# Preliminary Results of Focused Land Subsidence Analysis – Friant-Kern Canal Area

April 17, 2019

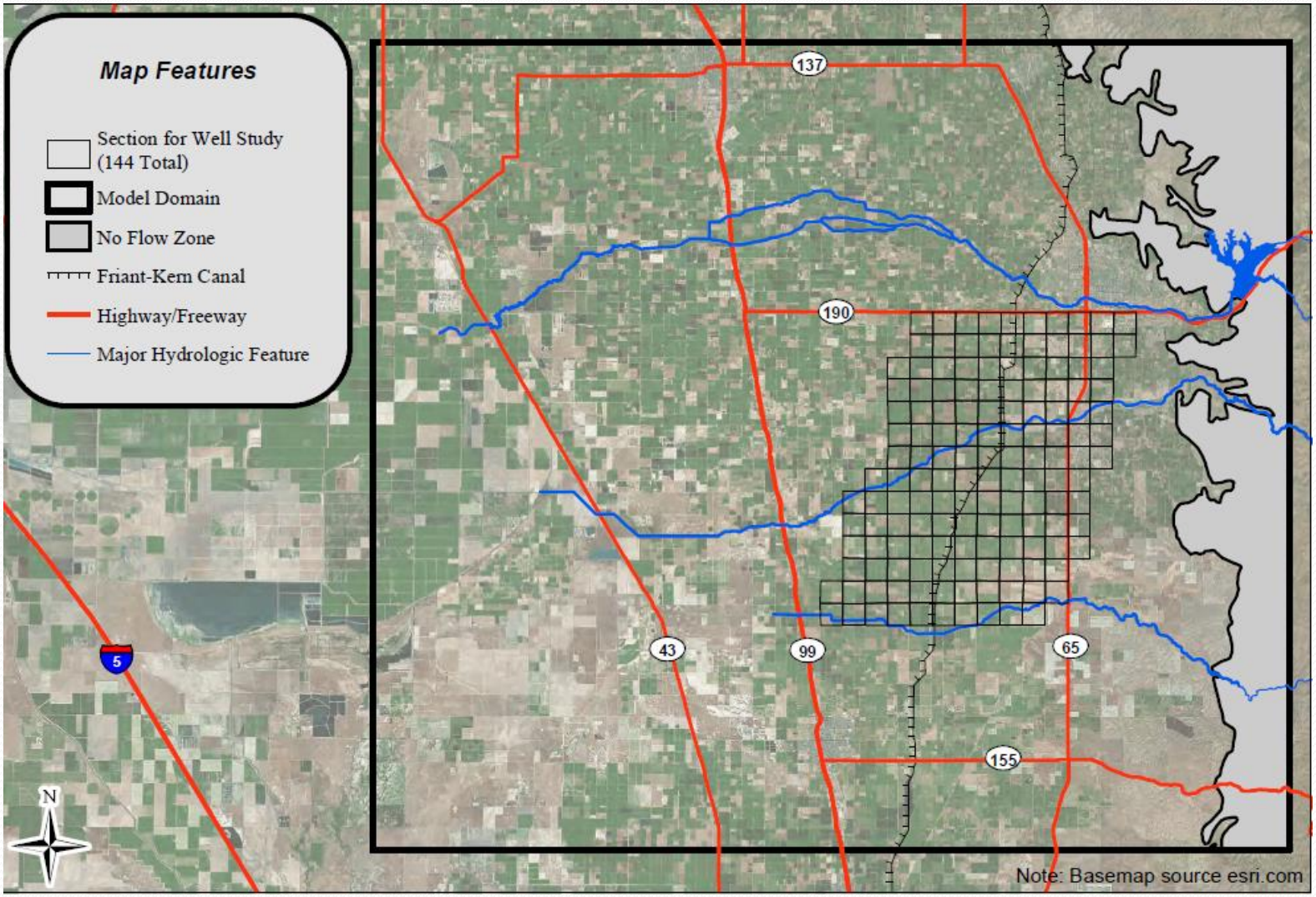
**Preliminary Draft**
**For Discussion Purposes Only**

Thomas Harder & Co.
Groundwater Consulting

# The purpose of this presentation is to provide a narrative for our process to identify the Friant-Kern Canal Area of Subsidence Concern (AOSC) and Potential Focused Managed Area Within the AOSC

- Study Area
- Cause of Land Subsidence Due to Groundwater Withdrawal
- Process for Evaluating Potential Future Subsidence Along the Friant-Kern Canal
- Preliminary Results of Our Analysis
- Next Steps

# Area for Focused Subsidence Analysis

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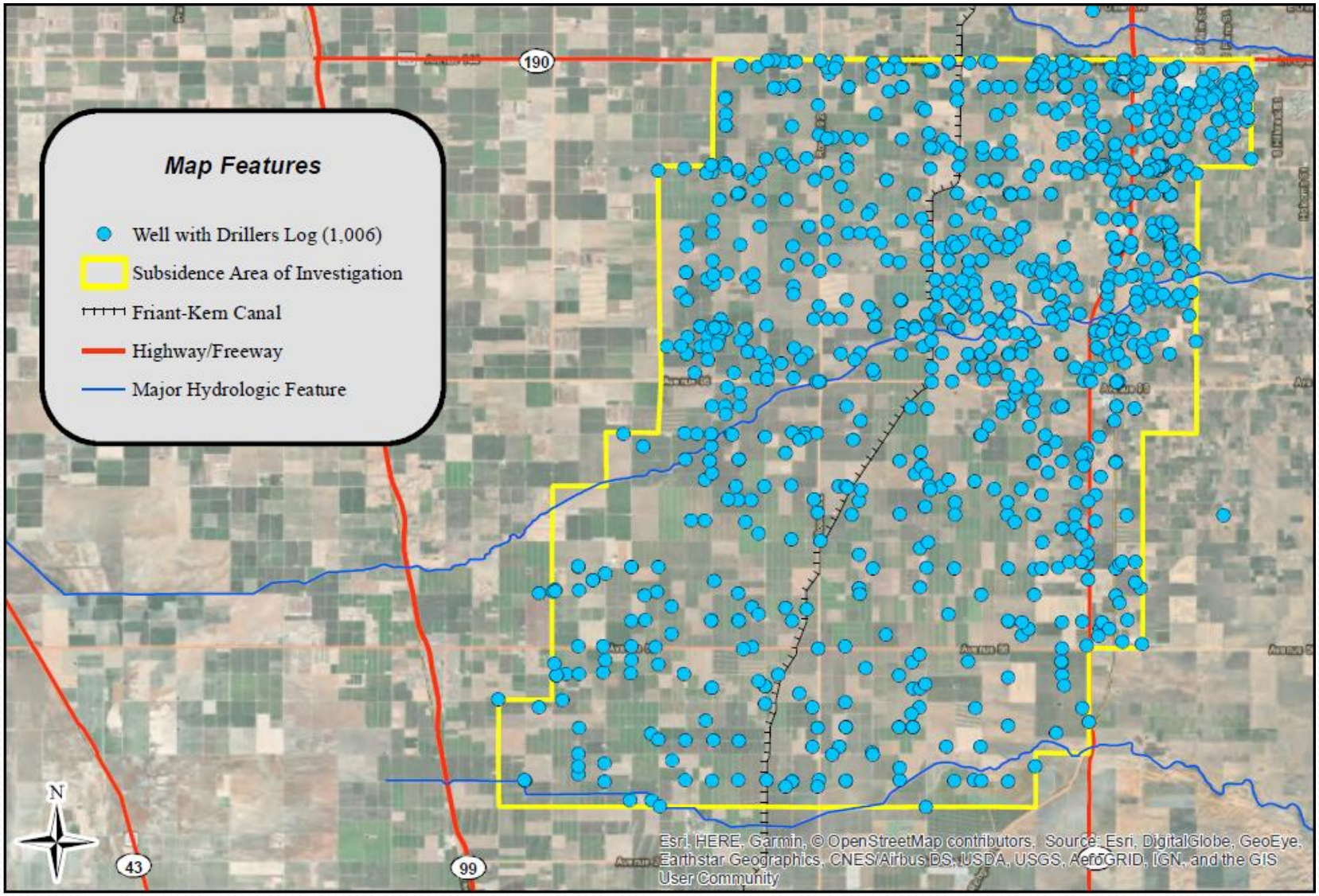
# 1,006 Wells in the DWR Well Database

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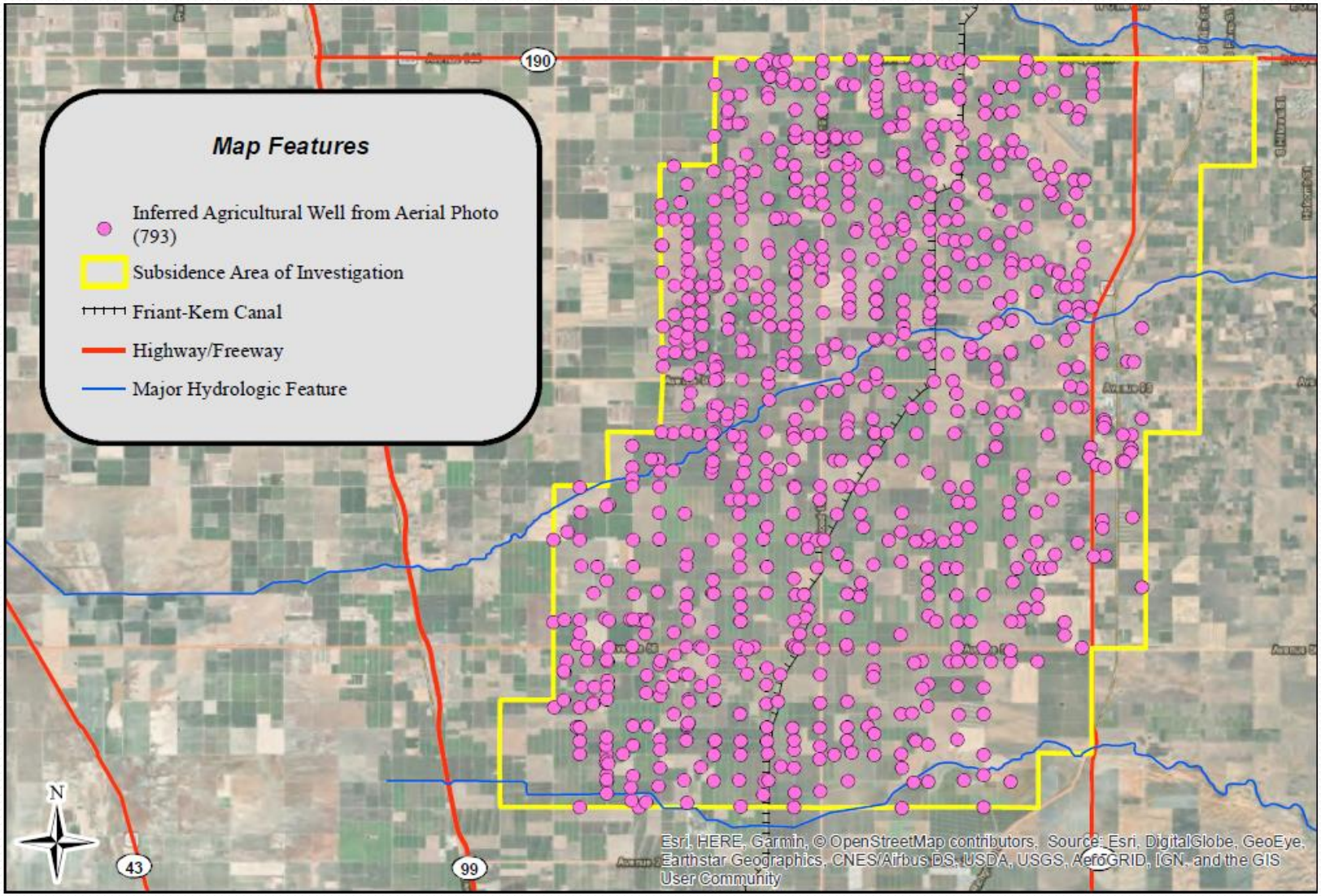
# 793 Wells Identified from Air Photos

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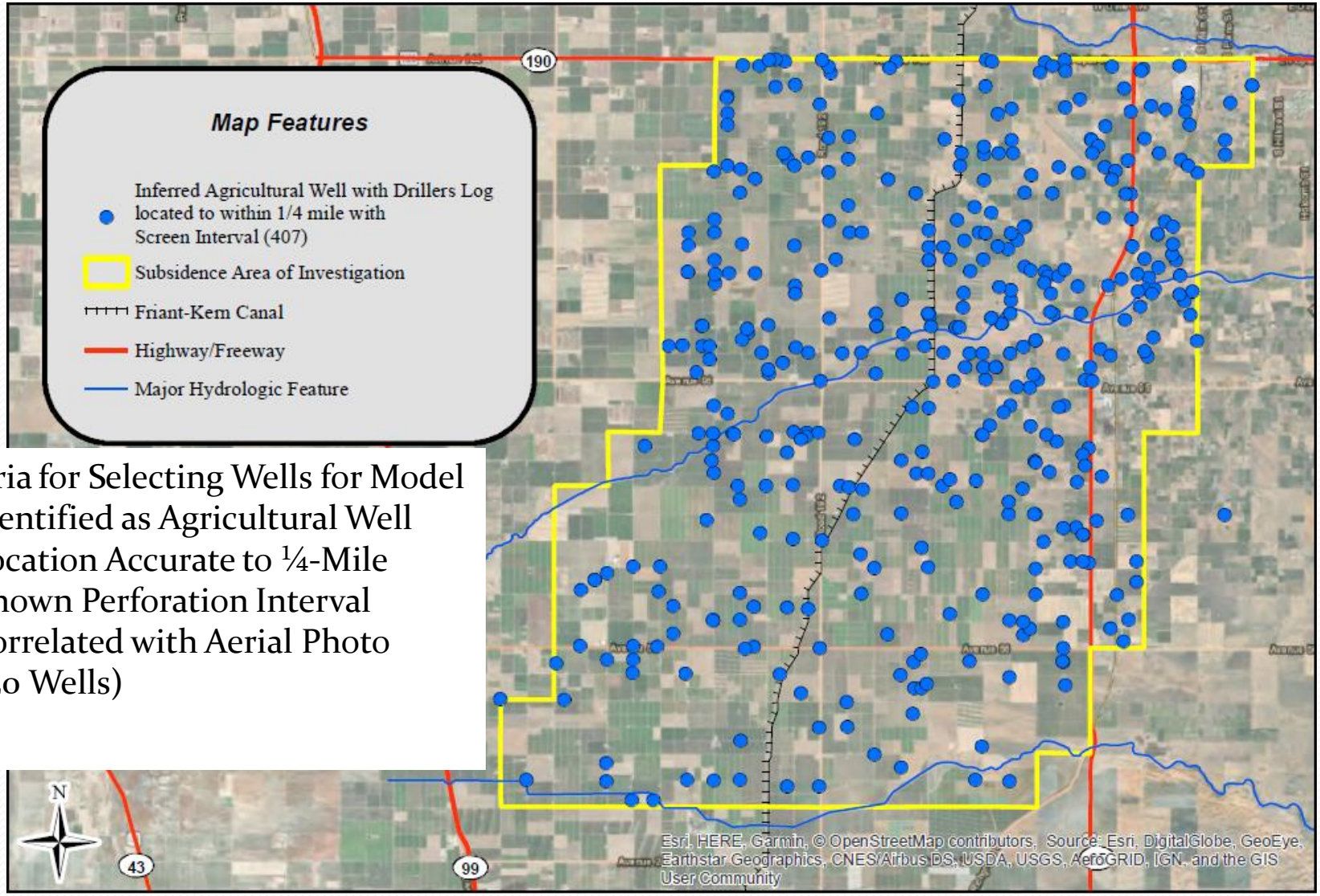
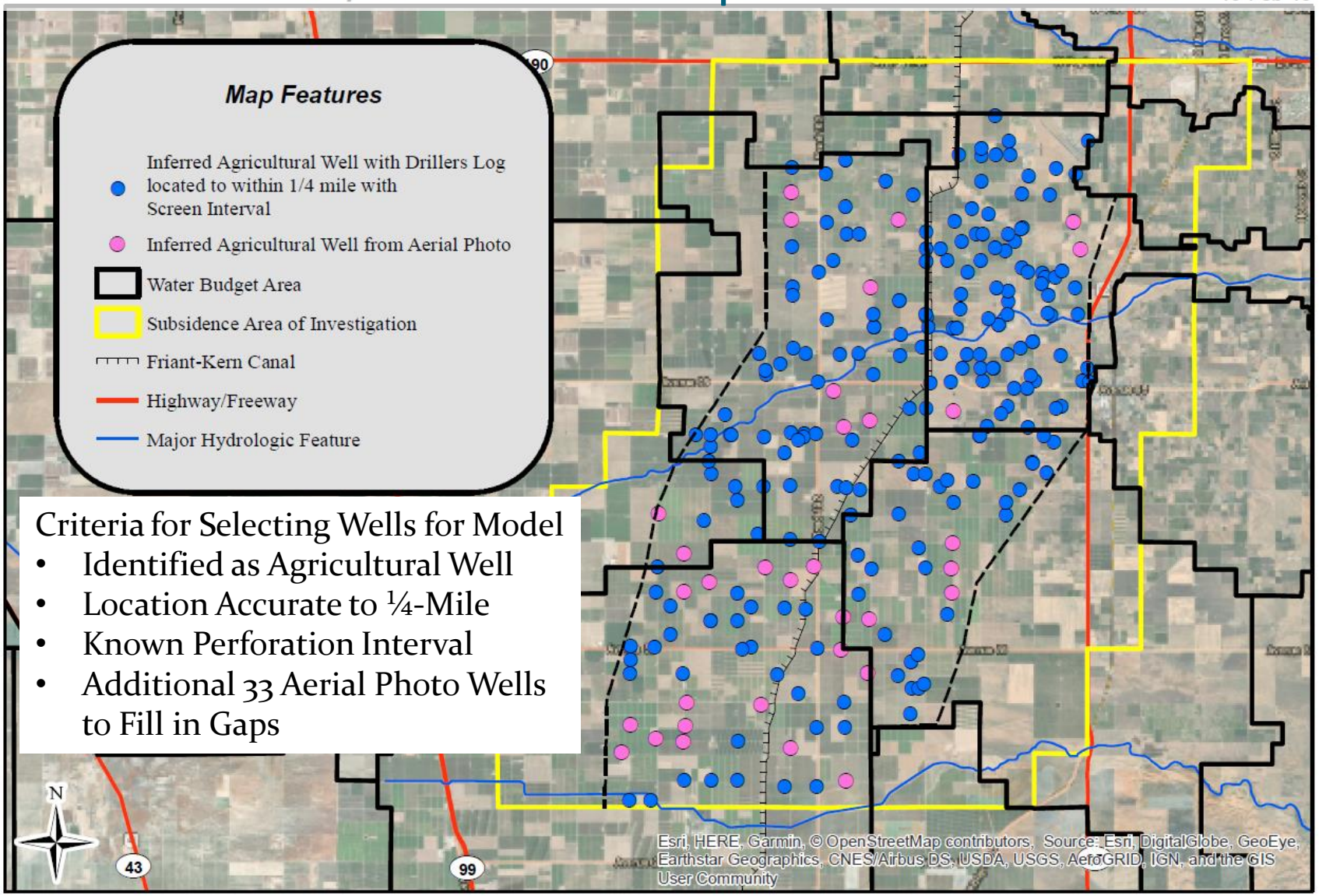
# 407 Agricultural Wells with Acceptable Data for Use in the Model




