### Executive Summary

The Texas Integrated Flooding Framework (TIFF) Steering Committee and the Texas Water Development Board (TWDB) hosted a virtual subsidence workshop with 177 participants(see Workshop Invitees/Participants) on September 7, 2022, to improve statewide coordination for subsidence data collection and sharing. The goal of the workshop was to gather insights from subsidence experts, including the TIFF Technical Advisory Team (TAT) members and faculty from various universities, about acquisition and resource needs for advancing subsidence data in Texas.

Subsidence is a multi-faceted problem that affects not only land but also groundwater and surface water systems. Many agencies, universities, and organizations across the state are advancing their knowledge and data related to subsidence, but efforts are needed to centralize and synergize this work. The workshop served as a starting point to tackle this problem and initiate a coordinated effort to improve collaboration among experts working on subsidence issues.

The workshop opened with the screening of [nine pre-recorded presentations](https://nam04.safelinks.protection.outlook.com/?url=https%3A%2F%2Ftwdb-my.sharepoint.com%2F%3Af%3A%2Fg%2Fpersonal%2Fjenna_rao_twdb_texas_gov%2FEiC1mvWYiBNLqfxyEGhorUkB9CUd9zdEcj6TbFVacuyIWA%3Fe%3DesvJv0&data=05%7C01%7Cannahuff%40txstate.edu%7Cf686e231d1a0402d2a7808dab3b0861f%7Cb19c134a14c94d4caf65c420f94c8cbb%7C0%7C0%7C638019868059846972%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000%7C%7C%7C&sdata=jZ4QP0ZN03ND7XbNOutUWGrEaUvmjn7kHZIyOp1GruA%3D&reserved=0) from subsidence data experts to provide a broad overview of the current state of data availability and science related to subsidence in Texas. Presenters from academia, and state and federal agencies, described the tools and data sets available from their respective organizations and their plans for subsidence data in the coming years. Presenters from academia also provided an overview of their subsidence research and initiatives in geology, Interferometric Synthetic Aperture Radars (InSAR), global positioning systems (GPS), and tide gauges. Participants had the option to view the pre-recorded presentations before the workshop, which accumulated a total of 720 views before the event. The links to view the pre-recorded presentations are provided in Attachments.

The second half of the workshop included an open discussion and question-and-answer among the presenters and participants to uncover participants’ needs and goals related to subsidence data in Texas. Some key takeaways from the discussion include:

* While the U.S. Geological Society (USGS) has limited funding for subsidence work, they have collected groundwater level and subsidence data in Harris, Galveston, and Fort Bend counties since 1931. Many reports published by USGS also document changes in water levels and land subsidence in the greater Houston area. USGS is releasing a new GULF Model in November 2022 that will simulate current groundwater flow and land subsidence in the Gulf Coast Aquifer system and replace the [Houston Area Groundwater Model](https://txpub.usgs.gov/houston_subsidence/viewer.html).
* TWDB is currently undergoing a statewide flood planning process. The 15 regional flood planning groups are creating flood plans for their respective geographic areas that will incorporate future flood risk. Though very little data is available to project future risk, TWDB and the regional flood planning groups are estimating topographic changes to build subsidence into the planning process. TWDB also regularly updates topographic information for the state to better understand and project flood risk, which is available on the [Texas Disaster Information System website](https://idrt.tamug.edu/tdis/). And recently, TWDB achieved statewide LiDAR coverage.
* TWDB has dedicated funding for specific program areas, but they do not have a program area dedicated to subsidence. However, TWDB does have some discretionary funds available to further the causes of flood science, which could fund some research related to flooding and subsidence. Currently the TWDB is working with TDIS to collect and display where current subsidence data is located in Texas.
* California was very similar to Texas in the fact that there had not been a single entity responsible for collecting subsidence data prior to the 2015 passage of California’s Sustainable Groundwater Management Act. That act was the catalyst that funded the State of California’s [Department of Water Resources](https://water.ca.gov/) (DWR) to operationalize the collection and reporting of ground-based and air/space-based [subsidence data](https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub). While many other California agencies use it for other purposes, their data is primarily used for sustainable groundwater management planning. The annual cost to collect and maintain their subsidence data set is about $1.5 million.

The meeting concluded with a [poll](https://twdb-my.sharepoint.com/:b:/g/personal/jenna_rao_twdb_texas_gov/EUT2gEeUd61Kg_EU1iV8fMgBvQAghIh0nUPl0f8PKGr2NA?e=pQxXmA) to gather participant feedback and gauge interest in their continued involvement with the collaborative subsidence efforts. TIFF and TWDB plan to continue hosting similar events in the future to better understand how the state agencies can support and help advance subsidence data in Texas.

