Eastern Tule Groundwater Sustainability Agency
Recommendations for Revisions to the Land Subsidence Management Plan

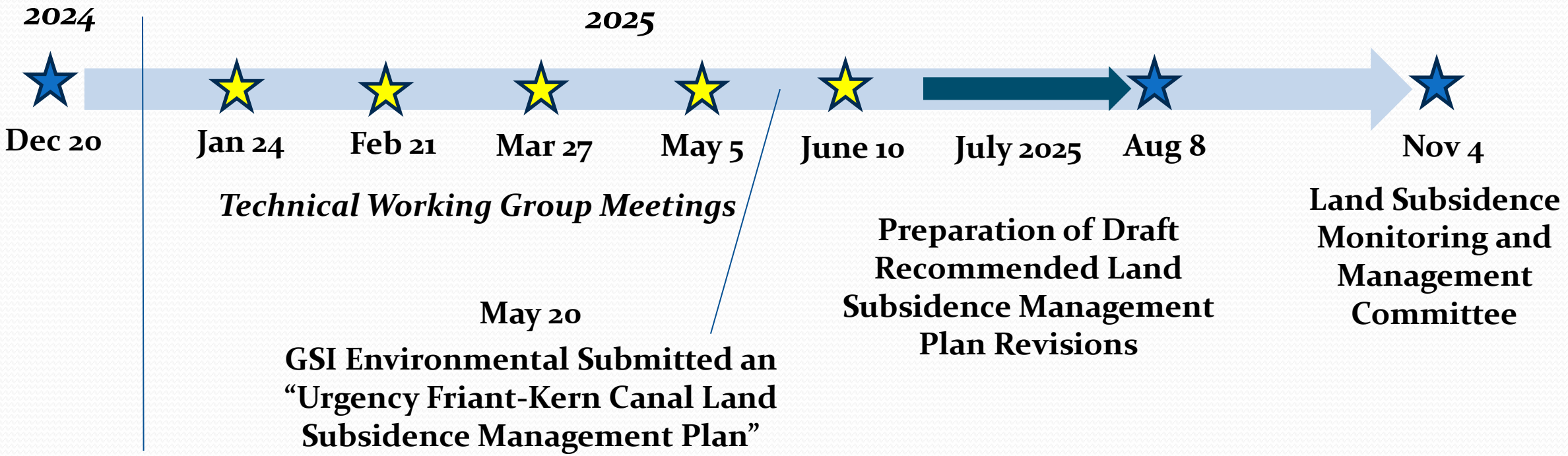
December 4th, 2025

Thomas Harder & Co.
Groundwater Consulting

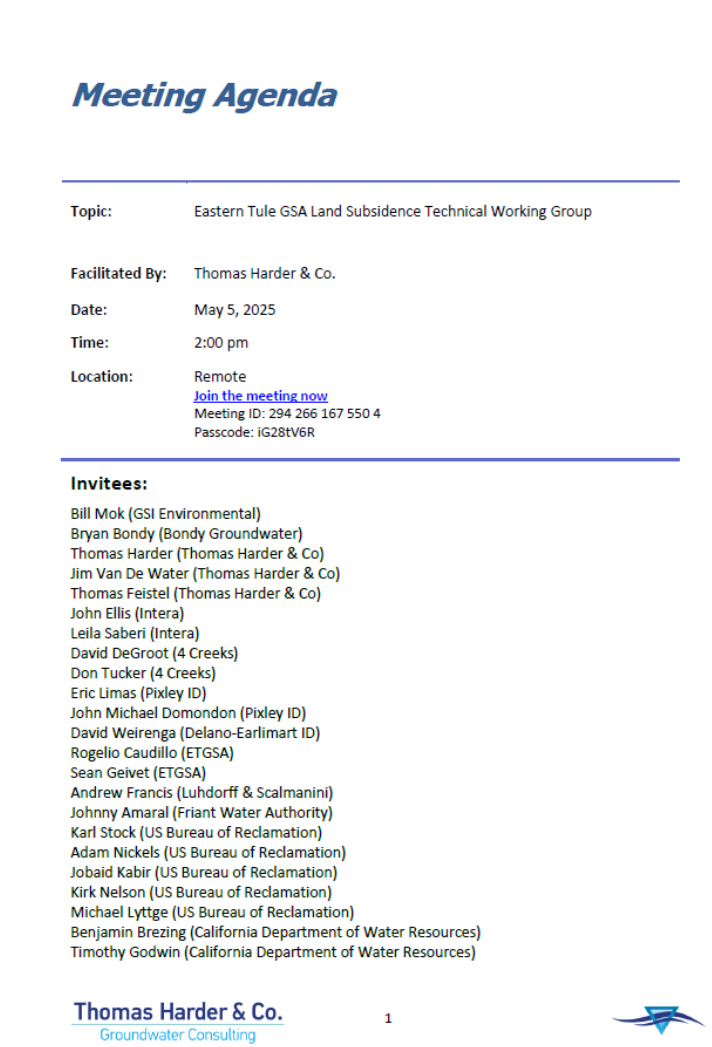
Presentation

1. Overview of Technical Working Group Process
2. General Conclusions and Recommendations of the Technical Working Group
3. Summary of Recommended Changes to the ETGSA Land Subsidence Management Plan

Technical Working Group Process



Technical Working Groups Have Included Technical Experts from the Following:



Meeting Agenda

Topic:	Eastern Tule GSA Land Subsidence Technical Working Group
Facilitated By:	Thomas Harder & Co.
Date:	May 5, 2025
Time:	2:00 pm
Location:	Remote Join the meeting now Meeting ID: 294 266 167 550 4 Passcode: iG28tV6R

Invitees:

Bill Mok (GSI Environmental)
Bryan Bondy (Bondy Groundwater)
Thomas Harder (Thomas Harder & Co)
Jim Van De Water (Thomas Harder & Co)
Thomas Feistel (Thomas Harder & Co)
John Ellis (Intera)
Leila Saberi (Intera)
David DeGroot (4 Creeks)
Don Tucker (4 Creeks)
Eric Limas (Pixley ID)
John Michael Domondon (Pixley ID)
David Weirenga (Delano-Earlimart ID)
Rogelio Caudillo (ETGSA)
Sean Geivet (ETGSA)
Andrew Francis (Luhdorff & Scalmanini)
Johnny Amaral (Friant Water Authority)
Karl Stock (US Bureau of Reclamation)
Adam Nickels (US Bureau of Reclamation)
Jobaid Kabir (US Bureau of Reclamation)
Kirk Nelson (US Bureau of Reclamation)
Michael Lyttge (US Bureau of Reclamation)
Benjamin Brezing (California Department of Water Resources)
Timothy Godwin (California Department of Water Resources)

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EASTERN TULE
GROUNDWATER SUSTAINABILITY AGENCY

CALIFORNIA DEPARTMENT OF
WATER RESOURCES

BUREAU OF
RECLAMATION

Friant
WATER AUTHORITY

DELANO–
EARLIMART
IRRIGATION DISTRICT

Lower Tule River Irrigation District
Pixley Irrigation District

White Area Growers

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Recommendations for Revisions to the Land Subsidence Management Plan are Described in a Technical Memorandum

Technical Memorandum

To:	Rogelio Caudillo Eastern Tule Groundwater Sustainability Agency
From:	Thomas Harder, P.G., C.HG. Thomas Harder & Co.
Date:	5-Nov-25
Re:	Recommended Revisions to the Friant-Kern Canal Land Subsidence Management Plan

1. Introduction

This technical memorandum (TM) describes recommendations to update the Eastern Tule Groundwater Sustainability Agency (ETGSA) Land Subsidence Management Plan for the Friant-Kern Canal (LSMP). The initial version of the LSMP was finalized in February 2022 (see Attachment A). While the ETGSA Land Subsidence Monitoring and Management Committee has been making recommendations to the ETGSA Board annually regarding allowable groundwater pumping for individual zones within the Land Subsidence Management Area (LSMA) of the LSMP, the recommendations in this TM involve changes to the plan itself and include management actions that are more aggressive than previously specified in the plan.

1.1 Background

In their initial review of the Tule Subbasin Groundwater Sustainability Plans (GSPs),[1] the California Department of Water Resources (CDWR) made the following general comments as they relate to land subsidence:

1. *For areas defined as adjacent to the Canal in the Eastern Tule GSP, Delano-Earlimart Irrigation District GSP, and Lower Tule River Irrigation District GSP areas, the GSAs should identify, through analysis, the total amount of subsidence that can be tolerated by the Canal during implementation of the GSPs to maintain the ability to reasonably operate*

[1] CDWR, 2022. Incomplete Determination of the 2020 Groundwater Sustainability Plans Submitted for the San Joaquin Valley – Tule Subbasin. Letter dated January 28, 2022.

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In General, the Technical Memorandum Includes:

1. Background
2. Analyses of Potential Residual Subsidence
3. Recommended Revisions to Lower Aquifer Groundwater Level Sustainable Management Criteria
4. Recommended Revisions to the Land Subsidence Management Plan
5. Attachments A through I
    a. Original Plan
    b. Meeting Agendas and Minutes
    c. FWA Comments on the LSMP
    d. PID/SID/Terra Bella Letter Comments
    e. Aug 8 Land Subsidence Committee Agenda/Comments
    f. 1D Compaction Model Presentations
    g. Analysis to Estimate Critical Head
    h. Analysis to Correlate Land Subsidence and Pumping
    i. ETGSA Eleventh Amended Rules and Regulations