Criteria for Selecting Wells for Model

- Identified as Agricultural Well
- Location Accurate to ¼-Mile
- Known Perforation Interval
- Correlated with Aerial Photo (120 Wells)

# Of the 1,799 Wells Identified in the Area of Investigation, 246 Were Selected for Incorporation into the Model

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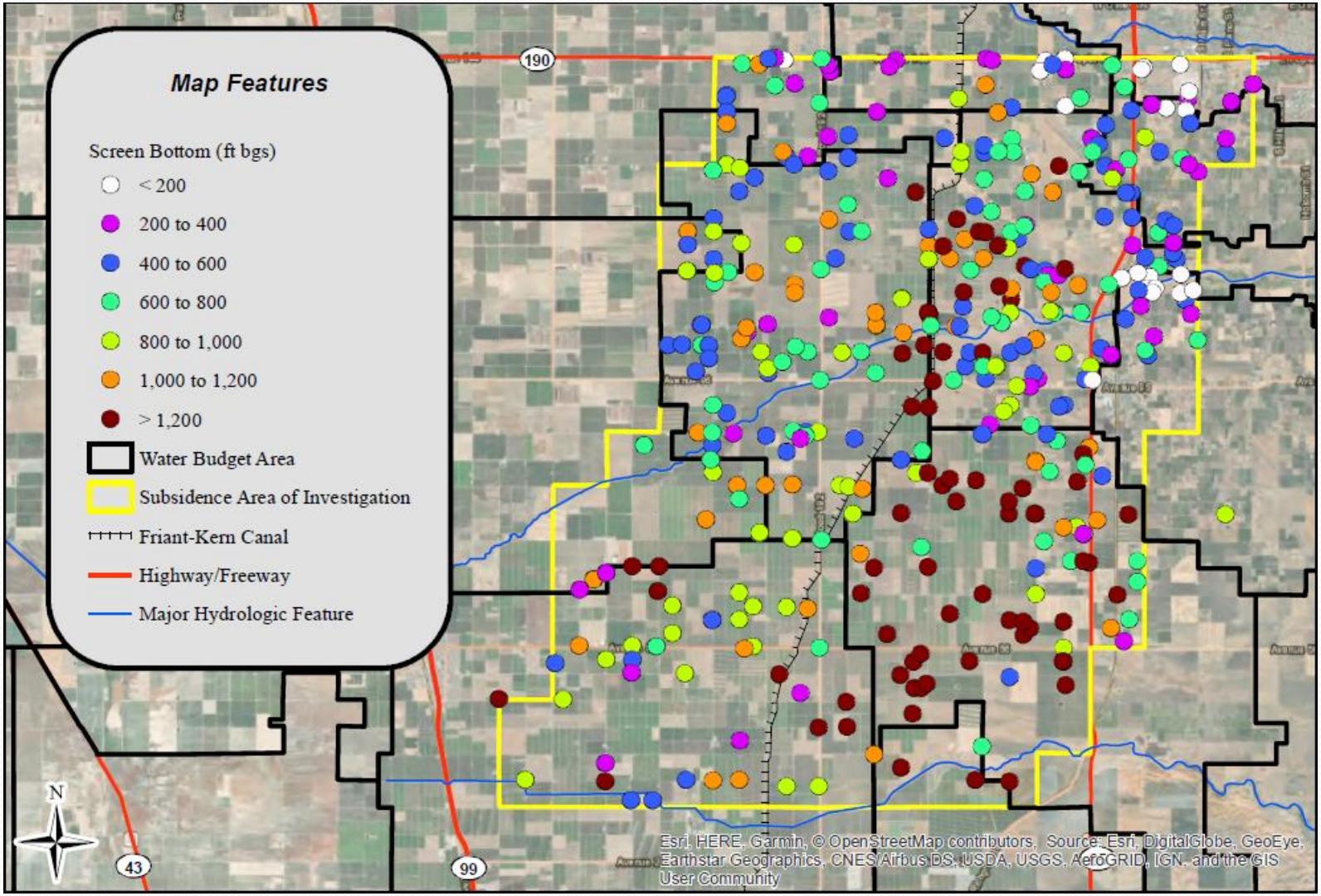
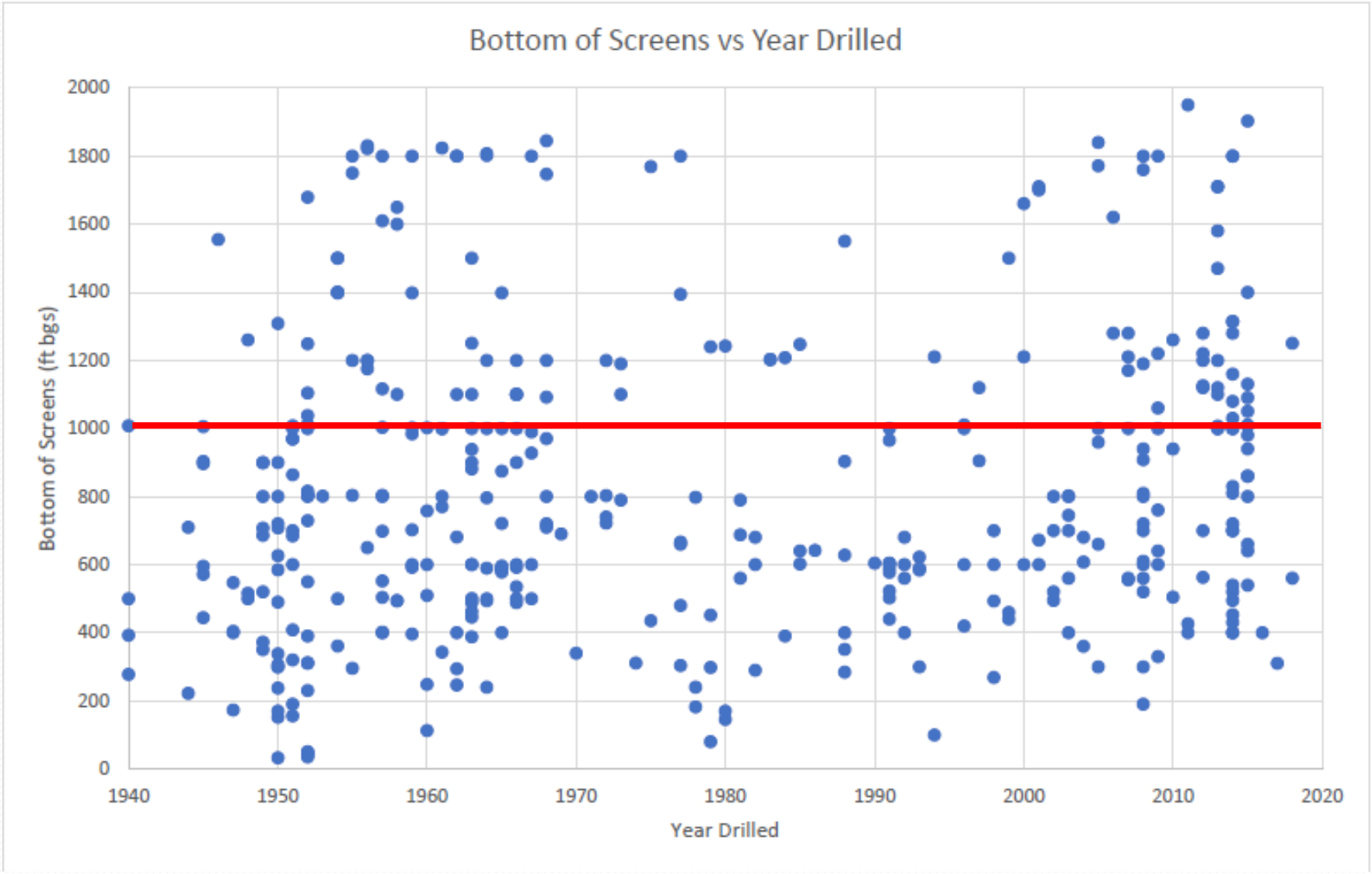
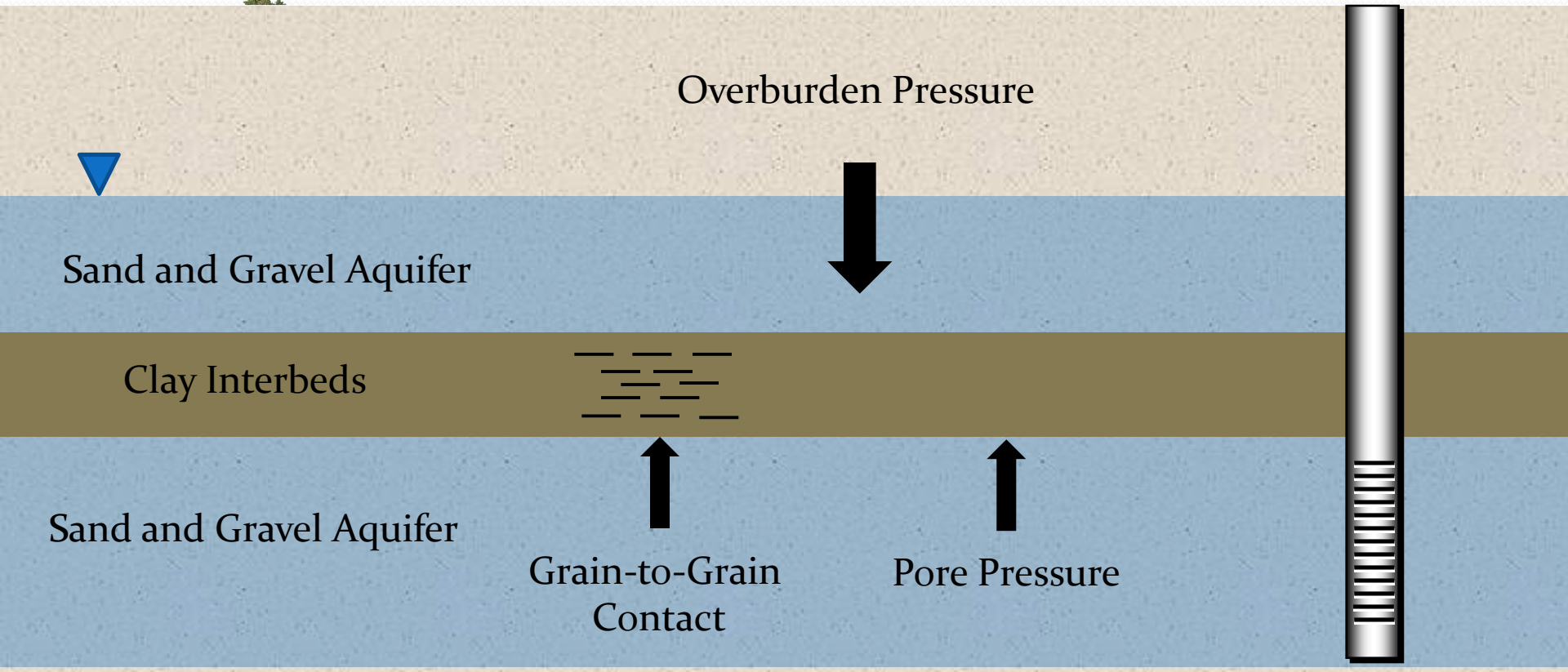
# Well Depths


Map Features
Screen Bottom (ft bgs)
< 200
200 to 400
400 to 600
600 to 800
800 to 1,000
1,000 to 1,200
> 1,200
Water Budget Area
Subsidence Area of Investigation
Friant-Kern Canal
Highway/Freeway
Major Hydrologic Feature
190
43
99
N
Esri, HERE, Garmin, © OpenStreetMap contributors, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

