2015 ANNUAL GROUNDWATER REPORT

(40th Annual Report)

YEAR ENDING - DECEMBER 31, 2015

Harris-Galveston Subsidence District
1660 West Bay Area Blvd., Friendswood, TX 77546
(281) 486-1105 / www.hgsubsidence.org

www.hgsubsidence.org

Board Draft Adopted 6/8/16 by HGSD Resolution # 2016-990
2015 Groundwater Hearing

TABLE OF CONTENTS

Introduction ..................................................................................................................................................1
Testimony and Findings ...............................................................................................................................2
Subsidence District Testimony ....................................................................................................................3
  Precipitation Measurements for 2015 ....................................................................................................4
    HGSD Exhibit No. 1: Weather Station Locations Map ................................................................4
    HGSD Exhibit No. 2: Annual Precipitation 2015 Bush Intercontinental Airport ..........................5
    HGSD Exhibit No. 3: Five-Year Precipitation, 2011-2015 Bush Intercontinental Airport .............6
    HGSD Exhibit No. 4: Ten-Year Precipitation, 2006-2015 Bush Intercontinental Airport ............7
    HGSD Exhibit No. 5: Annual Precipitation, 2015 Hobby Airport ..................................................8
    HGSD Exhibit No. 6: Five-Year Precipitation, 2011-2015 Hobby Airport ....................................9
    HGSD Exhibit No. 7: Ten-Year Precipitation, 2006-2015 Hobby Airport .....................................10
    HGSD Exhibit No. 8: Annual Precipitation 2015 National Weather Service Office (NWSO) ....11
    HGSD Exhibit No. 9: Five-Year Precipitation, 2011-2015 NWSO ..............................................12
    HGSD Exhibit No. 10: Ten-Year Precipitation, 2006-2015 NWSO .............................................13
    HGSD Exhibit No. 11: Annual Precipitation, 2015 Galveston Island ............................................14
    HGSD Exhibit No. 12: Five-Year Precipitation, 2011-2015 Galveston Island .............................15

Groundwater Withdrawals and Total Water Demand for 2015 ..............................................................17
    HGSD Exhibit No. 14: Groundwater Withdrawals, 1976-2015 ....................................................18
    Regulatory Area One .........................................................................................................................18
    HGSD Exhibit No. 15: Groundwater Withdrawals, 1976-2015 ....................................................19
    Regulatory Area Two ........................................................................................................................19
    HGSD Exhibit No. 16: Groundwater Withdrawals, 1976-2015 ....................................................20
    Regulatory Area Three ......................................................................................................................20
    HGSD Exhibit No. 17: Groundwater Withdrawals, 1976-2015, By Use ......................................21
    HGSD Exhibit No. 18: Groundwater Withdrawals, 1976-2015, By Use ......................................22
    By Regulatory Area ..........................................................................................................................22
    HGSD Exhibit No. 19: Alternate Water (Surface and Re-Use), 1976-2015 By Source ...............23
    HGSD Exhibit No. 20: Total Water Demand, 1976-2015 By Source .............................................24
    HGSD Exhibit No. 21: Tri-County Groundwater Withdrawals, 1990-2015 ..............................25
    By County .......................................................................................................................................25
    HGSD Exhibit No. 22: Tri-County Groundwater Withdrawals, 1990-2015 By Use ..................26
    HGSD Exhibit No. 23: Groundwater Withdrawals, Galveston Co., 1976-2015 By Use ...............27
    HGSD Exhibit No. 24: Groundwater Withdrawals, Harris Co., 1976-2015 By Use ....................28
Subsidence District Testimony (Continued) Measured Land Surface Subsidence Using CORS, PAMS and Extensometers

HGSD Exhibit No. 26: GPS Monitoring Network
HGSD Exhibit No. 27: Ellipsoid Height Change 2014-2015
HGSD Exhibit No. 28: Ellipsoid Height Change 2010-2015
HGSD Exhibit No. 29: Ellipsoid Height Change 2000-2015

HEARING CONCLUSION

WRITTEN COMMENTS

APPENDICES

Appendix A1: PAMs Change Tables
Appendix A2: CORS Change Tables
Appendix A3: Extensometer Change Tables

Appendix USGS: Provisional Water-Level Change Maps, Water-Level Altitudes and Compaction Data

Presented by the United States Geological Survey at the Public Hearing

HGSD Exhibit No. A1: Water-Level Monitoring Network
HGSD Exhibit No. A2: 2015-2016 Chicot Aquifer Water-Level Change
HGSD Exhibit No. A3: 2015-2016 Evangeline Aquifer Water-Level Change
HGSD Exhibit No. A4: 2015-2016 Jasper Aquifer Water-Level Change
HGSD Exhibit Nos. A5 and A6: 2015-2016 Water-Level Change Summary
HGSD Exhibit No. A7: 1977-2016 Chicot Aquifer Water-Level Change
HGSD Exhibit No. A8: 1977-2016 Evangeline Aquifer Water-Level Change
HGSD Exhibit No. A10: Conceptualization of Groundwater Flow and Subsidence
HGSD Exhibit No. A11: Lake Houston, Northeast, East End, Southwest, JSC NASA and Addicks Extensometers
HGSD Exhibit No. A12: Texas City, Baytown and Seabrook Extensometers
HGSD Exhibit No. A13: Clear Lake and Pasadena Extensometers
HGSD Exhibit No. A14 and A15: Summary
USGS Exhibit No. A16: Location of the Cinco Ranch Extensometer .......................................................... 66
USGS Exhibit No. A17: 2016 Water-Level Altitude - Chicot Aquifer ...................................................... 67
USGS Exhibit No. A18: 2016 Water-Level Altitude - Evangeline Aquifer ............................................. 68
USGS Exhibit No. A19: 2016 Water-Level Altitude - Jasper Aquifer ...................................................... 69
INTRODUCTION

Pursuant to Harris-Galveston Subsidence District (District) Resolution No. 2016-986 passed on March 9, 2016, the Board of Directors held the Annual Groundwater Hearing beginning at 10:00 a.m. on April 26, 2016 at the District’s office in Houston, Texas. The public hearing fulfills the requirements of Section 8801.117, Texas Special Districts Local Laws Code, which states that each year, the Board of Directors shall hold a public hearing for the purpose of taking testimony concerning the effects of groundwater withdrawals on the subsidence of land within the District during the preceding year.

This report was prepared by Mr. Robert Thompson of the District’s staff, with special assistance from Mr. Greg Lackey, Mr. Mike Chrismer, along with other’s from the District staff; from Mr. Mark Kasmarek, from the US Geological Survey; and Mr. Cliff Middleton of the National Geodetic Survey (retired). The following findings were presented for this Groundwater Report for the year ending December 31, 2015.

Helen Stewart Truscott
Hearing Examiner
Ms. Helen Truscott, the Hearing Examiner, opened the Hearing at approximately 10:00 a.m. She stated that representatives from the District and the USGS would give testimony. She also asked that anyone else giving testimony or asking questions, should state their name and whom they were representing. The record was left open until Friday, May 13, 2016 at 12:00 noon.