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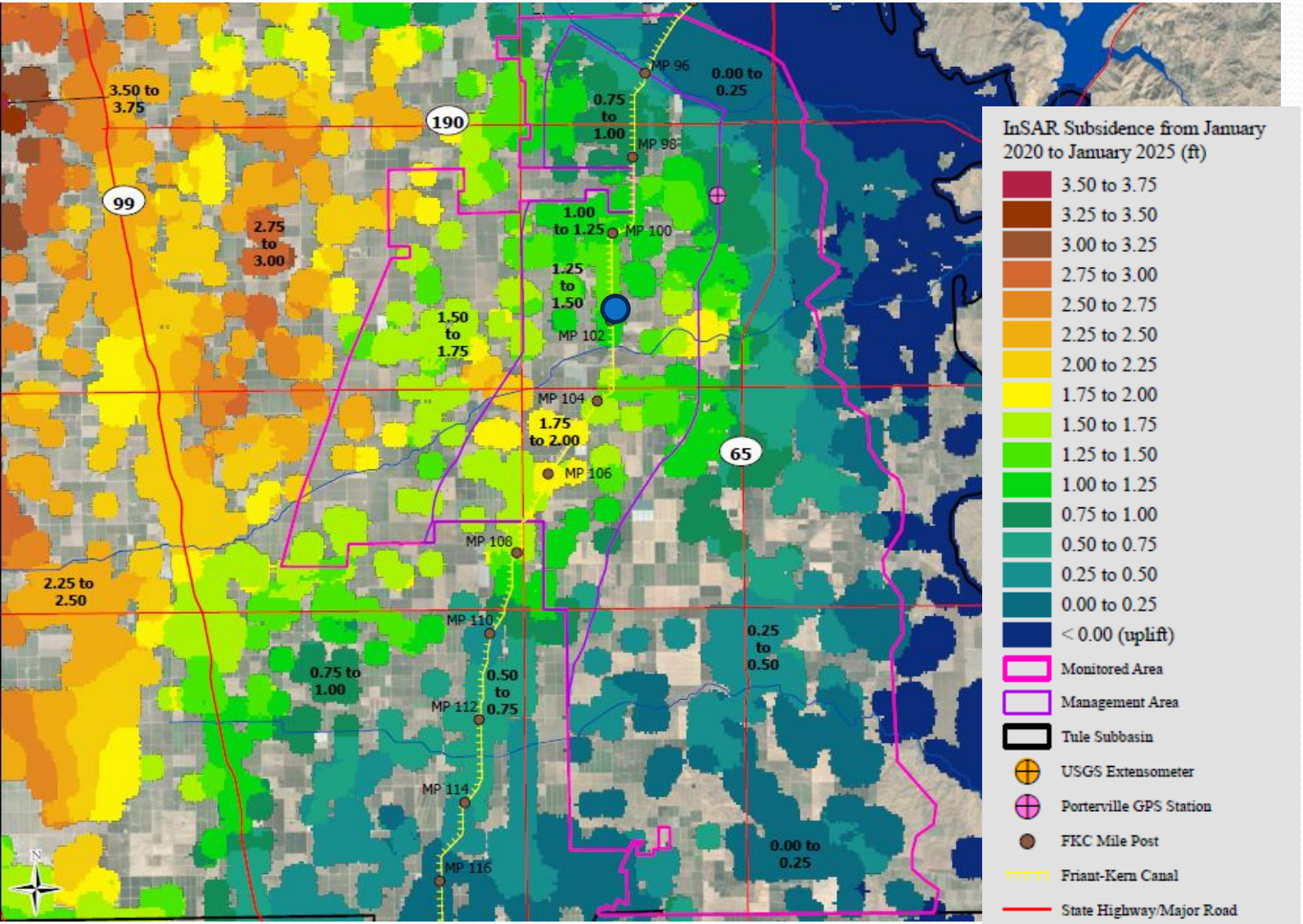
Potential Residual Subsidence Was Informed from 1D Subsidence Model Analyses Conducted by GSI Environmental, Intera and TH&Co



Each 1D Model was Based On Data from the USGS Extensometer Located Adjacent to the FKC

- USGS Extensometer

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Analysis of Residual Subsidence Showed that it is Not Likely Possible to Meet Land Subsidence Goals if Groundwater Levels are Maintained at 2024 Levels

Consultant	2024 Groundwater Elevation Range (feet amsl)*	Assumed Groundwater Elevation Between 2025 and 2040 (feet amsl)	Estimated Residual Subsidence between 2025 and 2040 (feet)	Measured Subsidence from 2020 to 2025 (feet)	Total Forecast Subsidence in 2040 (feet)
GSI Environmental	15 – 115 (Ave 65)	15 – 115	2	1.3	3.3
		85 – 185 (Ave 135)	0	1.3	1.3
Intera	15 - 115	91	2.5 – 3	1.3	3.8 – 4.3
		141	1.5	1.3	2.8
TH&Co	15 - 115	90	1.1 – 2.4	1.3	2.4 – 3.7
		140	0 – 1.7	1.3	1.3 – 3.0

*feet amsl = feet above mean sea level

Red numbers indicate a projected exceedance of the 3-foot allowable land subsidence MT

It Will Be Necessary to Raise Groundwater Levels in Order to Avoid New Land Subsidence and Minimize Residual Subsidence