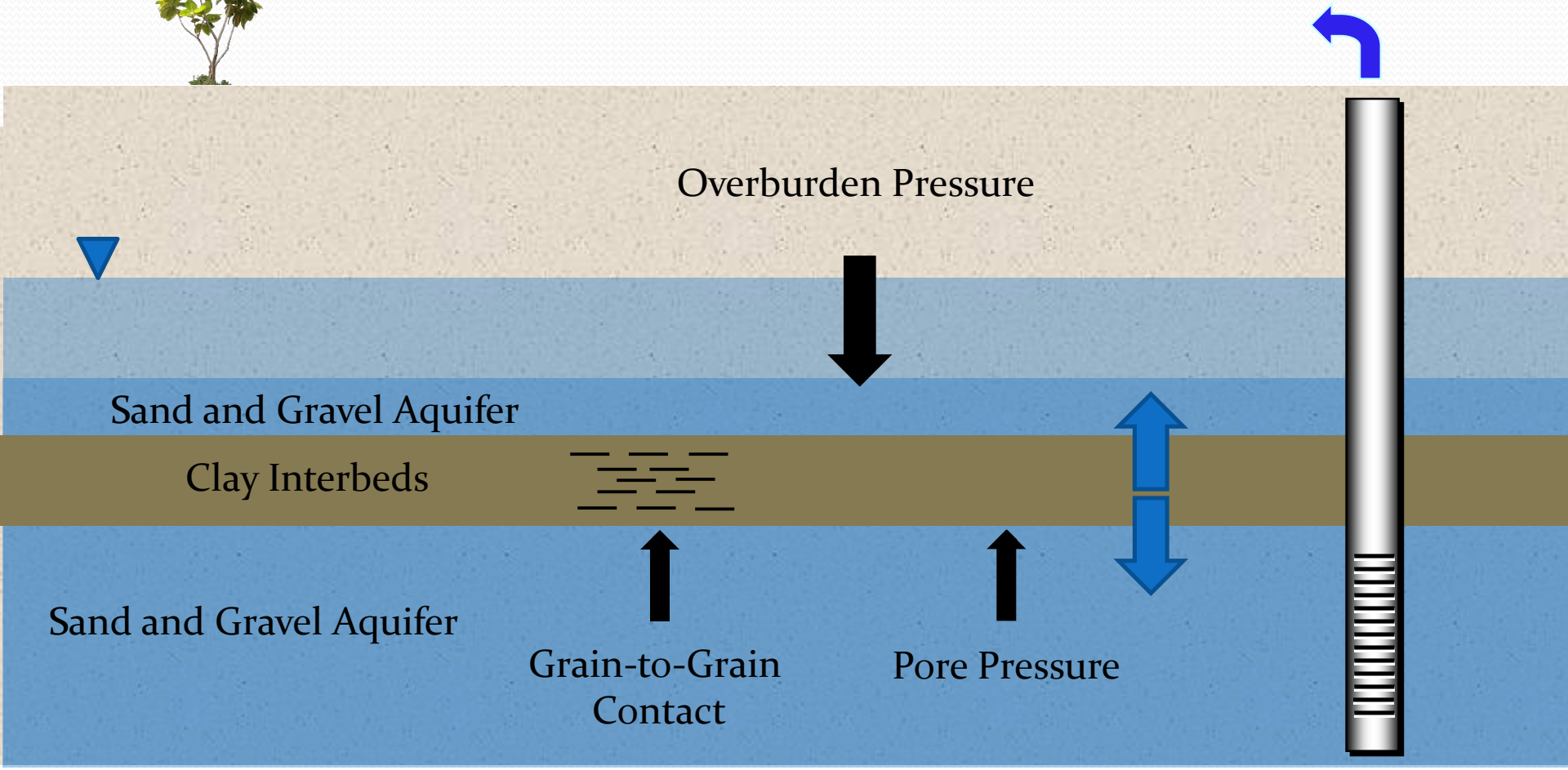
# There is No Correlation Between Well Depth and Year Drilled in the Study Area



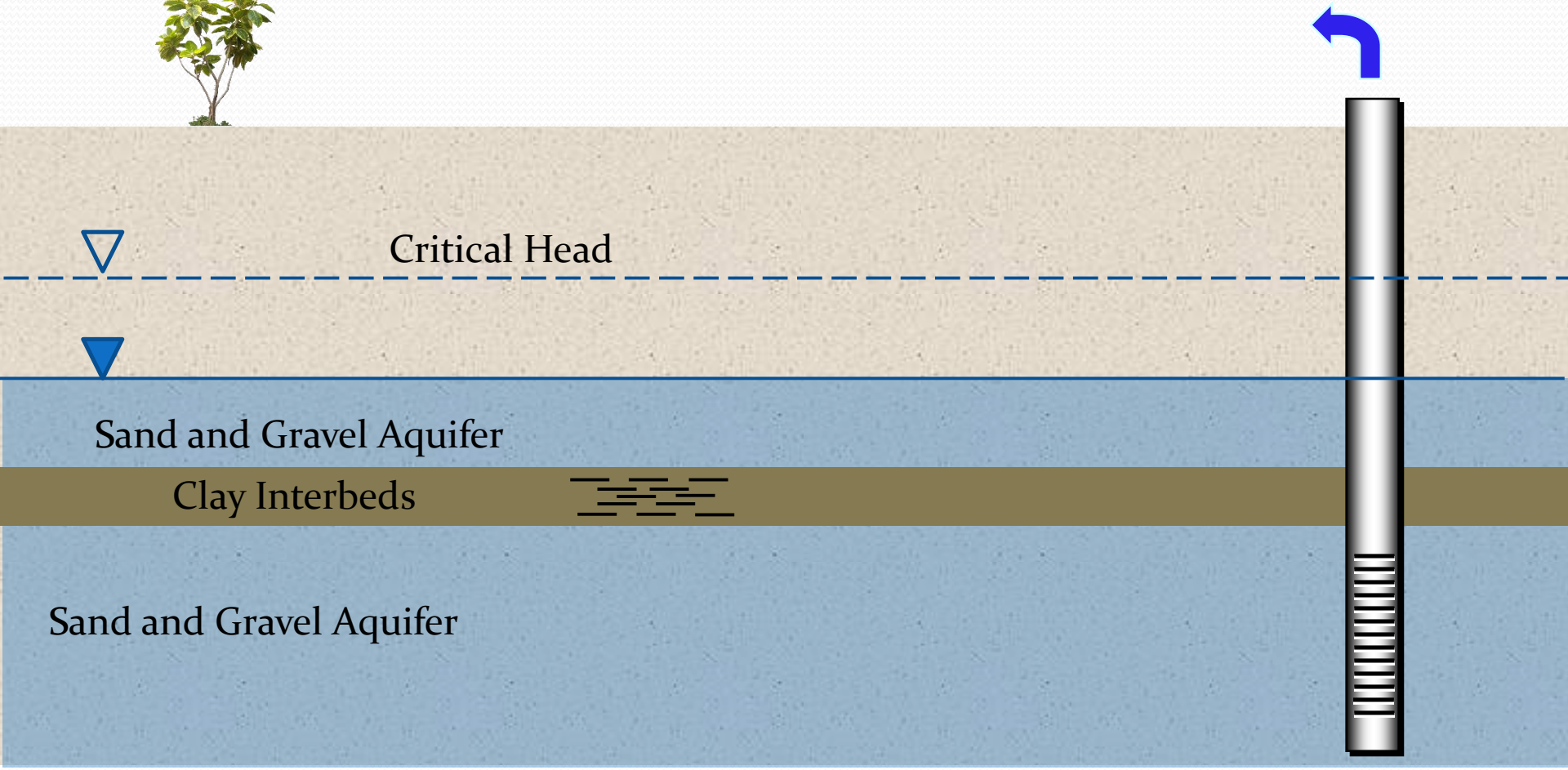
# What Causes Land Subsidence from Groundwater Withdrawal?



# Land Subsidence Occurs When Groundwater Levels Drop for Long Periods of Time in Areas with Thick Subsurface Clay Layers

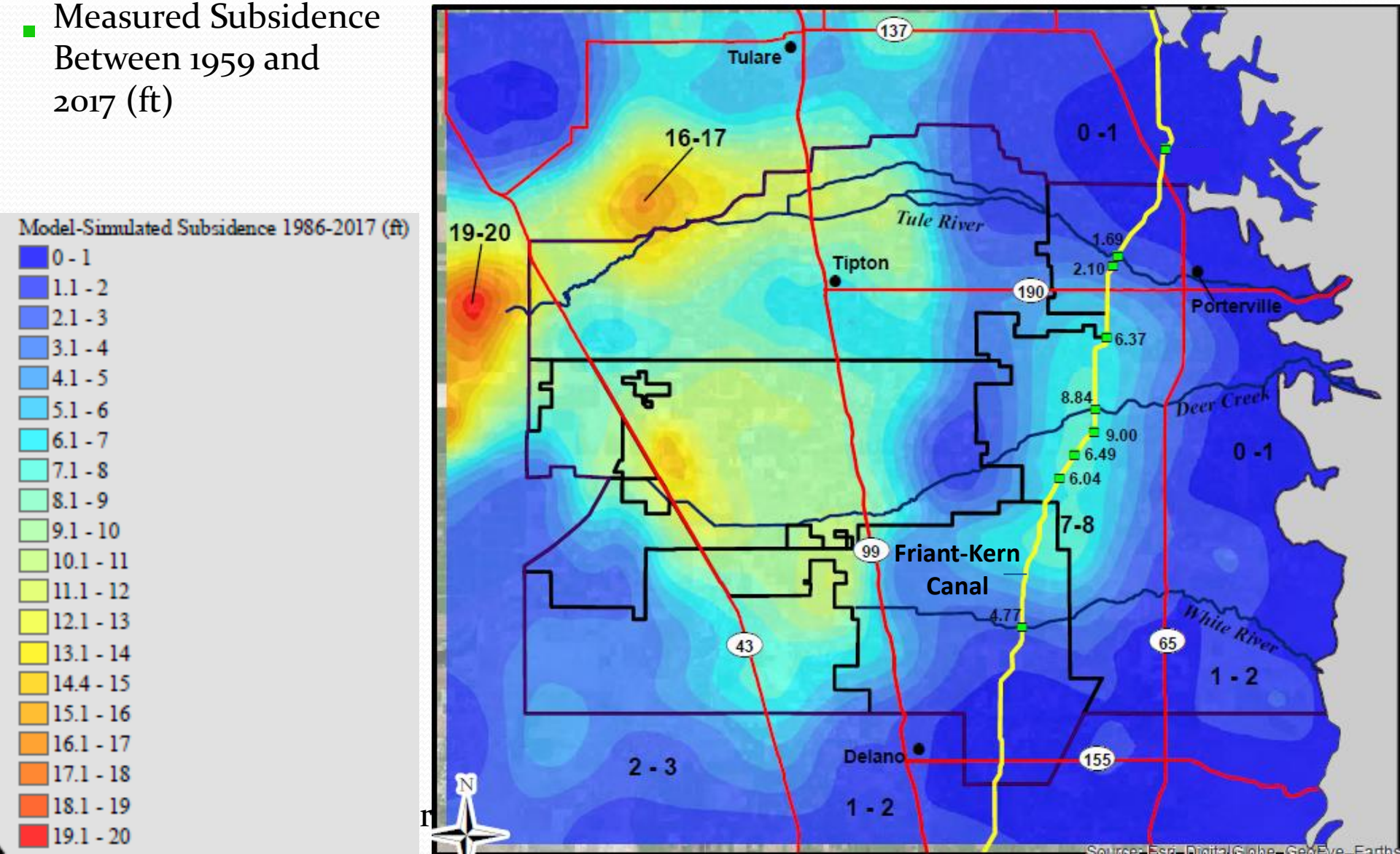


# The Groundwater Level at which Non-Recoverable Aquitard Compaction Can Occur is Called the Critical Head



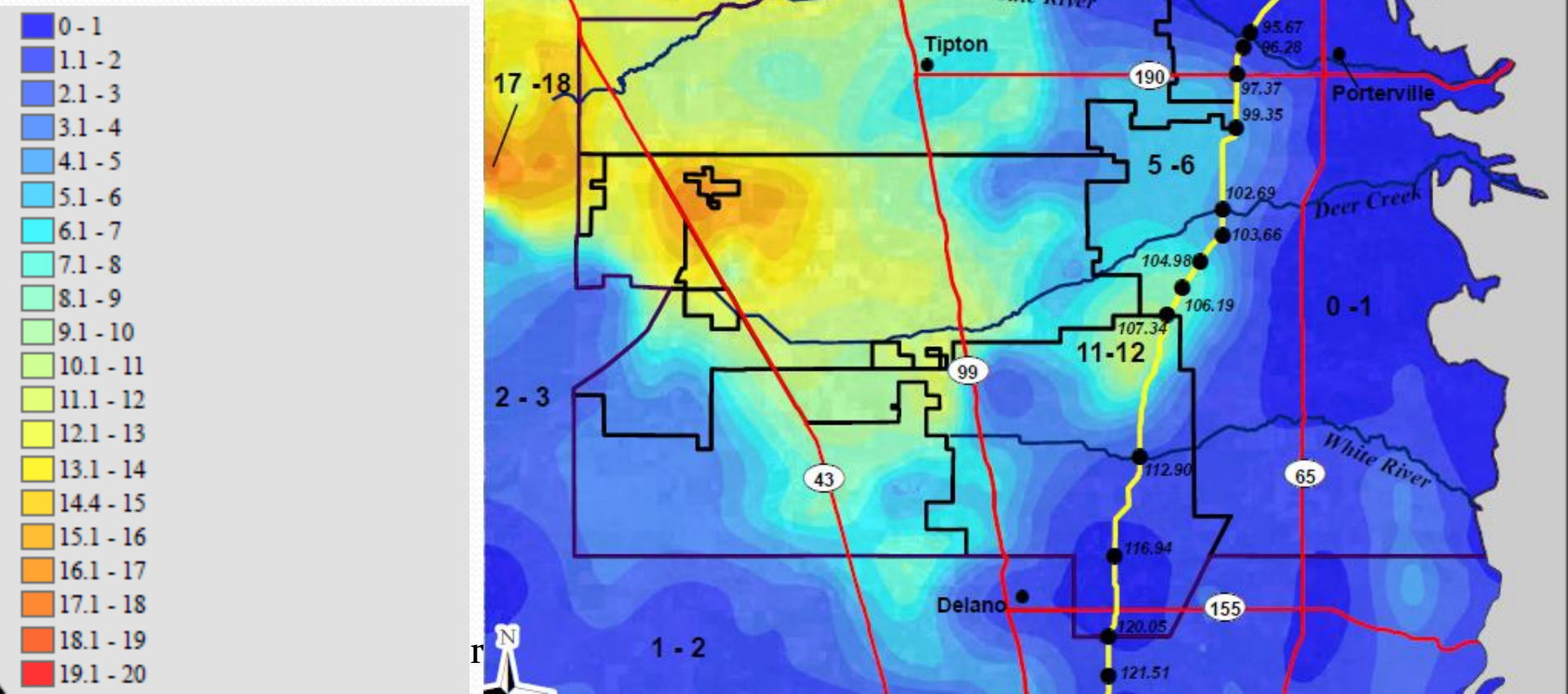
# Model-Simulated Land Subsidence 1986 - 2017

- Measured Subsidence Between 1959 and 2017 (ft)

