



KT GROUNDWATER

Tools and Insights: Data-Driven Groundwater Resource Management in Bell County

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Mike Keester, P.G., Philip Webster, P.G.

Acknowledgements

Clearwater

Underground Water Conservation District



Every drop counts!

Reproducible

Defensible

Data-driven



Aquifer Data Analysis Tool

- Change over time?
- Water quality?



CGMM Tool

- Evaluate modeled impacts of adding pumping

Aquifer Data Analysis Tool

History of Aquifer Data Analysis Tool

2014

Equations in
Excel workbook



2016

Created a
dashboard using
R



2017-2021

Added
functionality to
R dashboard
(water level
maps, water
quality analyses,
bug fixes)

2022-2024

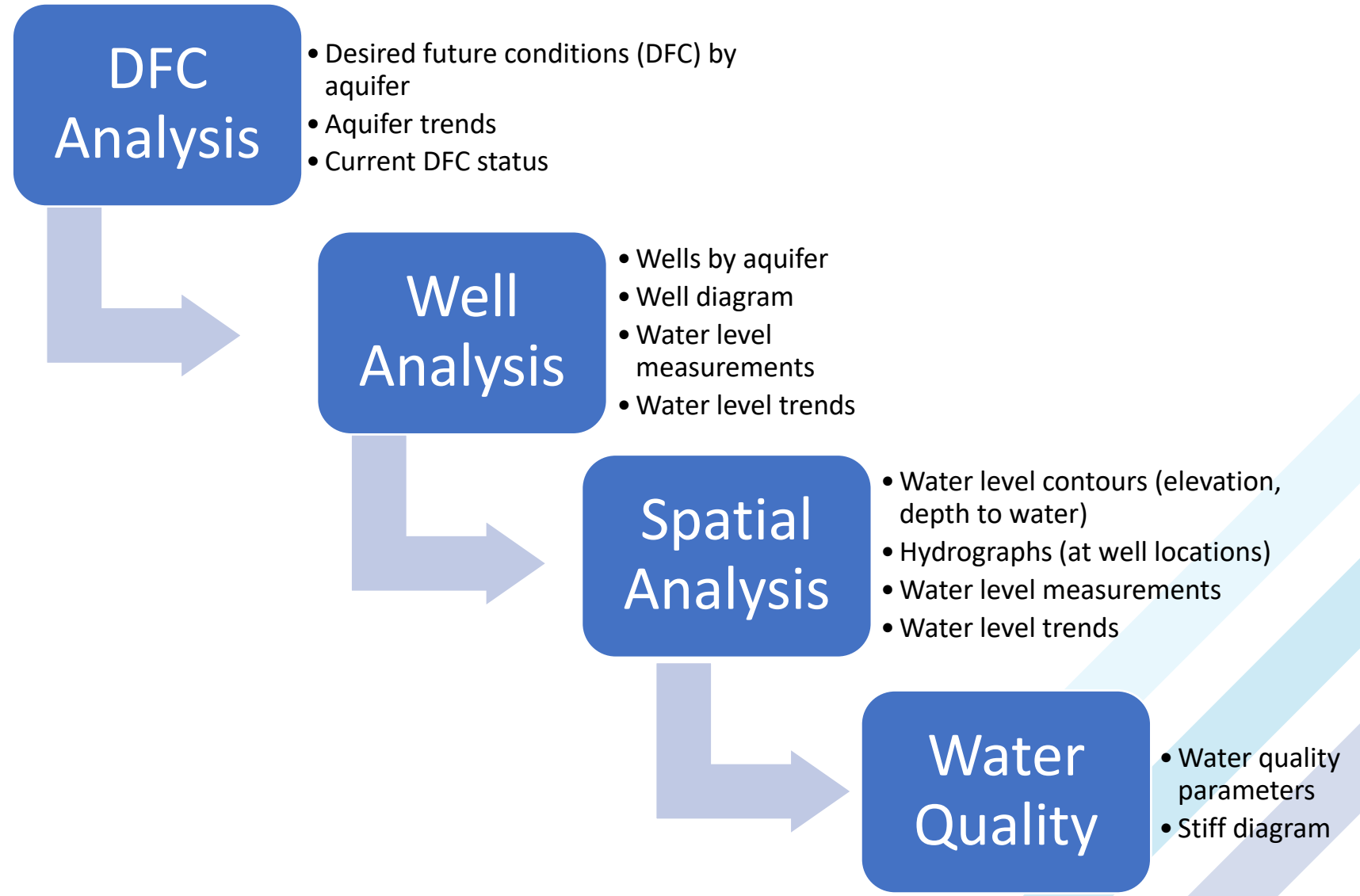
Maintained
tool; no major
updates

2025

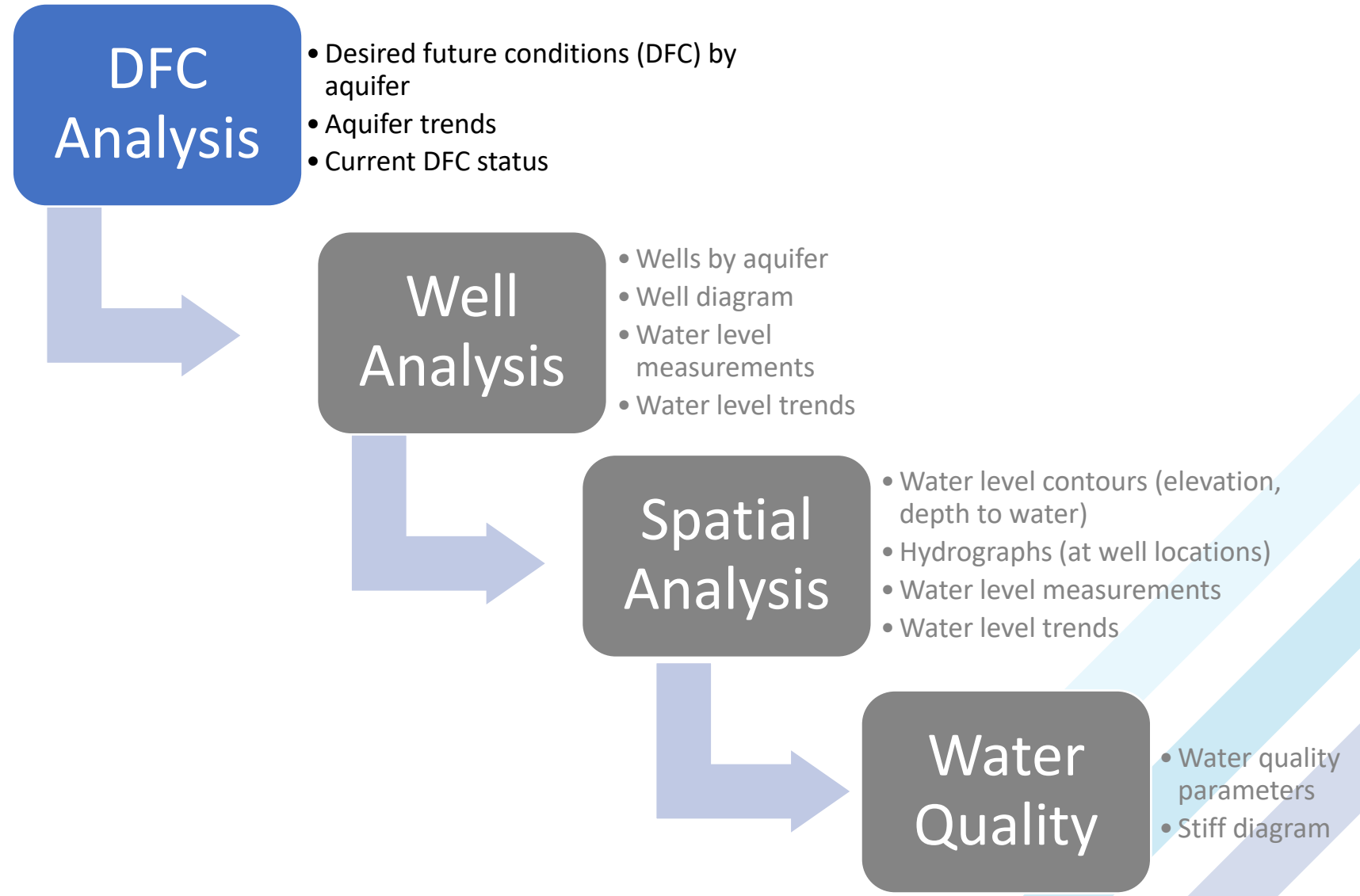
Update tool
programming,
appearance, and
accessibility
using Python



Aquifer Data Analysis Tool - Overview



Aquifer Data Analysis Tool - Overview



DFC Results

Edwards (BFZ) DFC

Upper Trinity DFC

Middle Trinity DFC

Lower Trinity DFC

DFC Summary for Slope Analysis

Aquifer	Adopted DFC (ft of Avg. Drawdown)	Annual DFC (ft/yr of Avg. Drawdown)	Average Current Trend (ft/yr)	Median Current Trend (ft/yr)
Edwards (BFZ)			-0.13	-0.09
Upper Trinity	83	-1.17	-2.45	-1.98
Middle Trinity	145	-2.04	-6.26	-4.44
Lower Trinity	375	-5.28	-4.97	-4.65

DFC Results	Edwards (BFZ) DFC	Upper Trinity DFC	Middle Trinity DFC	Lower Trinity DFC
DFC Summary for Slope Analysis				
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Aquifer	Adopted DFC (ft of Avg. Drawdown)
Edwards (BFZ)	
Upper Trinity	83
Middle Trinity	145
Lower Trinity	375

Acceptable feet of drawdown from 2010 - 2080

DFC Results		Edwards (BFZ) DFC	Upper Trinity DFC	Middle Trinity DFC	Lower Trinity DFC
DFC Summary for Slope Analysis					
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Annual DFC (ft/yr of Avg. Drawdown)

-1.17

-2.04

-5.28

Average acceptable feet of drawdown per year

DFC Results		Edwards (BFZ) DFC	Upper Trinity DFC	Middle Trinity DFC	Lower Trinity DFC
DFC Summary for Slope Analysis					
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Average Current Trend (ft/yr)
-0.13
-2.45
-6.26
-4.97

Current yearly average change in water level

Current yearly average change in water level

DFC Results		Edwards (BFZ) DFC	Upper Trinity DFC	Middle Trinity DFC	Lower Trinity DFC
DFC Summary for Slope Analysis					
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Median Current Trend (ft/yr)
-0.09
-1.98
-4.44
-4.65

Middle value of all water level changes

Edwards Wells Selection for DFC Slope Analysis

Aquifer	Adopted DFC (ft of Avg. Drawdown)	Annual DFC (ft/yr of Avg. Drawdown)	Average Current Trend (ft/yr)	Median Current Trend (ft/yr)
Edwards (BFZ)			-0.13	-0.09

Well Data & Slope Trends

	Well Name	Number of Water Level Measurements	Slope (ft/year)	Management Zone
<input checked="" type="checkbox"/>	EDWARDS (BFZ) (WELL NAME)	271	-0.47	Eastern
<input checked="" type="checkbox"/>	EDWARDS (BFZ) (WELL NAME)	244	-0.09	Eastern
<input checked="" type="checkbox"/>	EDWARDS (BFZ) (WELL NAME)	243	0.06	Eastern
<input checked="" type="checkbox"/>	EDWARDS (BFZ) (WELL NAME)	243	-0.13	Stillhouse Hollow
<input checked="" type="checkbox"/>	EDWARDS (BFZ) (WELL NAME)	240	-0.01	Stillhouse Hollow
<input checked="" type="checkbox"/>	EDWARDS (BFZ) (WELL NAME)	240	1.34	Eastern
<input checked="" type="checkbox"/>	EDWARDS (BFZ) (WELL NAME)	233	0.13	Stillhouse Hollow

Edwards Wells Selection for DFC Slope Analysis

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Well Data & Slope Trends

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243	-0.13	Stillhouse Hollow	
240	-0.01	Stillhouse Hollow	
240	1.34	Eastern	
233	0.13	Stillhouse Hollow	

Total number of water level measurements made at the well

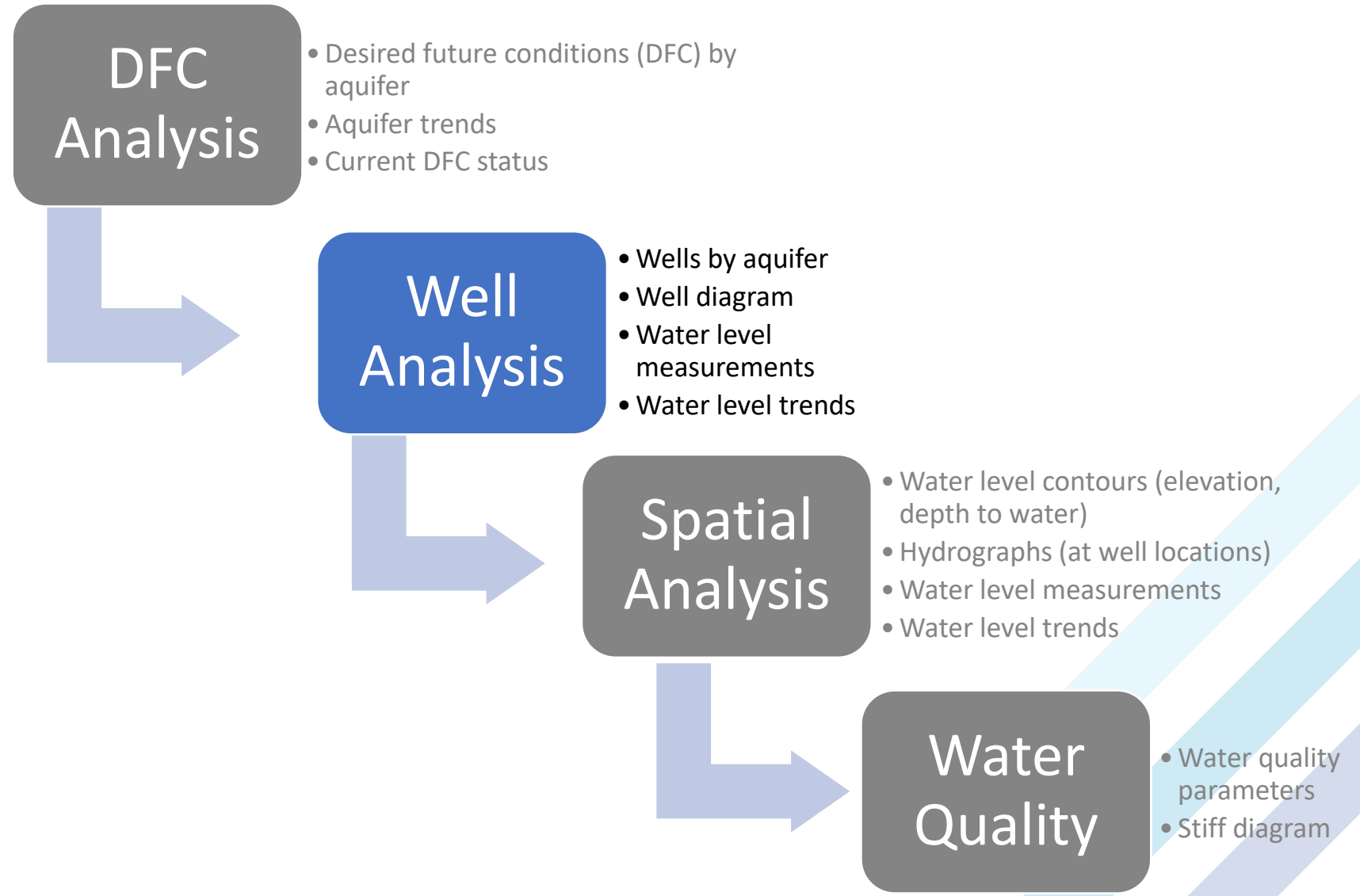
Can sort table by well name, number of measurements, slope, or management zone