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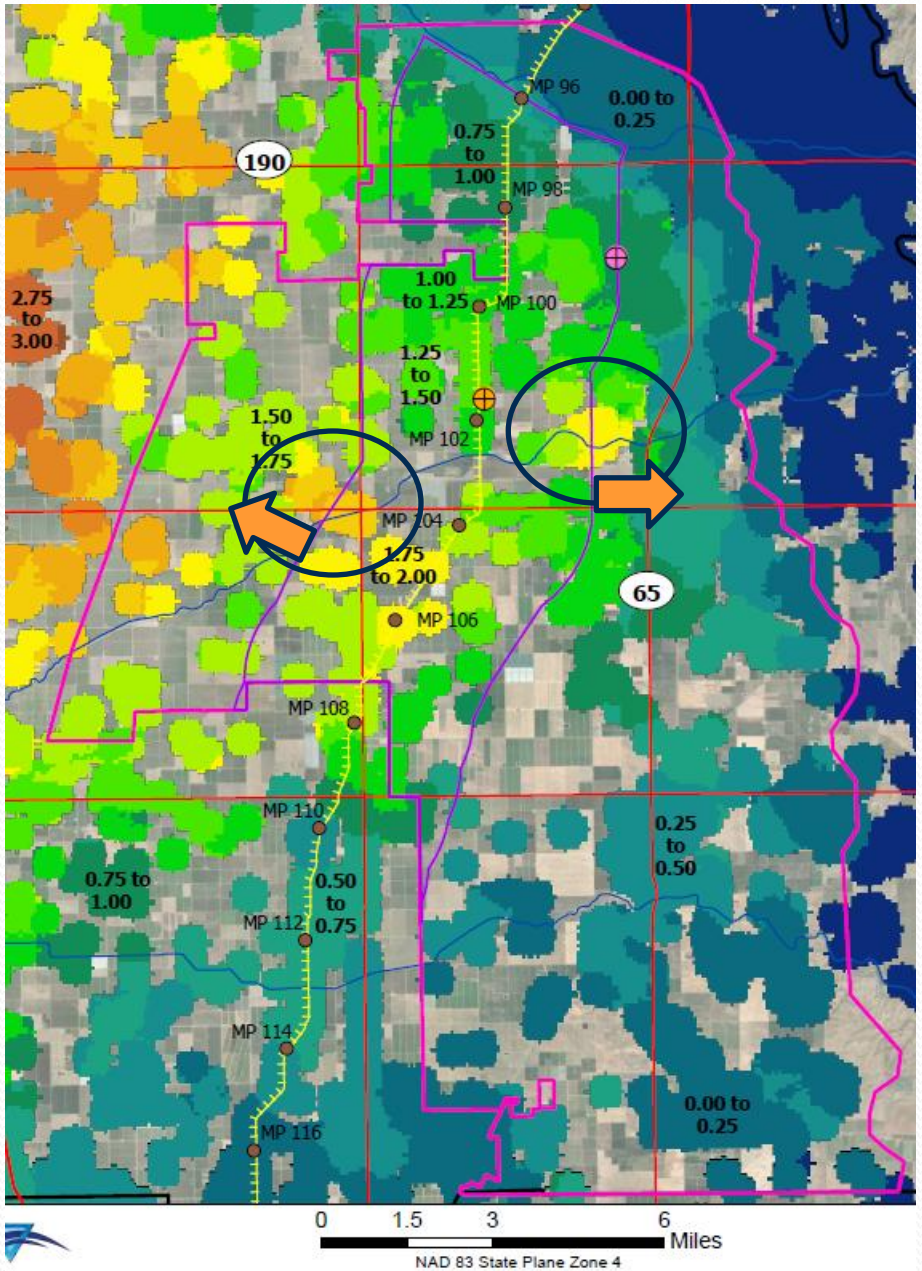
General Conclusions of the Technical Working Group

- High Land Subsidence Rates on the Eastern and Western Boundaries of the Existing LSMA Require Expanding the Management Area Boundaries to the East and West
- It Will Be Necessary to Raise Groundwater Levels Relative to 2024 Levels to Avoid and Minimize Land Subsidence Relative to ETGSA Goals
- Raising Groundwater Levels Will Require Immediate Reductions in Groundwater Pumping in the LSMA



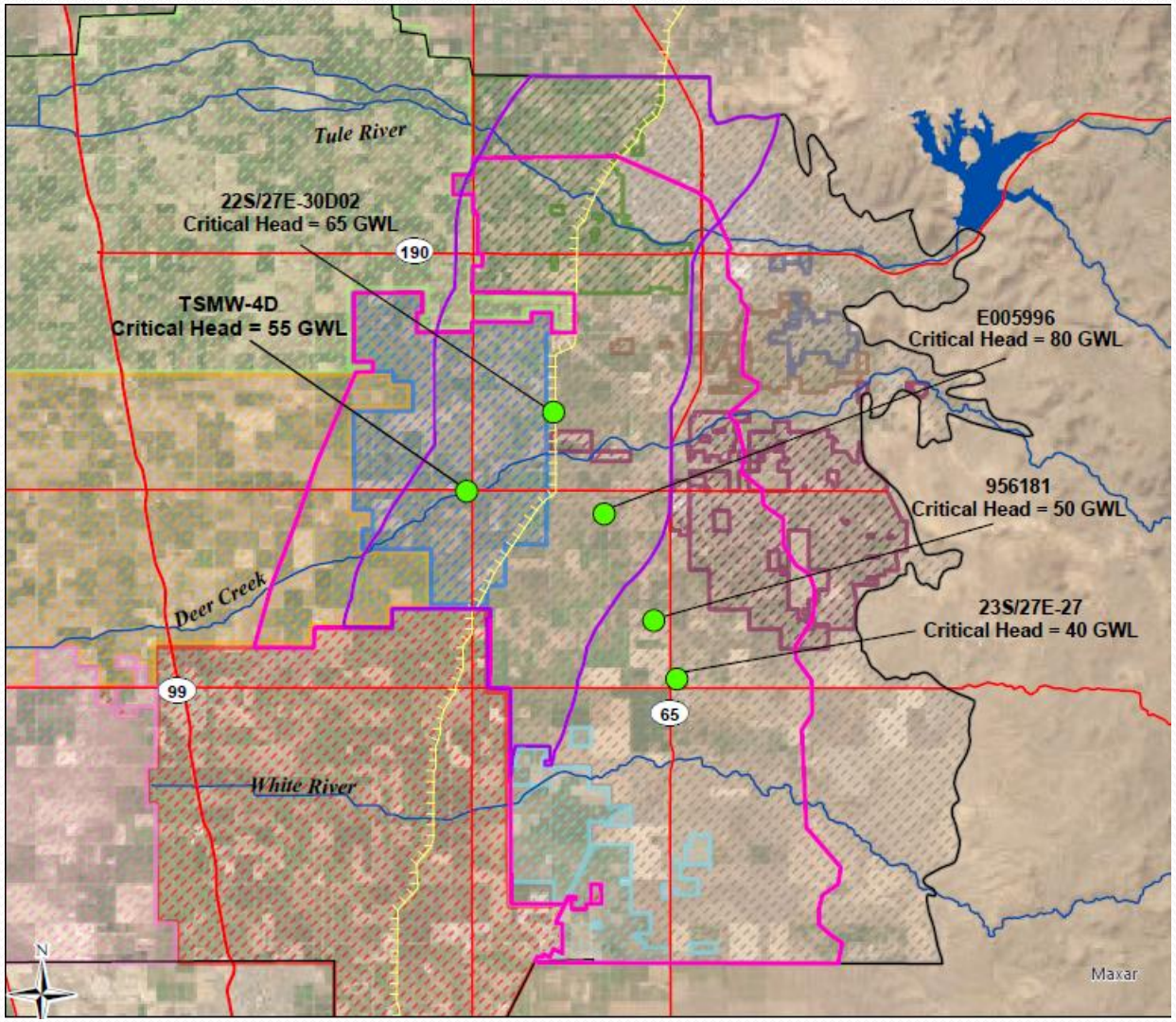
General Conclusions of the Technical Working Group (Cont)