### Attachments

* **Subsidence Workshop Agenda:**

<https://twdb-my.sharepoint.com/:b:/g/personal/jenna_rao_twdb_texas_gov/EYmSDV762tNFu-0ek-LE6pQBMzYndWl2EZfHFyd0qlP1fw?e=QpKprT>

* **Subsidence Workshop Recording:**

<https://twdb-my.sharepoint.com/:v:/g/personal/jenna_rao_twdb_texas_gov/EQQMyAsH4rhIn0qViTB1mE0B9laNUa14oCgXicr4eWEcWg>

* **Workshop Participant Poll Results:**

<https://twdb-my.sharepoint.com/:b:/g/personal/jenna_rao_twdb_texas_gov/EUT2gEeUd61Kg_EU1iV8fMgBvQAghIh0nUPl0f8PKGr2NA?e=pQxXmA>

* **Subsidence Pre-Recorded Video Presentations & Summary Slides:**
* [**Land Subsidence and Groundwater Level Monitoring**](https://twdb-my.sharepoint.com/:v:/g/personal/jenna_rao_twdb_texas_gov/ETVKj_x23_1IjRoo2T1s0q0Bu328HVpaCx8XhGBHB8dsEA?e=yggmtk)*John Ellis, P.G., Gulf Coast Studies Section Chief, USGS Oklahoma-Texas Water Science Center*
* [**Subsidence in the Houston-Galveston Area**](https://twdb-my.sharepoint.com/:v:/g/personal/jenna_rao_twdb_texas_gov/EXFoJjTBZBZLsOMn6D9IUFYBPr__6vvSj9BdIqen0x3mqQ?e=P1YliC)  
  *Chris Bayes, E.I.T., Hydraulics, TxDOT Houston District*
* [**TWDB & TIFF Subsidence Workshop**](https://twdb-my.sharepoint.com/:v:/g/personal/jenna_rao_twdb_texas_gov/EUmGuUCvMjhGileQgAXavHoBpXt7CV9widrHWFornHvREg?e=9mfv2o)  
  *Ashely Greuter, P.G., Program Manager, Harris Galveston/Fort Bend Subsidence District*
* [**Vertical Land Motion**](https://twdb-my.sharepoint.com/:v:/g/personal/jenna_rao_twdb_texas_gov/EVOL_je9SPxFkFw_ovPvMUYBMVrals41YOvAxpcyBt_W2A?e=xto58n)  
  *Daniel Roman, Ph.D., Chief Geodesist, NOAA National Geodetic Survey & Daniel Prouty, Ph.D., Southern Plains Geodetic Advisor, NOAA National Geodetic Survey*
* [**Geology/Summary Land Deformation (Academic Panel)**](https://twdb-my.sharepoint.com/:v:/g/personal/jenna_rao_twdb_texas_gov/ETx8tgKMYEFJlektmdNju7EBYf7ivVuagjsx9ZjzGlpJZQ?e=tEPGxy)
  + *Shuhab Khan, Ph.D, Professor of Geology, Earth & Atmospheric Sciences, University of Houston*
  + *Yi Liu, Ph.D., Assistant Professor, Civil Engineering, Morgan State University*
  + *Nick Fang, Ph.D., P.E., Associate Professor, Civil Engineering, University of Texas at Arlington*
* [**InSAR (Academic Panel)**](https://twdb-my.sharepoint.com/:v:/g/personal/jenna_rao_twdb_texas_gov/EeDJvDpRvnxJu8xZneVAGcUBTFMtZ5u21c04eXmQWBl25A?e=aMwYwf)
  + *Shubab Khan, Ph.D.*