Number of Water Level Measurements	Slope (ft/year)	Management Zone
271	-0.47	Eastern
244	-0.09	Eastern
243	0.06	Eastern
243	-0.13	Stillhouse Hollow
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240	1.34	Eastern
233	0.13	Stillhouse Hollow

Water level decreasing

Water level increasing

Aquifer Data Analysis Tool - Overview



Highest Water Level (Feet Below Ground Level)
75.59

Highest and lowest water level ever recorded

Lowest Water Level (Feet Below Ground Level)
103.19

Historic Largest Change (feet)
27.6

Largest water level change recorded

Most Recent Water Level Change (feet)
0

Slope (feet/year)	NTWGAM Initial Head (ft bgl)
-0.12	84

Water level trend

Edwards Well Analysis	Upper Trinity Well Analysis	Middle Trinity Well Analysis	Lower Trinity Well Analysis
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Well Selection & Filters

× ▾
 Start Date → End Date

Period of Record
 1 Year
 DFC Period

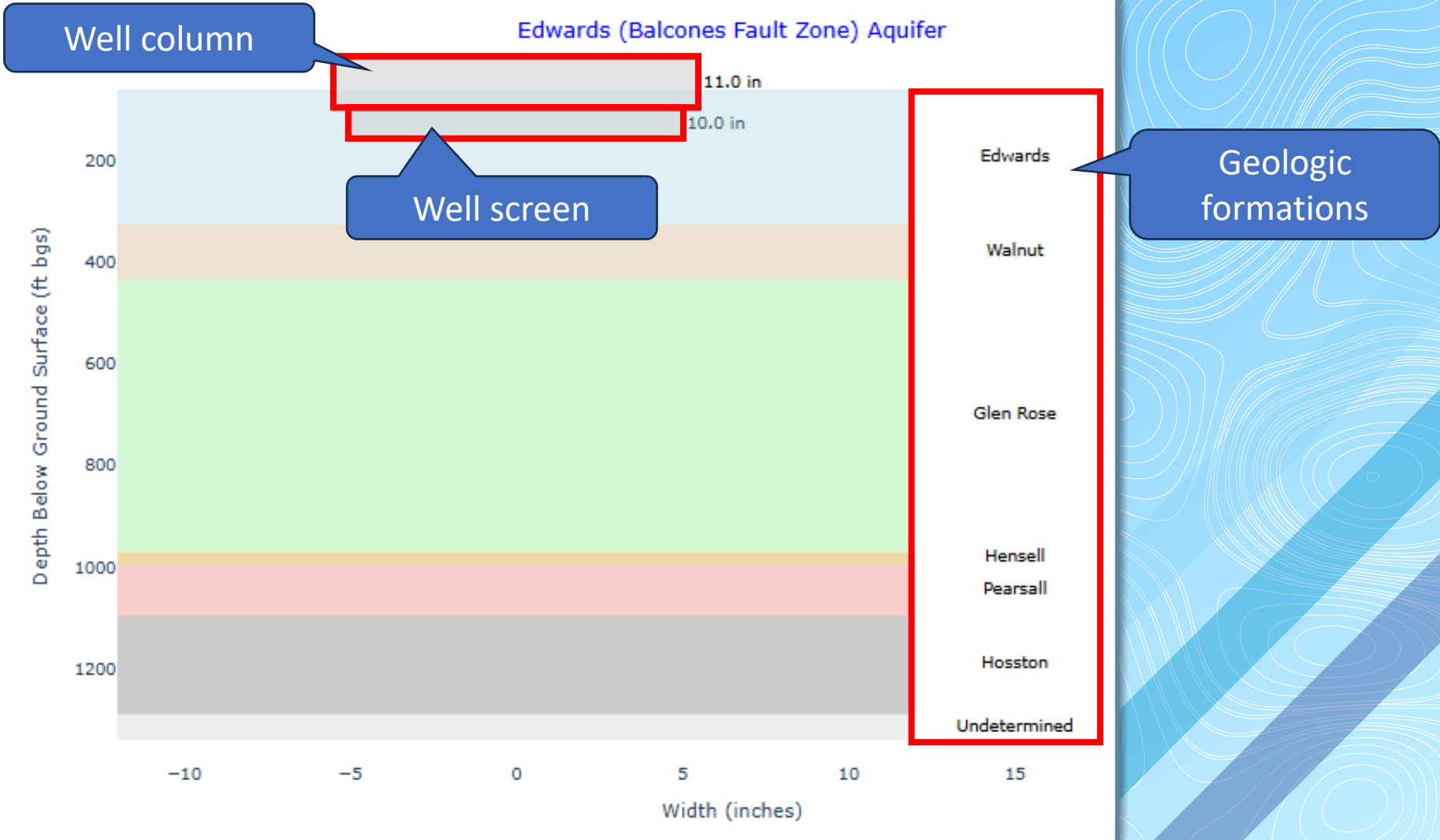
Choose time period

Well Details

State Well Number: N/A
Primary Water Use: Public Supply
Latitude:
Longitude:
Aquifer: Edwards (BFZ)
Well ID:
Total Records: 233

Well Diagram

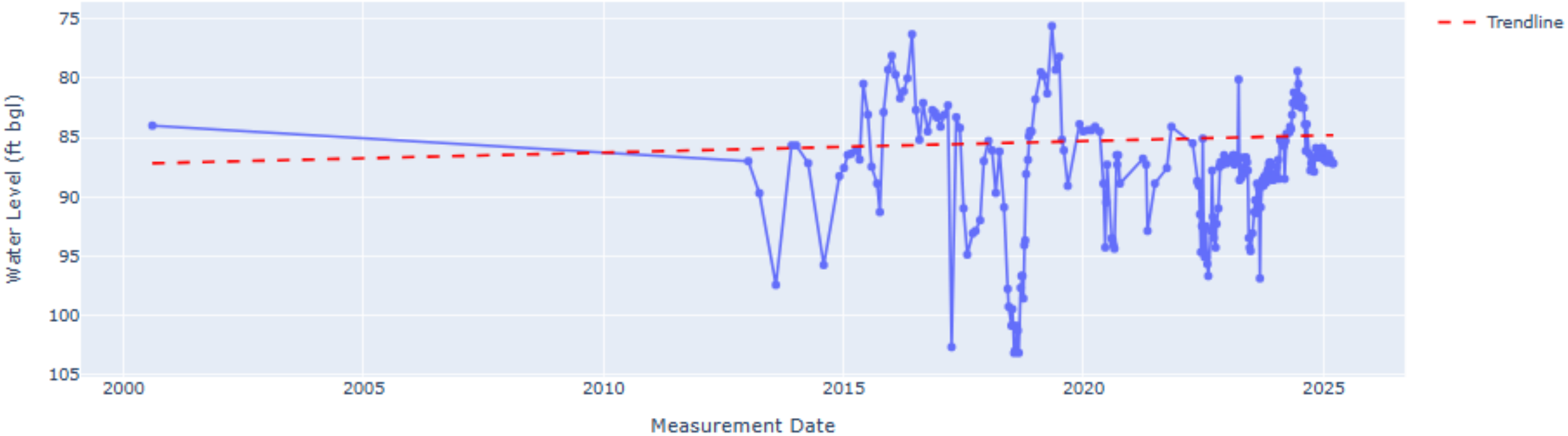
Well Diagram: CUWCD Well Number N2-02-010G / State Well Number 5804512



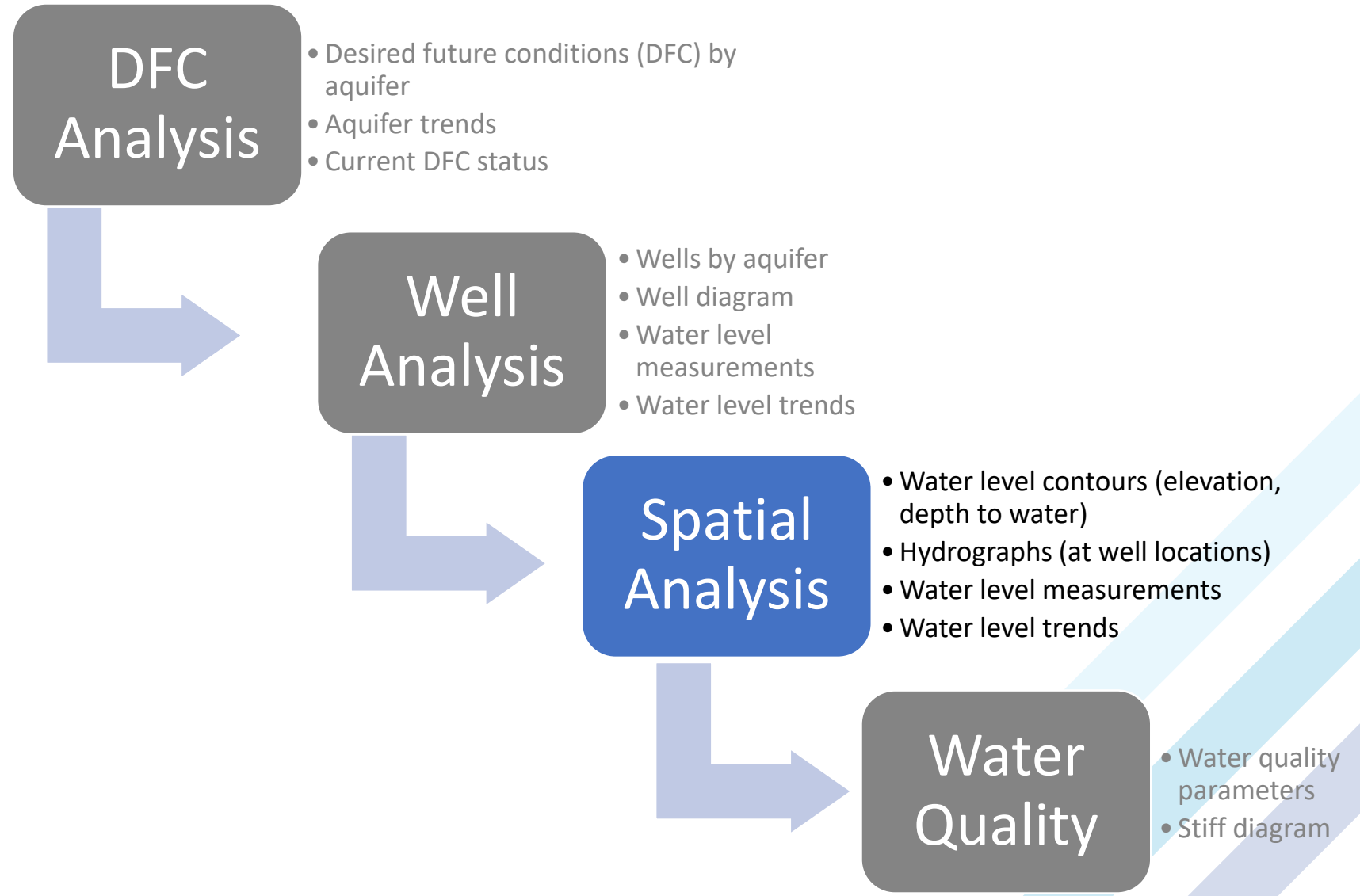
Historic
water level
data

Hydrograph

Water Level Hydrograph



Aquifer Data Analysis Tool - Overview

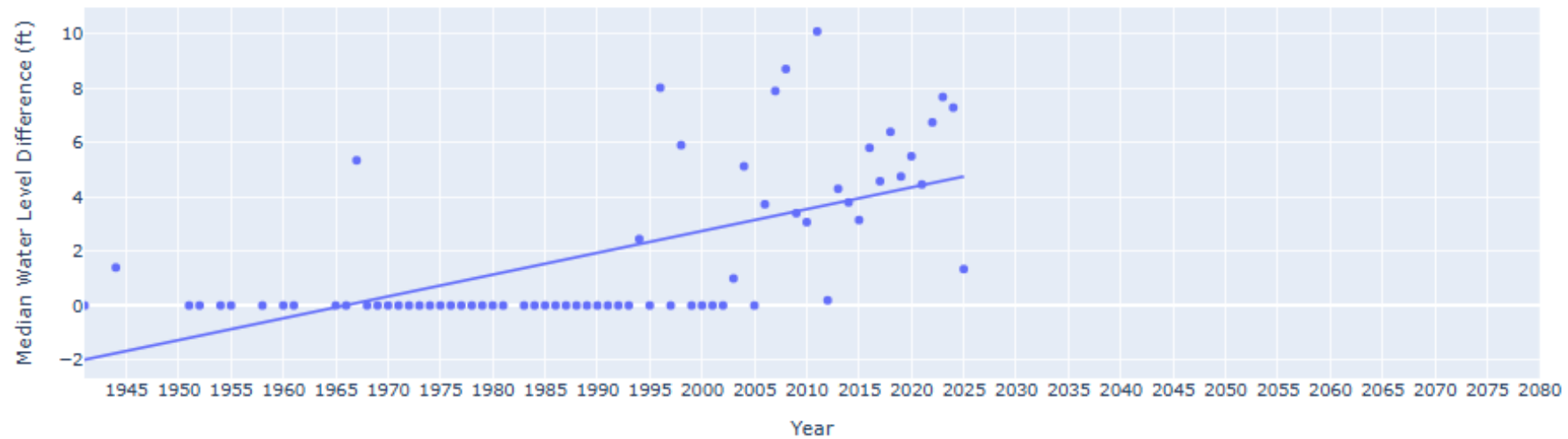


Select Time Period Range

Results Table

Average Slope (ft/yr)	Median Slope (ft/yr)
-4.97	-4.65

Hydrograph



2024-12-31

Water Elevation (ft)

