A New Tool for Quantifying Impacts to Hydro-Economic Well Performance

Justin C. Thompson, Ph.D.

Groundwater Protection Council Annual Forum

Environmental Data Management

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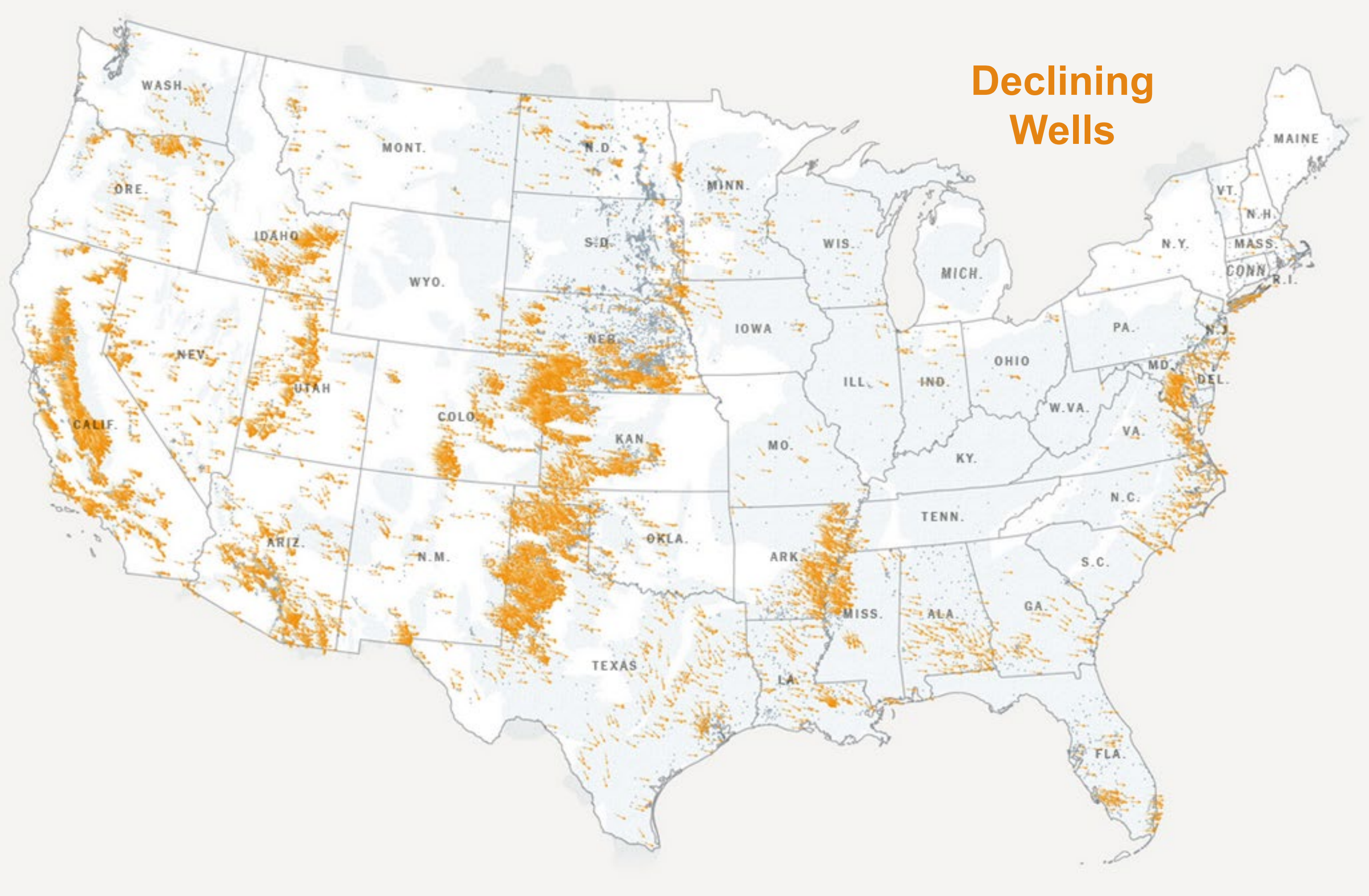
Bureau of Economic Geology

TEXAS Geosciences
The University of Texas at Austin
Jackson School of Geosciences

MOTIVATION

Depth-to-water (DTW) is increasing…

- What are the impacts?
- How can impacts be remediated? Mitigated?



"America Is Using Up Its Groundwater Like There's No Tomorrow"

New York Times, August 28, 2023

APPROACH

Analytically quantifying changes in hydro-economic well performance

APPROACH

1. Operational

Available head **declines** with increasing DTW

Can the well meet pumping demand without failing?

Remediation?

Threshold:
Operational Failure

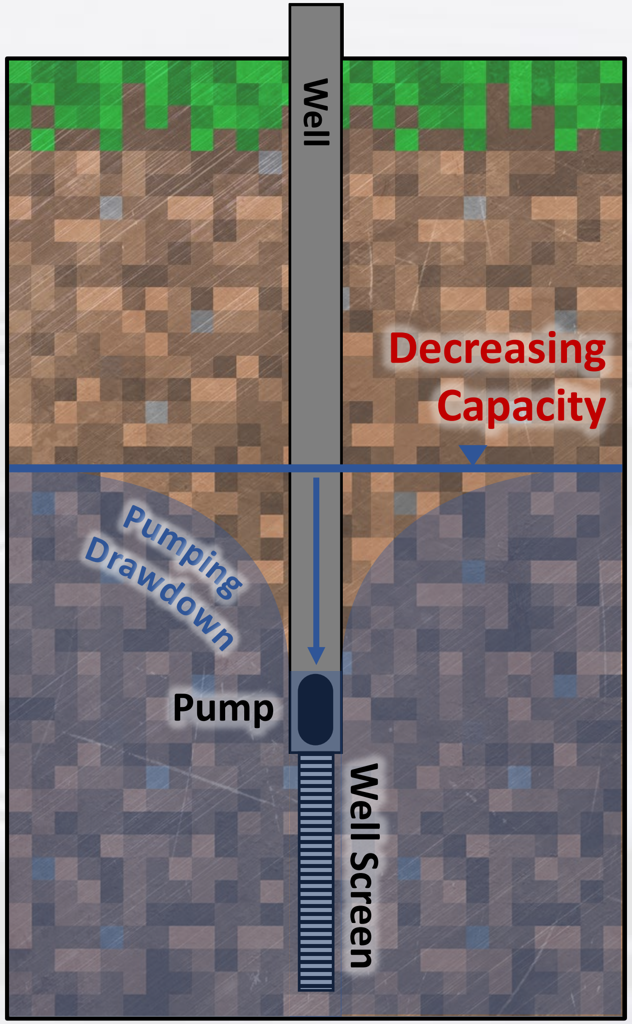
2. Economic

Costs **rise** with increasing DTW

How do pumping costs change? Are they affordable?