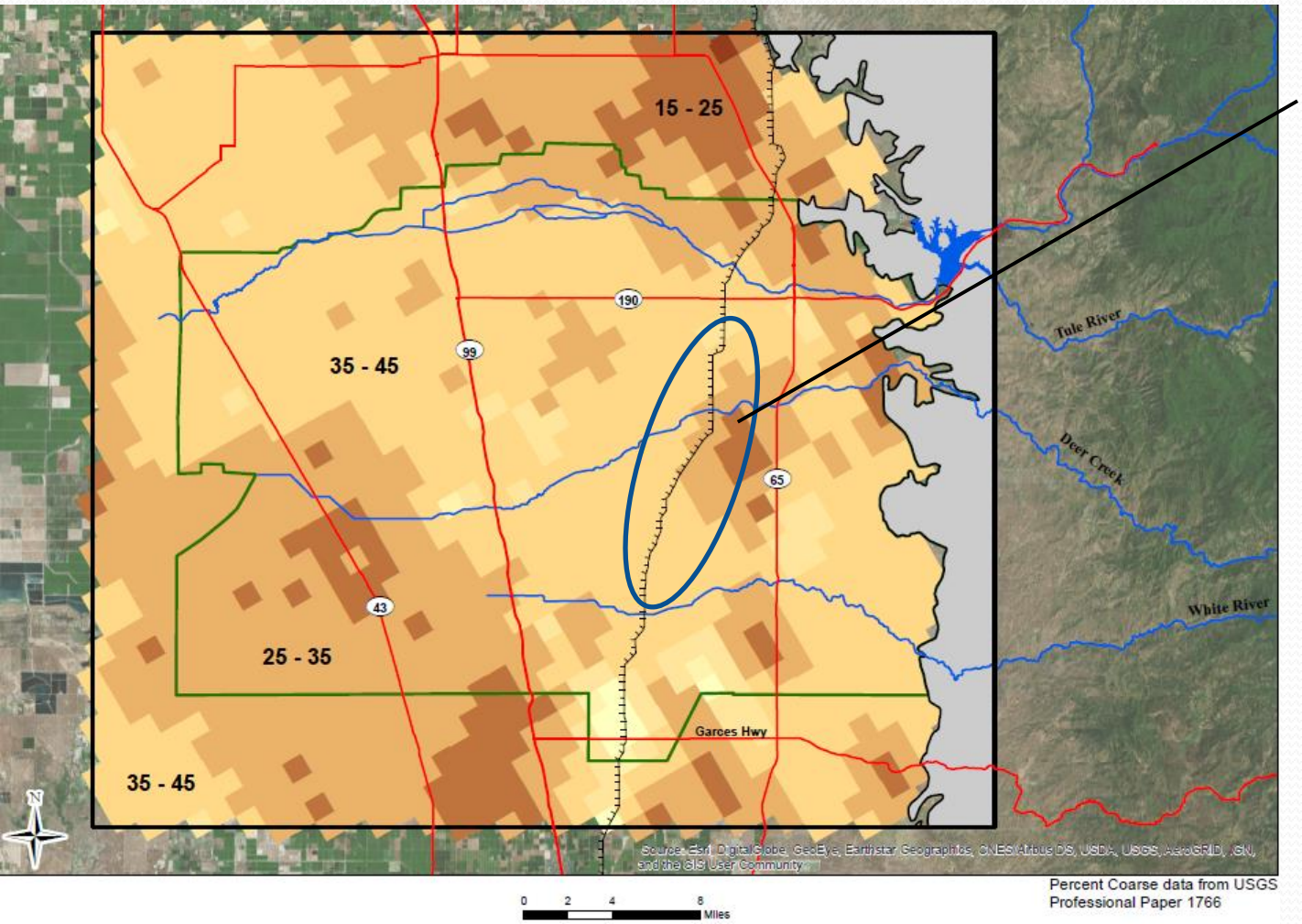


# Without Management Actions, Land Subsidence is Predicted to Continue Into the Future Throughout the Tule Subbasin

This Map Shows the Additional Model-Predicted Subsidence that Could Occur Between 2020 and 2040 If Groundwater Production Continues At Current Rates Throughout the Subbasin



# Upper Aquifer (Model Layer 1) – Areas of Fine-Grained Sediments




Layer 1 Is Generally Land Surface to 180 Ft Below Land Surface In this Area

Percent Coarse Grained Sediments

- 4 - 10
- 10 - 15
- 15 - 25
- 25 - 35
- 35 - 45
- 45 - 55
- 55 - 65
- 65 - 75

Percent Coarse data from USGS Professional Paper 1766

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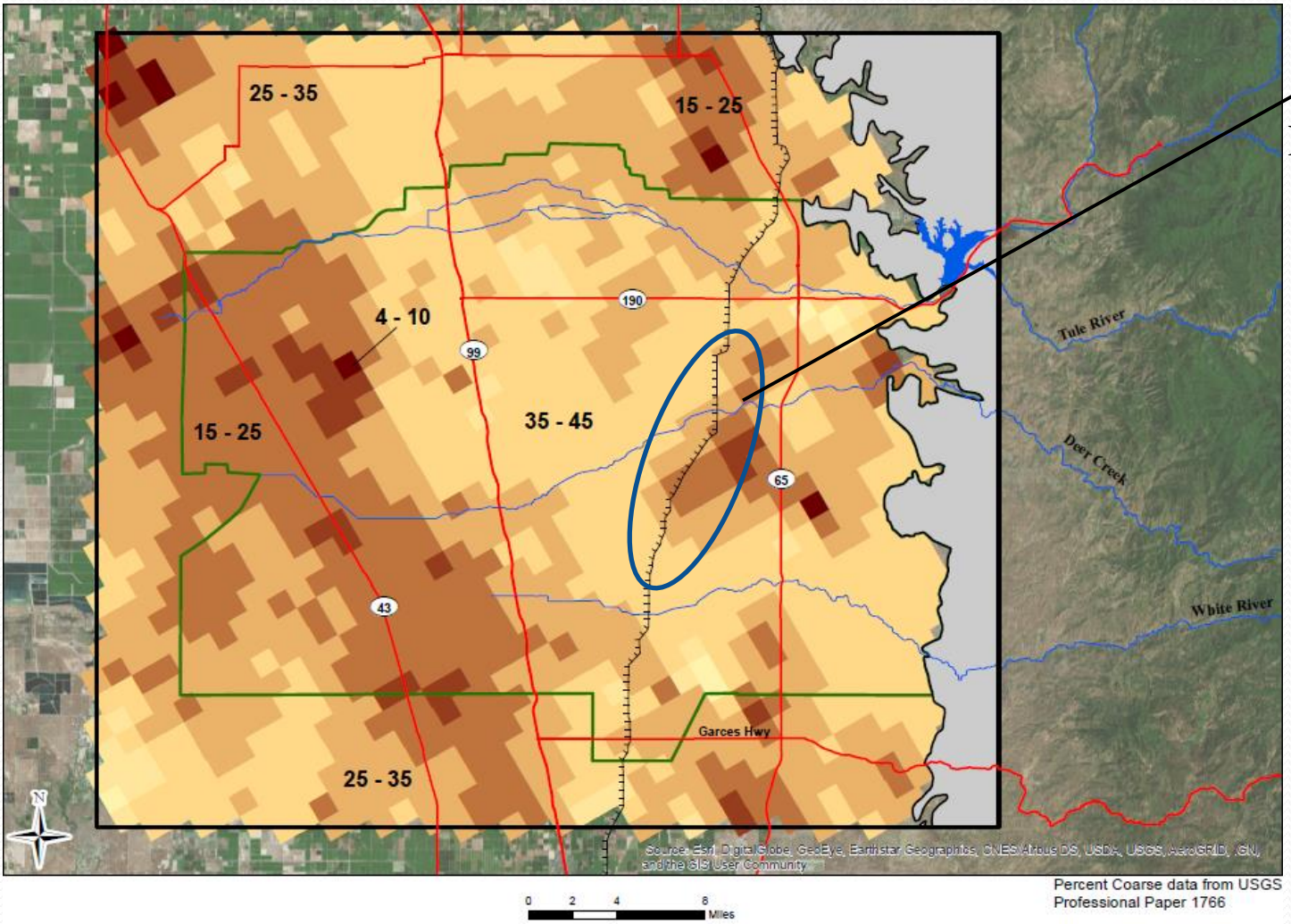
# Model Layer 2 – Areas of Fine-Grained Sediments




Layer 2 Is Generally
180 to 290
Ft Below Land Surface
In this Area

Percent Coarse Grained Sediments

- 4 - 10
- 10 - 15
- 15 - 25
- 25 - 35
- 35 - 45
- 45 - 55
- 55 - 65
- 65 - 75

Percent Coarse data from USGS Professional Paper 1766

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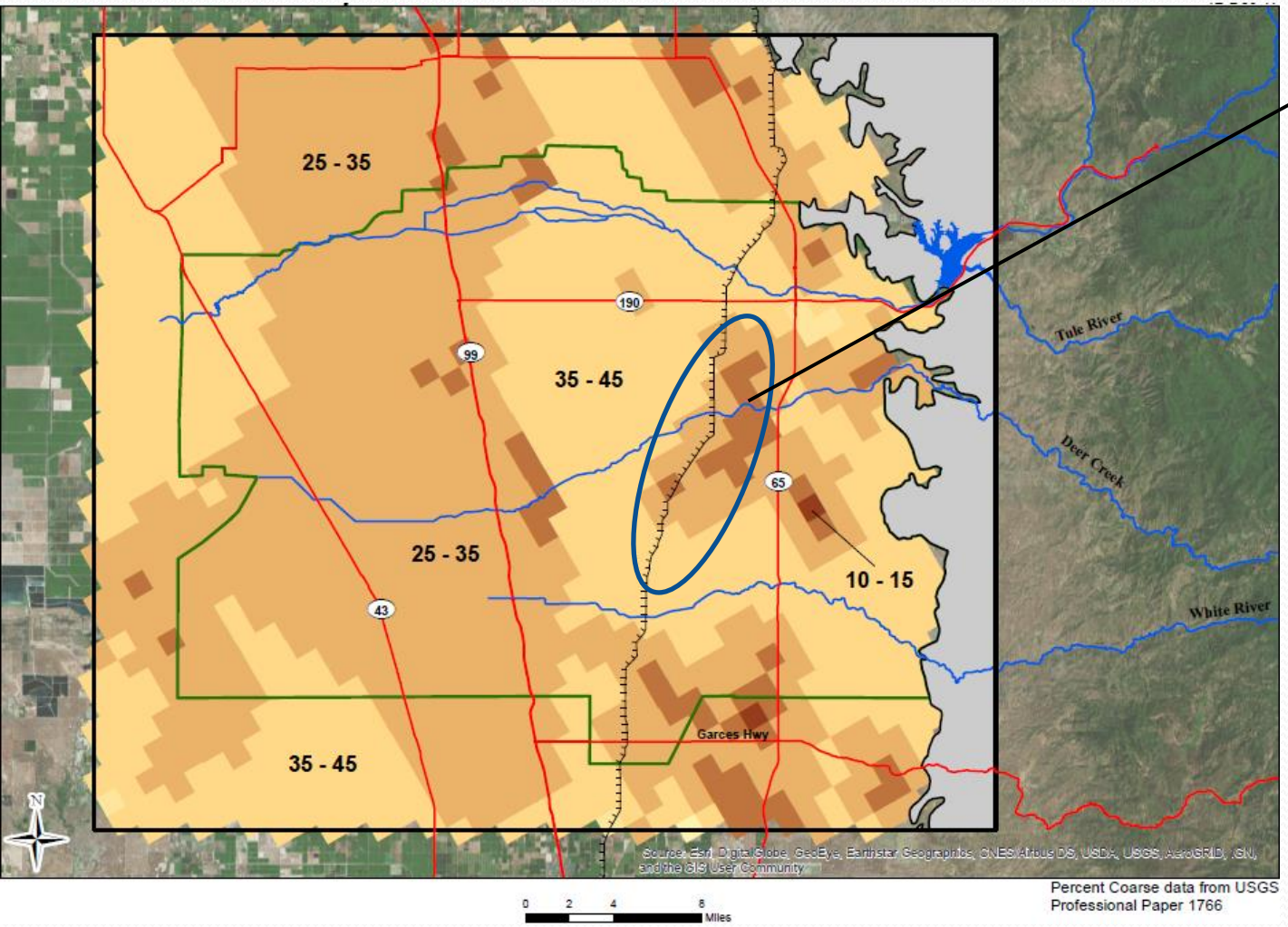
# Lower Aquifer (Model Layer 3) – Areas of Fine-Grained Sediments




Layer 3 Is Generally 290 to 800 Ft Below Land Surface In this Area

Percent Coarse Grained Sediments

- 4 - 10
- 10 - 15
- 15 - 25
- 25 - 35
- 35 - 45
- 45 - 55
- 55 - 65
- 65 - 75

Percent Coarse data from USGS Professional Paper 1766

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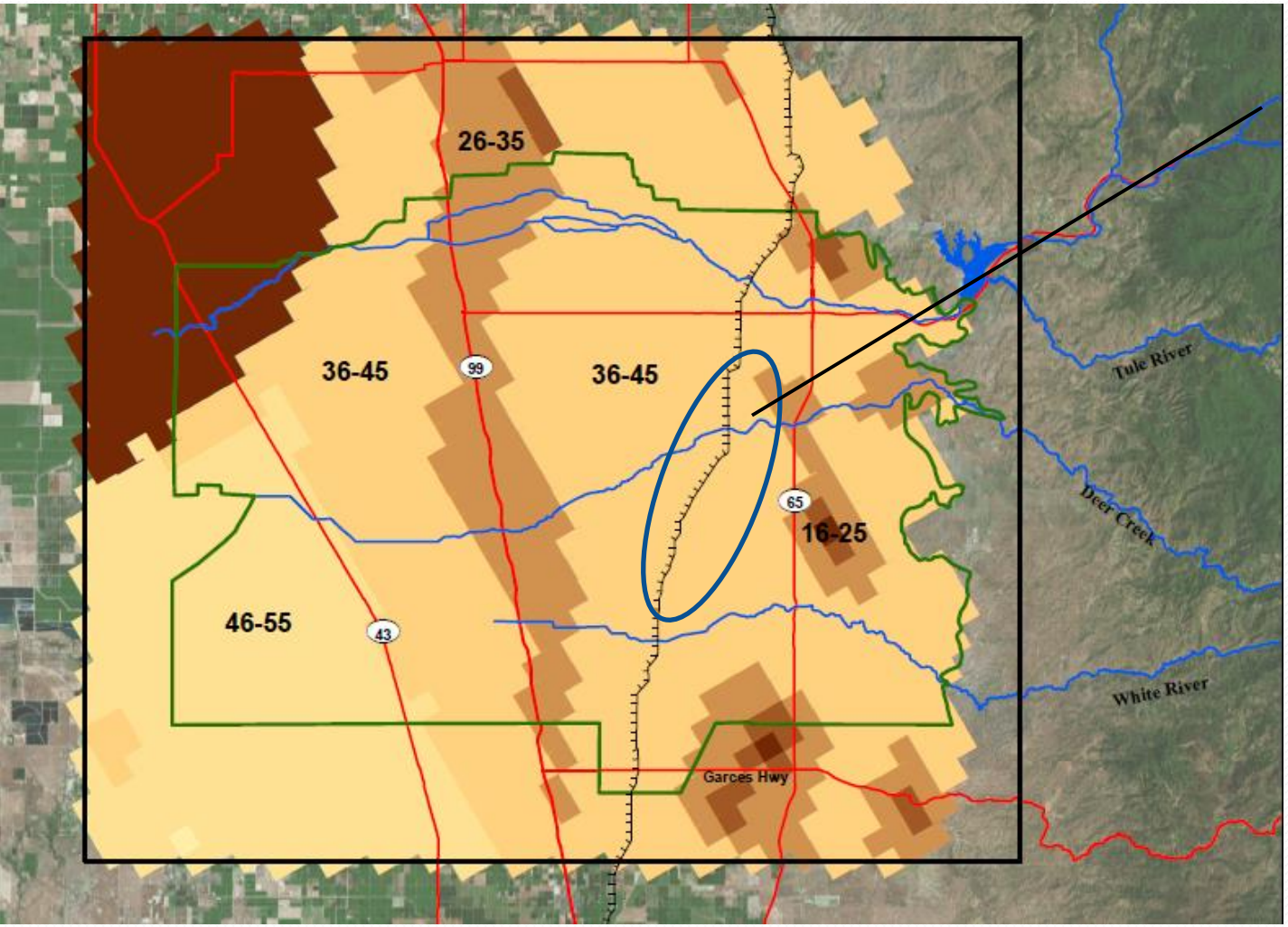
# Very Deep Aquifer (Model Layer 4) – Areas of Fine-Grained Sediments