0

20

40

60

80

100

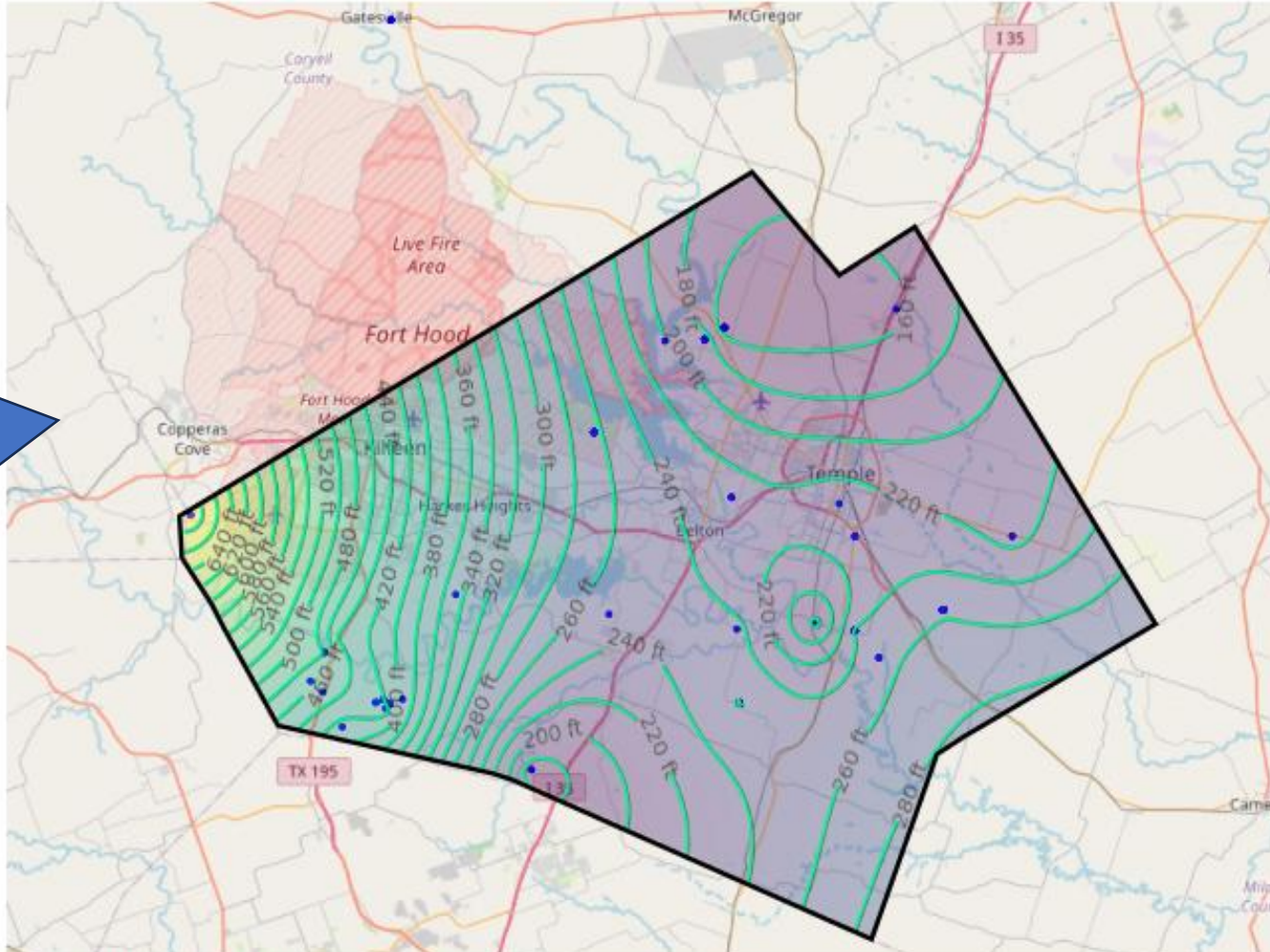
120

140

160

180

Map Of Existing Wells



Water level decreases from west to east

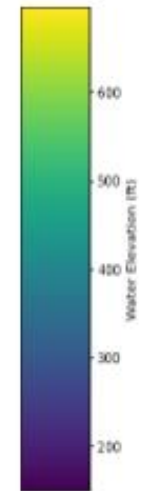
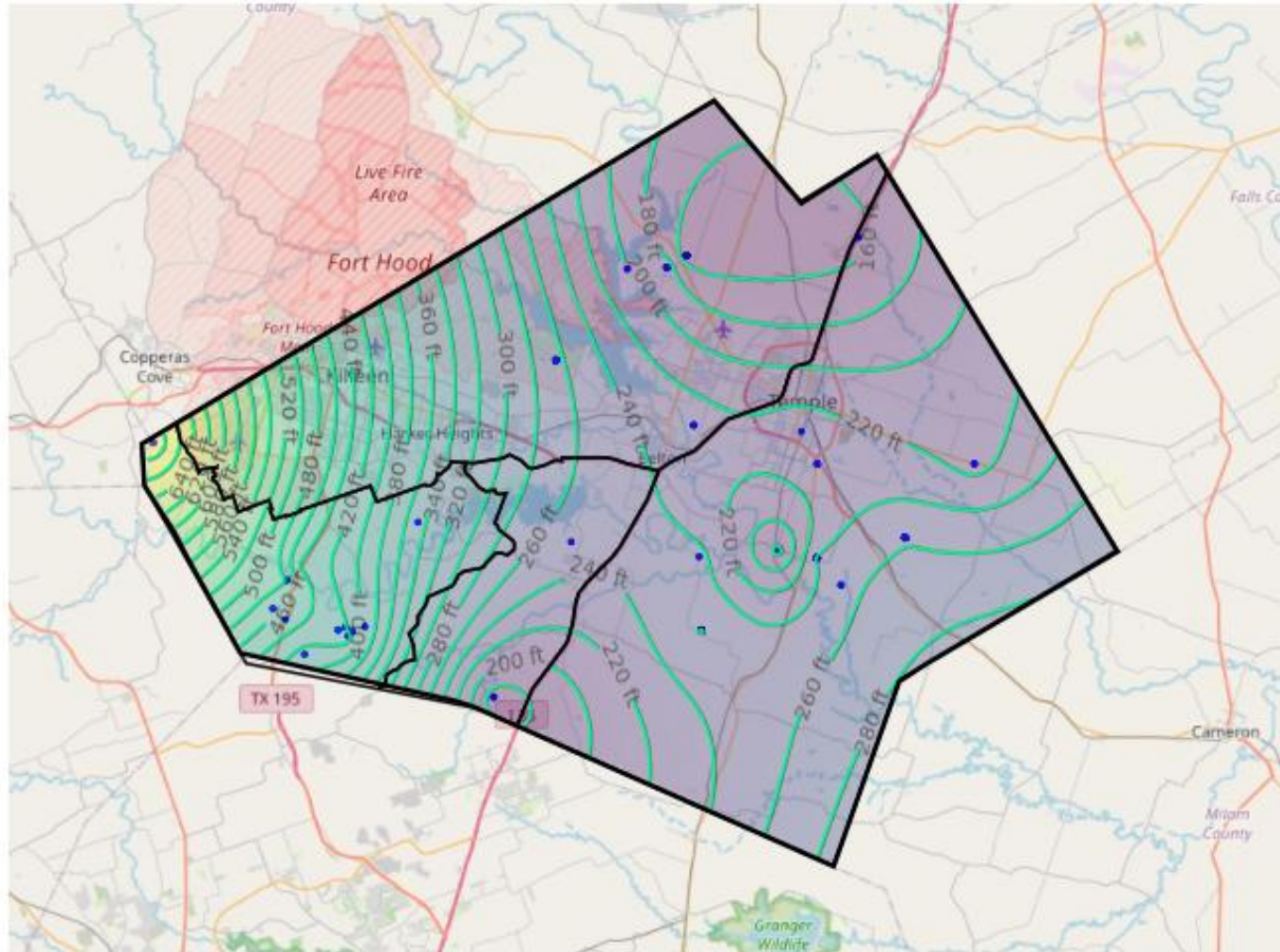
Management Zones Faults

2024-12-31

Water Elevation (ft)



Map Of Existing Wells



Management Zones Faults

2024-12-31



Water Elevation (ft)