Remediation costs?

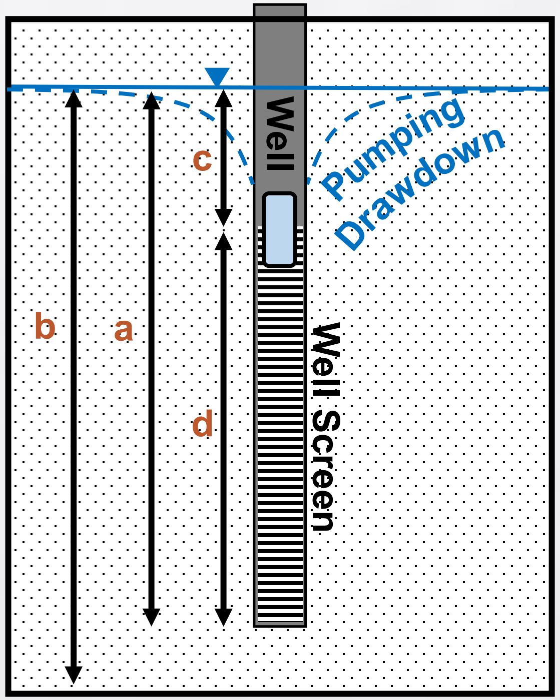
Threshold:
Costs = Willingness-to-Pay

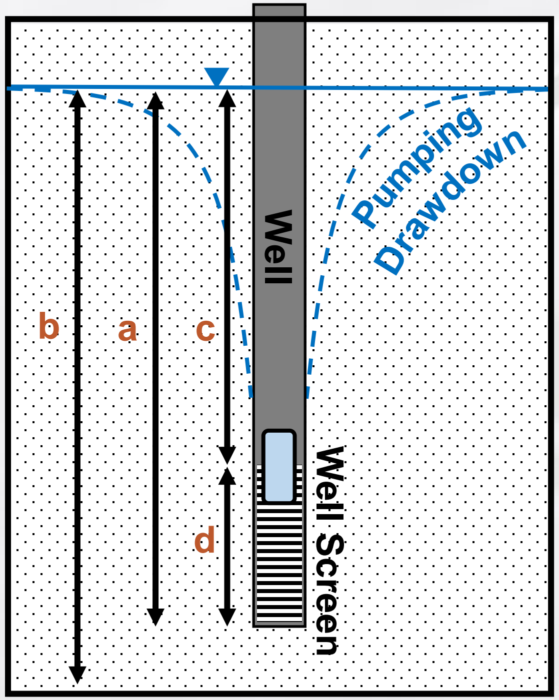


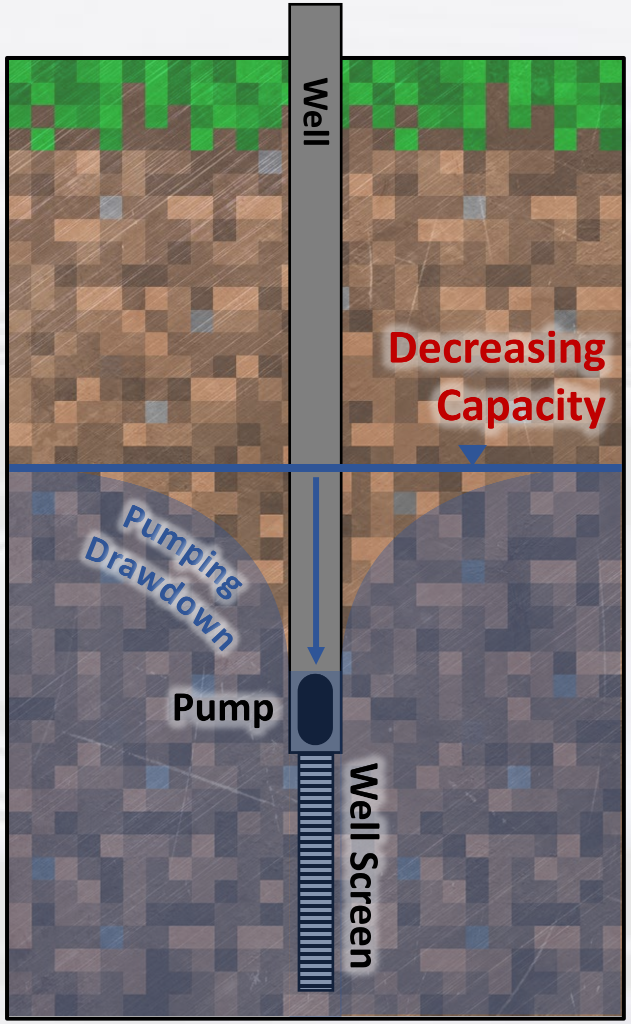
APPROACH

Pumping Drawdown

- *Specific Capacity* (Gailey et al. 2019, 2022; Thompson et al. 2020)
- $Theis^{\dagger} = \frac{Q}{4\pi T}\int_{u}^{\infty}\frac{e^{-y}}{y}dy \qquad u = \frac{r^2(S)}{4Tt}$
- $Hantush^{\dagger\dagger} = \frac{Q}{2\pi T}\frac{2b}{\pi d}\sum_{n=1}^{\infty}\frac{1}{n}\left[\sin\left(\frac{n\pi a}{b}\right) - \sin\left(\frac{n\pi c}{b}\right)\right]\cos\left(\frac{n\pi z}{b}\right)K_o\left(\frac{n\pi r\left(\frac{Kz}{Kx}\right)}{b}\right)$







[†Theis 1935. AGU Transactions, 16:519-524.] [††Hantush MS. 1961. JHD. ASCE, 87:HY4:83-98.]

