Conceptual Model Update for the Hill Country Portion of the Trinity Aquifer
TWDB Contract No. 1648302061

SOUTHWEST RESEARCH INSTITUTE®

July 13th, 2017
San Antonio, Texas
Project Team

- Ron Green, PhD, PG: Southwest Research Institute (SwRI) Project Manager
  - Nate Toll: Technical Lead, Hydrogeologist
  - Ron McGinnis: Structural Geologist, Geologic Modeler
  - Gary Walter, PhD: Hydrogeologist, Aqueous Geochemist
  - Leanne Stepchinski: Geologist
  - Beth Fratesi, PhD: Hydrogeologist
  - Rebecca Nunu: Hydrologist
  - Kirk Gulliver: Geoscientist

- Neil Deeds, PhD, PG, PE: (Intera) Project Manager and Technical Lead
  - Jevon Harding, PG: Geologist
Background

- Increasing demand on the Trinity Aquifer as a resource
- “The fastest-growing region in the country is a 74-mile corridor (I-35) anchored at either end by San Antonio and Austin that is coalescing”
  (Oct. 2016, Forbes Magazine)
- Materials Industry (Limestone Quarries)
History of GAMs for the Hill Country Portion of the Trinity Aquifer

- Texas Water Development Board completed a GAM in 2000 in cooperation with the Trinity Aquifer Advisory Committee
- In 2011, TWDB completed an update to the model to include the lower Trinity
- 2017, the TWDB contracted Southwest Research Institute (SwRI) to update the conceptual model for the Hill Country Portion of the Trinity Aquifer
Approach

- Objectives of this study include:
  - **Expansion** of the model region
  - Develop an understanding of the **interformational flow between the Trinity Aquifer and the Edwards Balcones Fault Zone (BFZ) Aquifer**
  - **Extend the datasets** for water levels, water chemistry, recharge, discharge, and hydraulic parameters both temporally and spatially
A key objective of this study was to expand the model domain.

- Include downdip/confined portions of the Trinity Aquifer
  - Address inter-formational flow to the Edwards Aquifer
  - These portions are being utilized for water resources
- Expand the model to the west to include portions of the Trinity Aquifer similar to the Northeastern portion.
  - Model will be coincident with the current Edwards Aquifer Authority numerical model domain.
- Include all of GMA 9

This is **Not the domain** for the future numerical model.
Approach

- Project had seven main tasks
  1. Project Management
  2. Stakeholder Communication
  3. Data Acquisition and Data Management
  4. Geologic and Hydrostratigraphic Modeling
  5. Hydraulic Data Analysis
  6. Conceptual Model Synthesis
  7. Reporting
Geologic and Hydrostratigraphic Modeling

- Task 4 - Geologic Interpretation and Hydrostratigraphic Modeling
- Geophysical log interpretation will be central to providing information relating to the upper and lower Trinity Formation boundaries and fault locations for each hydrogeological framework model layer.
- The results of this work will enhance the Hill Country portion of the Trinity Aquifer conceptual model and will be incorporated into the GAM geodatabase.
Model Workflow

- 3 part workflow
  - Hydrostratigraphic horizon and fault input (Petrel)
  - Hydrostratigraphic framework modeling (Petrel)
  - Finalize hydrostratigraphic raster surfaces (ArcGIS)
Stratigraphic Characterization

- 877 wells
- 3,960 stratigraphic formation picks for 12 units

Source:
- Bracks database
- IHS database
- Literature
- Stakeholders
Stratigraphic and Hydrostratigraphic Domains

Modified from Barker and Ardis, 1996 and Rose, 2016
Stratigraphic and Hydrostratigraphic Domains

Modified from Barker and Ardis, 1996 and Rose, 2016
Updip Limits and Lateral Distribution of Trinity Units

Modified from Barker and Ardis, 1996
Generalized Geologic Cross-Section

Modified from Barker and Ardis, 1996
Generalized Geologic Cross-Section

Modified from Barker and Ardis, 1996
Stratigraphy and Hydrostratigraphy

Modified from Rose, 2016
Edwards Top

Edwards Group
Top Elevation (feet above MSL)
High: 2421.26
Low: -4375.22

Study Area  County Boundary  State Boundary

Miles
0  20  40

SwRI

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swri.org
Upper Glen Rose Top

Upper Glen Rose Top Elevation (feet above MSL)