0

20

40

60

80

100

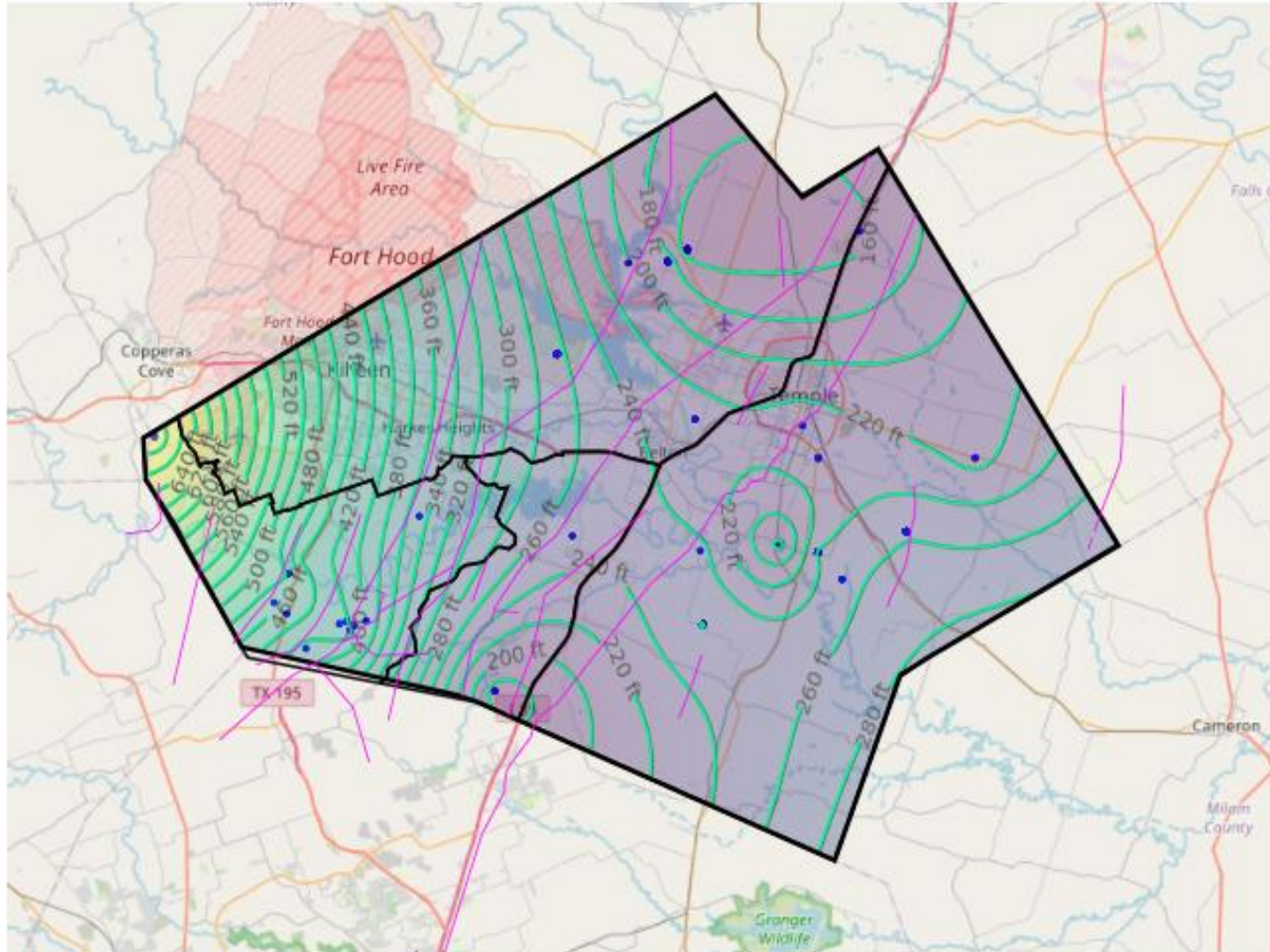
120

140

160

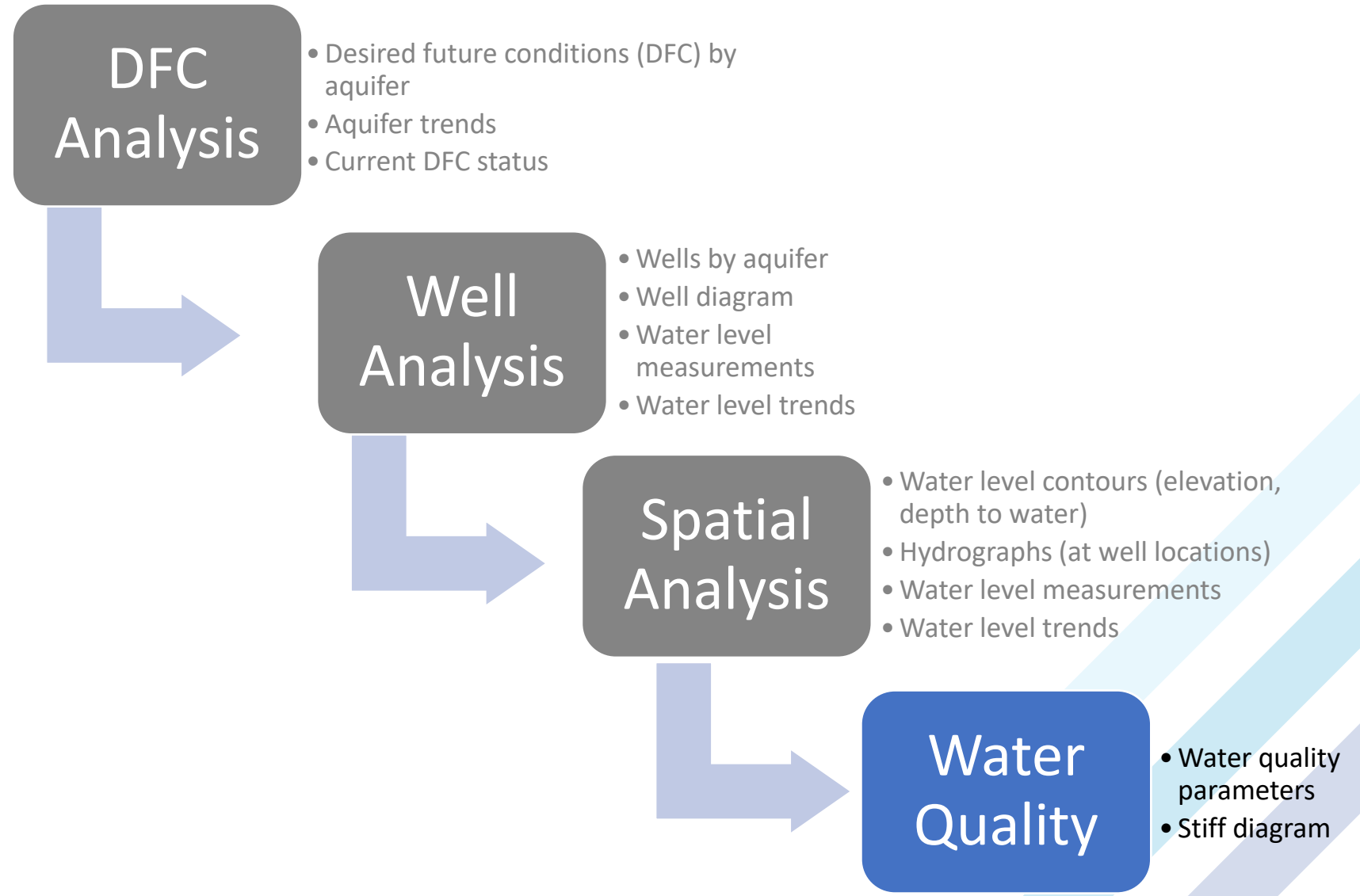
180

Map Of Existing Wells



Management Zones Faults

Aquifer Data Analysis Tool - Overview



Edwards Water Quality

Upper Trinity Water Quality

Middle Trinity Water Quality

Lower Trinity Water Quality

Select Water Quality Parameter

TDS (mg/L)

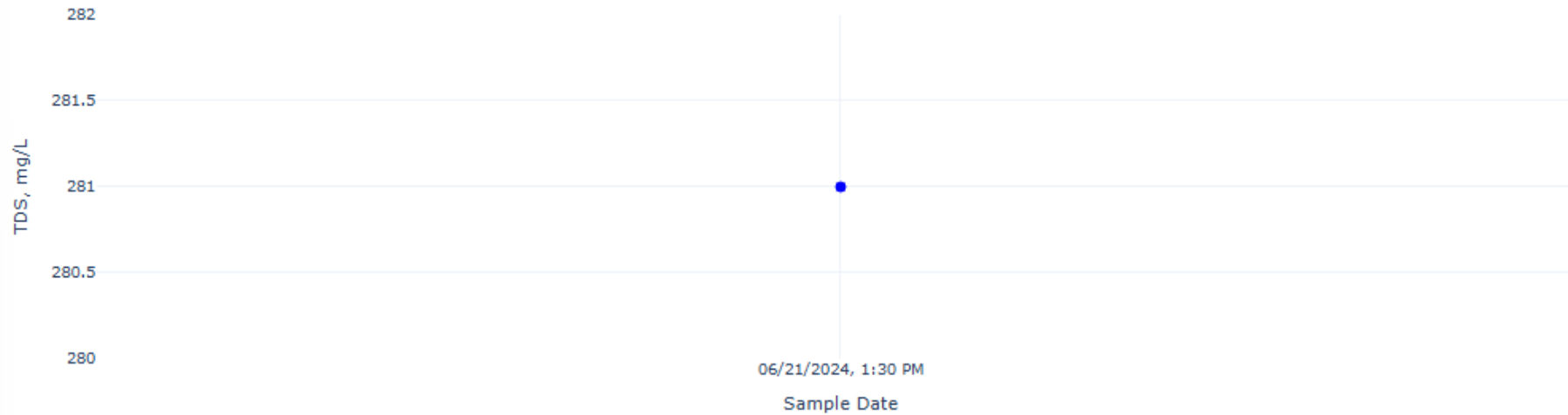


Select Edwards Well with Parameter Data

██████████



TDS, mg/L over time for well ██████████

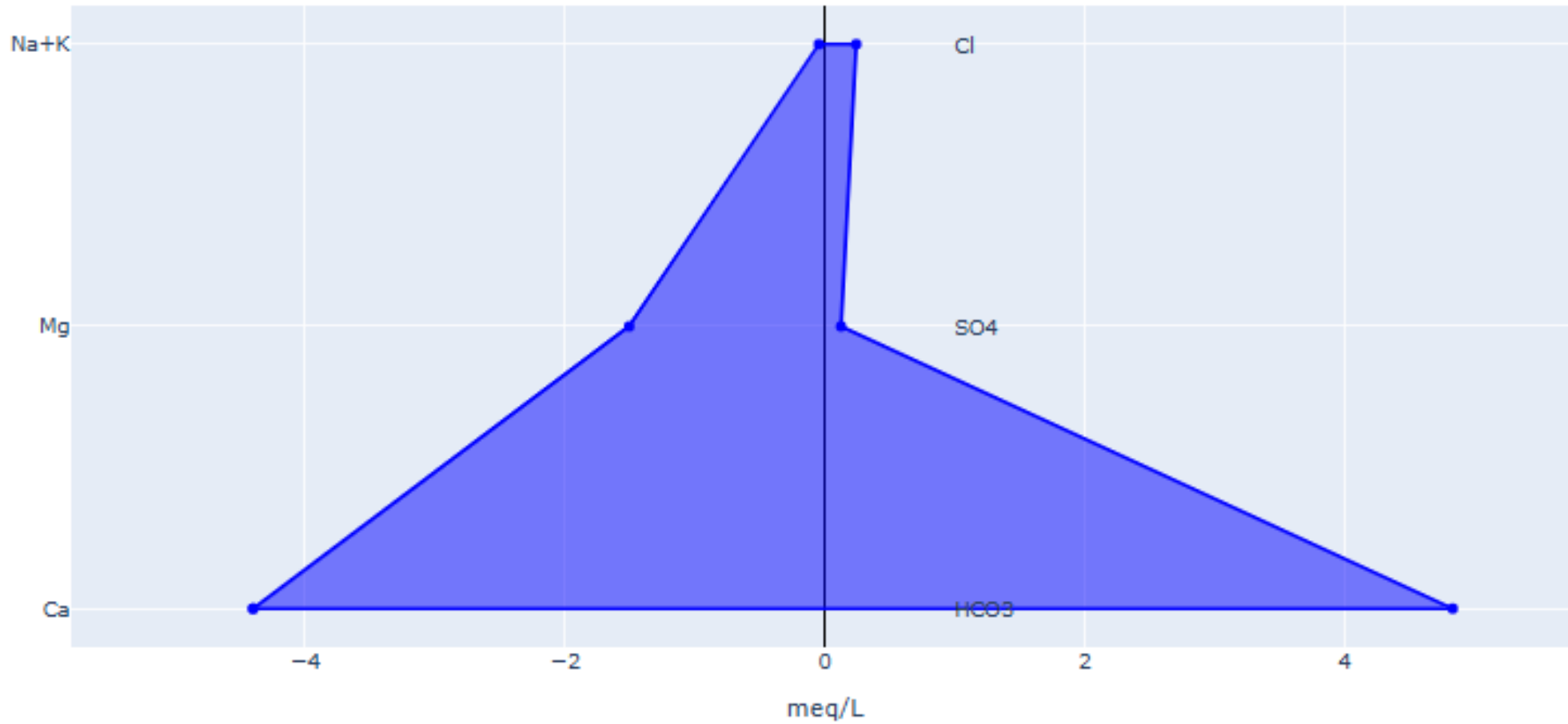


Water Quality

Test Date/Time	TDS, mg/L
06/21/2024, 1:30 PM	281

Stiff Diagram

Stiff Diagram



Measurement Date: June 21, 2024

Why?



Understand impact
of wells on aquifer



View long-term
trends



Access data in one
central location



Improve
accessibility

CGMM Dashboard

History of CGMM Dashboard

2014

New regional
GAM adopted



2016

Updated
regional GAM
Lower Trinity
with local
transmissivity
data



2019

Created
drawdown
prediction tool



2020

Updated
regional GAM
Lower Trinity to
include
additional local
transmissivity
data



2022-2023

Developed local
CGMM to
incorporate
detailed
structure and
hydraulic
properties



2024-2025

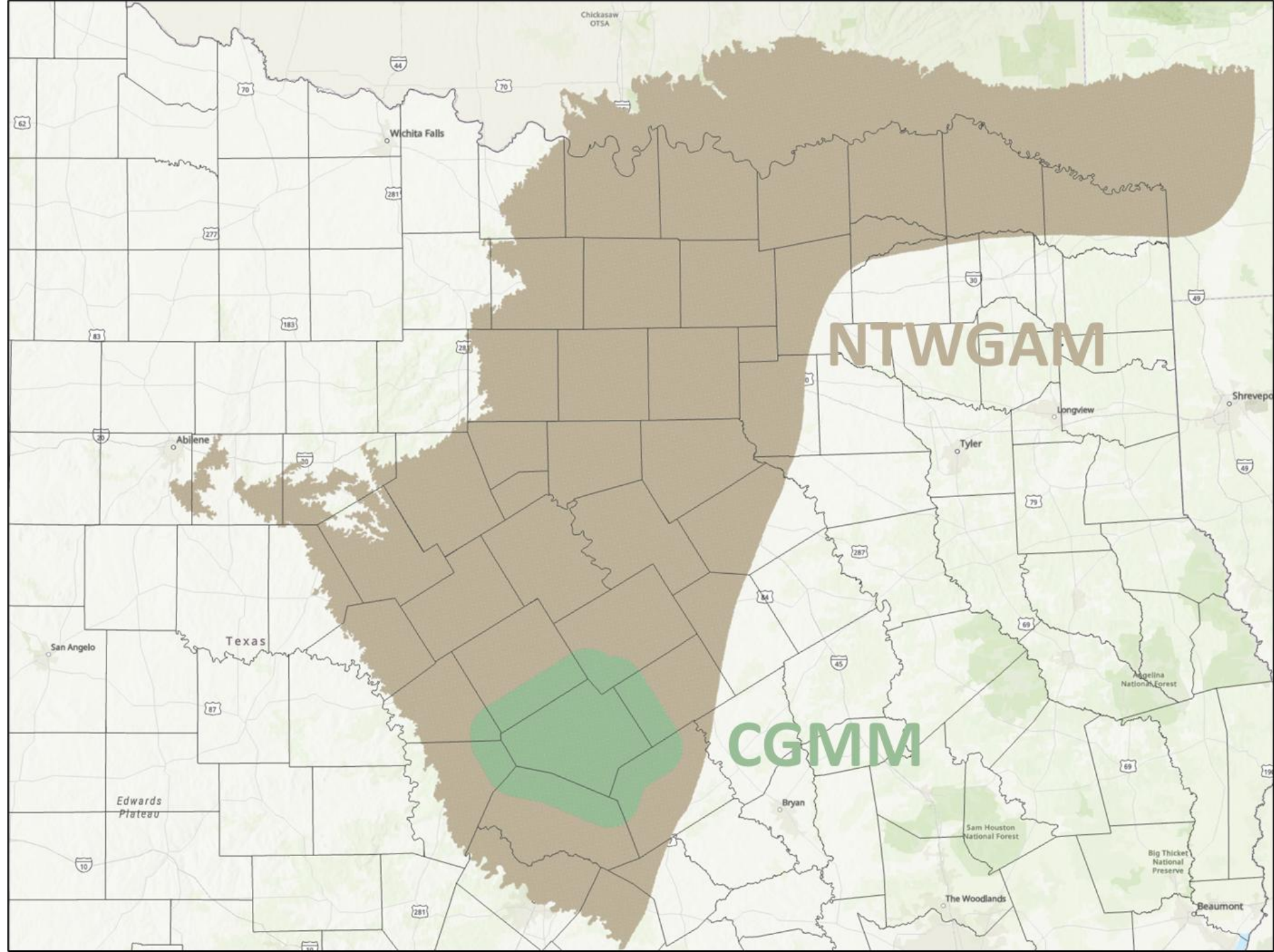
New regional
GAM (in
progress)



2025

CGMM
dashboard to
improve model
accessibility

Localized Clearwater Groundwater Management Model



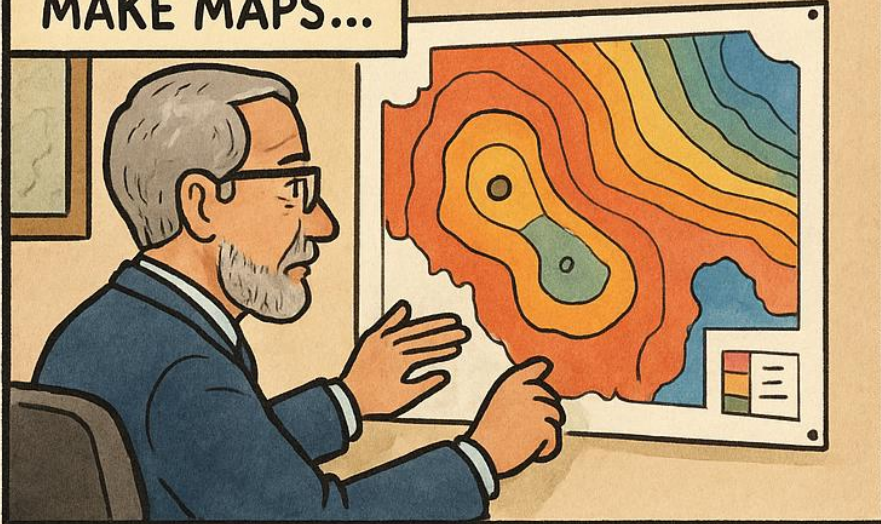
**TRADITIONALLY, RUNNING
GROUNDWATER MODELS REQUIRES
TECHNICAL EXPERTISE AND TIME-
CONSUMING PROCESSES**



CALL CONSULTANT...