- Implementation and Monitoring of Pumping Reductions will Require Mandatory Registration of All Wells in the LSMA and Groundwater Extraction Based Reduction In Groundwater Pumping
- Additional Monitoring Wells Are Needed in the LSMA to Verify Achievement of the Groundwater Elevations Needed to Avoid and Minimize Land Subsidence

In General Recommendations Include:

- Expansion of the LSMA
- Immediate Reductions in Groundwater Pumping in the LSMA
- Mandatory Well Registration and Metering for all Agricultural and Industrial Wells in the LSMA
- Accommodations for Adaptive Management
- Recommendations for Neighboring GSAs

Recommended Revisions to Lower Aquifer Groundwater Level Sustainable Management Criteria - *New*



"GSAs should revise the groundwater level sustainable management criteria to be set at or above the critical head level."

DWR Draft Land Subsidence BMP, Sept 2025

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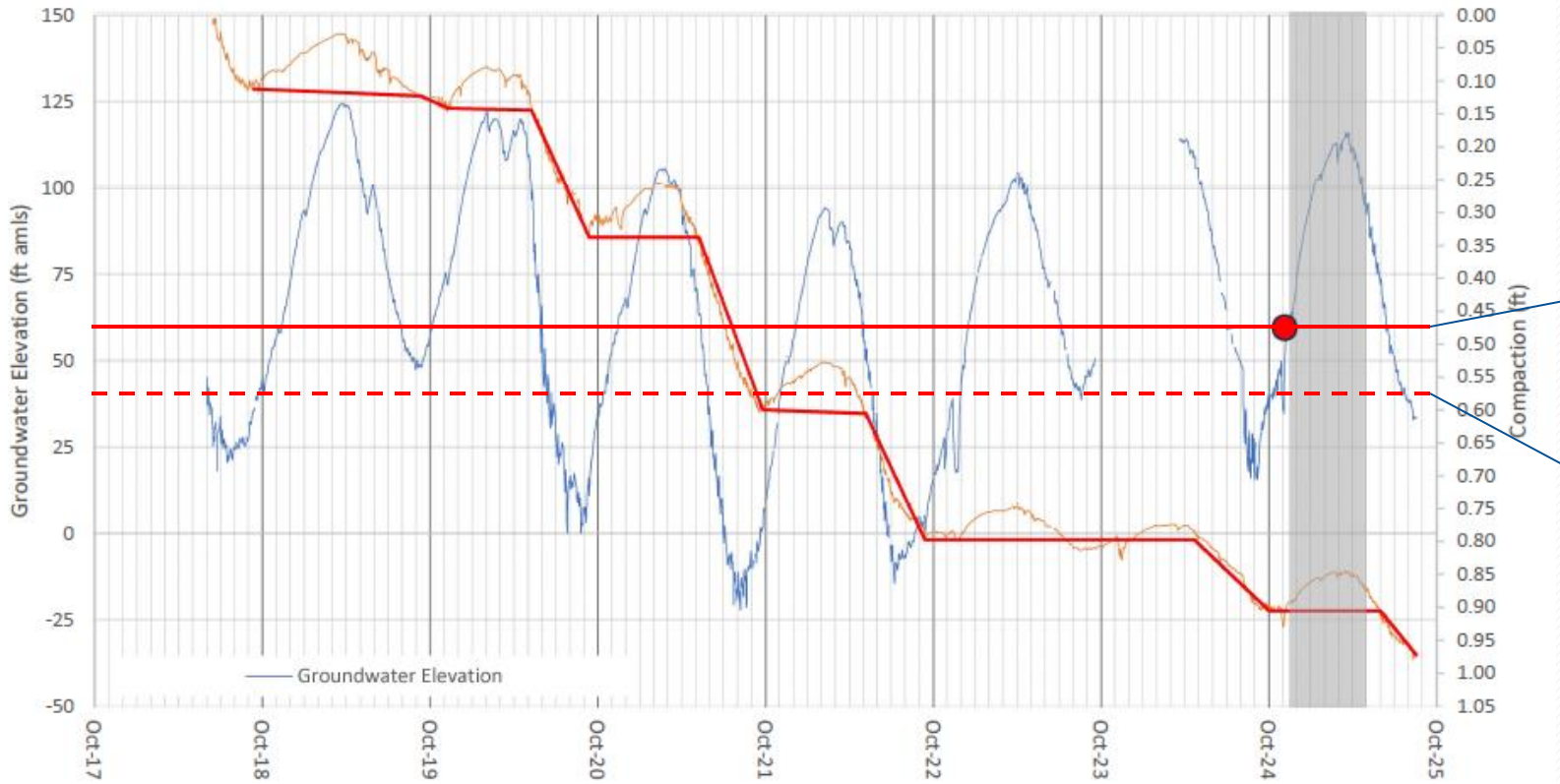
Critical Head Was Estimated at Each RMS Using the "Empirical Analysis" Method