- High: 2270.34
- Low: -5115.99

Study Area
County Boundary
State Boundary

Miles
0  20  40

SwRI

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Pre Cretaceous Top
HCT Framework Model Cross-Section

Strata above Edwards Group
Edwards Group
Upper Glen Rose
Lower Glen Rose
Hensell
Cow Creek
Hammett
Sligo
Hosston
Top of Pre-Cretaceous rocks

8x Vertical Exaggeration
HCT Framework Model
Data Acquisition and Data Management

- Mine all publically available digital datasets to acquire data relevant to stratigraphy, water levels, water chemistry, recharge, discharge, and hydraulic parameters.
- Search commercial data sources for geophysical logs and geologic interpretations.
- Conduct literature reviews for above data and geologic or hydrogeologic interpretations of the Trinity Aquifer.
- Evaluate submissions.
- Compile GAM Geodatabase for use in future numerical model.
Hydraulic Data Analysis

- Water Levels were analyzed to identify wells in each formation to serve as calibration targets, establish initial conditions, and inform our understanding of groundwater flow.
- Recharge and Discharge data were estimated for the study period.
- Water Chemistry was analyzed to determine if spatial and temporal trends exist and if it can inform our understanding of interformational flow.
- Hydraulic parameters will be analyzed to improved the empirical basis for the numerical model parameters.
## Assignment to hydrostratigraphic units

<table>
<thead>
<tr>
<th>Layer</th>
<th>Above Edwards</th>
<th>Edwards</th>
<th>Upper Trinity</th>
<th>Middle Trinity</th>
<th>Lower Trinity</th>
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<td></td>
<td></td>
<td>well</td>
<td>well</td>
<td>well</td>
</tr>
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</table>

- **Edwards**
  - Upper Trinity
    - Upper Glen Rose
    - Lower Glen Rose
    - Hensell
    - Cow Creek
  - Middle Trinity
    - Hammett
    - Sligo
    - Hosston

- **Pre-K**
Assignment to hydrostratigraphic units

- Above Edwards
- Edwards
  - Upper Trinity
    - Upper Glen Rose
    - Lower Glen Rose
    - Hensell
    - Cow Creek
  - Middle Trinity
  - Lower Trinity
    - Hammett
    - Sligo
    - Hosston

Well screens:
- Upper Trinity well: Avg UT screen
- Middle Trinity well: Avg MT screen
- Lower Trinity well: Avg LT screen
Water Elevation

- Water level contours:
  - 4 hydrostratigraphic units:
    - Edwards
    - Upper Trinity
    - Middle Trinity
    - Lower Trinity
  - 4 time periods:
    - Pre-development
    - 1990
    - 2000
    - 2010

- Long-term Water Level records (calibration targets)
Water level elevation data

Edwards Hydrostratigraphic Unit
- Number of Water Level Measurements
- Number of Wells

Middle Trinity Hydrostratigraphic Unit
- Number of Water Level Measurements
- Number of Wells

Upper Trinity Hydrostratigraphic Unit
- Number of Water Level Measurements
- Number of Wells

Lower Trinity Hydrostratigraphic Unit
- Number of Water Level Measurements
- Number of Wells
Example Water Level Contours (Edwards)

Water Level Elevation (ft amsl) in the Edwards Hydrostratigraphic Unit - 2010
Example Hydrographs (Middle Trinity)
Hydraulic Parameters

- Transmissivity data from long-term aquifer pumping tests
- Specific capacity data
- Spatial distribution of Transmissivity, Hydraulic Conductivity & Storage
- Representative values of Transmissivity, Hydraulic Conductivity & Storage
Transmissivity data

Data from Long-term aquifer tests

Data from Specific capacity tests
Example Transmissivity Spatial Distribution

Transmissivity (square feet/day) - Middle Trinity

- 0 - 25
- 25 - 50
- 50 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 800
- 800 - 1,000
- 1,000 - 2,000
- > 2,000

Specific capacity test transmissivity value
Aquifer test transmissivity value

Study Area Boundary
County Boundary
State Boundary
Outcrop
Subcrop
## Representative values by HSU