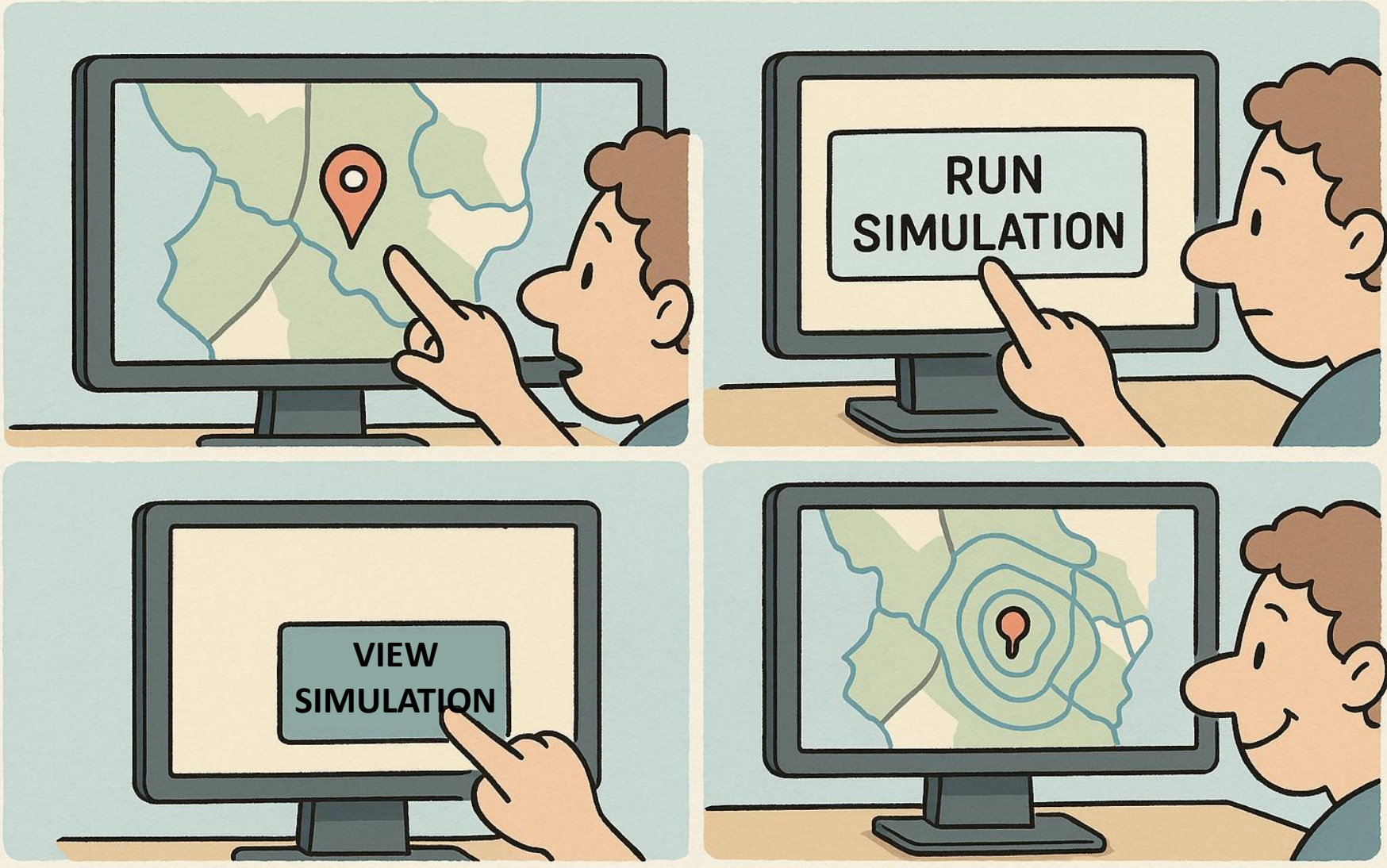


MAKE MAPS...



EMAIL RESULTS BACK

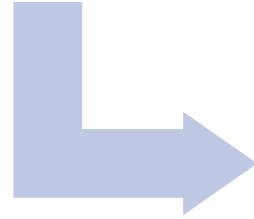




Clearwater Groundwater Management Model Dashboard

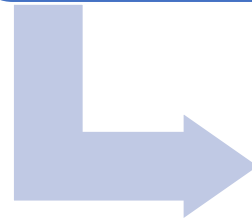
Add
Well(s)

- Drop pin on a map
- Pumping rate, aquifer, duration
- Multiple wells capability
- Save scenarios



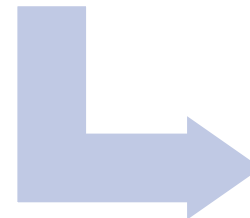
Run
Simulation

- Select scenario & run the model



View
Results

- Water Level Contours (Elevation, Depth to Water, Artesian Head)
- Drawdown Contours
- Hydrographs (at well locations)



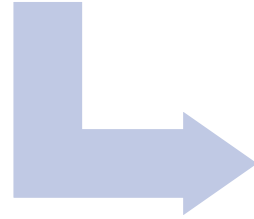
Drawdown
Analysis

- Select scenario and buffer distance
- Table displays wells with drawdown > 1 ft by end of model run

Clearwater Groundwater Management Model Dashboard

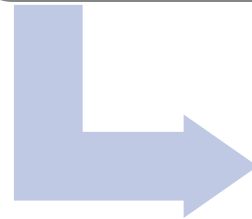
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- Pumping rate, aquifer, duration
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- Save scenarios



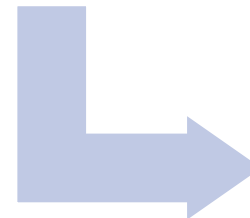
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Drawdown
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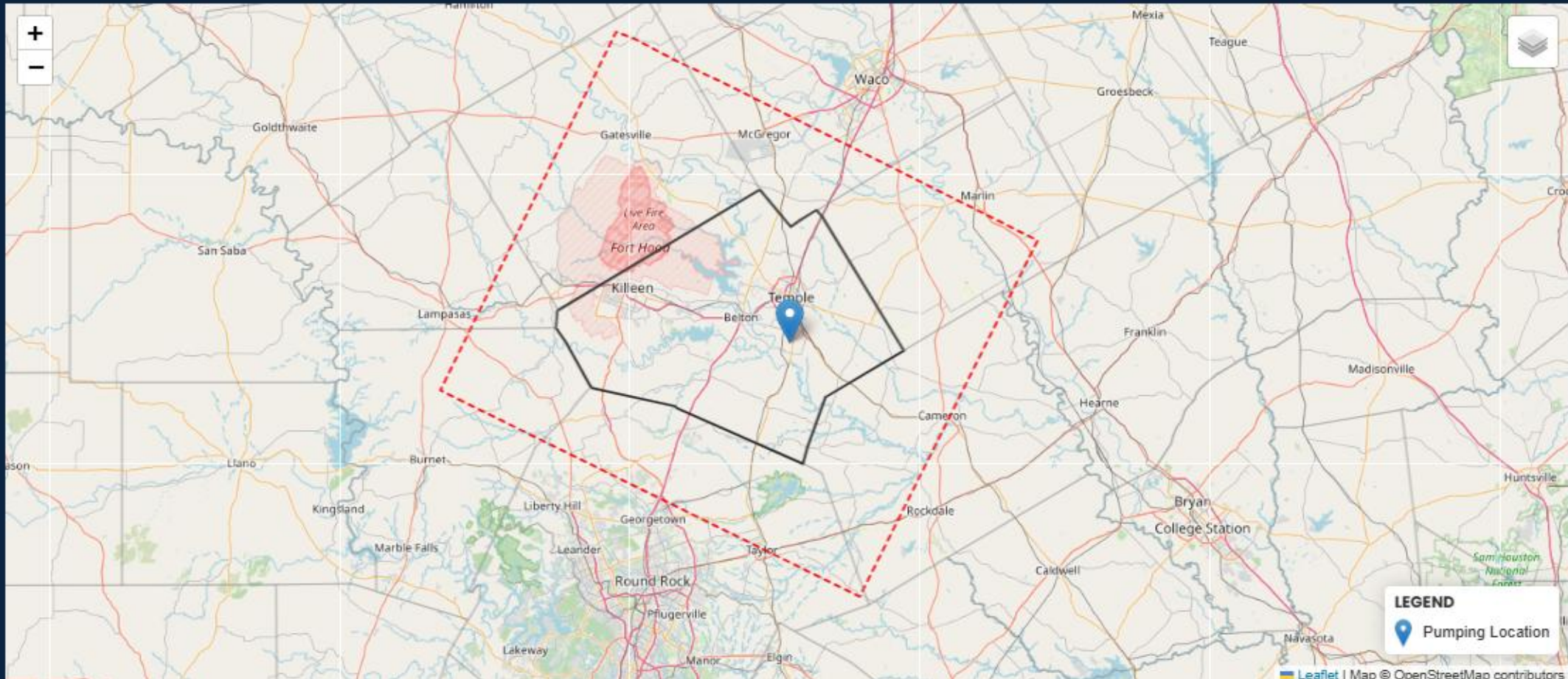
- Select scenario and buffer distance
- Table displays wells with drawdown > 1 ft by end of model run



SELECT WELL LOCATION

Drag the marker or click on the map to set the well location. Enter the pumping rate below.

 Load Previous Simulation





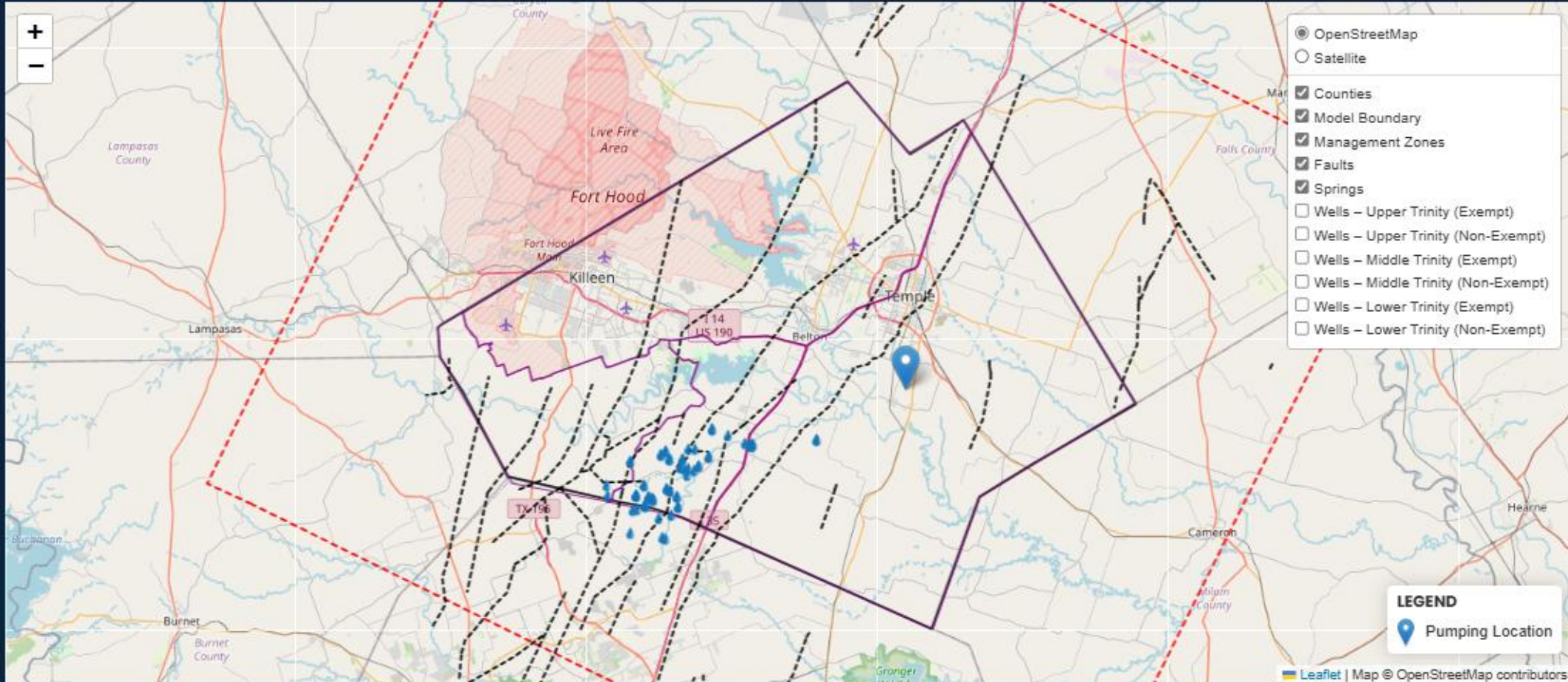
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Load Previous Simulation