Approximately 20 people attended the 2015 Groundwater Hearing: several interested parties, members of the USGS Houston Sub-District staff, along with members of the Subsidence District’s staff and Board, and members of the public. Those giving testimony were Mr. Robert Thompson of the District and Mr. Mark Kasmarek, Hydrologist, Houston Sub-District, Water Resources Division, United States Geological Survey, Department of the Interior. Mr. Thompson submitted in total, 29 exhibits including topics of precipitation, groundwater withdrawal, alternate-water usage, and subsidence measurements. Mr. Kasmarek presented 19 exhibits including topics of water-level altitudes, water-level changes, and land surface subsidence.

Following the presentations by the USGS and the Subsidence District, there were questions from the public.
Mr. Thompson presented testimony concerning monthly precipitation and groundwater withdrawals during the year 2015. The groundwater withdrawals for 2015 were compared with annual pumpage data since 1976. The groundwater withdrawal data for 2015 was compiled from annual groundwater pumpage reports submitted by well owners and water authorities whose wells were permitted by the District at any time during the calendar year of 2015. Section 8801.162 of the Texas Special Districts Local Laws Code requires each well owner to submit their water well pumpage annually to the District. There were 7947 permitted wells in 2015 and most owners had submitted their reports as of the date of the Groundwater Hearing. Missing reports were estimated to represent approximately 2.3 MGD, or 0.3% of the total pumpage. This amount is considered insignificant to the report conclusions in all categories of use and regulatory areas. The following exhibit descriptions contain summaries of Mr. Thompson’s presentation.
Mr. Thompson presented one map and twelve charts describing precipitation measurements for the 2015 calendar year in Harris and Galveston Counties. The weather data is broken out for each of the four sites within the District’s boundaries; Bush Intercontinental Airport located in Regulatory Area Three, Hobby Airport located in Regulatory Area Two, the League City National Weather Service Office (NWSO) located in Regulatory Area One, and the weather station on Galveston Island, also in Regulatory Area One. Precipitation data was retrieved from the NOAA National Data Center.

HGSD EXHIBIT NO. 1: WEATHER STATION LOCATIONS MAP
Monthly precipitation data for Bush Intercontinental Airport goes back to 1969 and for this document is reported for the year ending December 31, 2015. Normal precipitation is based upon three full decades (1981-2010). Precipitation for each month is depicted using light blue bars, and for comparison purposes, the normal amount for each month is depicted using dark blue bars.

The annual rainfall measured at Bush Intercontinental Airport for 2015 was 70.0 inches. The one-year cumulative departure from normal (49.8 inches) for 2015 was +20.2 inches and is shown in red.
The five-year annual precipitation data for Bush Intercontinental Airport is shown for the period of January 1, 2011 through December 31, 2015. The precipitation for each year is depicted using light blue bars, and for comparison purposes, the normal amount is depicted using a black line. The cumulative difference for the observation period is shown in red and the five-year trend is shown with a yellow line.

The five-year cumulative departure from normal (49.8 inches) was -30.6 inches and is depicted on the red line. Rainfall has been below normal for four of the last five years.
The ten-year annual precipitation data for Bush Intercontinental Airport is shown for the period of January 1, 2006 through December 31, 2015. The actual precipitation for each year is depicted using light blue bars, and for comparison purposes, the normal amount is depicted using a black line. The cumulative difference for the observation period is shown in red and the ten-year trend in yellow.

The ten-year cumulative departure from normal (49.8) was -13.5 inches.
The Hobby Airport site has weather data going back to 1970. Normal precipitation is based upon three full decades (1981-2010). Monthly precipitation data for Hobby Airport is reported for the year ending December 31, 2015. Actual precipitation for each month is depicted using light blue bars, and for comparison purposes, normal precipitation for each month is depicted using dark blue bars. The one-year cumulative departure is shown in red.

The annual rainfall measured for 2015 was measured at 77.1 inches. The one year cumulative departure from normal (54.7 inches) was +22.4 inches. Six months of the year the rainfall was above normal.
The five-year annual precipitation data for Hobby Airport is shown for the period of January 1, 2011 through December 31, 2015. The actual precipitation for each year is depicted using light blue bars, and for comparison purposes, the normal amount is depicted using a black line. The cumulative difference for the observation period is shown in red and the five-year trend in yellow.

The five-year cumulative departure from normal (54.7) was -35.9 inches.
The ten-year annual precipitation data for Hobby Airport is shown for the period of January 1, 2006 through December 31, 2015. The actual precipitation for each year is depicted using light blue bars, and for comparison purposes, the normal amount is depicted using a black line. The cumulative difference for the observation period is shown in red and the ten-year trend in yellow.

The ten-year chart shows a cumulative departure from normal (54.7) of -23.3 inches and the site has a slight negative trend due to receiving below average rainfall during six of the last seven years.
The National Weather Service established this site as its local headquarters in October 1990. Normal precipitation is based upon a twenty-year average from 1991 to 2010, not the standard thirty-year average. Due to the shorter length of time used to calculate average precipitation; extreme rainfall events can greatly affect average precipitation. Monthly precipitation data for League City is reported for the year ending December 31, 2015. Actual precipitation for each month is depicted using light blue bars, and for comparison purposes, normal precipitation for each month is depicted using dark blue bars. The one-year cumulative departure from normal is shown in red.

The cumulative departure from normal (58.4) was +28.5 inches with nine of the last twelve months receiving above normal rainfall amounts in 2015.
The five-year annual precipitation data for NWSO is shown for the period of January 1, 2011 through December 31, 2015. The normal precipitation of 58.4 inches per year is based upon two full decades (1991-2010). The actual precipitation for each year is depicted using light blue bars, and for comparison purposes, the normal amount is depicted using a black line. The cumulative difference for the observation period is shown in red and the five-year trend in yellow.

The five-year cumulative departure from normal (58.4 inches) was -31.8 inches with four of the last five years below normal.
The ten-year annual precipitation data for NWSO is shown for the period of January 1, 2006 through December 31, 2015. The normal precipitation of 58.4 inches per year is based upon two full decades (1991-2010). The actual precipitation for each year is depicted using light blue bars, and for comparison purposes, the normal amount is depicted using a black line. The cumulative difference for the observation period is shown in red and the ten-year trend in yellow.

The ten-year cumulative departure from normal (58.4 inches) was -33.4 inches with seven of the last ten years showing a deficit of rainfall.
This site has weather data going back to 1947, from several locations operated during offset time periods. The chart and analysis in this report is based on combined data from all of the sites. The normal precipitation 50.8 inches is based upon three full decades (1981-2010). Monthly precipitation data for Galveston Island is reported for the year ending December 31, 2015. Actual precipitation for each month is depicted using light blue bars, and for comparison purposes, normal precipitation for each month is depicted using dark blue bars. The one-year cumulative departure from normal is depicted in red.

The cumulative departure from normal (52.8 inches) was 8.8 inches above normal and with seven of the twelve months receiving an above normal amount of rain.
The five-year annual precipitation data for Galveston Island is shown for the period of January 1, 2011 through December 31, 2015. The actual precipitation for each year is depicted using light blue bars, and for comparison purposes, the normal amount is depicted using a black line. The cumulative departure from normal for the observation period is shown in red and the five-year trend in yellow.

The five-year cumulative departure from normal (52.8 inches) was -63.6 inches. Below normal rainfall was measured for four of the last five years.
The ten-year annual precipitation data for Galveston Island is shown for the period of January 1, 2006 through December 31, 2015. The actual precipitation for each year is depicted using light blue bars, and for comparison purposes, the normal amount is depicted using a black line. The cumulative departure from normal for the observation period is shown in red and the ten-year trend in yellow.

