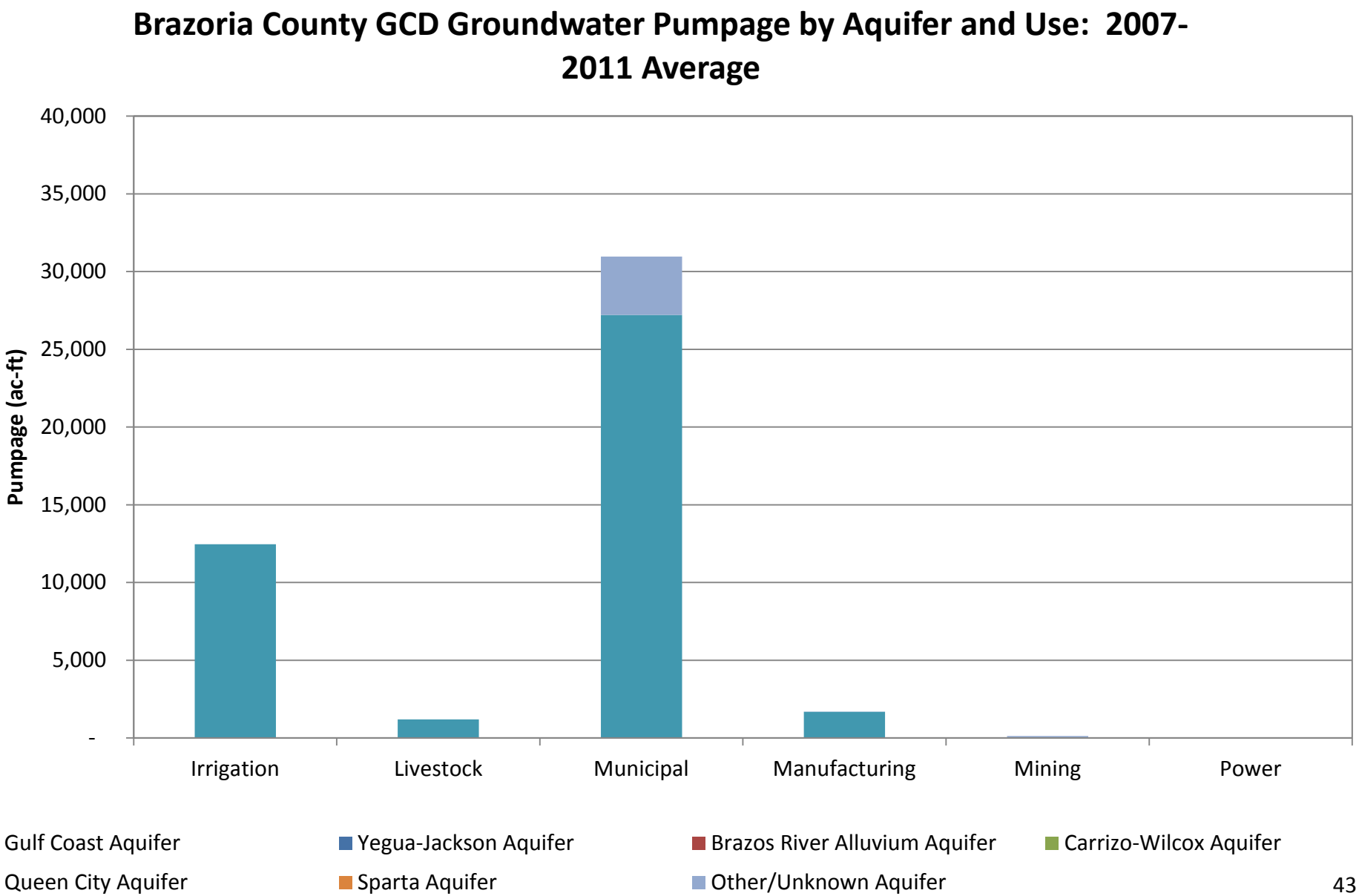
Supporting Materials

Aquifer Uses and Conditions



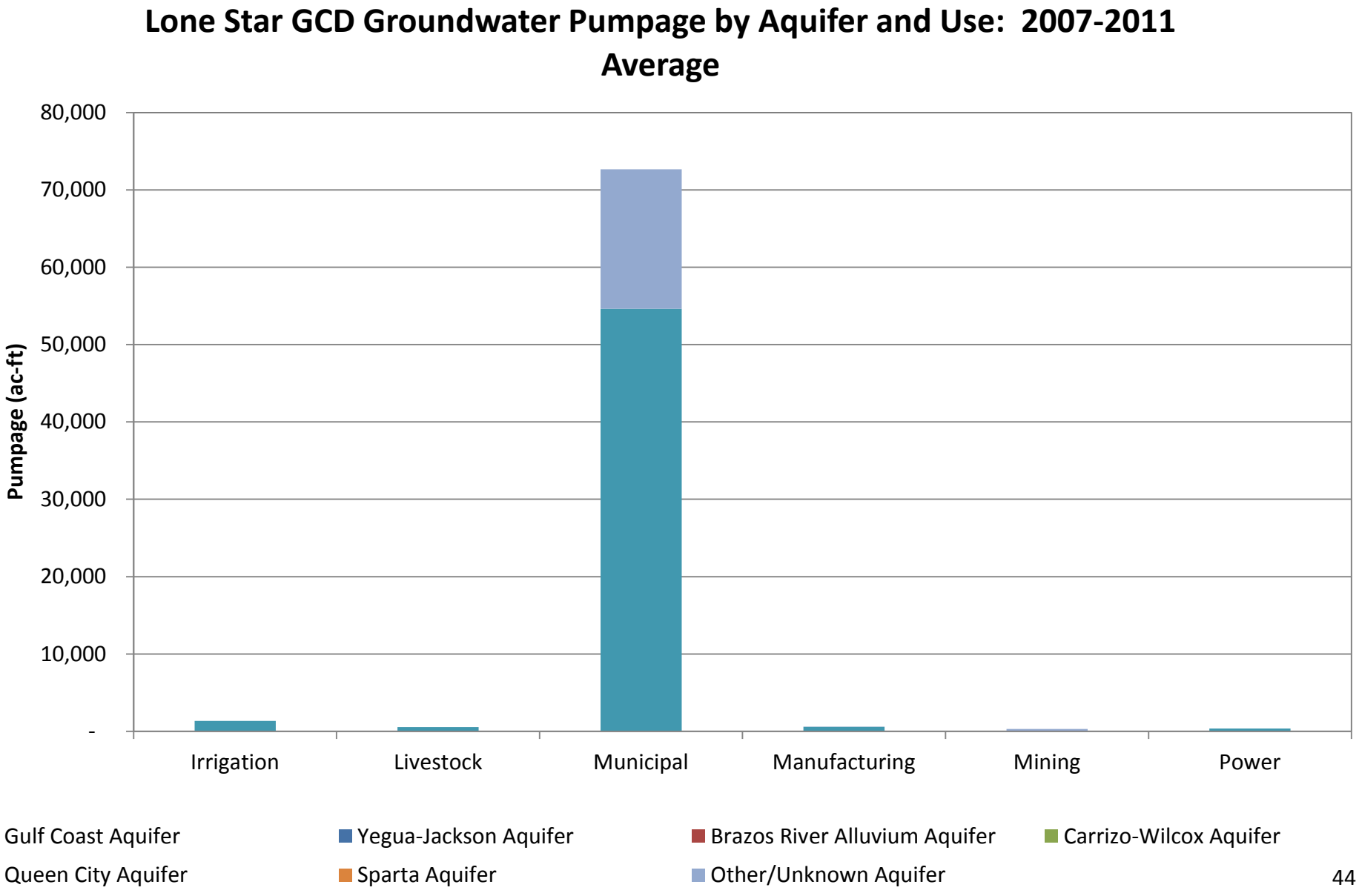
Supporting Materials

Aquifer Uses and Conditions



Supporting Materials

Aquifer Uses and Conditions



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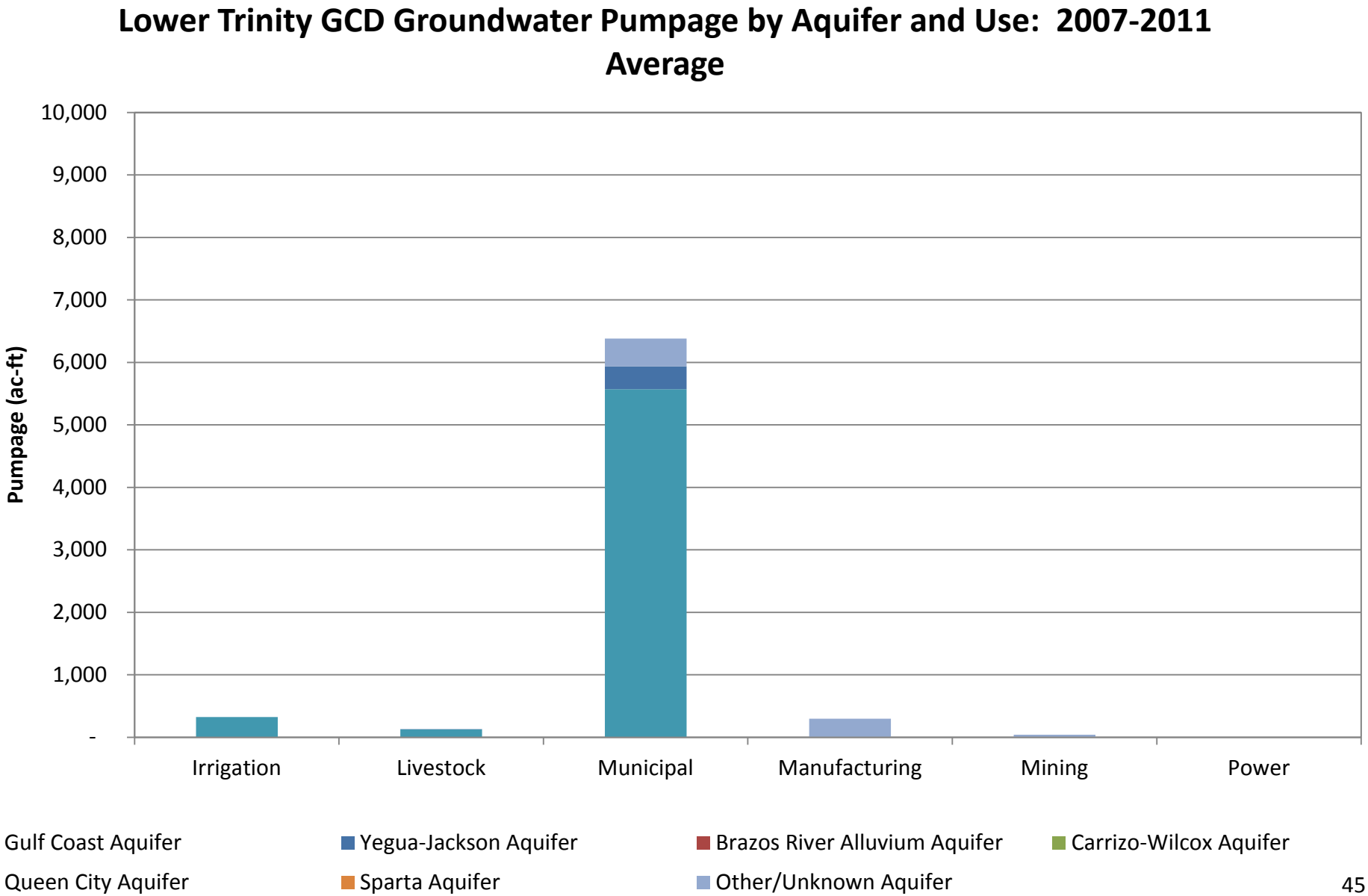
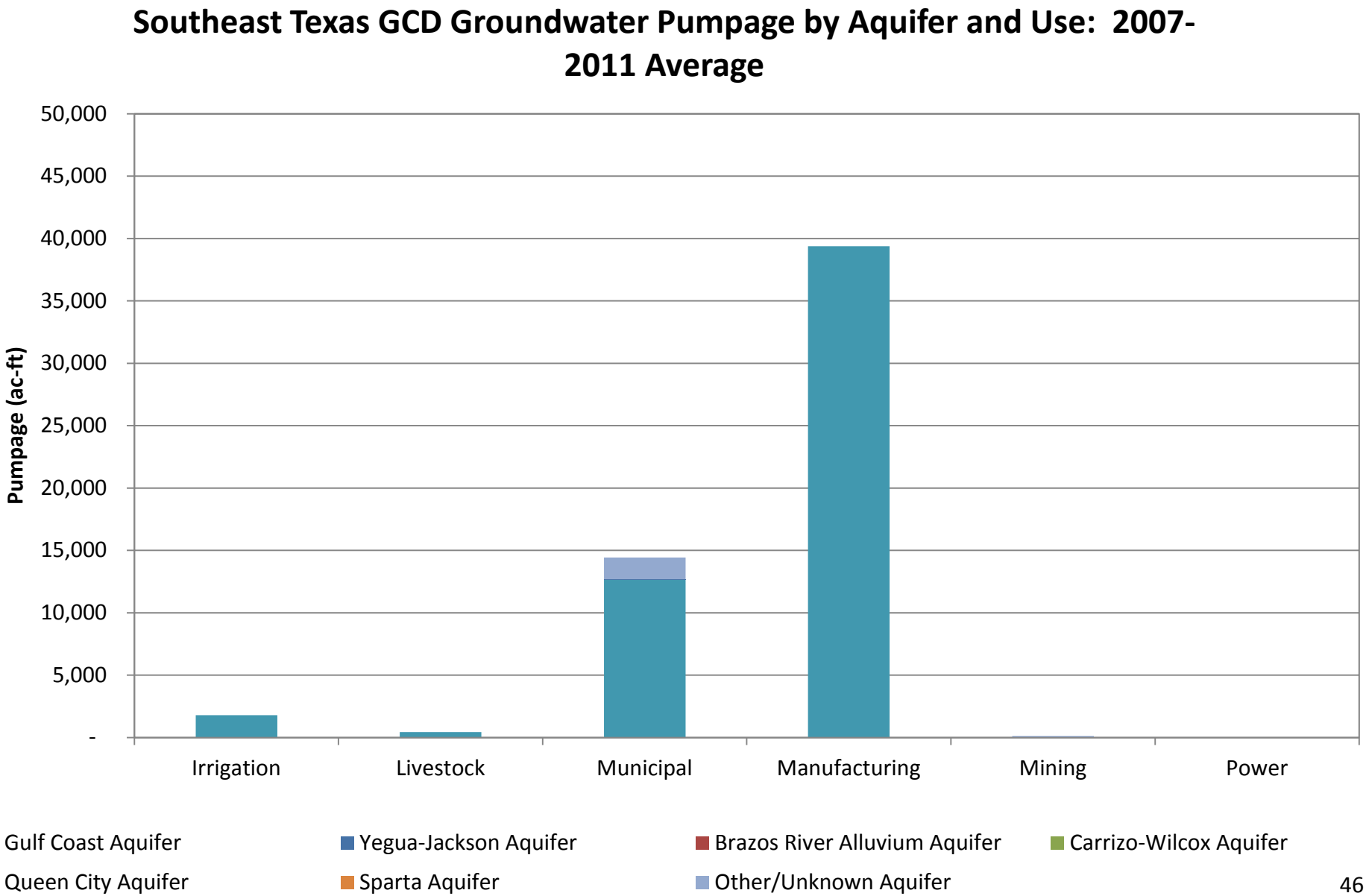
Aquifer Uses and Conditions



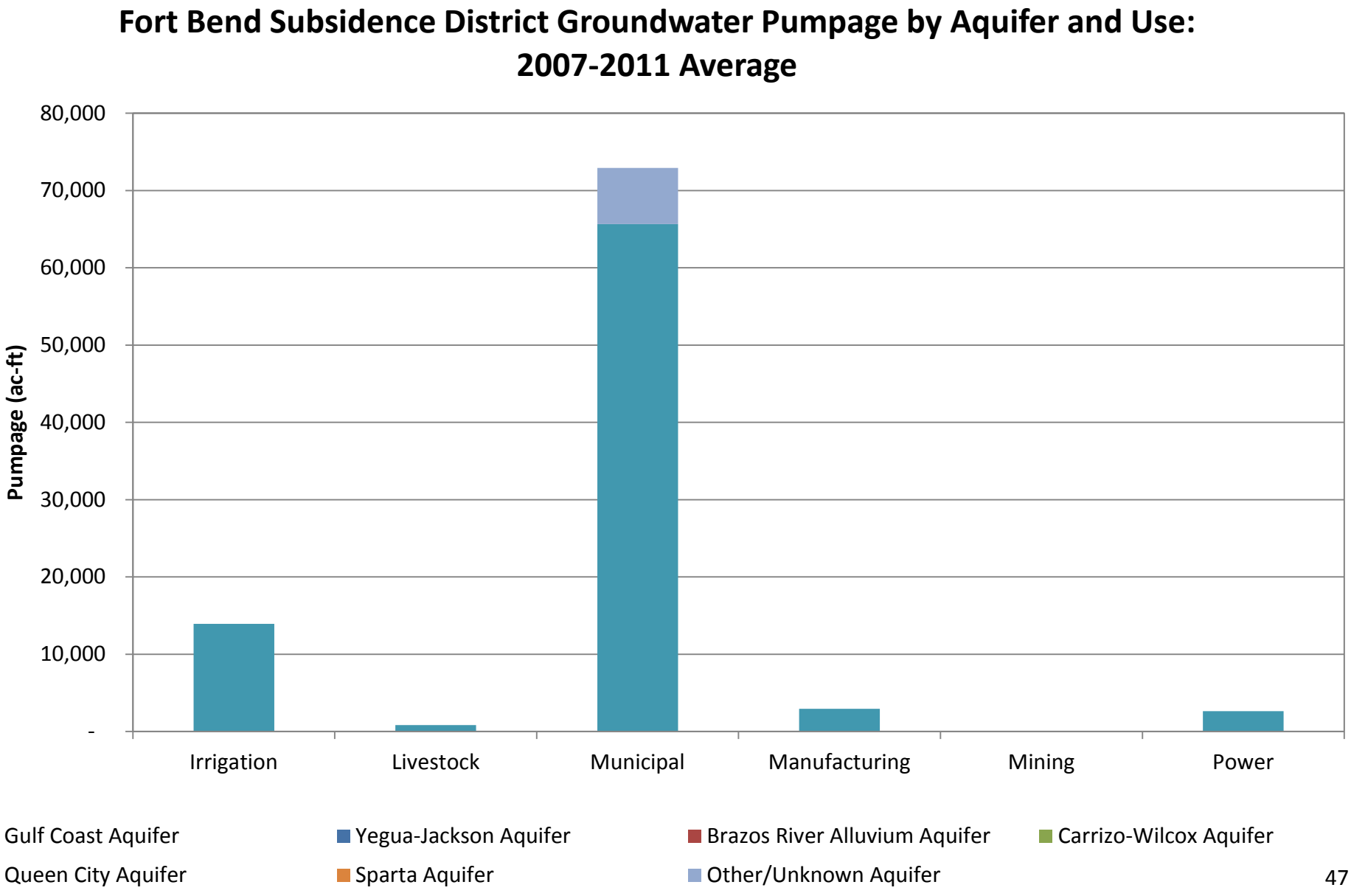
Supporting Materials

Aquifer Uses and Conditions



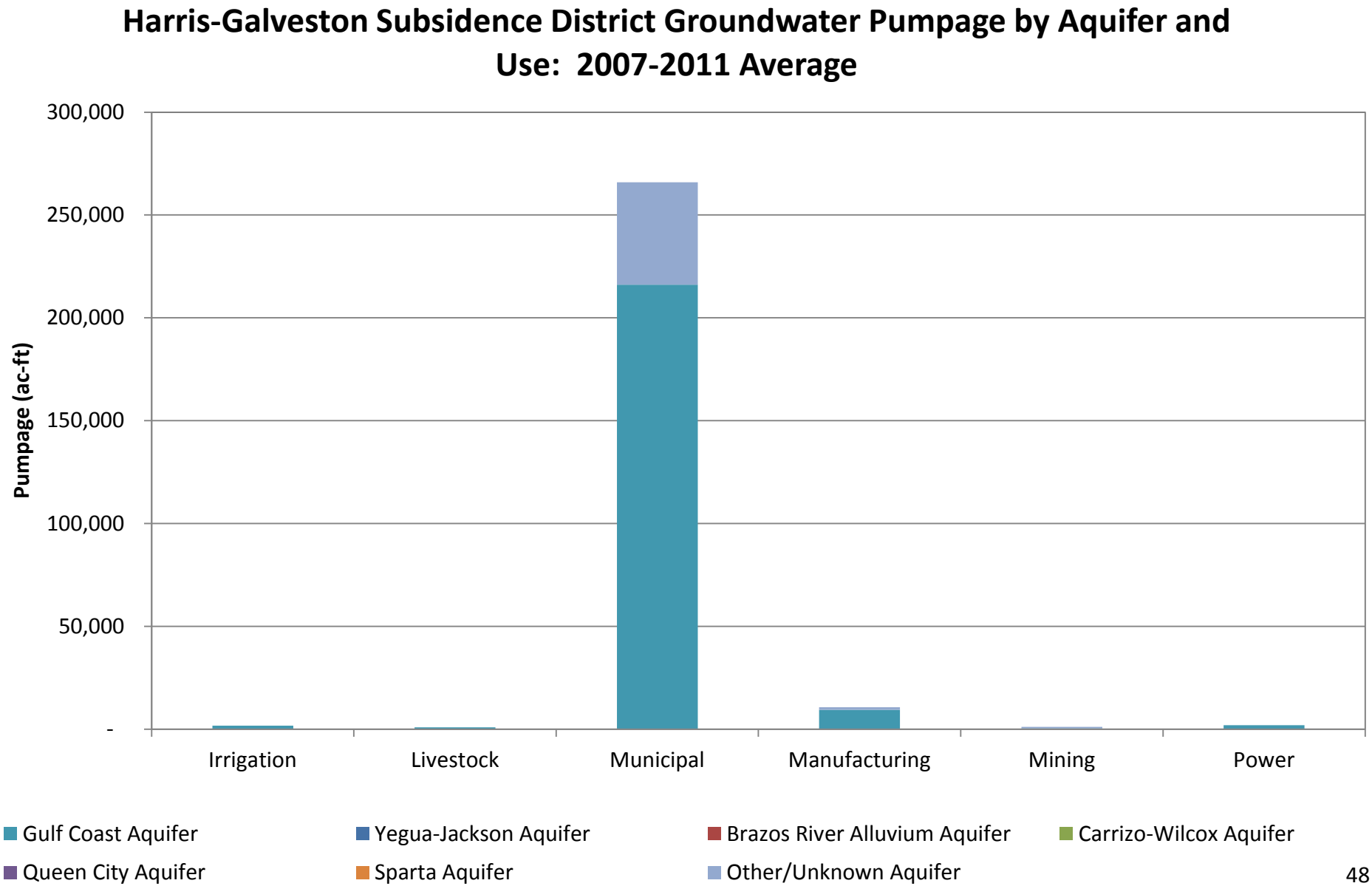
Supporting Materials

Aquifer Uses and Conditions



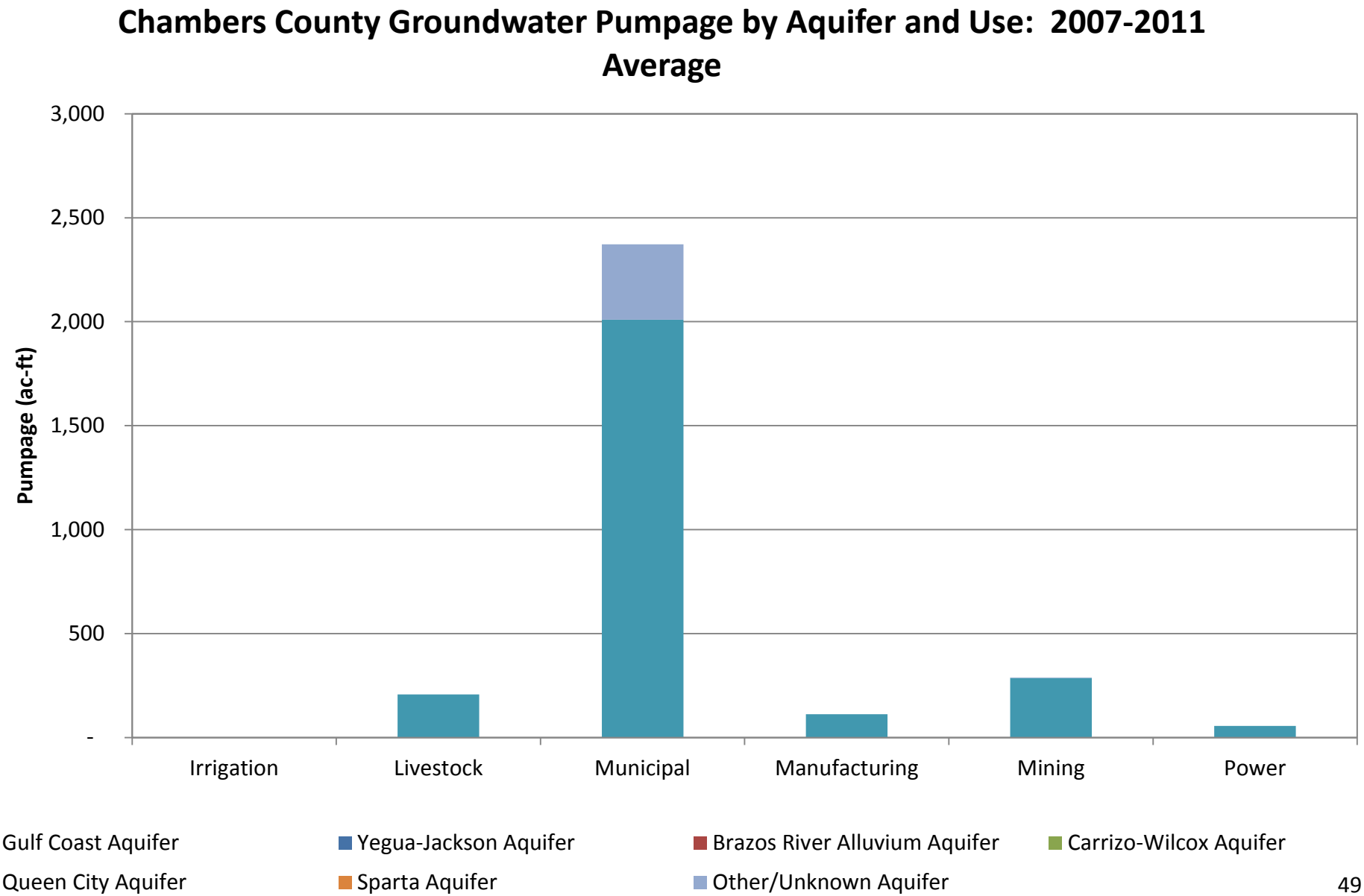
Supporting Materials

Aquifer Uses and Conditions



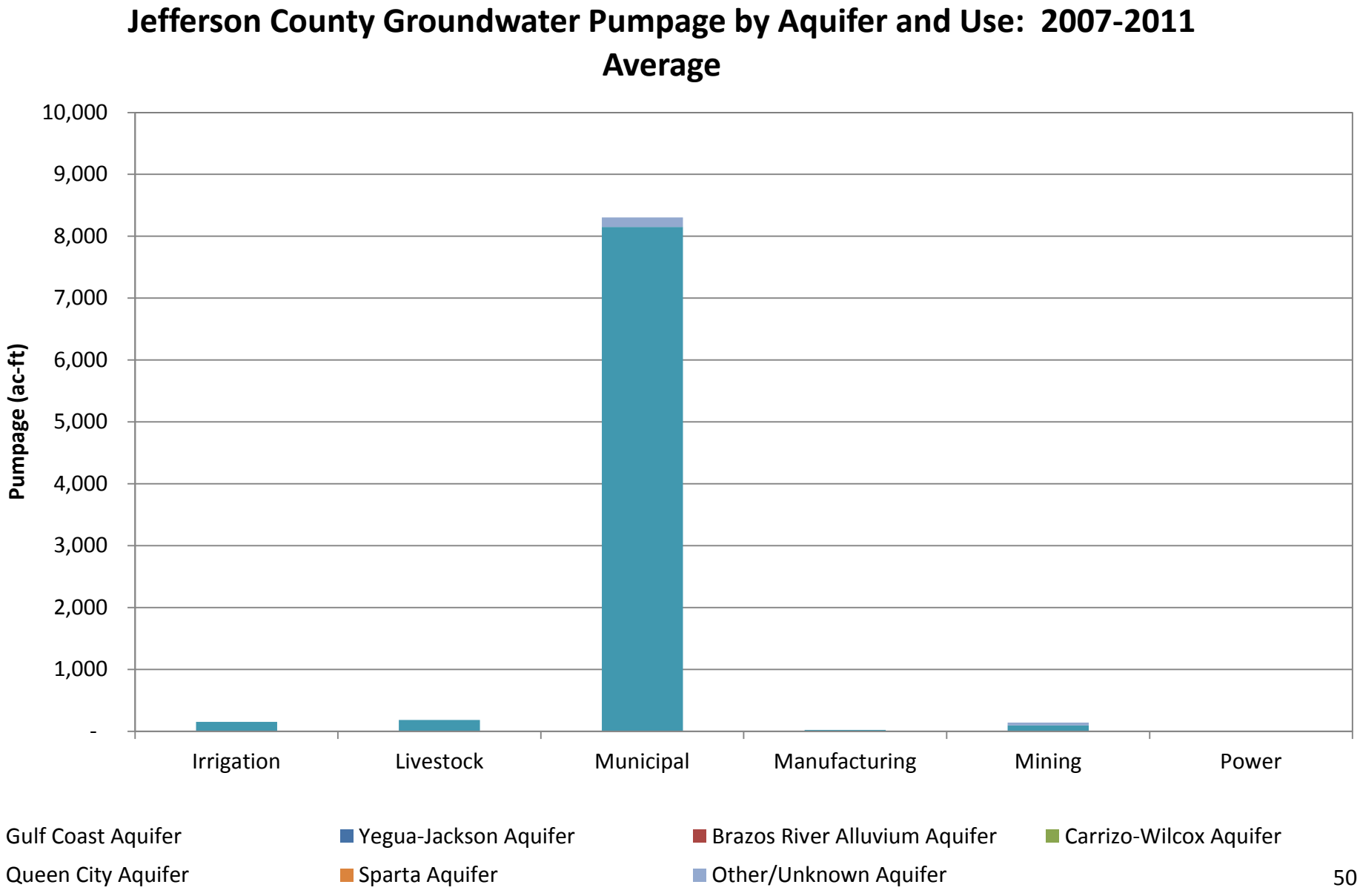
Supporting Materials

Aquifer Uses and Conditions



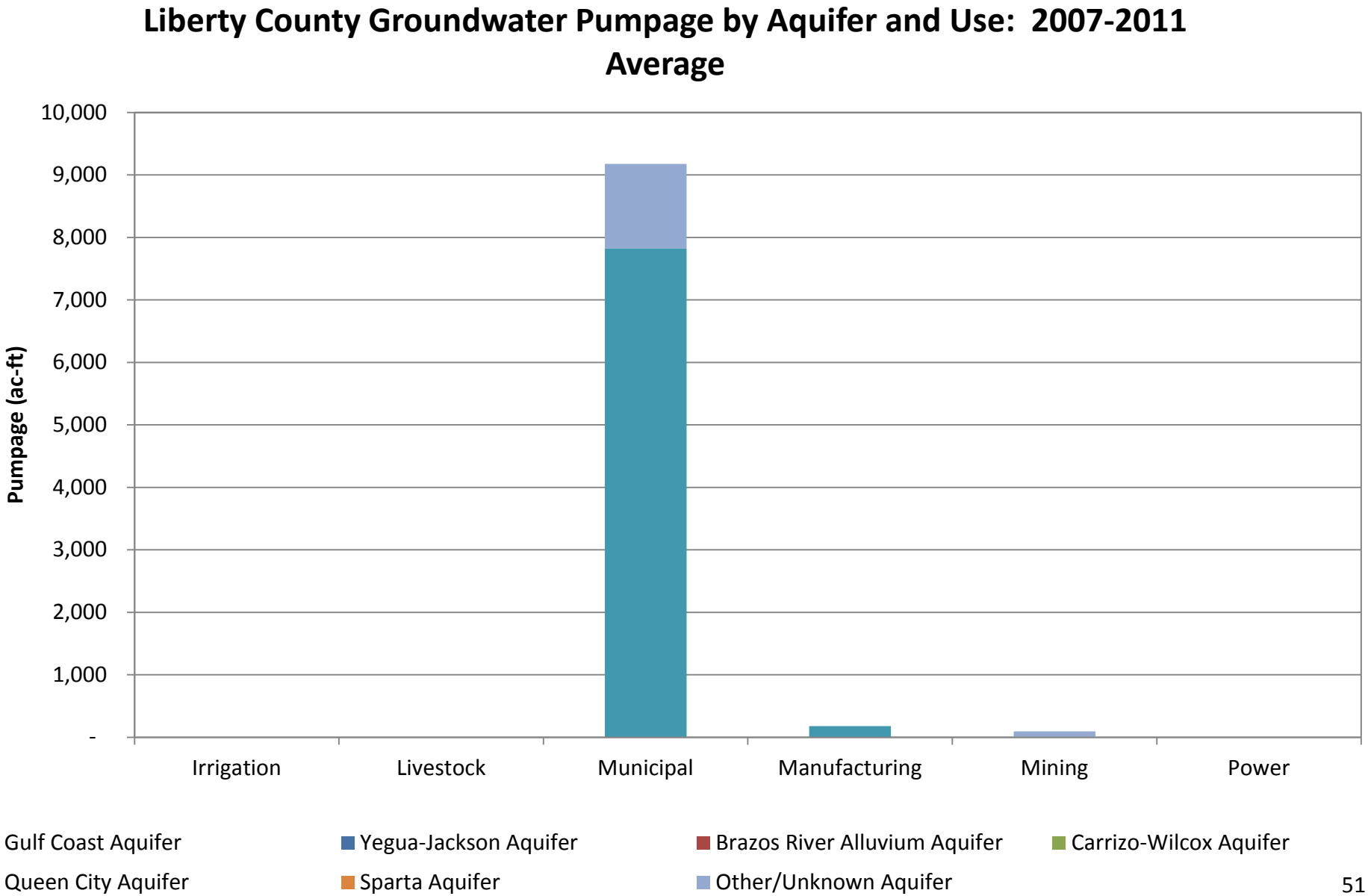
Supporting Materials

Aquifer Uses and Conditions



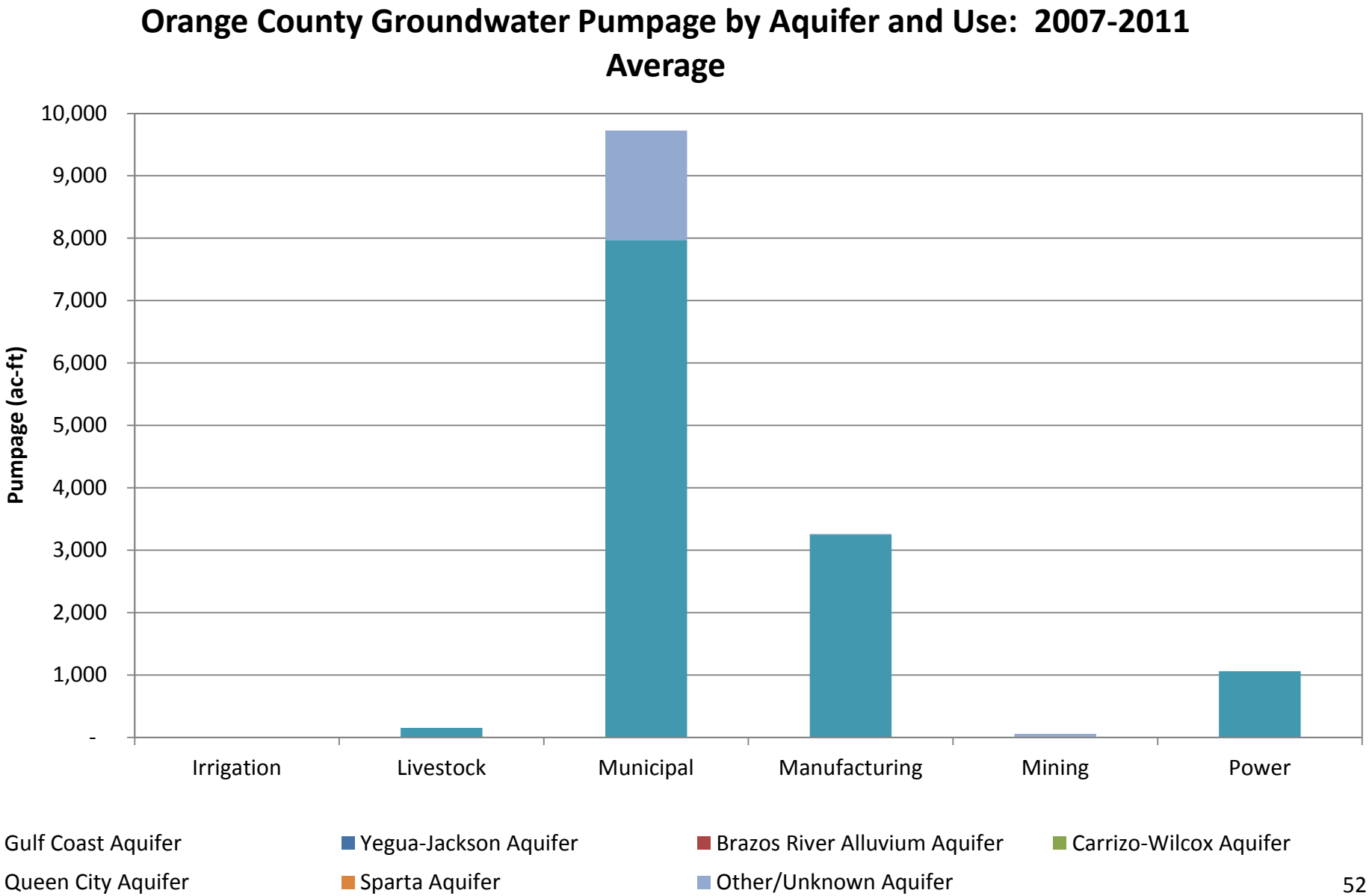
Supporting Materials

Aquifer Uses and Conditions



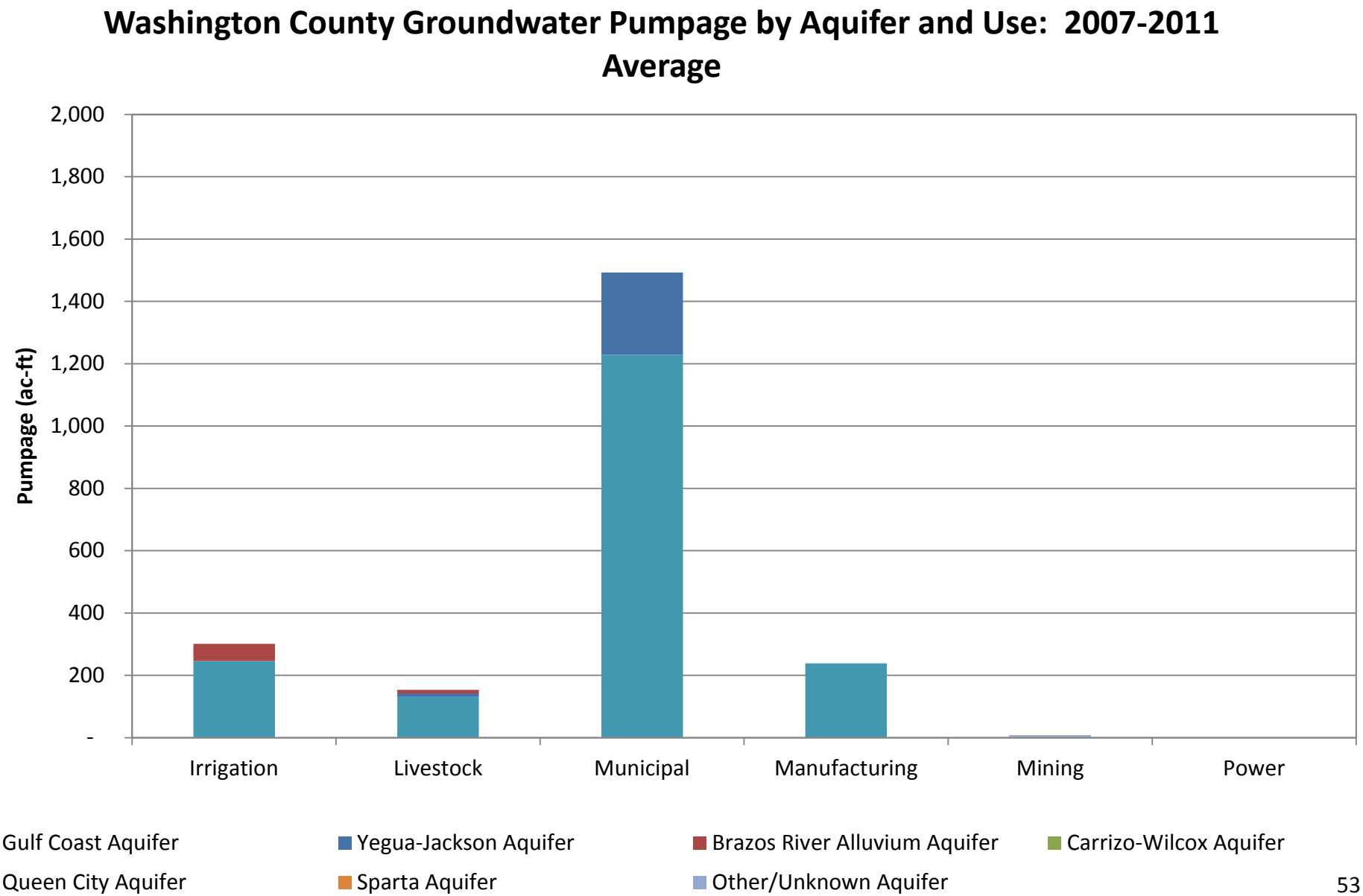
Supporting Materials

Aquifer Uses and Conditions



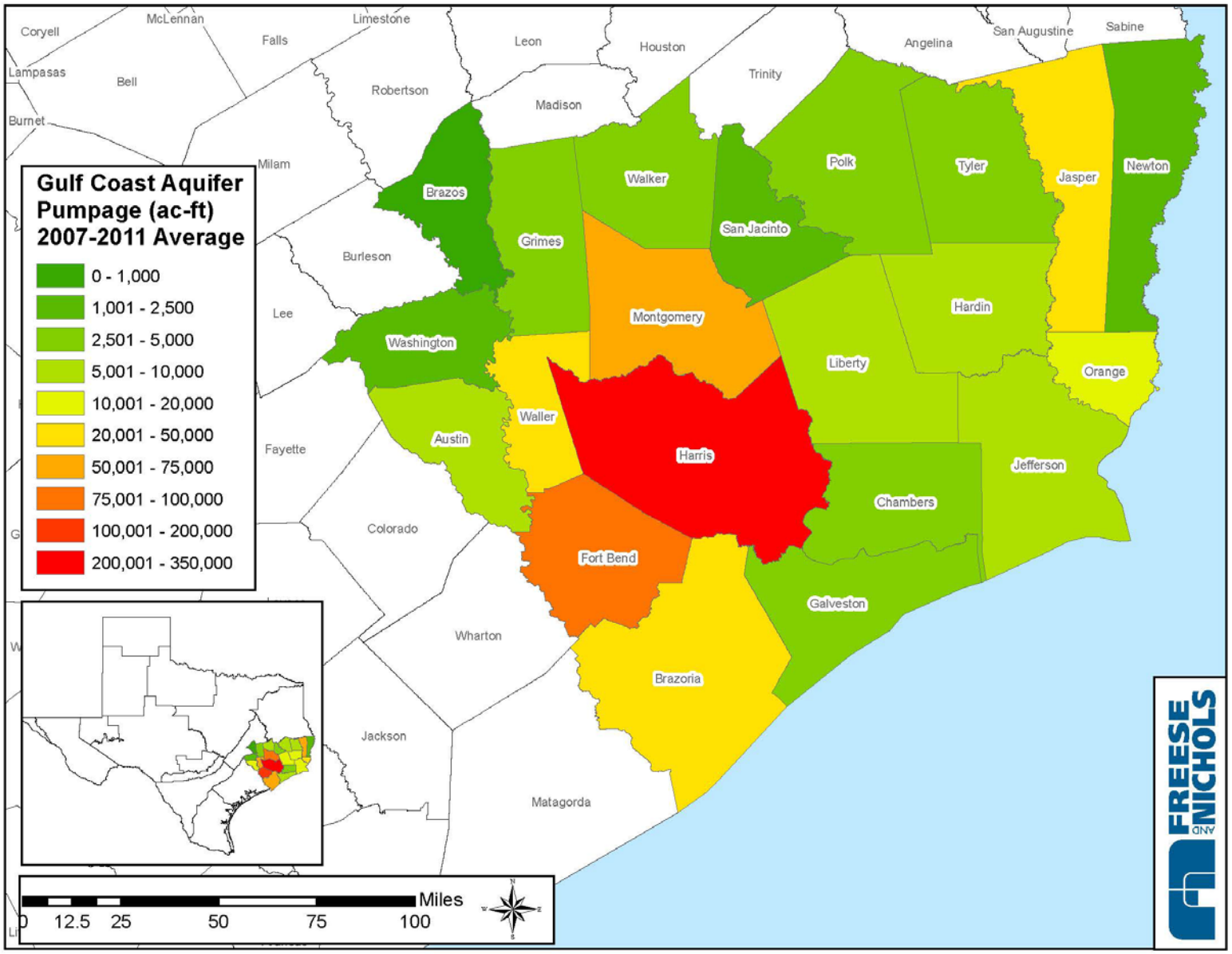
Supporting Materials

Aquifer Uses and Conditions



Supporting Materials

Aquifer Uses and Conditions



Supporting Materials

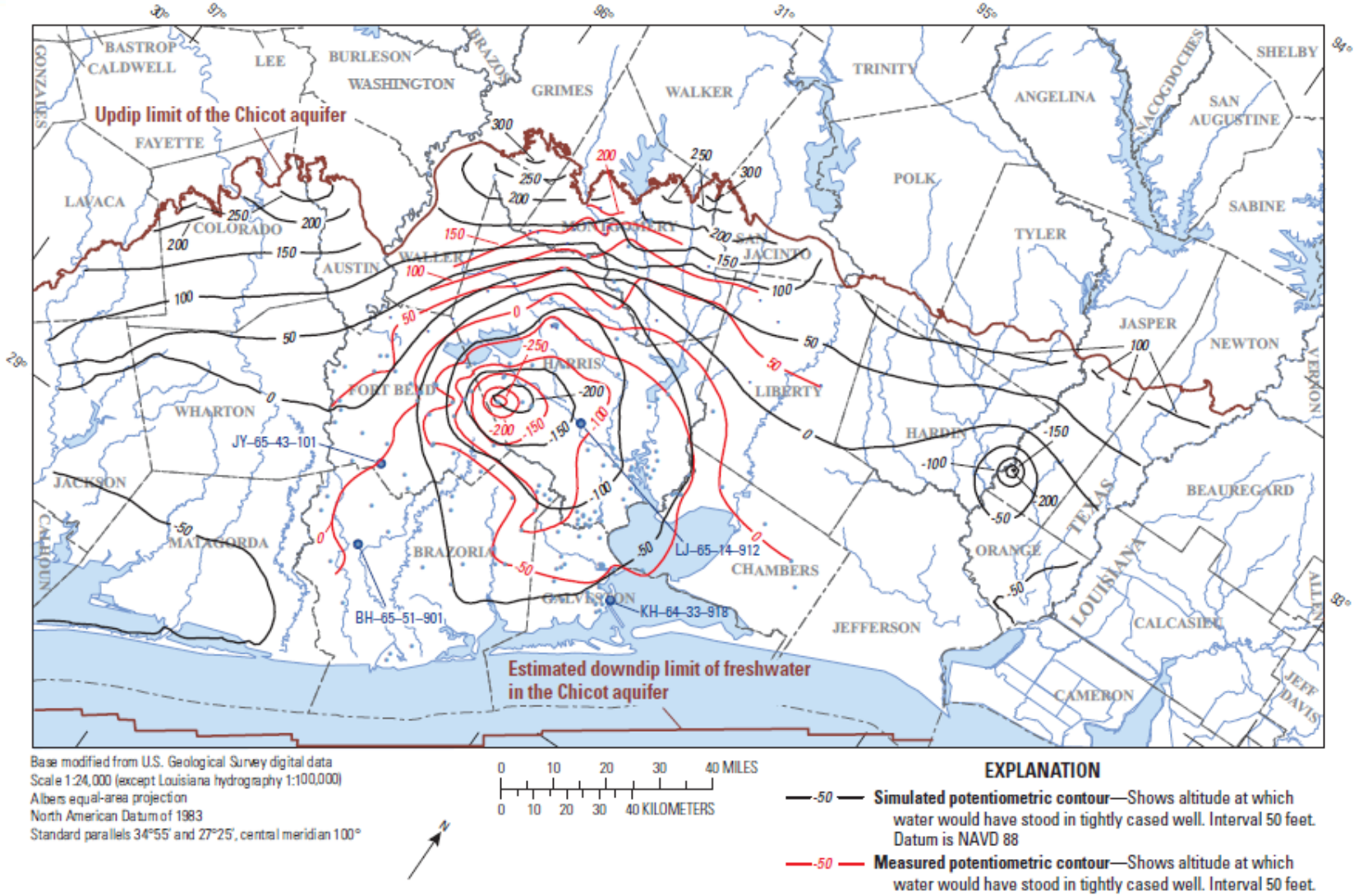
Aquifer Uses and Conditions

- Aquifer Conditions
  - Developed from existing reports

- Gulf Coast Aquifer
  - *Hydrogeology and Simulation of Groundwater Flow and Land-Surface Subsidence in the Northern Part of the Gulf Coast Aquifer* (USGS, Rev. 2012)
  - Water-level elevation
  - Subsidence

Supporting Materials

Aquifer Uses and Conditions



Base modified from U.S. Geological Survey digital data
Scale 1:24,000 (except Louisiana hydrography 1:100,000)
Albers equal-area projection
North American Datum of 1983
Standard parallels 34°55' and 27°25', central meridian 100°

0 10 20 30 40 MILES
0 10 20 30 40 KILOMETERS

N

EXPLANATION

-50 **Simulated potentiometric contour**—Shows altitude at which water would have stood in tightly cased well. Interval 50 feet. Datum is NAVD 88

-50 **Measured potentiometric contour**—Shows altitude at which water would have stood in tightly cased well. Interval 50 feet. Datum is NAVD 88