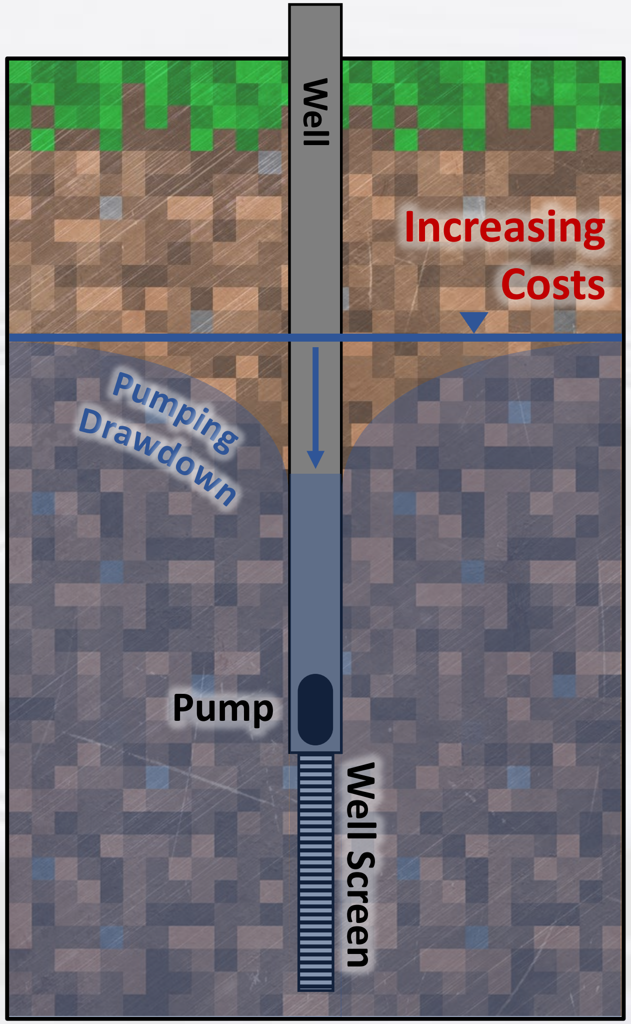
APPROACH

Cost Components

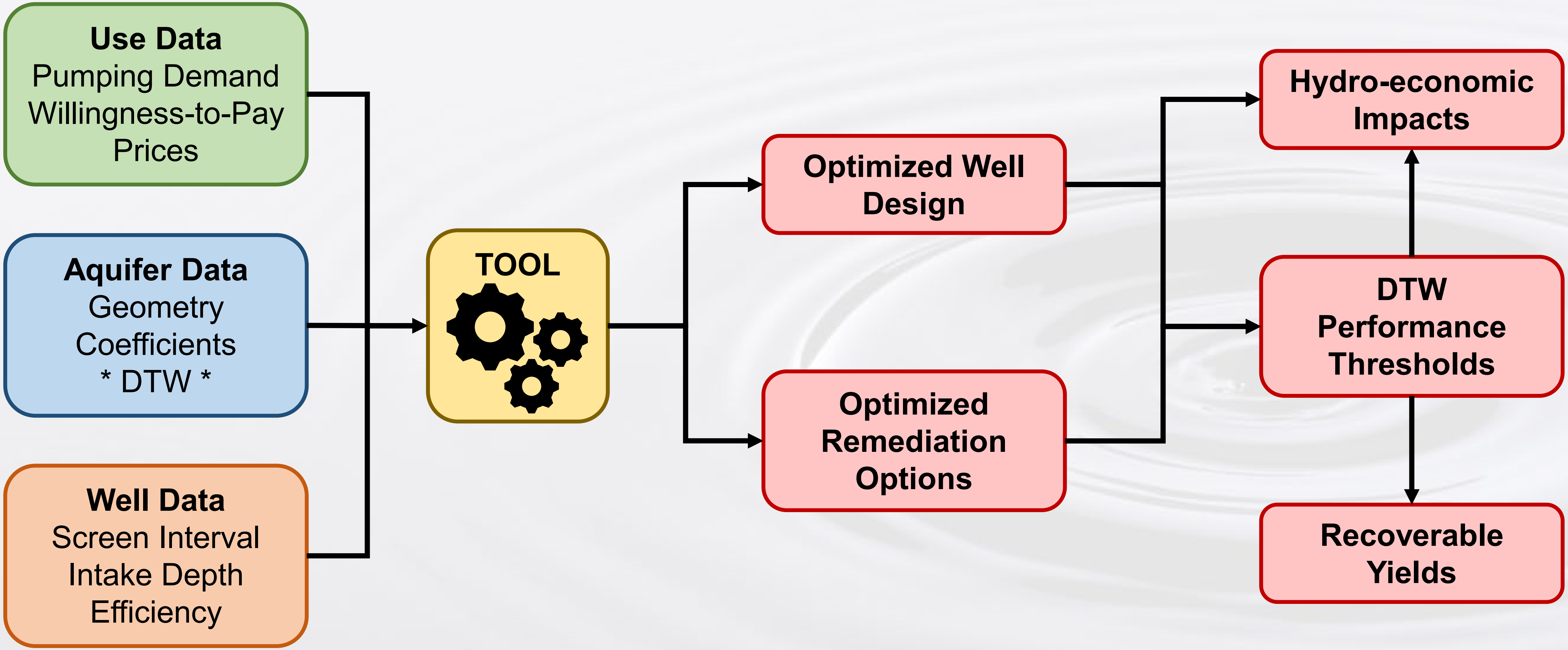
- $Lifting\ Energy = \left(\sum_{n=1}^{\max t} \frac{(DTW+s)\ Q\ 745.7\ P_p}{3960\ E}\right) \div Q\ t$
- $Pump\ Equipment = \frac{(DTW + \max s)\ Q\ P_u}{3960\ E\ L_u\ Q\ t}$
- $Drilling\ and\ Installation = \frac{P_d\ D}{L_w\ Q\ t}$

Remediation Costs

- Setting deeper pumps (*service cost)*
- Installing more powerful pumps (*equipment cost)*
- Well deepening (*drilling cost)*
- New wells (*drilling cost)*



APPROACH



Use Data
Pumping Demand
Willingness-to-Pay
Prices
Aquifer Data
Geometry
Coefficients
* DTW *
Well Data
Screen Interval
Intake Depth
Efficiency
TOOL
Optimized Well Design
Optimized Remediation Options
Hydro-economic Impacts
DTW Performance Thresholds
Recoverable Yields