The ten-year cumulative departure from normal (52.8 inches) was -146.9 inches. Galveston Island has the highest cumulative departure from norm over the last ten-year period of the four weather sites monitored within the District with nine of the last ten years below normal.
Mr. Thompson presented twelve exhibits: five exhibits depicting groundwater withdrawal by use and area; one exhibit showing surface and re-use water; one exhibit depicting total water demand by source; two exhibits of combined groundwater withdrawal from the Tri-County area of Harris, Galveston and Fort Bend Counties; and three exhibits showing total use by county.

As is usual, the groundwater withdrawal total was updated for the previously reported year of 2014. Subsequent data was added and corrections made after the 2014 Groundwater Report was presented in April 2015. The updated 2014 groundwater withdrawal total increased by 7.0 million gallons per day (MGD) to a new total of 199.5 MGD. These changes are made during the normal permitting and reporting process as part of the exchange between the District and its permittees. The changes include updating estimated amounts with actual amounts, correction of data entry errors, and errors in the submitted data.

For 2015, there were 540 wells with an allocation total of 835.7 MG not reporting as of April 2016. This equates to an estimated unaccounted for withdrawal of 2.3 MGD (or 0.3% of the reported withdrawals). This is considered an insignificant amount for the purposes of this report.

For comparison and as part of the continued cooperation between the District and the Fort Bend Subsidence District, recorded groundwater pumpage totals were used for Fort Bend County for its first full year of operation in 1990 through 2015.
HGSD EXHIBIT NO. 14: GROUNDWATER WITHDRAWALS, 1976-2015, REGULATORY AREA ONE

Regulatory Area One covers most of Galveston County as well as the southeastern portion of Harris County. Cities and villages included are Bacliff, Baytown, Bayou Vista, Channelview, Clear Lake Shores, Deer Park, Dickinson, El Lago, Galena Park, Galveston, Highlands, Hitchcock, Jacinto City, Kemah, La Marque, La Porte, League City, Morgan’s Point, Nassau Bay, Pasadena, San Leon, Santa Fe, Seabrook, Shoreacres, Taylor Lake Village, Texas City, Tiki Island, and Webster. Also included are Clear Lake, Johnson Space Center, and Bolivar Peninsula Areas.

In 2015, total groundwater withdrawal in Regulatory Area One was 8.3 MGD, a 4% (0.3 MGD) increase over the previous year. Public supply increased by 11%, industrial decreased by 2% and irrigation uses increased by 36%. Although irrigation usage is up, it is still a very small amount.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Pump</th>
<th>% Chg</th>
<th>Public Supply Pump</th>
<th>% Chg</th>
<th>Industrial Pump</th>
<th>% Chg</th>
<th>All Irrigation Pump</th>
<th>% Chg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>8.0</td>
<td>-14%</td>
<td>3.2</td>
<td>-11%</td>
<td>4.7</td>
<td>-15%</td>
<td>0.1</td>
<td>-48%</td>
</tr>
<tr>
<td>2015</td>
<td>8.3</td>
<td>4%</td>
<td>3.6</td>
<td>11%</td>
<td>4.6</td>
<td>-2%</td>
<td>0.2</td>
<td>36%</td>
</tr>
</tbody>
</table>
Regulatory Area Two covers a small northwestern slice of Galveston County and southeast Harris County. Cities, entities, and areas included are Bellaire, Cloverleaf, Crosby, Friendswood, Highlands, Hobby Airport, Pasadena, Sheldon, South Houston, West University, and large portions of the City of Houston. Like Regulatory Area One, Regulatory Area Two has been converted to alternate water sources where possible.

Total groundwater withdrawal increased in Regulatory Area Two from 20.1 MGD in 2014 to 25.2 MGD in 2015 (a 25% increase) with public supply use accounting for the majority of the increase. The majority of this increase is due to additional pumpage by the City of Houston. Industrial use decreased by 1% and irrigation usage increased by 6% for the year.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Pump</th>
<th>% Chg</th>
<th>Public Pump</th>
<th>% Chg</th>
<th>Industrial Pump</th>
<th>% Chg</th>
<th>All Irrigation Pump</th>
<th>% Chg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>20.1</td>
<td>0%</td>
<td>16.8</td>
<td>3%</td>
<td>2.2</td>
<td>-6%</td>
<td>1.1</td>
<td>-21%</td>
</tr>
<tr>
<td>2015</td>
<td>25.2</td>
<td>25%</td>
<td>21.8</td>
<td>30%</td>
<td>2.2</td>
<td>-1%</td>
<td>1.2</td>
<td>6%</td>
</tr>
</tbody>
</table>

HGSD EXHIBIT NO. 15: GROUNDWATER WITHDRAWALS, 1976-2015, REGULATORY AREA TWO
Regulatory Area Three covers north and west Harris County. Entities in this regulatory area were required to convert to alternate water beginning in 2010 with some entities converting early. Pumpage increased by 5% to 179.9 MGD in 2015.

The largest category of use remains public supply at 94% of the total. Public supply increased by 5%, industrial increased by 28% and irrigation uses decreased by 1%.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Pump</th>
<th>% Chg</th>
<th>Public Supply Pump</th>
<th>% Chg</th>
<th>Industrial Pump</th>
<th>% Chg</th>
<th>All Irrigation Pump</th>
<th>% Chg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>171.4</td>
<td>-9%</td>
<td>160.6</td>
<td>-8%</td>
<td>2.3</td>
<td>1%</td>
<td>8.5</td>
<td>-29%</td>
</tr>
<tr>
<td>2015</td>
<td>179.9</td>
<td>5%</td>
<td>168.6</td>
<td>5%</td>
<td>2.9</td>
<td>28%</td>
<td>8.4</td>
<td>-1%</td>
</tr>
</tbody>
</table>
This chart shows the way water is used across the District as a whole. In 2015, total groundwater withdrawal within the District increased by 7% (13.9 MGD) to 213.4 MGD. Public supply increased by 7%, industrial increased by 6% and there was no change for irrigation usage. Public supply remains the largest use category, accounting for 91% of the total water use within the District.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Public Supply</th>
<th>Industrial</th>
<th>All Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pump</td>
<td>% Chg</td>
<td>Pump</td>
<td>% Chg</td>
</tr>
<tr>
<td>2014</td>
<td>199.5</td>
<td>-9%</td>
<td>180.6</td>
<td>-7%</td>
</tr>
<tr>
<td>2015</td>
<td>213.4</td>
<td>7%</td>
<td>194.0</td>
<td>7%</td>
</tr>
</tbody>
</table>

Groundwater Withdrawals
Grouped By Use - Entire District
Pumpage increased in all three regulatory areas in 2015, with the majority of the increase in Regulatory Areas 2 and 3. Regulatory Area 1 increased by 4% (0.3 MGD), Regulatory Area 2 increased by 25% (5.0 MGD) and Regulatory Area 3 increased by 5% (8.5 MGD). The largest use of groundwater continues to take place in Regulatory Area 3 which withdraws 84% of the groundwater within the District.
Total alternate water use was down 42.9 MGD from 2014. Surface water came from all three rivers in the region with the greatest amount coming from the Trinity (67%), followed by the San Jacinto (21%), and the Brazos (11%). Re-use water accounted for only 0.5% of the total.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Alternate Water</th>
<th>Trinity River</th>
<th>San Jacinto River</th>
<th>Brazos River</th>
<th>Re-use Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>729.9</td>
<td>504.1</td>
<td>145.5</td>
<td>76.6</td>
<td>3.8</td>
</tr>
<tr>
<td>2015</td>
<td>687.0</td>
<td>462.5</td>
<td>144.4</td>
<td>76.6</td>
<td>3.5</td>
</tr>
</tbody>
</table>