### Hydrostratigraphic unit

<table>
<thead>
<tr>
<th>Hydrostratigraphic unit</th>
<th>Transmissivity values from Aquifer Pumping Tests (square feet/day)</th>
<th>Transmissivity values calculated from Specific Capacity (square feet/day)</th>
<th>All Transmissivity values from aquifer pumping tests and calculated from specific capacity (square feet/day)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>25th Percentile</td>
<td>Median</td>
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<tr>
<td>Upper Trinity</td>
<td></td>
<td>--</td>
<td>199</td>
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<tr>
<td>Middle Trinity</td>
<td>58</td>
<td>41</td>
<td>159</td>
</tr>
<tr>
<td>Lower Trinity</td>
<td>17</td>
<td>142</td>
<td>214</td>
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### Storativity

<table>
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<th>Formation</th>
<th>Storativity</th>
<th>Storativity Value</th>
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<tr>
<td></td>
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<td>Min</td>
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<tr>
<td>Upper Trinity</td>
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<td>--</td>
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<tr>
<td>Middle Trinity</td>
<td>28</td>
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<td>Lower Trinity</td>
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<tr>
<td>All Trinity</td>
<td>47</td>
<td>0.00001</td>
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Discharge Estimates

- TWDB Water Use Survey Data
- Rural Domestic Pumping based on Census data
- County Pumping by Hydrostratigraphic Unit
- County Pumping by Water Use
County Pumping by Hydrostratigraphic Unit
County Pumping by Water Use

Kendall County
(Trinity Aquifer & Edwards-Trinity Plateau Aquifer)

Blanco County
(Trinity Aquifer & Edwards-Trinity Plateau Aquifer)

Travis County
(Trinity Aquifer only)

Kerry County
(Trinity Aquifer & Edwards-Trinity Plateau Aquifer)

Bexar County
(Trinity Aquifer only)

Hays County
(Trinity Aquifer only)

Bandera County
(Trinity Aquifer & Edwards-Trinity Plateau Aquifer)

Comal County
(Trinity Aquifer only)
Discharge Estimates

- Natural Discharge to springs and streams is measured at USGS gauging stations throughout the HCT study domain.
- Spring discharge is aggregated to streams and not directly measured with few exceptions.
Stream Baseflow

8151500 Llano River at Llano, TX

Year


Stream Discharge (cubic feet per second)

16,000 14,000 12,000 10,000 8,000 6,000 4,000 2,000 0
Water Chemistry

- Solute transport is not simulated in Groundwater Availability Models but water chemistry is still considered as it impacts water use and informs the conceptualization of the Aquifer
- Major ion chemistry reviewed for trends
  - No major changes identified in available databases
- Water chemistry research reviewed for indicators of interformational flow
  - Indications of interformational flow between the Trinity aquifer and the Edwards aquifer exist in the unconfined portions of the Edwards aquifer in the San Antonio pool
TDS Concentrations Example
TDS Trends
Recharge Estimates

- An empirical model was developed to estimate the spatial and temporal distribution of recharge
- Model for diffuse recharge developed
- Model for focused recharge developed
Diffuse Recharge Estimates
Focused Recharge Estimates

Nov. 2004 Focused Recharge (inches)

- 0.08
- 0.09 - 0.10
- 0.11 - 0.50
- 0.51 - 1.00
- 1.01 - 4.00

Legend:
- Major Streams and Rivers TCEQ
- Counties
- Study Area
- Texas Outline
- Prism Focused Nodes
- Lakes and Reservoirs
Conceptual Model Synthesis

- The collection of data in discrete parts of the aquifer does not constitute a conceptual model.
- The SwRI team will developed a conceptual model that describes groundwater flow in the Hill Country portion of the Trinity Aquifer from recharge, through its path in the aquifer, to discharge at wells, springs, or rivers.
- Block models indicating flow in the aquifer were developed.
- The Conceptual model and the data accumulated during the project is described in the draft report to be issued final in September 2018 and be used in an updated GAM numerical model. We have highlighted key features here.
Conceptual Model Boundary
Conceptual Model Synthesis

- Lateral no flow boundaries
- Natural discharge to surface water dominates discharge followed by pumping and interformational flow
- Recharge is via diffuse and focused recharge, an empirical tool to estimate the temporal and spatial variability of recharge is provided
- Observed discharge to streams/springs should be included as a calibration parameter in addition to water elevations in the aquifer
- Interformational flow is still a challenge to estimate. Interformational flow will ultimately need to be determined during calibration of a numerical model
Conceptual Model Section Locations

[Map showing various river basins and section locations]
Conceptual Model
Section A
Conceptual Model
Section B
Conceptual Model
Section C
Conceptual Model Block Model
Schedule

- Comments from TWDB on draft report issued July 31\textsuperscript{st}, 2018
- Final conceptual model report will be issued on September 28\textsuperscript{th}, 2018
- No schedule is available for the development of a numerical groundwater flow model
Submission Contacts

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Questions and Responses

Q: There's an interesting anticline in the model cross section. The Maverick basin is known to have inversion features.
A: This is an area of sparse data. This could be an effect of these different structure variations and complexities in the domain. It could also be the result of Laramide deformation similar to the Chittim anticline and Zavala Syncline that exist just to the southwest of the study domain.