  + *Ann Chen, Ph.D., Assistant Professor, Orbital Mechanics, University of Texas at Austin*
  + *Mohamed Ahmed, Ph.D., Assistant Professor, Physical & Environmental Sciences, Texas A&M University Corpus Christi*
  + *Pietro Milillo, Ph.D., Assistant Professor, Civil and Environmental Engineering, University of Houston*
  + *Manoochehr Shirzaei, Ph.D., Associate Professor of Geophysics and Remote Sensing, Geosciences, Virginia Tech*
  + *Zhong Lu, Ph.D., Shuler-Foscue Professor of Geophysics, Earth Sciences, Southern Methodist University*
  + *Ashraf Rateb, Ph.D., Research Scientist Associate IV, Bureau of Economic Geology, University of Texas at Austin*
* [**GPS Geodetic Infrastructure in Texas for Land Subsidence Studies (Academic Panel)**](https://twdb-my.sharepoint.com/:v:/g/personal/jenna_rao_twdb_texas_gov/EascR8hrNu1Gg-WbCmXaWDYBwAEJkpHMX3vw5vOWiioIPA?e=dEuKdy)
  + *Bob Wang, Ph.D., Professor of Geophysics, Geodesy, and Geosensing Systems Engineering, University of Houston*
  + *Ibraheem Ali, Ph.D., Geospatial Analyst, Texas A&M University Corpus Christi*
  + *Joseph M. Kruger, Ph.D., Chair, Earth and Space Sciences, Lamar University*
* [**Tide Gauges for Coastal Subsidence Studies in Texas (Academic Panel)**](https://twdb-my.sharepoint.com/:v:/g/personal/jenna_rao_twdb_texas_gov/Ef0sdmfj525MnA5wj5XhKBsBWnEX32ig6UJHiGVHfEulHA?e=AVuid7)
  + *Bob Wang, Ph.D., Professor of Geophysics, Geodesy, and Geosensing Systems Engineering, University of Houston*
  + *Tianxing Chu, Ph.D., Assistant Professor, Engineering and Computing Sciences, Texas A&M University-Corpus Christi*
  + *Yi Liu, Ph.D.*
  + *Philippe Tissot, Ph.D., Interim Director, Conrad Blucher Institute and Associate Research Professor, Texas A&M University-Corpus Christi*
* [**California Department of Water Resource’s Land Subsidence Monitoring and Reporting**](https://txst-my.sharepoint.com/:v:/g/personal/alh4_txstate_edu/Ed6a4E0CRmdEkeDUUDysOLoBDno_tbCHaFBYRdObejSsOg?e=SLHS1P)*Benjamin Brezing, Senior Water Resources Engineer, California Department of Water Resources and Steven Springhorn, SGMA Technical Assistance Manager, California Department of Water Resources*
* [**Combined Speaker Summary Slides**](https://twdb-my.sharepoint.com/:f:/g/personal/jenna_rao_twdb_texas_gov/EkbaF5n-T3NGhknOKYtj8vMBqMG9ZNNTEFJPE-u66Gr4Kg?e=JMqfnn)