The graph illustrates the distribution of alternate water use (surface and re-use) by source from 1976 to 2015, with the Trinity River being the primary source for the majority of the period.
Total water demand (surface water, re-use water, and groundwater) within the District decreased to 900.3 MGD during 2015 (down 29.2 MGD from 2014). The Trinity River, as it has been for over two decades, is still the single largest source of water in the District. Groundwater remains the second largest source of water for the District as a whole.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Demand</th>
<th>Groundwater</th>
<th>Trinity River</th>
<th>San Jacinto River</th>
<th>Brazos River</th>
<th>Re-use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amt</td>
<td>% Chg</td>
<td>Amt</td>
<td>% Chg</td>
<td>Amt</td>
<td>% Chg</td>
</tr>
<tr>
<td>2014</td>
<td>929.5</td>
<td>-1%</td>
<td>199.5</td>
<td>-9%</td>
<td>504.1</td>
<td>-3%</td>
</tr>
<tr>
<td>2015</td>
<td>900.3</td>
<td>-3%</td>
<td>213.4</td>
<td>7%</td>
<td>462.5</td>
<td>-8%</td>
</tr>
</tbody>
</table>

HGSD EXHIBIT NO. 20: TOTAL WATER DEMAND, 1976-2015 BY SOURCE
The next two exhibits include data from Fort Bend County as well as Harris and Galveston Counties to give a picture of groundwater use in the Harris, Galveston, and Fort Bend Tri-County area. In 2015, total groundwater withdrawal for the three counties was 284.8 MGD, a 11.2 MGD increase from 2014. Harris County withdrew 75% of the three-county total, Fort Bend 25%, and Galveston County 0.2%.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Pump</th>
<th>% Chg</th>
<th>Fort Bend Pump</th>
<th>% Chg</th>
<th>Galveston Pump</th>
<th>% Chg</th>
<th>Harris Pump</th>
<th>% Chg</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>273.6</td>
<td>-13%</td>
<td>74.2</td>
<td>-23%</td>
<td>0.6</td>
<td>-34%</td>
<td>198.9</td>
<td>-8%</td>
</tr>
<tr>
<td>15</td>
<td>284.8</td>
<td>4%</td>
<td>71.4</td>
<td>-4%</td>
<td>0.7</td>
<td>6%</td>
<td>212.7</td>
<td>7%</td>
</tr>
</tbody>
</table>
While there was increased pumping in 2015, the breakout of how groundwater is used in the Tri-County area remains consistent with only minor changes. Eighty-seven percent of the groundwater that is withdrawn in the three counties is used for public supply, 5% is used for industrial purposes, and 4% for agricultural purposes. Four percent of the total groundwater withdrawn is used for other purposes including landscape irrigation, amenity ponds, etc.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Pump</th>
<th>% Chg</th>
<th>Agricultural Pump</th>
<th>% Chg</th>
<th>Industrial Pump</th>
<th>% Chg</th>
<th>Public Pump</th>
<th>% Chg</th>
<th>Other Pump</th>
<th>% Chg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>273.7</td>
<td>-13%</td>
<td>12.5</td>
<td>-20%</td>
<td>12.7</td>
<td>-11%</td>
<td>235.6</td>
<td>-11%</td>
<td>12.9</td>
<td>-34%</td>
</tr>
<tr>
<td>2015</td>
<td>284.8</td>
<td>4%</td>
<td>11.2</td>
<td>-10%</td>
<td>13.2</td>
<td>4%</td>
<td>247.9</td>
<td>5%</td>
<td>12.4</td>
<td>-4%</td>
</tr>
</tbody>
</table>
Examining the three counties separately, Galveston County used the least amount of groundwater during 2015. The county as a whole used 0.7 MGD. That amount was 6% higher than the previous year. That amount represents 1.6% of the amount pumped in 1976, when the District was created.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Agricultural</th>
<th>Industrial</th>
<th>Public</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pump</td>
<td>% Chg</td>
<td>Pump</td>
<td>% Chg</td>
<td>Pump</td>
</tr>
<tr>
<td>2014</td>
<td>0.6</td>
<td>-34%</td>
<td>0.0</td>
<td>0%</td>
<td>0.1</td>
</tr>
<tr>
<td>2015</td>
<td>0.7</td>
<td>6%</td>
<td>0.1</td>
<td>0%</td>
<td>0.1</td>
</tr>
</tbody>
</table>

From a high in 1976 of 27.4 MGD (0.0 agricultural, 8.9 industrial, 18.5 public supply and 0.0 other) to this year’s total of only 0.7 MGD (0.1 agricultural, 0.1 industrial, 0.4 public supply and 0.1 other), Galveston County has decreased its total groundwater use by more than 98% in the past 40 years.
In Harris County the 2015 groundwater withdrawals totaled 212.7 MGD, an increase of 7%. Public supply increased by 7%, industrial increased by 6%, agricultural decreased by 21% and other uses increased slightly.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Agricultural</th>
<th>Industrial</th>
<th>Public</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pump</td>
<td>% Chg</td>
<td>Pump</td>
<td>% Chg</td>
<td>Pump</td>
</tr>
<tr>
<td>2014</td>
<td>198.9</td>
<td>-8%</td>
<td>1.6</td>
<td>-17%</td>
<td>9.0</td>
</tr>
<tr>
<td>2015</td>
<td>212.7</td>
<td>7%</td>
<td>1.2</td>
<td>-21%</td>
<td>9.5</td>
</tr>
</tbody>
</table>

Exhibit 24 – From a high in 1976 of 428.9 MGD (44.6 agricultural, 141.4 industrial, 234.8 public supply and 8.1 other) to last year’s groundwater withdrawal of 212.7 MGD (0.0 agricultural, 9.5 industrial, 193.6 public supply and 8.4 other), Harris County has decreased its groundwater usage by 50.4% over the last 40 years.
In Fort Bend County overall and for all water groups, groundwater pumpage decreased during 2015.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Agricultural</th>
<th>Industrial</th>
<th>Public</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pump</td>
<td>% Chg</td>
<td>Pump</td>
<td>% Chg</td>
<td>Pump</td>
</tr>
<tr>
<td>2014</td>
<td>74.2</td>
<td>-23%</td>
<td>10.9</td>
<td>-20%</td>
<td>3.6</td>
</tr>
<tr>
<td>2015</td>
<td>71.4</td>
<td>-4%</td>
<td>9.9</td>
<td>-9%</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Exhibit 25 – From a withdrawal rate in 1990 of 62.6 MGD (17.1 agricultural, 6.5 industrial, 34.9 public supply and 4.1 other), to the 2015 withdrawal of 71.4 MGD (9.9 MGD agricultural, 3.5 MGD industrial, 54.0 MGD public supply and 4.0 MGD other), Fort Bend County has increased its groundwater withdrawals by 14% in 26 years, even with the tremendous growth. This is due in large part to the required reductions in 2014.

