ALTERNATIVE WATER MANAGEMENT STRATEGIES AND SUBSIDENCE GROUNDWATER DESALINATION

Harris-Galveston Subsidence District
Michael J. Turco – General Manager

What is Subsidence?

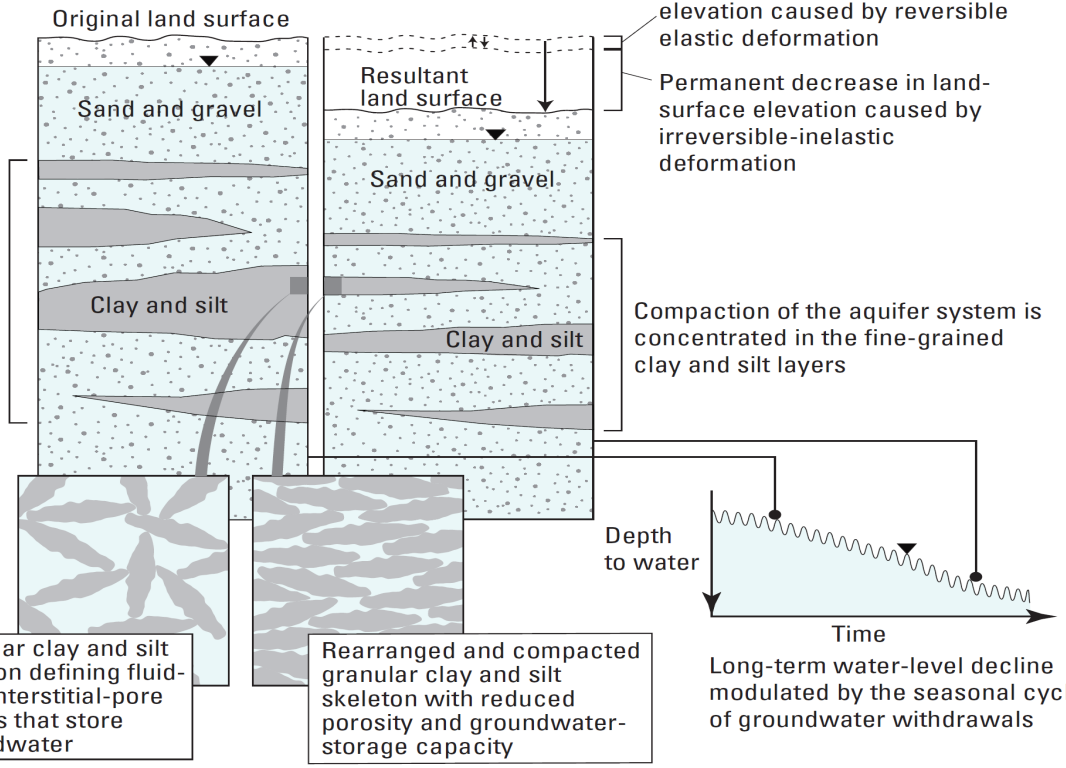
- Subsidence is the lowering of the elevation of land surface over time.
- Subsidence can have a wide range of consequences depending on the location of the occurrence and its proximity to surface drainage and coastal zones
- In this area, clay compaction resulting from groundwater withdrawal is the primary cause for subsidence

USGS
science for a changing world

HGSD
HARRIS-GALVESTON SUBSIDENCE DISTRICT

Mechanism for Subsidence in the Gulf Coast

When long-term withdrawals lower groundwater levels and raise pressure on the clay and silt layers beyond a threshold amount, the clay and silt layers compact, and the land-surface elevation decreases permanently