Data point—Well in which water-level measurement was made

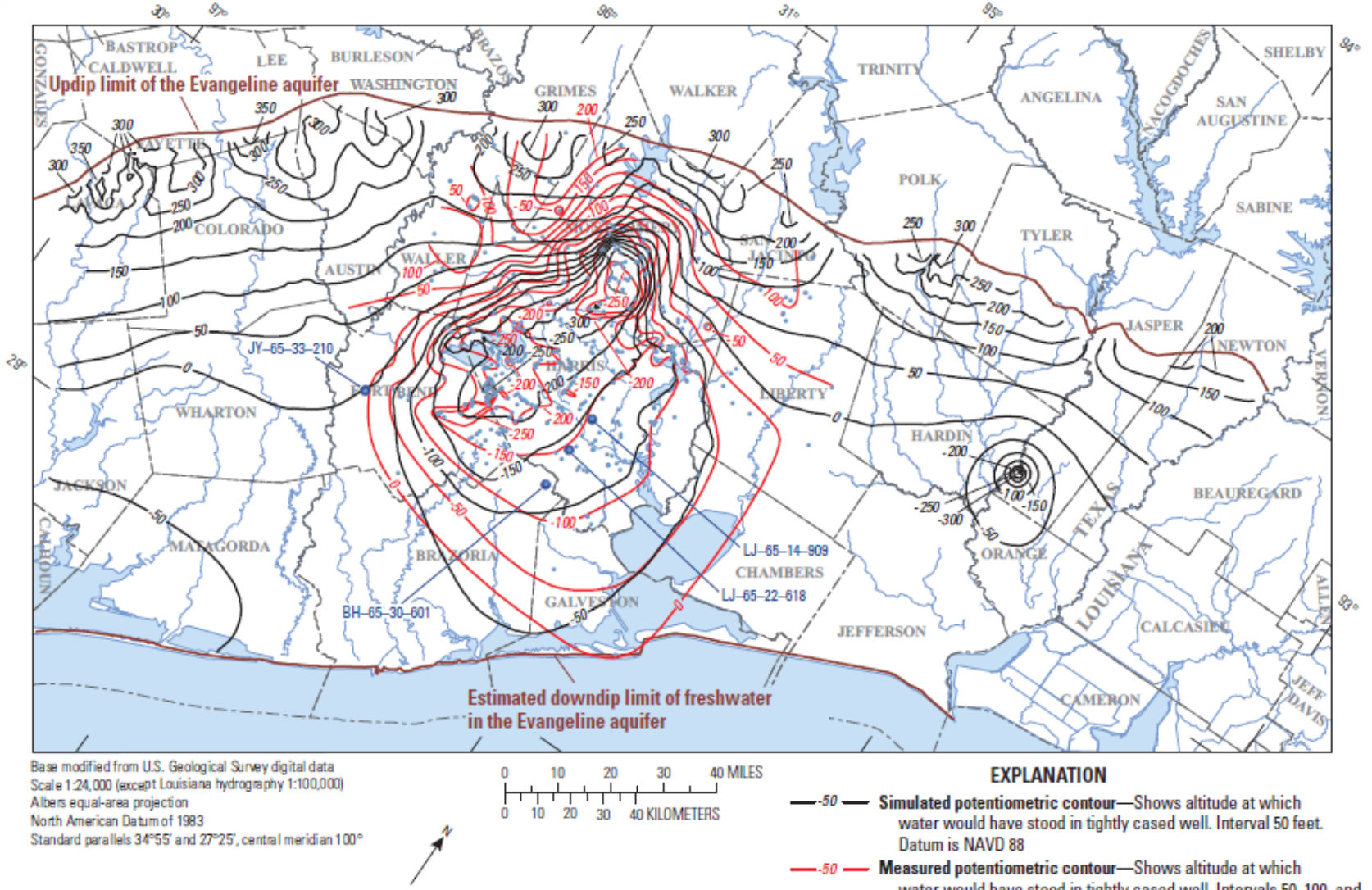
LJ–65–14–912 **Data point and well number**—Well in which water-level measurement was made and for which hydrograph is shown on figure 26

NAVD 88, North American Vertical Datum of 1988

Chicot Formation
Simulated and Measured Contours

Supporting Materials

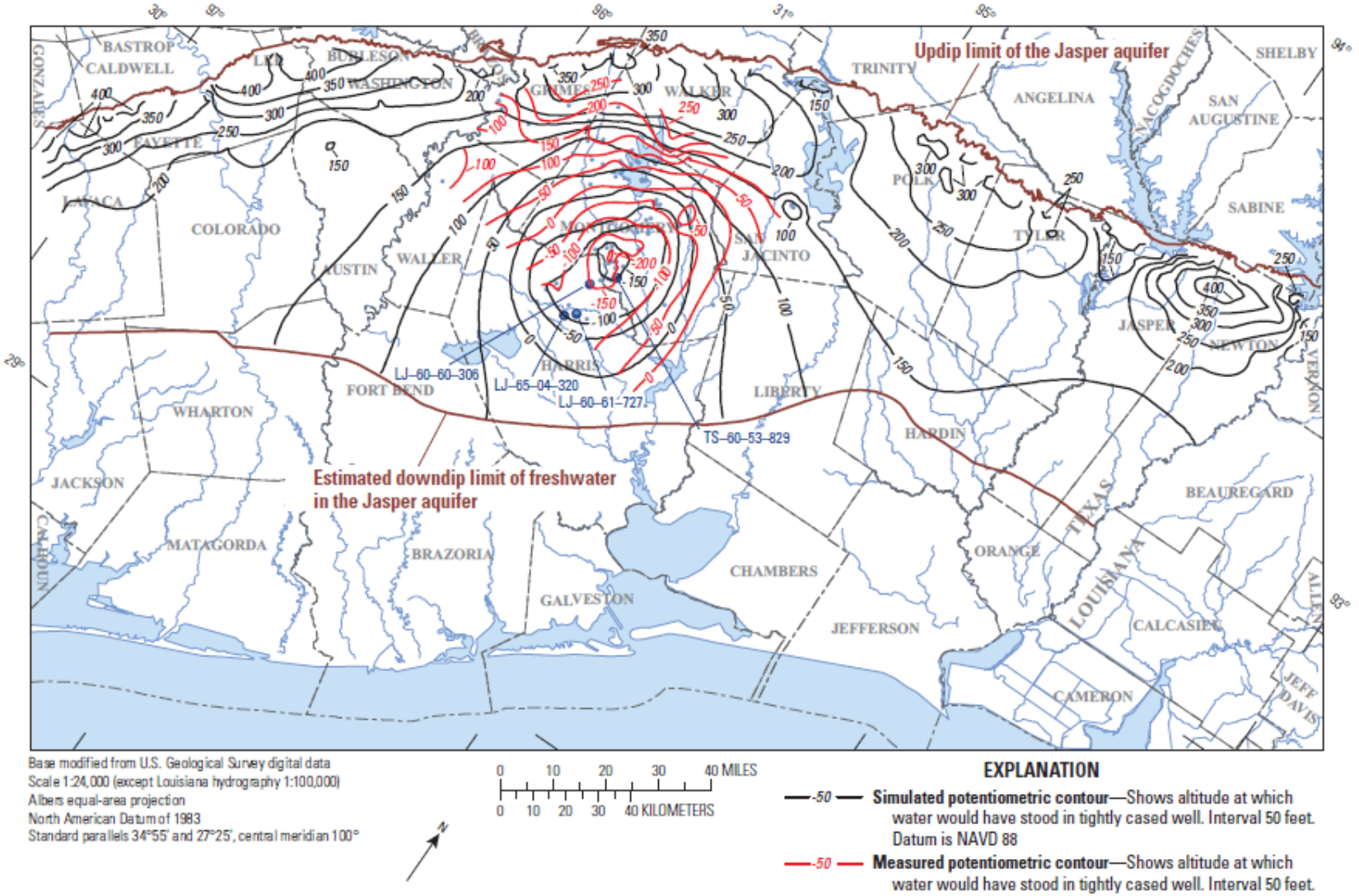
Aquifer Uses and Conditions



Evangeline Formation
Simulated and Measured Contours

Supporting Materials

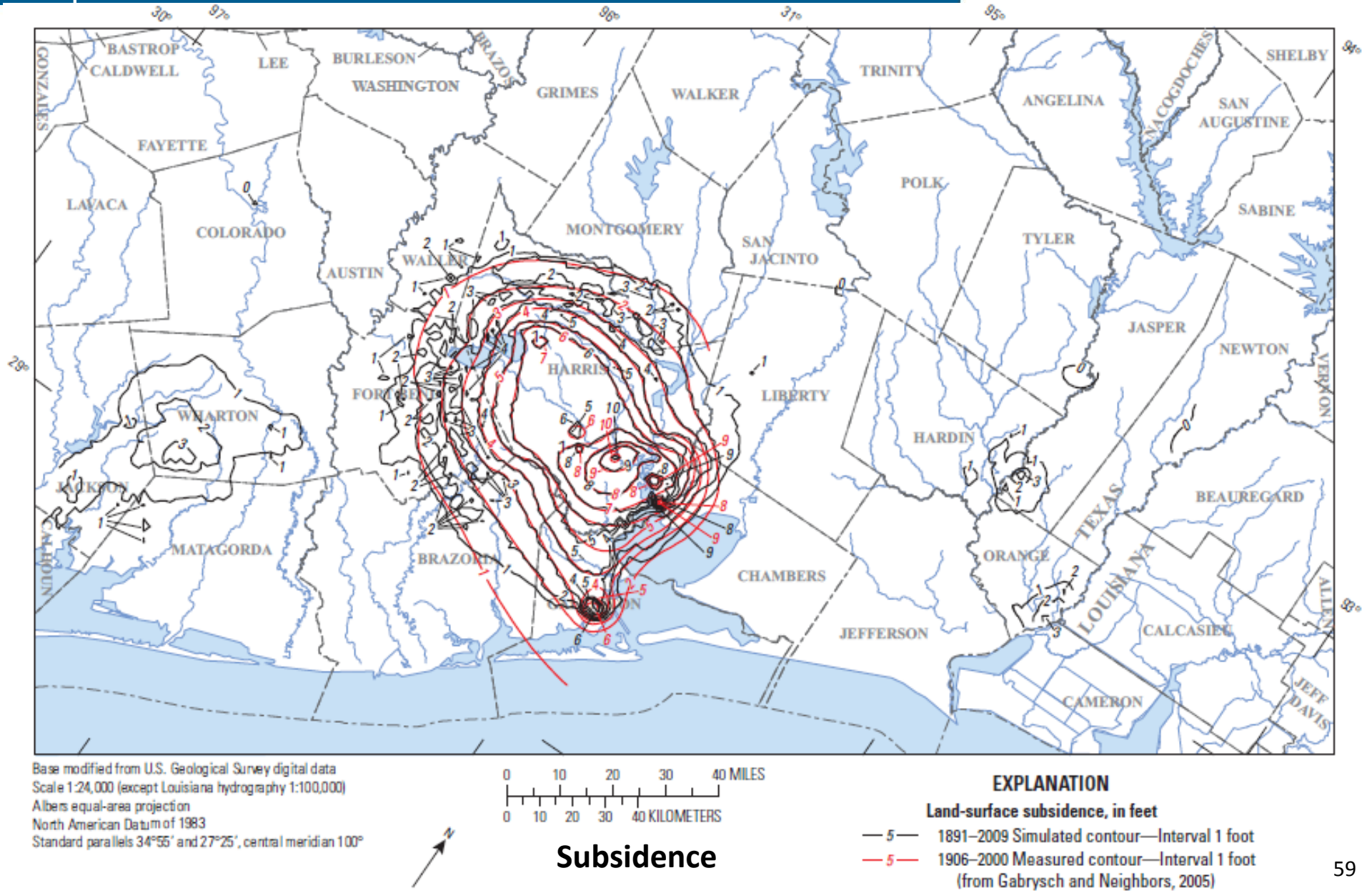
Aquifer Uses and Conditions



Jasper Formation
Simulated and Measured Contours

Supporting Materials

Aquifer Uses and Conditions



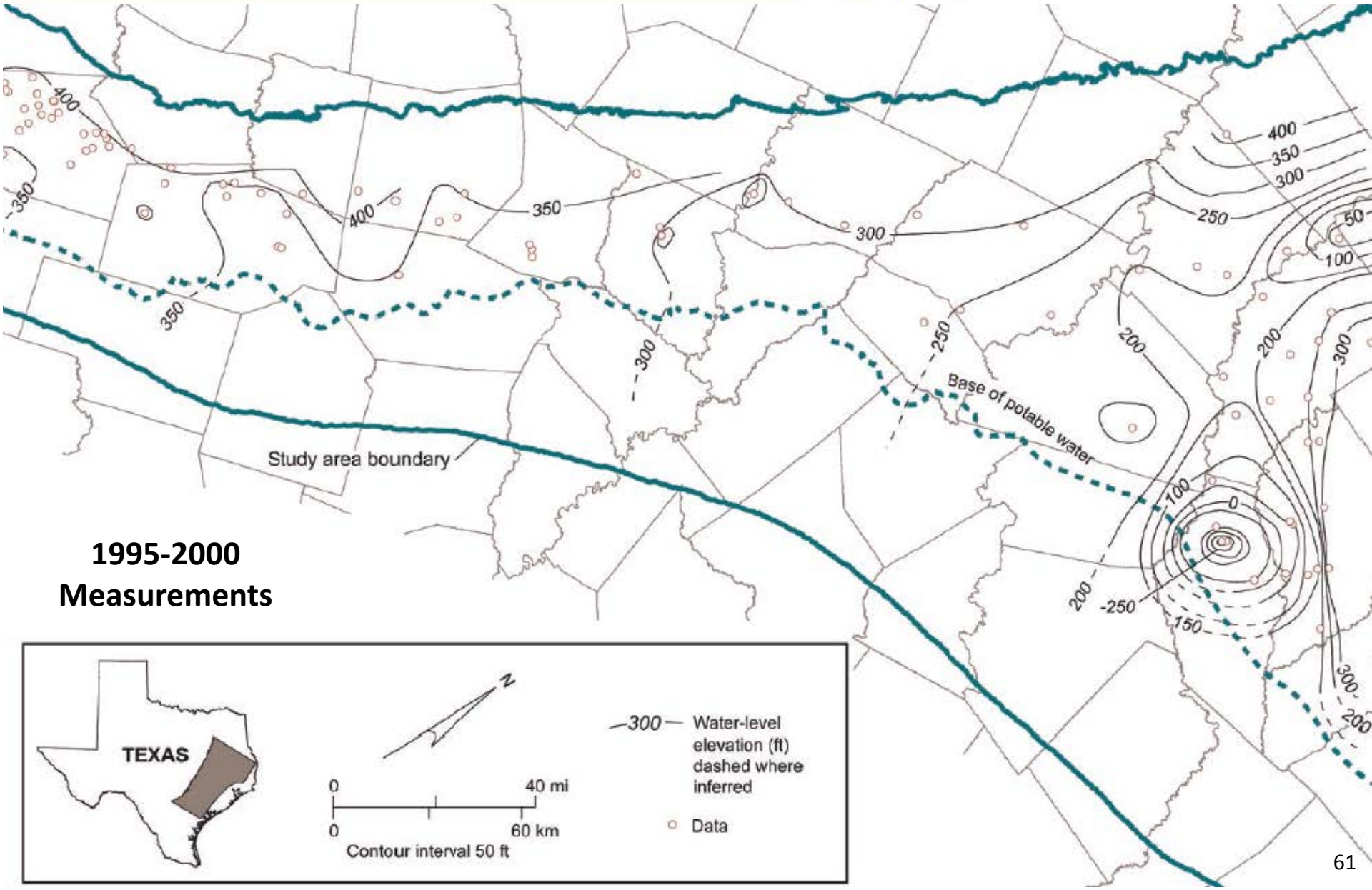
Subsidence

Supporting Materials
Aquifer Uses and Conditions

- Carrizo Sand Aquifer
  - *Groundwater Availability Model for the Central Part of the Carrizo-Wilcox Aquifer in Texas* (BEG, 2003)
  - Water-level elevation

Supporting Materials

Aquifer Uses and Conditions



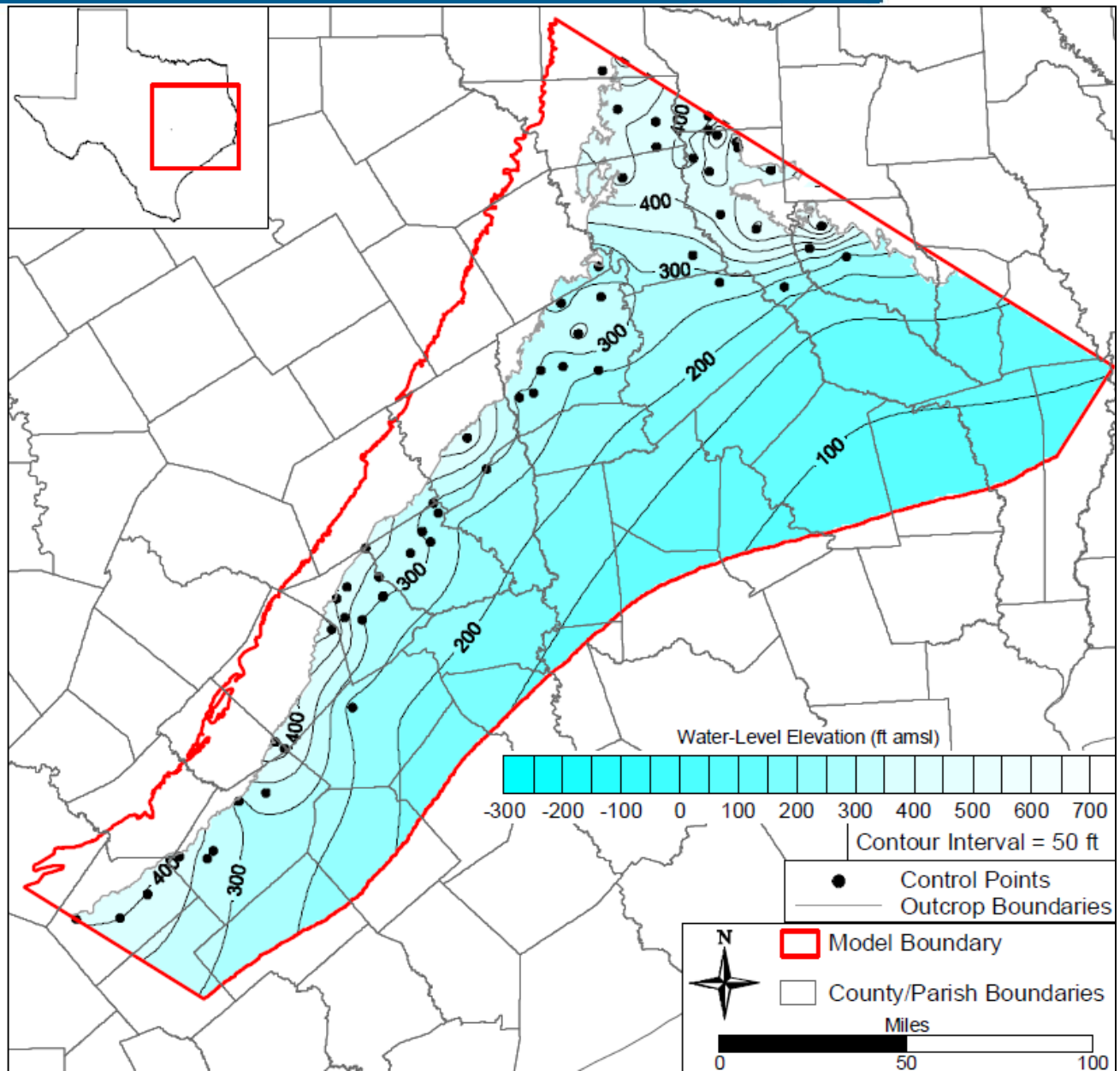
Supporting Materials

Aquifer Uses and Conditions

- Queen City Aquifer
  - *Groundwater Availability Models for the Queen City and Sparta Aquifers* (INTERA, 2004)
  - Water-level elevation

Supporting Materials

Aquifer Uses and Conditions



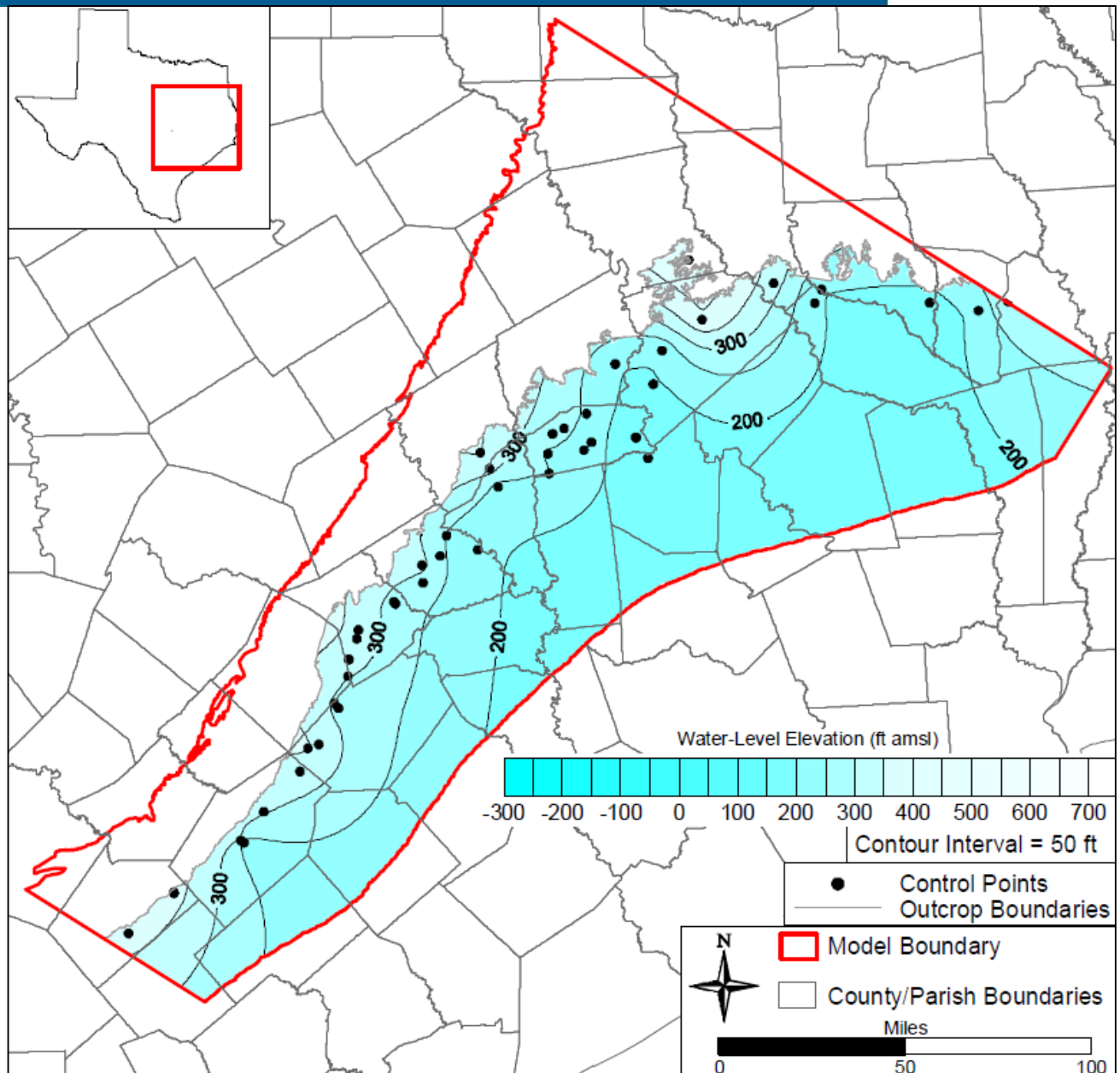
1999 Estimated

Supporting Materials
Aquifer Uses and Conditions

- Sparta Aquifer
  - *Groundwater Availability Models for the Queen City and Sparta Aquifers* (INTERA, 2004)
  - Water-level elevation

Supporting Materials

Aquifer Uses and Conditions



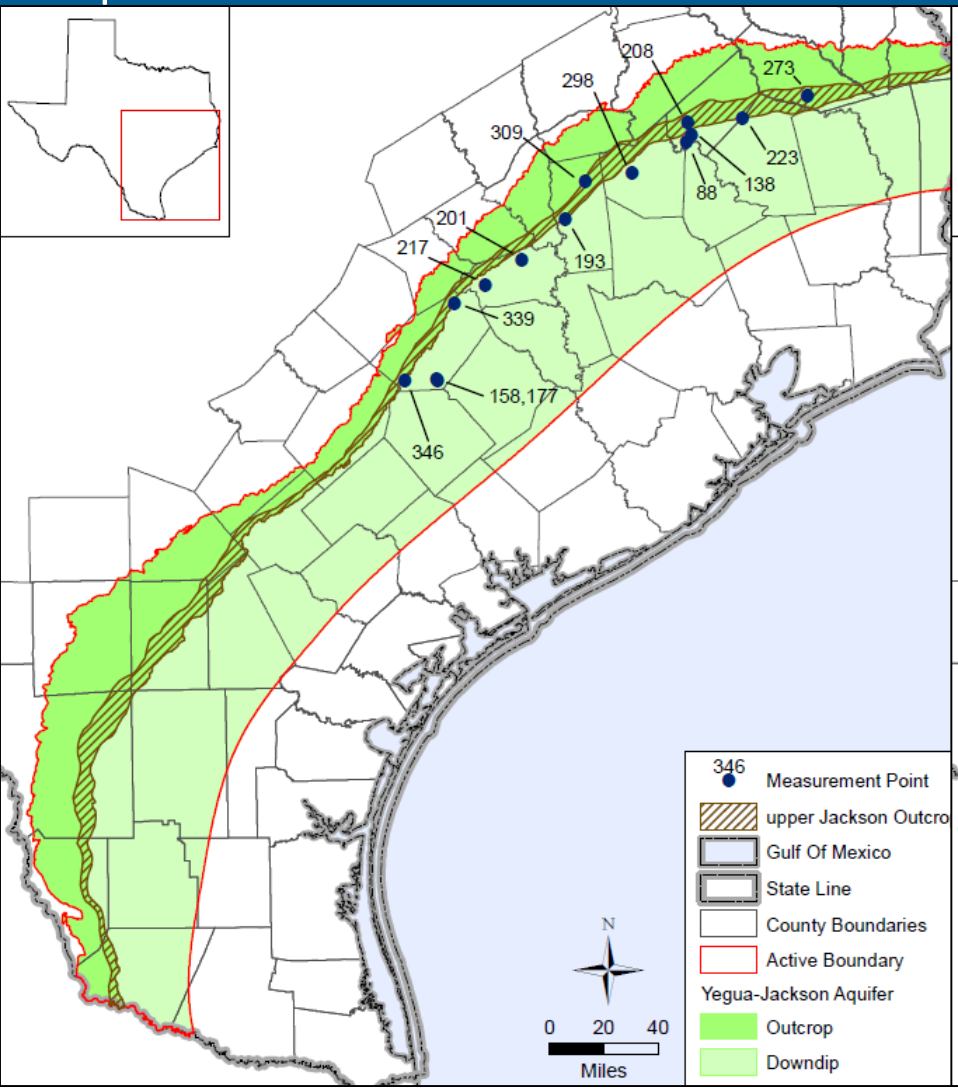
1999 Estimated

Supporting Materials
Aquifer Uses and Conditions

- Yegua-Jackson Aquifer
  - *Final Report: Groundwater Availability Model for the Yegua-Jackson Aquifer* (INTERA, Rev. 2010)
  - Water-level elevation

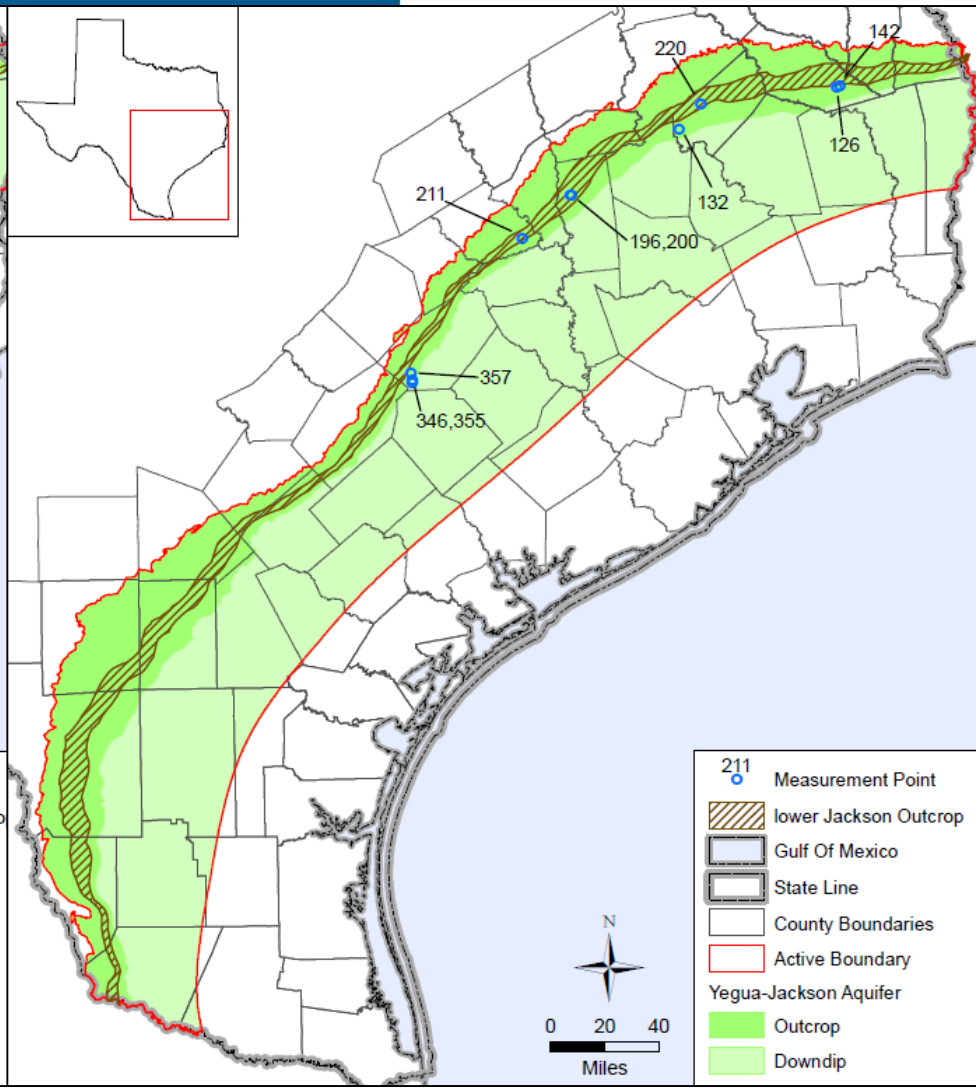
Supporting Materials

Aquifer Uses and Conditions



Upper Jackson

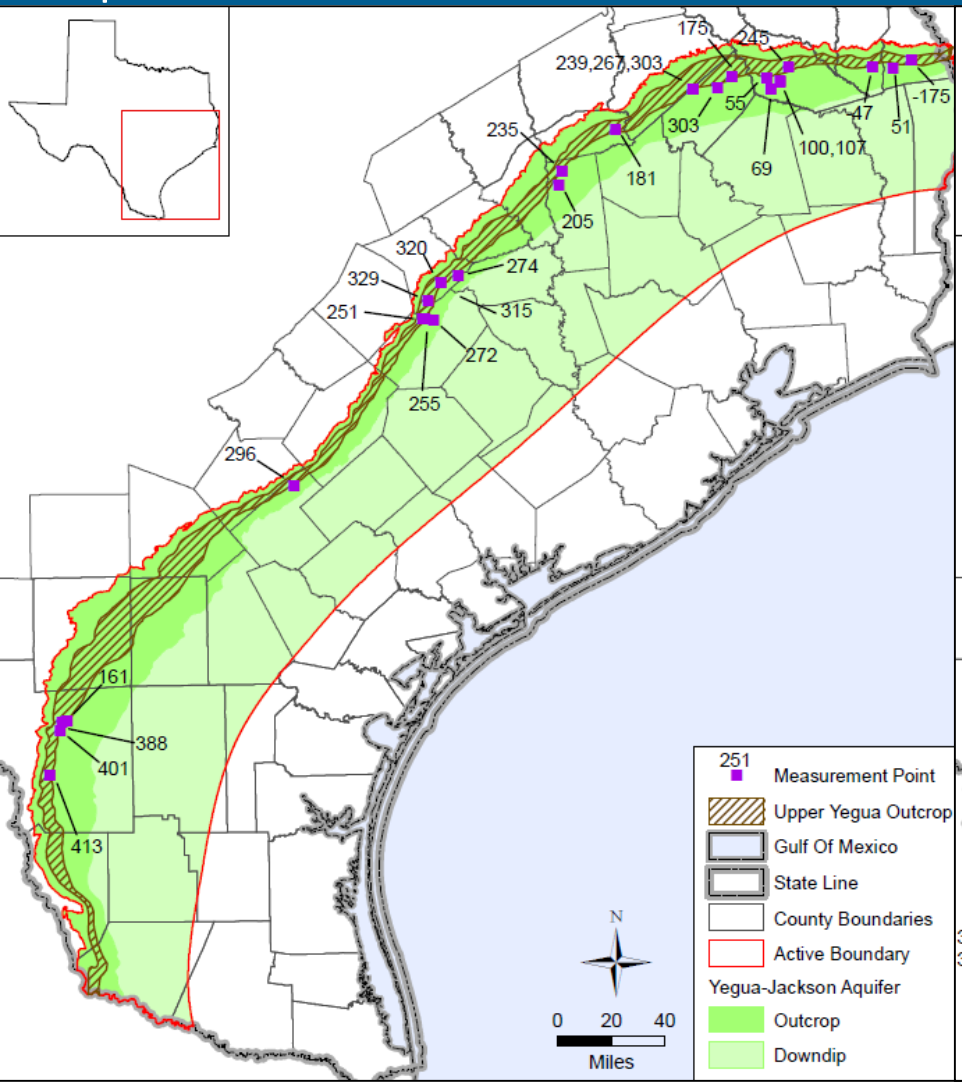
1997 Estimated

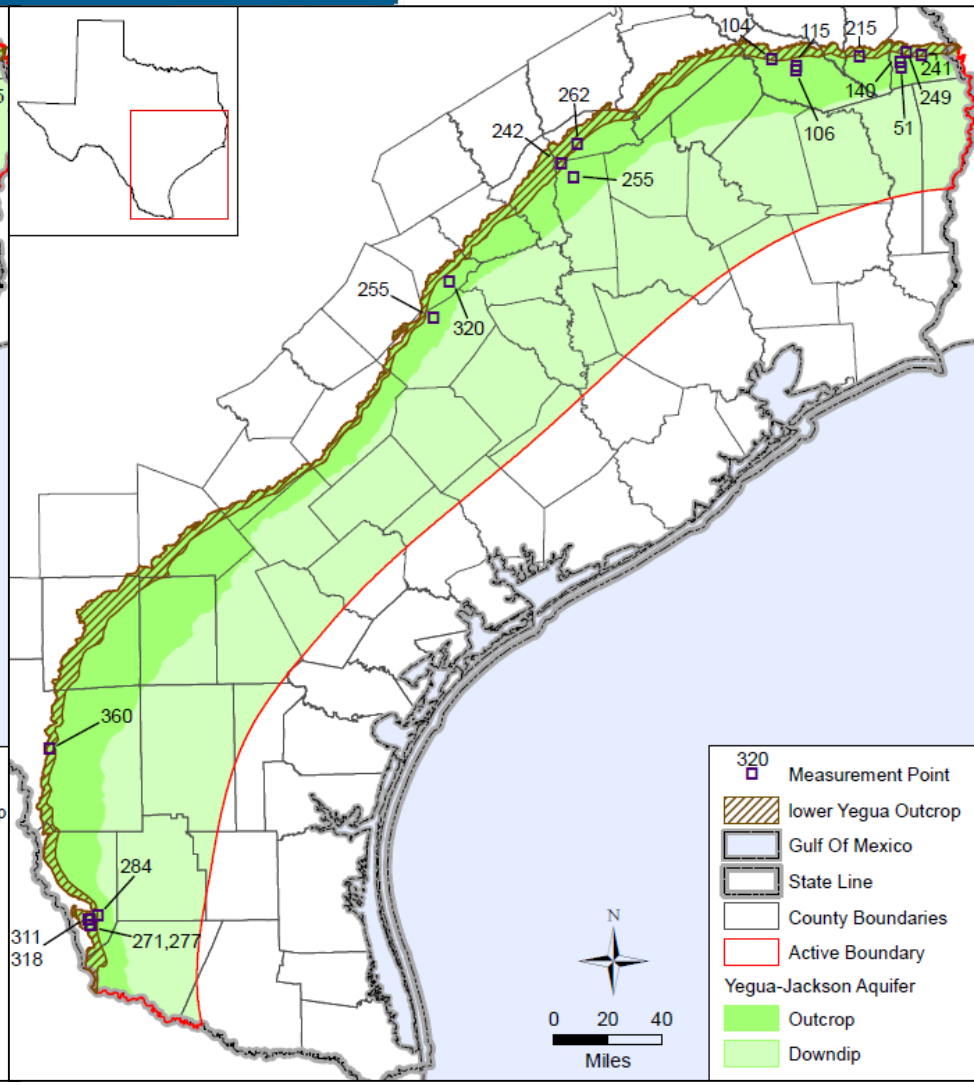


Lower Jackson

Supporting Materials

Aquifer Uses and Conditions





Upper Yegua

1997 Estimated

Lower Yegua

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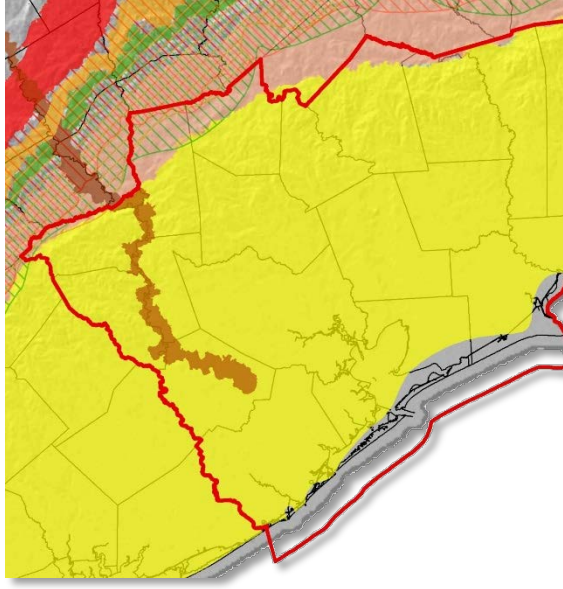
FREESE AND NICHOLS



Supporting Materials

WATER SUPPLY NEEDS AND STRATEGIES

June 24, 2015

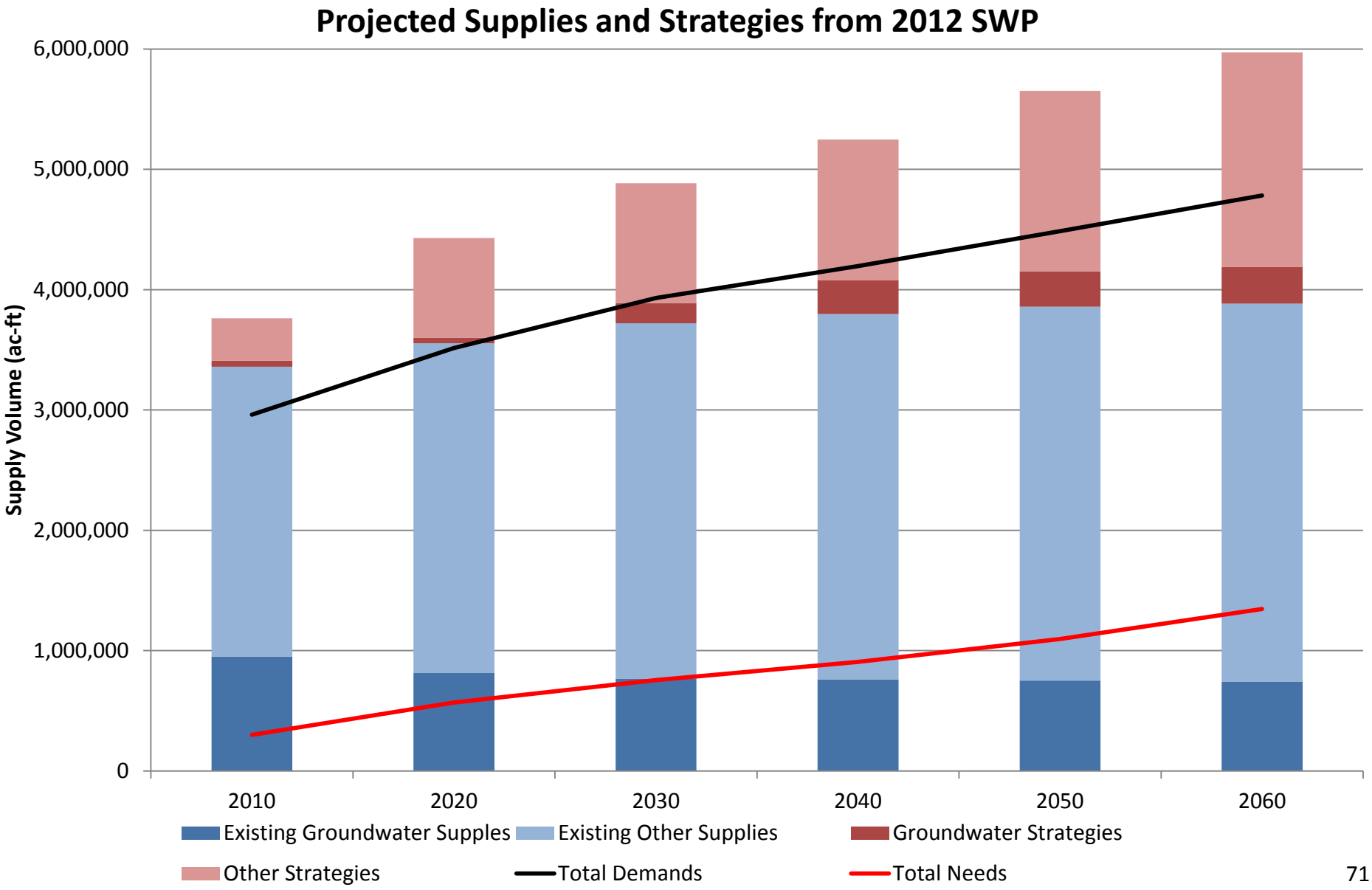
Supporting Materials

Water Supply Needs and Strategies

- Water Supply Needs and Strategies
  - *"the water supply needs and water management strategies included in the state water plan;" TWC 36.108 (d) (2)*
  - 2012 State Water Plan
  - Year 2010 to 2060
  - Summarized by county

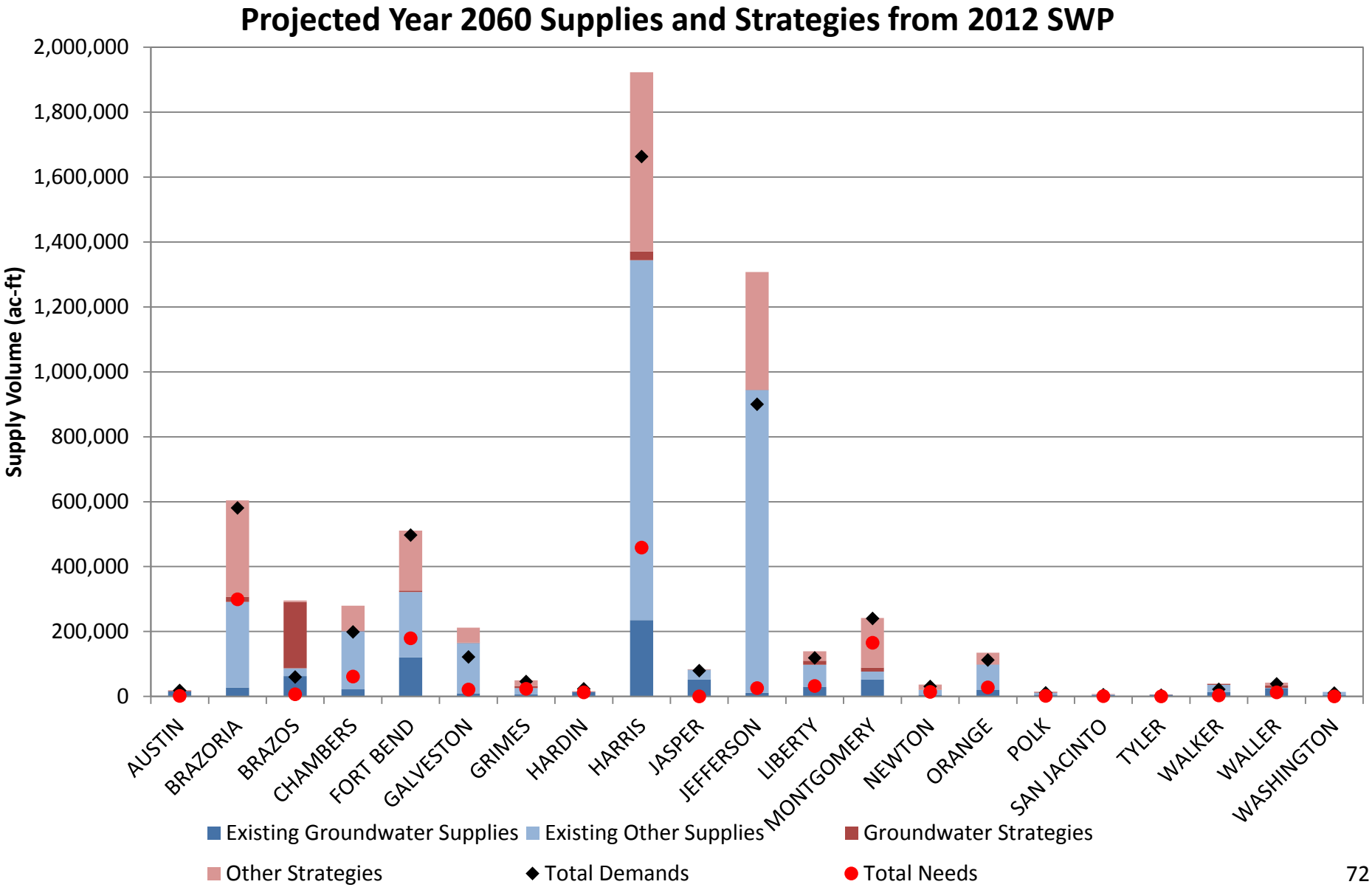
Supporting Materials

Water Supply Needs and Strategies



Supporting Materials

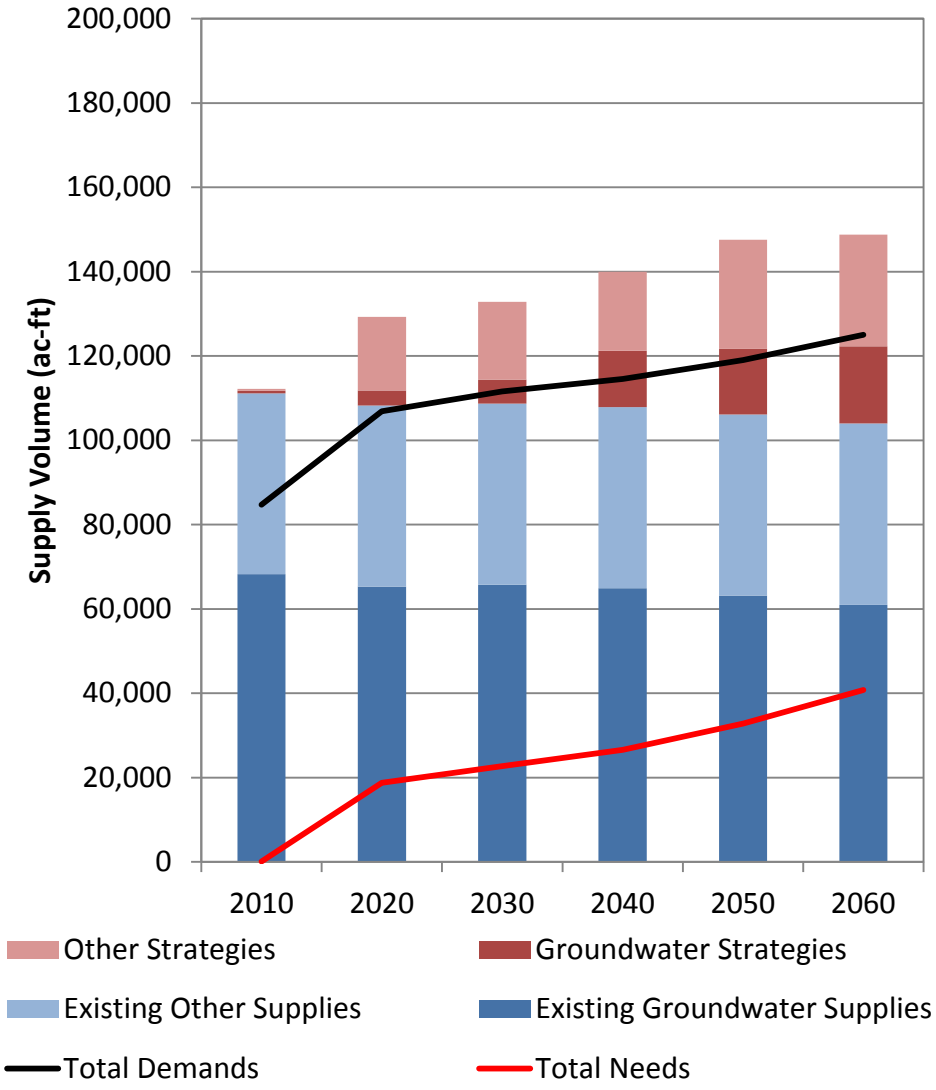
Water Supply Needs and Strategies



Supporting Materials

Water Supply Needs and Strategies

Bluebonnet GCD Projected Supplies and Strategies from 2012 SWP

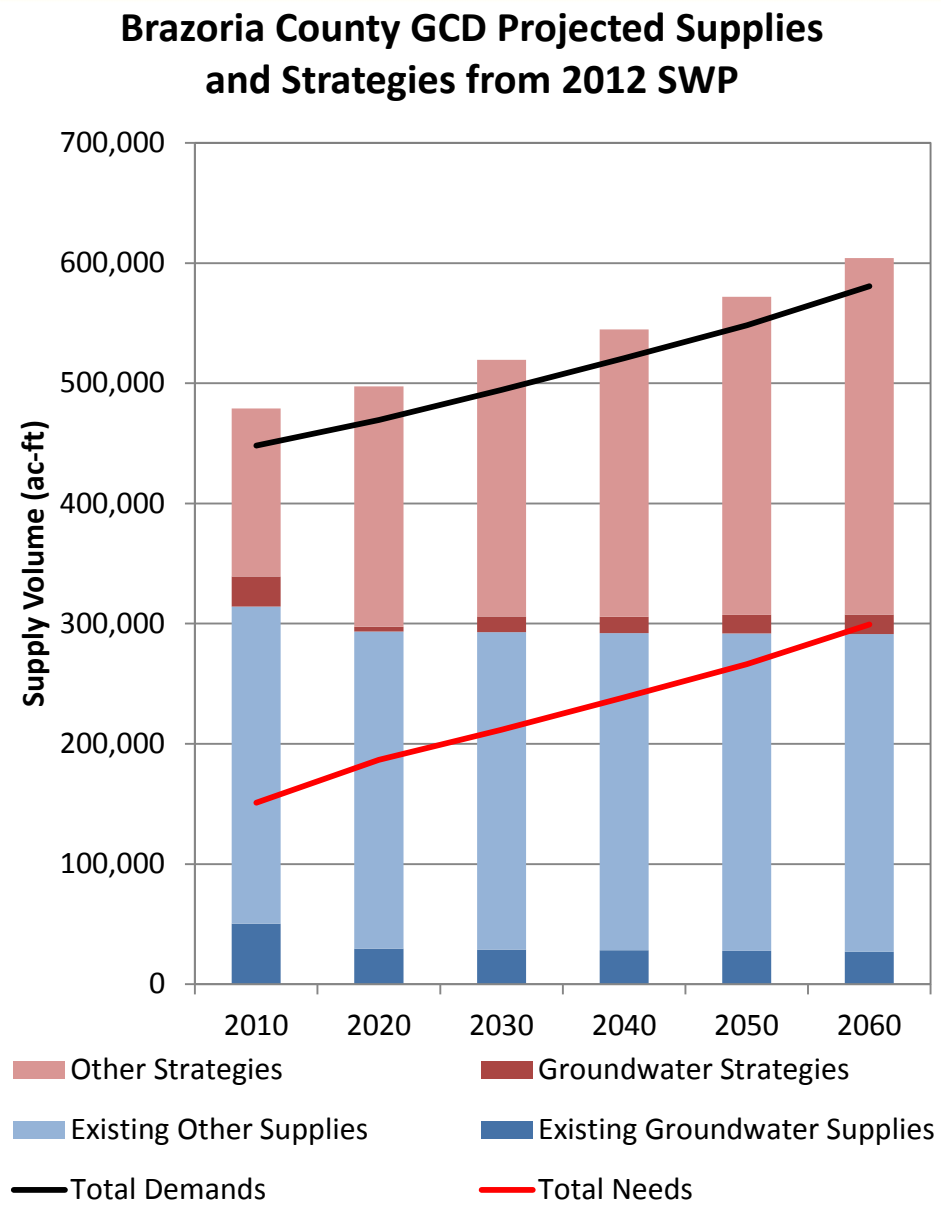


Major Strategies

- Expanded use of groundwater
- Purchase water from City of Bryan
- Conservation
- Raise level of Gibbons Creek Reservoir
- Wastewater Reuse