Mr. Thompson yielded to Mr. Kasmarek from the USGS.
Mr. Mark Kasmarek, a Groundwater Hydrologist with the USGS, presented testimony concerning annual water-level measurements, taken in December 2015 through March 2016 and compaction measurements taken monthly from thirteen extensometer sites. The United States Geological Survey (USGS) collects water level and subsidence measurements as part of a joint funding agreement with the District, the Fort Bend Subsidence District, the City of Houston, the Brazoria County Groundwater Conservation District, and the Lone Star Groundwater Conservation District. Mr. Kasmarek submitted for the USGS, a total of 19 exhibit drafts, as part of a U.S. Department of the Interior, USGS Open File Report to be released mid-summer 2016, upon final national review.
Mr. Kasmarek gave a brief description of the history of the USGS and an overview of the project.
Mr. Kasmarek presented 19 exhibits describing the network of monitor wells and the changes in aquifer pressures (water-level changes) which occurred from 2015 to 2016, from 2000 to 2016 and from 1977 to 2016, including water-level altitude maps for each aquifer. The water-level measurements are usually taken from December through March due to the increasing number of measurements.
The area involved in the ongoing study of water level changes is depicted in the map below.
The Gulf Coast Aquifer System has three main aquifers within the greater Houston area. The Chicot Aquifer is the shallowest aquifer and generally has supplied much of Galveston County and the coastal areas of the District. The Evangeline Aquifer lies beneath the Chicot Aquifer and has supplied much of Harris County and the farther inland areas of the District. The Jasper Aquifer is generally considered too salty for public consumption, throughout most of the District, but has been pumped in Montgomery County and in more recent years has been pumped in far northern Harris County. The cross-section depicts aquifer depths and thicknesses along a line from Grimes County to Galveston County based on recorded well logs throughout the area.
USGS EXHIBIT NO. 4: STRATIGRAPHIC COLUMN OF THE GEOLOGIC AND HYDROGEOLOGIC UNITS

Stratigraphic Column of Geologic and Hydrogeologic Units of the Gulf Coast Aquifer System
Exhibit 5 gives a description of the criteria of the wells used in the water-level network.

**Network Description**

- **The water-level-monitoring network for this project requires strong collaboration with local well owners, municipalities, MUDs, PUDs, and other entities.**

- **Because the Gulf Coast aquifer system consists of three primary water bearing units and the Catahoula aquifer being developed as an alternative water source, each well in the water-level monitoring network must be screened solely within one of the four aquifers.**

- **Therefore, no cross-formational wells are included in this long-term annual groundwater project.**

- **Currently, the number of wells used to construct the 14 sheets of the 2016 SIM consist of wells screened in the Chicot (178), Evangeline (320), Jasper (109) aquifers, and Catahoula confining system (9).**
Mr. Kasmarek presented five exhibits including a location map depicting the thirteen extensometers in Harris and Galveston Counties and three graphs showing the compaction measured at the extensometers. The site compaction measurements are continuously chart recorded with a modified Type F Recorder and read approximately every twenty-eight days.

---

**USGS EXHIBIT NO. 6: OVERVIEW OF SUBSIDENCE MECHANISMS**

The drawing below depicts an overview of how groundwater withdrawal leads to the compaction that is associated with land subsidence in this region.
This map shows the location of the extensometer sites (two extensometers, one shallow depth and one deep located at both the Baytown and Clear Lake Sites); and three extensometer sites (Addicks, Northeast Houston and Lake Houston) are equipped with GPS antennas atop the extensometer’s inner pipe and are included in the NGS Continuous Operating Reference Station (CORS) Program.

This concluded Mr. Kasmarek’s testimony.

The rest of the Exhibits for the USGS have been included in the Appendices under “Provisional Water-Level Change Maps, Water-Level Altitudes and Compaction Data Presented by the United States Geological Survey at the Public Hearing.”

They can also be found at the following link: https://www.sciencebase.gov/catalog/item/56c235f5e4b0946c651fc290.

The above site will also have the final report when it has been approved later this summer.
Mr. Thompson returned to present four exhibits including one location map and three subsidence charts. The charts showed data from three types of sites across ten counties.

**Measurement Methodology and Notes**

GPS heights are derived at each of the occupied GPS sites every thirty seconds during the duration of monitoring (generally a seven day period, every eight weeks). The data for each site is processed against each of the District’s three CORS/extensometers (Addicks, Northeast Treatment Plant and Lake Houston) and published as a daily height. These daily heights are then averaged for that week of observations for each site. This average is represented as a single point on the subsidence chart for that site.

The one-year and cumulative change amounts listed in the tables found in the appendix are computed using only the beginning and ending averaged weekly data points. As such, they do not take into account intermittent extreme weather, unusual climatic events, or random seismic activity at the site and may not portray the entire year’s subsidence activity at that site as well as the trends displayed on the subsidence charts themselves. While these numbers are helpful and lend meaning to the charts, true understanding of the subsidence occurring at a site is found in the long term view (trend) of the data rather than a beginning and ending point snapshot.
This is a map that shows the location of the GPS sites within the District and the surrounding counties. On the following maps, and for each of the time periods, dots are only shown if the GPS site was there for the entire period. (A unique Site ID number has been assigned to each of the marks. The corresponding name and type of mark can be found in the table beginning in Appendix A1.)
This map shows the amount of compaction at the different locations for the period from 2014 to 2015. The larger the dot the more change. Red dots represent declines or compaction and the blue dots represent a slight increase or expansion at the locations shown. For this period there were 108 marks used. They range from a rise of about 1.5 inches to a decline of about 2.2 inches.
This map shows the different locations for the period from 2010 to 2015 (five years). For this period there were 85 marks used. They range from a rise of about 1.8 inches to a decline of about 7.9 inches.
This map shows the different locations for the period from 2000 to 2015 (15 years). For this period there were 31 marks used. They range from a rise of about 0.1 inches to a decline of about 16.7 inches.
HEARING CONCLUSION

Ms. Truscott asked for additional testimony. There was no additional testimony given.

Ms. Truscott opened it up for questions.

WRITTEN COMMENTS

No other additional testimony was presented. The record was held open until May 13, 2016 at 12:00 noon to allow for written comments and corrections.

There were no written comments submitted.
APPENDICES

The one-year and a cumulative change figures in the tables are computed using only the beginning and ending averaged data points. As such, they do not take into account intermittent extreme weather, unusual climatic events, or random seismic activity at the site and may not portray the subsidence activity at that site as well as the trend lines on the subsidence charts in the previous section.