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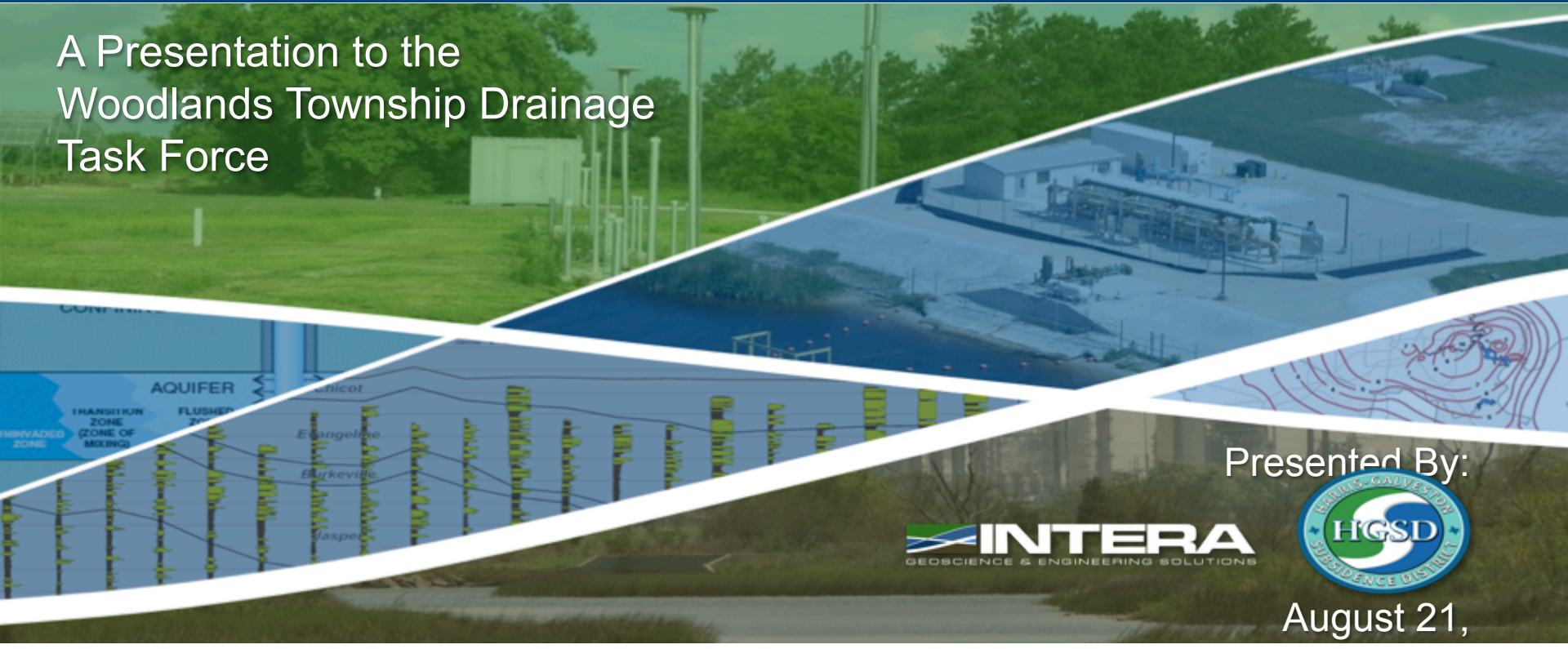
Investigation of Brackish Resources in the Gulf Coast Aquifer and Determination of the Potential Subsidence Risk From Resource Development

A Presentation to the
Woodlands Township Drainage
Task Force



Presented By:

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

HGSD
HARRIS-GALVESTON SUBSIDENCE DISTRICT

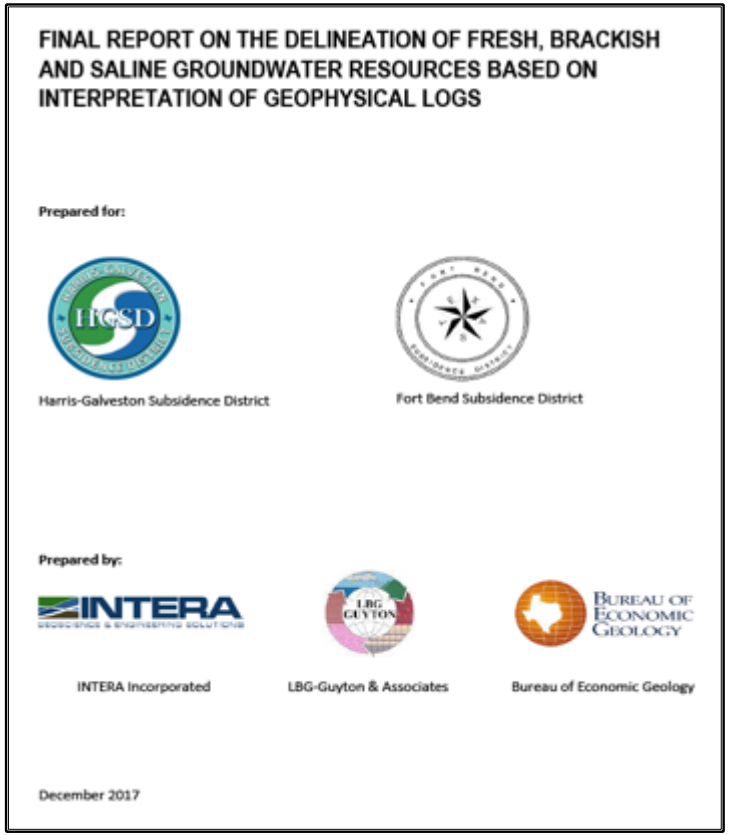
August 21,

Study Motivation & Products

- The Districts' Science and Research Plan calls for the determination of the occurrence and hydrogeologic characteristics of the brackish resources within the District and surrounding areas
- Two Primary Work Products
  - Report and data delineating brackish groundwater resources with the Harris-Galveston and Fort Bend Subsidence Districts
  - Risk Analysis for Subsidence from Development of the Brackish Jasper Aquifer
- This study: (1) provides foundational information to inform future subsidence studies; (2) provides an improved understanding of the historically undeveloped brackish resources; and informs potential regulation of brackish resources

Brackish Resources Delineation Report

- Study Area - the Harris-Galveston and Fort Bend Subsidence Districts and surrounding counties
- Study builds on the analysis begun by the TWDB HB-30 work increasing the resolution of the analysis
- Performed a detailed assessment of aquifer structure, lithology and salinity in Gulf Coast Aquifer System
- Fully digital dataset of aquifer lithology (sand/clay) and salinity
  - 299 geophysical logs – Salinity
  - 294 geophysical logs – Lithology
  - 209 geophysical logs - Stratigraphy



FINAL REPORT ON THE DELINEATION OF FRESH, BRACKISH AND SALINE GROUNDWATER RESOURCES BASED ON INTERPRETATION OF GEOPHYSICAL LOGS

Prepared for:

Harris-Galveston Subsidence District

Fort Bend Subsidence District

Prepared by:

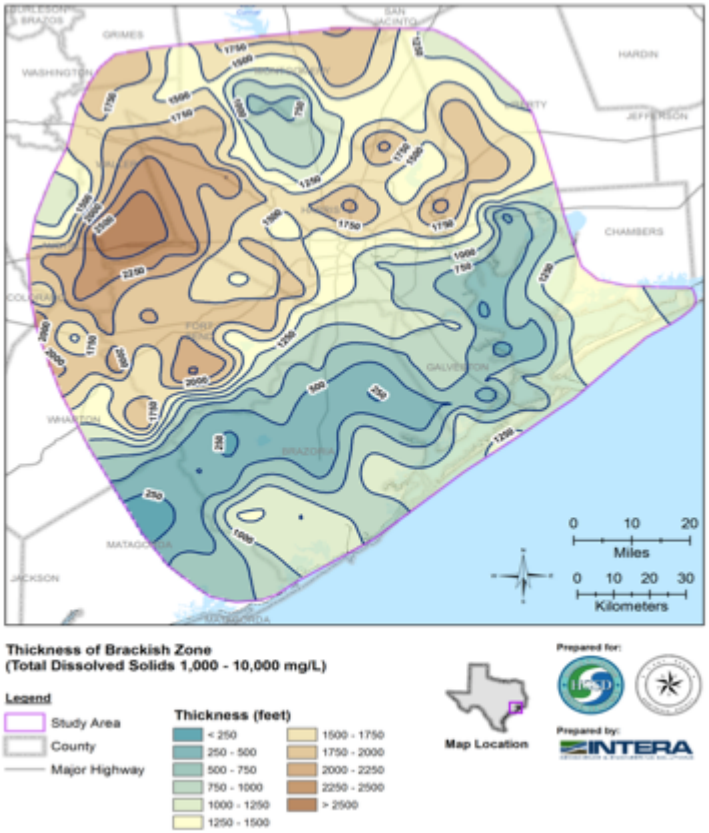
INTERA Incorporated

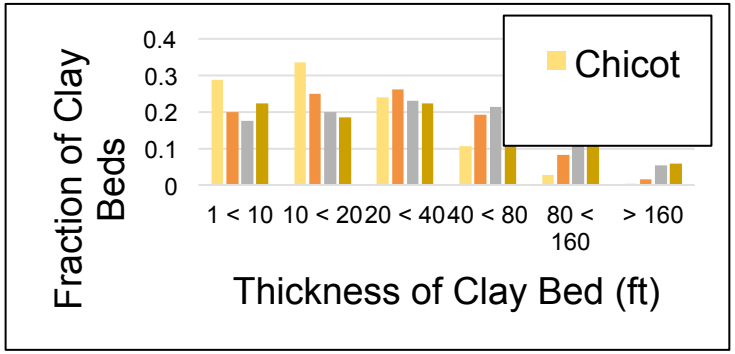
LBG-Guyton & Associates

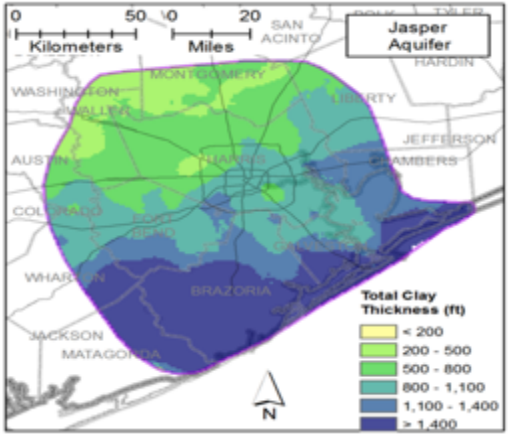
Bureau of Economic Geology

December 2017

Characterization of Water Quality and Lithology (Clay and Sand)