Supporting Materials

Water Supply Needs and Strategies

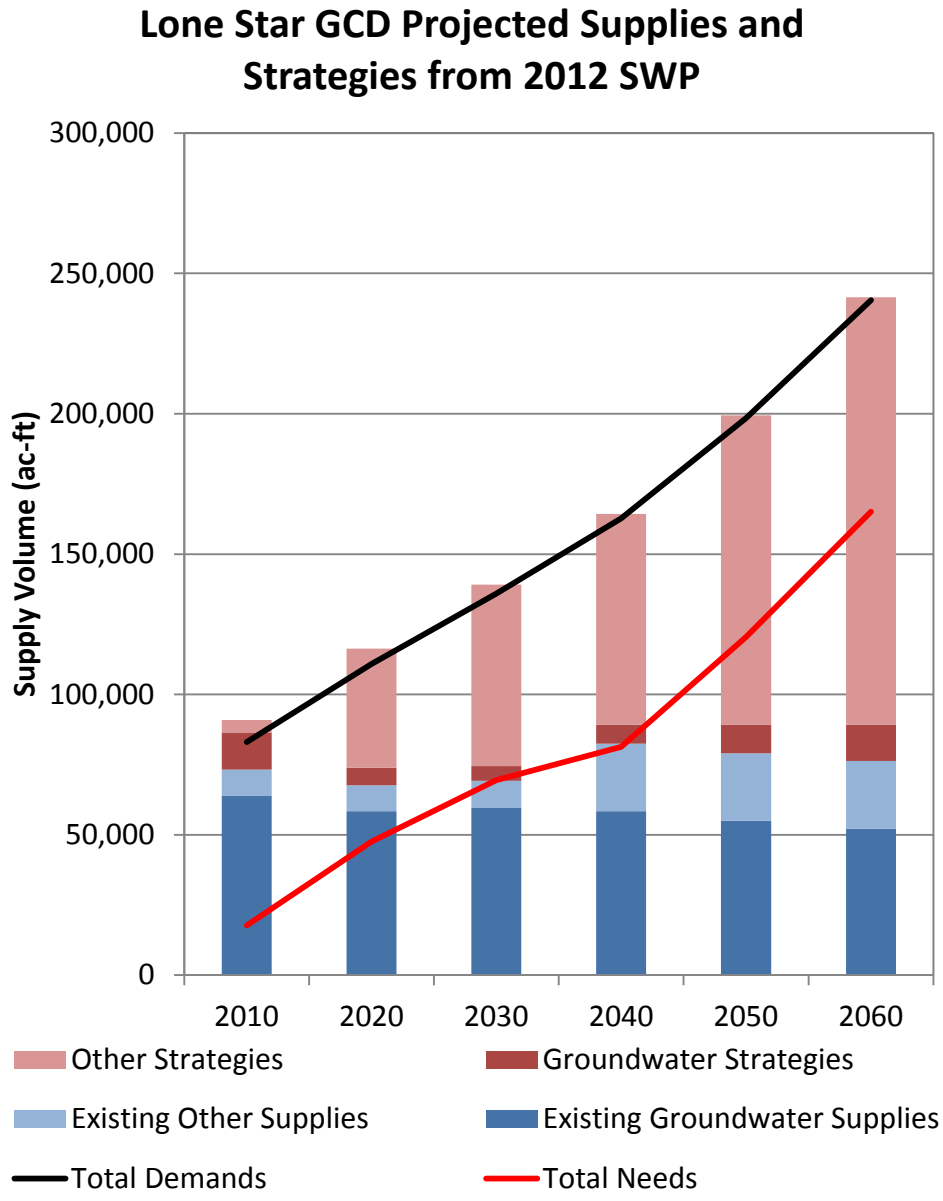


Major Strategies

- Expanded use of groundwater
- Allens Creek Reservoir
- Brazoria, DOW, and GCWA OCRs
- Conservation
- Freeport Desal
- Interruptible Irr. Supplies
- Supply reallocation
- Wastewater reclamation for municipal irrigation

Supporting Materials

Water Supply Needs and Strategies



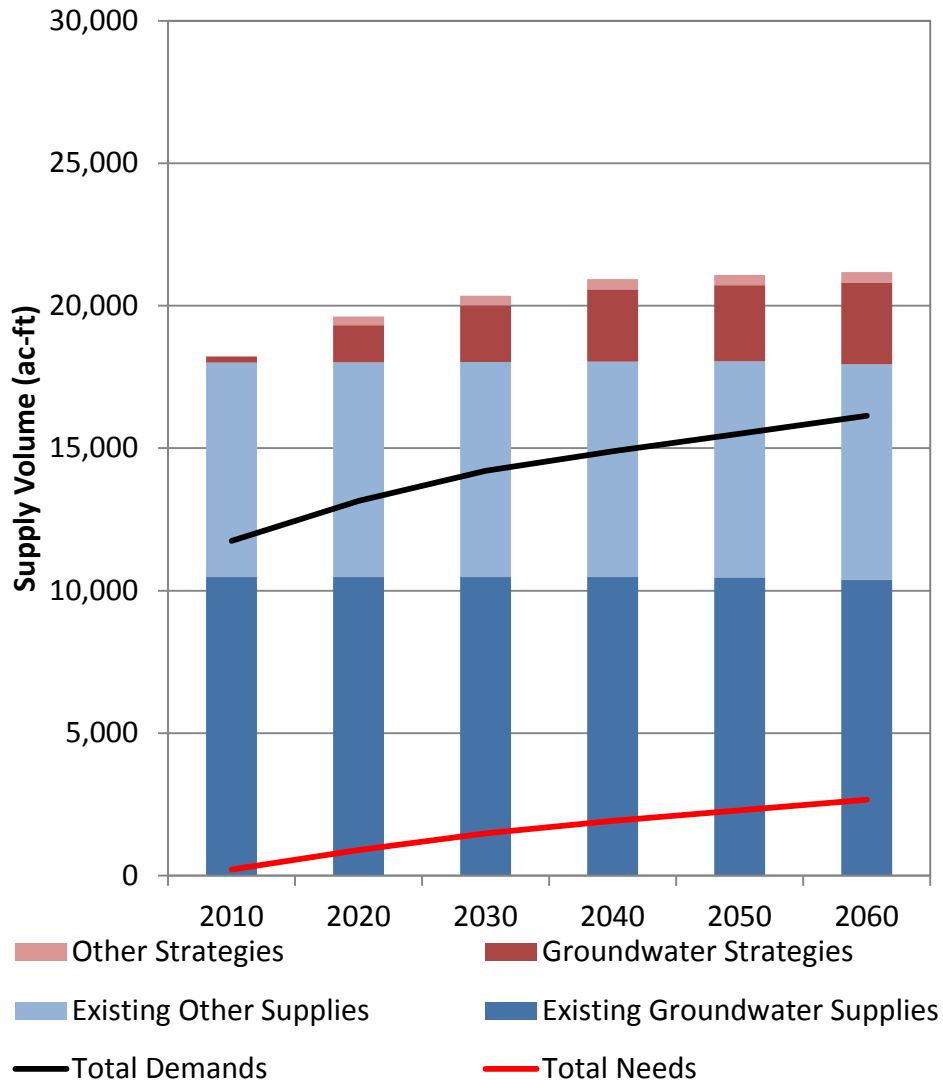
Major Strategies

- Expanded use of groundwater
- Interim groundwater use
- MC MUD 8 and 9 reuse
- Municipal conservation
- SJRA WRAP
- TRA to SJRA Contract
- Wastewater reclamation for municipal irrigation

Supporting Materials

Water Supply Needs and Strategies

Lower Trinity GCD Projected Supplies and Strategies from 2012 SWP



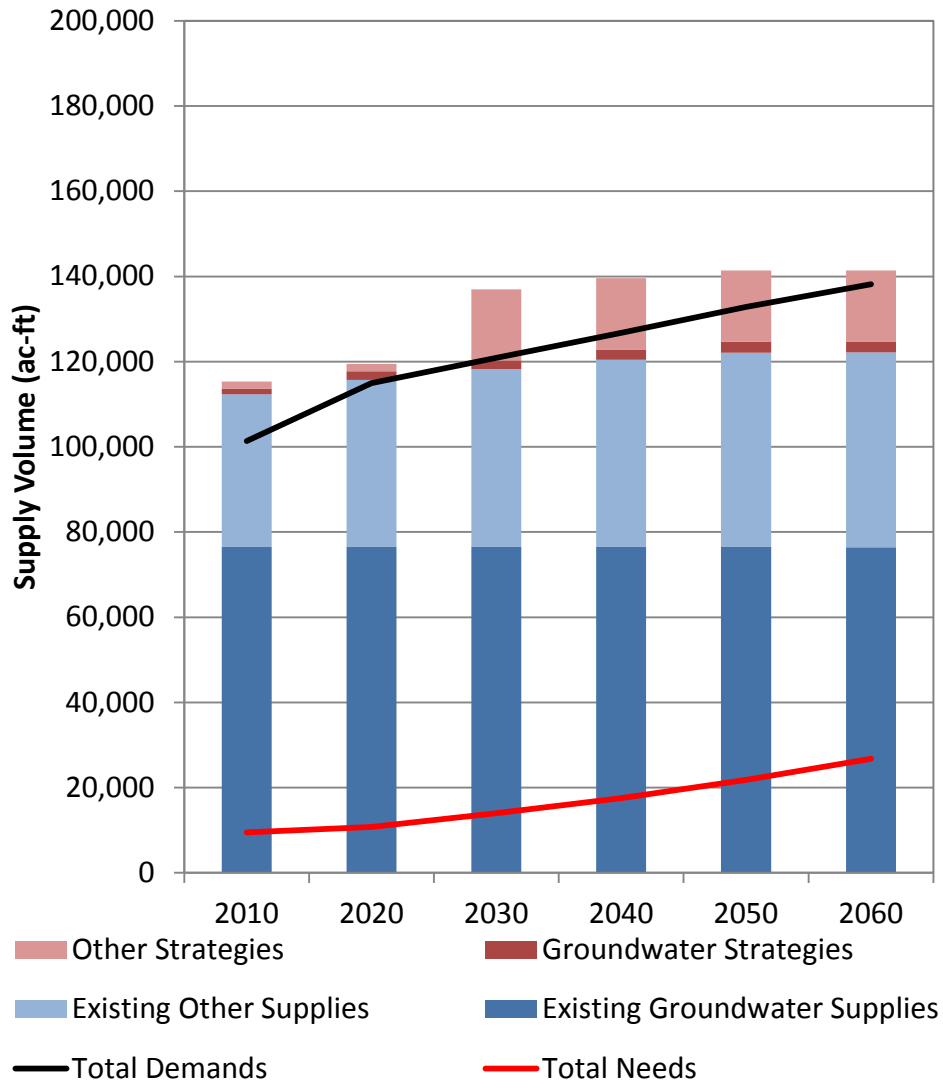
Major Strategies

- Expanded use of groundwater
- Municipal conservation

Supporting Materials

Water Supply Needs and Strategies

Southeast Texas GCD Projected Supplies and Strategies from 2012 SWP



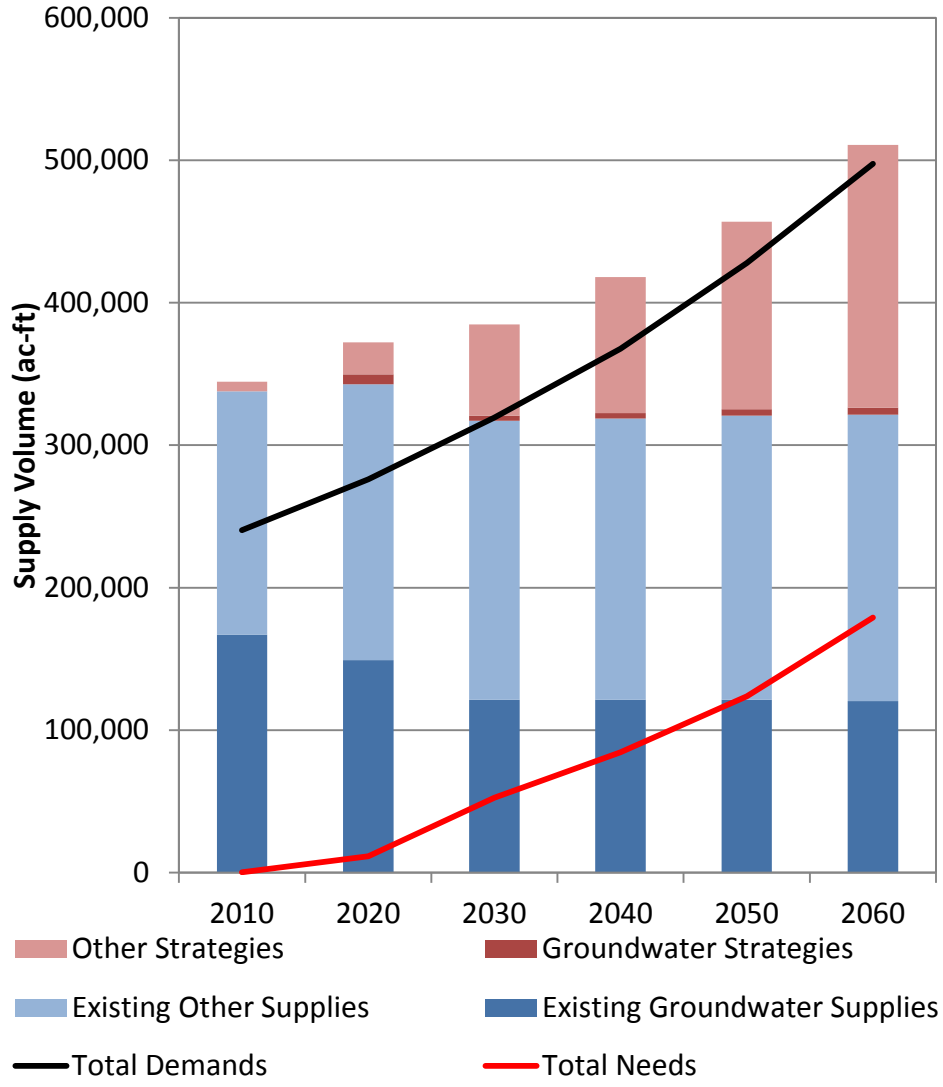
Major Strategies

- Expanded use of groundwater
- Overdrafting
- Purchase water from provider

Supporting Materials

Water Supply Needs and Strategies

Fort Bend Subsidence District Projected Supplies and Strategies from 2012 SWP

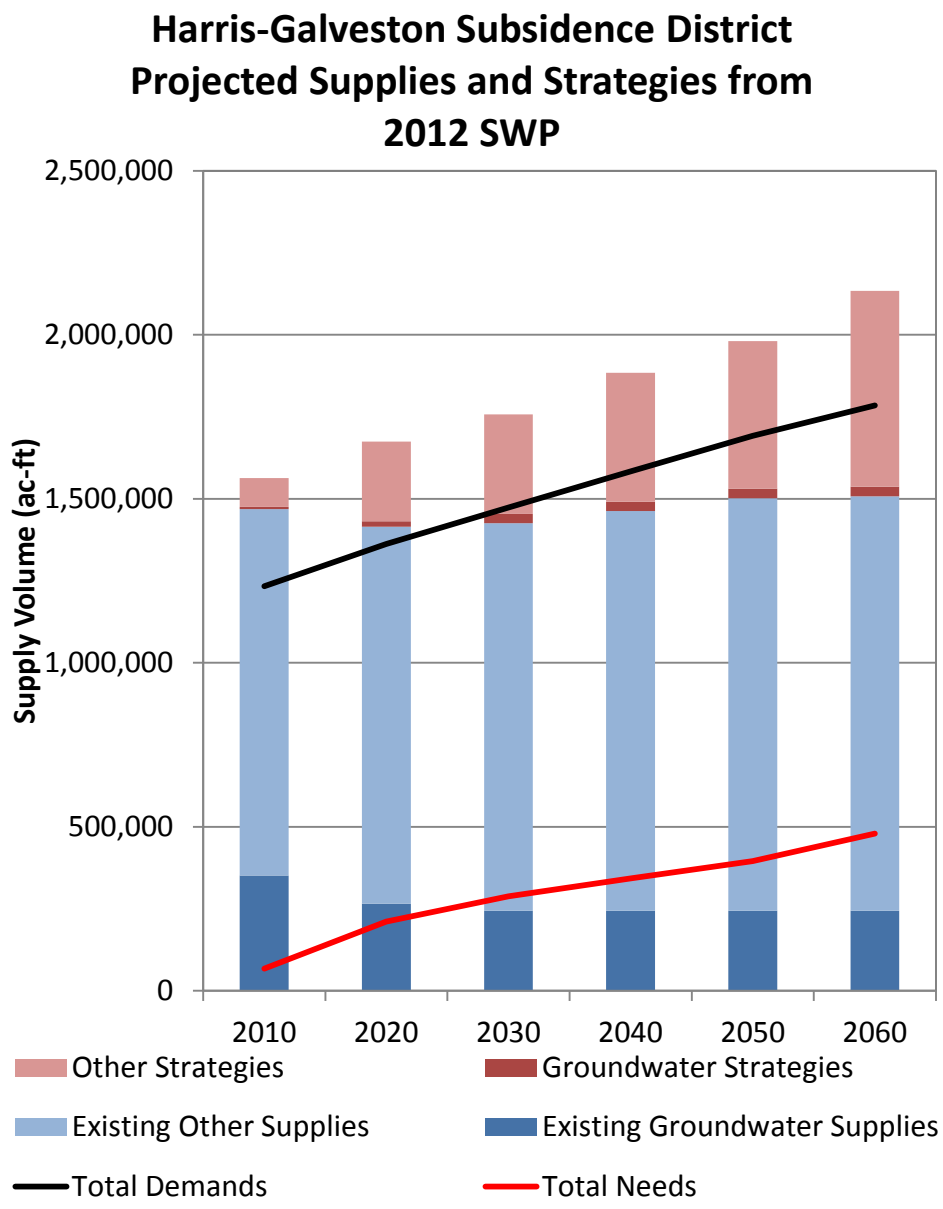


Major Strategies

- Expanded use of groundwater
- Allens Creek Reservoir
- BRA System Operations permit
- Fort Bend OCR
- Conservation
- Supply reallocation
- TRA to Houston contract
- Wastewater reclamation for municipal irrigation
- GRPs

Supporting Materials

Water Supply Needs and Strategies

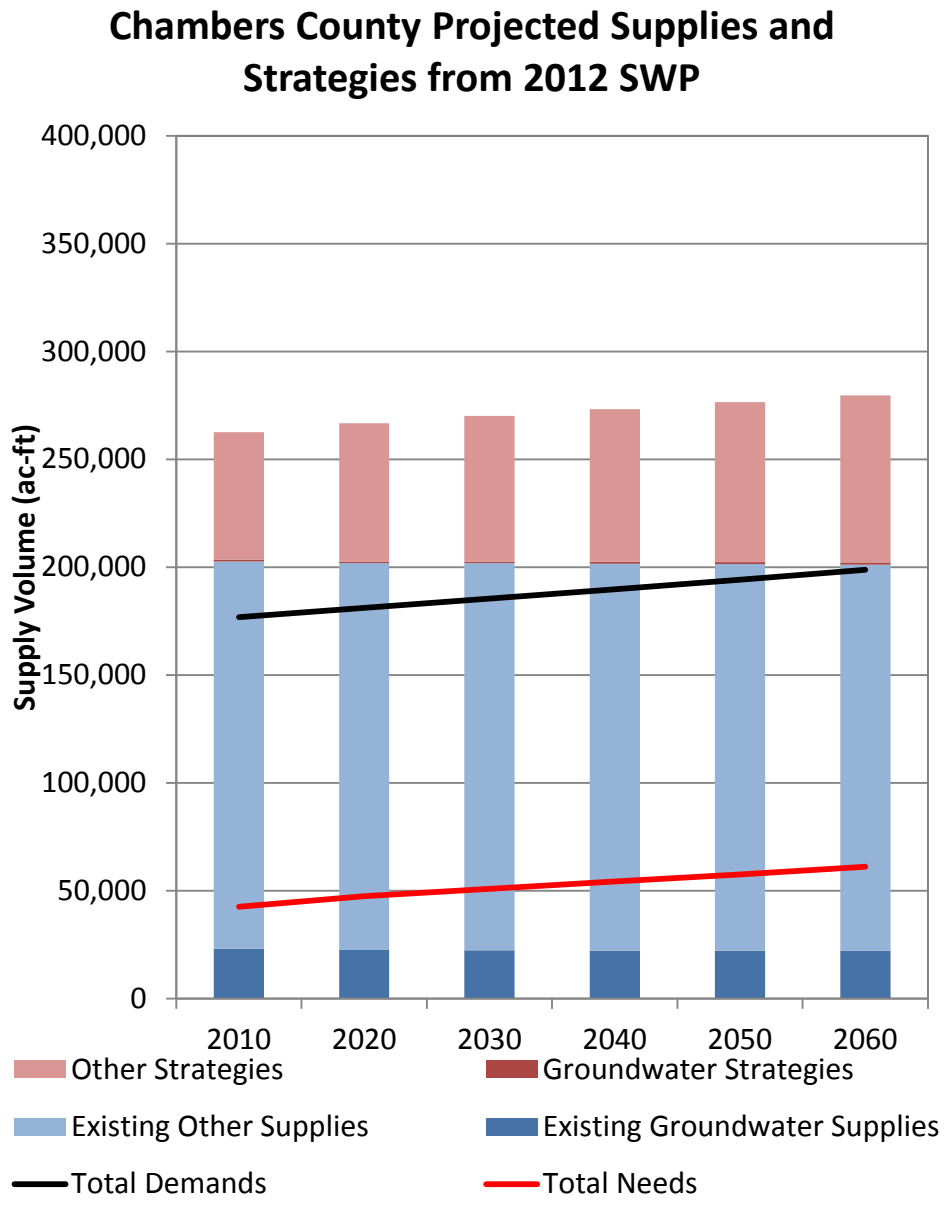


Major Strategies

- Expanded use of groundwater
- Allens Creek Reservoir
- Conservation
- Contract expansions
- Houston indirect reuse
- Supply reallocation
- TRA to Houston contract
- Wastewater reclamation for municipal irrigation
- Wastewater reuse for industry
- GRPs

Supporting Materials

Water Supply Needs and Strategies

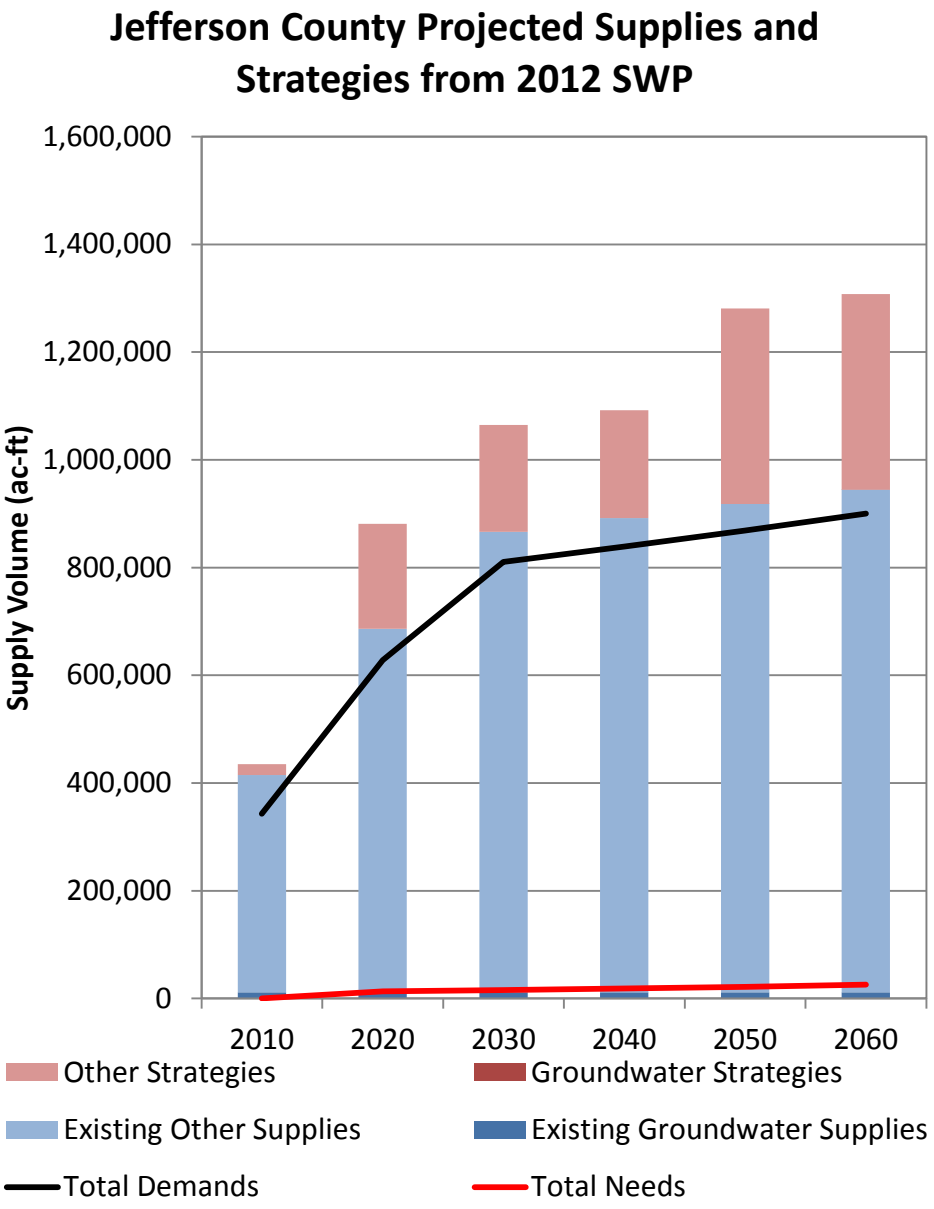


Major Strategies

- Expanded use of groundwater
- CLCND West Chambers system
- Conservation
- New contracts
- Supply reallocation

Supporting Materials

Water Supply Needs and Strategies

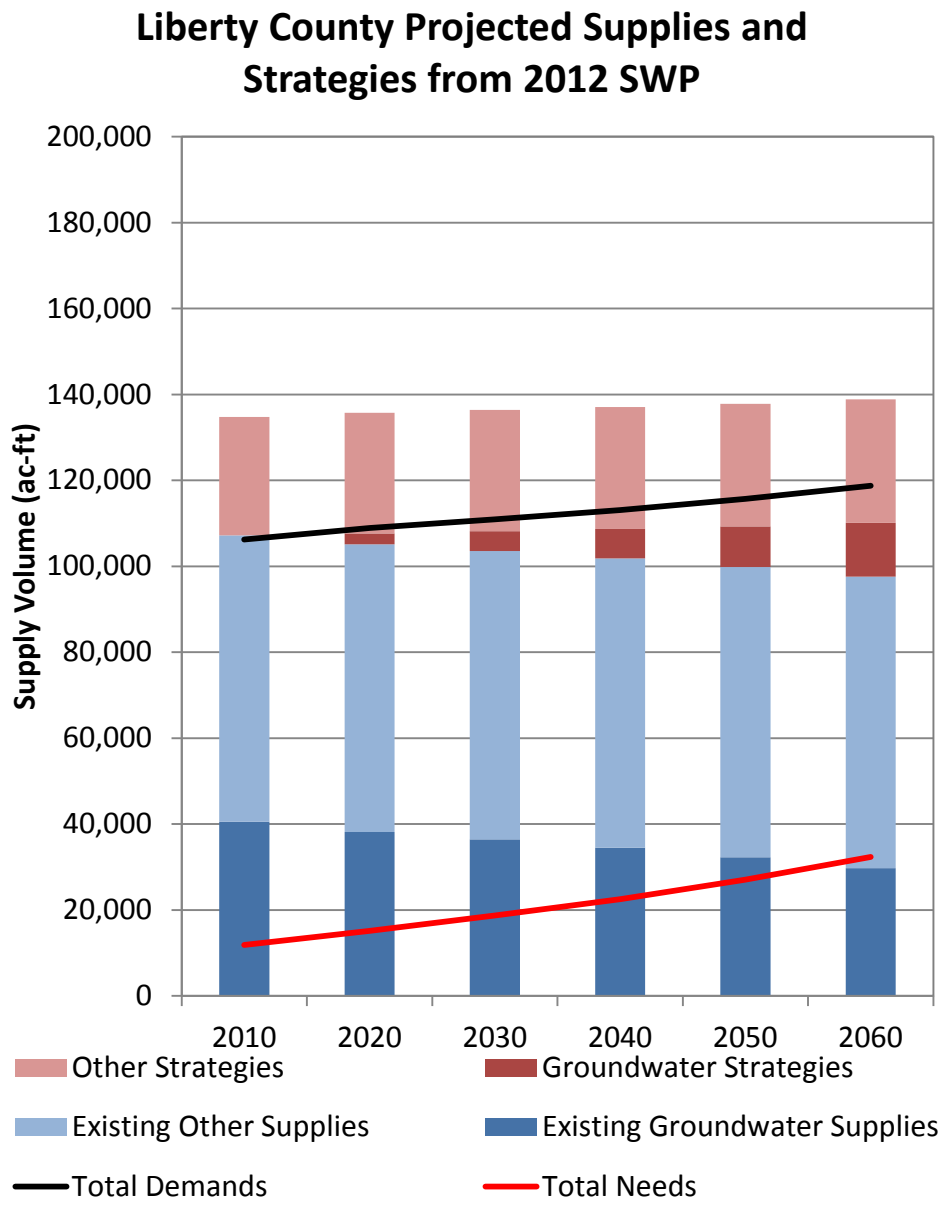


Major Strategies

- Expanded use of groundwater
- Permit amendment for Sam Rayburn
- Purchase water from provider
- Reallocation of flood storage
- Saltwater barrier conjunctive operation
- Wholesale customer conservation

Supporting Materials

Water Supply Needs and Strategies

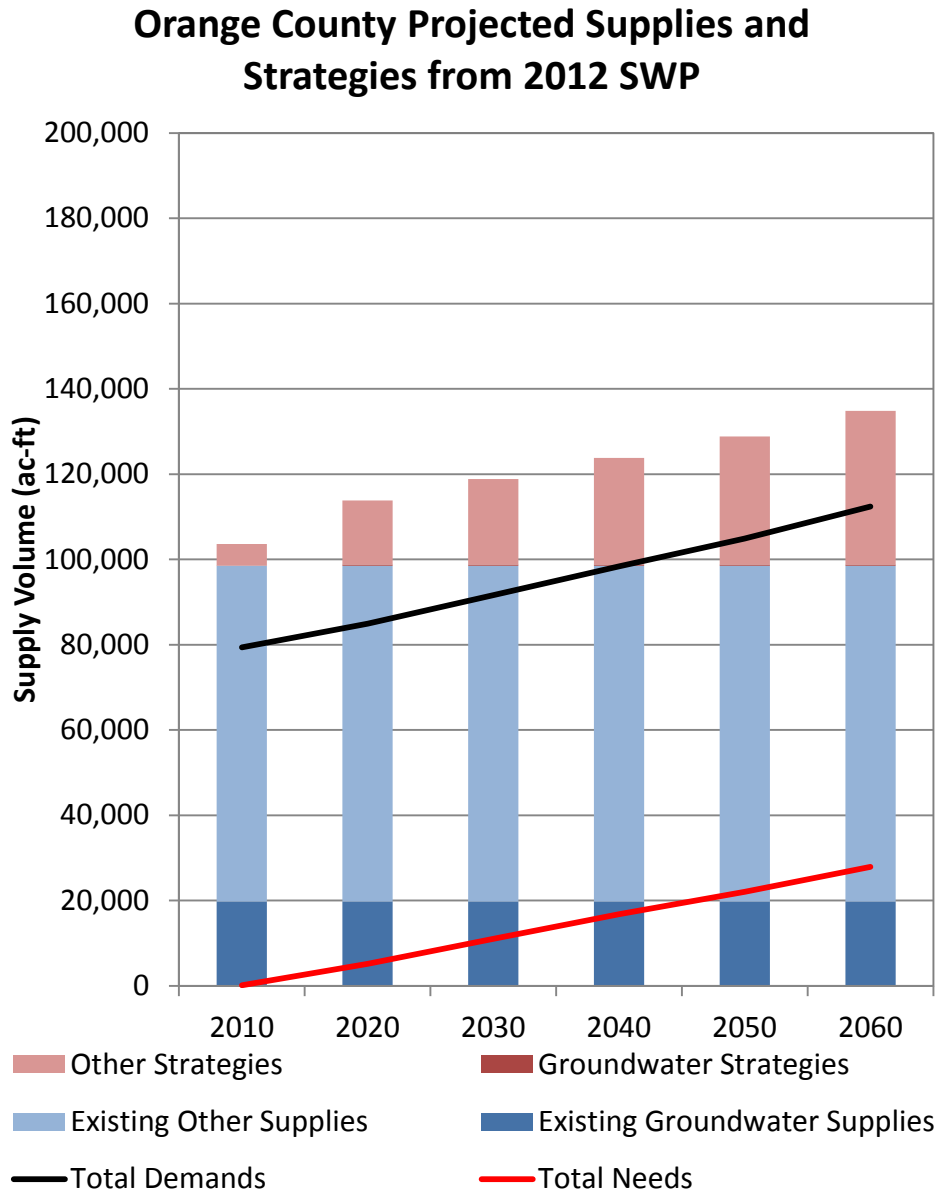


Major Strategies

- Expanded use of groundwater
- Conservation
- Supply reallocation

Supporting Materials

Water Supply Needs and Strategies

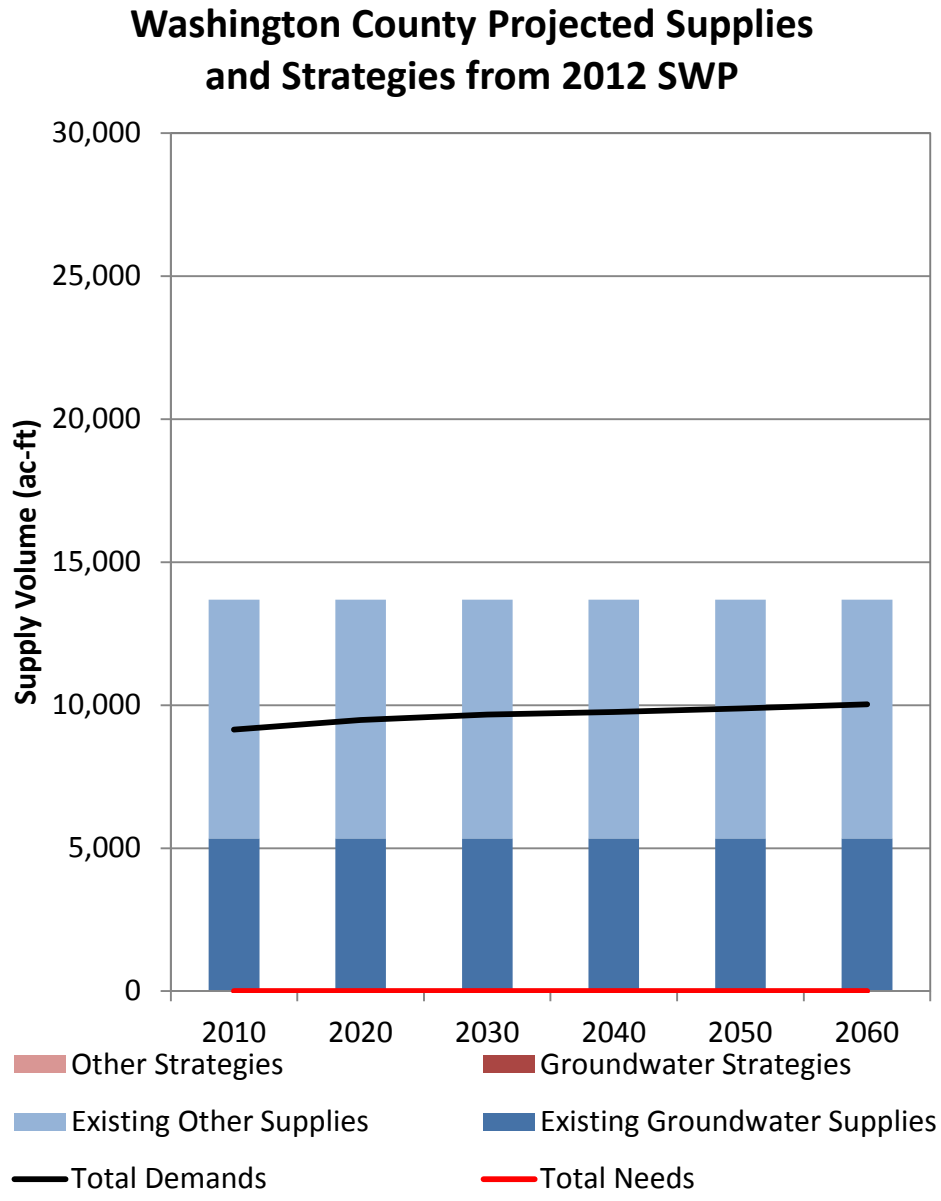


Major Strategies

- Expanded use of groundwater
- Overdrafting
- Purchase water from provider

Supporting Materials

Water Supply Needs and Strategies

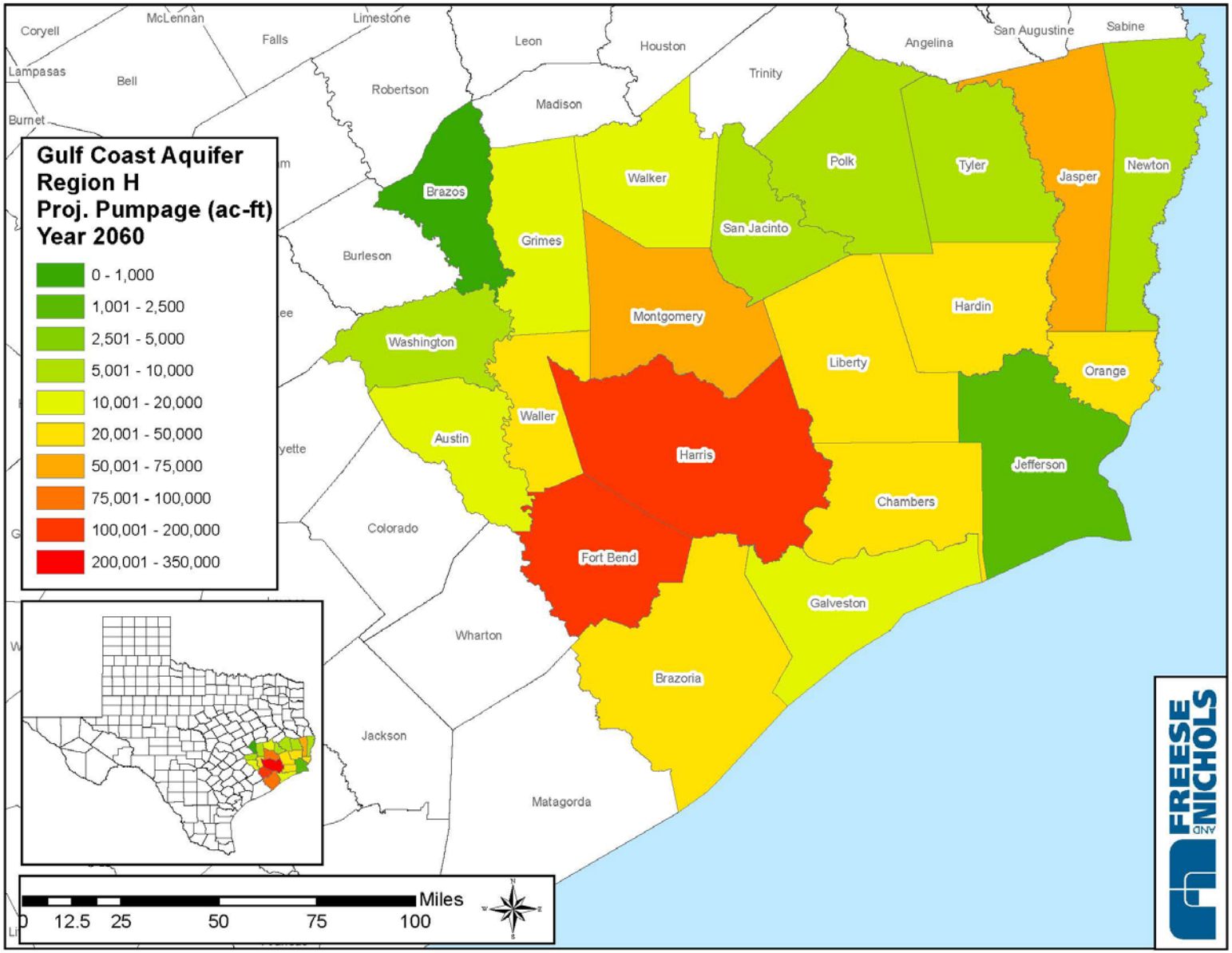


Major Strategies

- None

Supporting Materials

Water Supply Needs and Strategies



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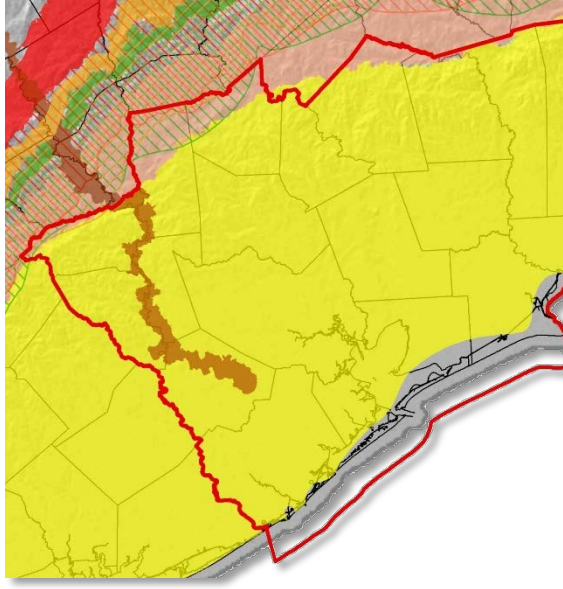


Supporting Materials

HYDROLOGICAL CONDITIONS

June 24, 2015

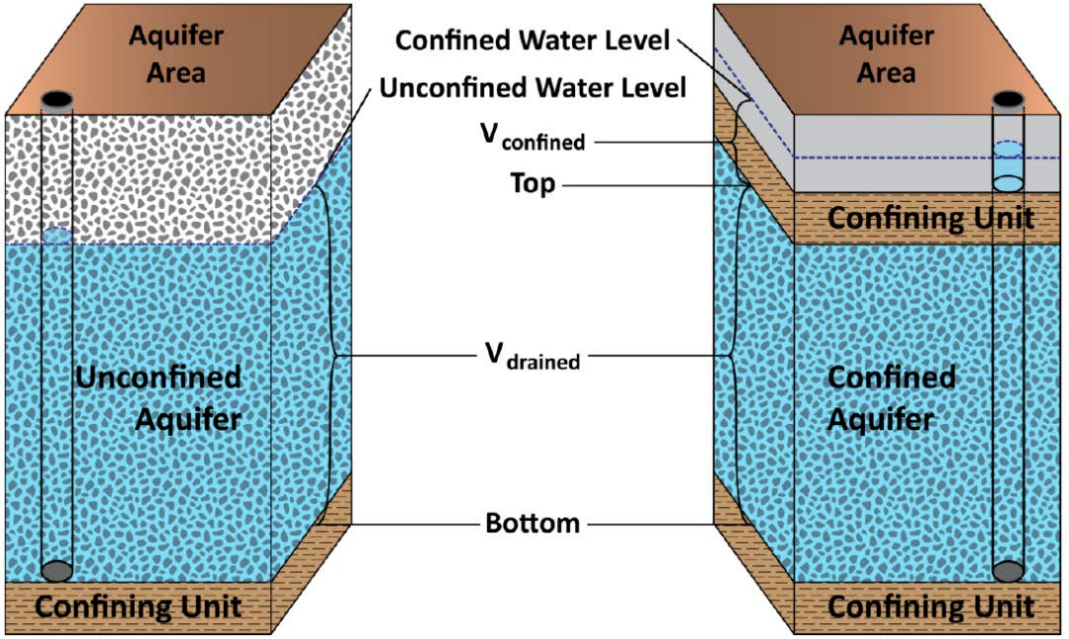
Supporting Materials
Hydrological Conditions

- Hydrological Conditions
  - *"hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge;" TWC 36.108 (d) (3)*
  - Location (examined under "aquifer conditions")
  - Water Surface (examined under "aquifer conditions")
  - Long-Term Trends
  - Water Budget
    - Recharge
    - Discharge to Surface
    - Inflow/Outflow
  - Total Estimated Recoverable Storage (from TWDB)

Supporting Materials
Hydrological Conditions

- Total Estimated Recoverable Storage

– TWDB assumed between 25 and 75 percent of total volume could be removed by pumping



Supporting Materials
Hydrological Conditions

- Gulf Coast Aquifer
  - *Hydrogeology and Simulation of Groundwater Flow and Land-Surface Subsidence in the Northern Part of the Gulf Coast Aquifer* (USGS, Rev. 2012)
  - Northern Gulf Coast GAM Run
  - TWDB GAM Task 13-037

Supporting Materials

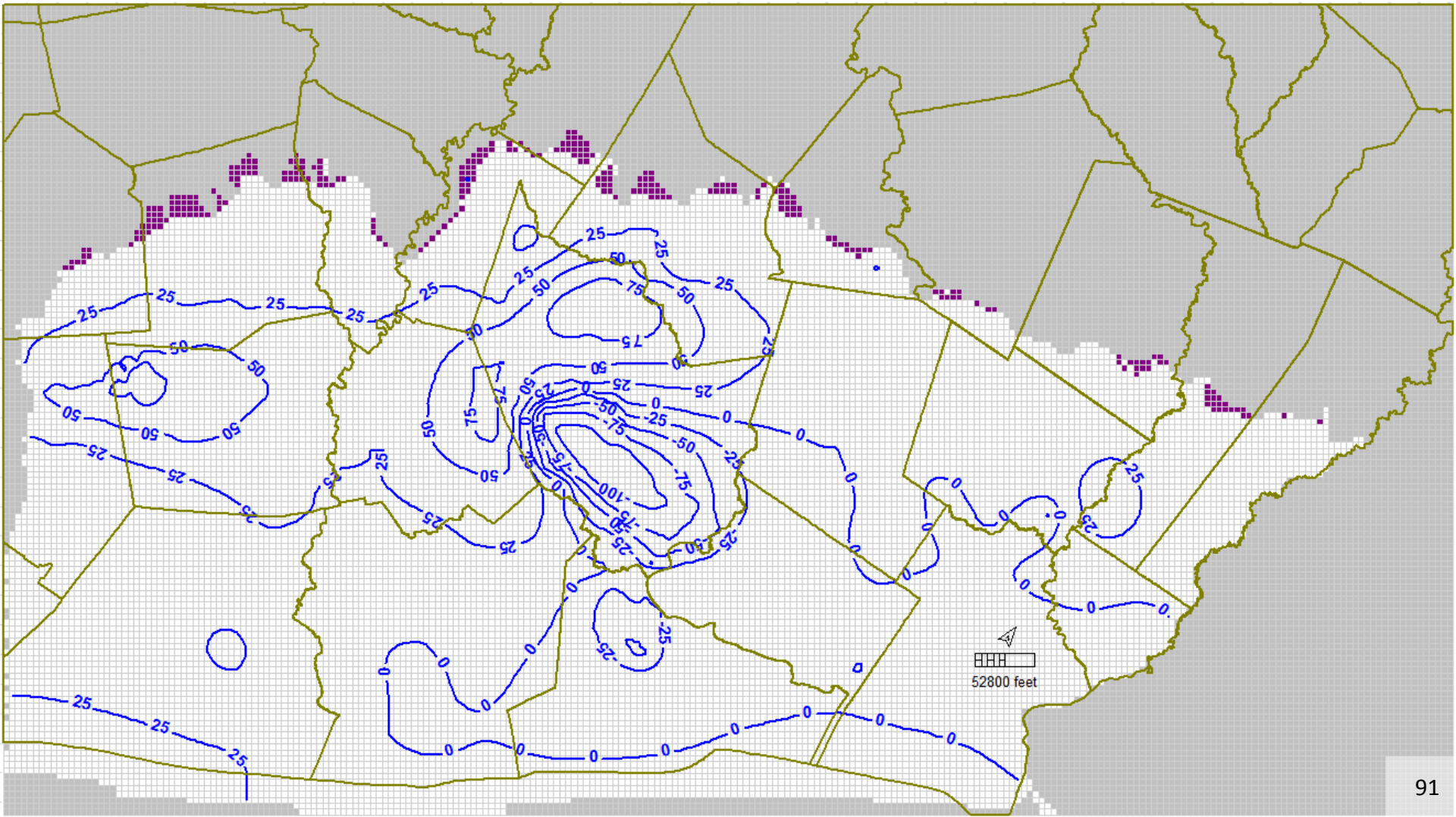
Hydrological Conditions

Gulf Coast Aquifer Stratigraphy

Geologic (stratigraphic) units			Hydrogeologic units	Model layer
System	Series	Formation	Aquifers and confining units	
Quaternary	Holocene	Alluvium	Chicot aquifer	1
	Pleistocene	Beaumont Formation		
		Montgomery Formation		
		Bentley Formation		
		Willis Formation		
Tertiary	Pliocene	Goliad Sand	Evangeline aquifer	2
	Miocene	Fleming Formation	Burkeville confining unit	3
		Oakville Sandstone	Jasper aquifer	4
		Catahoula Sandstone		
		Anahuac Formation[1]		
		Frio Formation[1]	Catahoula confining system	