APPENDIX A1: PAMS CHANGE TABLES

<table>
<thead>
<tr>
<th>Map ID</th>
<th>PAM ID</th>
<th>Location</th>
<th>Observation Date</th>
<th>Observation</th>
<th>2015</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0</td>
<td>HGSD</td>
<td>8/10/1999</td>
<td>0.0</td>
<td>-0.04</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td>Highway 290 at FM 1960</td>
<td>1/2/1996</td>
<td>0.03</td>
<td>-1.78</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>2</td>
<td>Interstate 45 at FM 1960</td>
<td>1/2/1996</td>
<td>0.08</td>
<td>-1.61</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>3</td>
<td>Bear Creek Park</td>
<td>11/8/1999</td>
<td>0.11</td>
<td>-0.92</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>4</td>
<td>Sugar Land (FB)</td>
<td>8/2/1996</td>
<td>-0.05</td>
<td>-0.73</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>5</td>
<td>Addicks PAM</td>
<td>9/11/1996</td>
<td>-0.07</td>
<td>-1.10</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>6</td>
<td>West Houston Airport</td>
<td>8/14/1997</td>
<td>-0.02</td>
<td>-1.41</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>7</td>
<td>Jones Road at FM 1960</td>
<td>2/11/1999</td>
<td>-0.18</td>
<td>-1.82</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>8</td>
<td>Walters Road at FM 1960</td>
<td>8/11/1999</td>
<td>0.01</td>
<td>-1.15</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>9</td>
<td>East Lake Houston</td>
<td>9/2/1999</td>
<td>0.07</td>
<td>-0.20</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>10</td>
<td>Rosenberg (FB)</td>
<td>1/15/1999</td>
<td>-0.01</td>
<td>-0.17</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>11</td>
<td>Hockley</td>
<td>5/6/1999</td>
<td>0.07</td>
<td>-0.34</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>12</td>
<td>West Kingwood (M)</td>
<td>11/23/2000</td>
<td>-0.03</td>
<td>-0.37</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>13</td>
<td>Woodlands (M)</td>
<td>11/30/2000</td>
<td>-0.09</td>
<td>-0.82</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>14</td>
<td>Smithers’ Lake (FB)</td>
<td>11/17/2000</td>
<td>0.10</td>
<td>-0.18</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>16</td>
<td>Kitty Hollow Park (FB)</td>
<td>11/9/2000</td>
<td>-0.01</td>
<td>-0.31</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>17</td>
<td>Tomball</td>
<td>12/21/2000</td>
<td>-0.11</td>
<td>-0.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Location</td>
<td>Date</td>
<td>z</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>-----------------------------------</td>
<td>------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>37</td>
<td>18</td>
<td>Highway 6 at FM 1960</td>
<td>12/8/2000</td>
<td>0.02</td>
<td>-0.96</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>19</td>
<td>North Katy</td>
<td>11/22/2000</td>
<td>-0.12</td>
<td>-0.57</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>20</td>
<td>Kemah (G)</td>
<td>1/15/2002</td>
<td>0.15</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>21</td>
<td>Pearland (B)</td>
<td>1/30/2002</td>
<td>0.10</td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>22</td>
<td>Hitchcock (G)</td>
<td>1/15/2002</td>
<td>0.01</td>
<td>-0.13</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>23</td>
<td>Texas City (G)</td>
<td>1/23/2002</td>
<td>0.02</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>24</td>
<td>La Porte</td>
<td>2/12/2002</td>
<td>0.03</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>26</td>
<td>Jamaica Beach (G)</td>
<td>3/12/2002</td>
<td>0.06</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>27</td>
<td>Seabrook</td>
<td>5/14/2002</td>
<td>-0.01</td>
<td>-0.15</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>28</td>
<td>Cedar Bayou (C)</td>
<td>3/13/2002</td>
<td>0.07</td>
<td>-0.05</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>29</td>
<td>Katy (FB)</td>
<td>4/28/2007</td>
<td>0.05</td>
<td>-0.38</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>30</td>
<td>Fulshear (FB)</td>
<td>5/8/2007</td>
<td>0.01</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>31</td>
<td>Needville (FB)</td>
<td>5/8/2007</td>
<td>-0.05</td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>32</td>
<td>Greatwood (FB)</td>
<td>5/8/2007</td>
<td>0.01</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>33</td>
<td>Friendswood (G)</td>
<td>2/13/2007</td>
<td>0.03</td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>34</td>
<td>West Texas City (G)</td>
<td>5/6/2010</td>
<td>-0.02</td>
<td>-0.10</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>35</td>
<td>League City (G)</td>
<td>2/13/2007</td>
<td>-0.12</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>36</td>
<td>San Leon (G)</td>
<td>2/6/2007</td>
<td>0.07</td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>37</td>
<td>CWA Plant</td>
<td>5/15/2007</td>
<td>0.02</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>38</td>
<td>Edgebrook at Highway 3</td>
<td>5/10/2007</td>
<td>0.04</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>39</td>
<td>Sims Bayou</td>
<td>2/3/2011</td>
<td>0.11</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>40</td>
<td>Arcola (FB)</td>
<td>5/8/2007</td>
<td>-0.07</td>
<td>-0.24</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>41</td>
<td>610 Loop Southwest</td>
<td>6/27/2007</td>
<td>-0.19</td>
<td>-0.21</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>42</td>
<td>Highway 6 at Bissonnet Road</td>
<td>7/5/2007</td>
<td>-0.06</td>
<td>-0.11</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>43</td>
<td>San Luis Pass (G)</td>
<td>2/27/2007</td>
<td>-0.02</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>44</td>
<td>Cypress Creek EMS</td>
<td>4/27/2007</td>
<td>-0.08</td>
<td>-0.33</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>45</td>
<td>Melrose Park</td>
<td>5/1/2007</td>
<td>-0.10</td>
<td>-0.12</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>46</td>
<td>Louetta Road at Hwy 249</td>
<td>4/27/2007</td>
<td>-0.03</td>
<td>-0.53</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>47</td>
<td>Spring</td>
<td>5/4/2007</td>
<td>-0.11</td>
<td>-0.66</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Location Details</td>
<td>Date</td>
<td>Value 1</td>
<td>Value 2</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>------------------------------------------</td>
<td>------------</td>
<td>---------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>48</td>
<td>Hwy 249 at Spring-Cypress Road</td>
<td>4/27/2007</td>
<td>-0.04</td>
<td>-0.36</td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>49</td>
<td>Bolivar Peninsula (G)</td>
<td>1/23/2007</td>
<td>0.02</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>50</td>
<td>Mont Belvieu (C)</td>
<td>2/8/2007</td>
<td>-0.09</td>
<td>-0.12</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>51</td>
<td>Interstate 69 at North Beltway 8</td>
<td>5/4/2007</td>
<td>0.02</td>
<td>-0.05</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>52</td>
<td>Sheldon</td>
<td>5/4/2007</td>
<td>-0.11</td>
<td>-0.09</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>53</td>
<td>Crosby</td>
<td>5/4/2007</td>
<td>-0.07</td>
<td>-0.04</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>54</td>
<td>Highlands</td>
<td>1/31/2007</td>
<td>0.06</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>55</td>
<td>East Beltway 8 at Interstate 45</td>
<td>1/25/2007</td>
<td>0.01</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>56</td>
<td>Rushing Park</td>
<td>4/27/2007</td>
<td>0.08</td>
<td>-0.08</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>57</td>
<td>South Cinco Ranch (FB)</td>
<td>2/19/2009</td>
<td>-0.03</td>
<td>-0.12</td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>58</td>
<td>George Ranch (FB)</td>
<td>8/4/2010</td>
<td>0.01</td>
<td>-0.06</td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>59</td>
<td>Pecan Grove (FB)</td>
<td>7/28/2010</td>
<td>-0.01</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>60</td>
<td>Fulshear at Gaston Road (FB)</td>
<td>2/8/2013</td>
<td>-0.07</td>
<td>-0.15</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>61</td>
<td>Simonton (FB)</td>
<td>2/16/2011</td>
<td>-0.05</td>
<td>-0.11</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>62</td>
<td>Orchard (FB)</td>
<td>2/16/2011</td>
<td>-0.08</td>
<td>-0.07</td>
<td></td>
</tr>
<tr>
<td>81</td>
<td>63</td>
<td>Missouri City at Brazos River Pump Inlet (FB)</td>
<td>6/7/2011</td>
<td>-0.02</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>64</td>
<td>Little York-Not installed</td>
<td>-</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>83</td>
<td>65</td>
<td>Huffman VFD</td>
<td>6/6/2013</td>
<td>-0.11</td>
<td>-0.20</td>
<td></td>
</tr>
<tr>
<td>84</td>
<td>66</td>
<td>Fairfield</td>
<td>3/2/2011</td>
<td>0.02</td>
<td>-0.19</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>67</td>
<td>Rosenberg at Interstate 69 (FB)</td>
<td>2/9/2011</td>
<td>-0.02</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>68</td>
<td>Woodlands W. Branch (M)</td>
<td>10/19/2011</td>
<td>-0.08</td>
<td>-0.27</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>69</td>
<td>St Luke's Way (M)</td>
<td>8/4/2011</td>
<td>-0.08</td>
<td>-0.41</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>70</td>
<td>Loop 336 (M)</td>
<td>10/5/2011</td>
<td>0.03</td>
<td>-0.04</td>
<td></td>
</tr>
<tr>
<td>89</td>
<td>71</td>
<td>Lake Conroe Dam (M)</td>
<td>11/10/2011</td>
<td>0.07</td>
<td>-0.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Location</td>
<td>Date</td>
<td>Value</td>
<td>Value</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>----------------------</td>
<td>--------------</td>
<td>-------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>72</td>
<td>New Caney (M)</td>
<td>12/28/2011</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>91</td>
<td>73</td>
<td>Magnolia (M)</td>
<td>1/19/2013</td>
<td>0.05</td>
<td>-0.10</td>
<td></td>
</tr>
<tr>
<td>92</td>
<td>74</td>
<td>Galena Park</td>
<td>12/20/2011</td>
<td>0.02</td>
<td>-0.13</td>
<td></td>
</tr>
<tr>
<td>93</td>
<td>75</td>
<td>Baytown</td>
<td>6/6/2013</td>
<td>-0.10</td>
<td>-0.14</td>
<td></td>
</tr>
<tr>
<td>94</td>
<td>76</td>
<td>Jack Brooks Park (G)</td>
<td>8/21/2013</td>
<td>-0.01</td>
<td>-0.08</td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>77</td>
<td>Warren Ranch</td>
<td>11/14/2013</td>
<td>0.02</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td>96</td>
<td>78</td>
<td>South Waller (W)</td>
<td>5/2/2014</td>
<td>-0.04</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td>97</td>
<td>79</td>
<td>Brazosport (B)</td>
<td>10/29/2014</td>
<td>0.01</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>98</td>
<td>80</td>
<td>Denbury East</td>
<td>11/11/2014</td>
<td>-0.01</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>81</td>
<td>Denbury West</td>
<td>11/8/2014</td>
<td>-0.02</td>
<td>-0.01</td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX A2: CORS CHANGE TABLES