GROUNDWATER MANAGEMENT MODEL DASHBOARD

- Add Well(s)
- Run Simulation
- View Results
- Drawdown





SELECT WELL LOCATION

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Load Previous Simulation

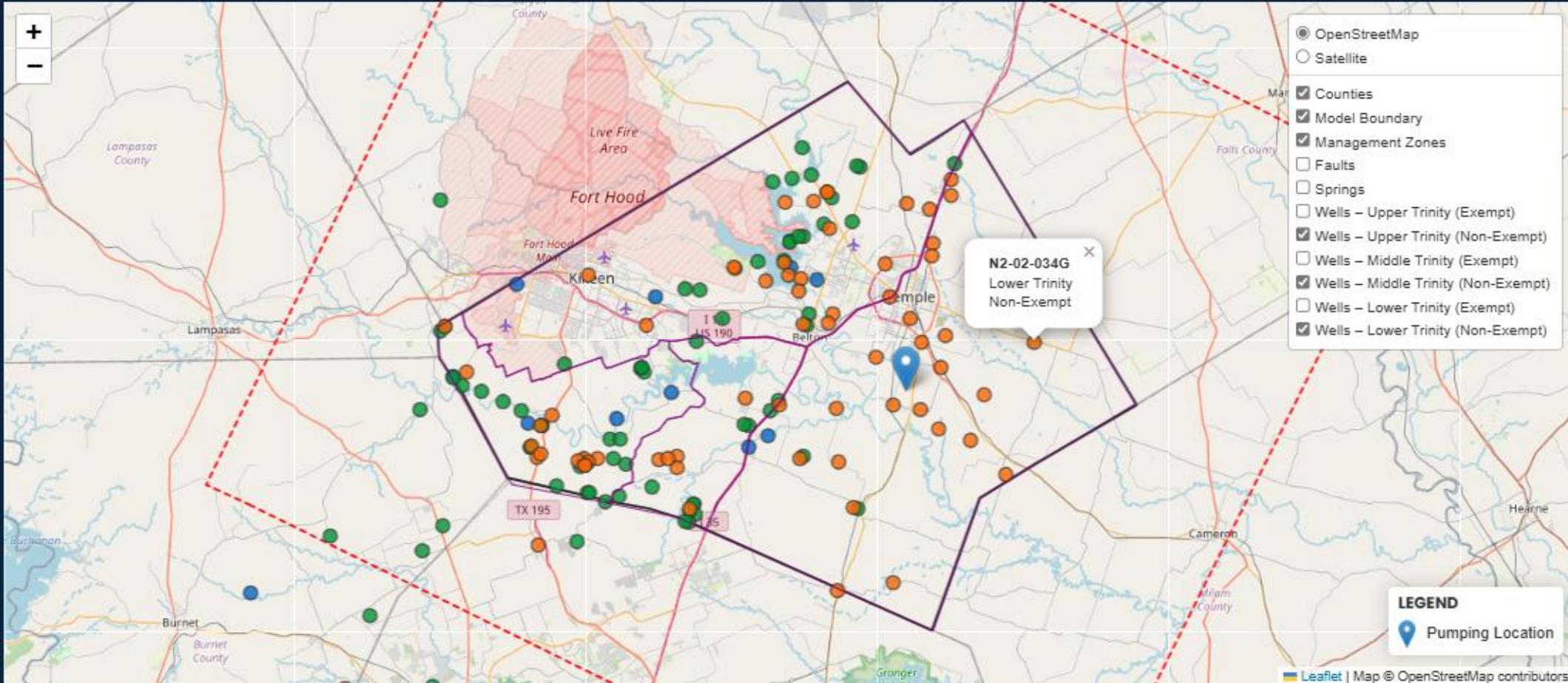
GROUNDWATER MANAGEMENT MODEL DASHBOARD

Add Well(s)

Run Simulation

View Results

Drawdown





SELECT WELL LOCATION

Drag the marker or click on the map to set the well location. Enter the pumping rate below.

Load Previous Simulation

The map interface displays a geographical area with various well locations marked by colored dots (green, orange, blue). A large blue button with a folder icon and the text "Load Previous Simulation" is overlaid on the map. A legend on the right side of the map lists various simulation parameters and their status:

- OpenStreetMap
- Satellite
- Counties
- Model Boundary
- Management Zones
- Faults
- Springs
- Wells - Upper Trinity (Exempt)
- Wells - Upper Trinity (Non-Exempt)
- Wells - Middle Trinity (Exempt)
- Wells - Middle Trinity (Non-Exempt)
- Wells - Lower Trinity (Exempt)
- Wells - Lower Trinity (Non-Exempt)

A "LEGEND" section at the bottom right shows a blue location pin icon next to the text "Pumping Location".

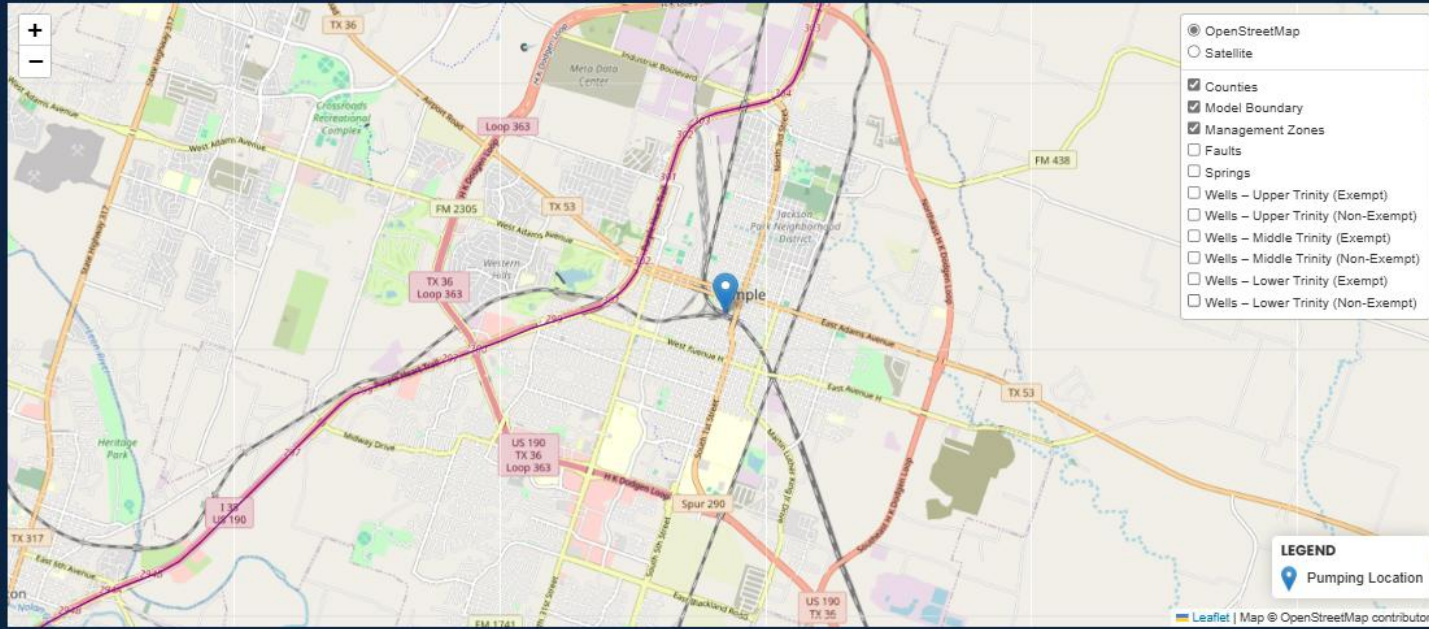
Add Well(s)

Run Simulation

View Results

Drawdown

Test Well



Simulation Folder Name

Test Well

Well Name

Test Well

Latitude

31.095572

Longitude

-97.345733

Pumping Rate (AF/year)

500

Model Layer

Hensell (Middle Trinity)

Pumping Start Year

2025

Pumping End Year

2070

Save Location

Add Another Well

- Add Well(s)
- Run Simulation
- View Results
- Drawdown

Test Well

Map controls: +, -

Map layers:

- OpenStreetMap
- Satellite
- Counties
- Model Boundary

Simulation Folder Name

Test Well

Well Name

Test Well

Latitude

31.095572

Longitude

-97.345733

Pumping Rate (AF/year)

500

Model Layer

Hensell (Middle Trinity) ▾

Pumping Start Year

2025

Pumping End Year

2070

Save Location

Add Another Well

2025 2070

Save Location Add Another Well

- Add Well(s)
- Run Simulation
- View Results
- Drawdown

Test Well

Map controls: +, -

Legend: OpenStreetMap, Satellite, Counties, Model Boundary

Simulation Folder Name

Test Well

Well Name

Test Well

Latitude

31.095572

Longitude

Pumping Rate (AF/year)

500

Pumping Start Year

2025

Pumping End Year

2070

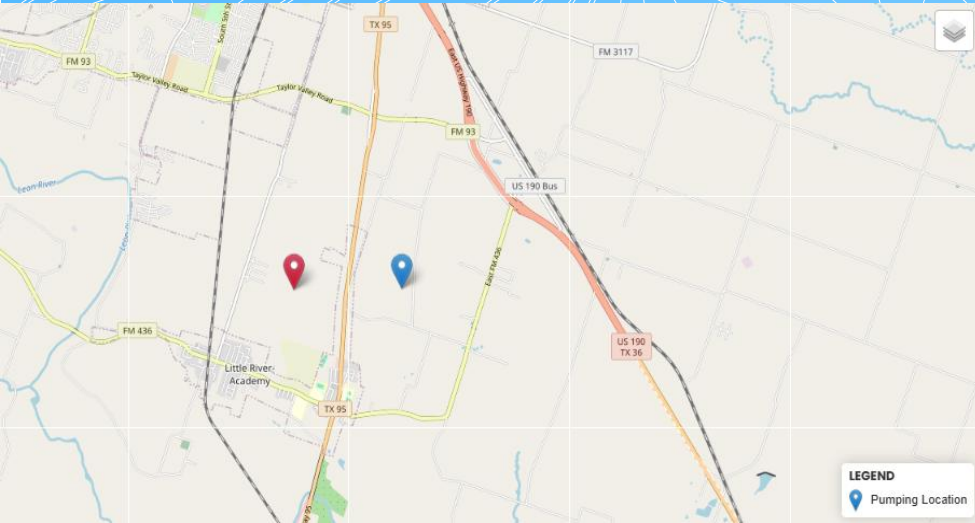
Add Another Well

Save Location

Add Another Well

2025 2070

Save Location Add Another Well



Simulation Folder Name

Multiple Wells Test

Well Name

Test Well 1

Latitude

30.999977

Longitude

-97.328565

Pumping Rate (AF/year)

500

Model Layer

Hosston (Lower Trinity)

Pumping Start Year

2025

Pumping End Year

2070

Well Name

Test Well 2

Latitude

31.000000

Longitude

-97.350000

Pumping Rate (AF/year)

500

Model Layer

Hosston (Lower Trinity)

Pumping Start Year

2025

Pumping End Year

2070

Save Location

Add Another Well

2 of 2 well(s) saved successfully to Multiple Wells Test.

Simulation Folder Name

Multiple Wells Test

Well Name

Test Well 1

Latitude

30.999977

Longitude

-97.328565

Save Location

Add Another Well



2 of 2 well(s) saved successfully to Multiple Wells Test.

Pumping Rate (AF/year)

500

Model Layer

Hosston (Lower Trinity)

Pumping Start Year

2025

Pumping End Year

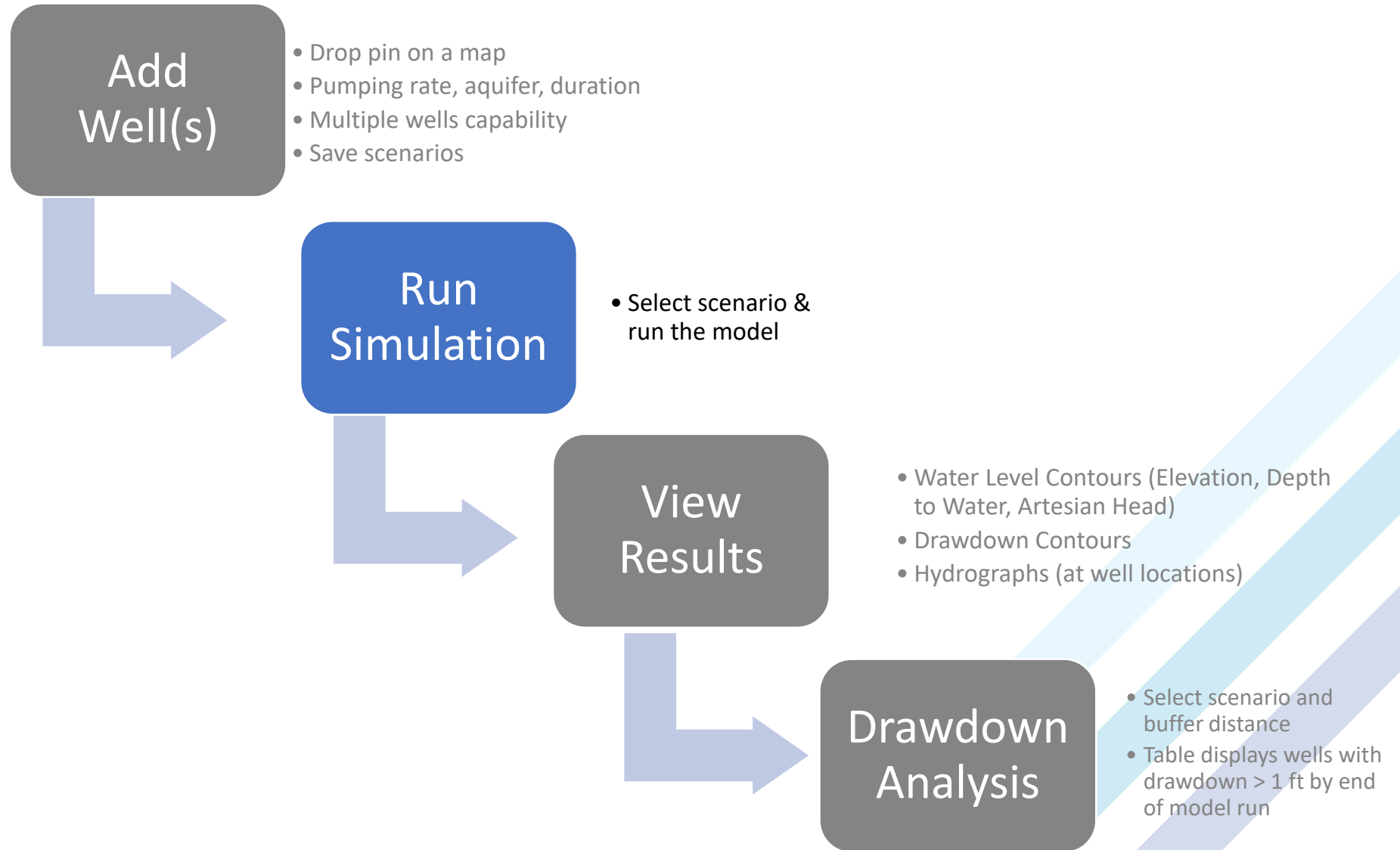
2070

Save Location

Add Another Well

2 of 2 well(s) saved successfully to Multiple Wells Test.