USGS Extensometer



Notes:

Data from USGS Site 355933119062001, https://maps.waterdata.usgs.gov/mapper/index.html

Extensometer depth 1,180 ft bgs and screened interval 1,083 to 1,180 ft bgs.

The Estimated Critical Head is the New Minimum Threshold at Each RMS

Updated Minimum Threshold (65 ft amsl)

2024 Minimum Threshold (40 ft amsl)

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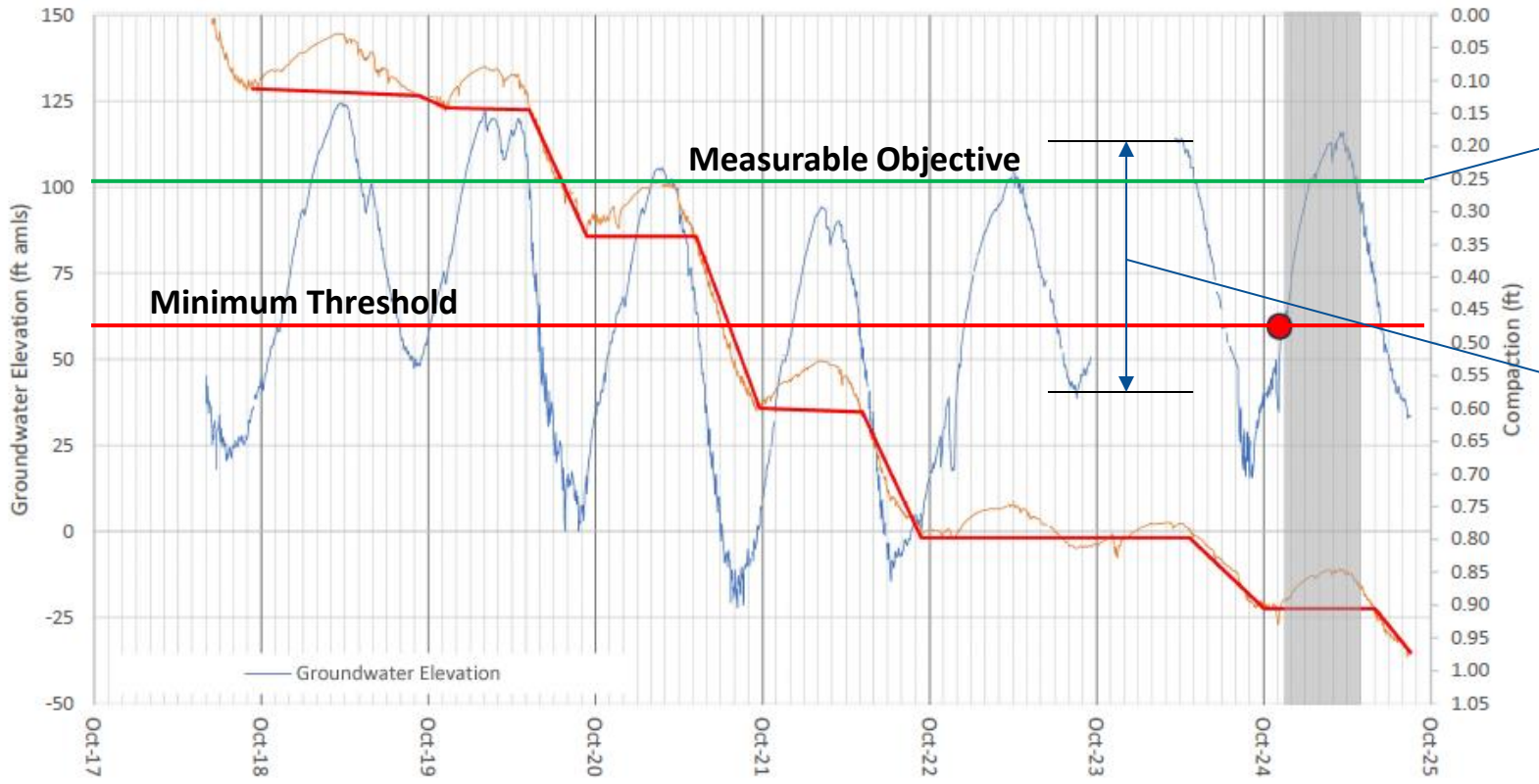
The Measurable Objectives Were Established to Consider Seasonal Variation Above the Minimum Threshold

USGS Extensometer



Notes:

Data from USGS Site 355933119062001, https://maps.waterdata.usgs.gov/mapper/index.html

Extensometer depth 1,180 ft bgs and screened interval 1,083 to 1,180 ft bgs.