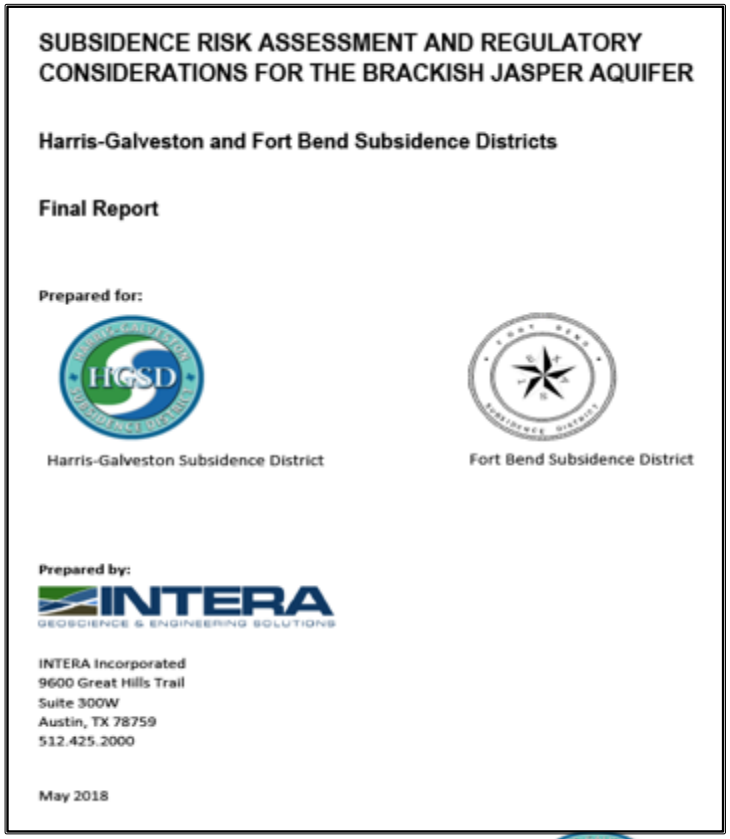






Characterization of Subsidence Risk in the Jasper Aquifer

- Performed a Risk Assessment for groundwater development from the Jasper Aquifer
  - Study area focused on brackish portions of the Jasper Aquifer (generally > 2,000 feet)
  - Developed a conceptual model and base-case parameters for assessment of compaction in the Jasper Aquifer
  - Normalized Risk Methodology based upon three performance metrics:
    - Compaction in the Jasper Aquifer
    - Land subsidence from Jasper compaction
    - Consequence from subsidence (flood plain)



SUBSIDENCE RISK ASSESSMENT AND REGULATORY CONSIDERATIONS FOR THE BRACKISH JASPER AQUIFER

Harris-Galveston and Fort Bend Subsidence Districts

Final Report

Prepared for:

Harris-Galveston Subsidence District

Fort Bend Subsidence District

Prepared by:

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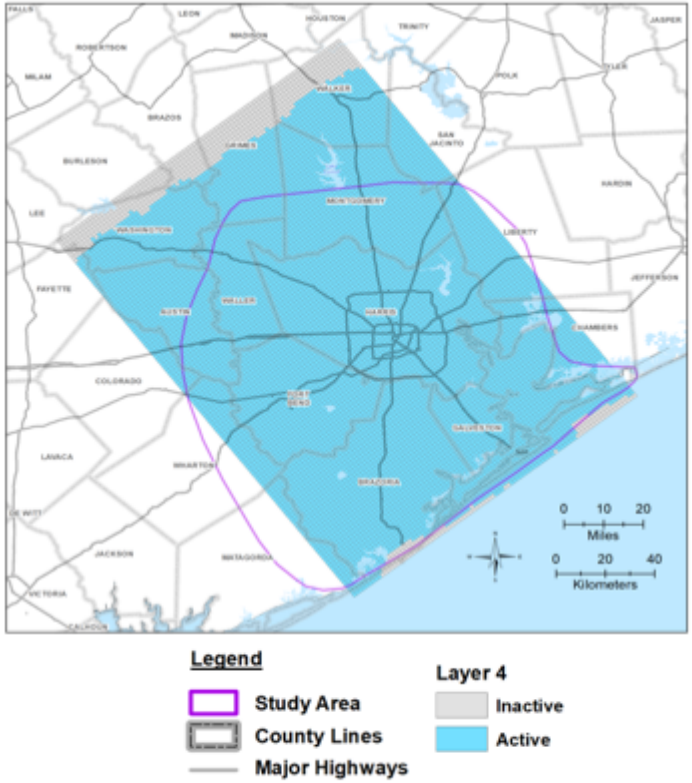
Numerical Simulation of Jasper Aquifer Compaction - JCM