Layer 4 Is Generally 800 to 1,400 Ft Below Land Surface In this Area

Percent Coarse Grained Sediments

- 4 - 10
- 10 - 15
- 15 - 25
- 25 - 35
- 35 - 45
- 45 - 55
- 55 - 65
- 65 - 75

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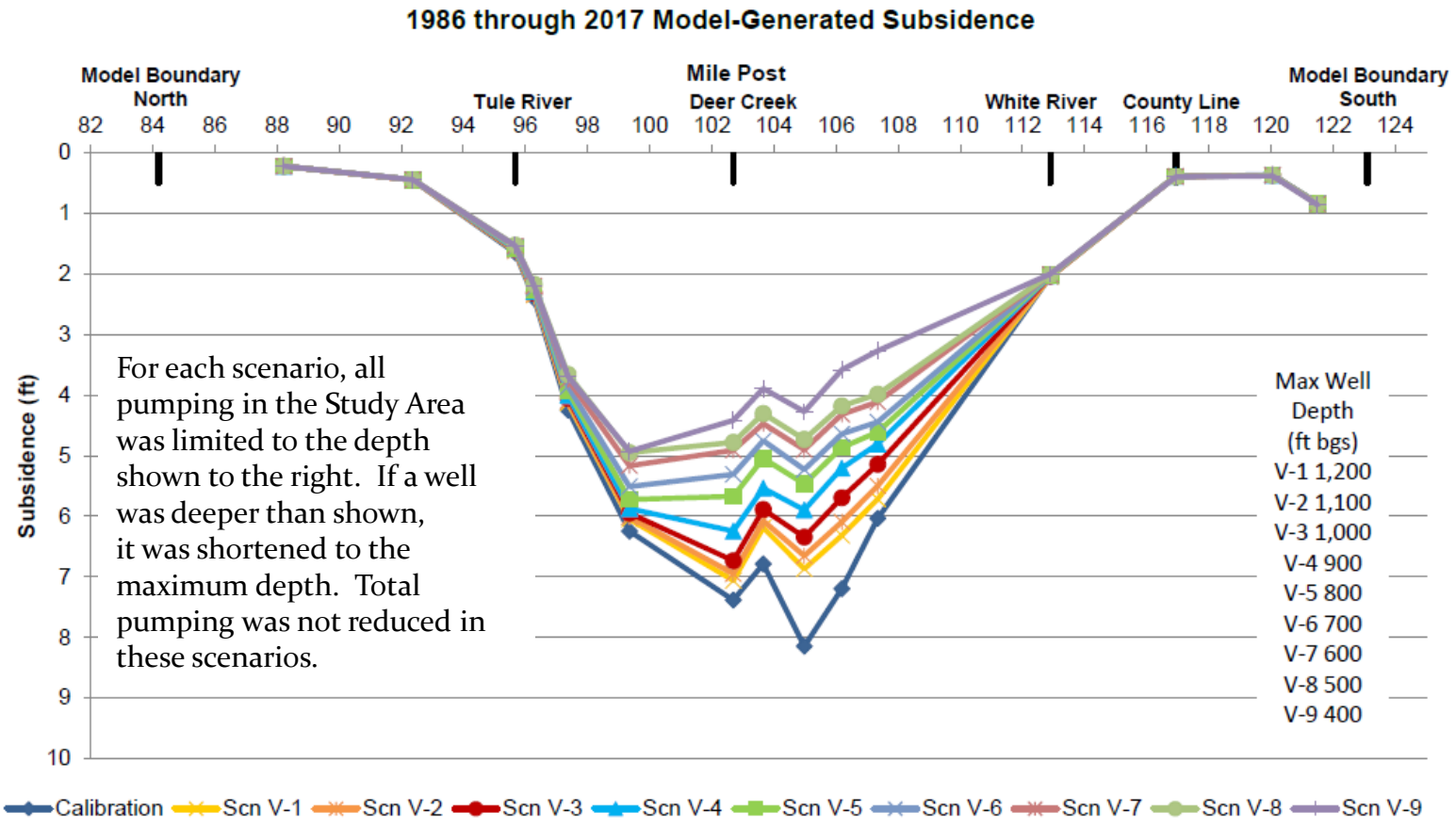
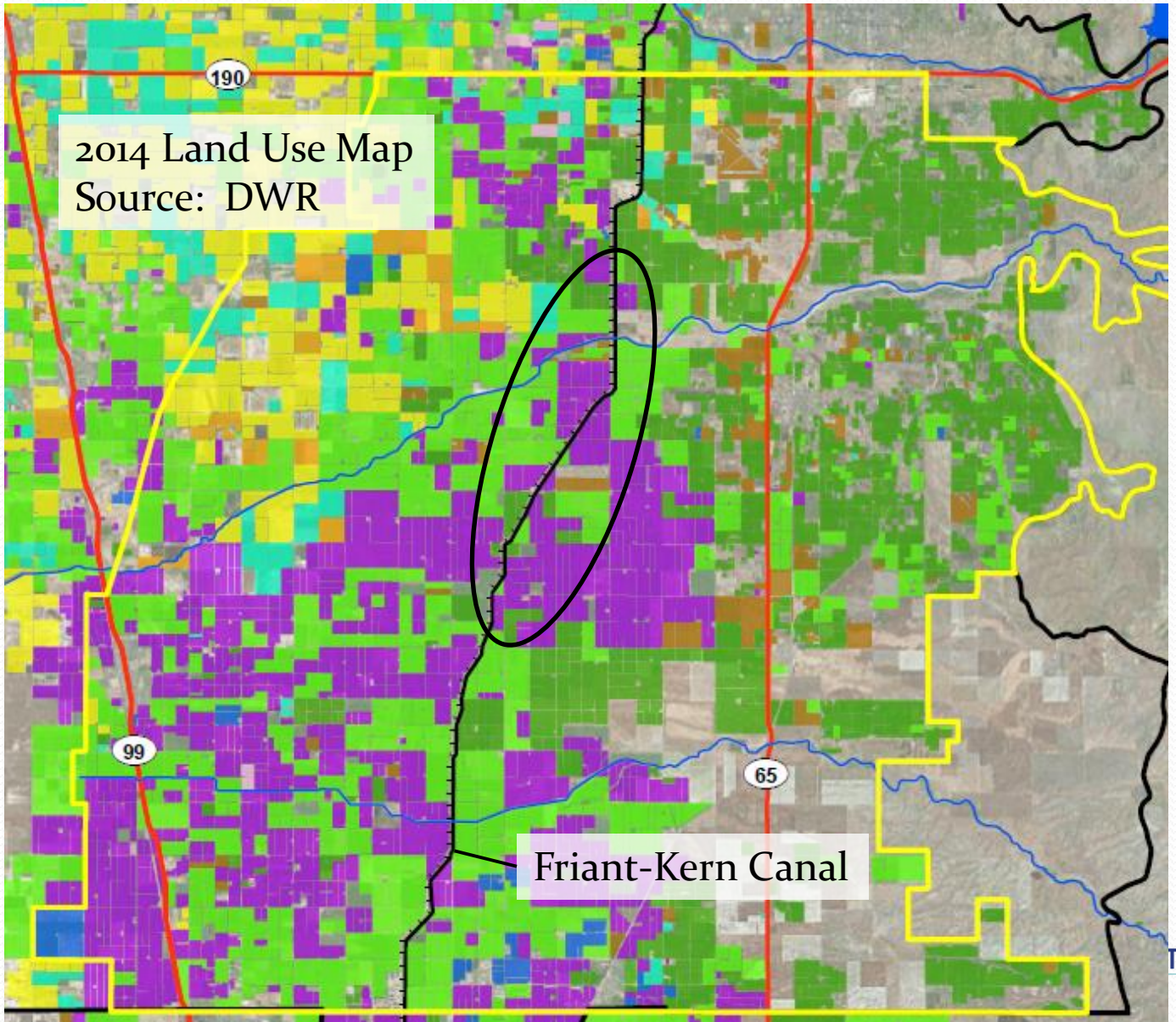
# Subsidence Simulation Results for Historical Model – Effect of Reducing Deep Pumping



# Crops in the Area of Historical Subsidence Along the Friant-Kern Canal Have Recently Been Primarily Grapes and Nuts




**Map Features**

- Grain and Hay
- Truck Crops
- Misc Field Crops
- Grapes
- Corn
- Cotton
- Deciduous, Fruit Trees
- Nuts
- Alfalfa, Pasture
- Basin Boundary
- Expanded Focused Subsidence Area
- Friant-Kern Canal
- Highway/Freeway
- Major Hydrologic Feature

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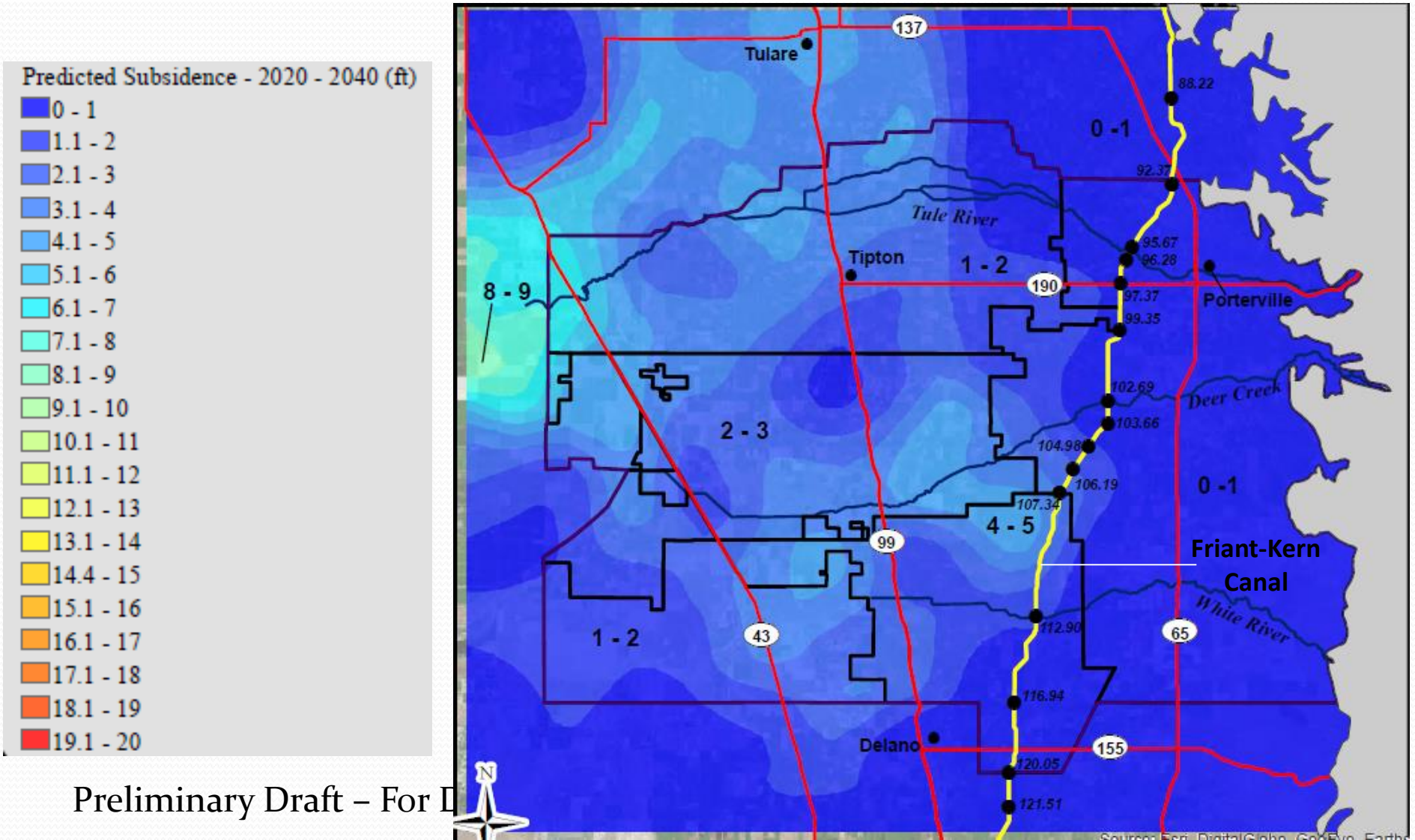
# Potential Future Subsidence Along the Friant-Kern Canal was Evaluated in the Context of Three Subbasin-Wide Pumping Transition Scenarios:

- Scenario 1
  - Regional Subbasin – 5-Yr Transitional Pumping
- Scenario 2
  - Regional Subbasin – 10-Yr Transitional Pumping
- Scenario 3
  - Regional Subbasin – 20-Yr Transitional Pumping