The Measurable Objective is One Half the Seasonal Variation Plus the Minimum Threshold (75/2 +65)

Seasonal Variation ~75 ft

The Objective is to Limit the Seasonal Low Groundwater Level to the Minimum Threshold

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Replacement of Evapotranspiration (ET) - Based Allocations with Extraction Based Allocations

To Date, Allocations of Sustainable Yield in the LSMA Have Been Based on:

- *The **Native Sustainable Yield** on an ET/Consumptive Use Basis (0.15 acre-ft/acre)*
- ***Precipitation** (Long-Term Average; In 2024 this was 0.84 acre-ft/acre)*

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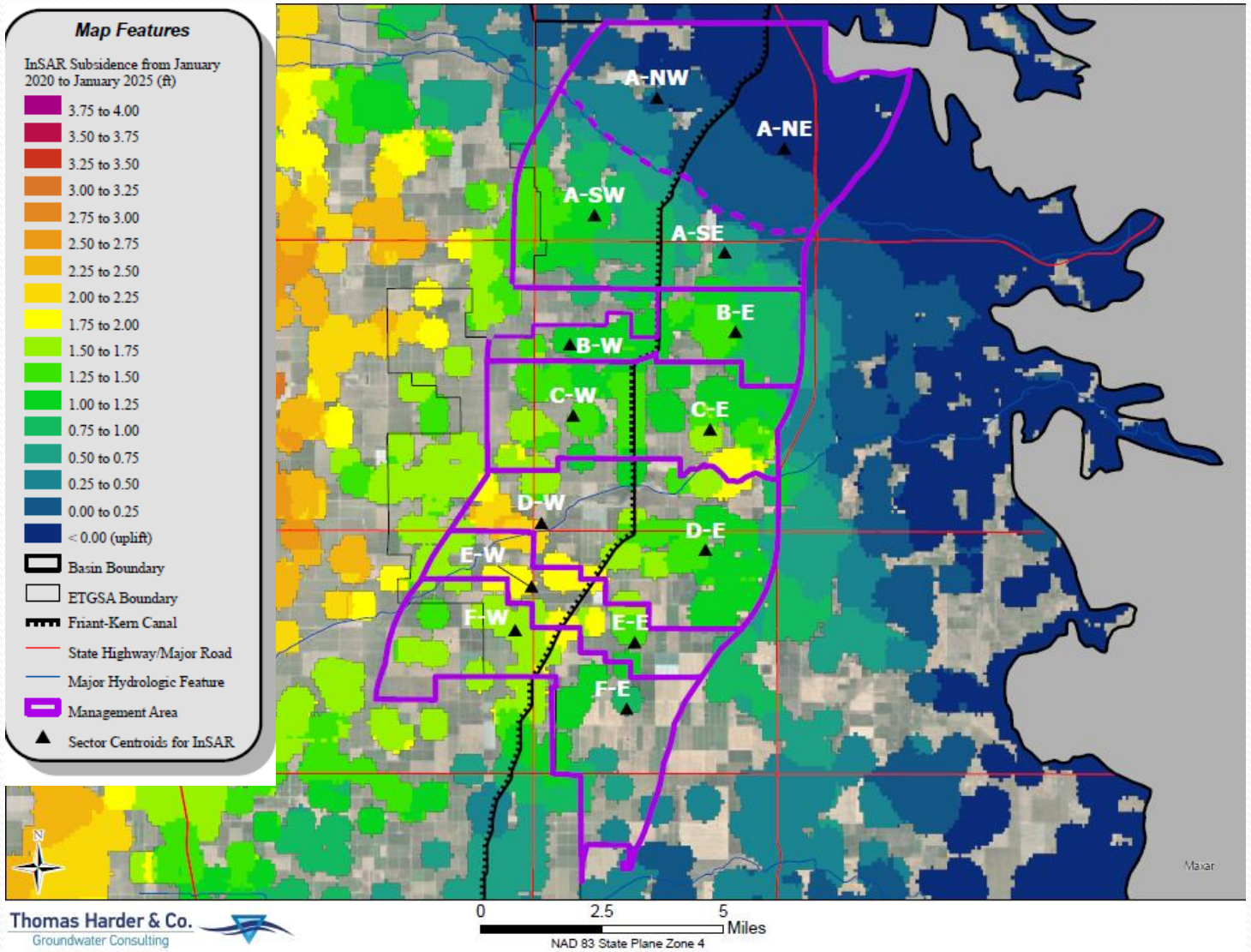
The Existing ET-Based Sustainable Yield Allocation Has Limitations with Respect to Managing Land Subsidence

- Limited Resolution of Spatial and Vertical Groundwater Extraction Needed to Manage Land Subsidence
- Incorporating Long-Term Precipitation into Annual Allowable Pumping Will Result in Over-Pumping in Dry Years and Risk of Subsidence

Recommendations Now Include Replacing the ET-Based Allocations with Extraction Based Allocations

- All Growers in the LSMA are Required to Register and Meter their Wells
- Reporting of Metered Groundwater Pumping is Required on a Monthly Basis
- The Native Sustainable Yield on a Groundwater Extraction Basis is **0.27 acre-ft/acre**

So How Much Groundwater Extraction Can Occur without Inducing Inelastic Land Subsidence?