<table>
<thead>
<tr>
<th>Map ID</th>
<th>CORS ID</th>
<th>Location</th>
<th>Observation</th>
<th>Subsidence (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ANG5</td>
<td>US Coast Guard – Angleton (B)</td>
<td>1/1/2008</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>COH1</td>
<td>City of Houston – Southwest</td>
<td>1/24/2007</td>
<td>-0.04</td>
</tr>
<tr>
<td>3</td>
<td>COH2</td>
<td>City of Houston – South</td>
<td>1/24/2007</td>
<td>0.01</td>
</tr>
<tr>
<td>6</td>
<td>COH6</td>
<td>City of Houston – Kingwood</td>
<td>1/24/2007</td>
<td>-0.08</td>
</tr>
<tr>
<td>118</td>
<td>DWI1</td>
<td>SMRTNT – Clute (B)</td>
<td>8/27/2009</td>
<td>0.01</td>
</tr>
<tr>
<td>101</td>
<td>TMCC</td>
<td>Texas Medical Center</td>
<td>4/9/2003</td>
<td>-0.02</td>
</tr>
<tr>
<td>123</td>
<td>TXAC</td>
<td>TxDoT – Anahuac (C)</td>
<td>1/12/2011</td>
<td>0.00</td>
</tr>
<tr>
<td>103</td>
<td>TXAG</td>
<td>TxDoT – Angleton (B)</td>
<td>1/23/2007</td>
<td>0.00</td>
</tr>
<tr>
<td>122</td>
<td>TXBC</td>
<td>TxDoT - Bay City (MA)</td>
<td>10/1/2009</td>
<td>-0.01</td>
</tr>
<tr>
<td>105</td>
<td>TXCN</td>
<td>TxDoT - Conroe (M)</td>
<td>1/23/2007</td>
<td>-0.08</td>
</tr>
<tr>
<td>106</td>
<td>TXEX</td>
<td>HGSD - Clear Lake CORS (H)</td>
<td>11/18/2010</td>
<td>NA</td>
</tr>
<tr>
<td>107</td>
<td>TXGA</td>
<td>TxDoT – East Galveston Island (G)</td>
<td>1/23/2007</td>
<td>-0.01</td>
</tr>
<tr>
<td>109</td>
<td>TXHE</td>
<td>TxDoT – Hempstead (W)</td>
<td>1/23/2007</td>
<td>-0.05</td>
</tr>
<tr>
<td>110</td>
<td>TXLI</td>
<td>TxDoT – Liberty (L)</td>
<td>1/23/2007</td>
<td>-0.02</td>
</tr>
<tr>
<td>111</td>
<td>TXLM</td>
<td>TxDoT - La Marque (G)</td>
<td>1/23/2007</td>
<td>0.00</td>
</tr>
<tr>
<td>115</td>
<td>TXNJ</td>
<td>NOAA – Bolivar Tide Gauge North Jetty (G)</td>
<td>9/29/2011</td>
<td>NA</td>
</tr>
<tr>
<td>116</td>
<td>TXRS</td>
<td>TxDoT – Rosenberg (FB)</td>
<td>5/15/2011</td>
<td>-0.01</td>
</tr>
<tr>
<td>117</td>
<td>TXWH</td>
<td>TxDoT – Wharton (WH)</td>
<td>3/27/2010</td>
<td>-0.02</td>
</tr>
<tr>
<td>114</td>
<td>ZHU1</td>
<td>FAA - Bush Intercontinental Airport</td>
<td>1/23/2007</td>
<td>-0.05</td>
</tr>
</tbody>
</table>

*Note: Problems at site caused erroneous cumulative total.
### APPENDIX A3: EXTENSOMETER CHANGE TABLES