Clearwater Groundwater Management Model Dashboard



GROUNDWATER MANAGEMENT MODEL DASHBOARD

Add Well(s)

Run Simulation

View Results

Drawdown

LAUNCH CGMM SIMULATION

Select a Simulation

example well

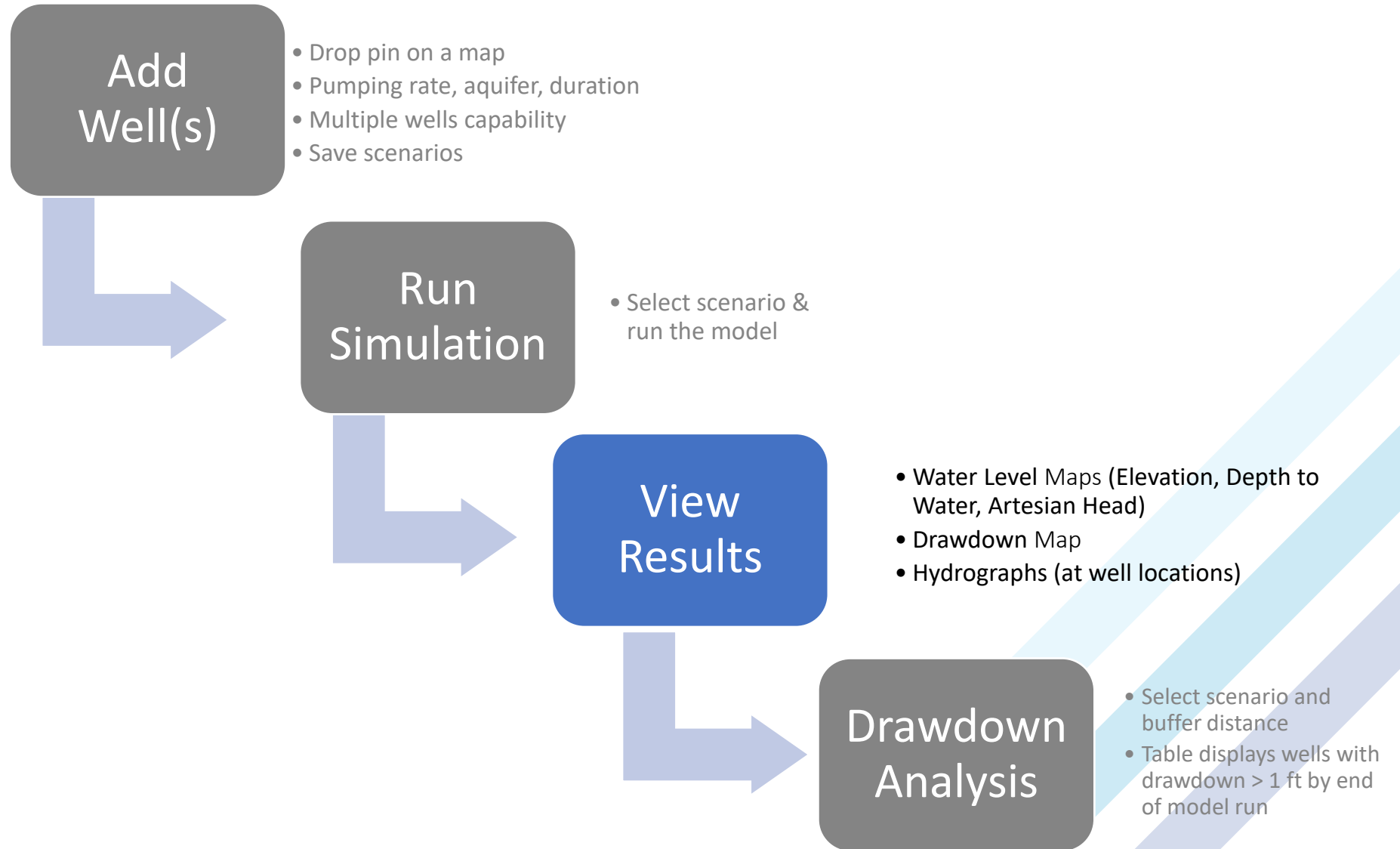
Run Model

Stop Run

SIMULATION LOGS

- Loading base model from: model\base
- Adding head observations for 2 well(s)
- Adding pumping for 2 well(s)

Clearwater Groundwater Management Model Dashboard



Display Mode:

Water Elevation (ft amsl)

Select Layer:

Hosston (Lower Trinity)

Select Scenario:

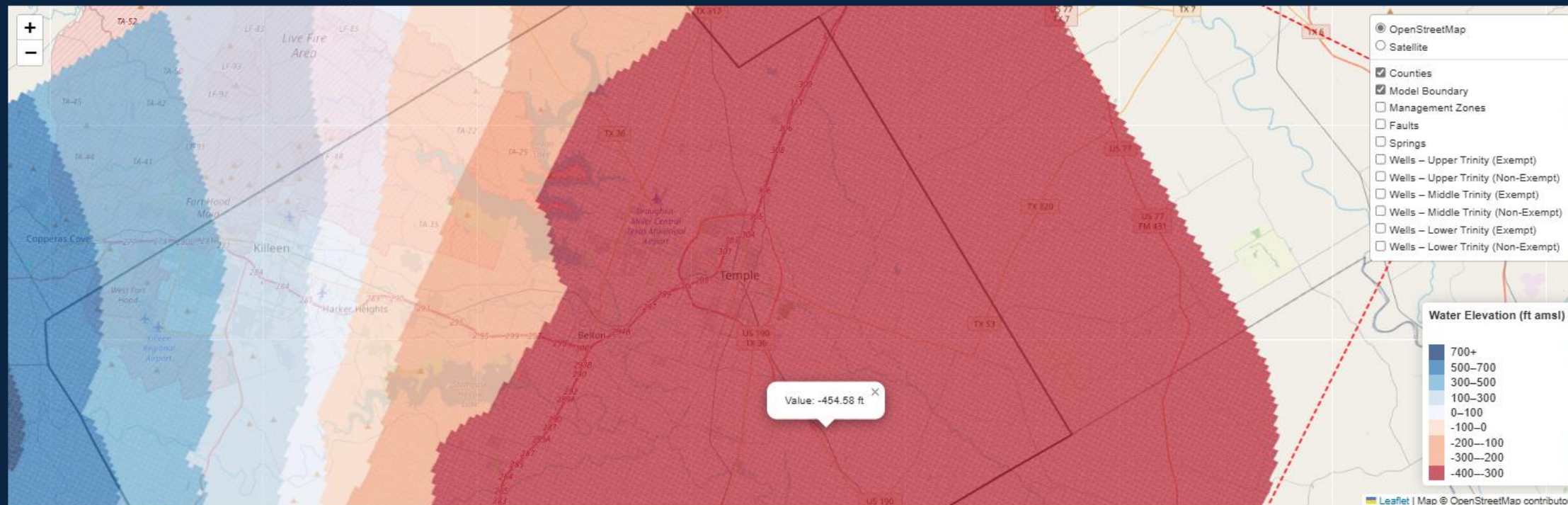
Base Model

Select Year: 2080

Progress bar

View Contour

WATER ELEVATION MAP (2080) – HOSSTON (LOWER TRINITY)



Export Map as Image

Display Mode:

Water Depth (ft bgs) ▼

Select Layer:

Hosston (Lower Trinity) ▼

Select Scenario:

Base Model ▼

Select Year: 2080



View Contour

WATER DEPTH MAP (2080) – HOSSTON (LOWER TRINITY)



Export Map as Image

Display Mode:

Artesian Head (ft) ▼

Select Layer:

Hosston (Lower Trinity) ▼

Select Scenario:

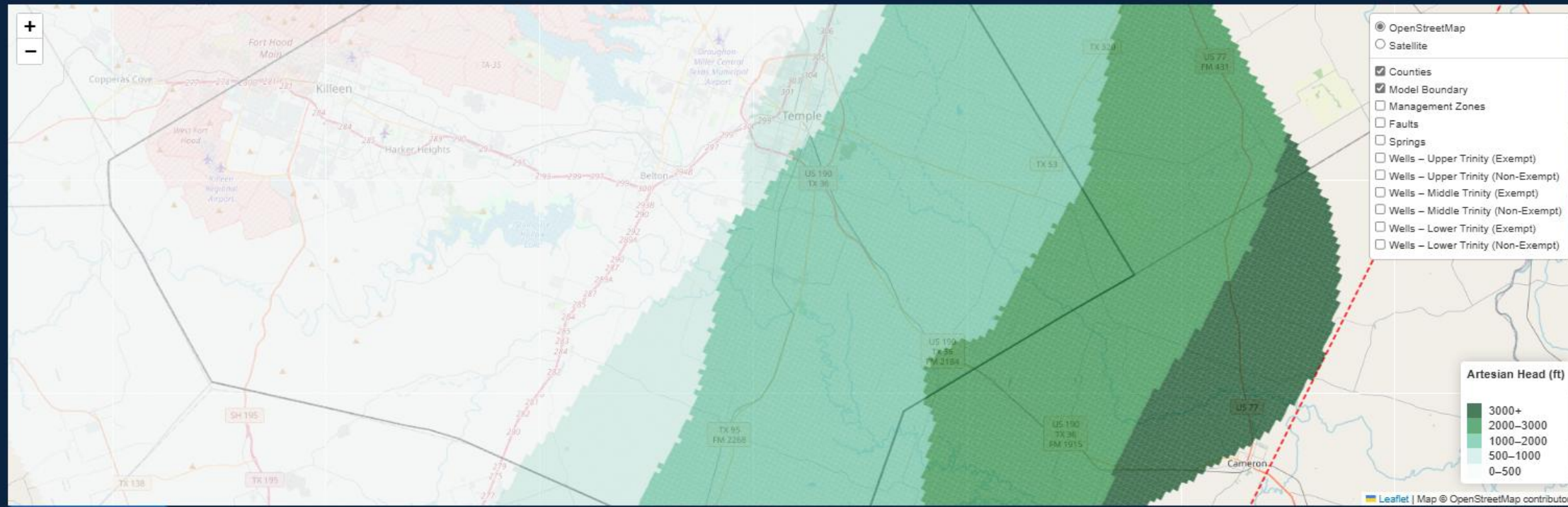
Base Model ▼

Select Year: 2080

Progress bar

View Contour

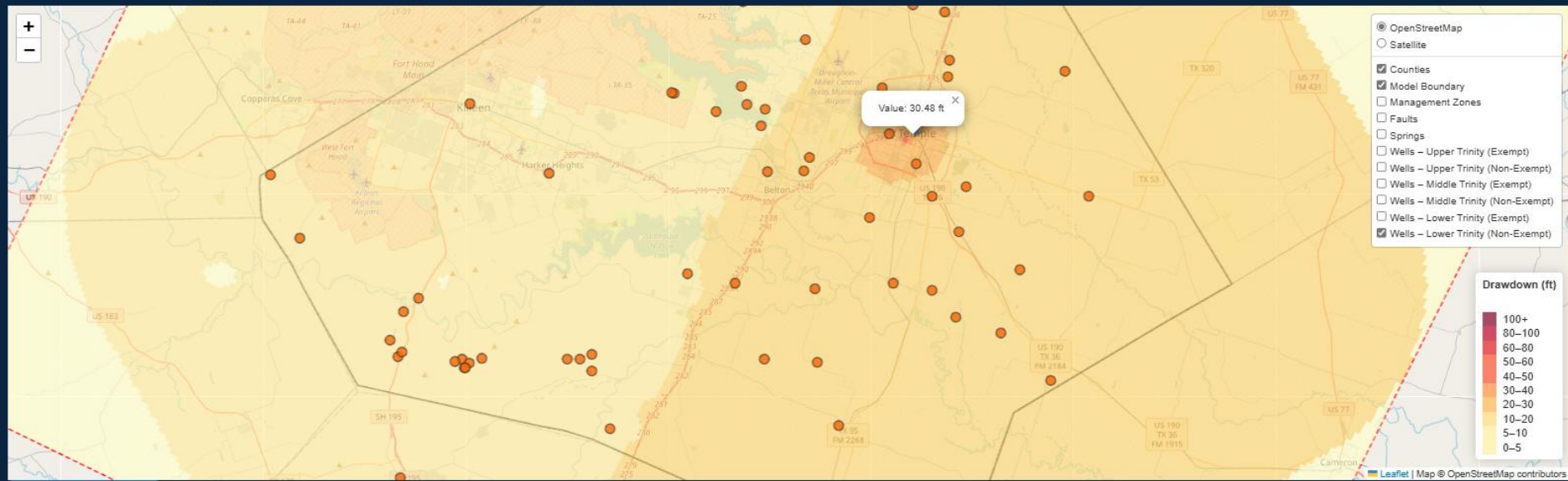
ARTESIAN HEAD MAP (2080) – HOSSTON (LOWER TRINITY)



Export Map as Image

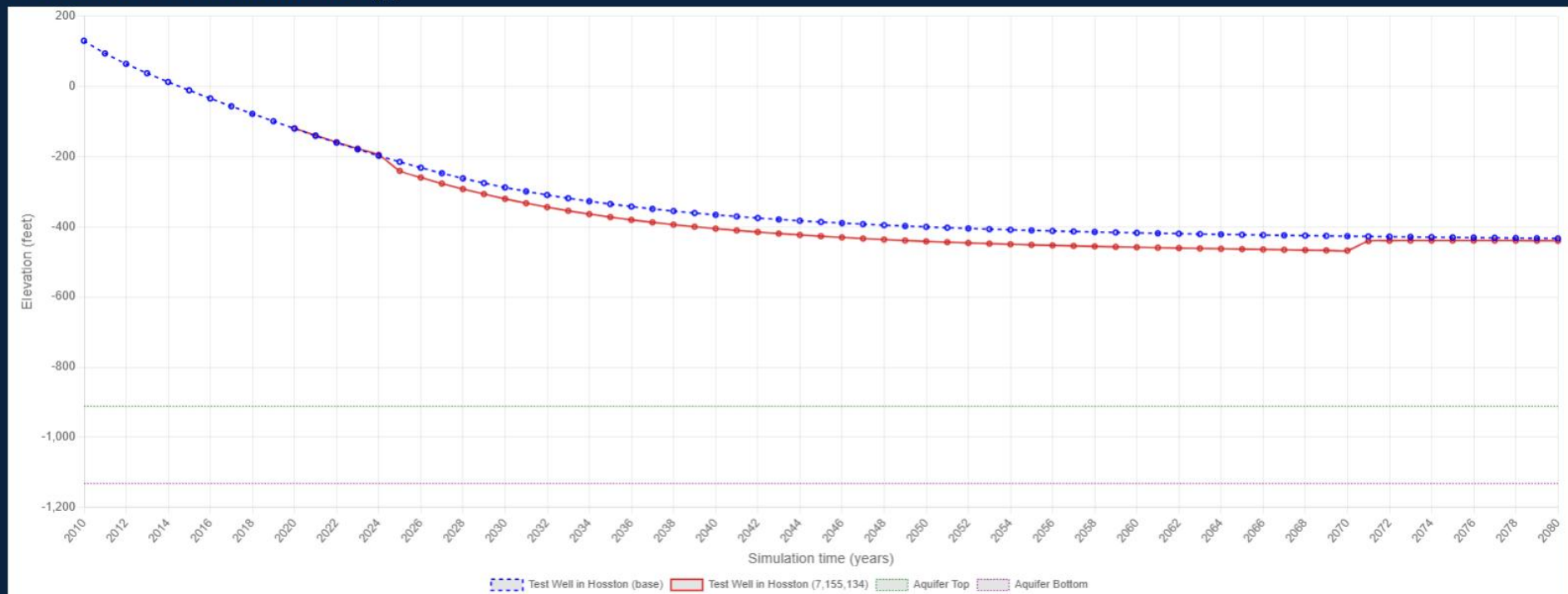
Example Well Hosston 500 AFY 2025 - 2070