# Under A 5-Yr Transitional Pumping Scenario, the Predicted Rate of Subsidence Beneath the Canal Reduces Significantly

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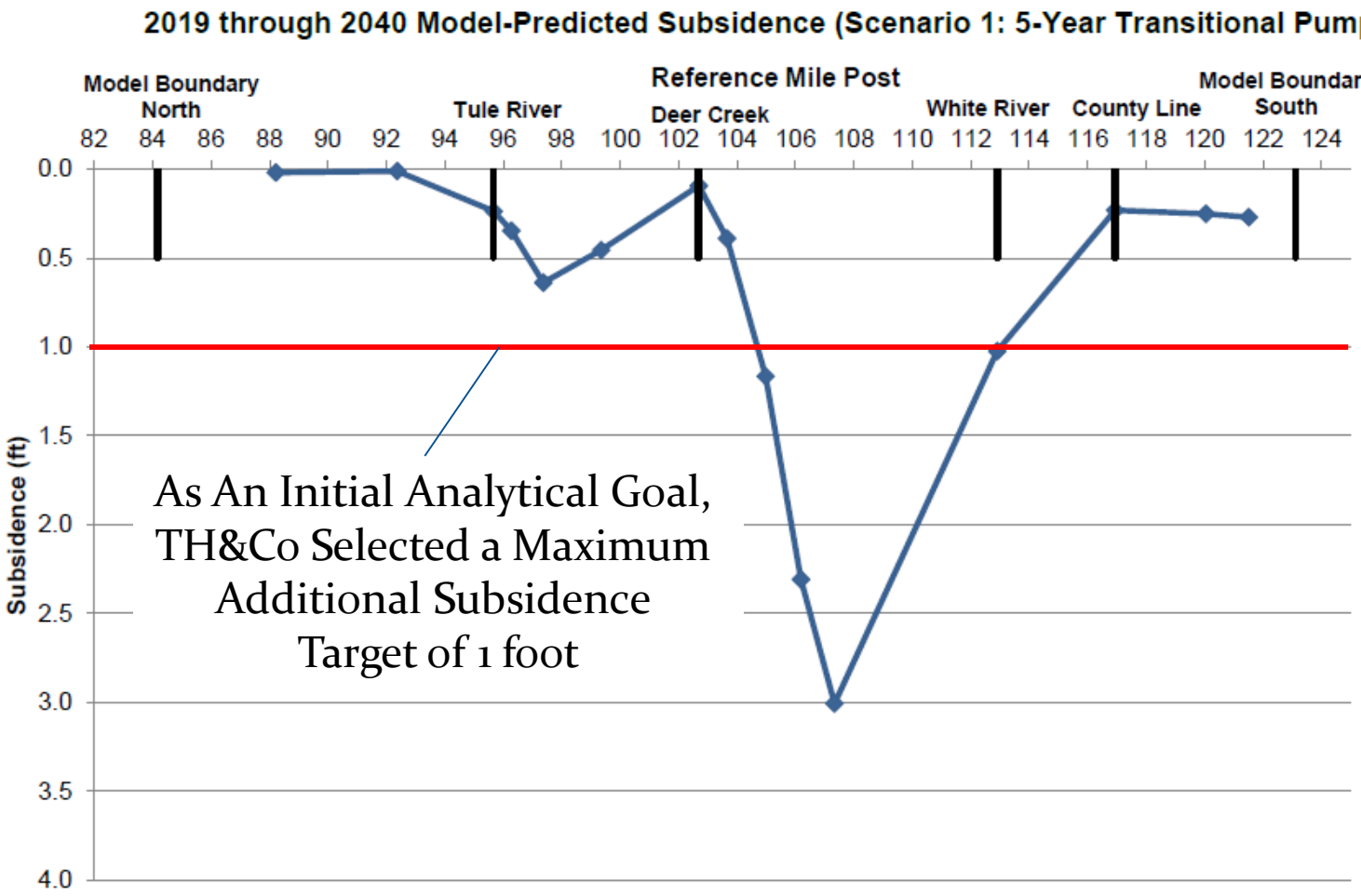
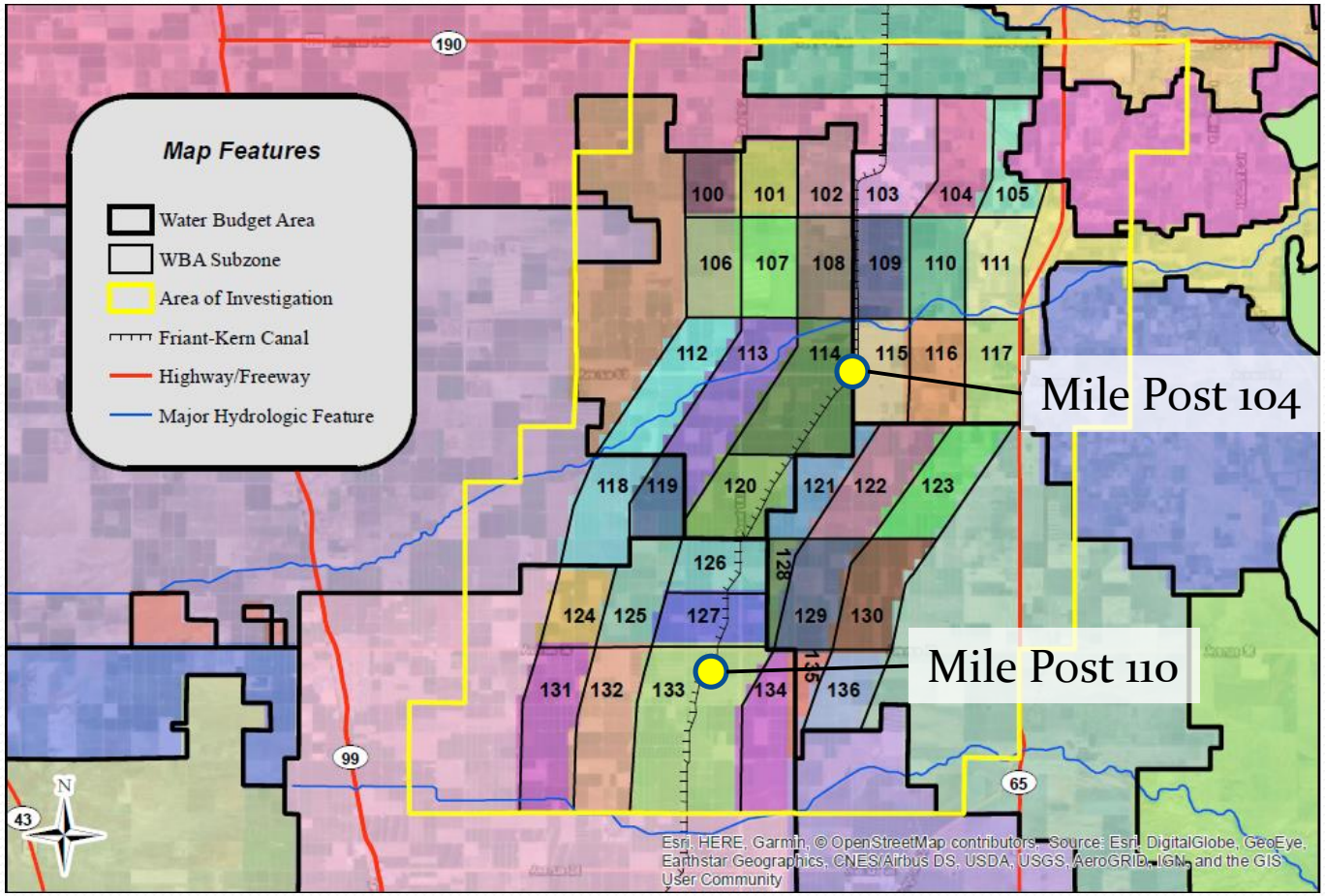
# However, Even with 5-Yr Transitional Pumping to Sustainable Levels, Subsidence Between Mile Post 104 and 110 Is Predicted to Increase By as Much as 3 Additional Feet Between 2020 and 2040



# In Order to Address the Subsidence Still Predicted to Occur, We Developed Refined Water Budget Zones in the Area of the Friant-Kern Canal and Analyzed the Effects of Eliminating Pumping in Selected Zones



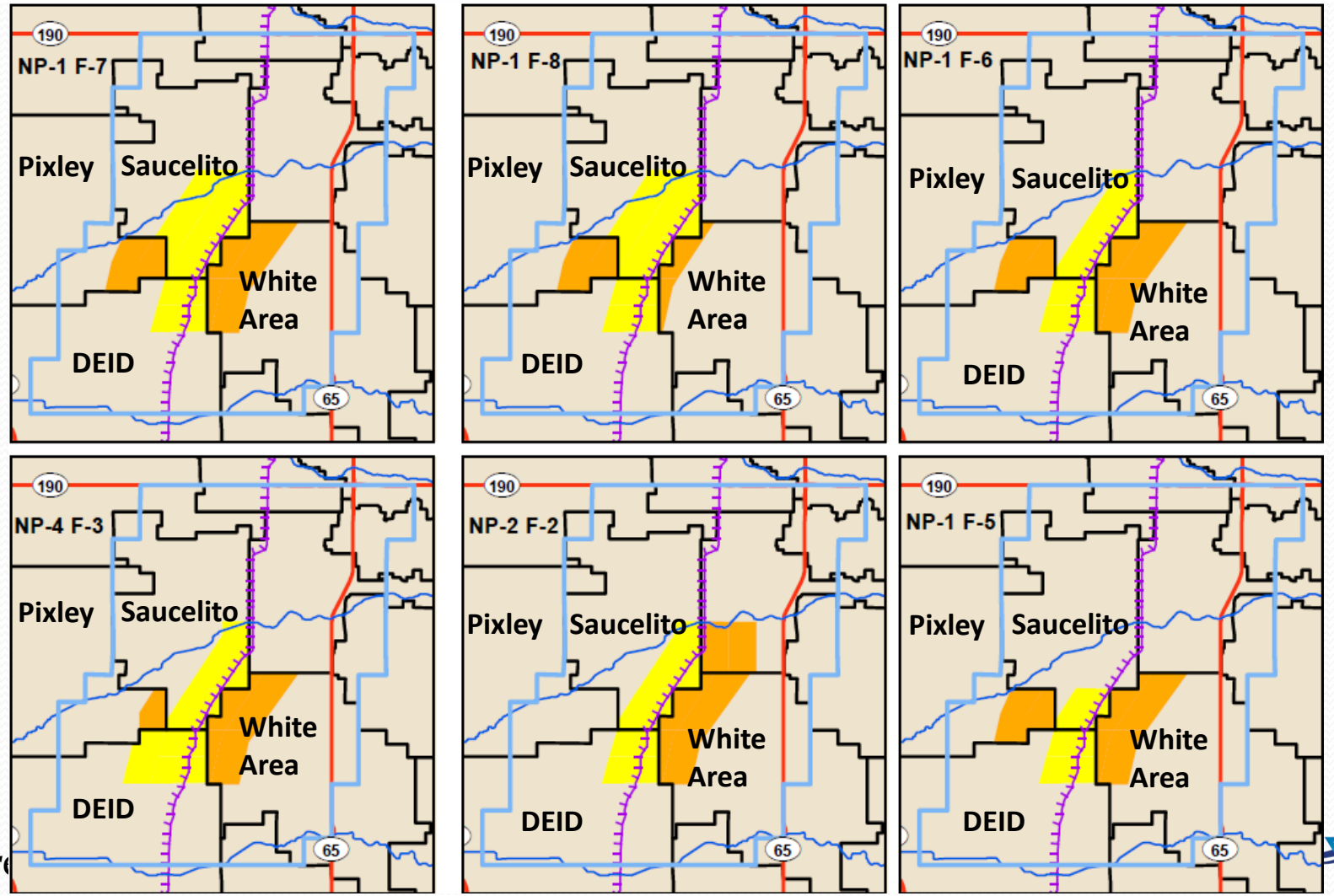

What Would the Subsidence Have Been in the Study Area if There had been No Groundwater Pumping In The Water Budget Zones In the Vicinity of Mile Posts 104 and 110?

# Assumptions for the Detailed Analysis Included:

- Groundwater Pumping in Each Water Budget Zone Modified for Analysis Was Discontinued in 2020
- For Water Budget Zones in Areas Where the Zone Coincided with an Agency with Surface Water Rights, It was Assumed that Consumptive Use would Continue at Sustainable Levels, Beginning in 2020
- The Sustainability Target for Consumptive Use of Crops with No Surface Water Supply (i.e. transitional pumping target) was 0.37 acre-ft/acre

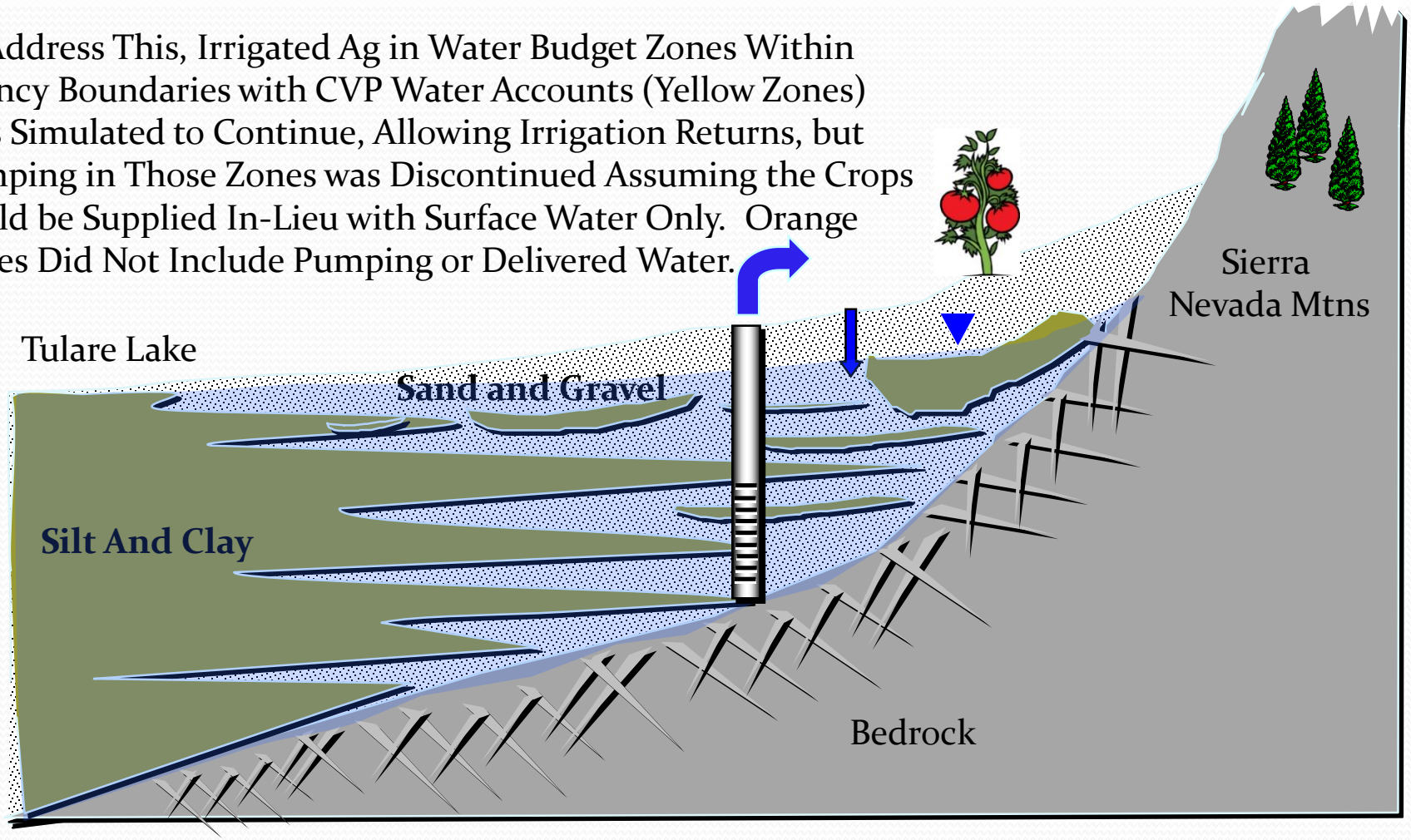
It Is Emphasized that Subsidence Mitigation Can Be Accomplished Through a Combination of Reduced Pumping, Increased Recharge, or a Combination of Both. The Analyses Performed to Date is Meant to Inform Basin Managers But Should Not Be Construed as a Final Remedy.

# TH&Co Analyzed A Total of 37 Water Budget Zone Configurations Under Scenario 1 (5-Yr Transitional Pumping). The Most Effective Zone Configurations At Limiting Future Subsidence to Less Than 1-ft are As Follows.

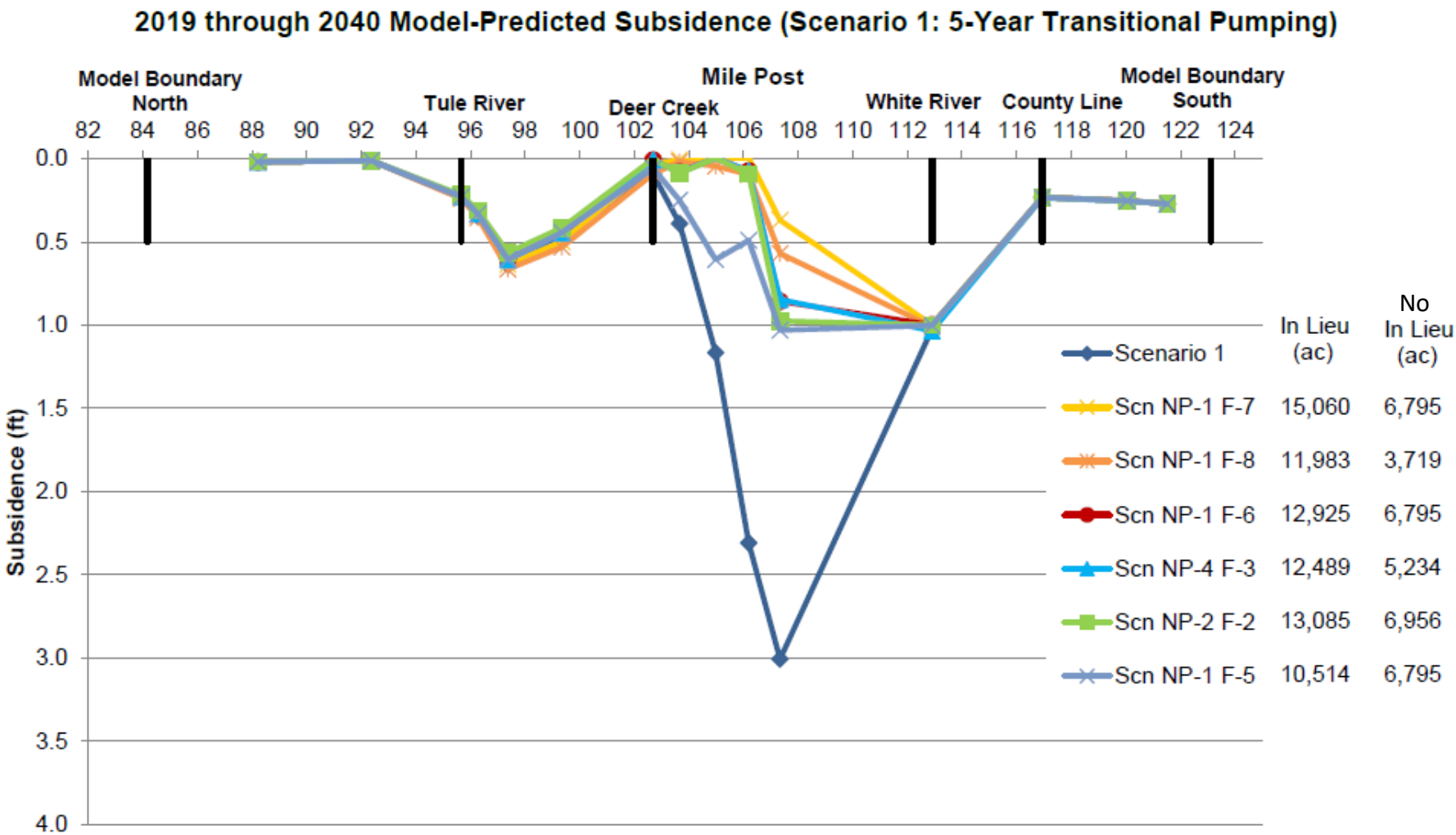


# During Analysis of Scenarios, It Was Found that Continued Irrigation Return Flow, Which Recharges the Upper Aquifer, Was Beneficial at Limiting Subsidence