Supporting Materials
Hydrological Conditions

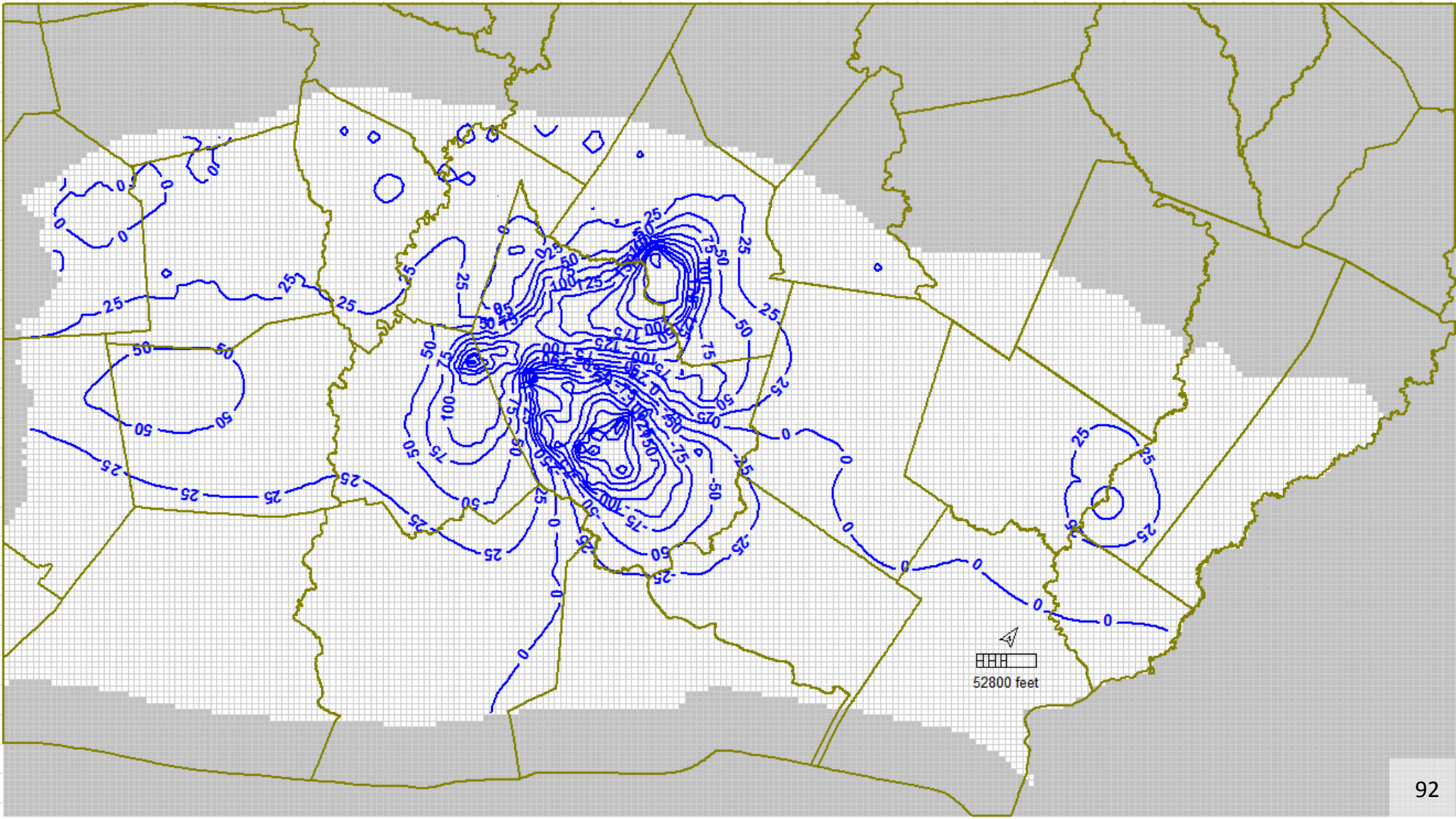
- 1980-2009 Drawdown – Chicot Aquifer



Supporting Materials

Hydrological Conditions

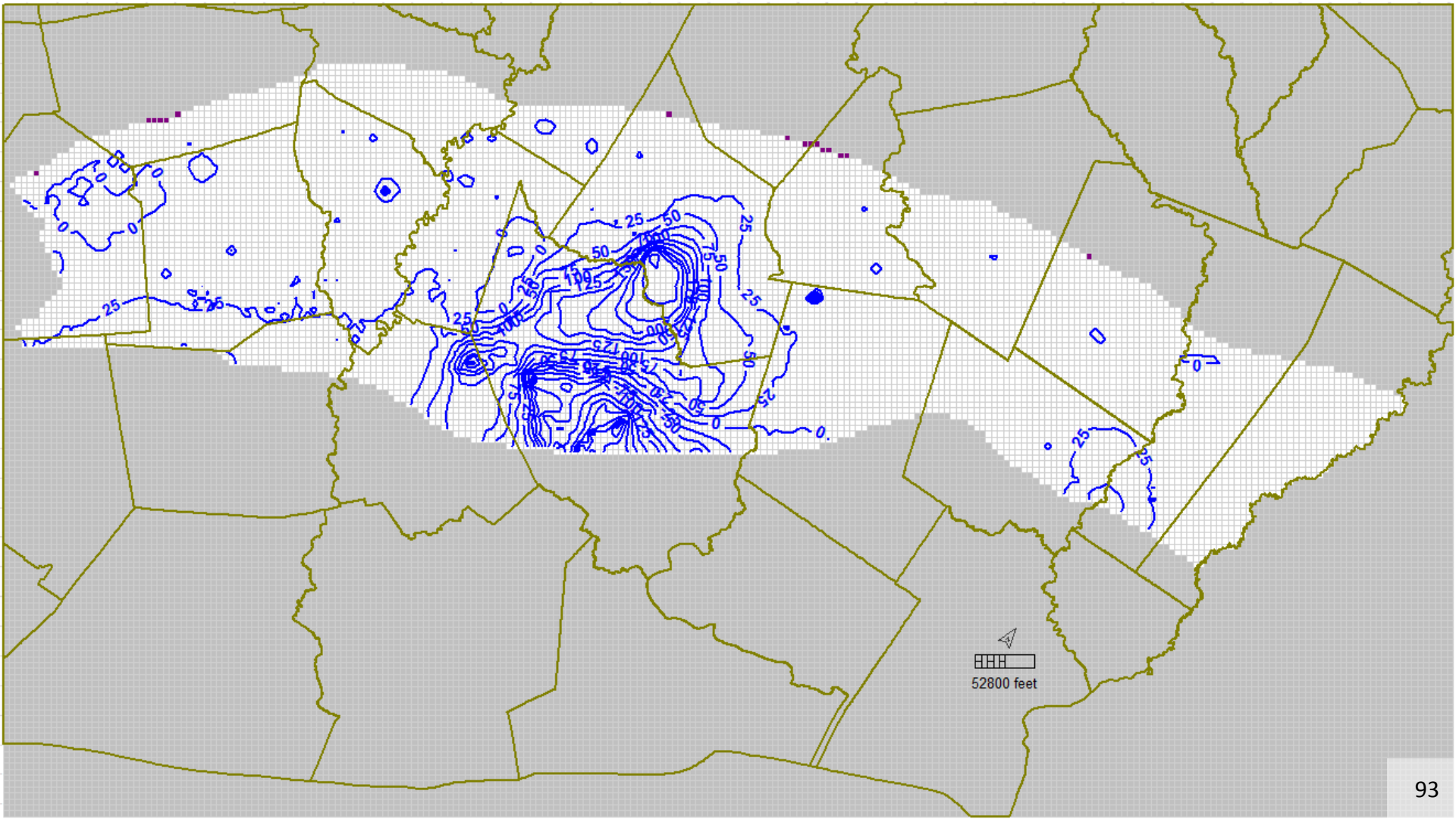
- 1980-2009 Drawdown – Evangeline Aquifer



Supporting Materials

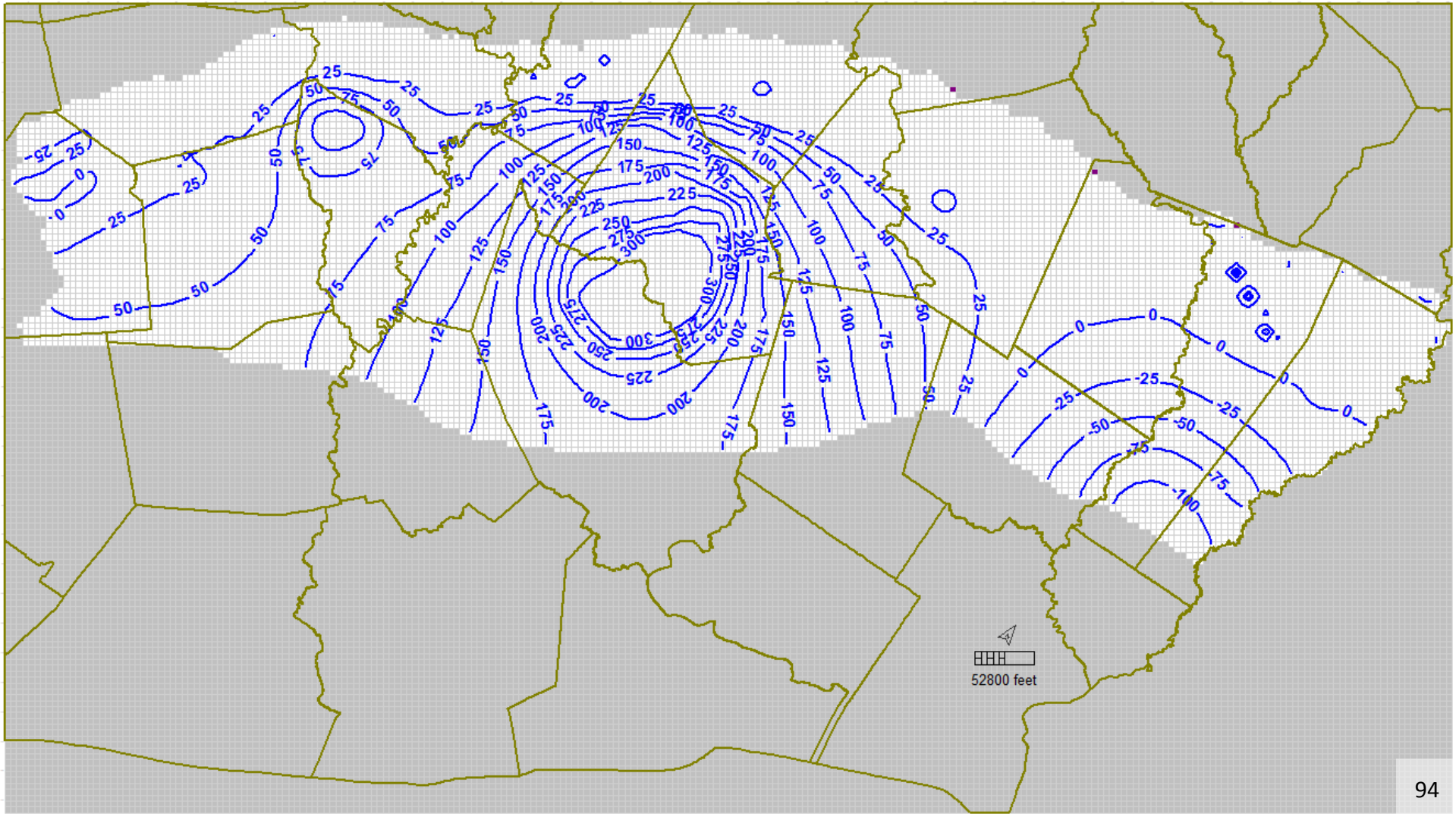
Hydrological Conditions

- 1980-2009 Drawdown – Burkeville Confining Unit



Supporting Materials
Hydrological Conditions

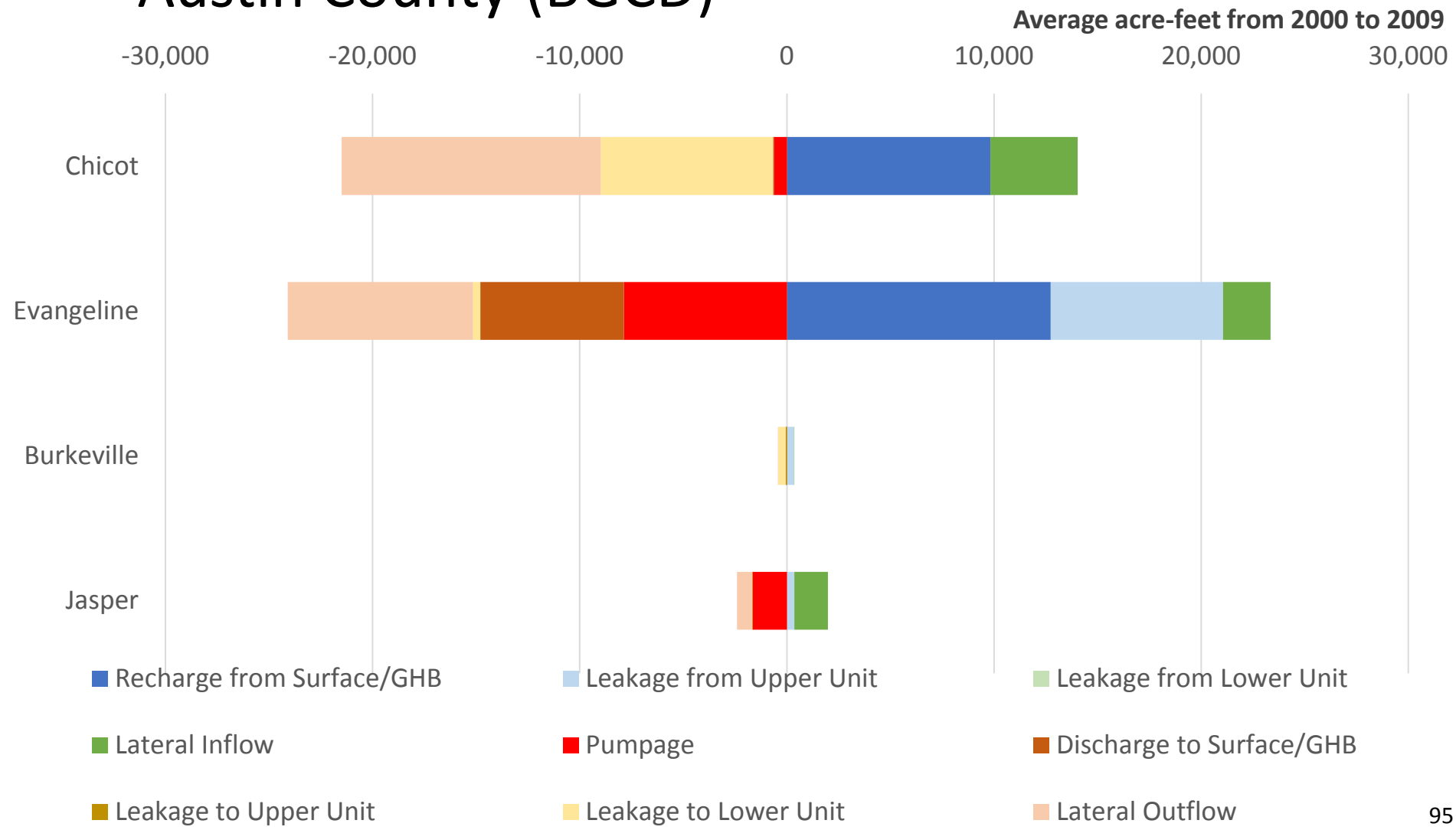
- 1980-2009 Drawdown – Jasper Aquifer



Supporting Materials
Hydrological Conditions

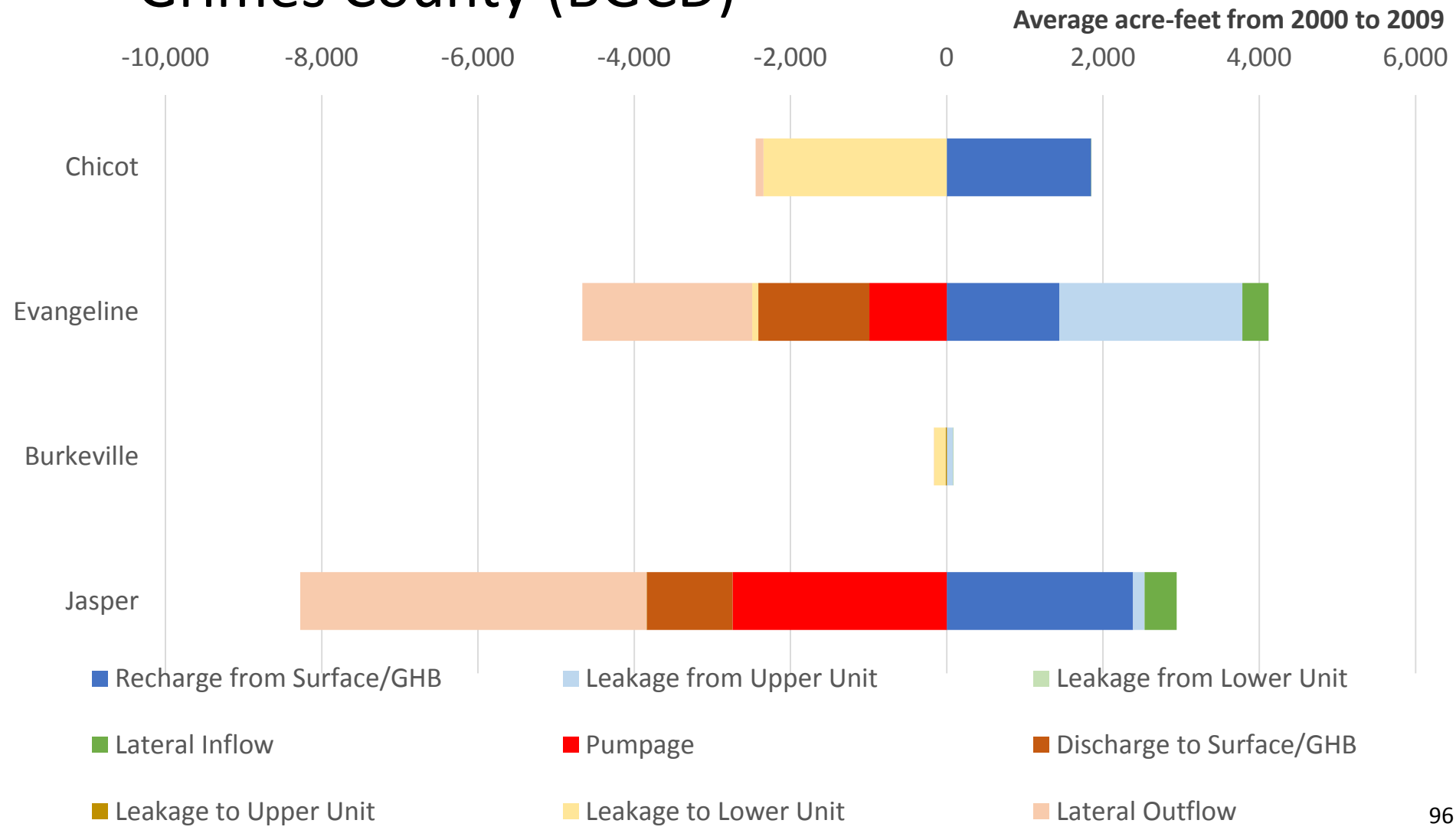
Gulf Coast Aquifer
Water Budget

- Austin County (BGCD)



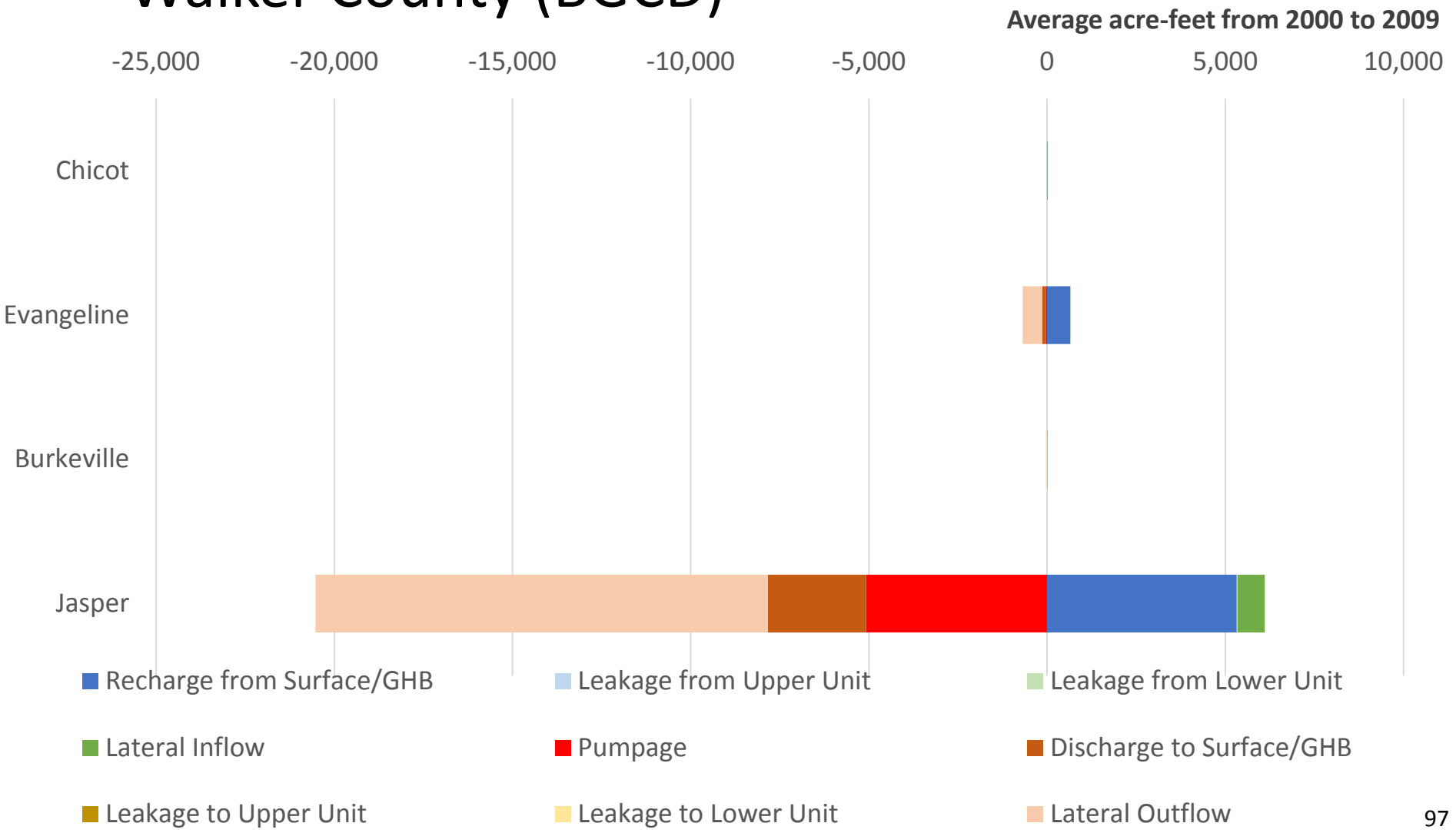
Supporting Materials
Hydrological Conditions

- Grimes County (BGCD)



Supporting Materials
Hydrological Conditions

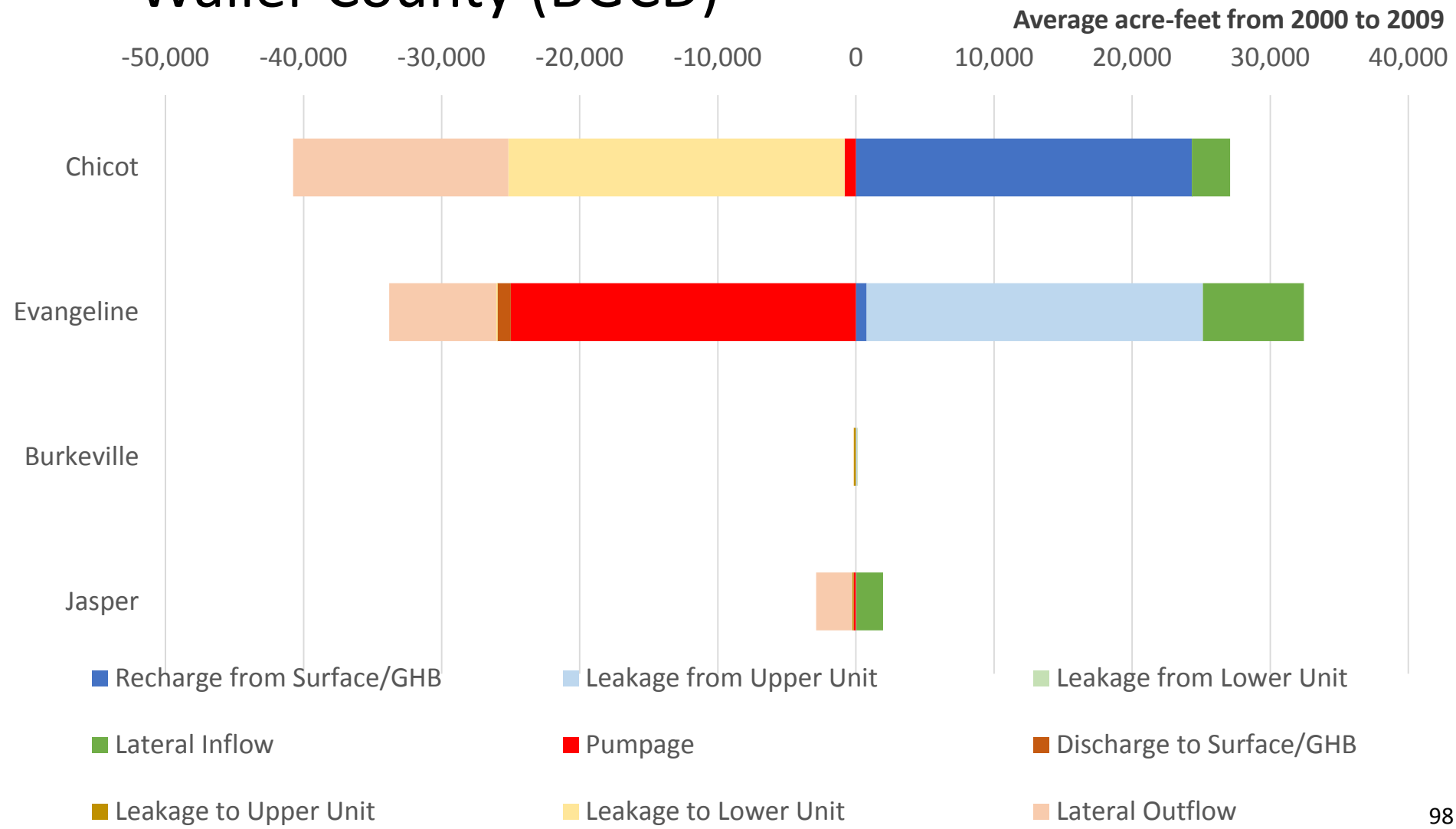
- Walker County (BGCD)



Supporting Materials
Hydrological Conditions

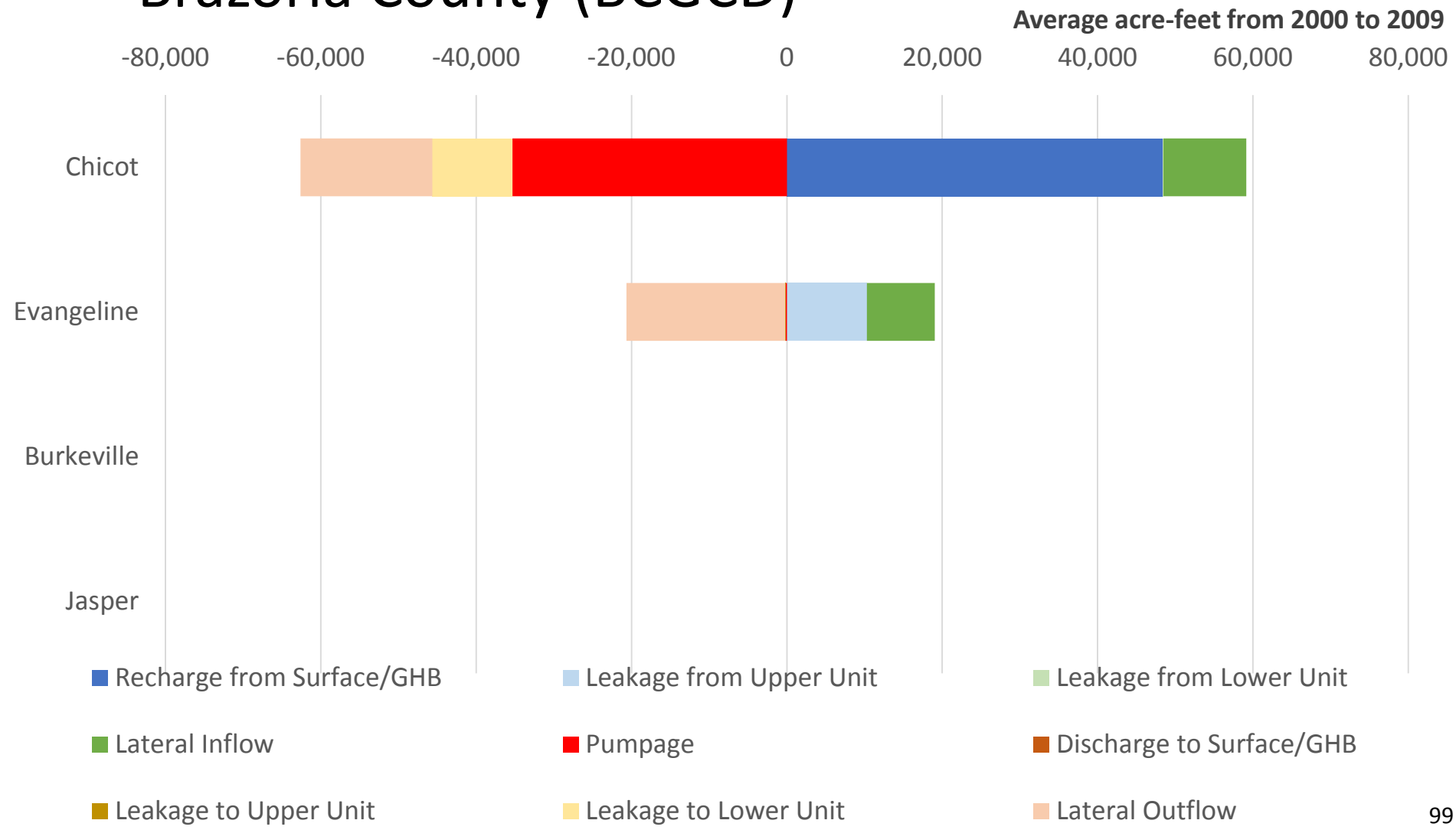
Gulf Coast Aquifer
Water Budget

- Waller County (BGCD)



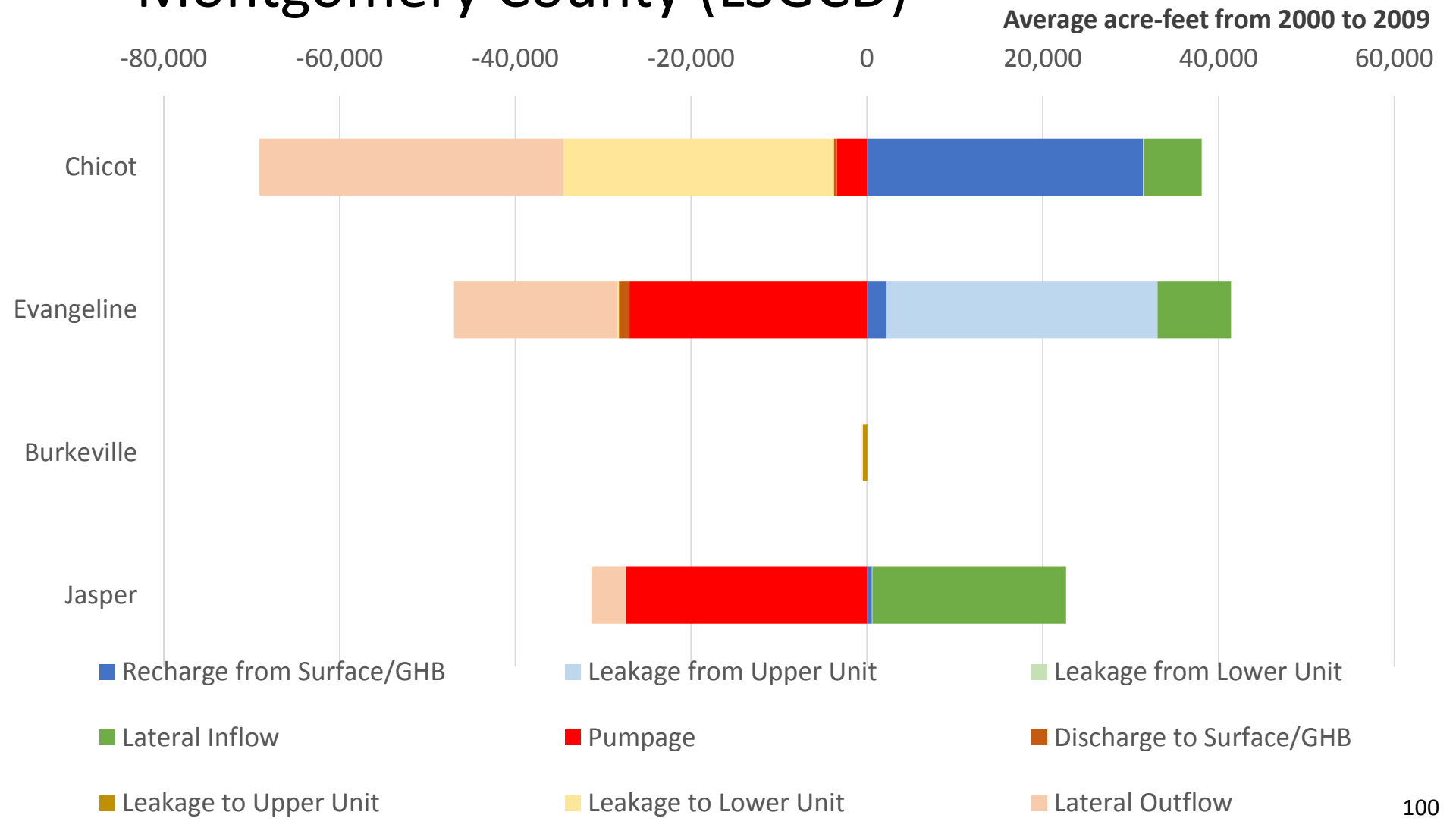
Supporting Materials
Hydrological Conditions

- Brazoria County (BCGCD)



Supporting Materials
Hydrological Conditions

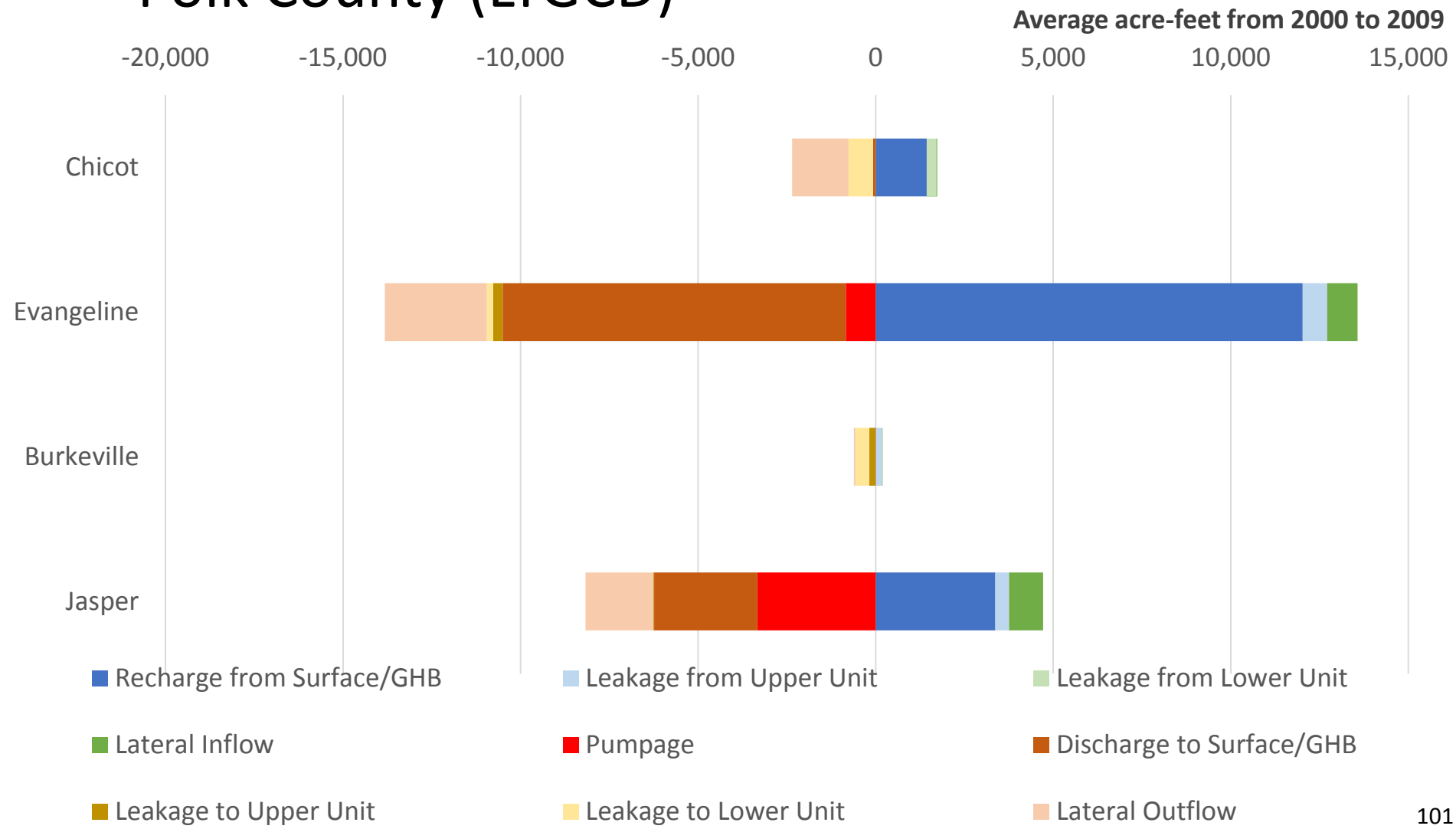
- Montgomery County (LSGCD)



Supporting Materials
Hydrological Conditions

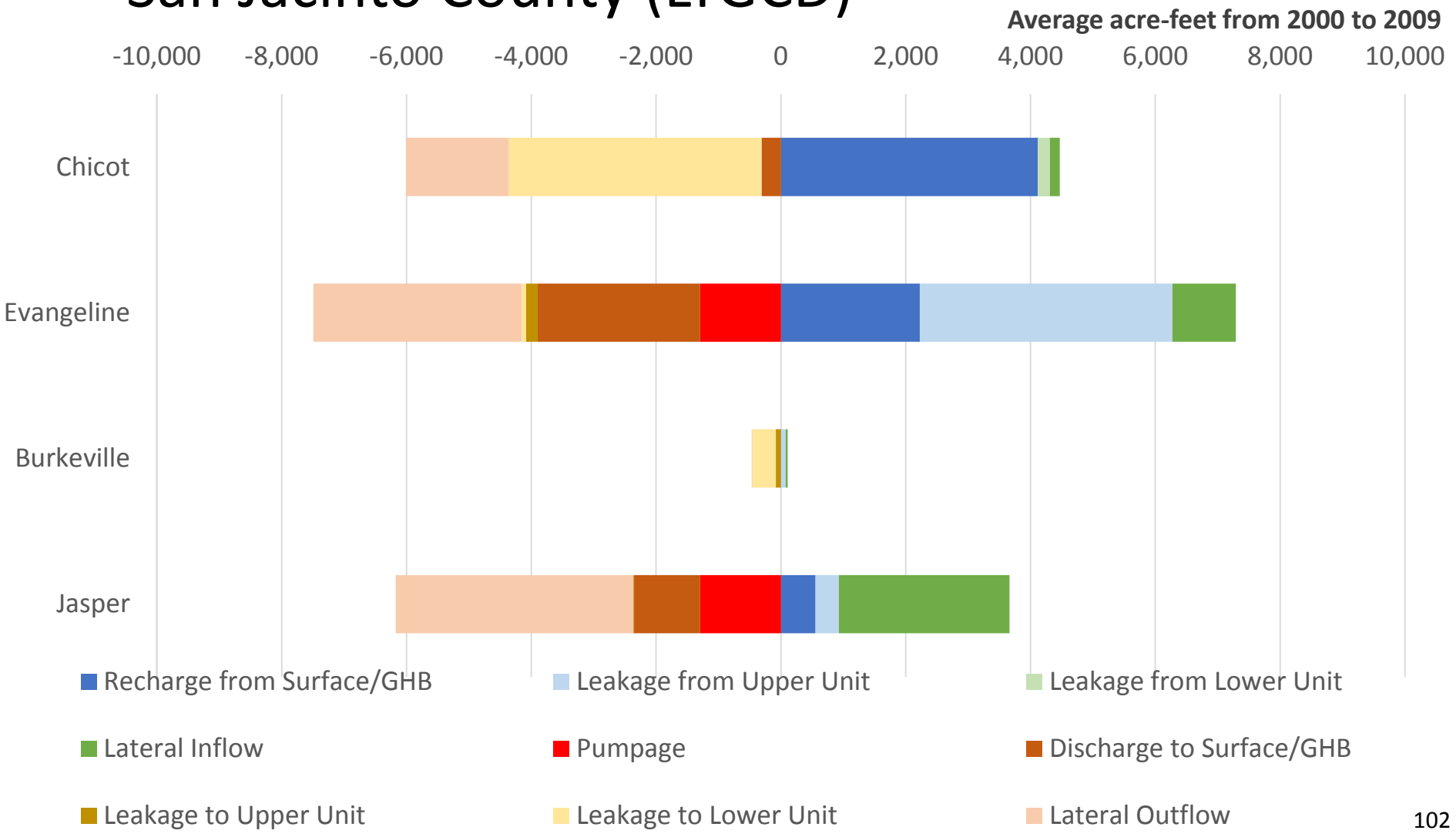
Gulf Coast Aquifer
Water Budget

- Polk County (LTGCD)



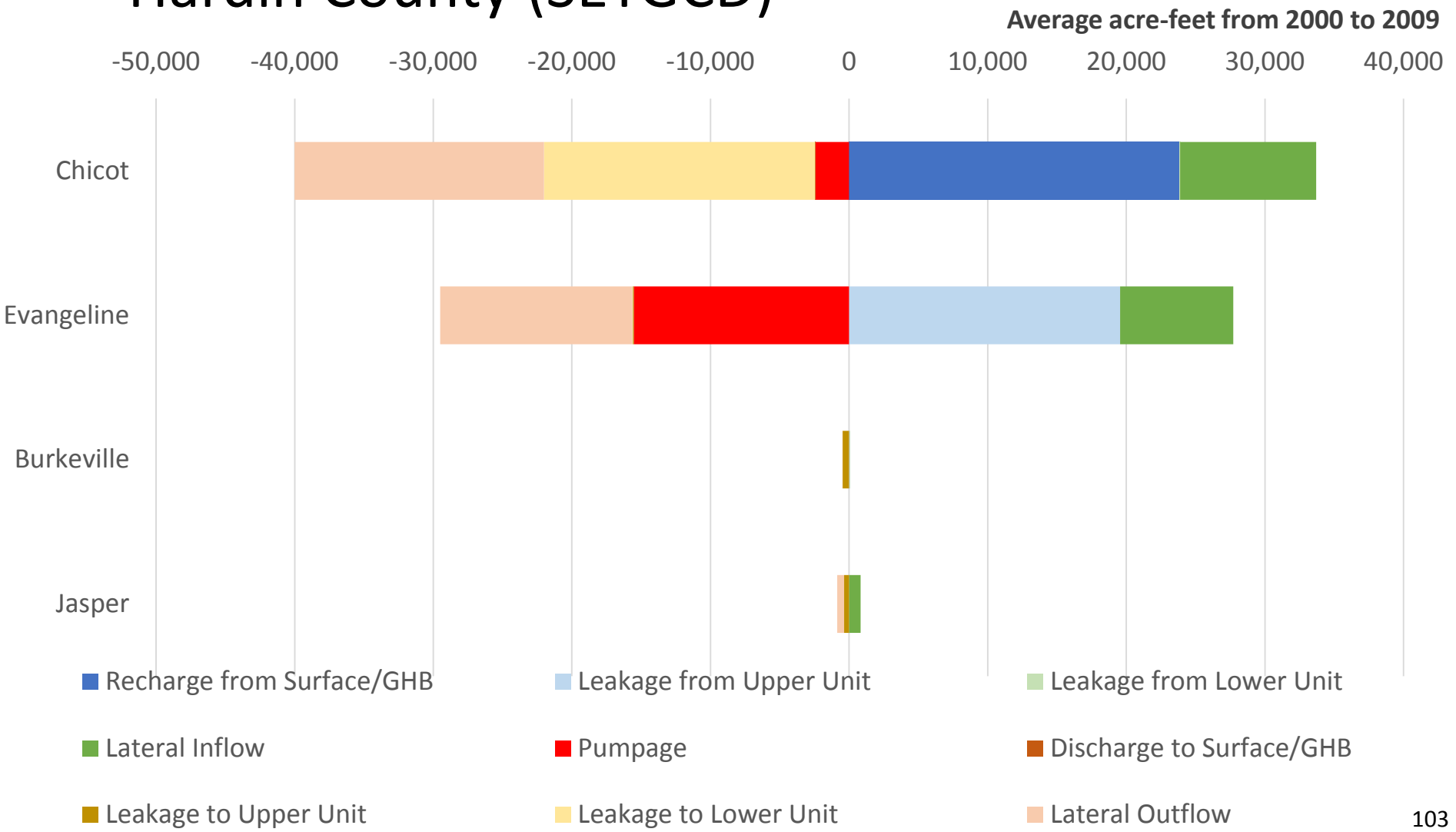
Supporting Materials
Hydrological Conditions

- San Jacinto County (LTGCD)



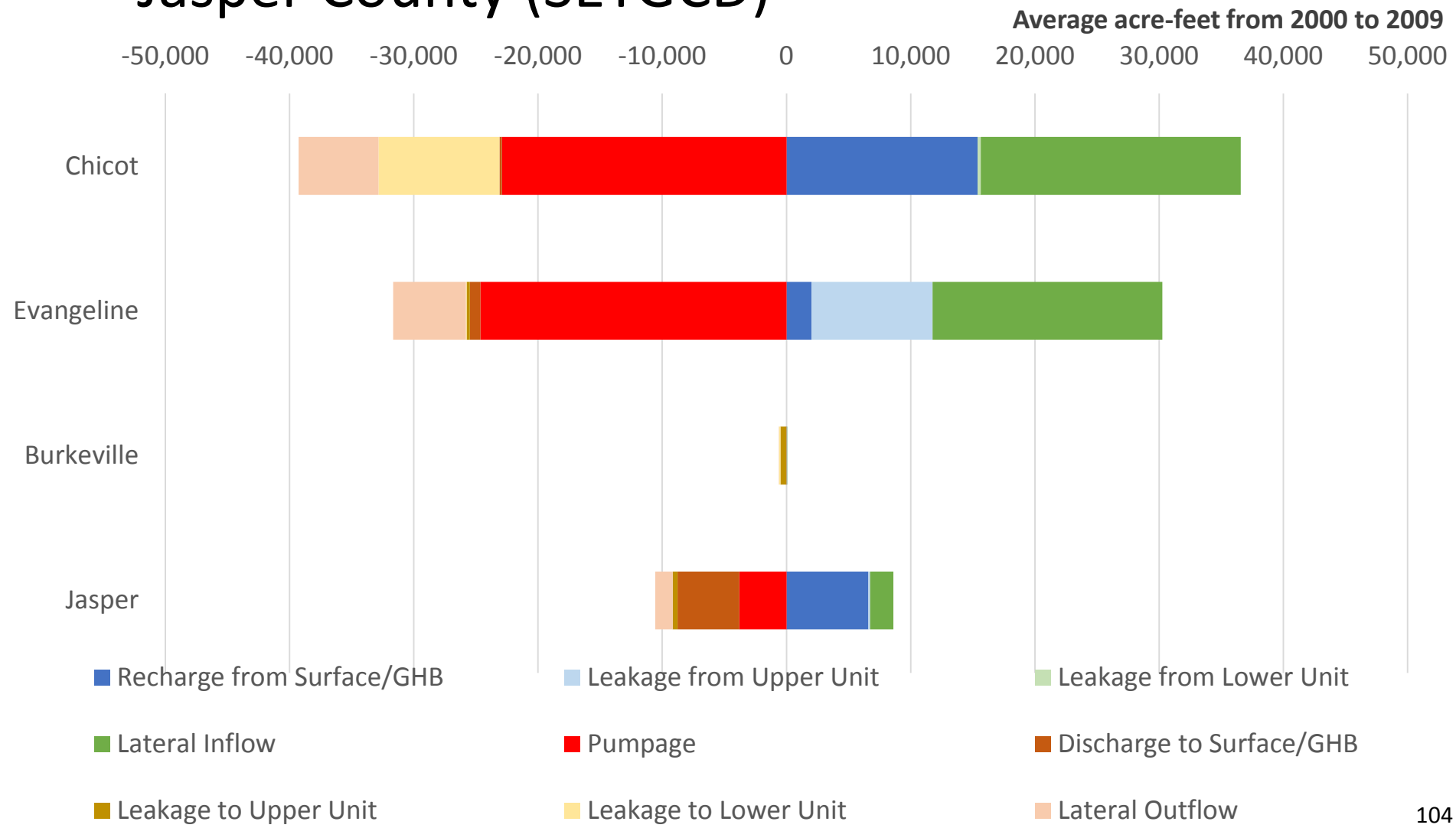
Supporting Materials
Hydrological Conditions