CASE STUDY

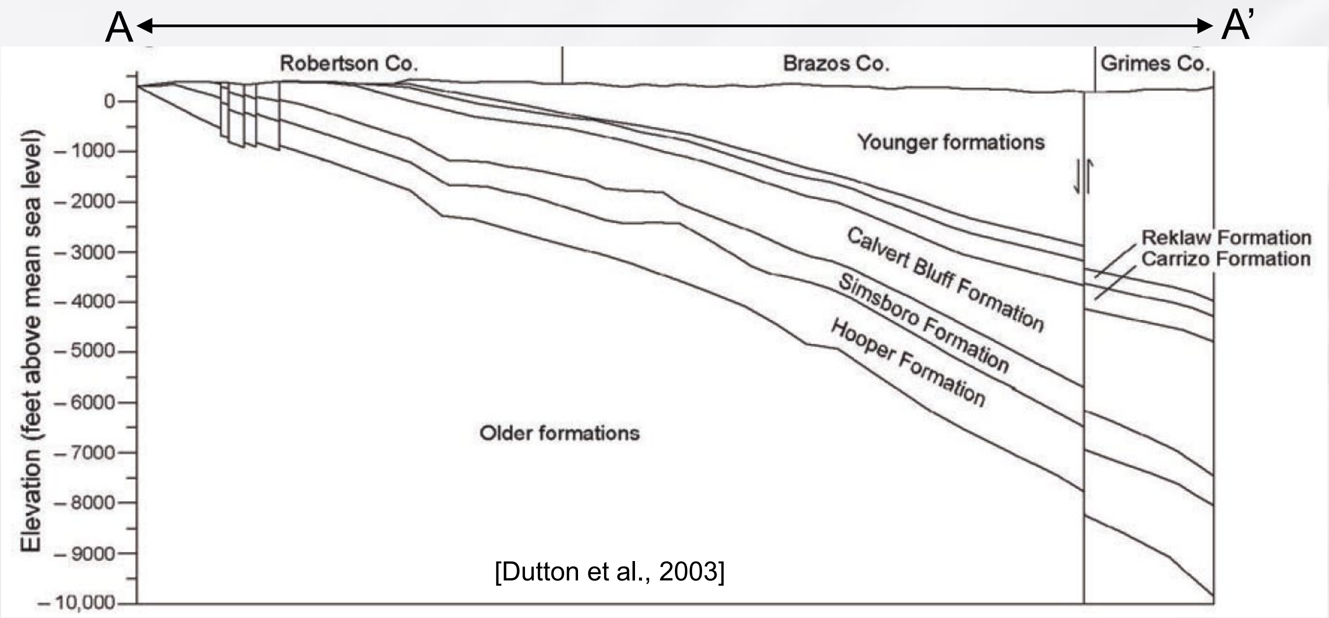
Carrizo-Wilcox Aquifer
Post Oak Savannah Groundwater Conservation District

CASE STUDY

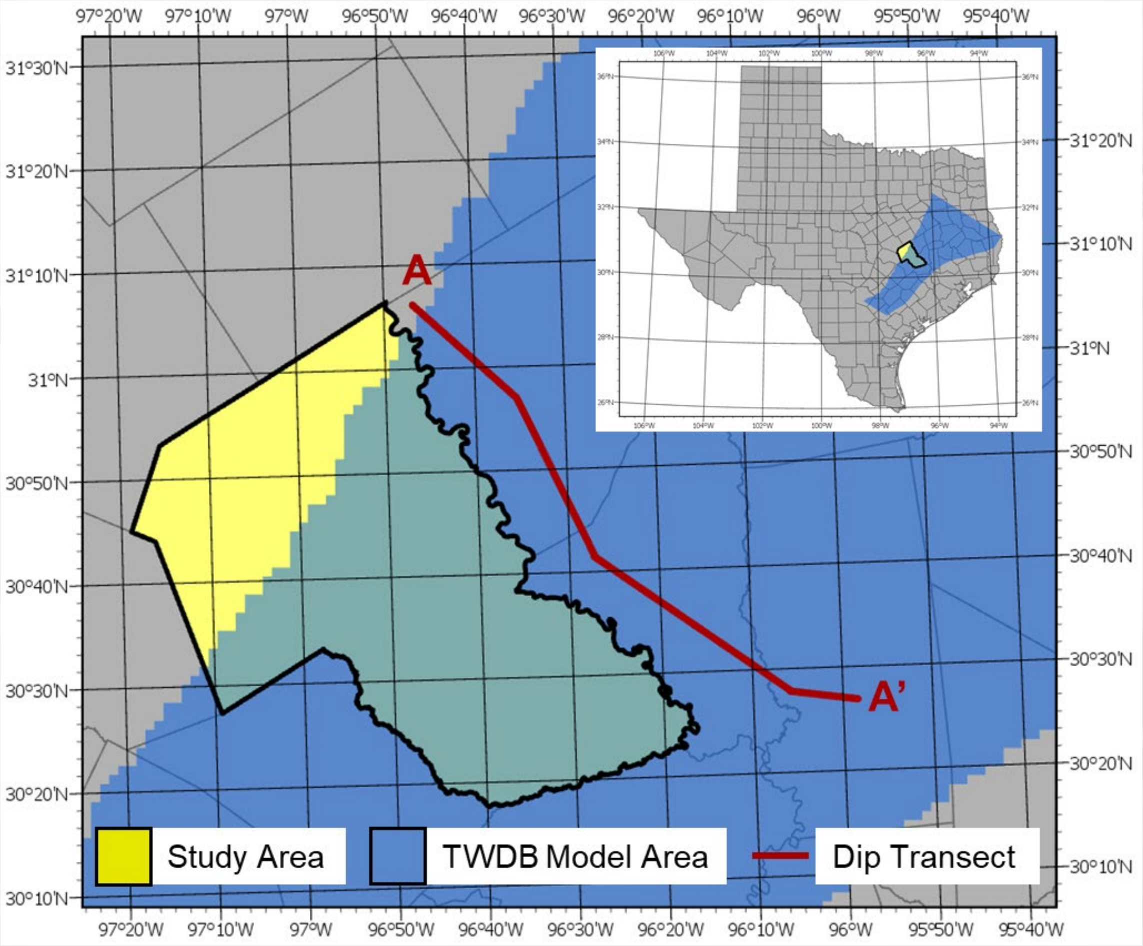
Post Oak Savannah GCD

- High storage, varied conditions
- 2010 – 2070 : ***50% to 109% increase in DTW***
- Vista Ridge Project
- Groundwater Well Assistance Program

	Carrizo Formation	Calvert Bluff Formation	Simsboro Formation	Hooper Formation
Plan	+146 ft	+156 ft	+278 ft	+178 ft
2010 DTW	292 ft	302 ft	256 ft	305 ft
2070 DTW	438 ft	458 ft	534 ft	483 ft
DTW Change	**+50%**	**+52%**	**+109%**	**+58%**



[Dutton et al., 2003]



PRELIMINARY!