### Workshop Invitees/Participants

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| NAME | AFFILIATION |
| Alex Noel | City of League City |
| Amin Kiaghadi (TIFF Steering Committee) | Texas Water Development Board |
| Ann Chen | University of Texas |
| Anna Huff (*Facilitator*) | The Meadows Center for Water and the Environment - Texas State University |
| Arnold Cross | Unknown |
| Ashley Greuter | Harris - Galveston Subsidence District |
| Ashraf Rateb | University of Texas |
| Augusto Sanchez Gonzalez | Cameron County |
| Ben Brezing | California Department of Water Resources |
| Ben Medina | City of Rio Hondo Texas |
| Bob Kosar | TLV-TX |
| Bob Wang | University of Houston |
| Brad Wilber | Chambers County Texas |
| Brent Elliott | Texas Railroad Commission - Surface Mining and Reclamation Division |
| Bridget Scanlon | University of Texas |
| Caimee Schoenbaechler | Texas Water Development Board |
| Carla Guthrie | Texas Water Development Board |
| Carrie Thompson (*Facilitator*) | The Meadows Center for Water and the Environment - Texas State University |
| Casey Hughes | Harris-Galveston Subsidence District |
| Chigala Hekerem | Texas Department of Transportation |
| Chris Bayes | Texas Department of Transportation |
| Corby D. Alexander | City of La Porte |
| Daniel Gao | Texas General Land Office |
| Daniel Morales | Texas Department of Transportation |
| Daniel Prouty | National Oceanic and Atmospheric Administration |
| Daniel Roman | National Oceanic and Atmospheric Administration |
| Darice Russell | South Plains Underground Water Conservation District |
| David A. Garza | Cameron County |
| David Wolcott | National Oceanic and Atmospheric Administration |
| David Holmes | Texas General Land Office |
| DianaJoyce Ojeda | Texas Water Development Board |
| Douglas Manning | Orange County Drainage District |
| Evan Turner | Texas Water Development Board |
| Evonne | City of Beach City |
| Feifei Qu | Southern Methodist University |
| Garza County UCD | Garza County UCD |
| Glenn Clingenpeel | Trinity River Authority |
| Gordon Wells | University of Texas |
| Greg Smithhart | University of Texas |
| James Beach | Advanced Groundwater Solutions, LLC |
| James Rizzo | Texas A&M University - Corpus Christi |
| Jason Ramage | U.S. Geological Society |
| Jay Dylla | Texas Department of Transportation |
| Jenna Rao | Texas Water Development Board |
| Jill Garcia | Upper Trinity Groundwater Conservation District |
| Jayantha Lorensuhewa | Texas Department of Transportation |
| Joey Thomas | Texas Water Development Board |
| John Anderson | Rice University |
| John Dupnik | Texas Water Development Board |
| John Ellis | Texas Water Development Board |
| John Swartz | The Water Institute of the Gulf |
| Joni Synatschk | City of Houston |
| Joseph Kruger | Lamar University |
| Joshua Oyer | Texas General Land Office |
| Julie Bernier | U.S. Geological Society |
| Kara Hickey | U.S. Army Corps of Engineers |
| Kate de Gennaro | Texas Water Development Board |
| Katie Dahlberg | Texas Water Development Board |
| Ke Wang | University of Texas |
| Kelley Rich | Texas Water Development Board |
| Kevin De Santiago | Texas Water Development Board |
| Kevin Frenzel | Texas General Land Office |
| Krista Schreiber | Texas General Land Office |
| Kristine Blickenstaff | U.S. Geological Society |
| Kyle Sunday | CobbFendley |
| Larry Voice | Federal Emergency Management Agency - Region 6 |
| Linzy Foster | U.S. Geological Society |
| Liv Haselbach | Lamar University |
| Lon Squyres | City of Jacinto City |
| Lorenzo Wingate | City of La Porte |
| Manoochehr (Manoo) Shirzaei | Virginia Tech |
| Mark Neugebauer | Texas Water Development Board |
| Matt Nelson | Texas Water Development Board |
| Melissa Lupher | Texas Water Development Board |
| Mike Grogan | Texas Water Development Board |
| Micah Voulgaris | Cow Creek Groundwater Conservation District |
| Michael E Kiflai | Texas Water Development Board |
| Michael Lee | U.S. Geological Society |
| Miguel Pavon | Texas Water Development Board |
| Mike Turco | Harris Galveston/Fort Bend Subsidence District |
| Mohamed Ahmed | Texas A&M University - Corpus Christi |
| Natalie Ballew | Texas Water Development Board |
| Nefi Garza | Tetra Tech |
| Nick Fang | University of Texas at Arlington |
| Omar Martinez | El Paso County Water Improvement District No. 1 |
| Paul Buschow | University of Houston |
| Philip Webster | Unknown |
| Philippe Tissot | Texas A&M University - Corpus Christi |
| Pietro Milillo | University of Houston |
| Ram Neupane | Texas Water Development Board |
| Rewati Niraula | Texas Water Development Board |
| Rick Henderson | Texas Department of Transportation |
| Ron Ellis | Texas Water Development Board |
| Rose Marie Klee | Texas Department of Transportation |
| Stephannie Resendez | Texas Water Development Board |
| Sally Caldera | City of Houston |
| Sam Rendon | U.S. Geological Society |
| Samantha Reiter | Lone Star Groundwater Conservation District |
| Satish Tripathi | City of Houston |
| Saul Nuccitelli | Texas Water Development Board |
| Shahidul Islam | U.S. Army Corps of Engineers |
| Shonda Mace | Texas General Land Office |
| Shuhab Khan | University of Houston |
| Srikanth Koka | Texas Water Development Board |
| Stacey V. Reese | Stacey Reese Law |
| Steven Springhorn | California Department of Water Resources |
| Suzanne Pierce | University of Texas |
| Tabish Khan | University of Houston |
| Taylor Christian | Texas Water Development Board |
| Temple McKinnon | Texas Water Development Board |
| Tianxing Chu | Texas A&M University - Corpus Christi |
| Todd Ward | Harris County Flood Control (HCFCD) |
| Travis Buaas | Texas General Land Office |
| Venus Price | City of Houston |
| William Mobley | Texas Advanced Computing Center (TACC) |
| Xiaojun Qiao | Texas A&M University - Corpus Christi |
| Yi Liu | Morgan State University |
| Yipeng Zhang | Texas State University |
| Yun Cho | Texas Water Development Board |
| Zhong Lu | Southern Methodist University |