- Hardin County (SETGCD)



Supporting Materials
Hydrological Conditions

- Jasper County (SETGCD)

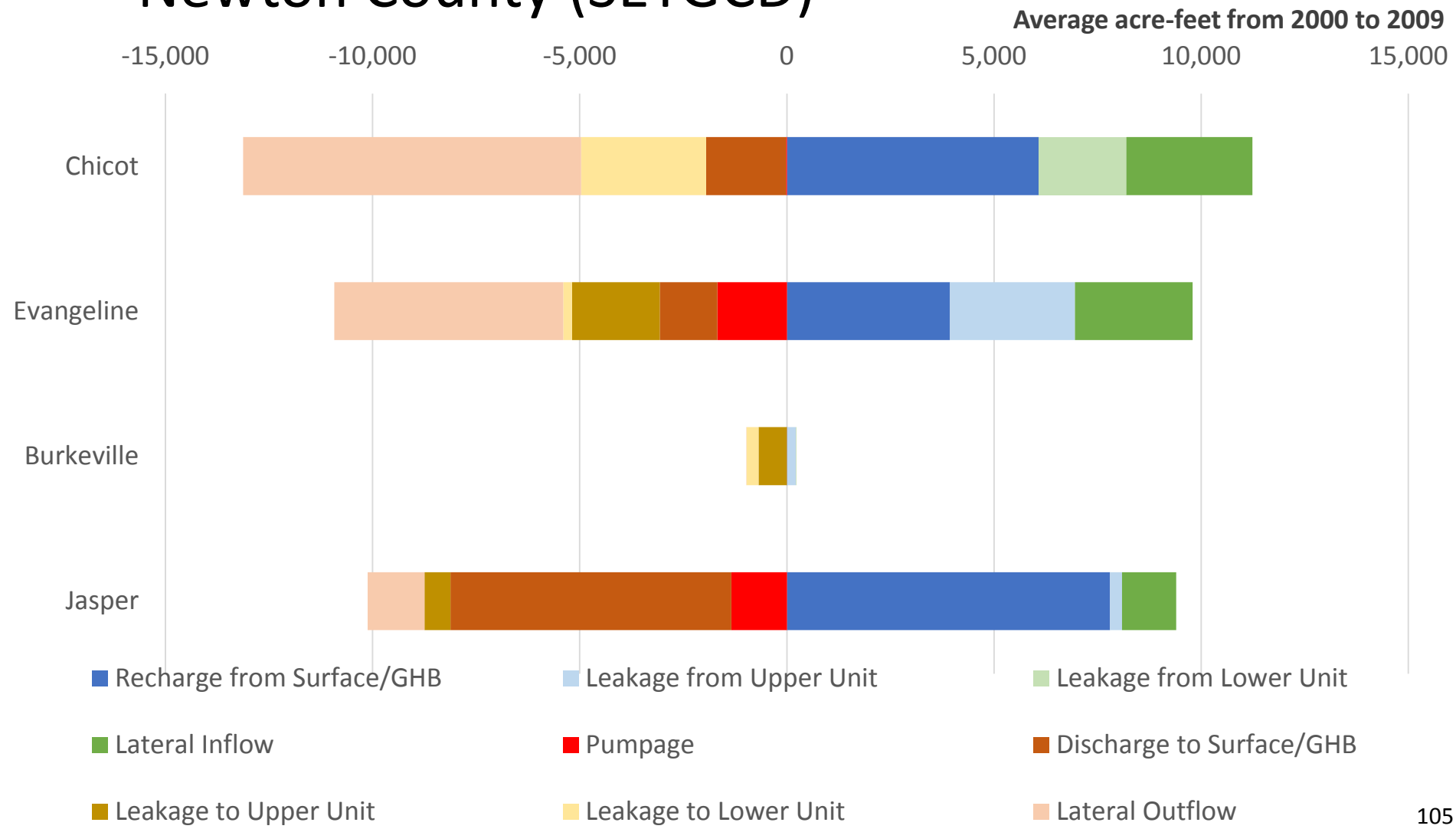


Supporting Materials

Hydrological Conditions

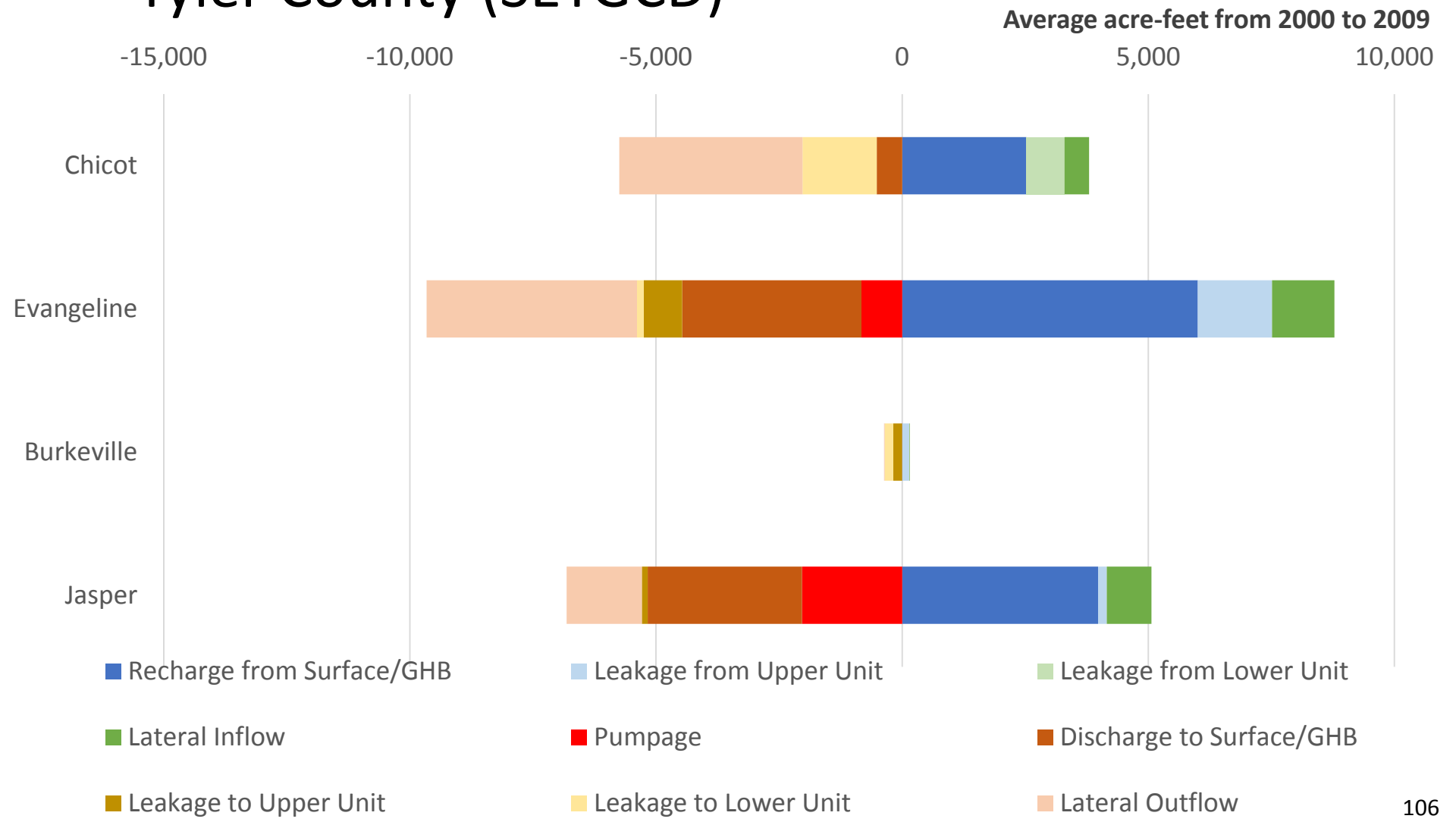
Gulf Coast Aquifer
Water Budget

- Newton County (SETGCD)



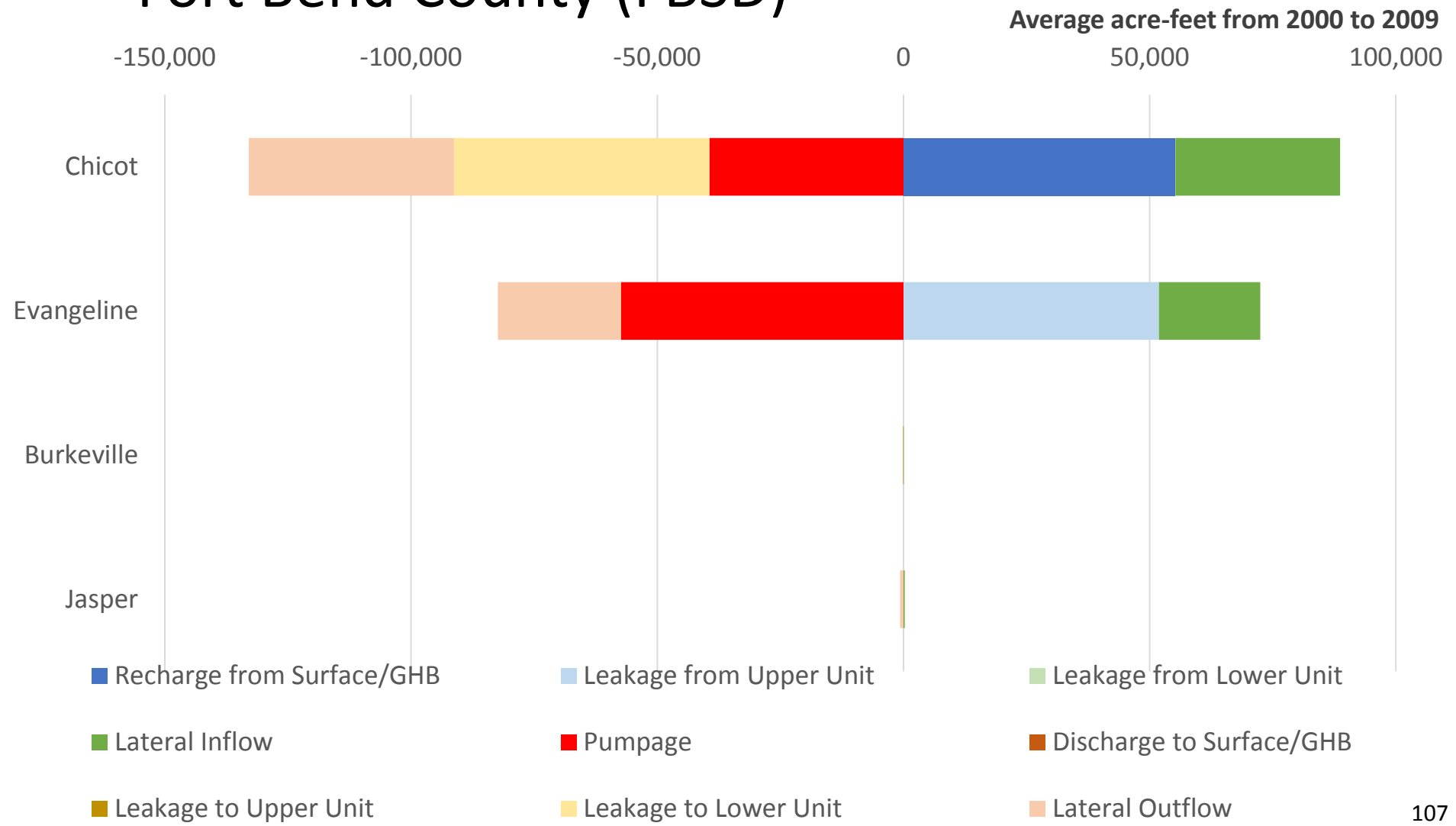
Supporting Materials
Hydrological Conditions

- Tyler County (SETGCD)



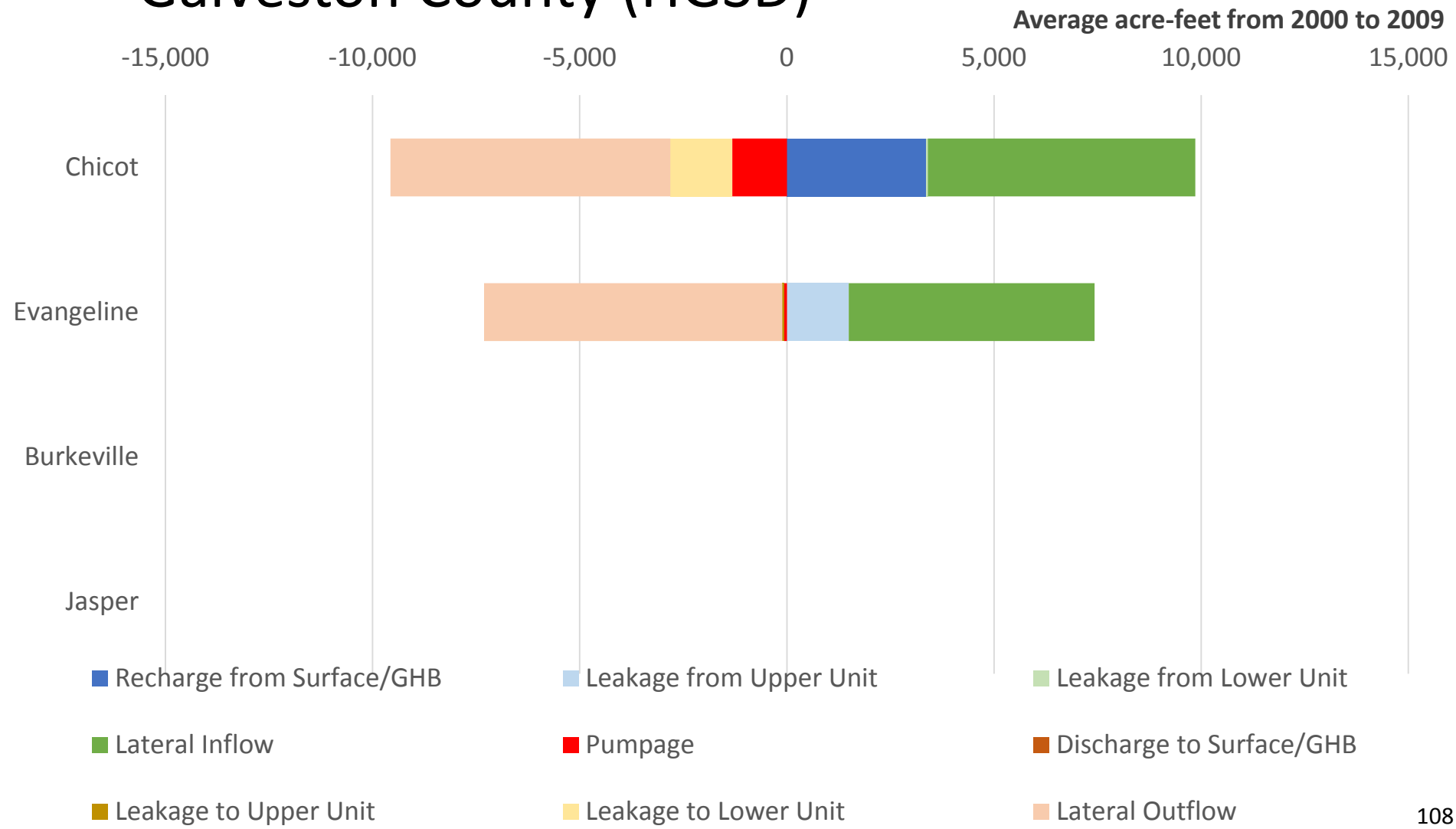
Supporting Materials
Hydrological Conditions

- Fort Bend County (FBSD)



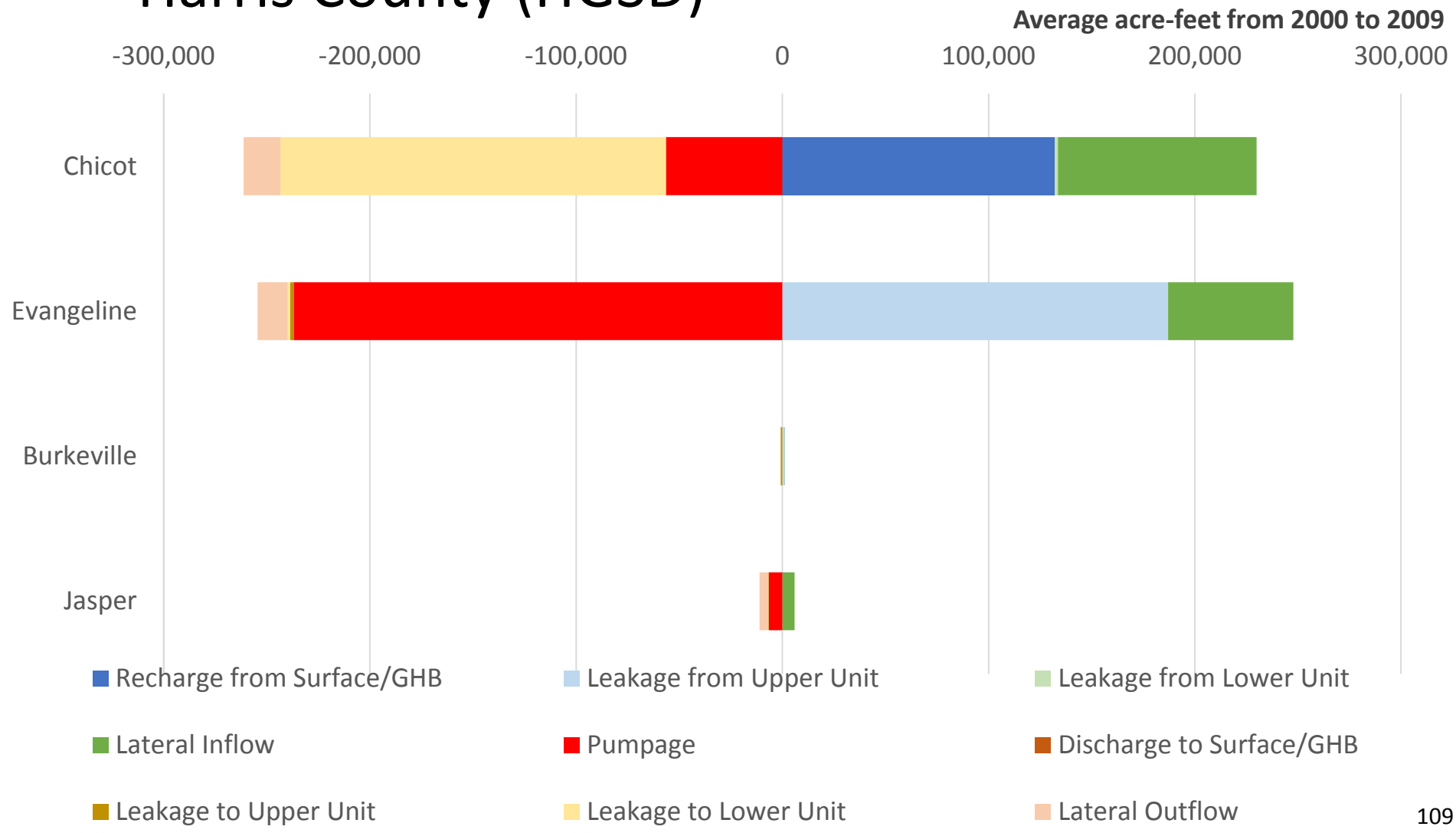
Supporting Materials
Hydrological Conditions

- Galveston County (HGSD)



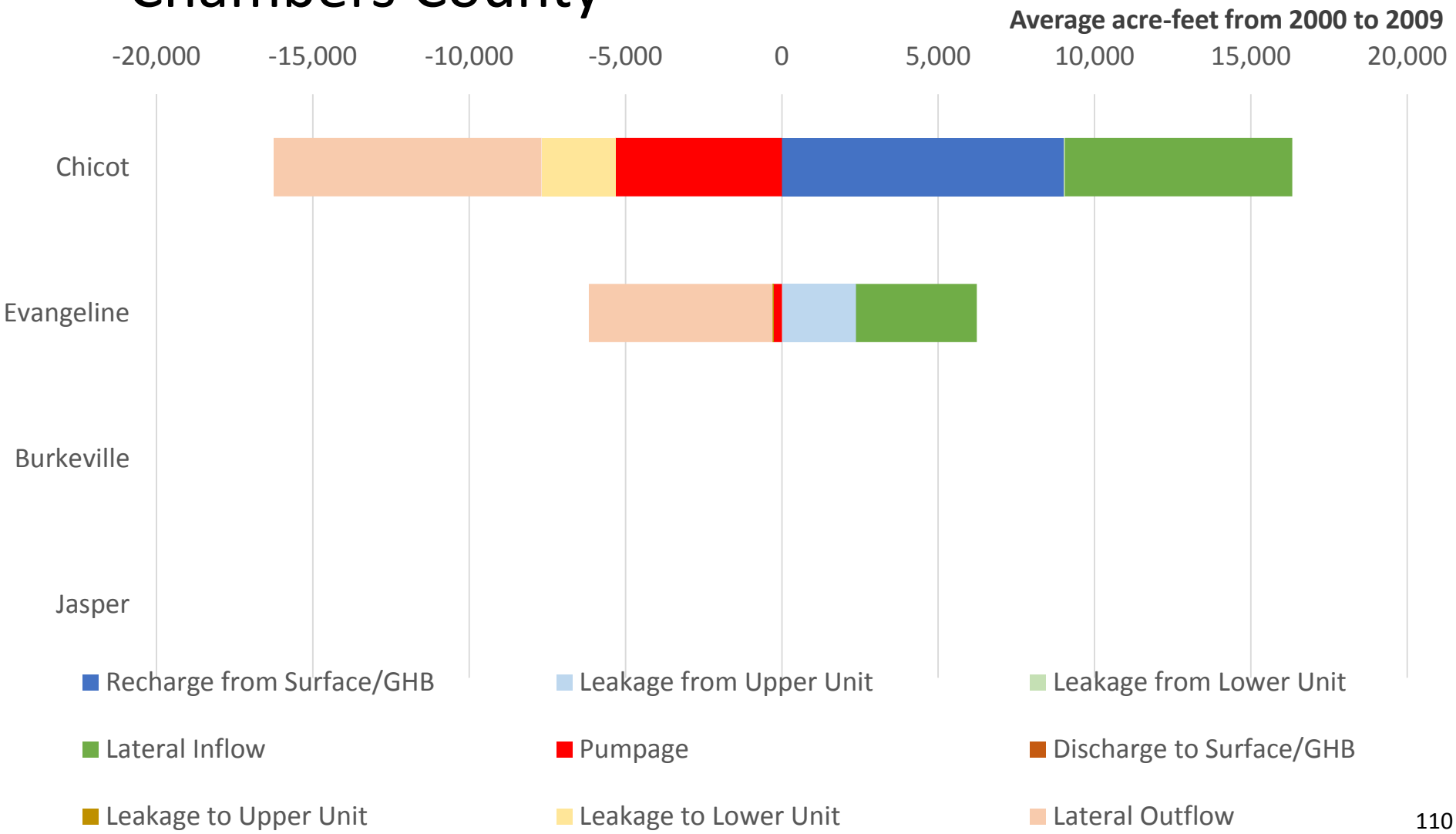
Supporting Materials
Hydrological Conditions

- Harris County (HGSD)



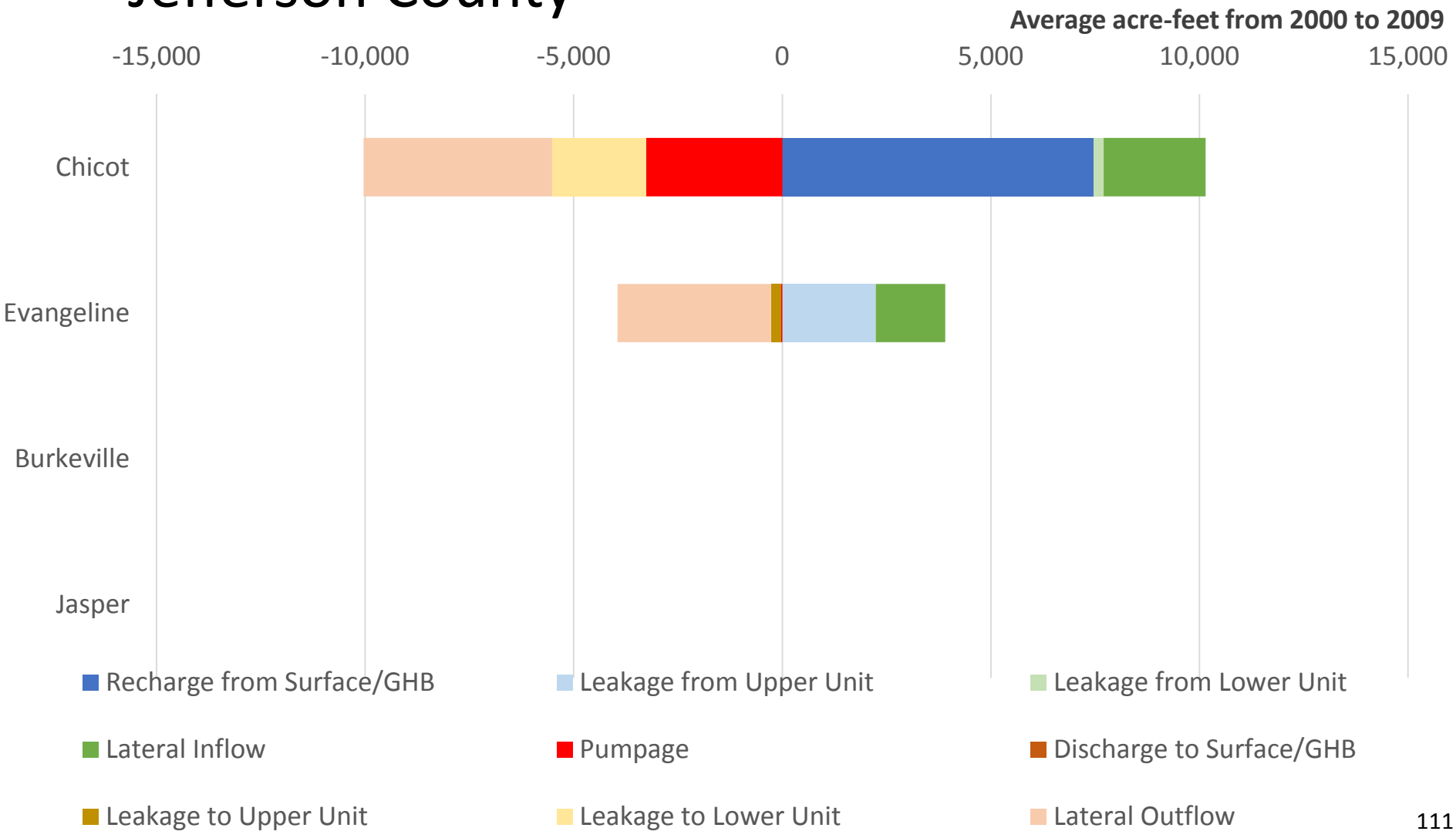
Supporting Materials
Hydrological Conditions

- Chambers County



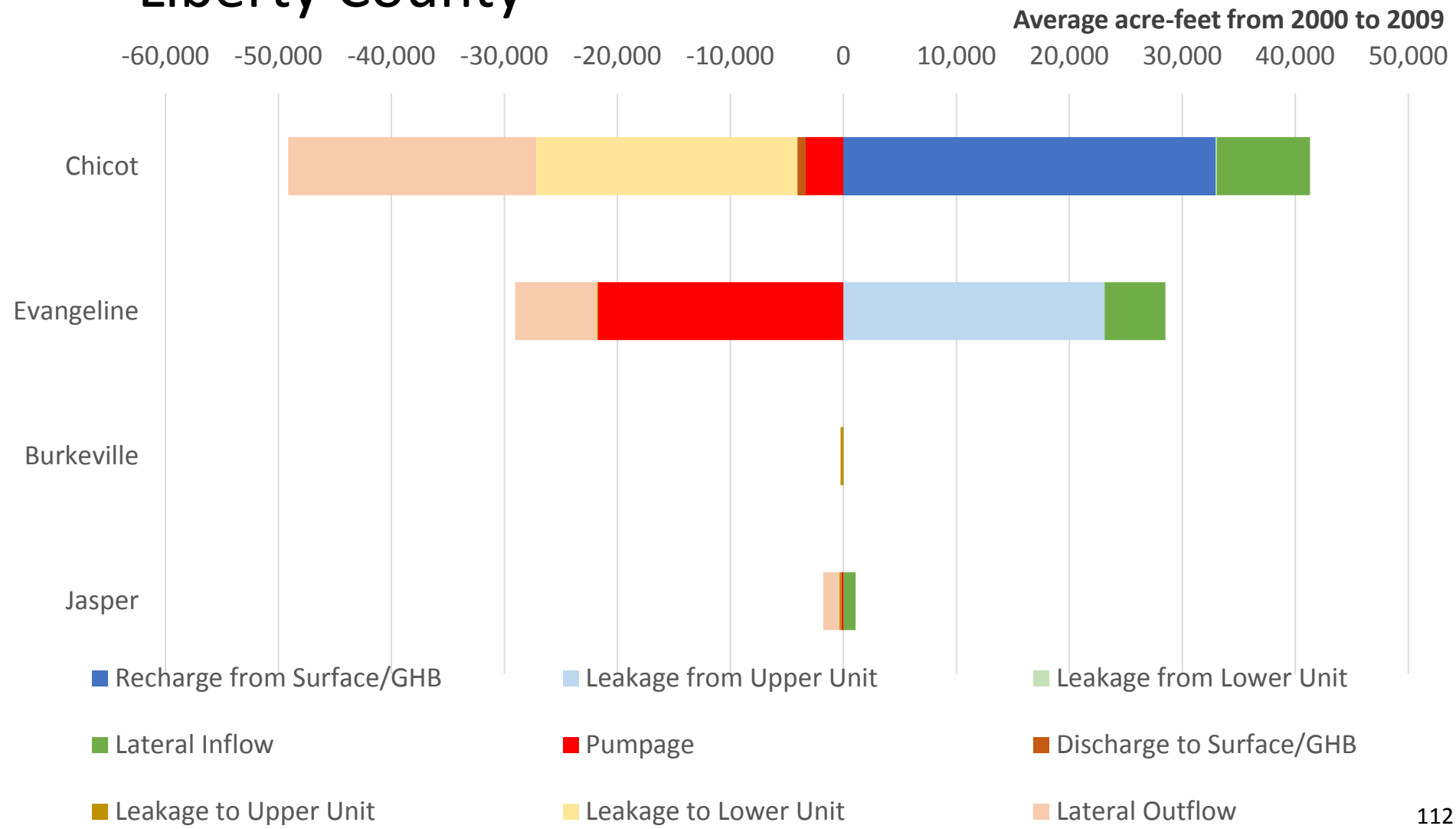
Supporting Materials
Hydrological Conditions

- Jefferson County



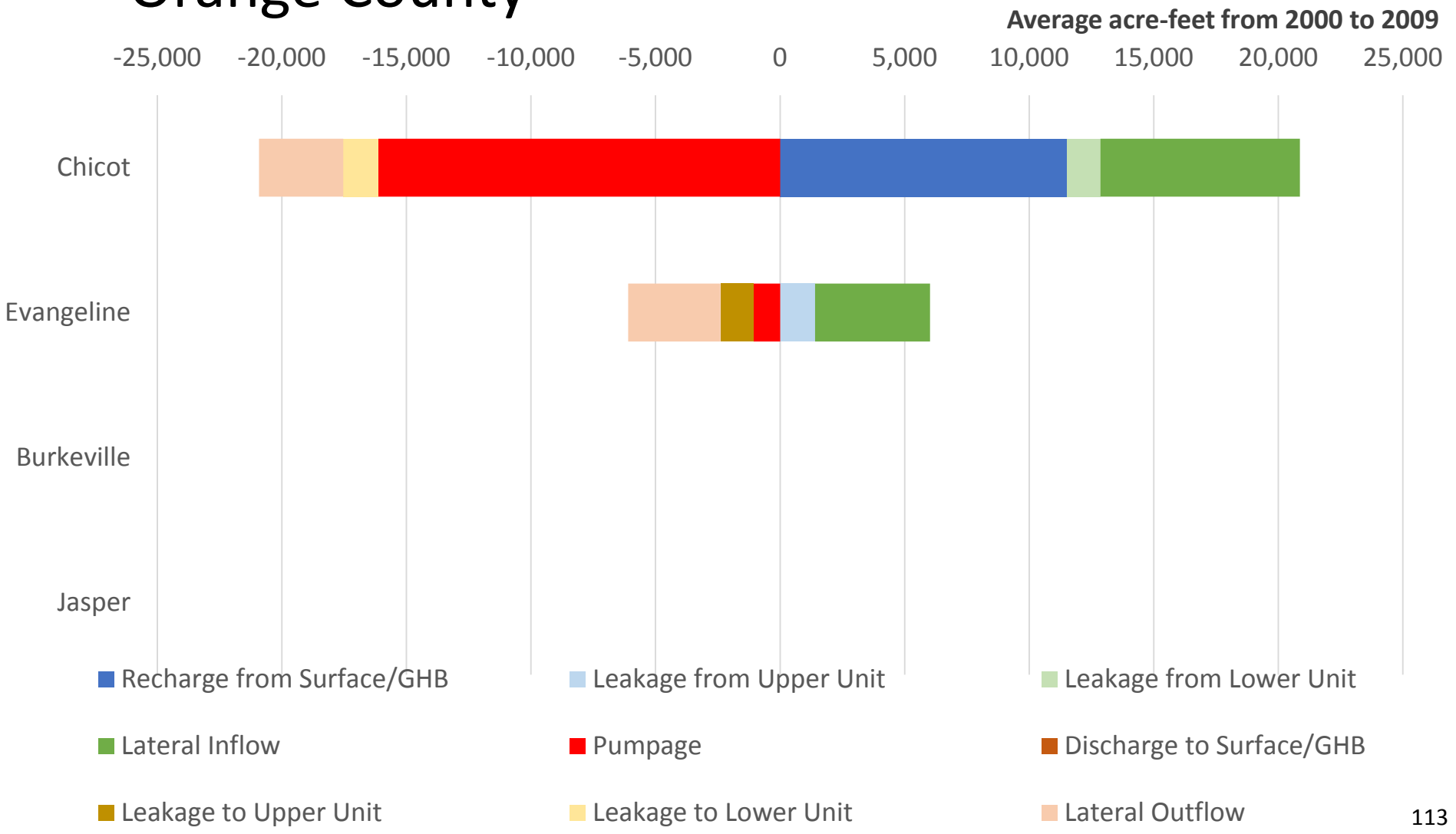
Supporting Materials
Hydrological Conditions

- Liberty County



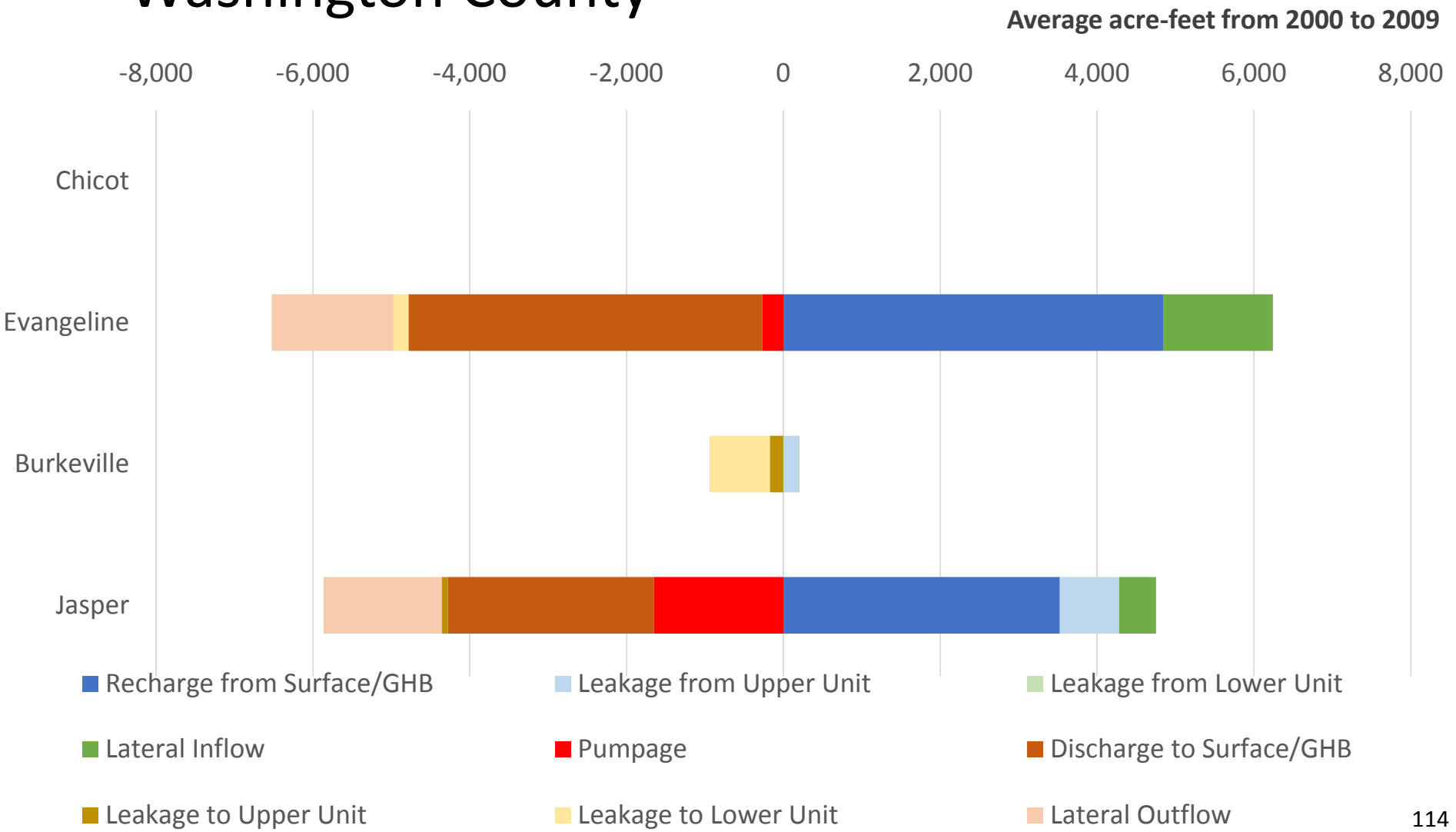
Supporting Materials
Hydrological Conditions

- Orange County



Supporting Materials
Hydrological Conditions

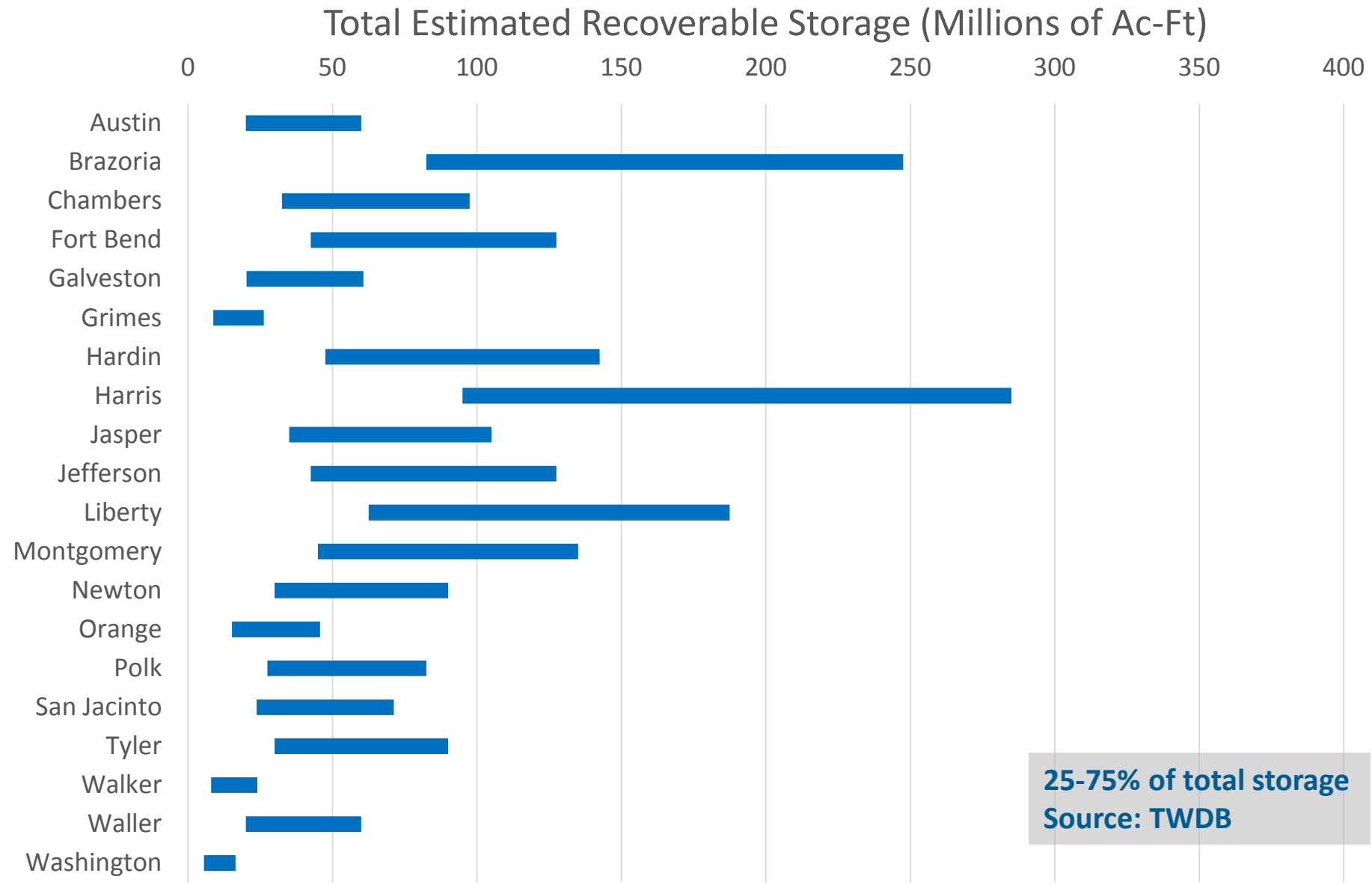
- Washington County



Supporting Materials

Hydrological Conditions

Gulf Coast Aquifer
Total Estimated
Recoverable Storage

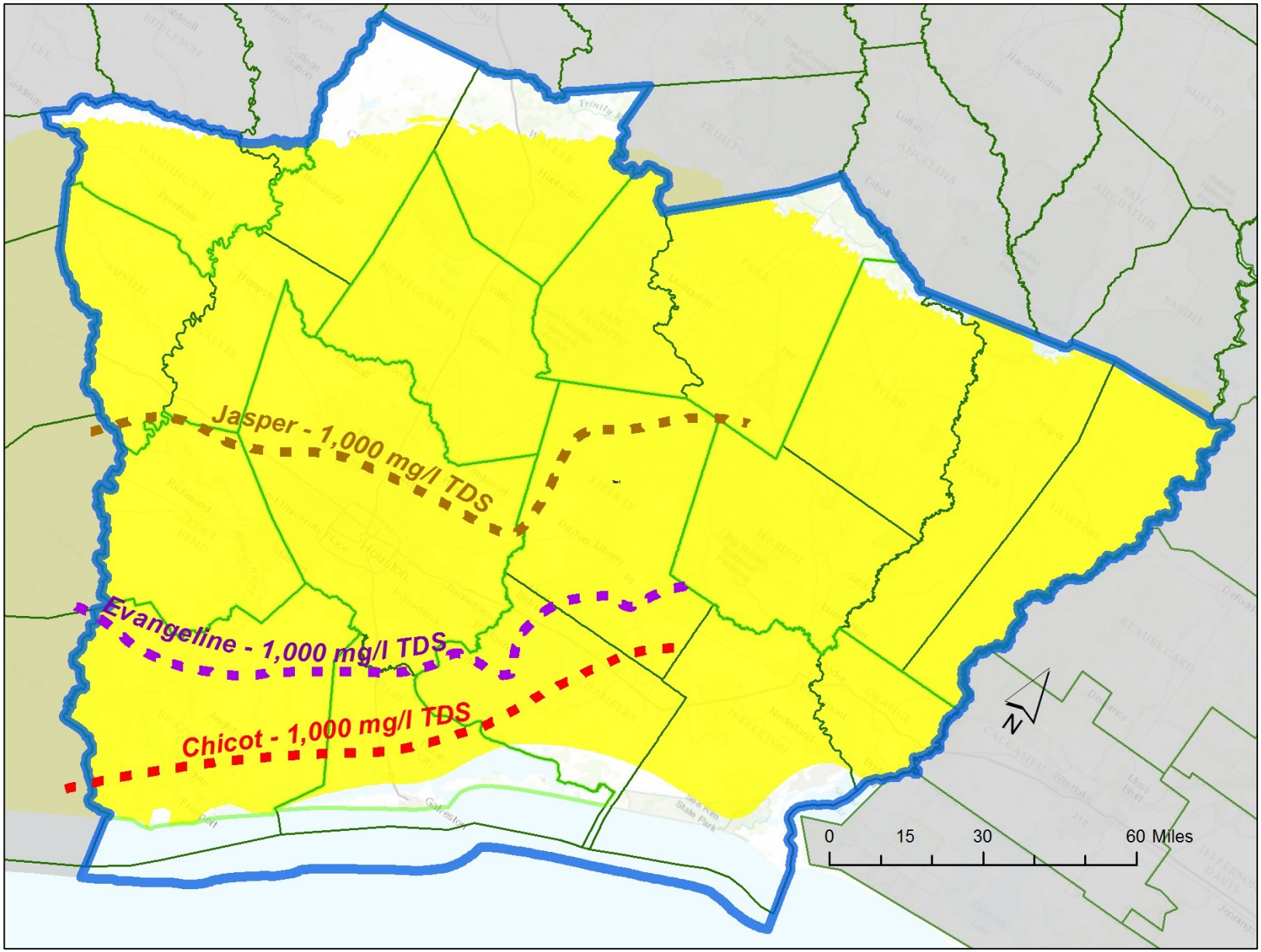


25-75% of total storage
Source: TWDB

Supporting Materials

Hydrological Conditions

Gulf Coast Aquifer
Location Map



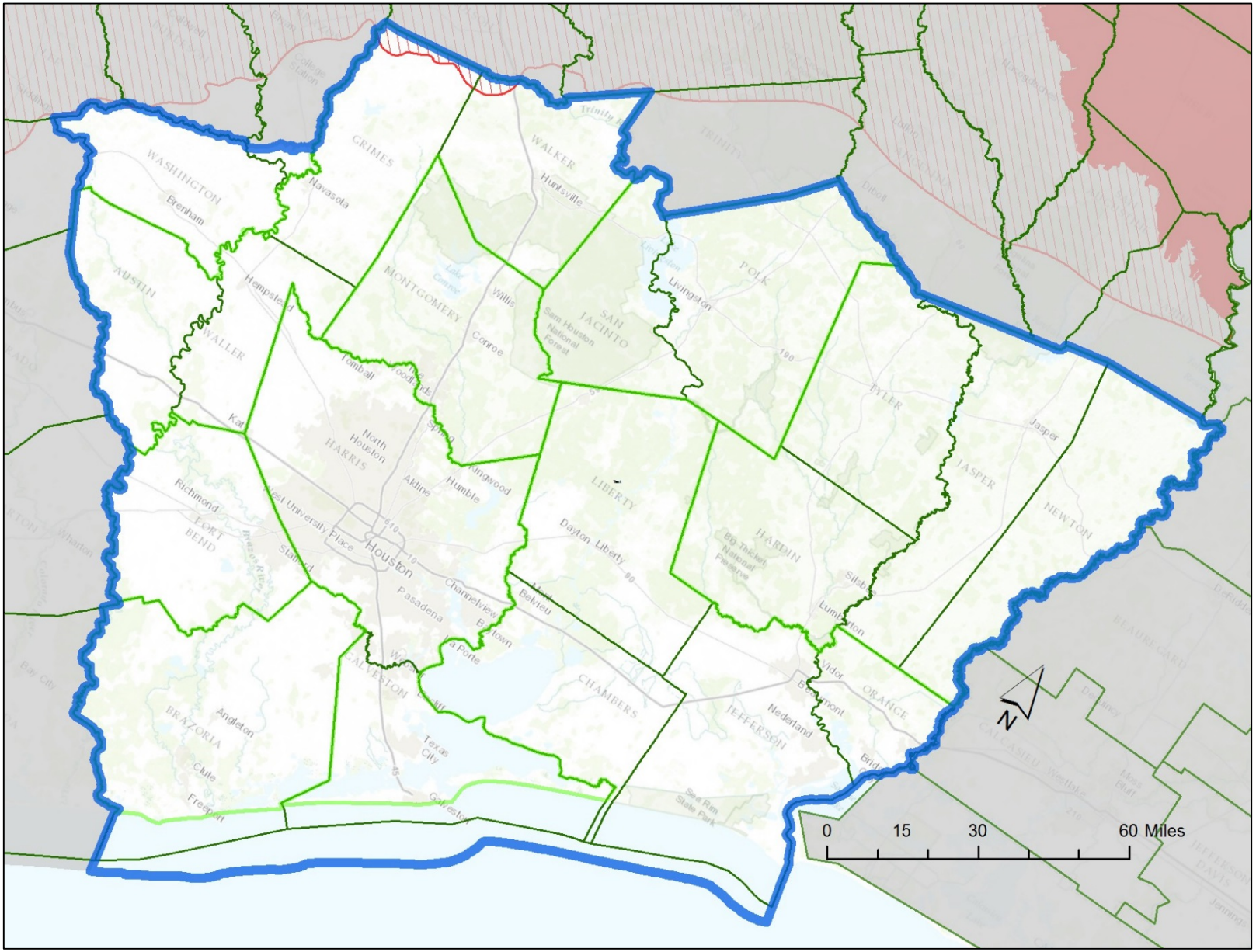
Supporting Materials
Hydrological Conditions