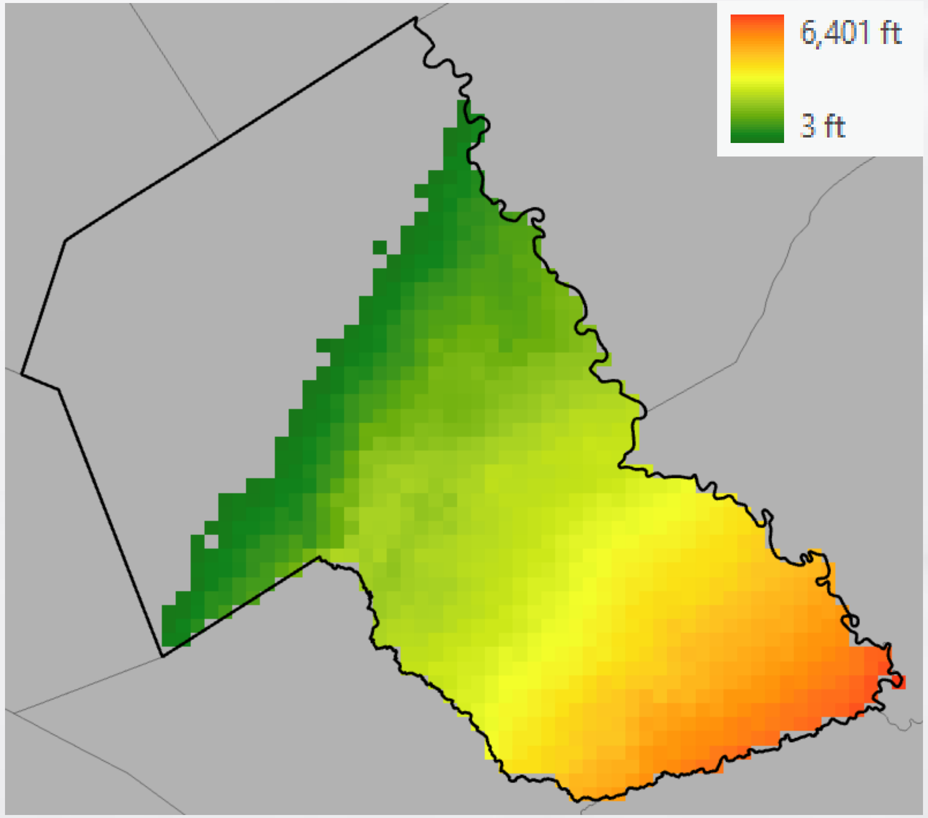
RESULTS

Post Oak Savannah Groundwater Conservation District

RESULTS

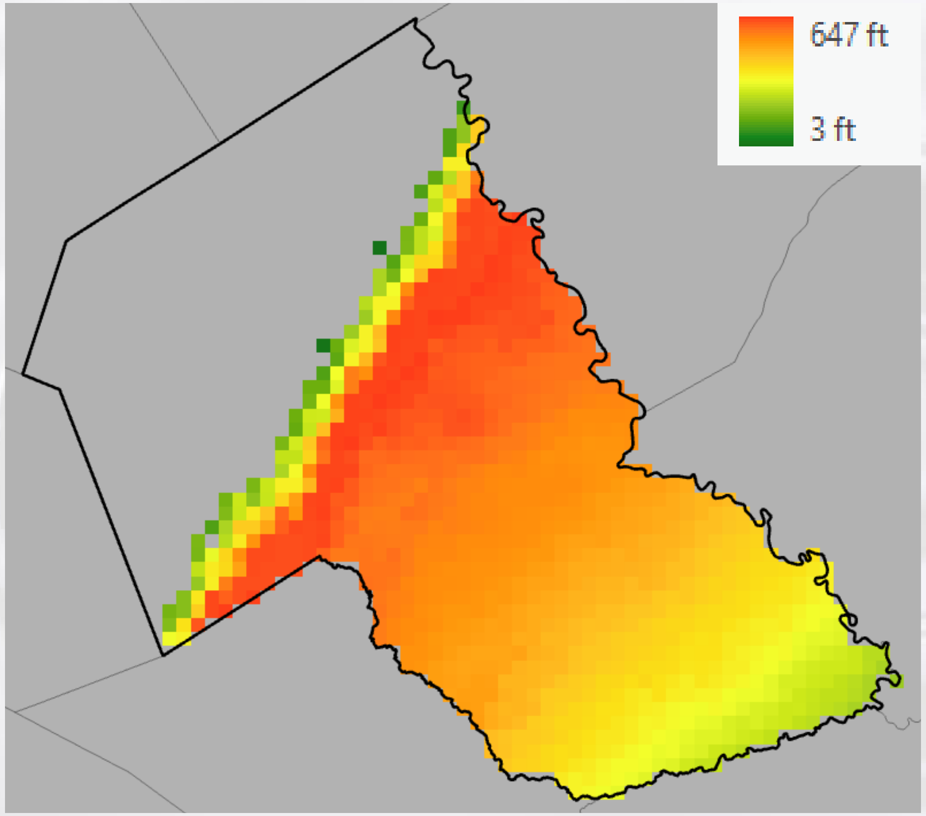
Model-optimized wells, agricultural use, 2010 DTW