<table>
<thead>
<tr>
<th>Map ID</th>
<th>Extensometer Sites</th>
<th>First</th>
<th>Subsidence (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Addicks</td>
<td>7/1/1974</td>
<td>0.00</td>
</tr>
<tr>
<td>10</td>
<td>Baytown - Shallow</td>
<td>7/1/1973</td>
<td>0.07</td>
</tr>
<tr>
<td>9</td>
<td>Baytown - Deep</td>
<td>7/1/1973</td>
<td>0.04</td>
</tr>
<tr>
<td>11</td>
<td>Clear Lake - Shallow</td>
<td>5/1/1976</td>
<td>0.00</td>
</tr>
<tr>
<td>119</td>
<td>Clear Lake - Deep</td>
<td>5/1/1976</td>
<td>0.00</td>
</tr>
<tr>
<td>12</td>
<td>East End</td>
<td>7/1/1973</td>
<td>0.01</td>
</tr>
<tr>
<td>14</td>
<td>JSC NASA</td>
<td>7/1/1973</td>
<td>0.00</td>
</tr>
<tr>
<td>13</td>
<td>Lake Houston</td>
<td>7/1/1980</td>
<td>0.01</td>
</tr>
<tr>
<td>15</td>
<td>Northeast Houston</td>
<td>6/1/1980</td>
<td>0.03</td>
</tr>
<tr>
<td>16</td>
<td>Pasadena</td>
<td>10/1/1975</td>
<td>0.11</td>
</tr>
<tr>
<td>17</td>
<td>Seabrook</td>
<td>7/1/1973</td>
<td>0.02</td>
</tr>
<tr>
<td>18</td>
<td>Southwest Houston</td>
<td>6/1/1980</td>
<td>-0.03</td>
</tr>
<tr>
<td>19</td>
<td>Texas City (G)</td>
<td>7/1/1973</td>
<td>0.01</td>
</tr>
</tbody>
</table>
APPENDIX USGS: PROVISIONAL WATER-LEVEL CHANGE MAPS, WATER-LEVEL ALTITUDES AND COMPACTION DATA PRESENTED BY THE UNITED STATES GEOLOGICAL SURVEY AT THE PUBLIC HEARING

For water-level change maps representing a time period of five years or more, water-level rises (increases) are depicted with blue contour lines and shading, while water-level declines are depicted with red contour lines and shading. For water-level change maps representing a time period of less than five years, water-level rises are depicted with blue, upward pointing triangles and labeled with the measured rise on an accompanying legend, while declines are depicted with red, downward pointing triangles and labeled with the measured decline on an accompanying legend.

USGS EXHIBIT NO. A1: WATER-LEVEL MONITORING NETWORK

In the map below, the blue dots depict the distribution of monitoring wells in the Chicot Aquifer, the red dots depict the wells in the Evangeline Aquifer, and the yellow dots depict the wells in the Jasper Aquifer. Together they make up the 2016 Water-Level Monitoring Network.
Water-level altitudes measured in 2016 are depicted in relationship to sea level. Altitudes for the Chicot Aquifer in Harris and surrounding counties were drawn based on 178 water wells screened solely in the Chicot Aquifer out of the total of 616 measurements taken.

Altitudes in the Chicot Aquifer ranged from a high of 26 feet near the Pearland to an area of decline of 39 feet near the West Loop.
Altitudes for the Evangeline Aquifer in Harris and surrounding counties were drawn based on 320 water wells screened solely in the Evangeline Aquifer out of the total of 616 measurements taken.

Altitudes in the Evangeline Aquifer ranged from a high of 61 feet near Acres Home to a decline of 65 feet in Southwest Houston.
Altitudes for the Jasper Aquifer in Harris and surrounding counties were drawn based on 109 water wells screened solely in the Jasper Aquifer out of the total of 616 measurements taken.

Altitudes in the Jasper Aquifer ranged from a high of 51 feet in Conroe to a decline of 38 feet near The Woodlands.
The following two exhibits provide another way of looking at the water-level changes in the Chicot, Evangeline and Jasper Aquifers.

PRELIMINARY – SUBJECT TO REVISION

Water-Level Changes 2015–16

USGS Exhibit A5

2015–16 Water-Level-Change Summary
This exhibit shows the changes in water altitude in the Chicot Aquifer as groundwater withdrawal regulations changed and groundwater dependence decreased.
This exhibit shows the changes in water altitude in the Evangeline Aquifer as groundwater withdrawal regulations changed and groundwater dependence decreased.
USGS EXHIBIT NO. A9: 2000-2016 JASPER AQUIFER WATER-LEVEL CHANGE

This exhibit shows the declines in water altitude in the Jasper Aquifer since 2000. Wells in the Jasper Aquifer are predominately located in Montgomery County.
This figure shows a conceptualized diagram of groundwater flow and subsidence. Here we can see the Houston-metro area sitting below land surface in something of a bowl, with presumably a very, very large well below it sucking up lots and lots of water which induces depressurization of subsurface sediments and the mechanism of compaction to begin.
Exhibit A11 is the first of three graphs and shows the Lake Houston (blue line), Northeast Houston (plum line), East End (brown line), Southwest Houston (red line), Johnson Space Center (purple line) and Addicks (green line) extensometers. Scaling is in 1/10th of one foot increments from top to bottom (0-3.7 feet) and in one year increments, left to right (1973 to 2016).
This second extensometer graph shows the measurements for Texas City (blue line), Baytown Shallow (brown line), Baytown Deep (purple line), and the Seabrook (green line) extensometers. All saw slight rises in 2015.
The final graph shows the readings for the Clear Lake Shallow (blue line), Clear Lake Deep (brown line) and Pasadena (blue line) extensometers.
Summary

- In the groundwater-level-monitoring network about 669 wells measured between December 2015 and March 2016 documenting the most current water-level status of the Gulf Coast aquifer system in the Houston-Galveston region.

- During 2015–16, most wells showed a water-level rise, the majority showing between 1 and 10 feet. Those showing declines were mostly in the Evangeline and Jasper aquifers.

- Long-term (1977–2016) water-level trends show a stabilized area of rebound in the Chicot and Evangeline aquifers centered in southeastern Harris County, but water-level declines were also documented in the western part of the study area. Continuing declines in the Jasper aquifer occurred in northern Harris and Montgomery Counties.
Summary (continued)

- 5 of the 13 borehole extensometers recorded additional compaction in 2015 (Northeast, Southwest, Addicks, Johnson Space Center, and Clear Lake [deep]) or a net decreases in land-surface elevation related to continuing groundwater withdrawals throughout the study area and the slow equilibration of excess-residual-pore pressure from the drought in 2011.

- 8 of the 13 borehole extensometers recorded increases in land-surface elevations in 2015 (Lake Houston, East End, Texas City-Moses Lake, Baytown C–1 (shallow), Baytown C–2 (deep), Seabrook, Clear Lake (shallow), and Pasadena).

- USGS is continuing to monitor these sites to determine if the recent compaction is primarily in the elastic or inelastic range.
Exhibit A16 shows the location of the new extensometer in Cinco Ranch. This extensometer is expected to be fitted with its own recording device later in 2016.
Exhibit A17 shows the altitude of the Chicot Aquifer for 2016.
USGS EXHIBIT NO. A18: 2016 WATER-LEVEL ALTITUDE - EVANGELINE AQUIFER

Exhibit A18 shows the altitude for the Evangeline Aquifer for 2016.
Exhibit A19 shows the altitude of the Jasper Aquifer for 2016.

The full report can be found at the following link:
https://www.sciencebase.gov/catalog/item/56c235f5e4b0946c651fc290.

The above site will also have the final report when it has been approved later this summer.