- Carrizo Sand Aquifer
  - *Groundwater Availability Model for the Central Part of the Carrizo-Wilcox Aquifer in Texas* (BEG, 2003)
  - Central Carrizo-Wilcox GAM Run
  - TWDB GAM Task 13-037

Supporting Materials

Hydrological Conditions

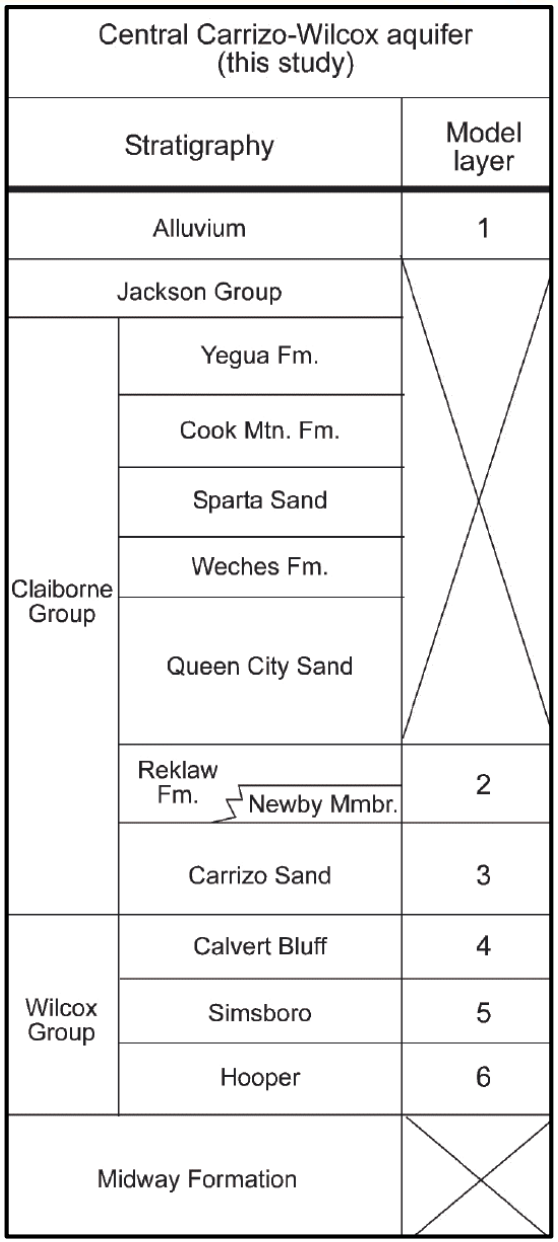
Carrizo Aquifer
Location Map



Supporting Materials

Hydrological Conditions

Carrizo Aquifer Stratigraphy

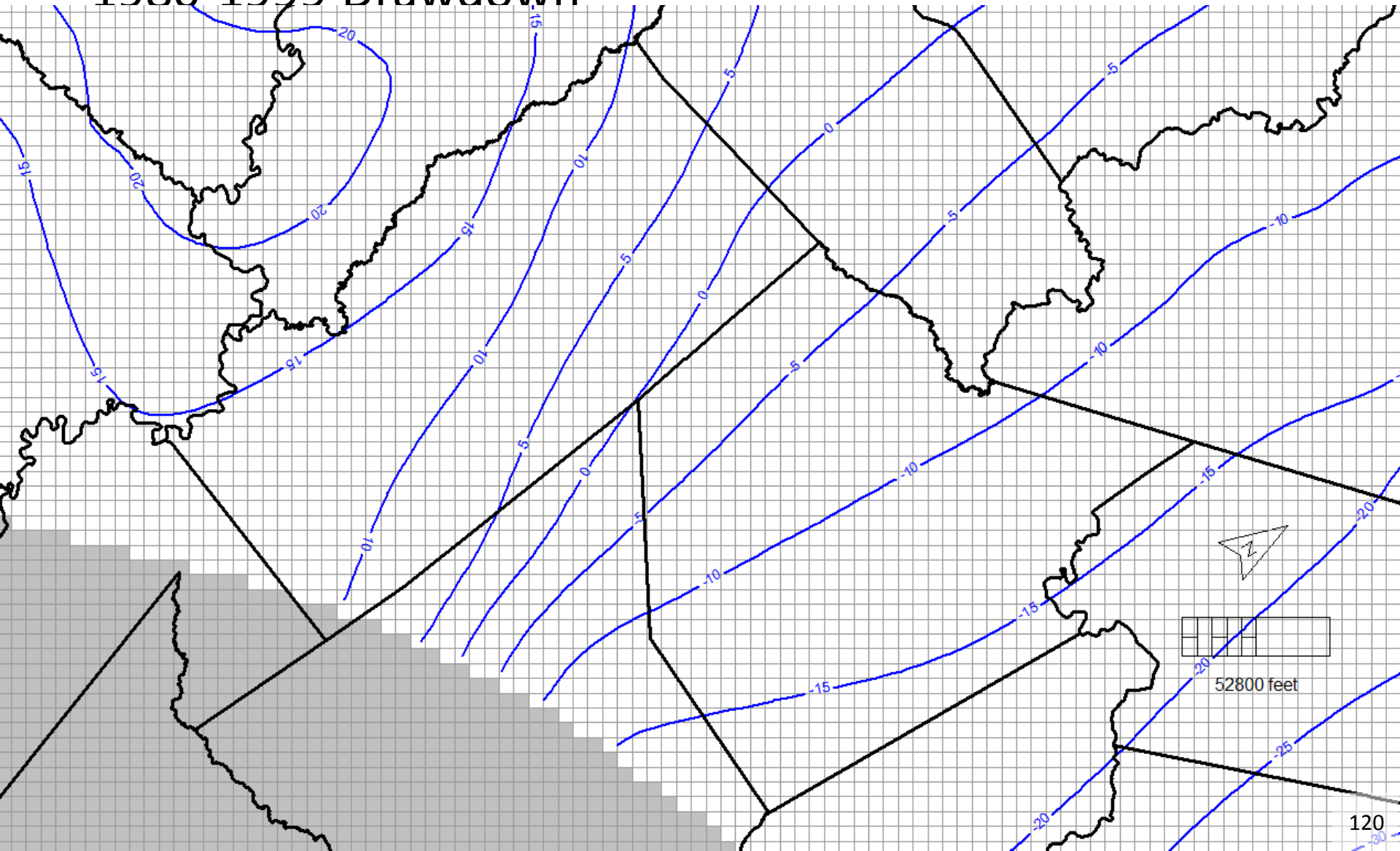


Supporting Materials

Hydrological Conditions

Carrizo Aquifer
Long-Term Trends

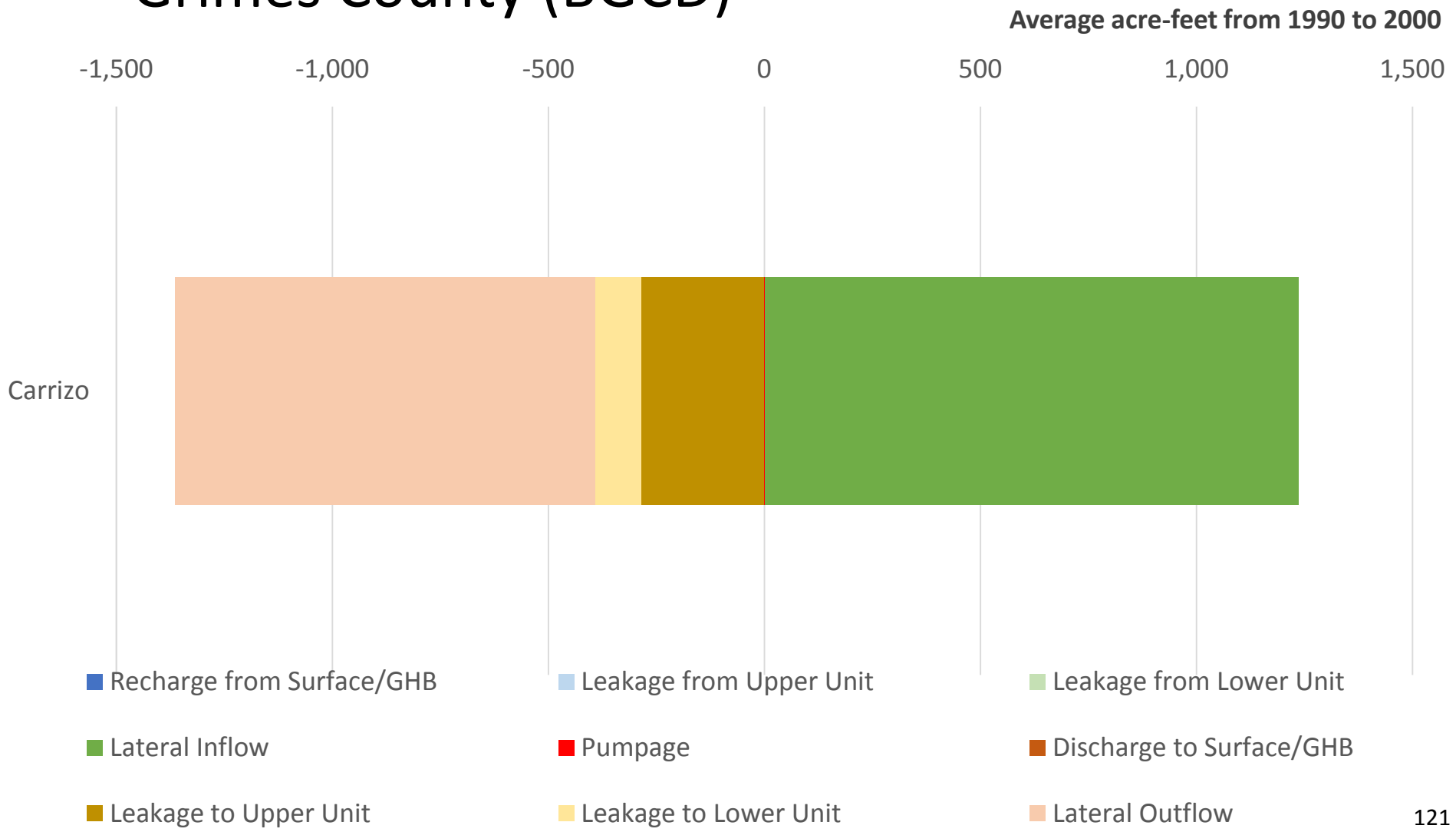
- 1980-1999 Drawdown



Supporting Materials
Hydrological Conditions

Carrizo Aquifer
Water Budget

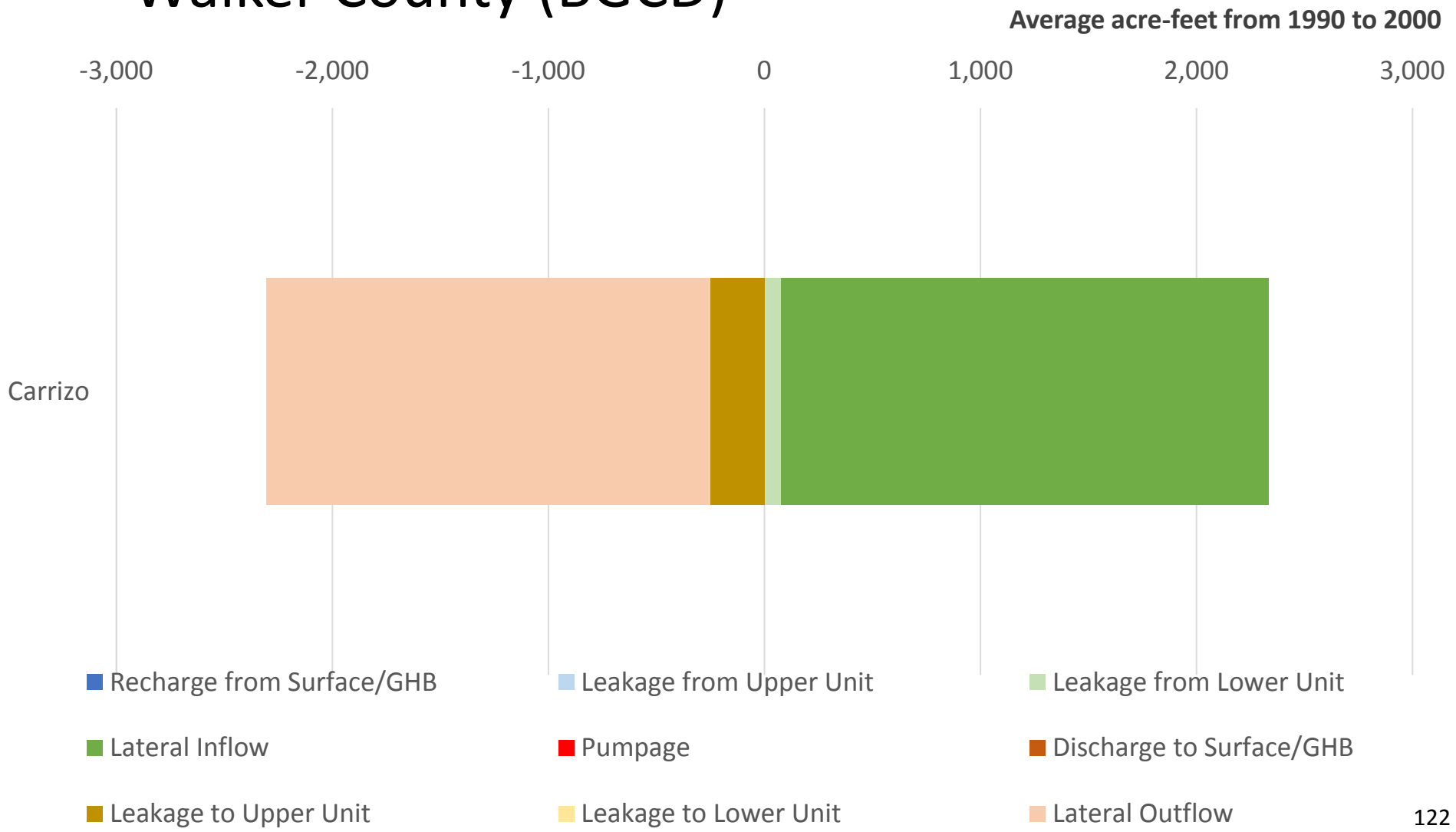
- Grimes County (BGCD)



Supporting Materials
Hydrological Conditions

Carrizo Aquifer
Water Budget

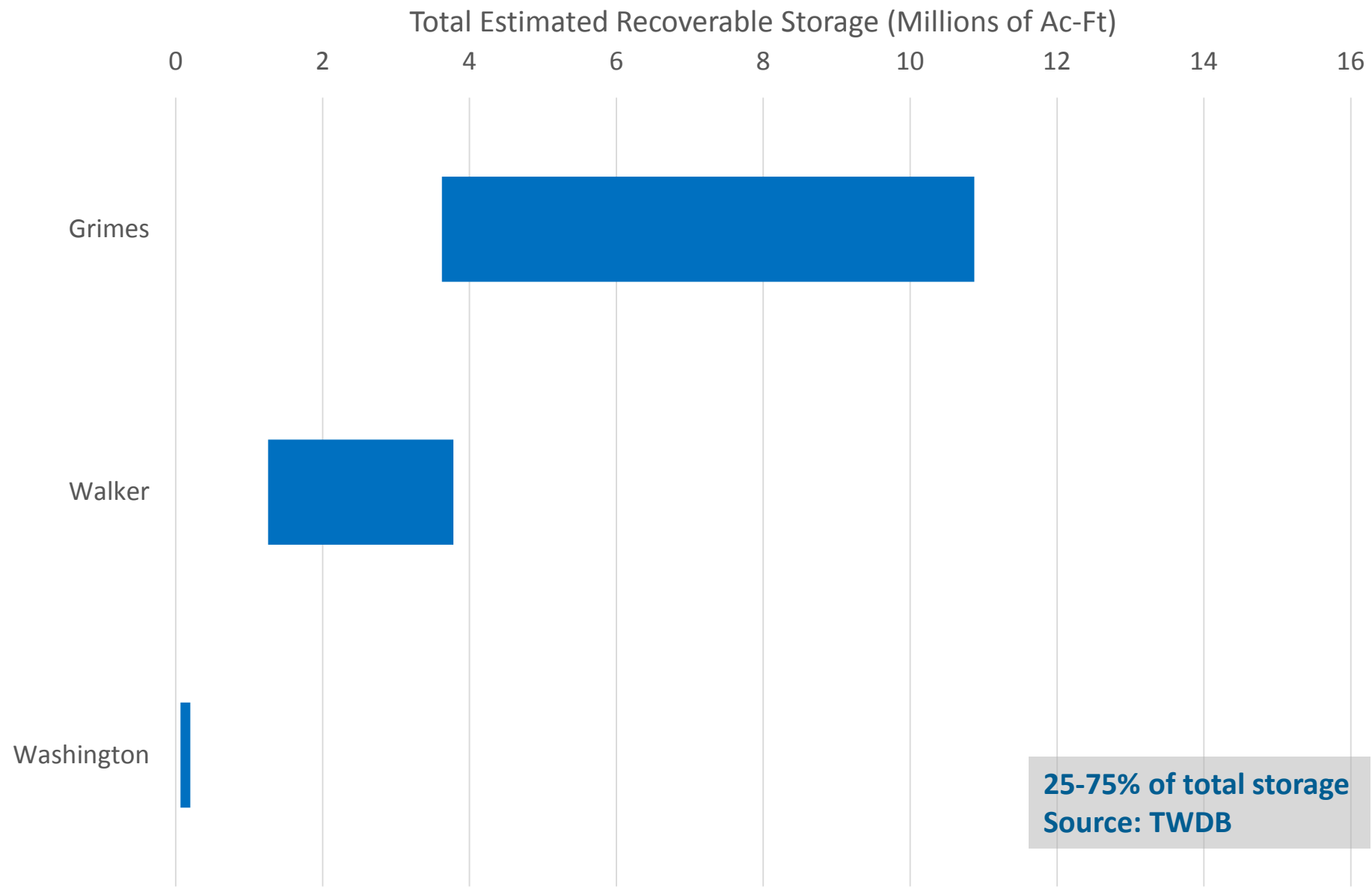
- Walker County (BGCD)



Supporting Materials

Hydrological Conditions

Carrizo Aquifer
Total Estimated
Recoverable Storage



25-75% of total storage
Source: TWDB

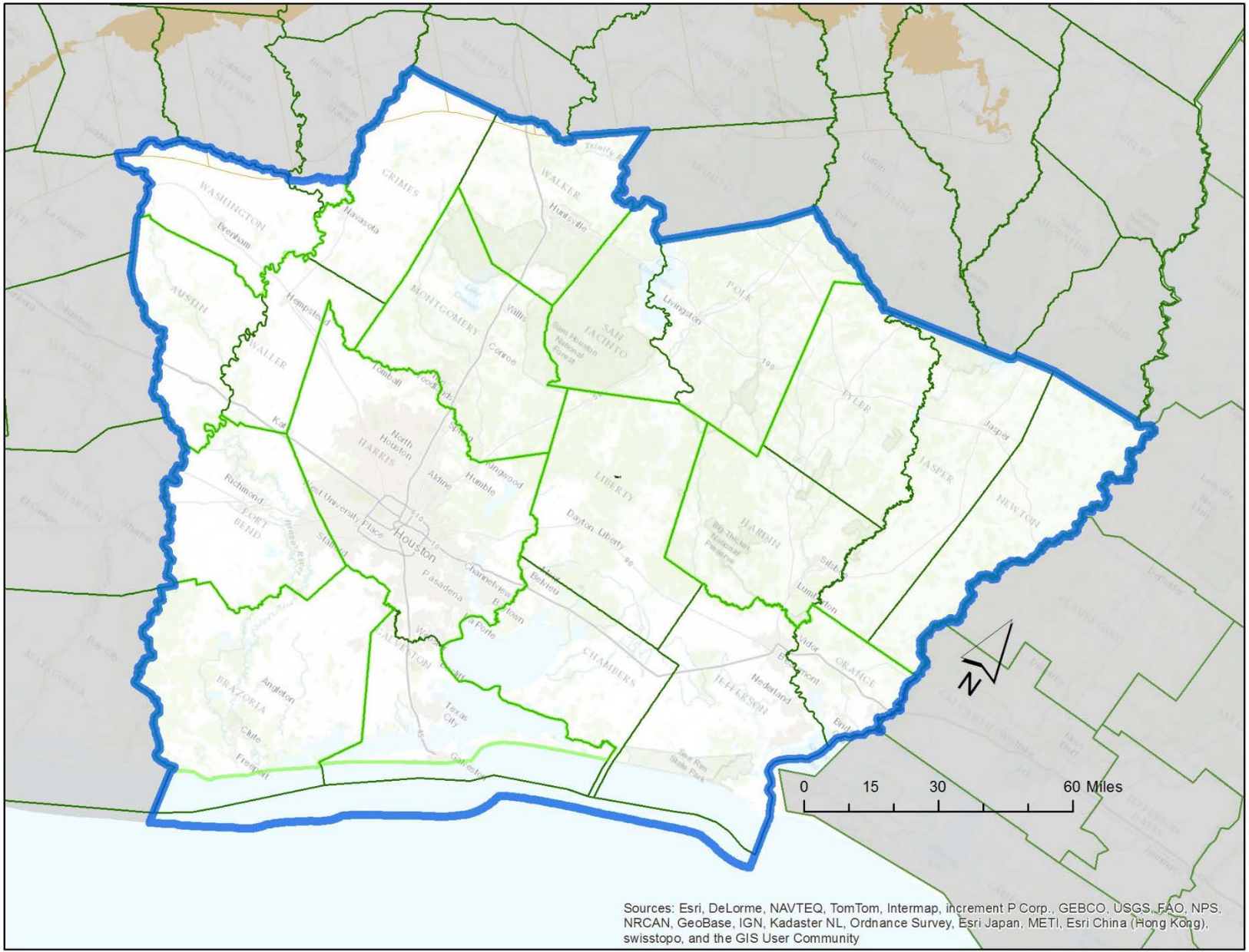
Supporting Materials
Hydrological Conditions

- Queen City Aquifer
  - *Groundwater Availability Models for the Queen City and Sparta Aquifers* (INTERA, 2004)
  - Central Carrizo-Wilcox GAM Run
  - TWDB GAM Task 13-037

Supporting Materials

Hydrological Conditions

Queen City Aquifer
Location Map



Supporting Materials

Hydrological Conditions

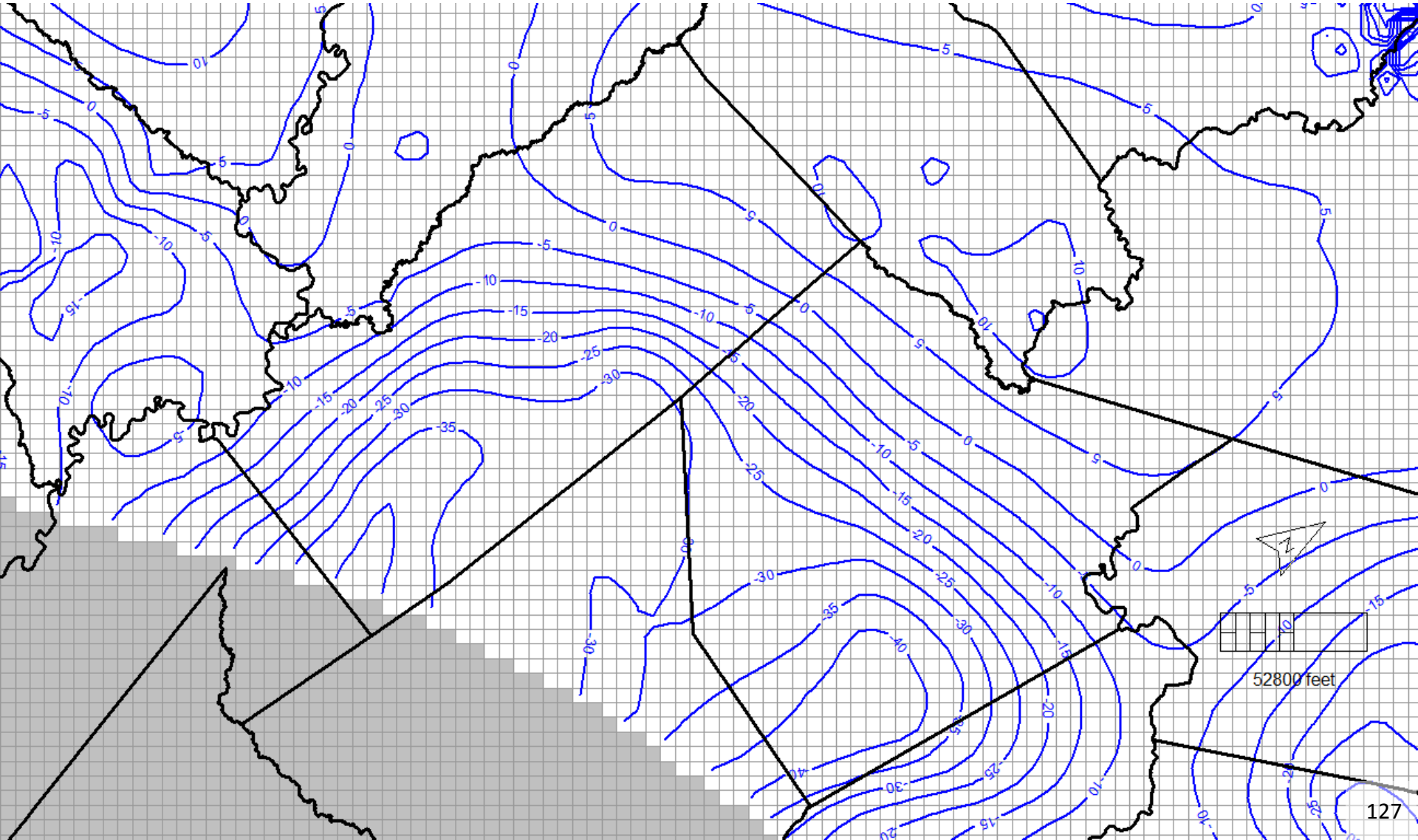
Queen City Aquifer Stratigraphy

Central Carrizo-Wilcox aquifer (this study)		
Stratigraphy		Model layer
Alluvium		1
Jackson Group		
Claiborne Group	Yegua Fm.	
	Cook Mtn. Fm.	
	Sparta Sand	
	Weches Fm.	
	Queen City Sand	
	Reklaw Fm. / Newby Mmbr.	2
	Carrizo Sand	3
Wilcox Group	Calvert Bluff	4
	Simsboro	5
	Hooper	6
Midway Formation		

Supporting Materials

Hydrological Conditions

- 1980-1999 Drawdown

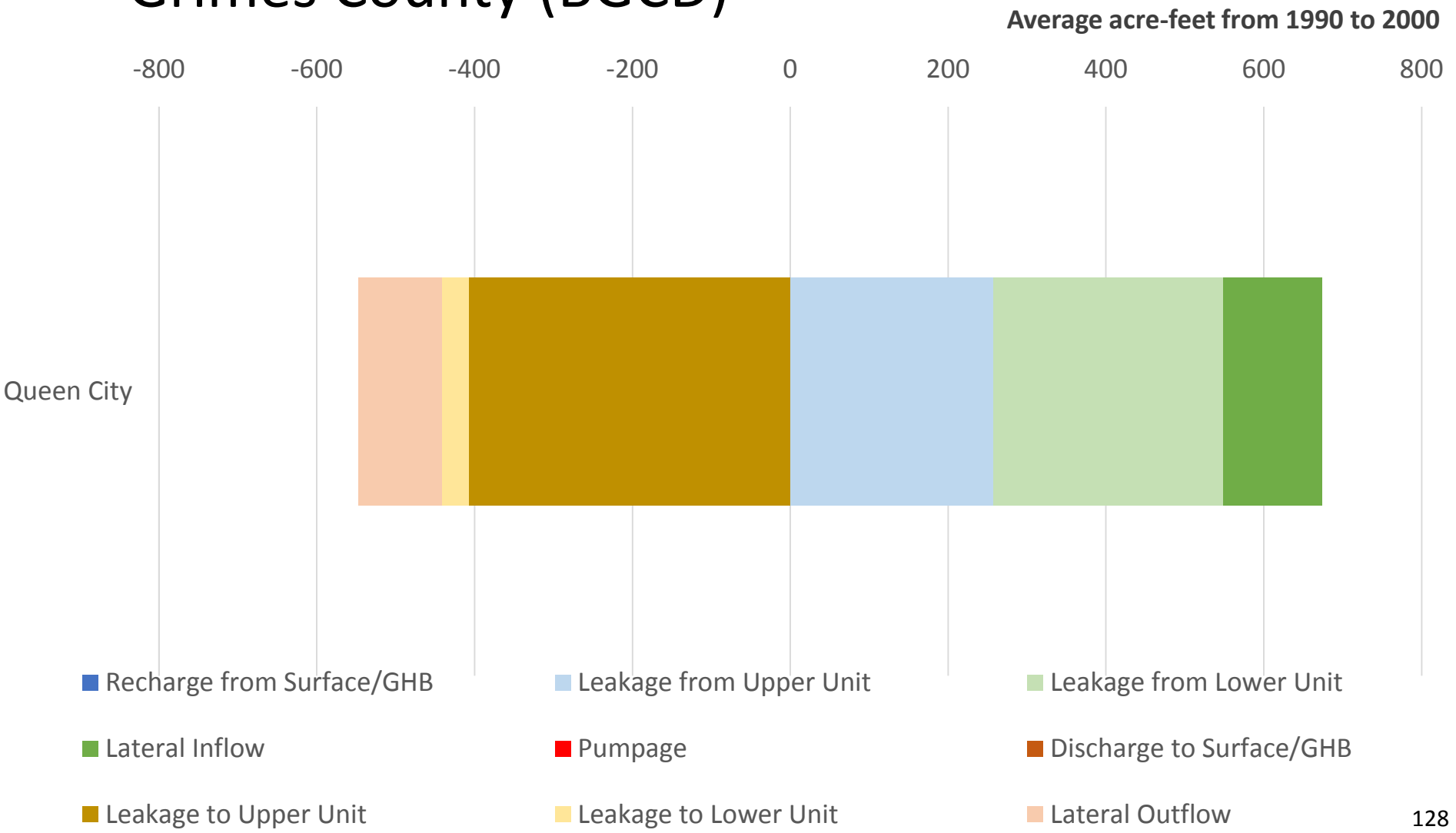


Supporting Materials

Hydrological Conditions

Queen City Aquifer
Water Budget

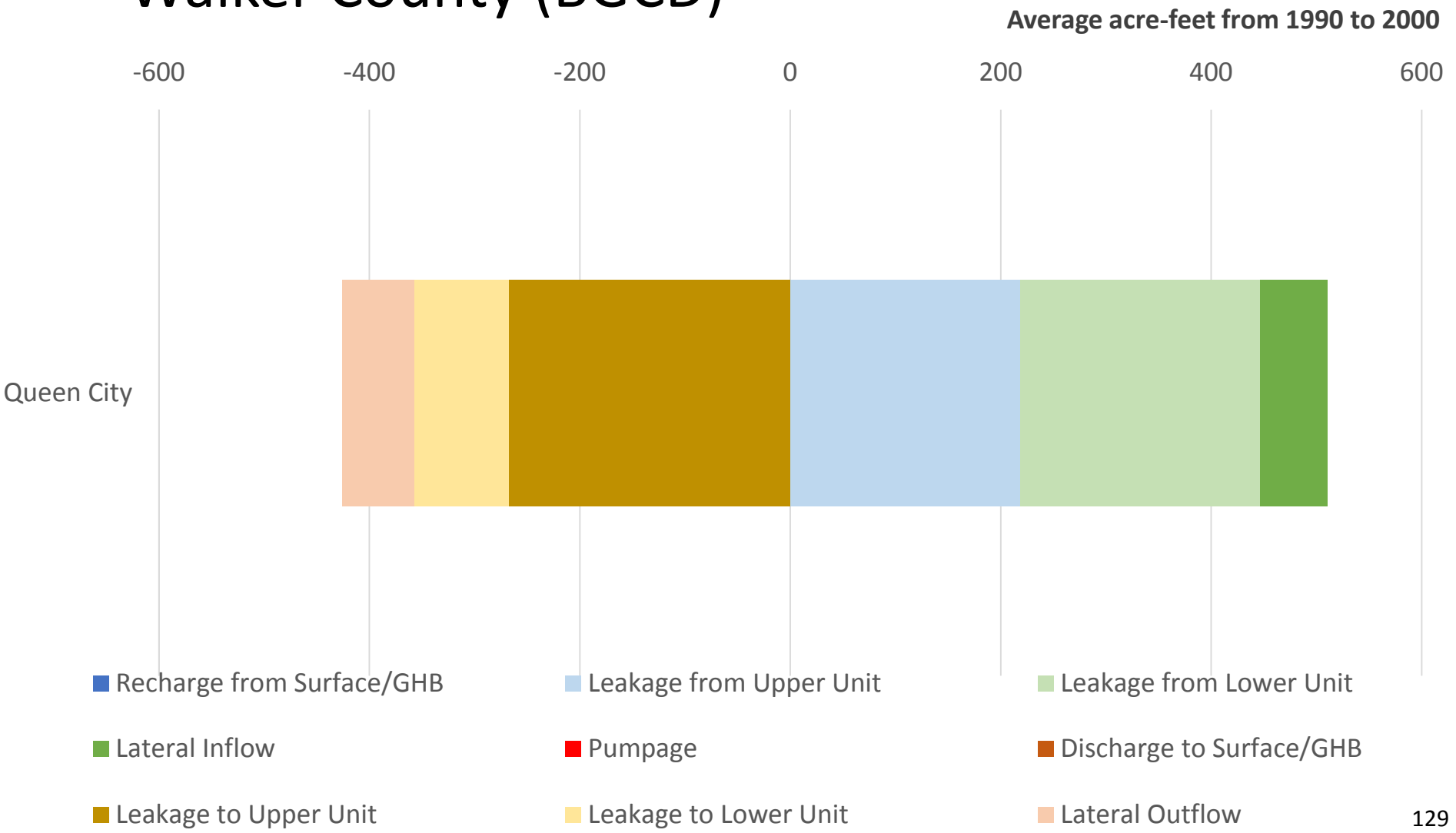
- Grimes County (BGCD)



Supporting Materials
Hydrological Conditions

Queen City Aquifer
Water Budget

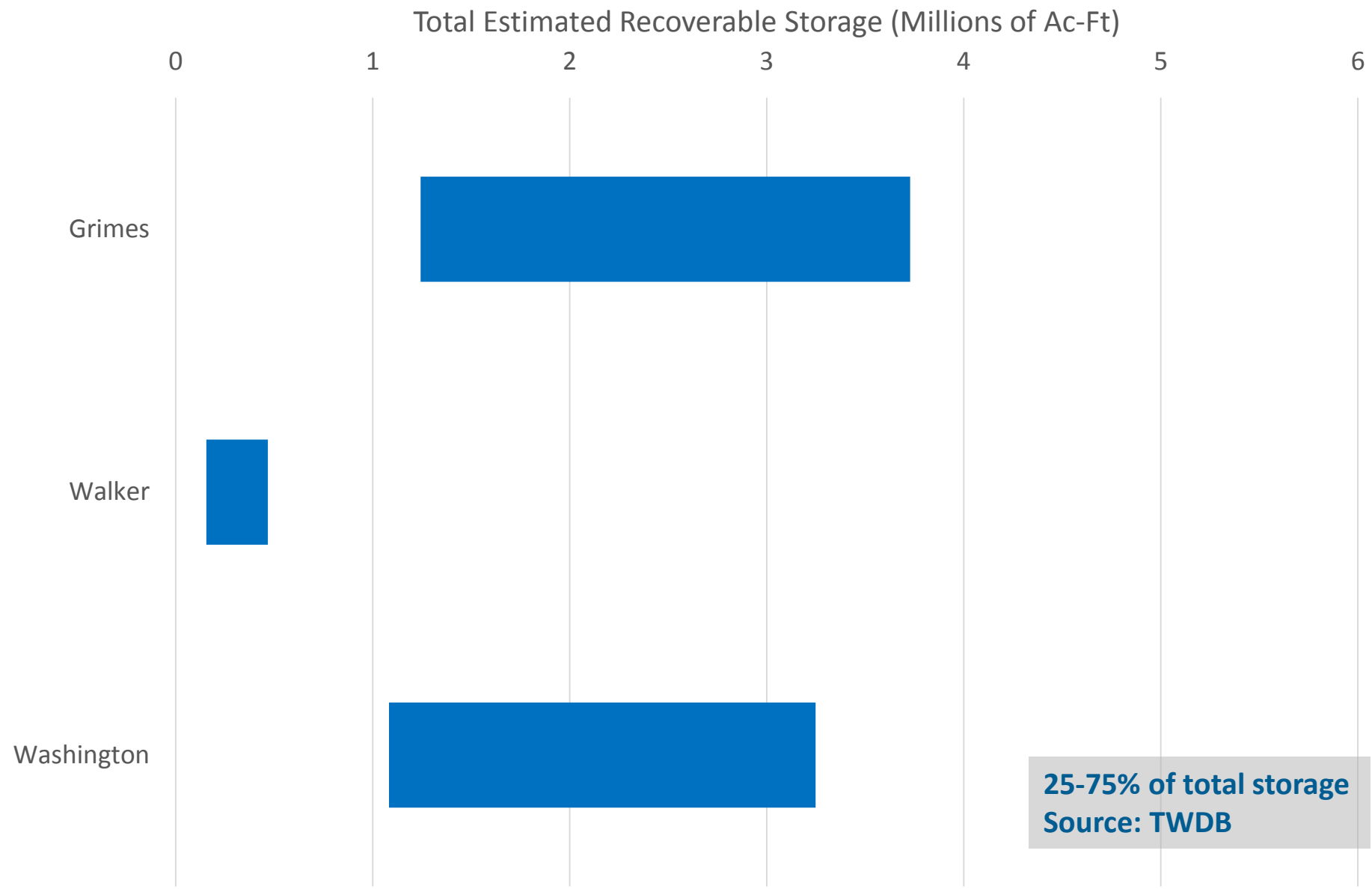
- Walker County (BGCD)



Supporting Materials

Hydrological Conditions

Queen City Aquifer
Total Estimated
Recoverable Storage



25-75% of total storage
Source: TWDB

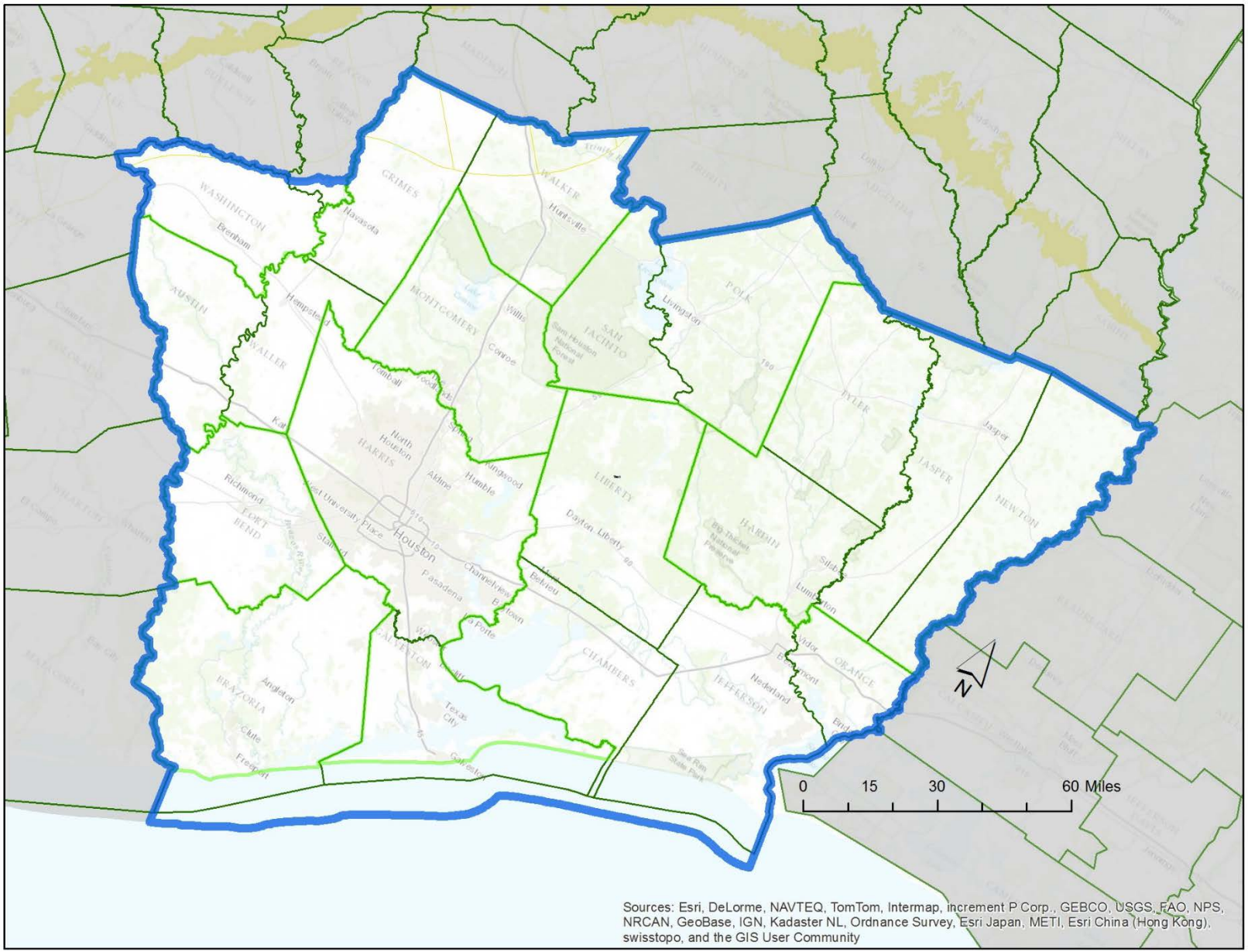
Supporting Materials
Hydrological Conditions

- Sparta Aquifer
  - *Groundwater Availability Models for the Queen City and Sparta Aquifers* (INTERA, 2004)
  - Central Carrizo-Wilcox GAM Run
  - TWDB GAM Task 13-037

Supporting Materials

Hydrological Conditions

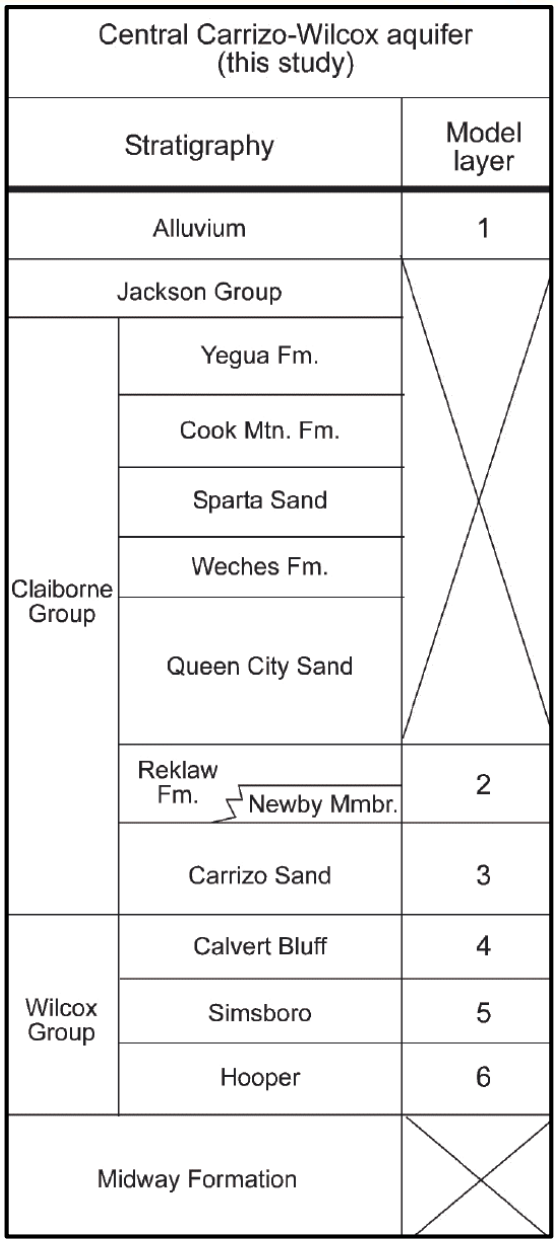
Sparta Aquifer
Location Map



Supporting Materials

Hydrological Conditions

Sparta Aquifer Stratigraphy

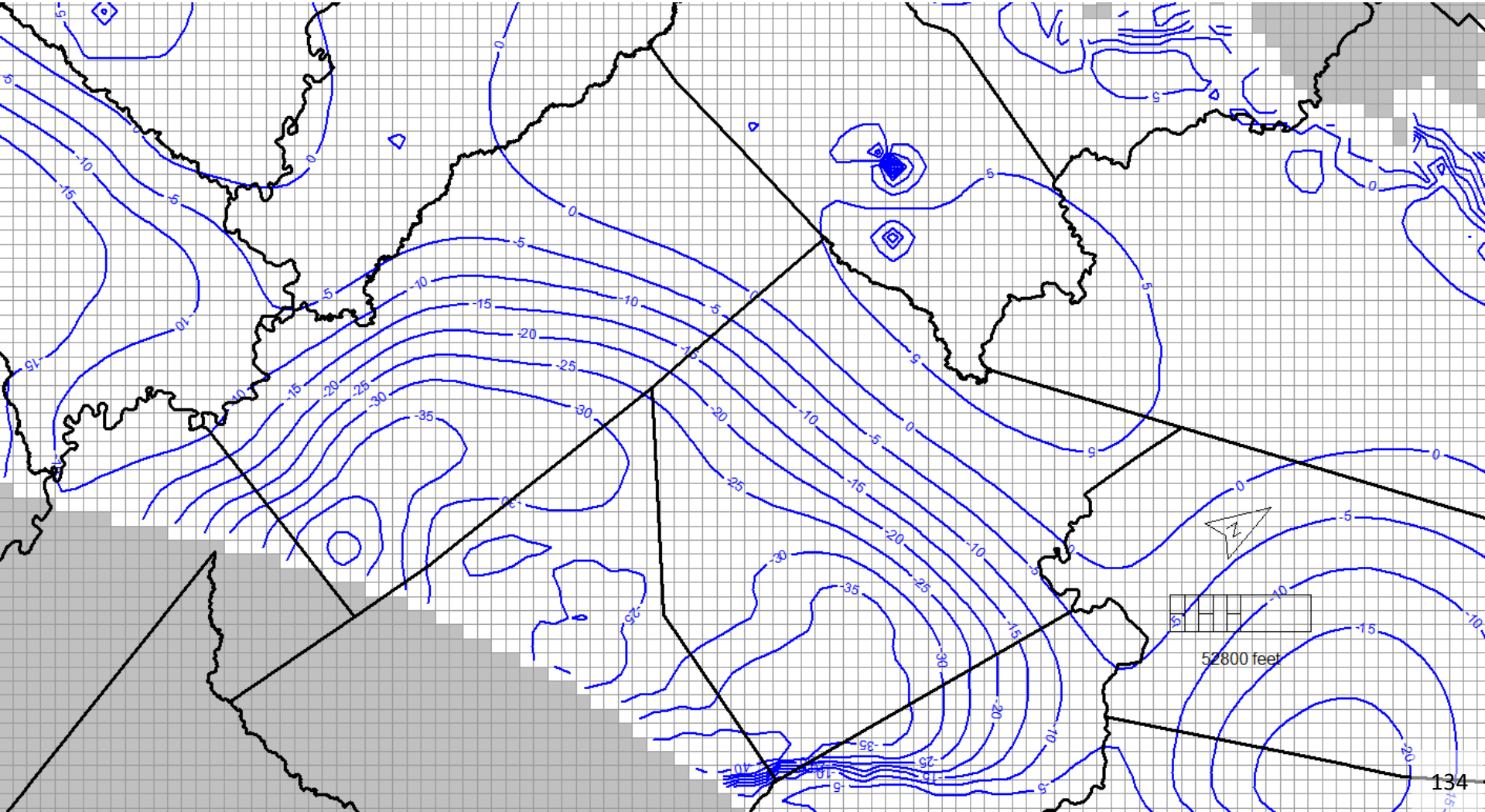


Central Carrizo-Wilcox aquifer (this study)		
Stratigraphy		Model layer
Alluvium		1
Jackson Group		
Claiborne Group	Yegua Fm.	
	Cook Mtn. Fm.	
	Sparta Sand	
	Weches Fm.	
	Queen City Sand	
	Reklaw Fm. / Newby Mmbr.	2
	Carrizo Sand	3
Wilcox Group	Calvert Bluff	4
	Simsboro	5
	Hooper	6
Midway Formation		