Operational Threshold



Simsboro Formation

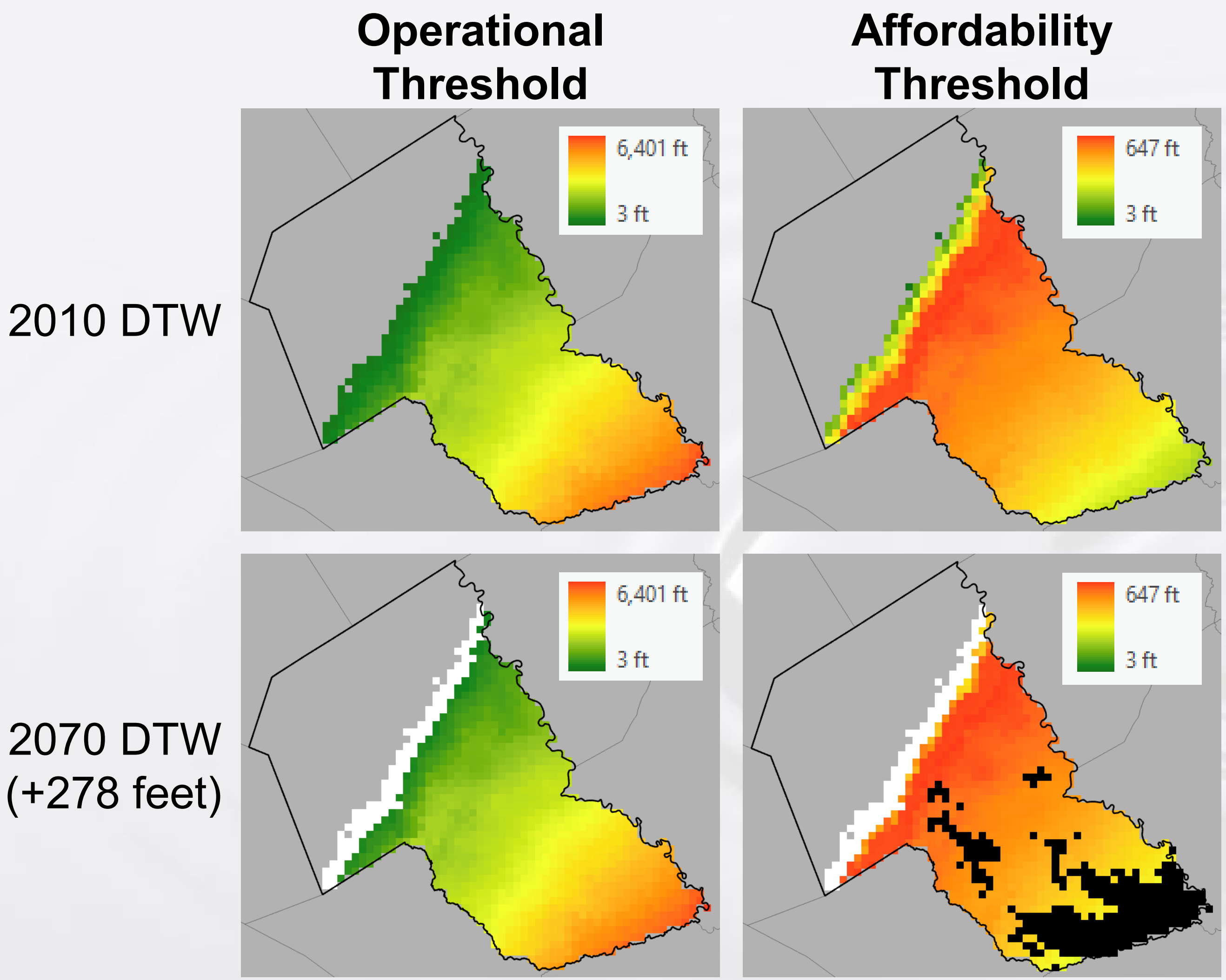
Affordability Threshold



Simsboro Formation

RESULTS

Model-optimized wells, agricultural use



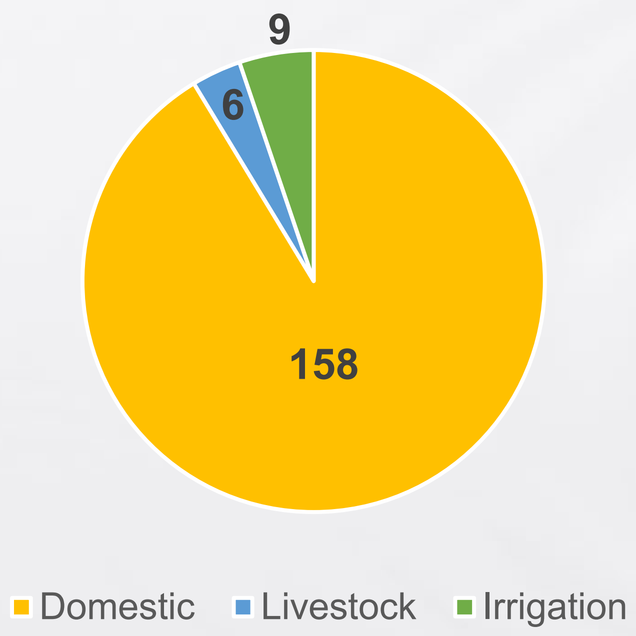
Simsboro Formation

RESULTS

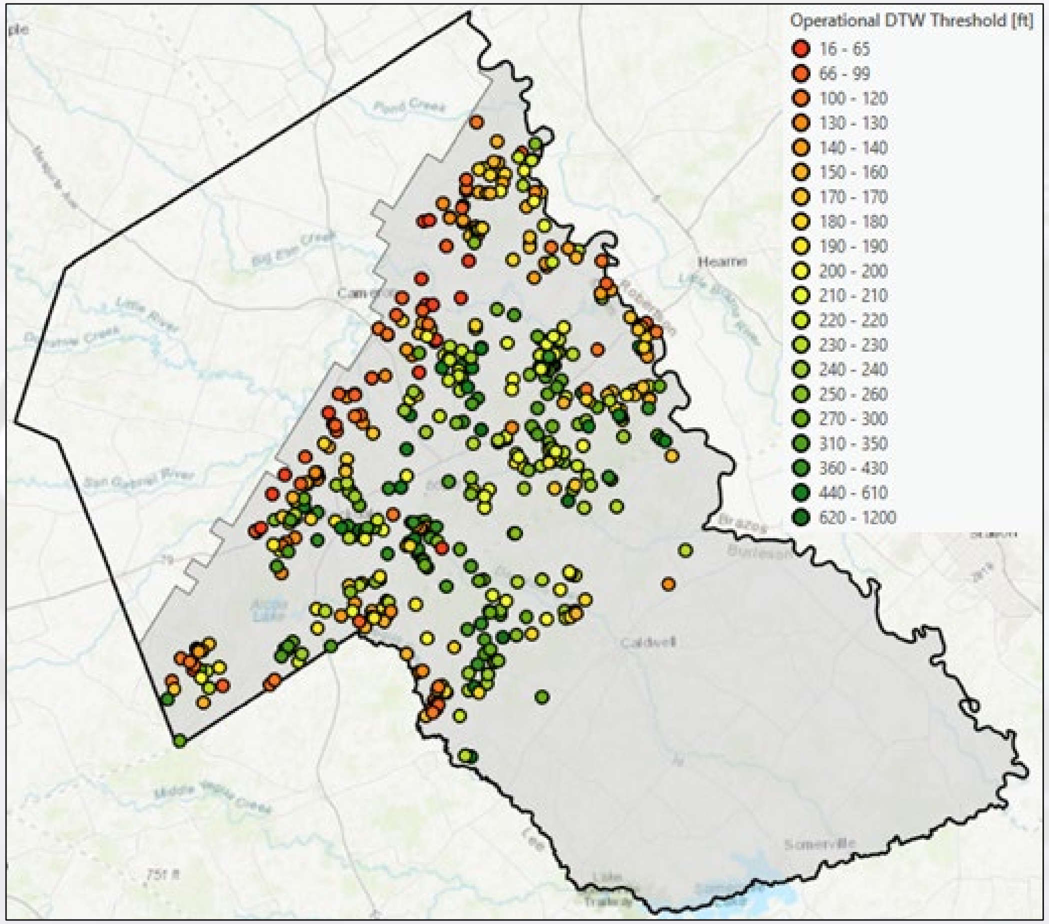
503 existing domestic, livestock, and irrigation wells