DRAWDOWN MAP (2070) – HOSSTON (LOWER TRINITY)



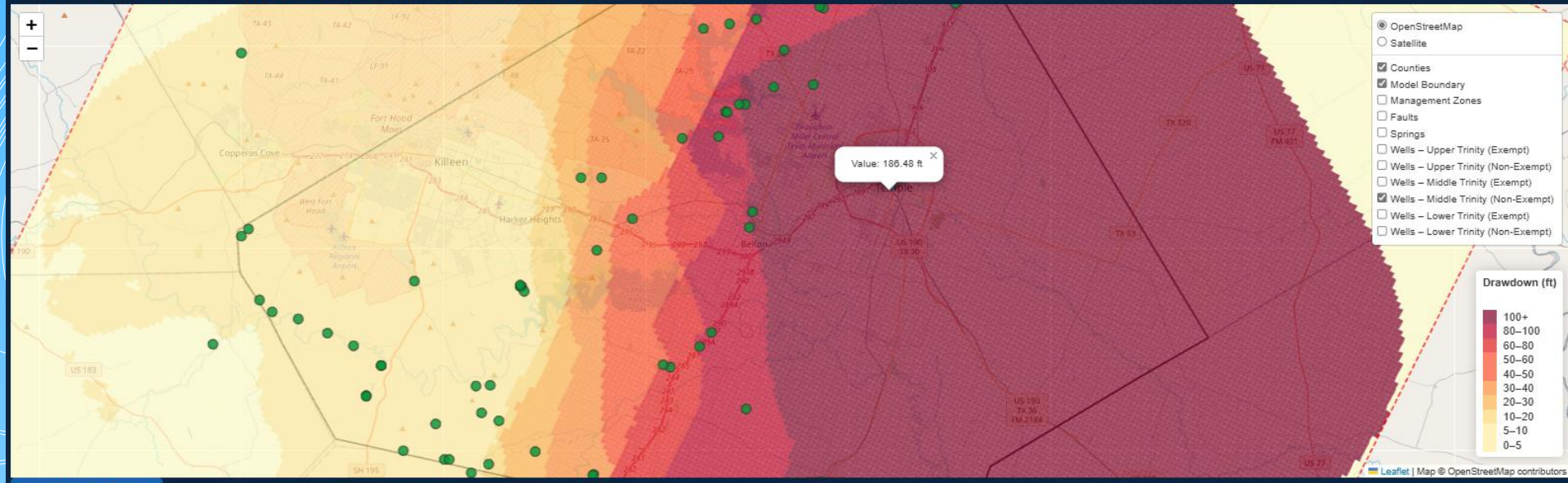
Export Map as Image

HYDROGRAPH AT WELL LOCATION(S)



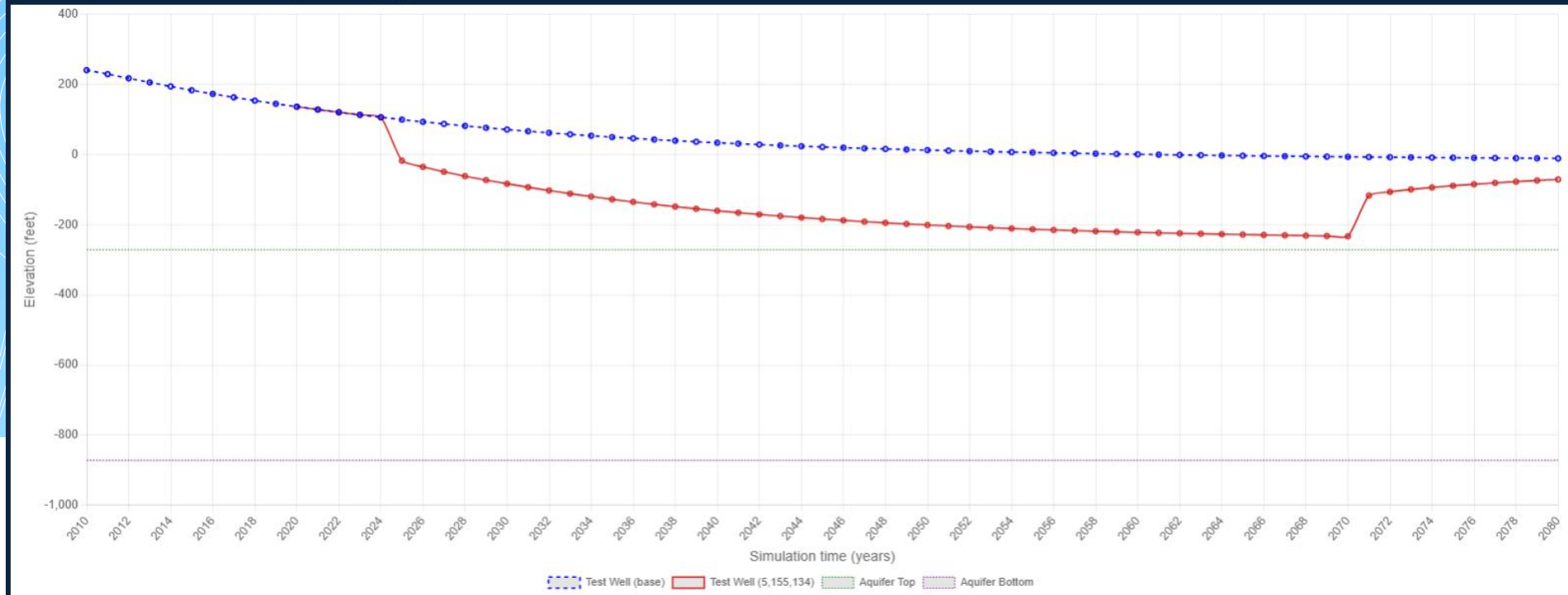
Example Well Hensell 500 AFY 2025 - 2070

DRAWDOWN MAP (2070) – HENSELL (MIDDLE TRINITY)

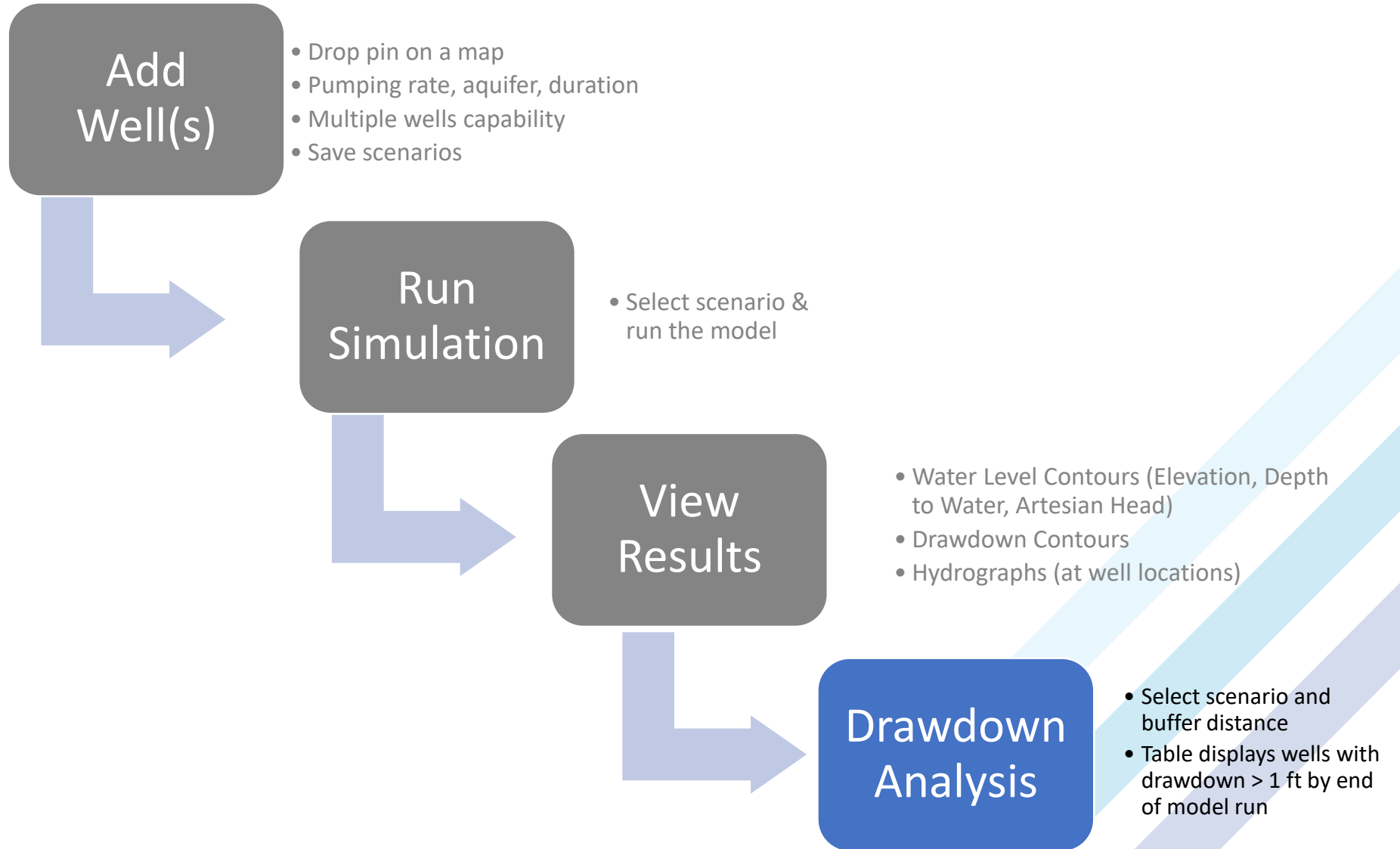


Export Map as Image

HYDROGRAPH AT WELL LOCATION(S)



Clearwater Groundwater Management Model Dashboard





DRAWDOWN TOOL

Simulation Folder:

Test Well

Radius (miles): 8

Slider bar for Radius (miles): 8

Select Year for Drawdown Evaluation: 2070

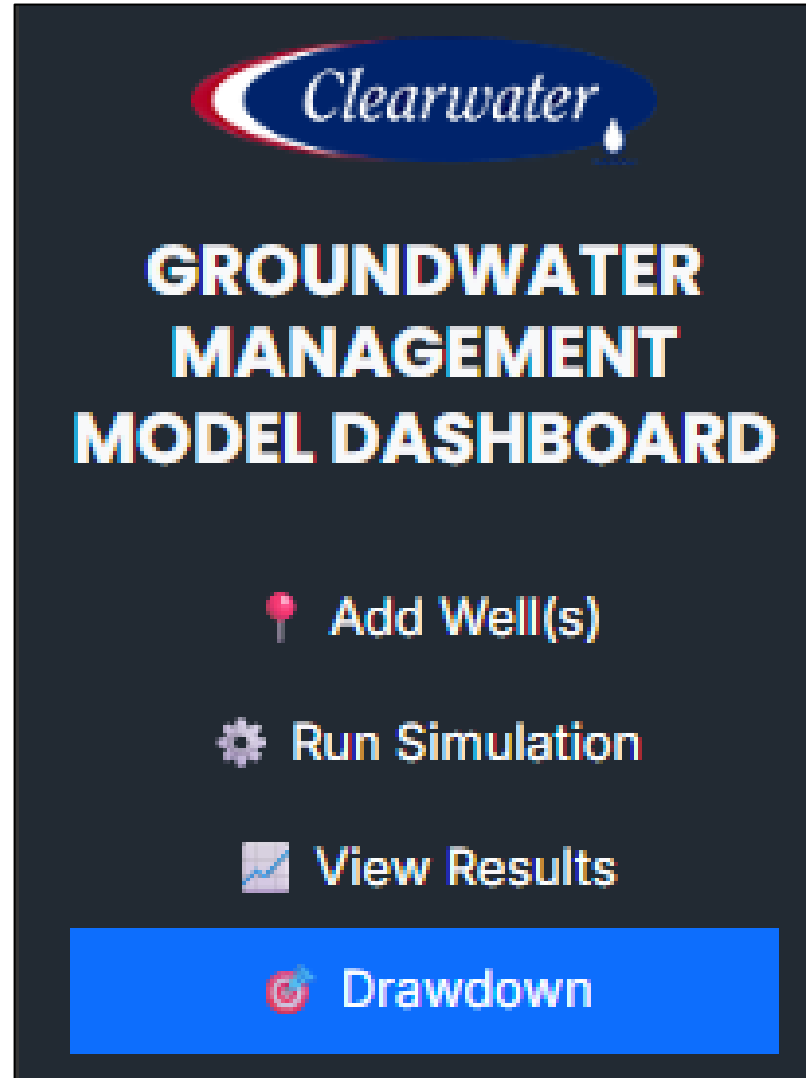
Slider bar for Select Year for Drawdown Evaluation: 2070

Run Analysis

WELLS WITH >1 FT DRAWDOWN

Well ID	Drawdown (ft)	Row	Col
E-08-031G	152.46	154	126
E-25-016P	123.5	140	144
E-03-102G	116.03	137	134
E-03-100G	115.96	138	132

CGMM Dashboard



- Tools bridges gap between District and its data
- Converts it into clear, visual, interactive outputs
- Team effort with the CUWCD Board

Development



Tool runs on web browser

Flask/Dash



Analyze/visualize trends

Theis (1935)
Ordinary kriging
Theil-Sen regression
RDP turning points



Compile large datasets

Pandas
GeoPandas
NumPy



Interactive, dynamic maps

GeoJSON
Plotly
Mapbox
Leaflet

Reproducible

Defensible

Data-driven