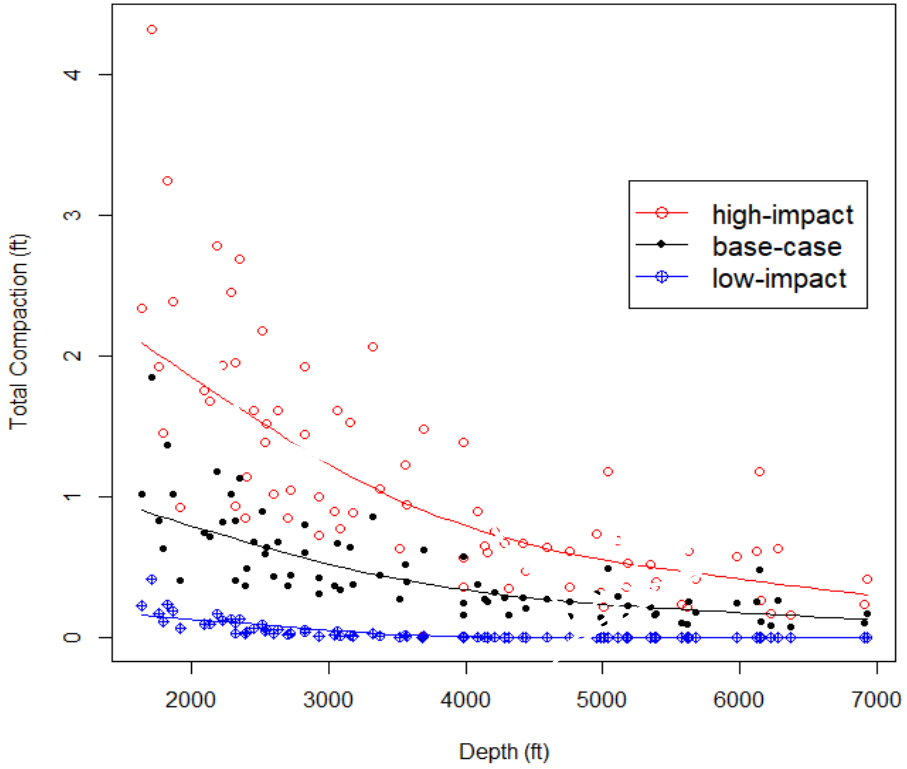
- A numerical model (JCM) of the Jasper Aquifer was developed to estimate compaction from a hypothetical brackish groundwater project
- Used the USGS flow model –

  MODFLOW-SUB
- The model can predict both the timing and amount of compaction that can occur accounting for the variability in clay bed occurrence and thickness
- 117 different models were developed - each representing an approximate 9 square-mile area to account for variability in clay properties and the depth of the Jasper Aquifer



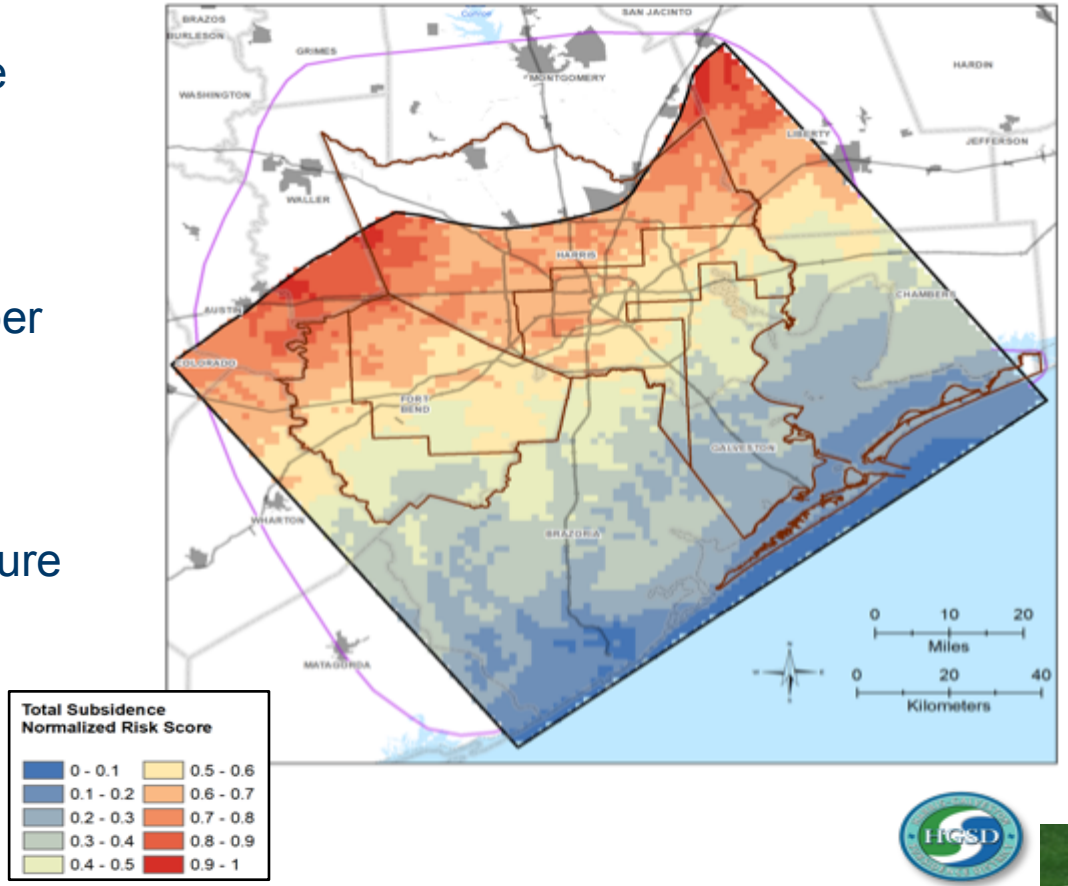
Simulated Variability in Compaction (ft) after 10 Years for Three Parameter Sensitivity Case