Supporting Materials

Hydrological Conditions

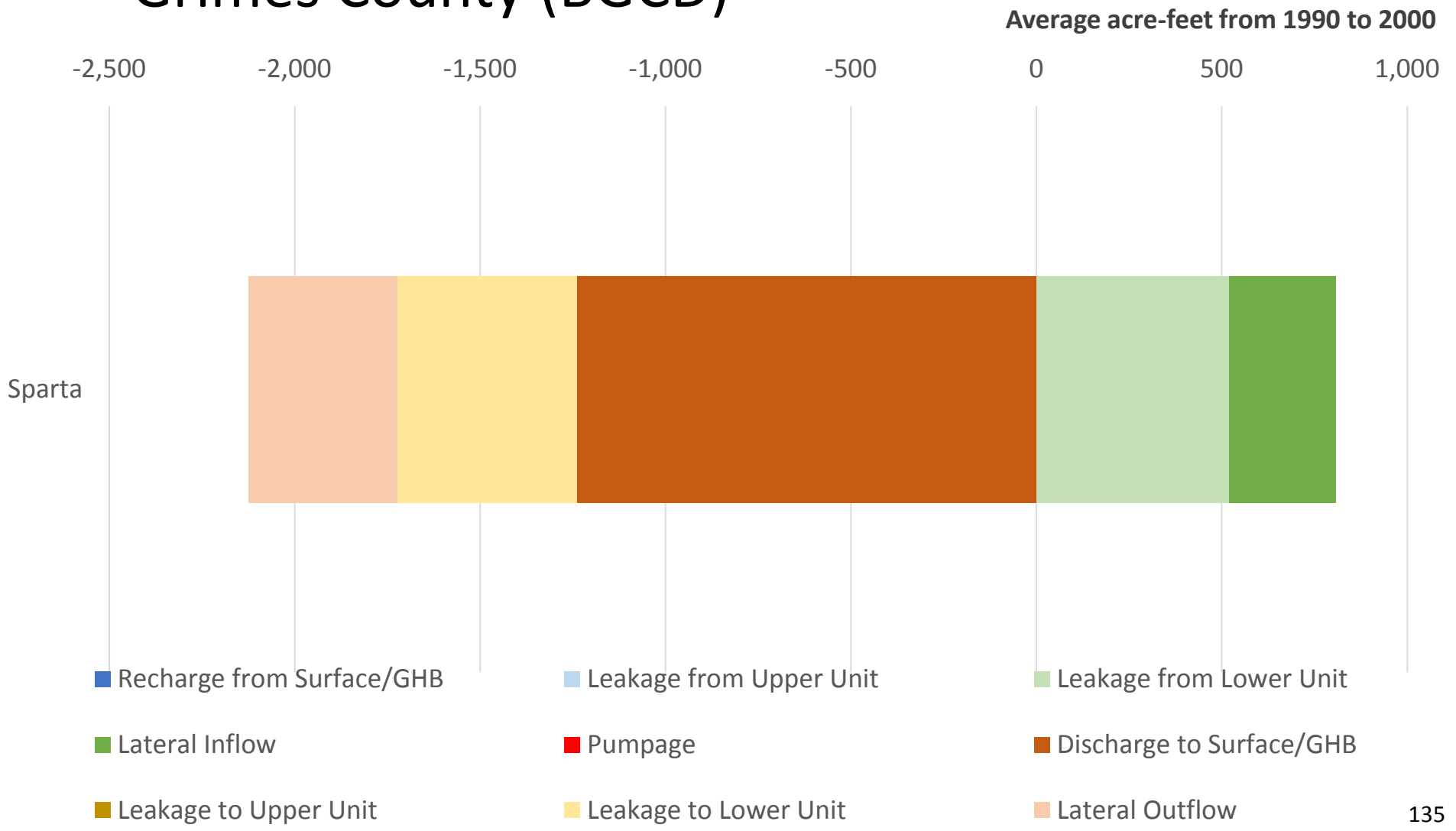
- 1980-1999 Drawdown



Supporting Materials
Hydrological Conditions

Sparta Aquifer
Water Budget

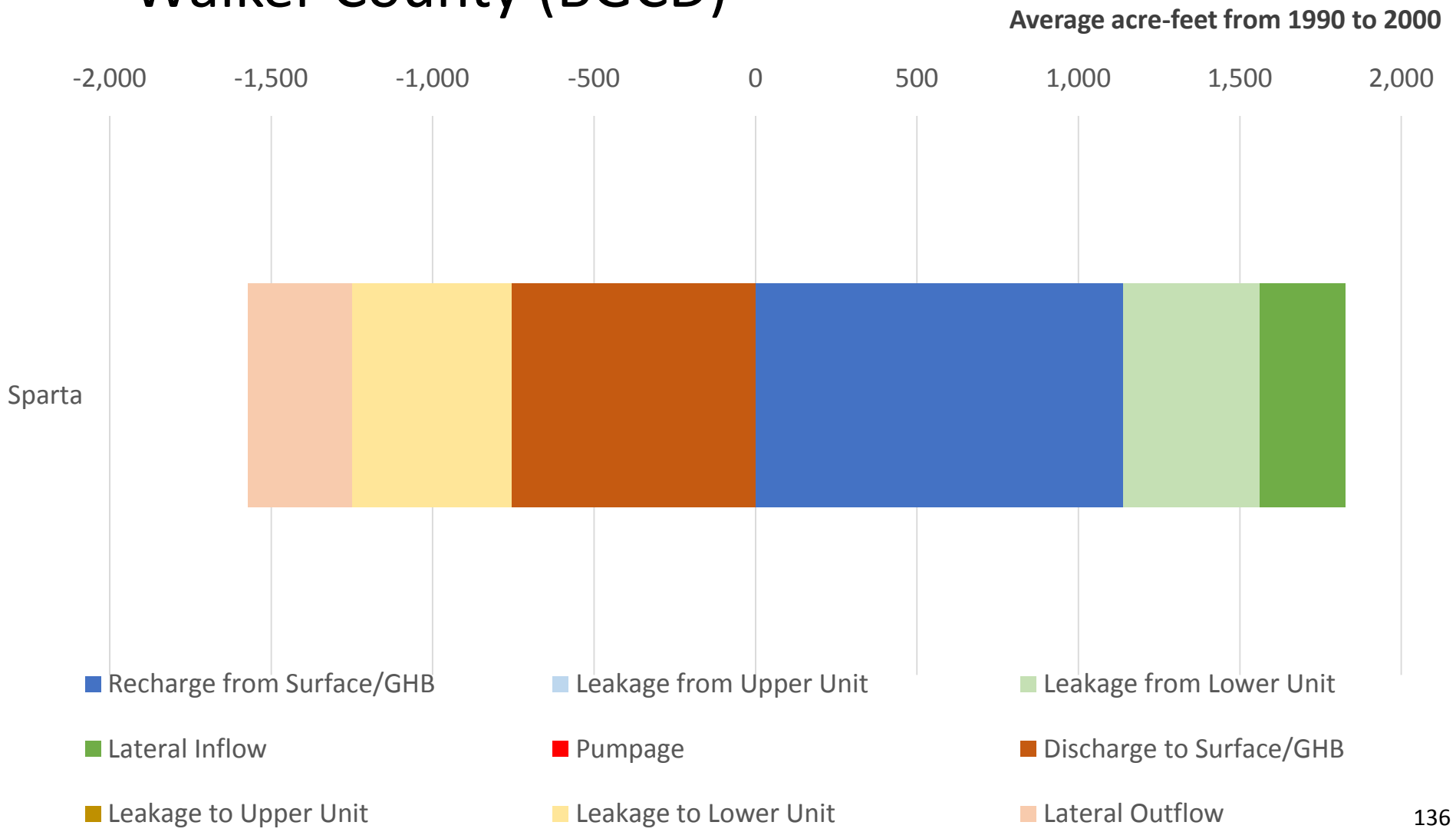
- Grimes County (BGCD)



Supporting Materials
Hydrological Conditions

Sparta Aquifer
Water Budget

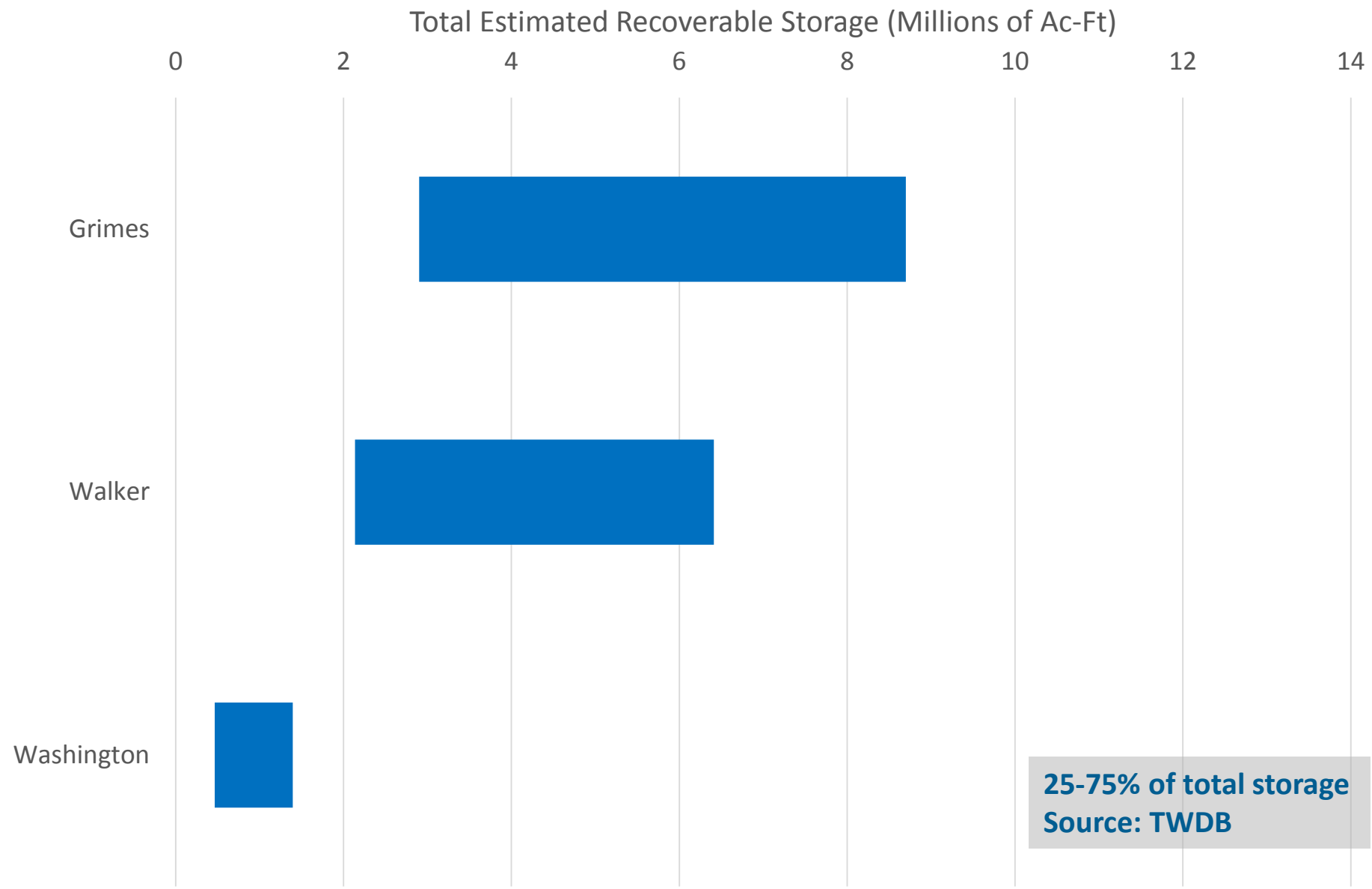
- Walker County (BGCD)



Supporting Materials

Hydrological Conditions

Sparta Aquifer
Total Estimated
Recoverable Storage



25-75% of total storage
Source: TWDB

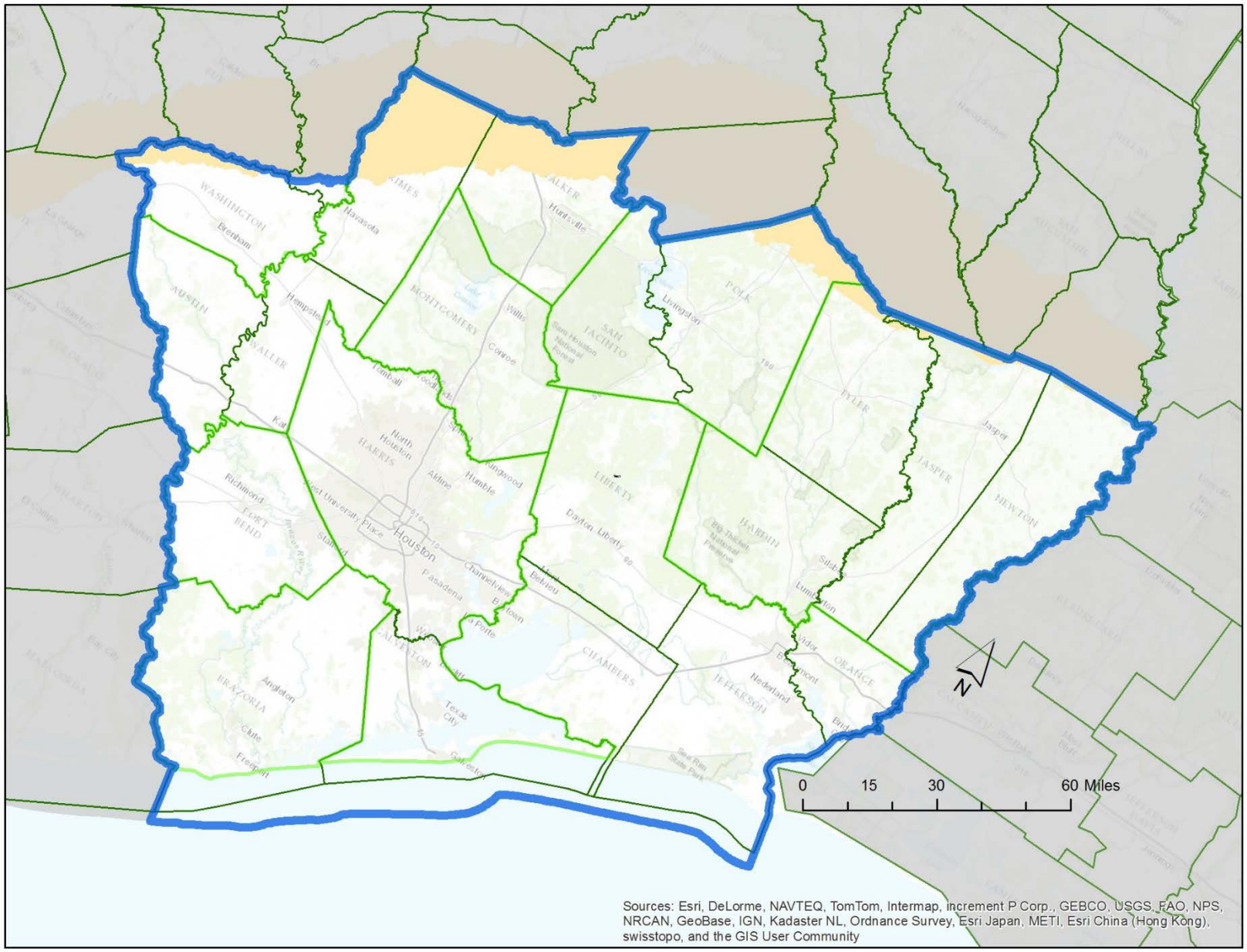
Supporting Materials
Hydrological Conditions

- Yegua-Jackson Aquifer
  - *Final Report: Groundwater Availability Model for the Yegua-Jackson Aquifer* (INTERA, Rev. 2010)
  - Yegua-Jackson GAM Run
  - TWDB GAM Task 13-037

Supporting Materials

Hydrological Conditions

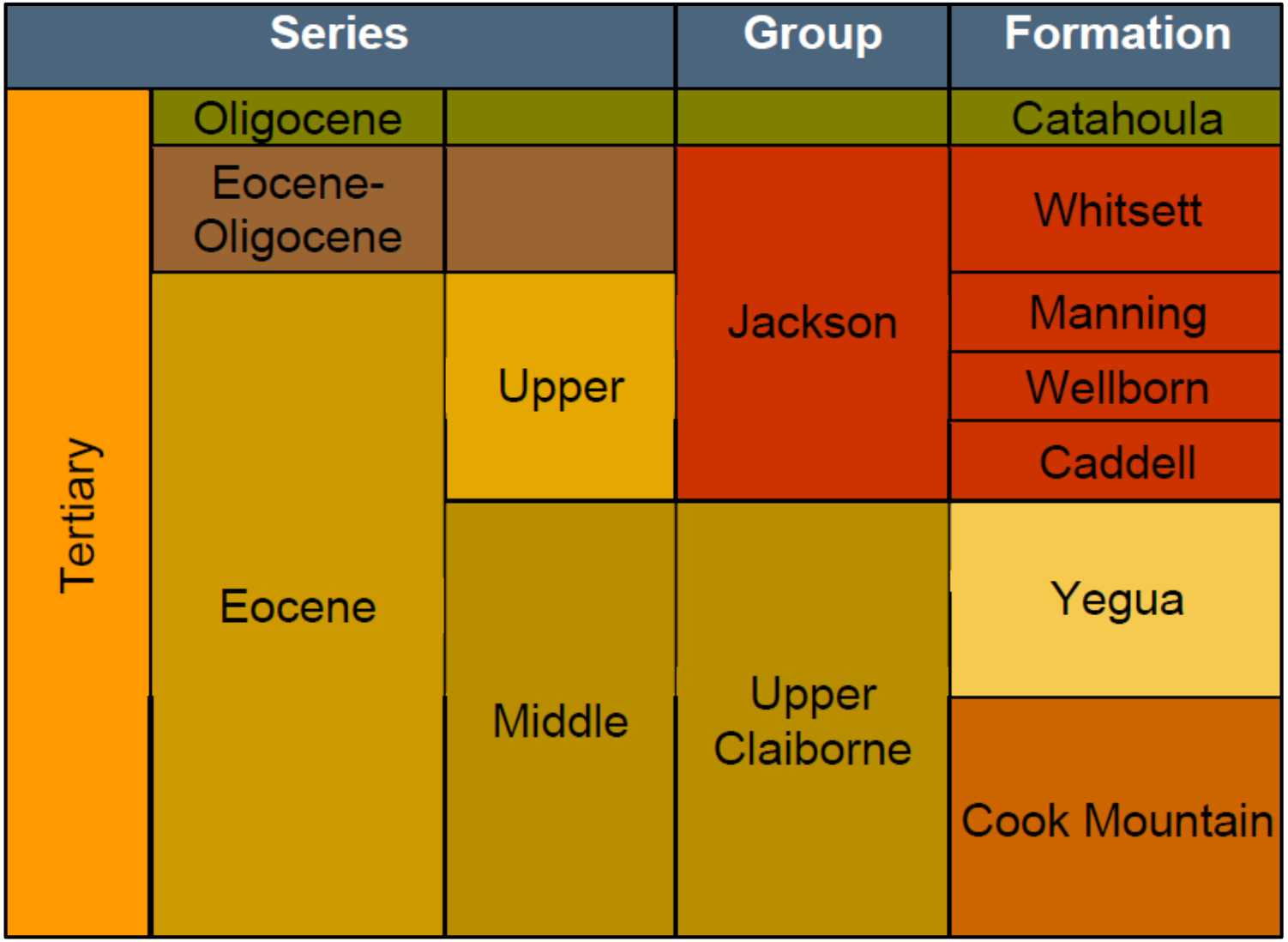
Yegua-Jackson Aquifer
Location Map



Supporting Materials

Hydrological Conditions

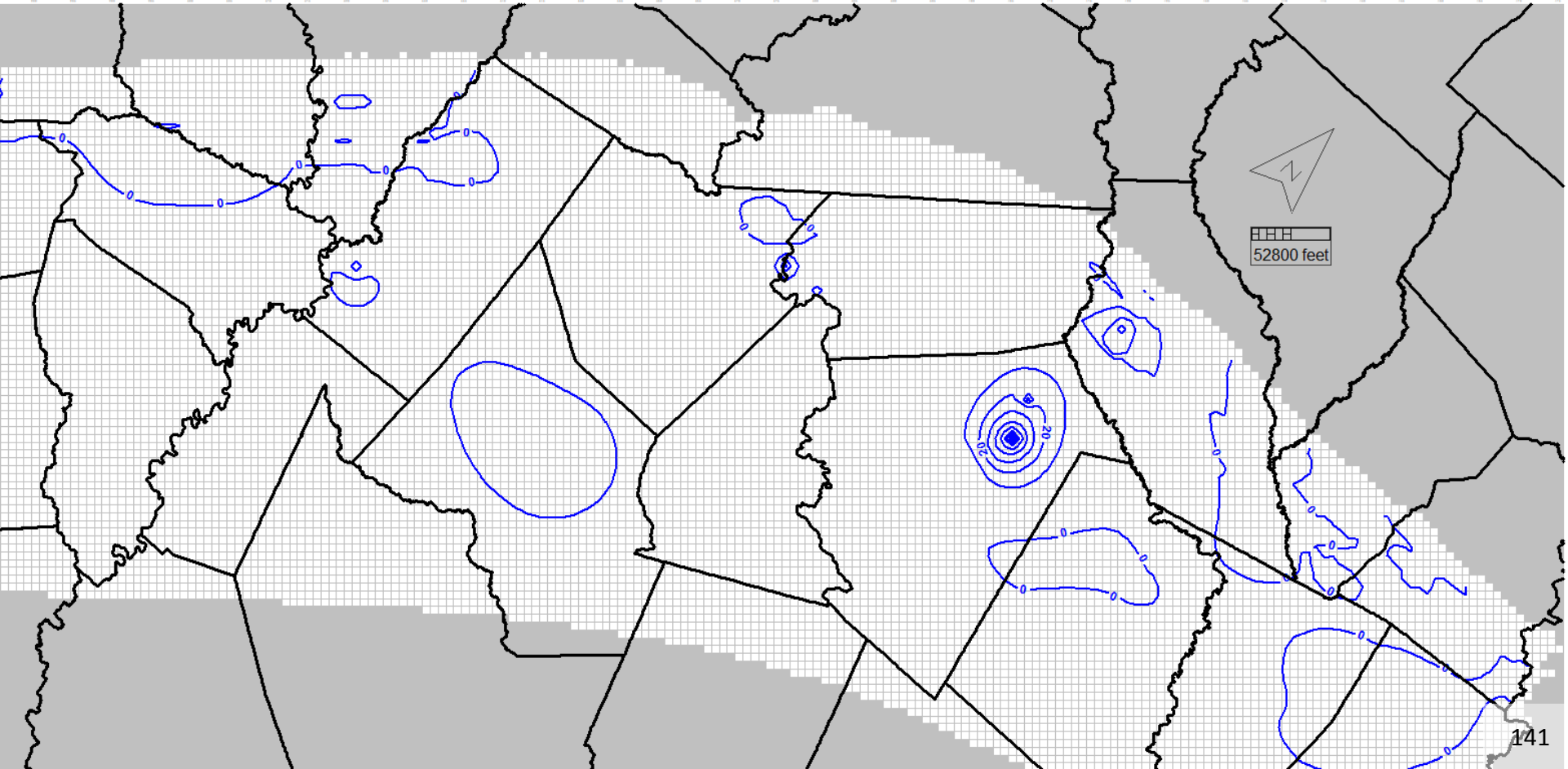
Yegua-Jackson Aquifer Stratigraphy



Supporting Materials

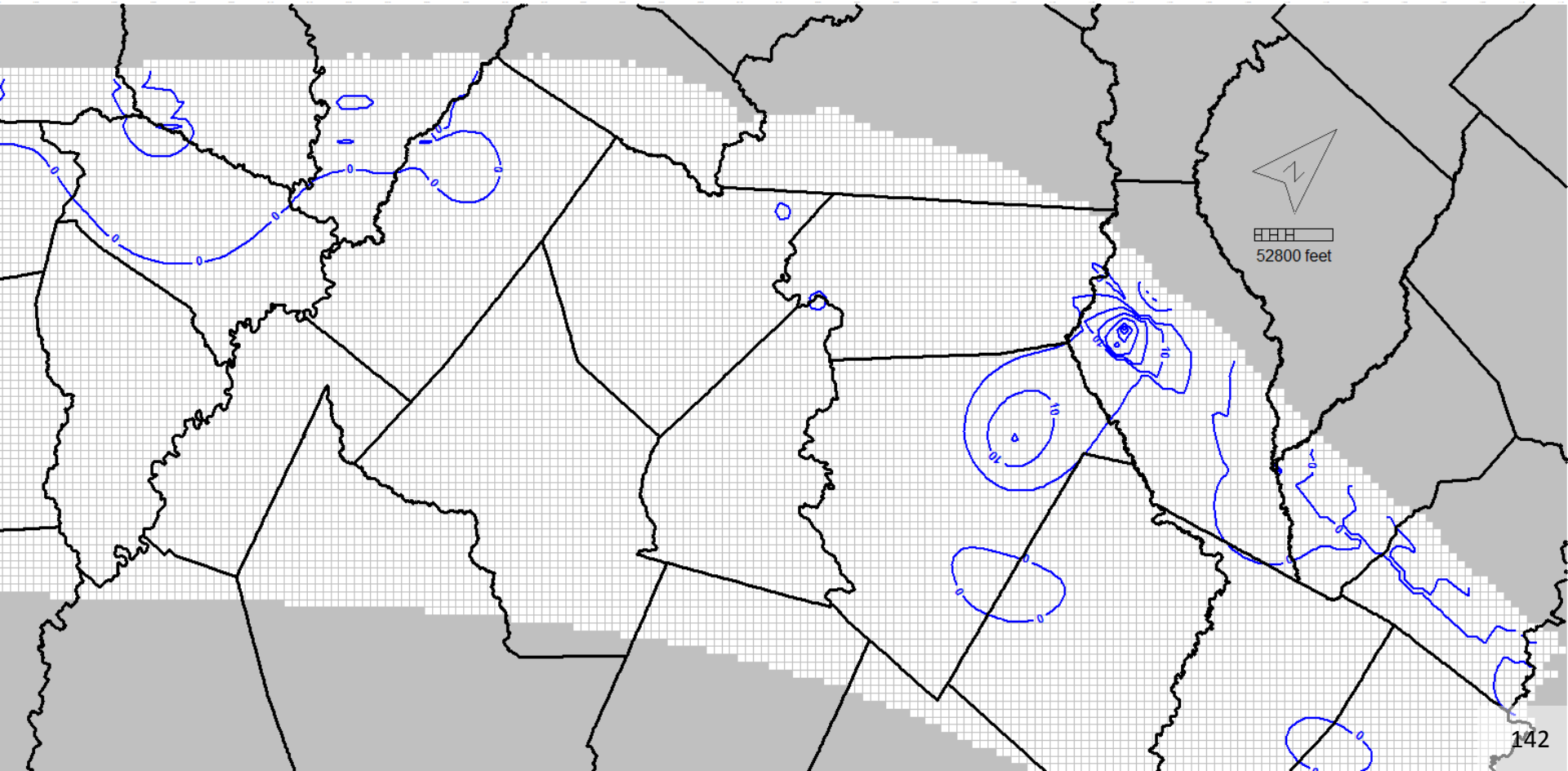
Hydrological Conditions

- 1980-1999 Drawdown – Upper Jackson



Supporting Materials
Hydrological Conditions

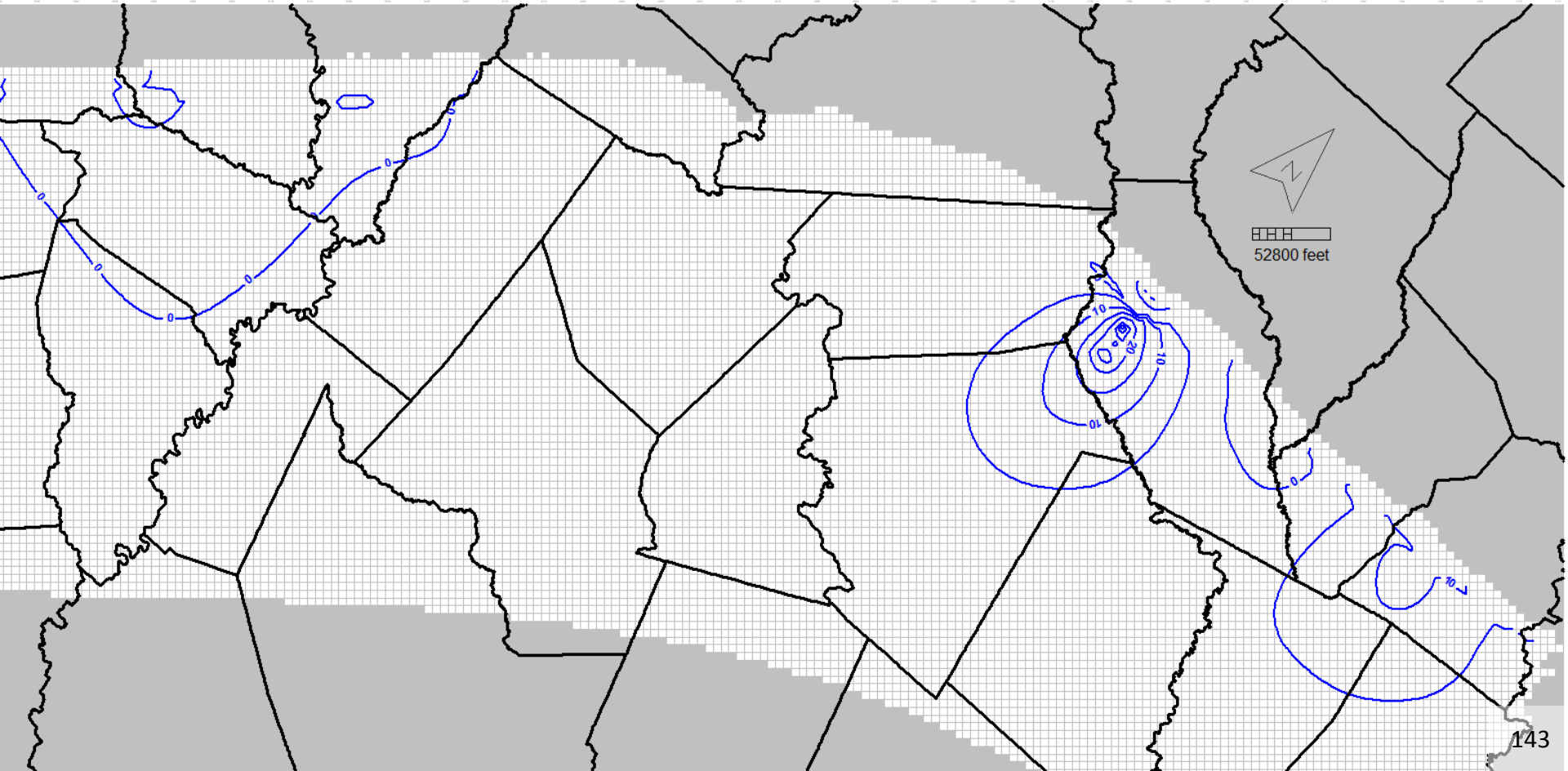
- 1980-1999 Drawdown – Lower Jackson



Supporting Materials

Hydrological Conditions

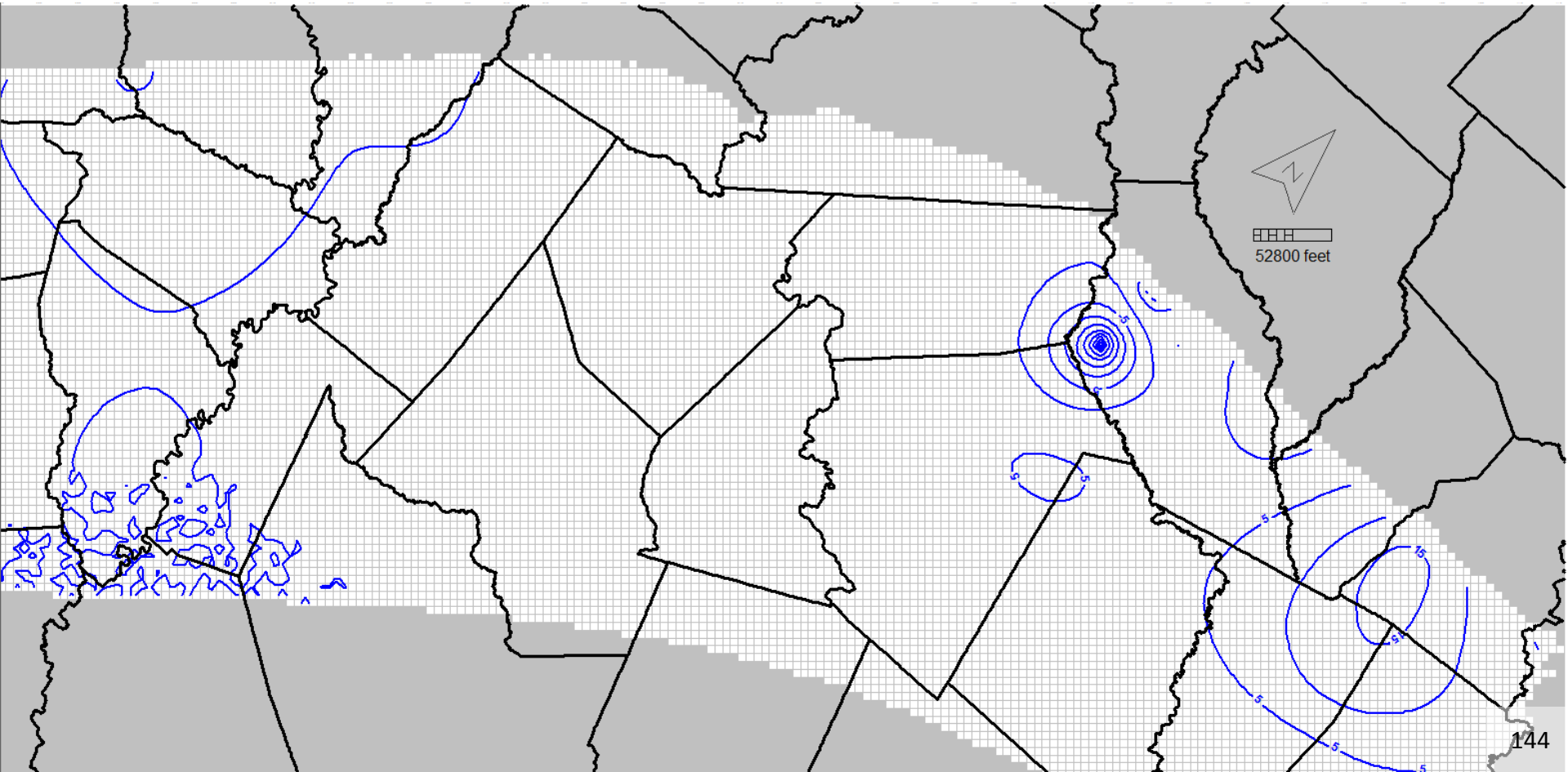
- 1980-1999 Drawdown – Upper Yegua



Supporting Materials

Hydrological Conditions

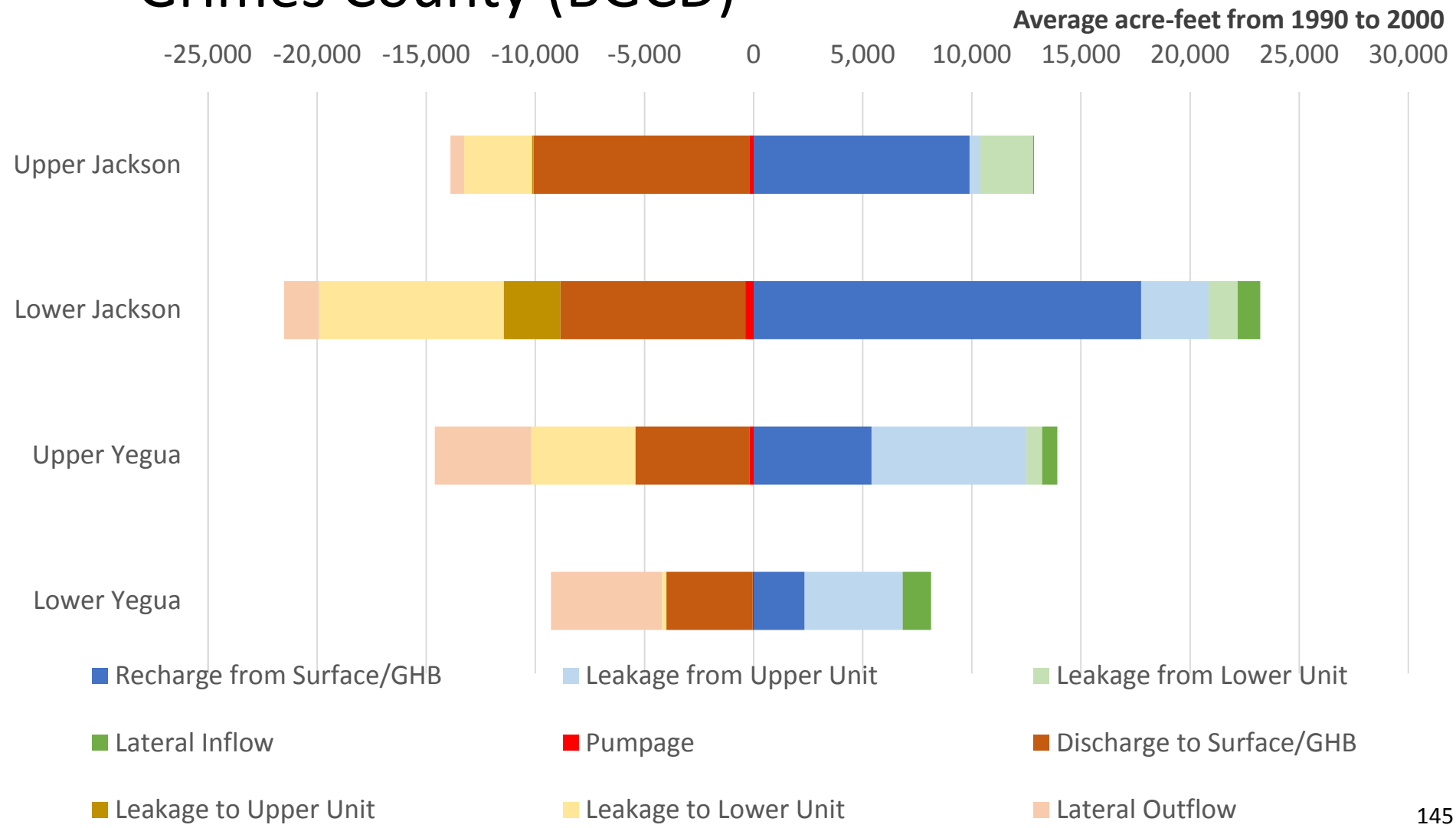
- 1980-1999 Drawdown – Lower Yegua



Supporting Materials
Hydrological Conditions

Yegua-Jackson Aquifer
Water Budget

- Grimes County (BGCD)

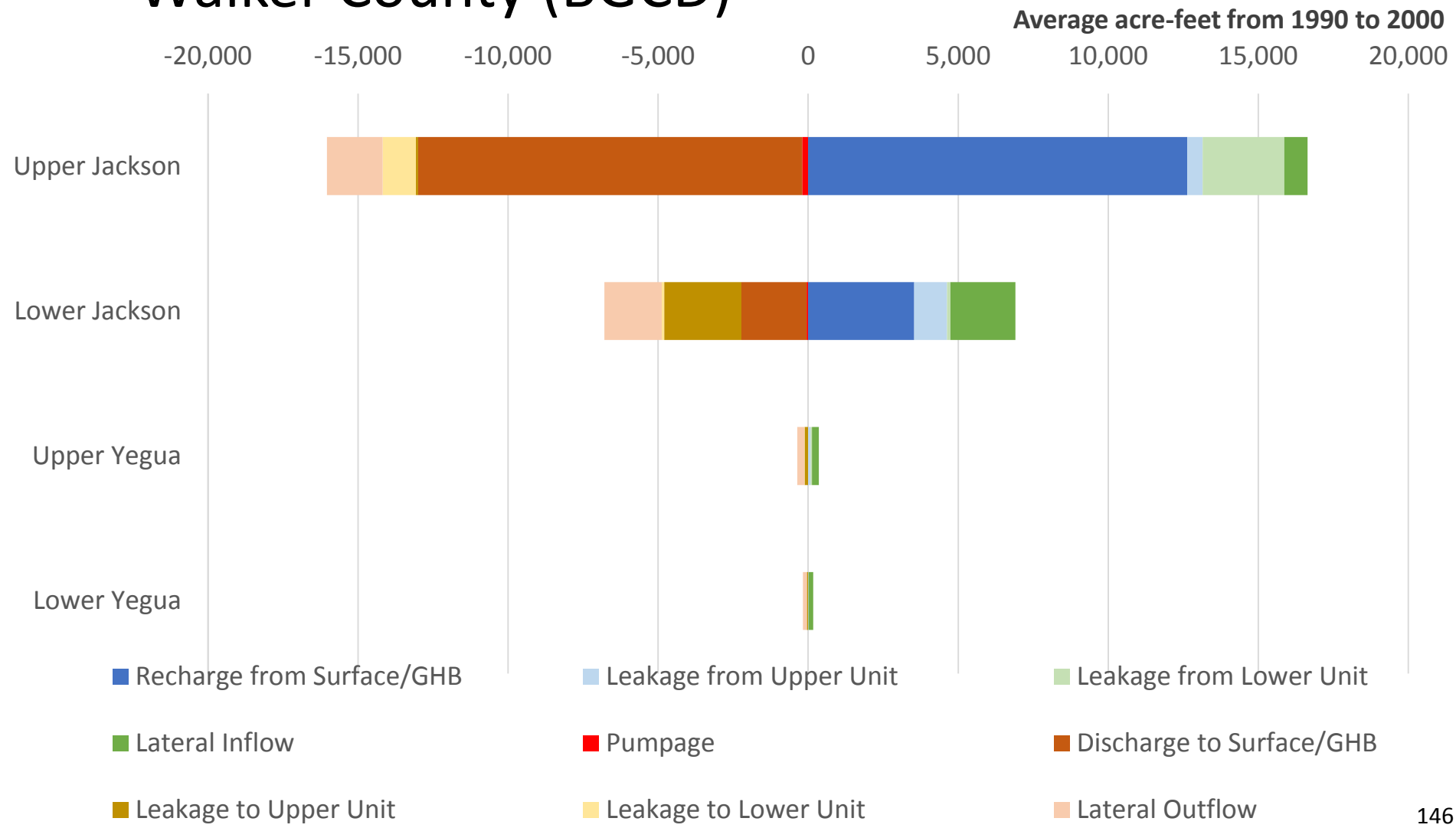


Supporting Materials

Hydrological Conditions

Yegua-Jackson Aquifer
Water Budget

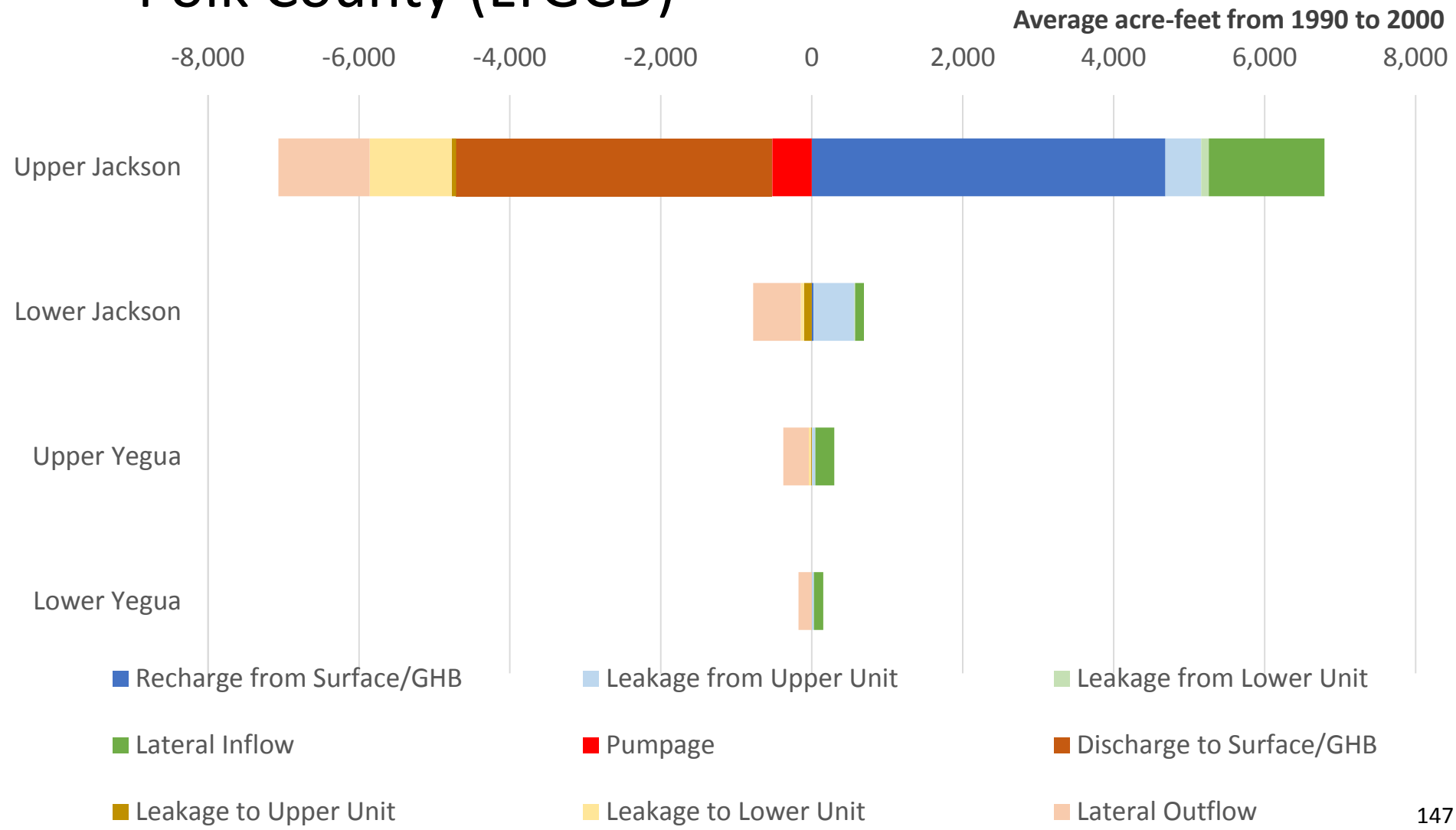
- Walker County (BGCD)



Supporting Materials
Hydrological Conditions

Yegua-Jackson Aquifer
Water Budget

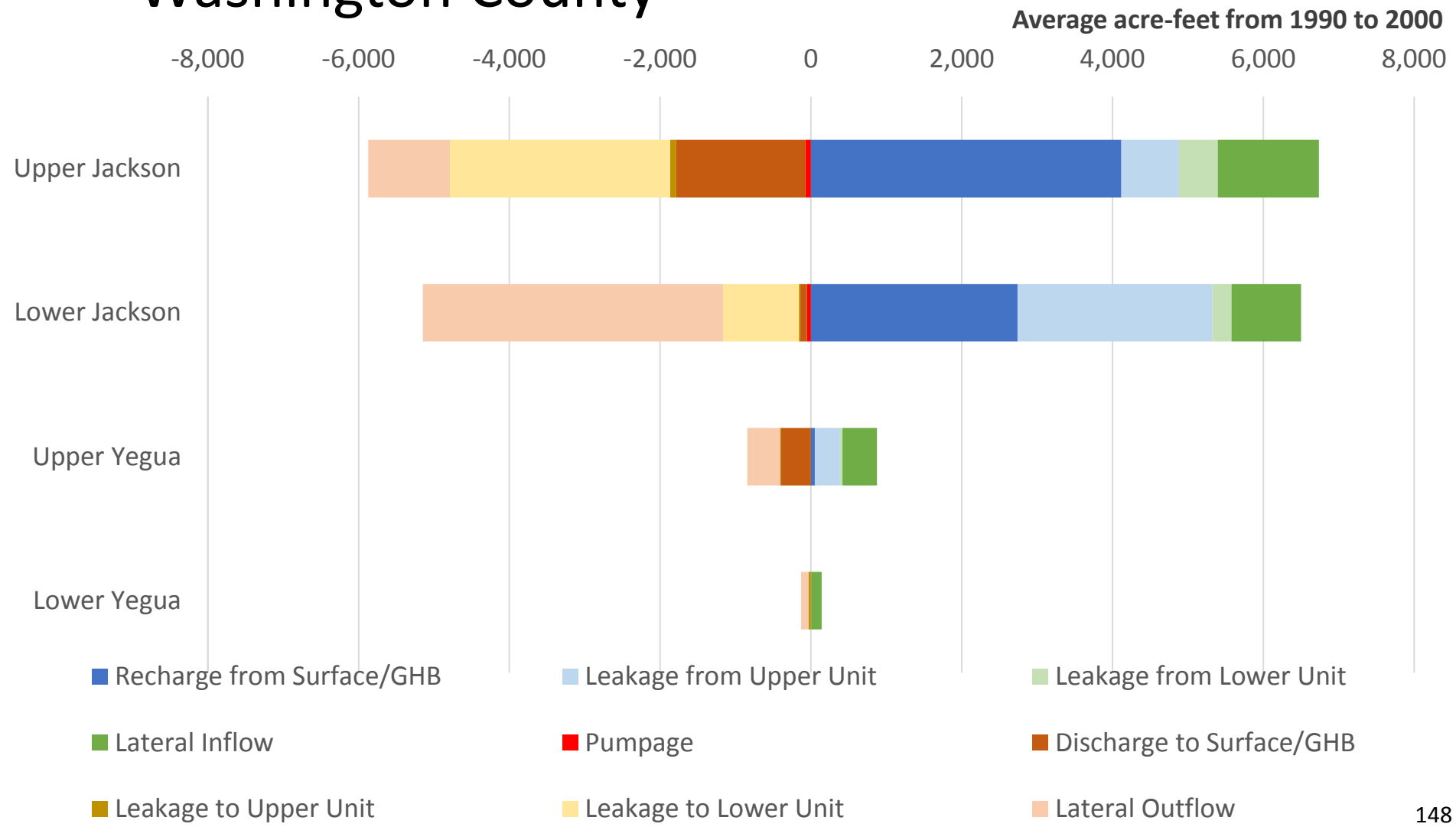
- Polk County (LTGCD)



Supporting Materials
Hydrological Conditions

Yegua-Jackson Aquifer
Water Budget

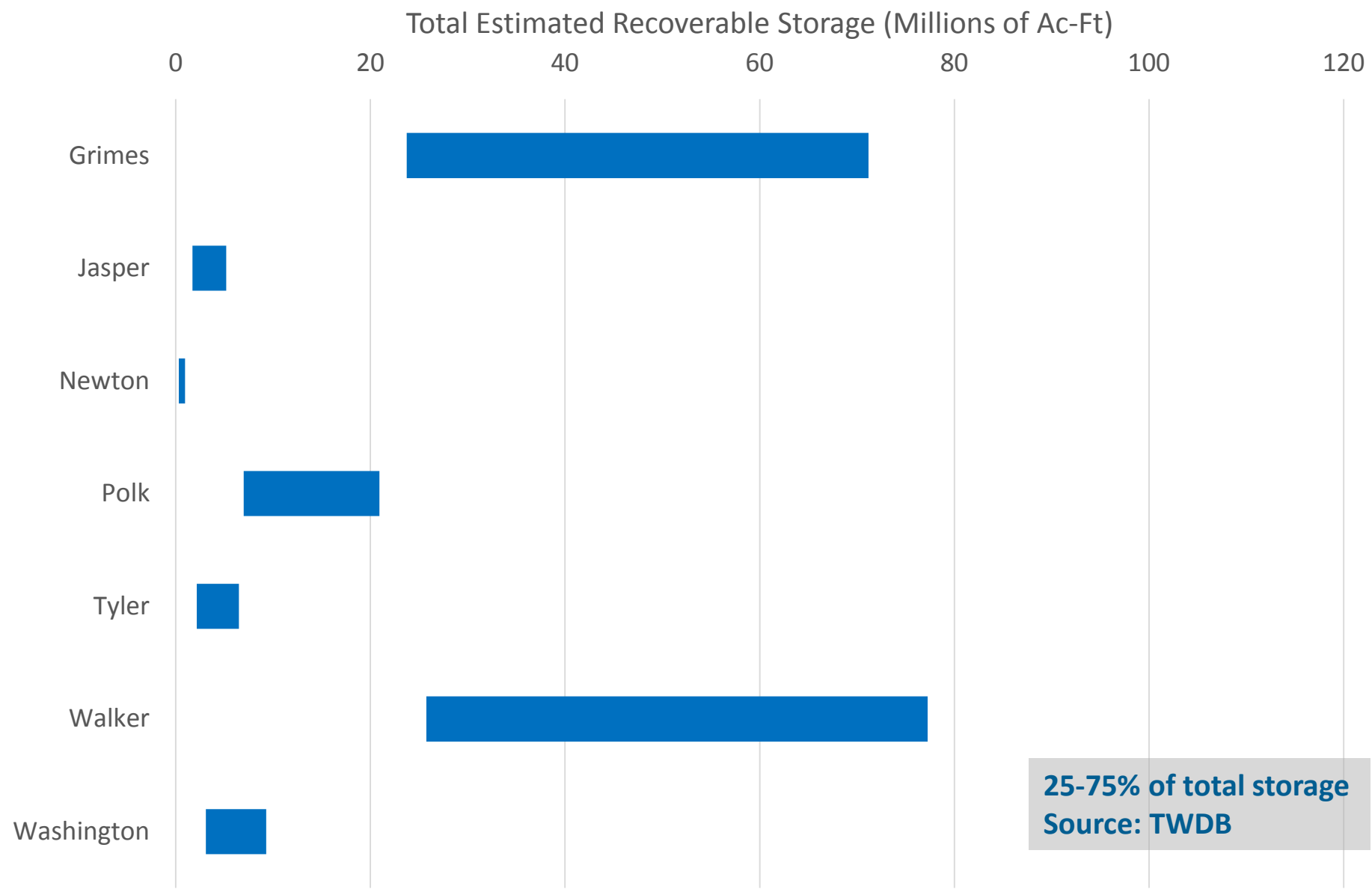
- Washington County



Supporting Materials

Hydrological Conditions

Yegua-Jackson Aquifer
Total Estimated
Recoverable Storage



25-75% of total storage
Source: TWDB

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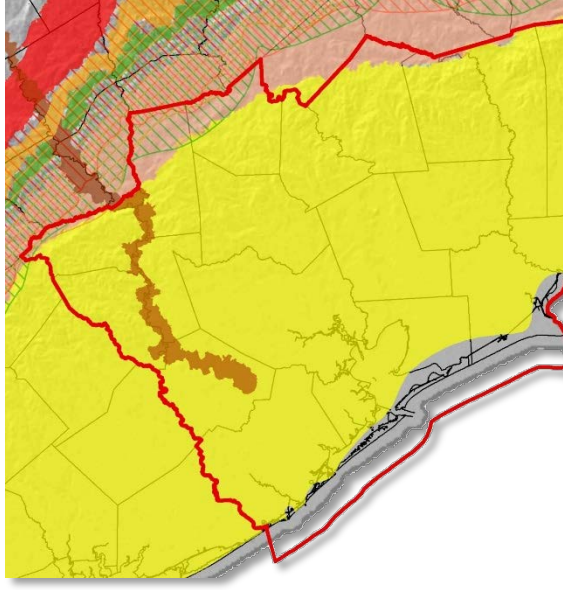
FREESE AND NICHOLS