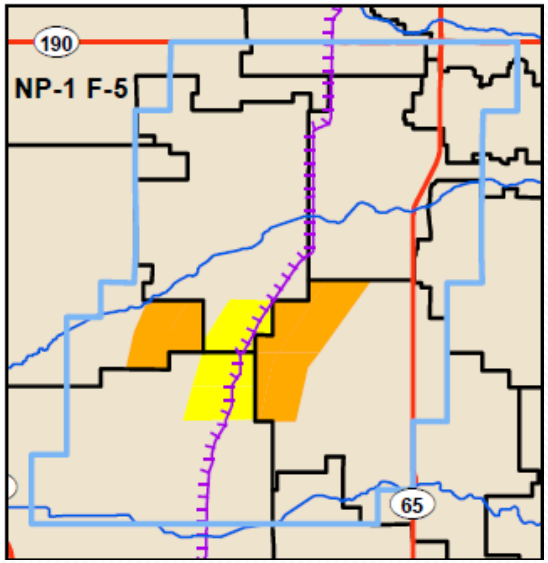
To Address This, Irrigated Ag in Water Budget Zones Within Agency Boundaries with CVP Water Accounts (Yellow Zones) Was Simulated to Continue, Allowing Irrigation Returns, but Pumping in Those Zones was Discontinued Assuming the Crops Could be Supplied In-Lieu with Surface Water Only. Orange Zones Did Not Include Pumping or Delivered Water.

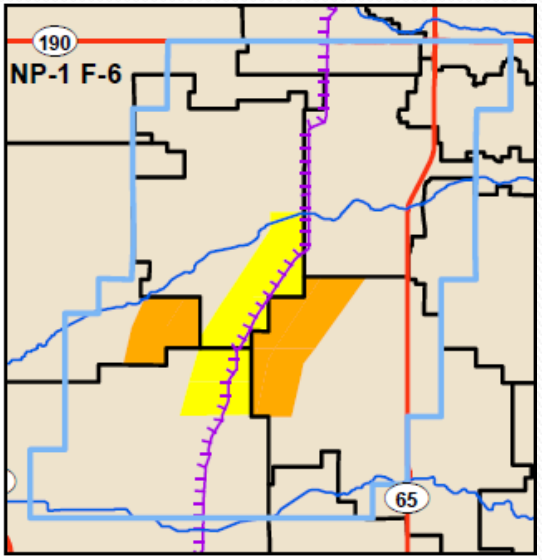


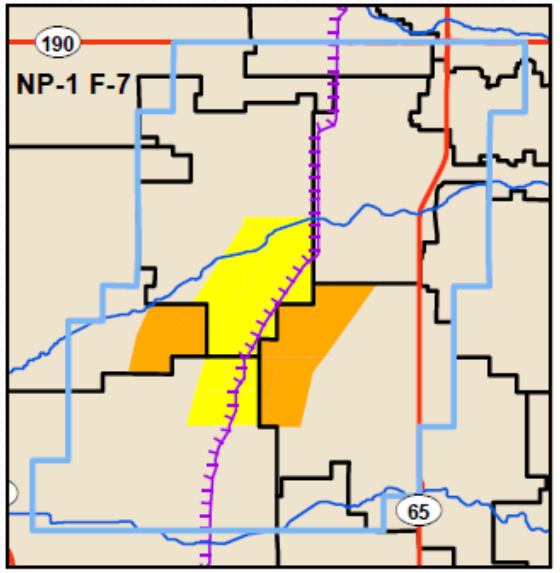
# Each of the Six Best Case Analyses Limits Subsidence Beneath the Friant-Kern Canal to Less than 1 Foot Under Scenario 1 (5-Yr Subbasin Transitional Pumping Conditions; Pumping in Focus Water Budget Area Off in 2020)

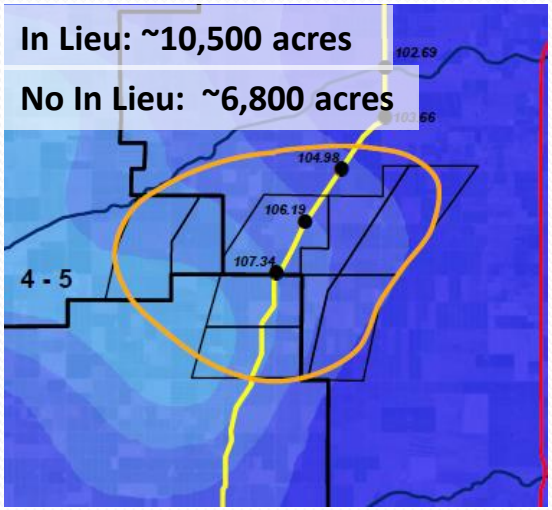


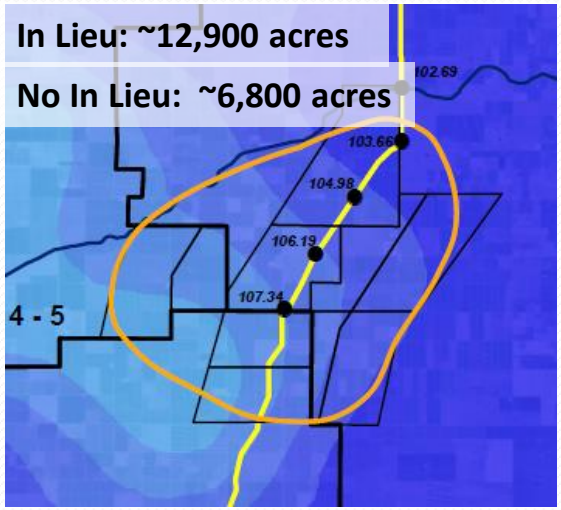
# TH&Co Developed Preliminary Subsidence Management Zones for Each of the Six Best Case Analyses Under Scenario 1

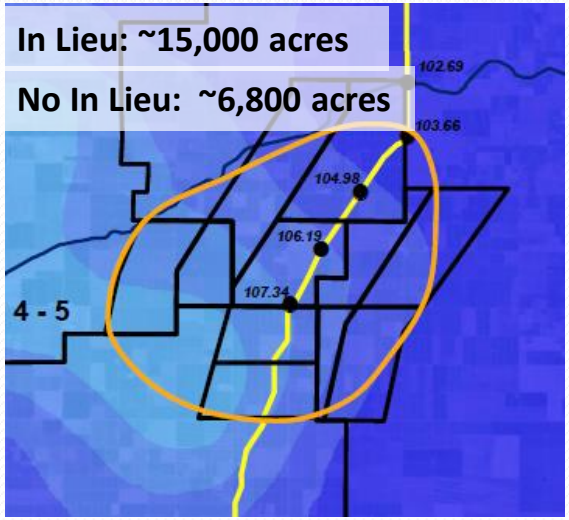
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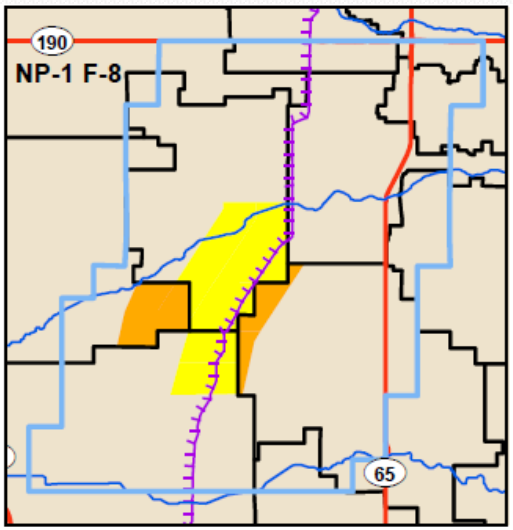
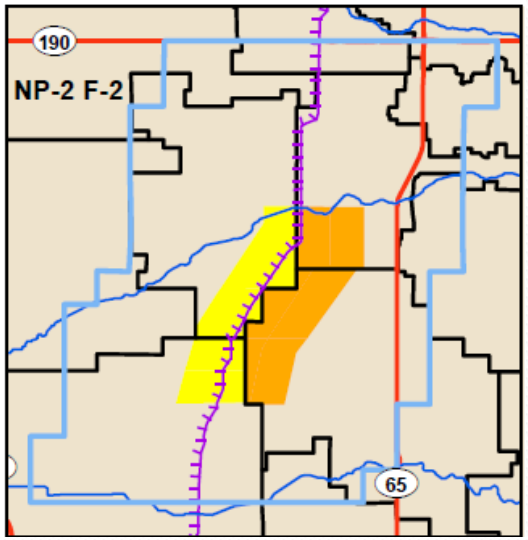
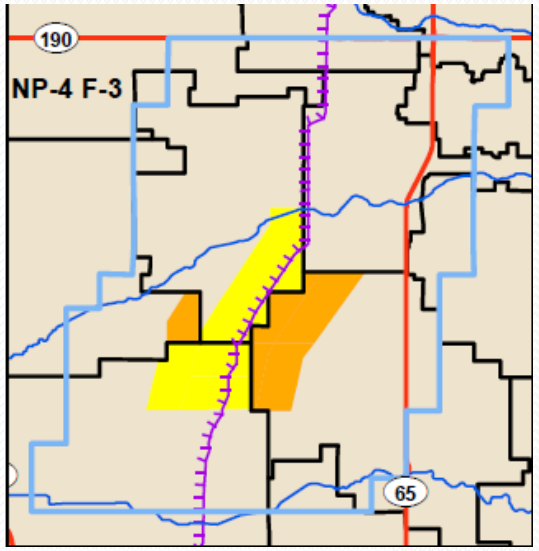
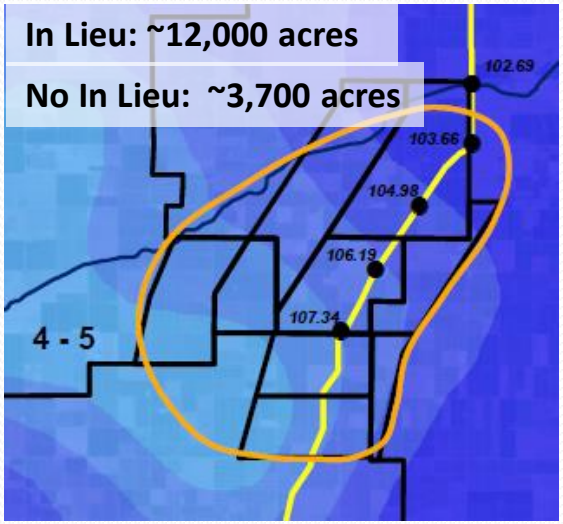
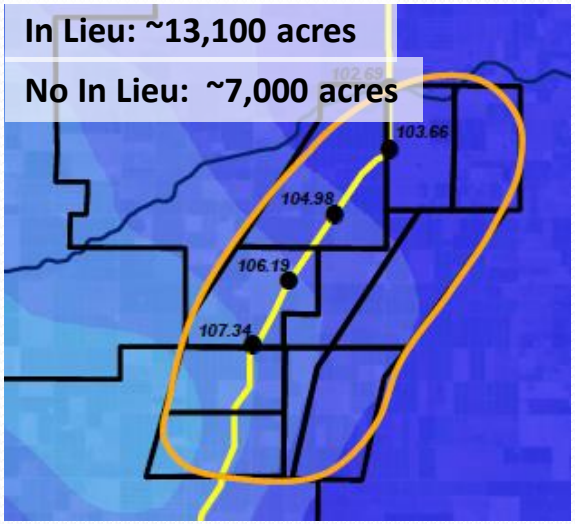
# TH&Co Developed Preliminary Subsidence Management Zones for Each of the Six Best Case Analyses Under Scenario 1