- Because there is uncertainty in best estimate Jasper Aquifer compaction properties, sensitivity simulations were developed
  - High-Impact Case
  - Low-Impact Case
- At shallower depths <2,000, an average of 1 foot of cumulative compaction occurs after 10 years of production for the base case



Jasper Aquifer Total Subsidence

- Normalized Risk Methodology based upon three performance metrics:
  - Compaction in the Jasper Aquifer (JCM)
  - Land subsidence from Jasper compaction (depth)
  - Consequence from subsidence (flood plain)
- The TSNRS is a relative measure of risk from Jasper brackish development relating one location from another



Conclusions and Potential Impact on Future Regulation

- The study has successfully developed a conceptual model for studying compaction in the brackish portions of the Jasper Aquifer.
- The study provides a basis to inform the potential regulation of brackish groundwater development in the Jasper Aquifer and provides a means to communicate relative risk of such development within the District
- The study provides recommendations for the collection of data and the performance of analyses based upon a general lack of deep data and a need to better understand and manage subsidence risk
- A two-tiered system of data collection and analysis activities were recommended for potential future brackish Jasper aquifer development projects consistent with the District's Mission and the need for additional data
  - Tier 1 activities are recommended activities
  - Tier 2 activities could be considered when a project is considered of higher risk

Category	Tier One Recommendations	Tier Two Recommendations
Well Design and Completion Documentation	Well Design Engineering Drawings Well Testing Plan Well Completion Report	*No Additional Recommendations Beyond Tier One Requirements*
Geophysical Logs	Caliper Density (Gamma Gamma) Temperature, Resistivity, Induction, Spontaneous Potential Porosity Cement-Bond	Acoustic Dipole Magnetic Resonance, Natural Gamma Spectroscopy, Elemental Capture Spectroscopy
Hydraulic Data	36-hour Aquifer Test Static Water-level	Installations of monitoring well(s) near wellhead
Geochemical Data	Water Quality Samples Water Quality Estimated from logs at Specific Depth Intervals Depth Dependent Water Quality Samples	Interval Specific Water Sampling
Geotechnical Core Data	*No Recommendation*	Clay Compressibility Clay Vertical Hydraulic Conductivity Clay Mineralogy
Modeling	Modeled drawdowns and radius of influence	Compaction model using District parameters and tools
Monitoring	Monthly Water Level Measurements Surface Land Subsidence Monitoring Station (PAM) Installation	Continuous water-level monitoring Extensometer Installation Maximum allowable drawdown
Subsidence Management Plan	Estimate potential subsidence over expected project timeline Establish protocol for monitoring and reporting subsidence Develop a plan to address measured subsidence	*No Additional Recommendations Beyond Tier One Requirements*

ANY QUESTIONS?