34% of Wells Operationally Fail

Remediation: 82% pump drop, 18% deepening



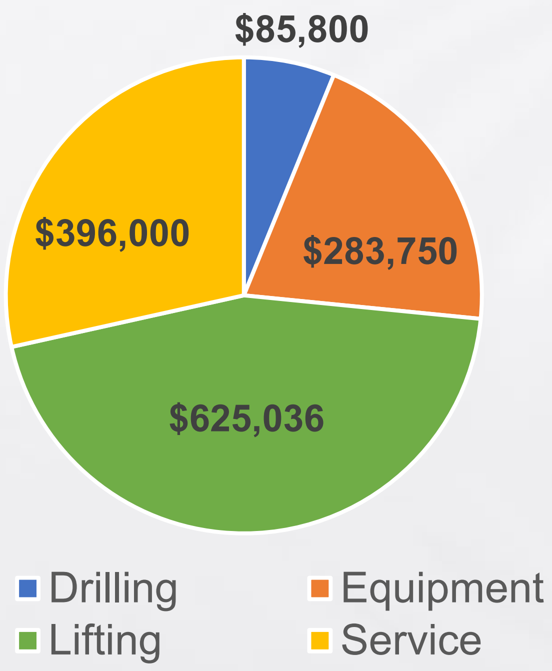
2070 DTW Operational Threshold



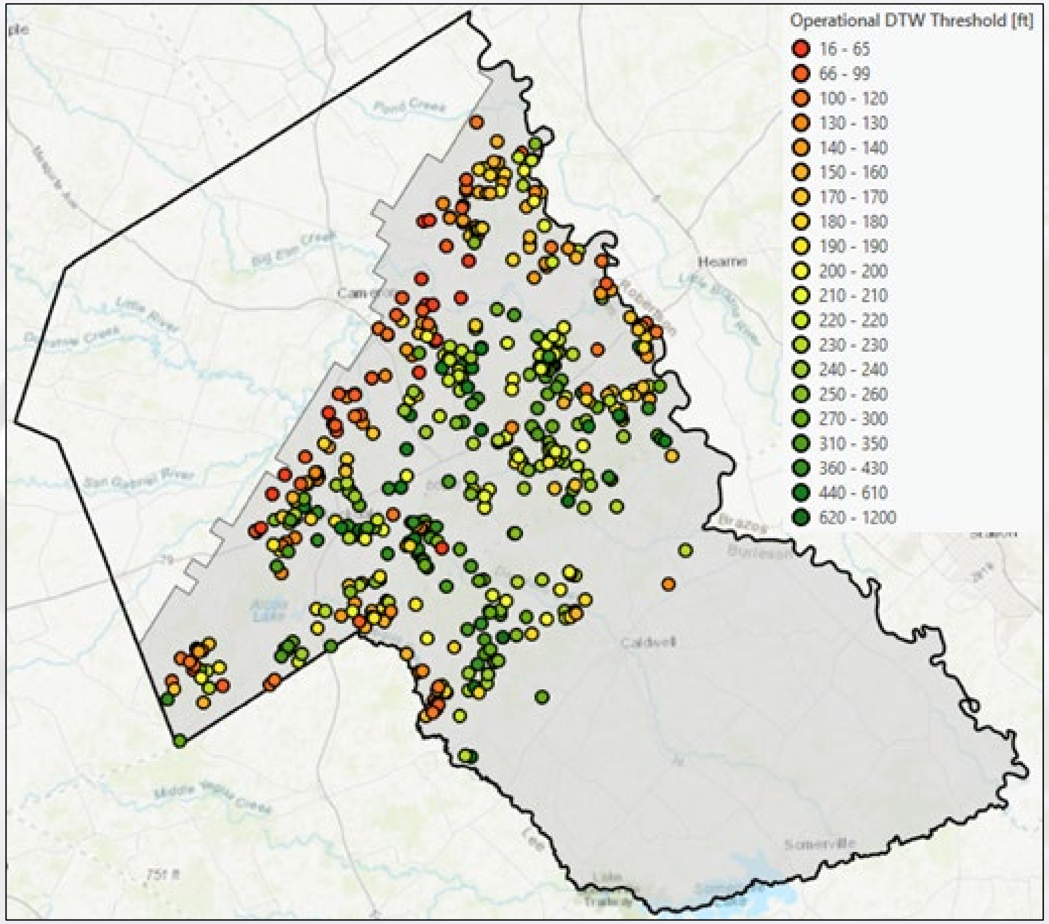
RESULTS

503 existing domestic, livestock, and irrigation wells

503 Domestic, Livestock & Irrigation Wells
45% Cost Increase ($1,390,580)



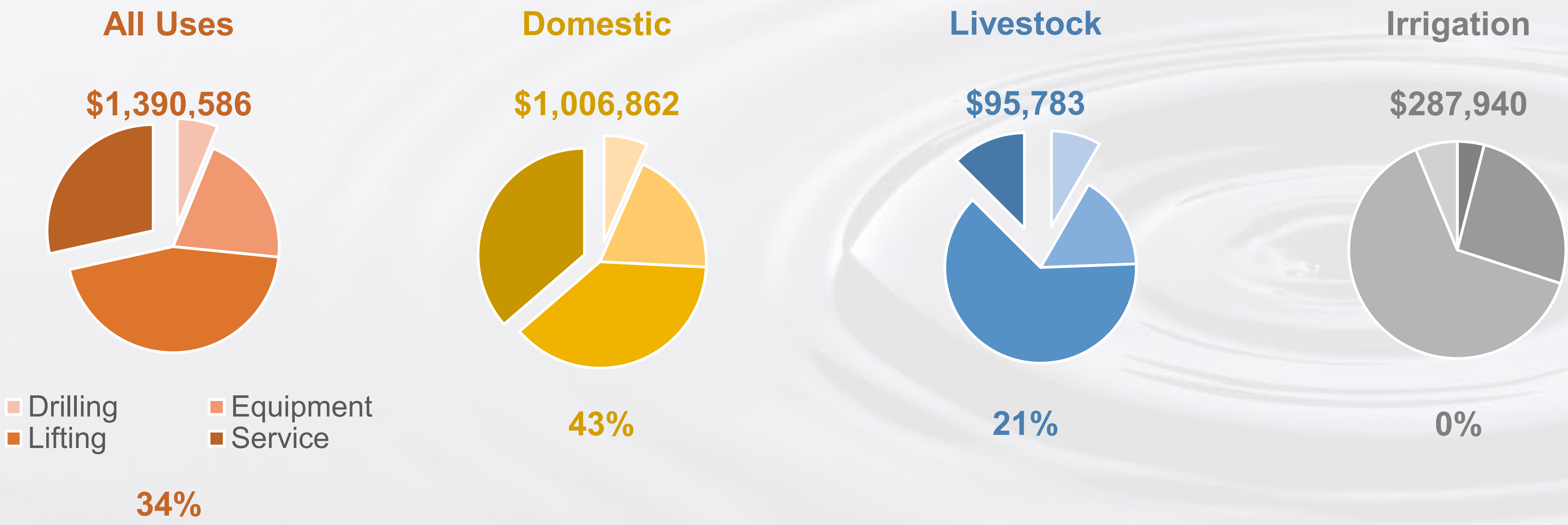
2070 DTW Operational Threshold



RESULTS

503 existing domestic, livestock, and irrigation wells

GWAP Eligible Added Costs at the 2070 DTW



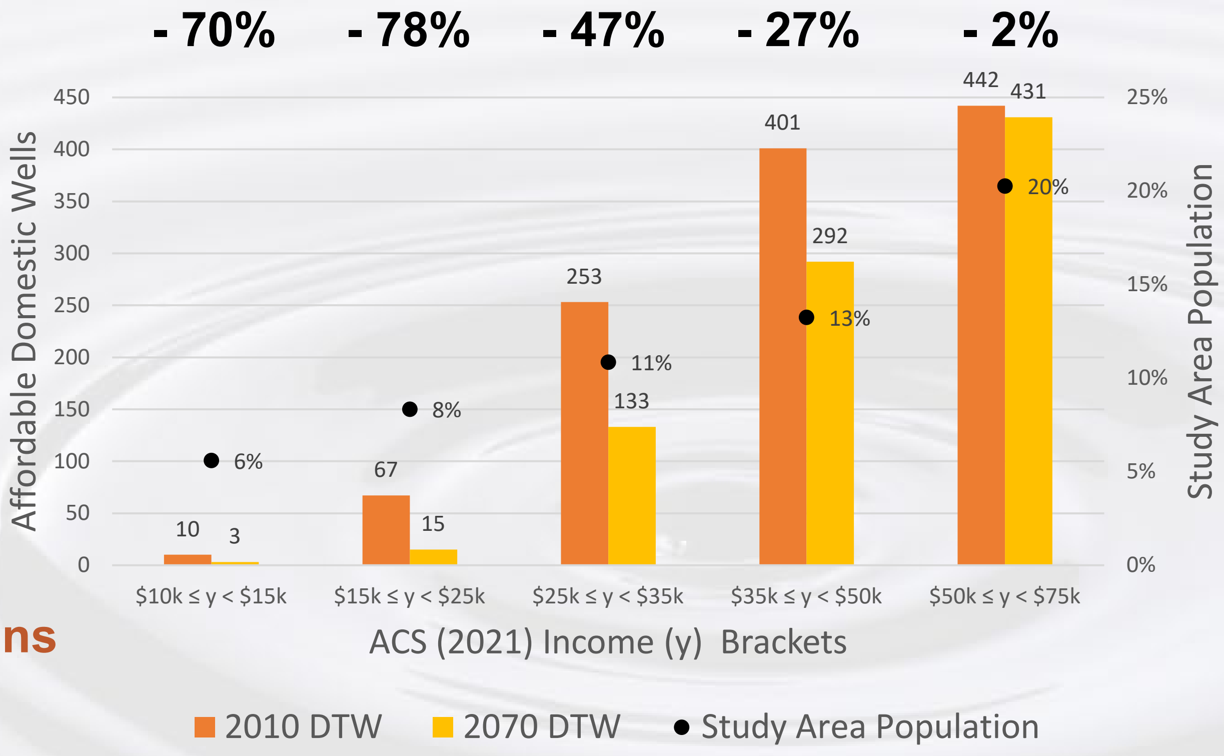
RESULTS

445 existing domestic wells

Domestic Affordability

- EPA affordability = 2.5% income
- Income data by census tract
- 99% of domestic wells affordable by MHI *but…*

- **Disproportionate impacts to low-income populations**



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KEY TAKEAWAYS

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New Tool

- Quantifying changes in hydro-economic well performance
- Drawdown as a key driver of performance
- Operational and affordability DTW thresholds and yields
- Cost impacts (by type over period, annual, or volume)
- Optimization solutions for well infrastructure
    - Least-cost remediation options
    - Maximized performance thresholds

ACKNOWLEDGEMENTS

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STARR

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Thank you for listening!

Questions?

justin.thompson@beg.utexas.edu

(512) 471-0217

[Pecos River, Val Verde County, J.C. Thompson]