Supporting Materials

ENVIRONMENTAL IMPACTS

June 24, 2015

Supporting Materials
Environmental Impacts

- Environmental Impacts
  - *"other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water" TWC 36.108 (d) (4)*
  - Groundwater-Surface Water Interaction
  - Spring Flow
  - Source Varies by Aquifer
    - Gulf Coast: Available literature and studies
    - Carrizo: Central Carrizo-Wilcox GAM
    - Queen City: Central Carrizo-Wilcox GAM
    - Sparta: Central Carrizo-Wilcox GAM
    - Yegua-Jackson: Yegua-Jackson GAM

Supporting Materials
Environmental Impacts

- Gulf Coast Aquifer
  - NGC GAM does not include the “stream package” used to estimate groundwater and surface water interaction
  - Groundwater and surface water interaction occurs based on USGS and TWDB studies
  - LCRA studies show groundwater and surface water interaction limited to the shallow groundwater system and the river, similar conditions could occur in GMA-14

Supporting Materials
Environmental Impacts

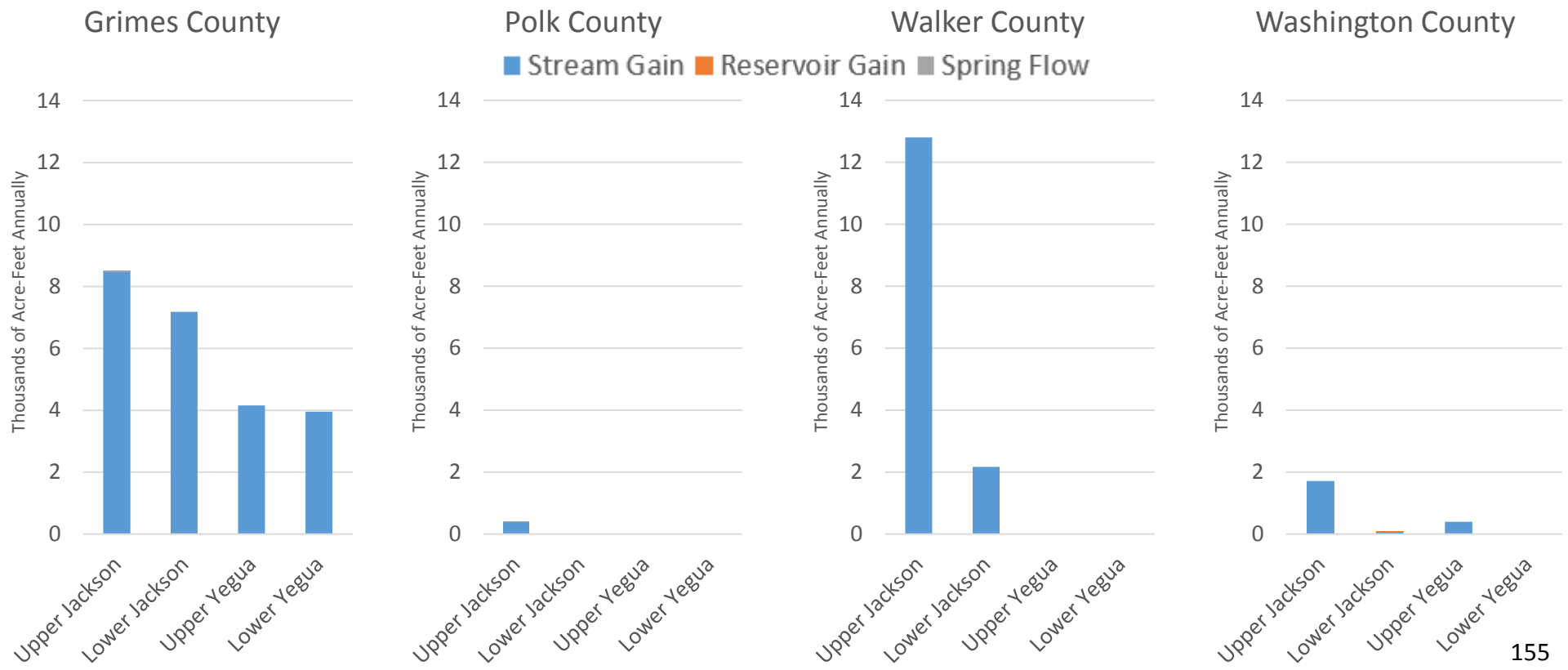
- Carrizo, Queen City, and Sparta Aquifers
  - Carrizo-Wilcox GAM
  - No outflow to streams, rivers, or springs within Grimes or Walker Counties

Supporting Materials
Environmental Impacts

- Yegua-Jackson Aquifer
  - Substantial amount of total recharge to Yegua-Jackson stays in shallow groundwater system to become stream discharge
  - Discharge to streams occurs in Grimes, Polk, Walker and Washington Counties
  - Yegua-Jackson is classified as a minor aquifer

Supporting Materials
Environmental Impacts

- Yegua-Jackson Aquifer
  - Includes Stream Gain, Reservoir Gain, and Spring Flow components in budget



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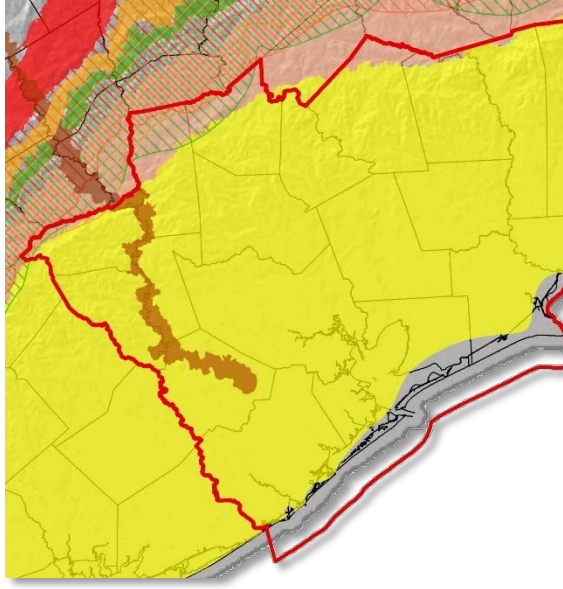


Supporting Materials

IMPACTS ON SUBSIDENCE

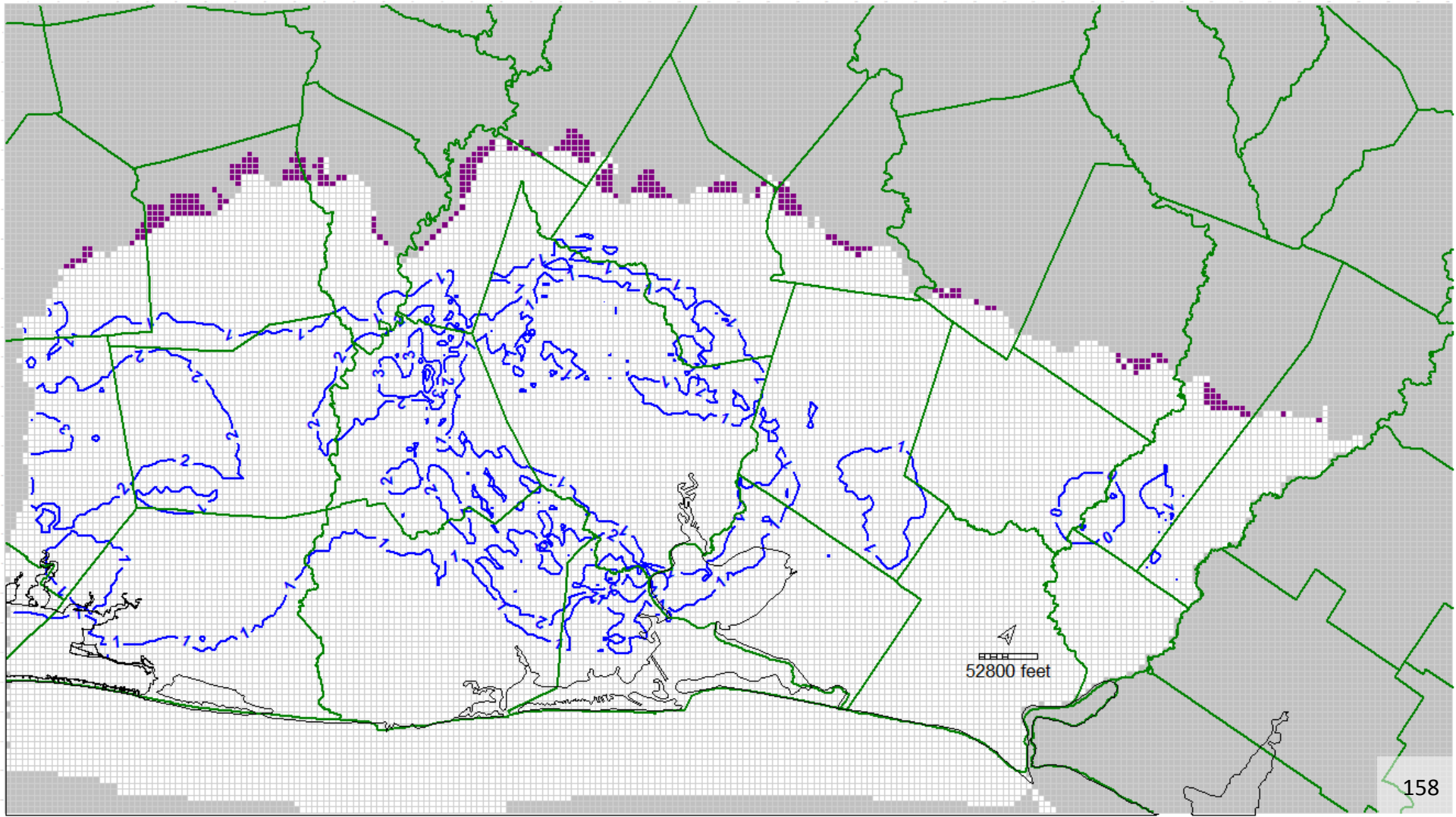
June 24, 2015

Supporting Materials
Subsidence

- Subsidence
  - *"the impact on subsidence" TWC 36.108 (d) (5)*
  - Fort Bend, Galveston, and Harris Counties
    - PRESS model results
  - All Other Counties
    - Results from NGC GAM Run 2 (SUB package)

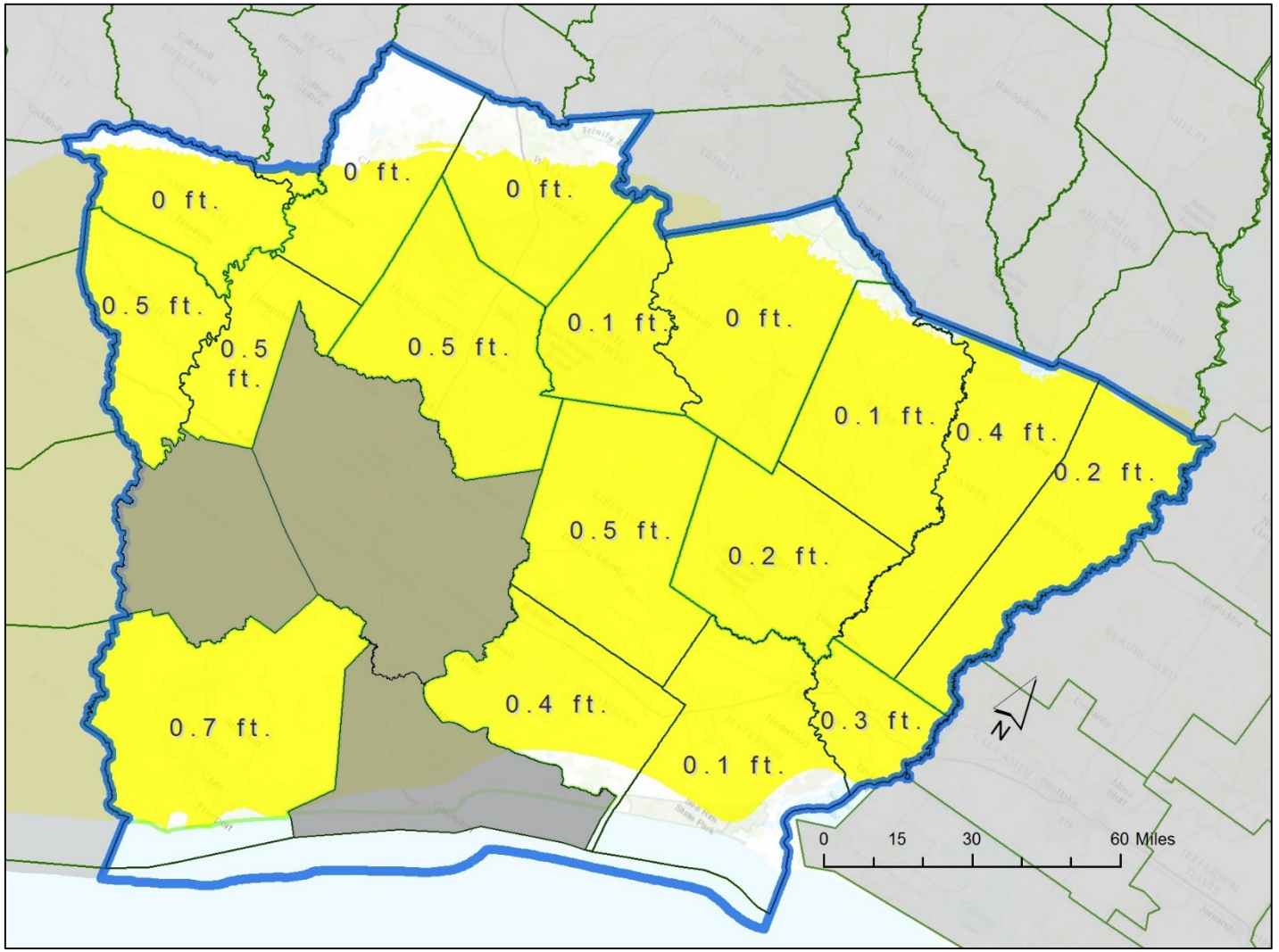
Supporting Materials
Subsidence

- SUB Results – 2010-2070 subsidence in feet



Supporting Materials
Subsidence

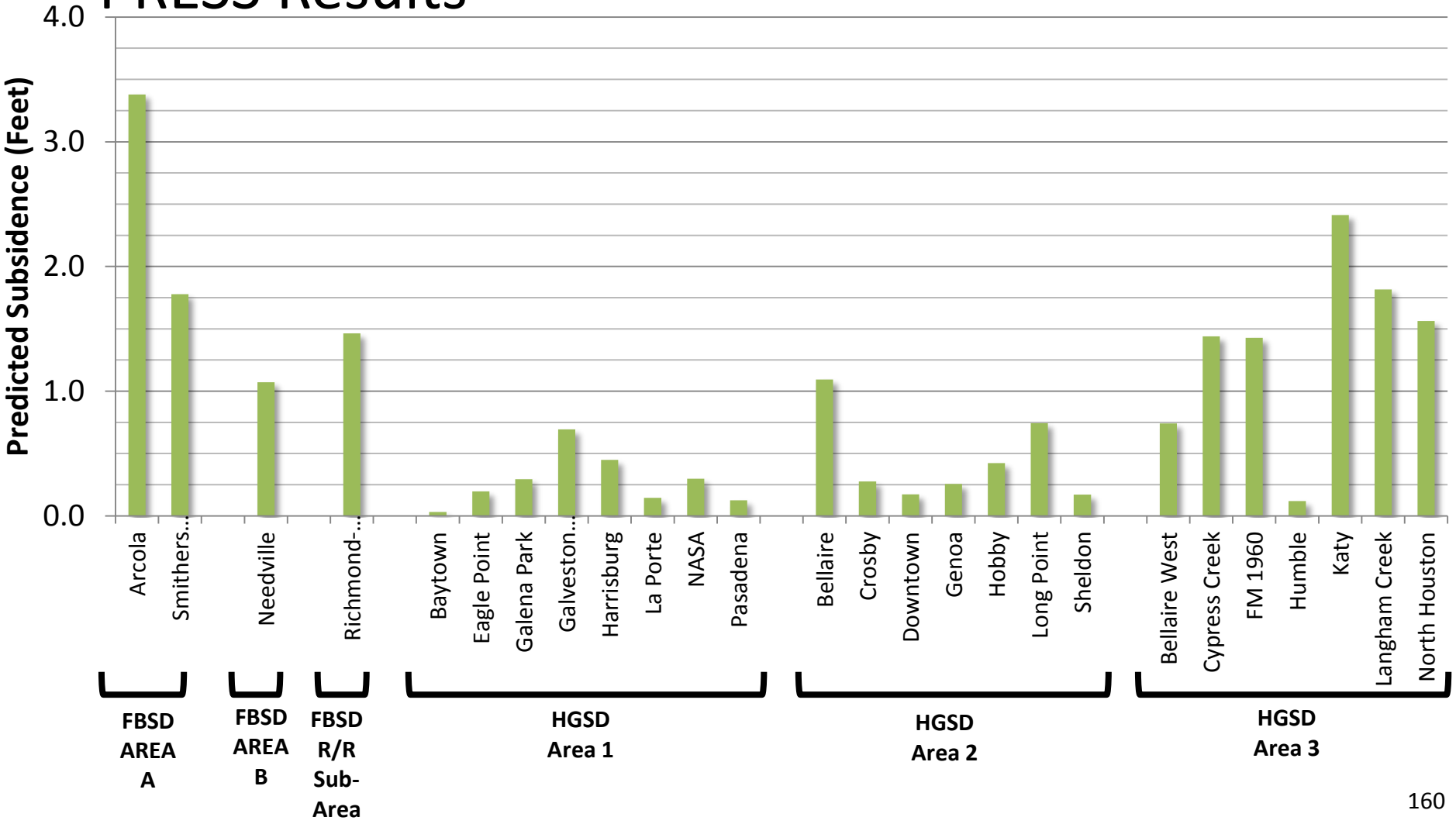
- SUB Results (2010-2070)



Supporting Materials

Subsidence

- PRESS Results



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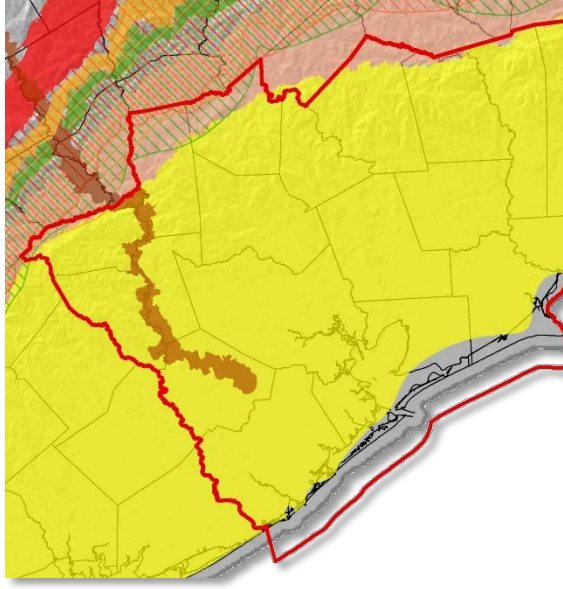


Supporting Materials

SOCIOECONOMIC IMPACTS

June 24, 2015

Supporting Materials

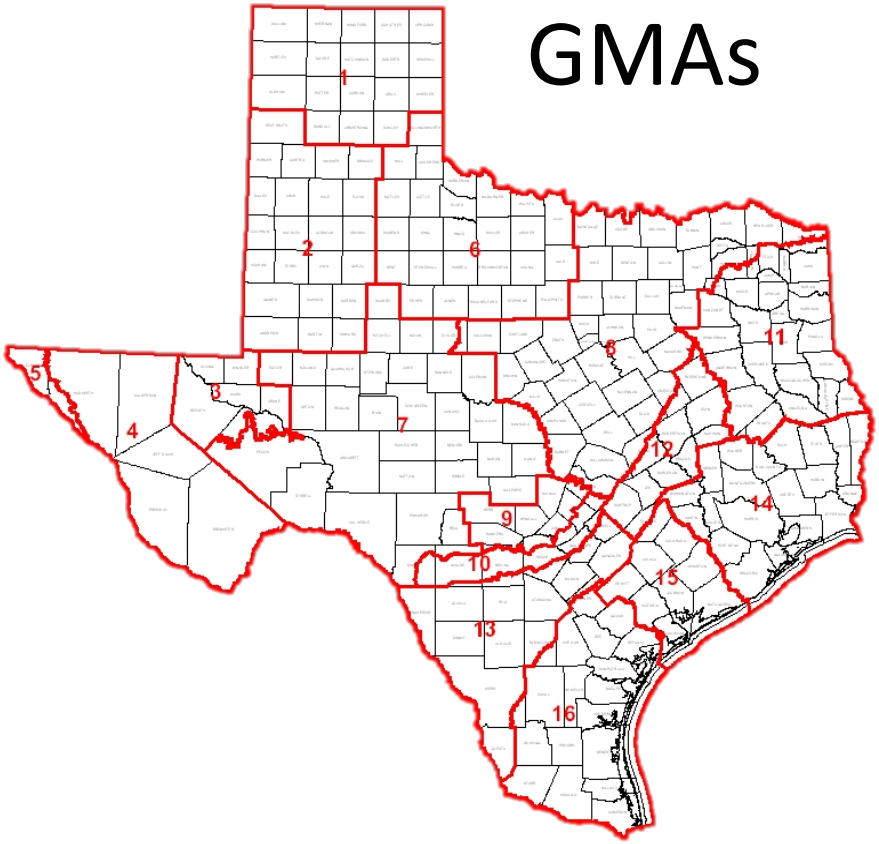
Socioeconomic Impacts

- Today's Considerations
  - TWC Section 36.108 (d) (6) – socioeconomic impacts reasonably expected to occur

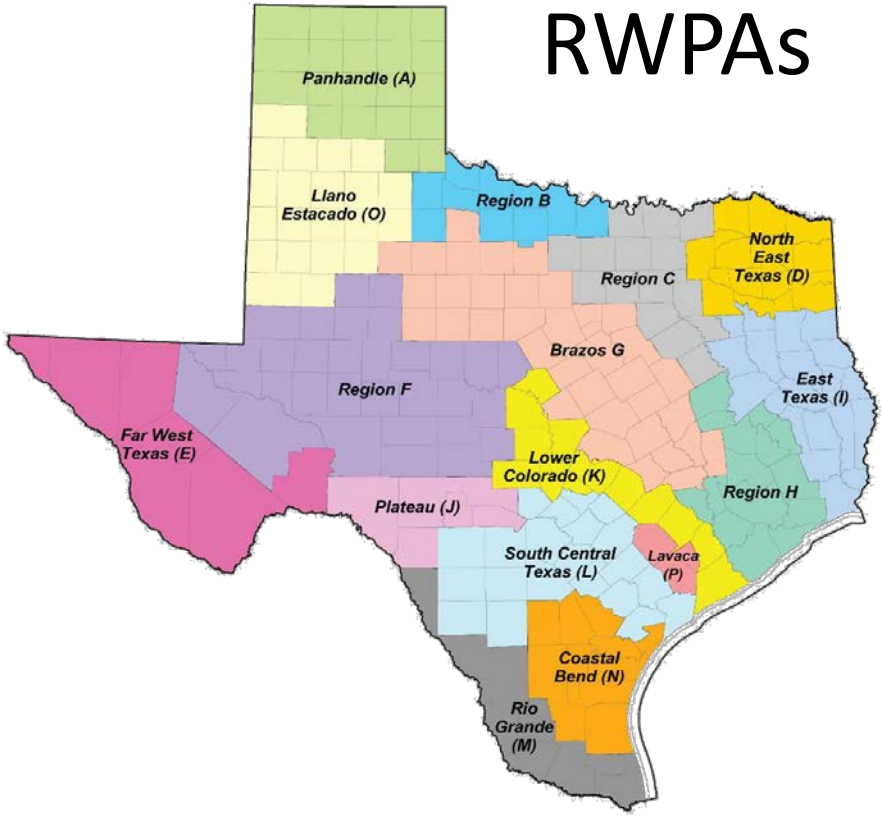
Supporting Materials

Socioeconomic Impacts

GMAs



RWPAs



Supporting Materials

Socioeconomic Impacts

- Socioeconomic Impacts and Water Planning in Texas – A Brief History
  - Texas Water Code Chapter 16.051 (a) the board shall prepare, develop, formulate, and adopt a comprehensive state water plan that . . . shall provide for . . . further economic development (companion provision in TWC Chapter 16.053 (a, b) for regional water plans).
  - Texas Administrative Code (TAC), Title 31, Chapter 357.7 (4)(A) states, “The executive administrator shall provide available technical assistance to the regional water planning groups, upon request, on water supply and demand analysis, including methods to evaluate the social and economic impacts of not meeting needs.”

- Socioeconomic Impacts and Water Planning in Texas – A Brief History (cont.)
  - TAC, Title 31, Chapter 357.40 (a) RWPs shall include a quantitative description of the socioeconomic impacts of not meeting the identified water needs pursuant to §357.33(c) of this title (relating to Needs Analysis: Comparison of Water Supplies and Demands).

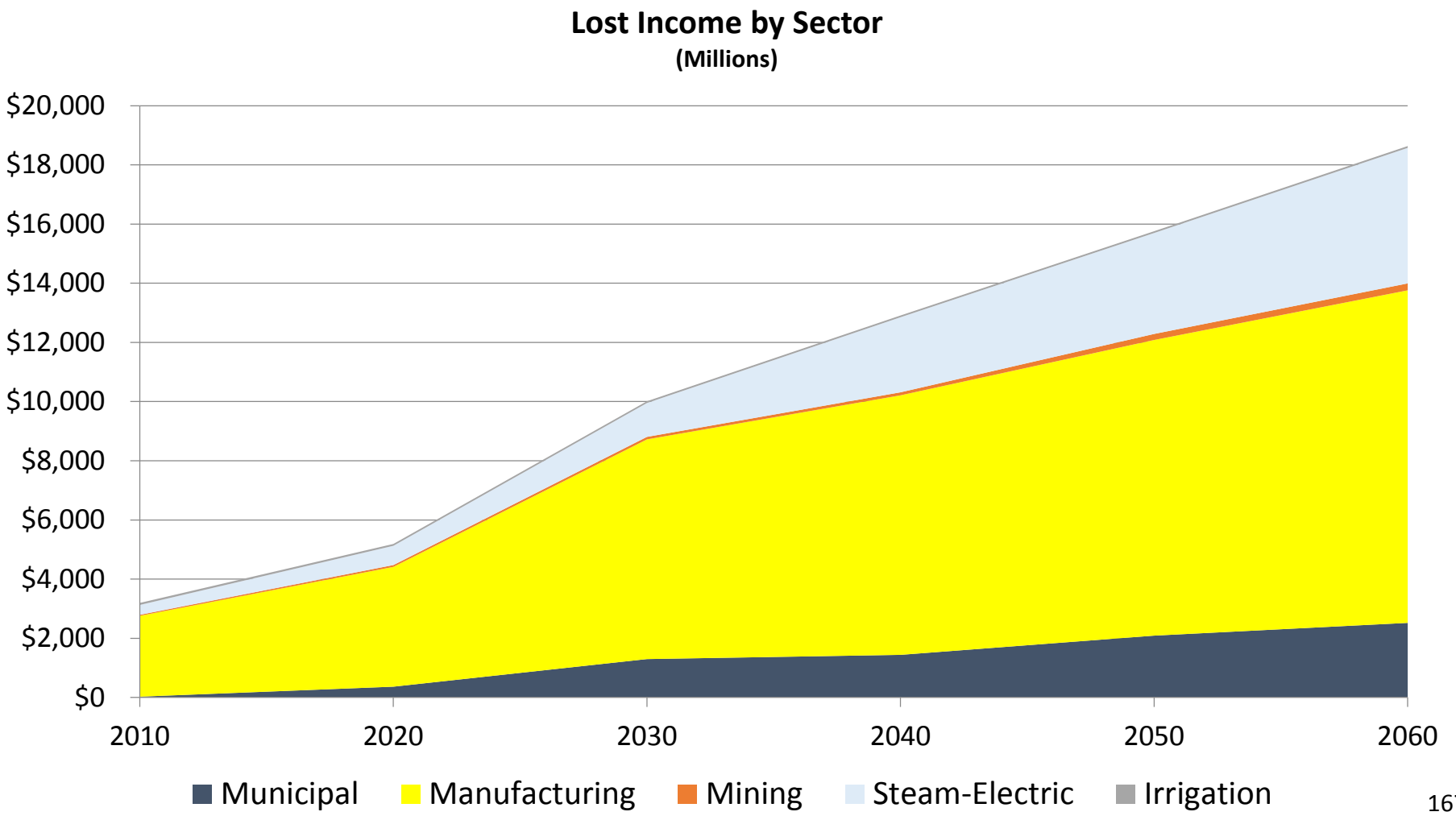
Supporting Materials
Socioeconomic Impacts

- Socioeconomic Impacts Analysis
  - Executed by TWDB at request of RWPGs
  - Uses water supply needs from Regional Water Plan
  - Point estimates of 1-year drought at 10-year intervals
  - Analysis attempts to measure the impacts in the event that water user groups do not meet their identified water supply needs associated with a drought of record for one year.
  - Multiple impacts examined
    - Sales, income, and tax revenue
    - Jobs
    - Population
    - School enrollment
  - Results incorporated into final Regional Water Plan

Supporting Materials

Socioeconomic Impacts

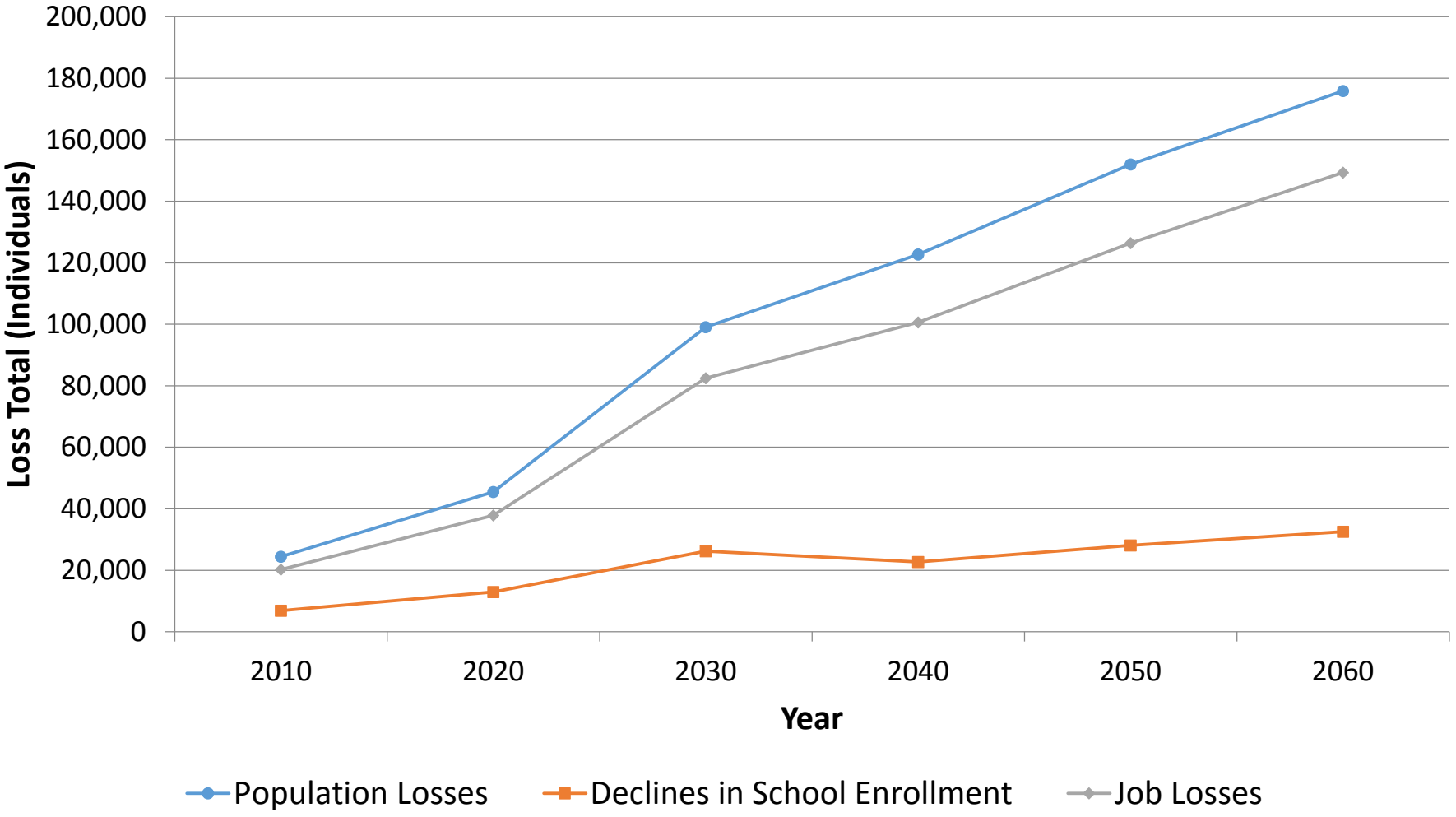
- Socioeconomic Impacts Analysis – 2011 Region H Water Plan



Supporting Materials

Socioeconomic Impacts

- Socioeconomic Impacts Analysis – 2011 Region H Water Plan



Supporting Materials
Socioeconomic Impacts

Socioeconomic impact of not meeting water supply needs vs. impact of proposed desired future conditions

- Regional Water Planning (from TWDB)
  - Generate Input-Output Models combined with Social Accounting Models (IO/SAM) and develop economic baselines. Utilizes IMPLAN (Impact for Planning Analysis) software.
    - Economic baseline developed for counties, planning regions, and the state based on variables for 528 economic sectors as follows:

Socioeconomic impact of not meeting water supply needs vs. impact of proposed desired future conditions

- output – total production of goods and services measured by gross sales revenues
- final sales – sales to end user in Texas (a region) and exports out of region
- Employment – number of full and part-time jobs required by a given industry
- Regional income – total payroll costs paid by industries, corporate income, rental income, and interest payments
- Business taxes – sales, excise, fees, licenses and other taxes paid during normal operation

Socioeconomic impact of not meeting water supply needs vs. impact of proposed desired future conditions

- Regional Water Planning (from TWDB – cont.)
  - Estimate direct and indirect impacts to business, industry, and agriculture
  - Impact associated with domestic water usage
- While useful for planning purposes, socioeconomic impacts developed for regional water planning do not represent a benefit-cost analysis.
- Analysis only executed for water user groups with needs for additional water supply.

Supporting Materials

Socioeconomic Impacts

- Impacts by County for the Brazos G Water Planning Area ($ millions)

Grimes County ($millions)						
	2010	2020	2030	2040	2050	2060
Wickson Creek SUD						
Monetary value of domestic water shortages	$0.38	$3.16	$5.02	$12.50	$13.81	$18.29
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$2.18	$2.73	$3.16
Lost jobs due to reduced commercial business activity	$0.00	$0.00	$0.00	69	86	100
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.31	$0.39	$0.45
Lost utility revenues	$0.58	$1.08	$1.41	$1.67	$1.89	$2.11
Steam-electric						
Lost income due to reduced electrical generation	$0.00	$264.45	$288.65	$314.58	$349.15	$401.00
Lost state and local business tax revenues due to reduced electrical generation	$0.00	$37.96	$41.43	$45.15	$50.11	$57.56
Lost jobs due to reduced electrical generation	0	899	981	1,069	1,187	1,363

The only other county in GMA 14 within the Brazos G Regional Water Planning Area is Washington County, which did not have any water supply needs in the 2011 Brazos G Regional Water Plan. For full analysis, see TWDB correspondence to Dale Spurgin from Stuart Norvell dated May 17, 2010, titled “Socioeconomic impact analysis of not meeting water needs for the 2011 Brazos G Regional Water Plan.”

Supporting Materials

Socioeconomic Impacts

- Impacts by County for the Region H Water Planning Area ($ millions)

Municipal ($millions)						
	2010	2020	2030	2040	2050	2060
Alvin						
Monetary value of domestic water shortages	$0.00	$0.16	$0.32	$0.44	$0.80	$1.09
Lost utility revenues	$0.00	$0.31	$0.58	$0.79	$1.14	$1.55
Ames						
Monetary value of domestic water shortages	$0.00	$0.03	$0.07	$0.12	$0.76	$1.12
Lost utility revenues	$0.00	$0.04	$0.08	$0.12	$0.17	$0.22
Angleton						
Monetary value of domestic water shortages	$0.32	$0.33	$0.35	$0.35	$0.42	$0.58
Lost utility revenues	$0.51	$0.52	$0.55	$0.57	$0.67	$0.83
Arcola						
Monetary value of domestic water shortages	$0.00	$1.17	$4.90	$5.56	$6.43	$8.83
Lost income from reduced commercial business activity	$0.00	$0.00	$0.12	$0.15	$0.19	$0.24
Lost jobs due to reduced commercial business activity	0	0	5	6	8	10
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.02	$0.02	$0.03	$0.04
Lost utility revenues	$0.00	$0.26	$0.56	$0.64	$0.74	$0.86
Bailey's Prairie						
Monetary value of domestic water shortages	$0.00	$0.01	$0.07	$0.13	$0.23	$0.02
Lost utility revenues	$0.00	$0.01	$0.01	$0.02	$0.02	$0.03
Beach City						
Monetary value of domestic water shortages	$3.82	$7.01	$8.99	$10.87	$12.77	$14.64
Lost income from reduced commercial business activity	$0.26	$0.41	$0.55	$0.67	$0.80	$0.93
Lost jobs due to reduced commercial business activity	10	17	22	27	32	38
Lost state and local taxes from reduced commercial business activity	$0.04	$0.06	$0.09	$0.10	$0.12	$0.14
Lost utility revenues	$0.45	$0.64	$0.82	$0.97	$1.13	$1.30
Beasley						
Monetary value of domestic water shortages	$0.00	$0.01	$0.04	$0.09	$0.58	$0.99
Lost utility revenues	$0.00	$0.02	$0.05	$0.08	$0.13	$0.18

Impacts by county are not presented in the 2011 Region H Water Plan. For full analysis, see TWDB correspondence to the Honorable Mark Evans from Stuart Norvell dated May 19, 2010, titled "Socioeconomic impact analysis of not meeting water needs for the 2011 Region H Regional Water Plan."

Supporting Materials

Socioeconomic Impacts

- Impacts by County for the Region H Water Planning Area ($ millions)

Municipal ($millions)						
	2010	2020	2030	2040	2050	2060
Athens						
Monetary value of domestic water shortages	$0.00	$1.25	$1.68	$1.34	$1.76	$2.32
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.09	$0.13	$0.18
Lost jobs due to reduced commercial business activity	0	0	0	3	5	7
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.01	$0.02	$0.03
Lost utility revenues	$0.00	$0.09	$0.12	$0.15	$0.21	$0.27
Brownsboro						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.06
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01
Bullard						
Monetary value of domestic water shortages	$0.00	$0.01	$0.05	$0.11	$0.25	$0.40
Lost utility revenues	$0.00	$0.02	$0.07	$0.13	$0.22	$0.34
Community Water Company						
Monetary value of domestic water shortages	$0.08	$0.97	$1.22	$1.84	$2.74	$4.27
Lost utility revenues	$0.07	$0.15	$0.20	$0.23	$0.30	$0.40
County-other (Anderson)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.07
County-other (Angelina)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.11
County-other (Hardin)						
Monetary value of domestic water shortages	$0.16	$0.30	$0.33	$0.35	$0.41	$0.55
County-other (Henderson)						
Monetary value of domestic water shortages	$0.11	$0.26	$0.44	$0.59	$0.93	$1.62
County-other (Jasper)						
Monetary value of domestic water shortages	$0.10	$0.19	$0.23	$0.15	$0.13	$0.13
County-other (Orange)						
Monetary value of domestic water shortages	$0.12	$0.08	$0.04	$0.01	$0.00	$0.00

Impacts by county are not presented in the 2011 East Texas Regional Water Plan. For full analysis, see TWDB correspondence to Kelley Holcomb from Stuart Norvell dated June 1, 2010, titled "Socioeconomic impact analysis of not meeting water needs for the 2011 East Texas Regional Water Plan."

Supporting Materials

Socioeconomic Impacts

- From a qualitative perspective, both positive and negative socioeconomic impacts may potentially result from implementation of proposed DFCs.
  - Proposed DFCs may require conversion to alternative supply, which may have increased costs associated to infrastructure, operation, and maintenance.
  - Proposed DFCs may reduce/eliminate the costs of lowering pumps and either drilling or deepening of wells.
  - Proposed DFCs may reduce/eliminate the costs associated with subsidence (including legal costs assigned to parties determined to be liable).

Supporting Materials
Socioeconomic Impacts

- Positive and negative socioeconomic impacts potentially resulting from implementation of proposed DFCs:
  - Proposed DFCs may serve to sustain/enhance economic growth due to assurances provided by diversified water portfolio.
  - Alternatives to proposed DFCs may result in short-term reduction in utility rates due to reduction in cost of water management strategy implementation.
  - Alternatives to proposed DFCs may result in significant but unquantified production costs due to transition from confined to unconfined conditions in local aquifers.

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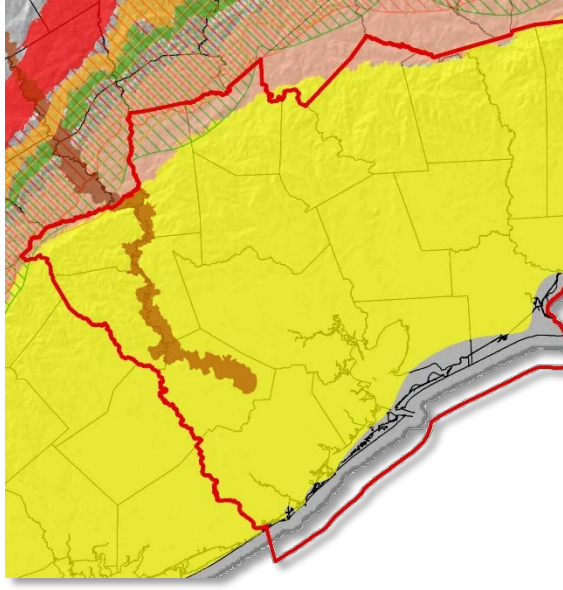

Supporting Materials

IMPACTS ON PRIVATE PROPERTY

June 24, 2015

Supporting Materials

Impacts on Private Property

- Texas Water Code Section 36.108 (d) (7)
  - Consideration of the impact on the interests and rights in private property, including ownership and the rights of management area landowners and their lessees and assigns in groundwater, as recognized under Texas Water Code Section 36.002.

Supporting Materials

Impacts on Private Property

- The procedural requirements for what should be considered in reviewing the private property rights factor are not prescribed in statute nor do TWDB rules provide any additional guidance. The following list of topics are suggested for discussion:
  - Existing uses within the GCD
  - Projected future uses within the GCD
  - Investment-backed expectations of existing users and property owners within the GCD

Supporting Materials

Impacts on Private Property

- Long-term viability of groundwater resources in area
- Availability of water to all properties and ability to allocate MAG through rules after DFC adoption
- Whether immediate cutbacks would be required in setting a particular DFC or whether cutbacks, if any, would need to occur over a certain timeframe
- For outcrop areas, how the outcrop depletes rapidly in dry times, and whether drought rules or triggers based on the DFC/MAG for the outcrop could be beneficial to ensure viability of the resource during dry times

Supporting Materials

Impacts on Private Property

- Economic consequences to existing users (i.e., cost to drop pumps, reconfigure or drill new wells upon water table dropping, etc.). Also consider the reverse—economic consequences of less water available to protect the existing users from the economic consequences relevant to existing users—reaching a balance between these two dynamics.

Supporting Materials

Impacts on Private Property

- Those GCDs with existing rules developed based on the current DFC might find it helpful to review the rules that the GCD considers relevant as we work to adopt DFCs over the next year. For example, the rules and Management Plan in place based on the current DFCs can help determine how a GCD currently impacts private property rights and whether those same interests are important as we work to adopt DFCs over the next 2 years.
- Focusing on finding a balance, as that balance is defined by each GCD, between all of these considerations

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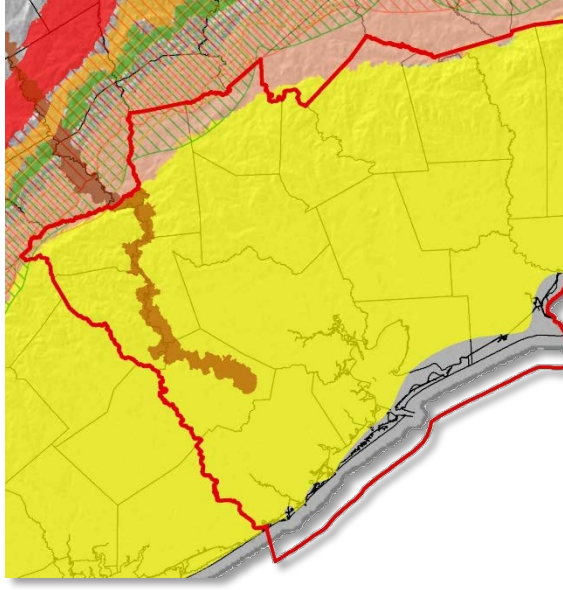

Supporting Materials

FEASIBILITY OF ACHIEVING DFC

June 24, 2015

Supporting Materials
Feasibility of Achieving DFC

- Feasibility Consideration
  - TWC Section 36.108 (d) (8) requires that, before voting on proposed DFCs, districts shall consider the feasibility of achieving the desired future conditions
  - This requirement was added to the joint-planning process with the passage in 2011 of Senate Bill 660 by the 82nd Texas Legislature.

Supporting Materials
Feasibility of Achieving DFC

- Historical Perspective
  - Concept dates back to the rules adopted by the Texas Water Development Board (TWDB) in 2007 to provide guidance as to what would be considered by the TWDB during a petition process regarding the reasonableness of an adopted DFC. In these rules, the TWDB required that an adopted DFC must be physically possible from a hydrological perspective.

Supporting Materials
Feasibility of Achieving DFC

- After SB 660
  - Upon passage of SB 660 in 2011, the TWDB made significant revisions to the rules contained in TAC Title 31 Chapter 356 to be consistent with requirements and terminology the new statutes. During this process, the reference to the need for a DFC to be *physically possible* or *physically compatible* was removed, under the rationale that the reference to consideration of feasibility of achieving a DFC included in TWC Chapter 36.108 (d)(8) equated to a DFC being physically possible or physically compatible.

Supporting Materials

Feasibility of Achieving DFC

- Physically possible = feasible
  - During the TWDB's review of multiple petitions regarding the reasonableness of adopted DFCs in groundwater management areas (GMAs) from 2010 - 2011, the evaluation of whether or not a proposed DFC was physically possible was based on if the DFC(s) could be reasonably modeled using the TWDBs adopted groundwater availability model for the aquifer(s) in question.
  - This was a valid approach because if an adopted DFC was not physically possible, then under the physical laws of hydrology, as incorporated in the mathematical calculations executed during GAM simulations, then the model would not execute the prescribed simulation successfully.

Supporting Materials
Feasibility of Achieving DFC

- Physically possible = feasible
  - There are many potential DFC scenarios considered in GMAs across Texas that are not physically possible.
  - The most common example is where significantly different DFCs are considered for adjoining subareas for an aquifer, i.e., in one area have limit drawdown to 10 feet and in an immediately adjoining area, allow 500 feet of drawdown. Due to the laws of hydrology, this condition generally could not be simulated in a GAM.

Supporting Materials
Feasibility of Achieving DFC

- Conclusion
  - The DFCs and resulting estimates of modeled available groundwater (MAG) presented during the June 24, 2014 GMA 14 meeting were successfully simulated.
  - The requested DFCs were successfully simulated and corresponding MAGs produced.
  - Therefore, utilizing the approach taken by the TWDB during the first round of joint planning that concluded on September 1, 2010, the DFCs currently under preliminary consideration are physically possible, and thus are feasible.

Supporting Materials

Feasibility of Achieving DFC

- Other aspects of feasibility?
  - Applicable statute and rules do not prescribe what is to be considered specifically when considering the feasibility of achieving a desired future conditions under consideration.
  - A common definition of feasibility is “capable of being accomplished or brought about; possible.”
  - Using this definition, it becomes important to consider the estimates of modeled available groundwater resulting from proposed DFCs with respect to both historic use and also compare to projected water demands.