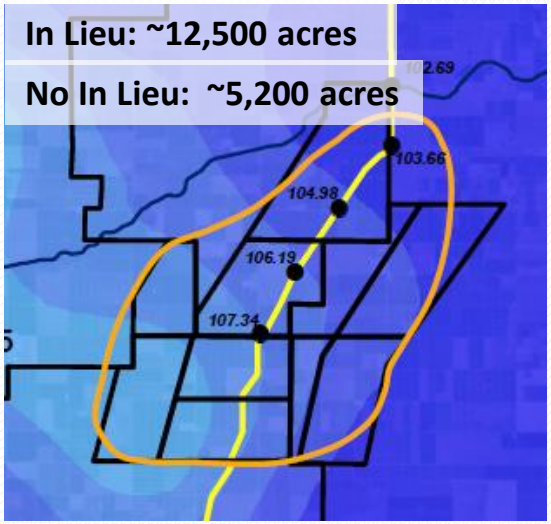
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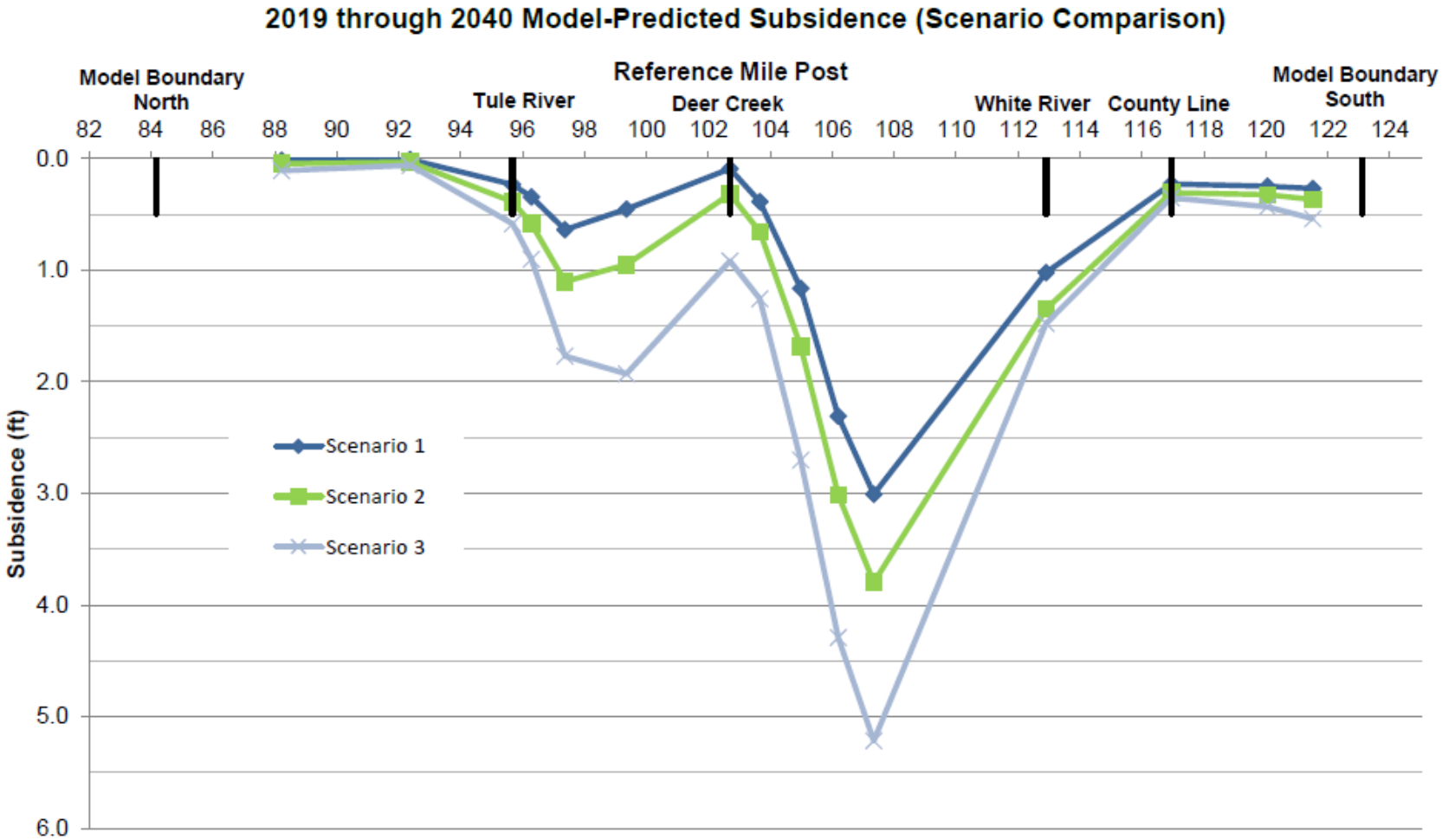
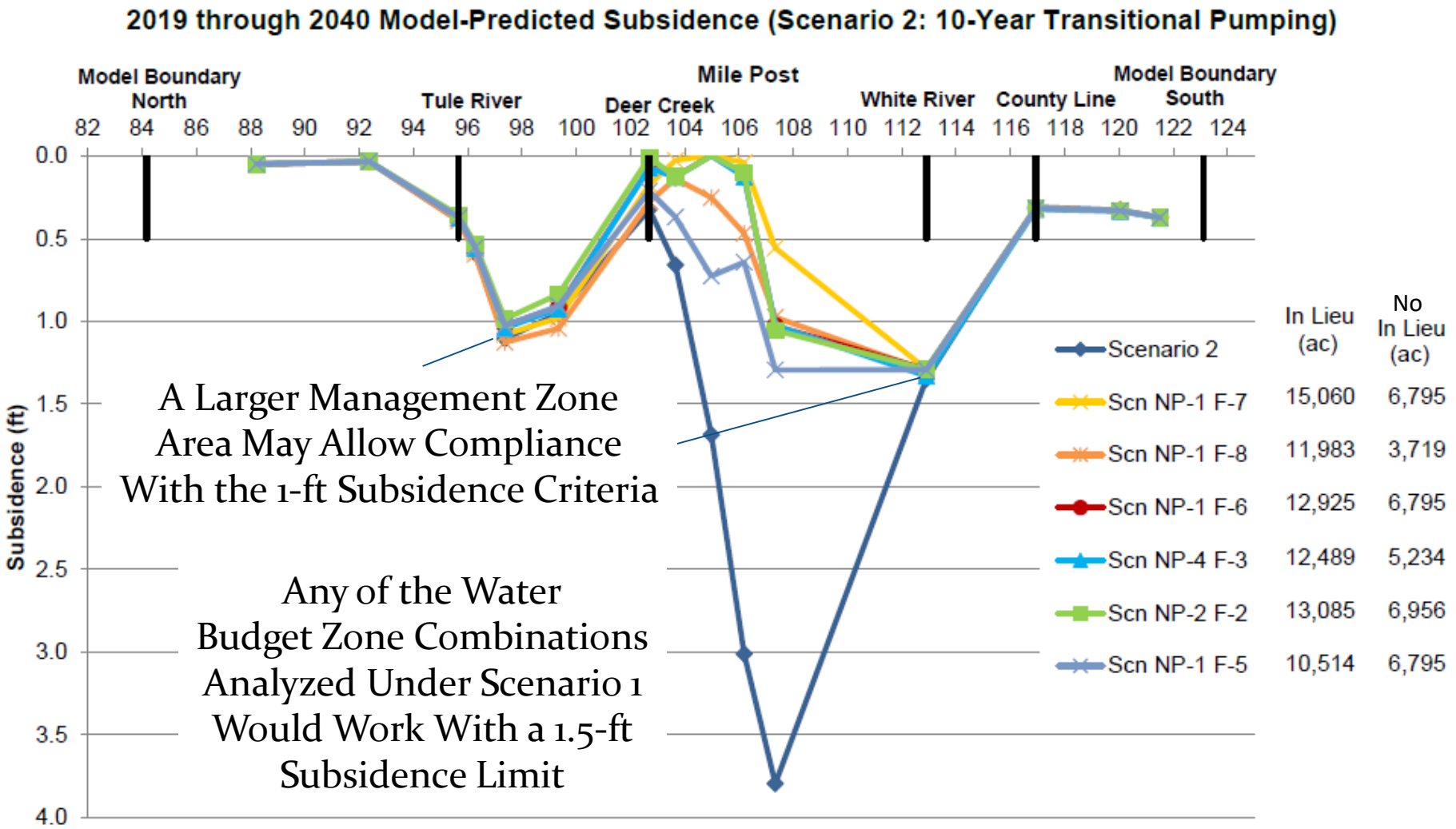
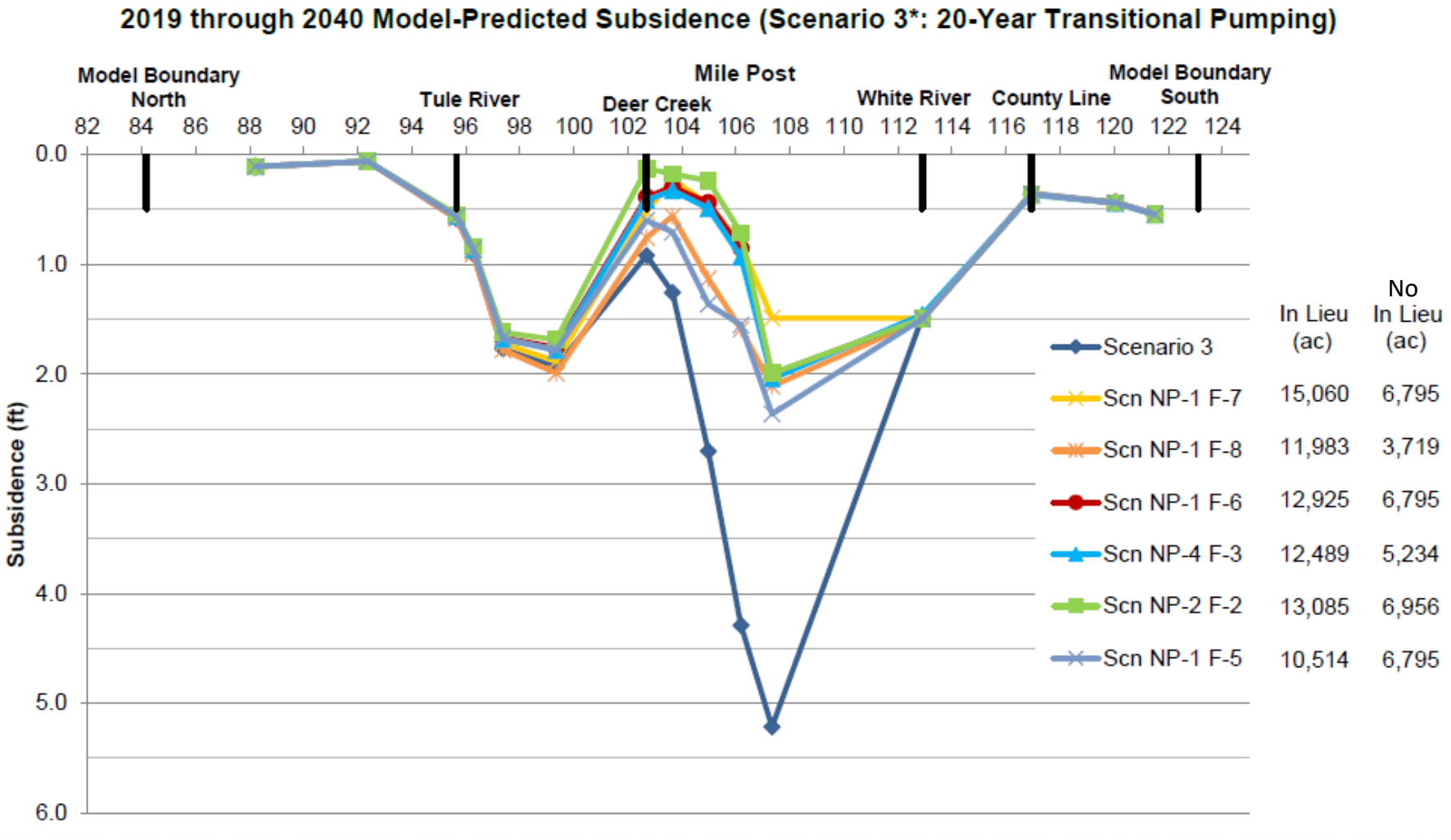
# Subbasin-Wide Transitional Pumping Under Scenario 2 (10-Yr) and Scenario 3 (20-Yr) Result in Progressively More Predicted Subsidence Beneath the Friant-Kern Canal



# Simulation of Scenario 2 (10-Yr Transitional Pumping) Using the Same Water Budget Zone Combinations Was Not Successful at Meeting the 1-foot Subsidence Criteria



# A Scenario 3, 20-Yr Transitional Pumping Would Require Either a Higher Allowable Subsidence Limit, a Larger Management Zone, or Both

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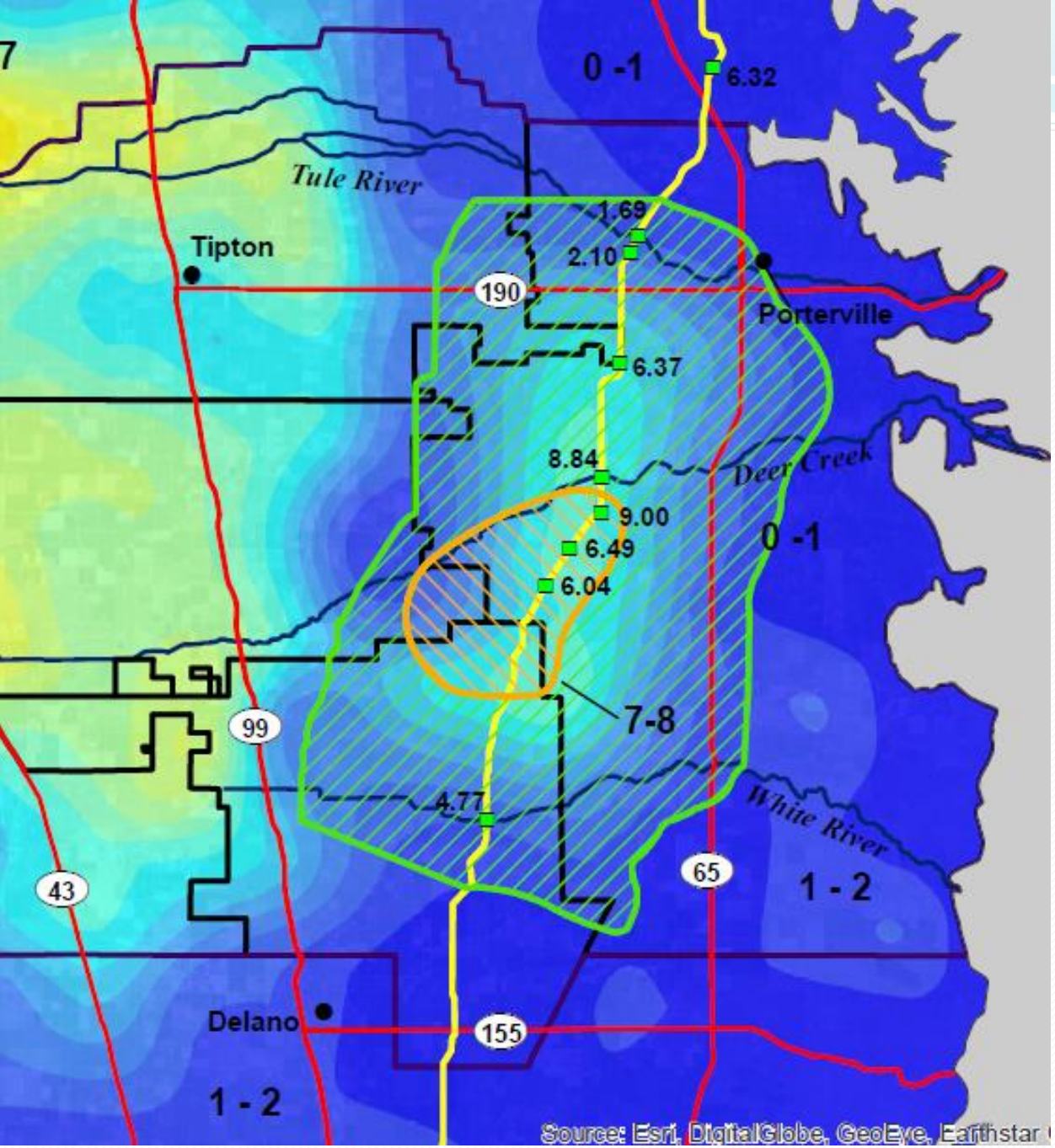
# Potential Subsidence Monitoring and Managed Areas




Preliminary Subsidence Monitoring Area

Potential Subsidence Managed Area

Model-Simulated Subsidence 1986-2017 (ft)

- 0 - 1
- 1.1 - 2
- 2.1 - 3
- 3.1 - 4
- 4.1 - 5
- 5.1 - 6
- 6.1 - 7
- 7.1 - 8
- 8.1 - 9
- 9.1 - 10
- 10.1 - 11
- 11.1 - 12
- 12.1 - 13
- 13.1 - 14
- 14.4 - 15

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# Findings to Date

- Of the Scenarios Analyzed, the Spatial Reduction in Pumping from Scenarios FP-1 F7 and FP-1 F8 Is the Most Effective at Limiting Additional Subsidence.
- A Subsidence Management Area Based on Scenario FP-1 F8 Would Be Approximately 16,000 Acres.
- Farming to Maintain Irrigation Return Flows Is Shown to be Beneficial to Subsidence Mitigation But Pumping Must be Discontinued As Well. Scenario FP-1 F8 Assumes that Water Supply for Approximately 12,000 Acres Would Be Supplied In-Lieu of Pumping.

# Findings to Date

- Additional Future Subsidence in the Managed Area Is Simulated to be Maintained Within Approximately 1 Foot Under A 5-Yr Subbasin Transitional Pumping Schedule and Implementation of Subsidence Management Area FP-1 F8 in 2020
- Additional Subsidence Is Simulated to be Maintained Within Approximately 1.5 Ft Under a 10-Yr Transitional Pumping Schedule
- Additional Subsidence Is Simulated to be Maintained Within Approximately 2.0 Ft Under a 20-Yr Transitional Pumping Schedule

# Upcoming Work

- Expanding Study Area to the South, East, and West to Address the Causes of Subsidence Near the White River
- Simulating Transitional Pumping in the Managed Area
- Simulating the Sensitivity of Deep Well Pumping on Subsidence in the Managed Area
- Incorporation of Projects and Management Actions

# Questions to Answer

- What Level of Future Subsidence Beneath the Friant-Kern Canal is Acceptable?
- What Combination of Regional Transitional Pumping and Subsidence Management Area is Acceptable?
- What Projects and/or Management Actions Can Be Implemented to Limit Land Subsidence Beneath the Friant-Kern Canal?