Q: Were ramps able to reveal themselves in the data? At the regional scale are they not as obvious?
A: A previous EAA [Edwards Aquifer Authority] project focusing on Edwards and Trinity done by SwRI had a more complex fault model. Relay ramps are better delineated in that fault model. Even though the data and resolution are sparse for this project, we still see evidence for ramp geometry in the data.

Q: Regarding the potentiometric surfaces – why is there a separation between Trinity Aquifer contours within and outside of the Balcones Fault Zone? In Hays and Travis counties, we see very continuous surfaces/no separate systems in these counties.
A: When you contour together, weird values occur along the zone due to large offsets. Studies have shown that separate water systems occur as Trinity Aquifer groundwater enters the Edwards Aquifer along the Balcones Fault Zone.

Q: What did you use to contour the potentiometric surfaces of Trinity units? Have you tried to use faults as barriers in that interpolation tool to avoid compartmentalizing two different systems (north and south of the Balcones Fault Zone)?
A: The control points are wells. The ArcGIS Topo-to-Raster function was used to generate the potentiometric surfaces. And no, we do not have fault lines to define barriers to see how it differs. This can be tested, but on a regional scale, this compartmentalization of Trinity Aquifer north and south of the Balcones Fault Zone was easiest. However, this is a complicated system, so this leaves many good options to explore.

Q: Did you consider gaining and losing streams in these potentiometric surfaces?
A: Yes, they were considered as control points (ex: springs) in predevelopment conditions.

Q: Did you look at measurement gain-loss sections?
A: Yes, it was not included in presentation but can be found in the draft final report. This is something that can inform the focused recharge model.

Q: Did you take into account age dating of water into the conceptual model?
A: We looked at it in the water chemistry analyses to assess inter-formational flow. In terms of the ages we evaluated, [they are] generally all meteoric.

Q: Regarding the block diagram: there are many arrows, which is a reflection of the remaining uncertainty of this system. We need to be careful about understanding these connections and how they may differ in different sections (for example, in Hays County, the continuous potentiometric surfaces have stark differences in geochemistry). I think the effort to simplify this large expanse can’t address certain things without more details. It does help to show that we are far away from understanding the whole system due to so many complexities. Not sure if any GAM-scale model will capture these complexities.

A: The Edwards Aquifer Authority inter-formational flow project will shed more light. The model will be relatively insensitive to some of these complexities. This is more constrained than it may appear but because of the effort to establish each of these arrows.

Q: Regarding the block diagram: there’s no interaction with the Pre-Cretaceous and Trinity?

A: This is addressed and discussed in the report. Primary and secondary porosity is sufficiently lower in the Pre-Cretaceous rocks. This may need to be addressed in the numerical model. Arrows were previously there but removed due to scale of permeabilities. There may be communication but it is challenging to constrain this.

Q: Regarding the inter-formational flow figures in the draft final report: there is not much text associated with them? Is there more discussion of spatial variation of inter-formational flow between the Edwards and Trinity aquifers?

A: We did not feel we had sufficient information to address this further. We haven’t had the information at our disposal. We expected Edwards Aquifer Authority inter-formational flow work to be further developed and anticipated this would be a great source of knowledge. I think we can do a better job of summarizing this in the report.
<table>
<thead>
<tr>
<th>Participant</th>
<th>Organization</th>
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<tbody>
<tr>
<td>Daniel Meyer</td>
<td>Plum Creek Conservation District</td>
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<tr>
<td>Marcus Gary</td>
<td>Edwards Aquifer Authority</td>
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<td>Paul Bertetti</td>
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<td>Kendall Bell-Enders</td>
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<td>Larry Schmidlapp</td>
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<tr>
<td>Genell Hobbs</td>
<td>Kinney County Groundwater Conservation District</td>
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<tr>
<td>Joel Pigg</td>
<td>Real-Edwards Conservation and Reclamation District</td>
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<td>Paul Tybor</td>
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