TH&Co Conducted an Analysis to Answer this Question:

1. Divided the LSMA into Sectors
2. Estimated Groundwater Pumping for Each Sector
3. Compiled InSAR Data for 2018 to 2024 at Each Triangle
4. Plotted Pumping vs. Land Subsidence

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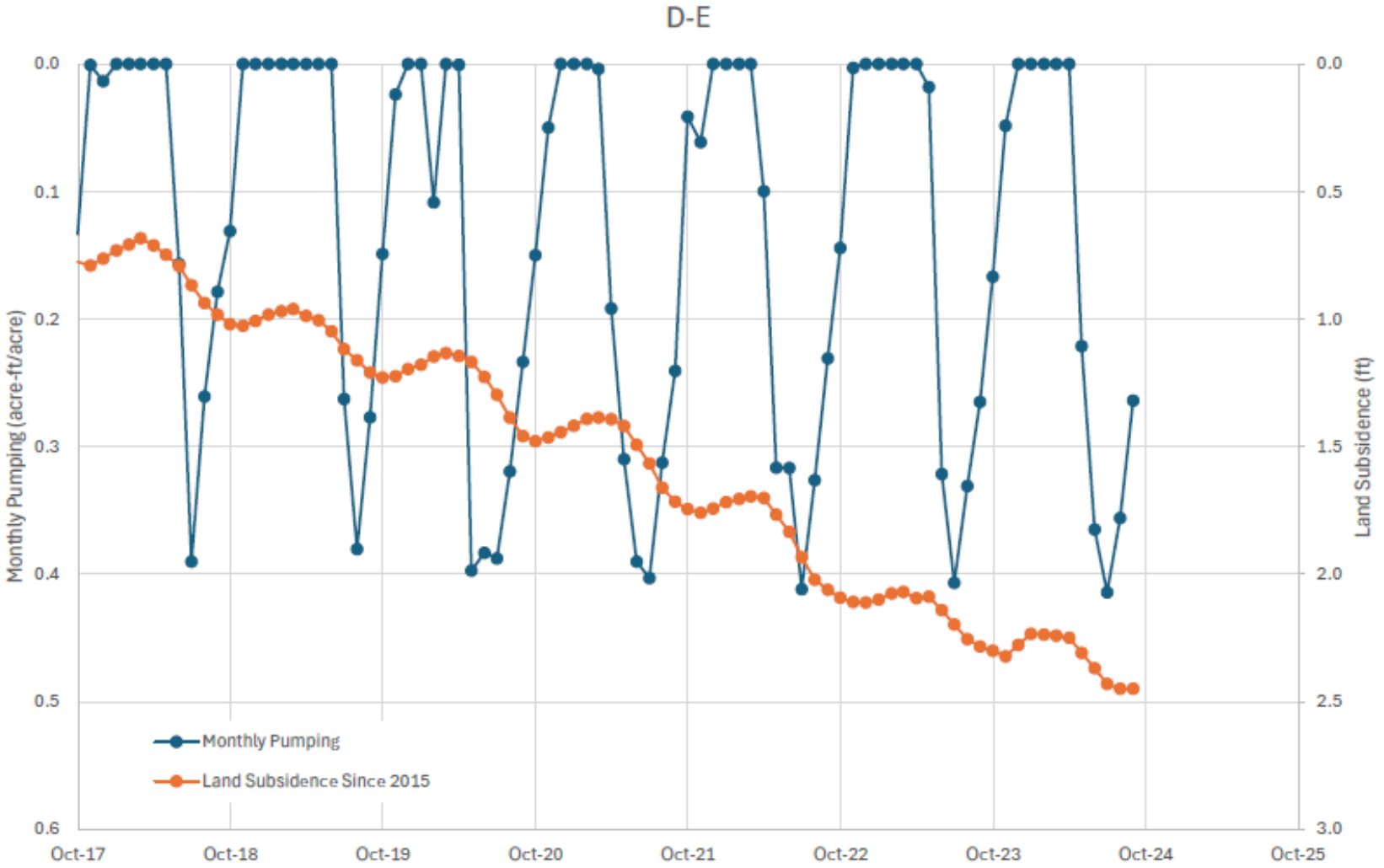
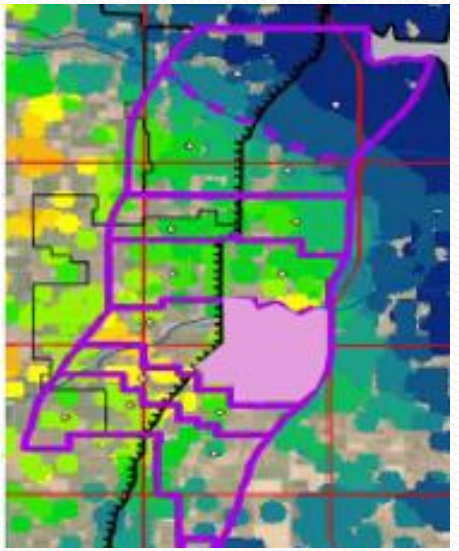
Estimated Monthly Pumping by Sector





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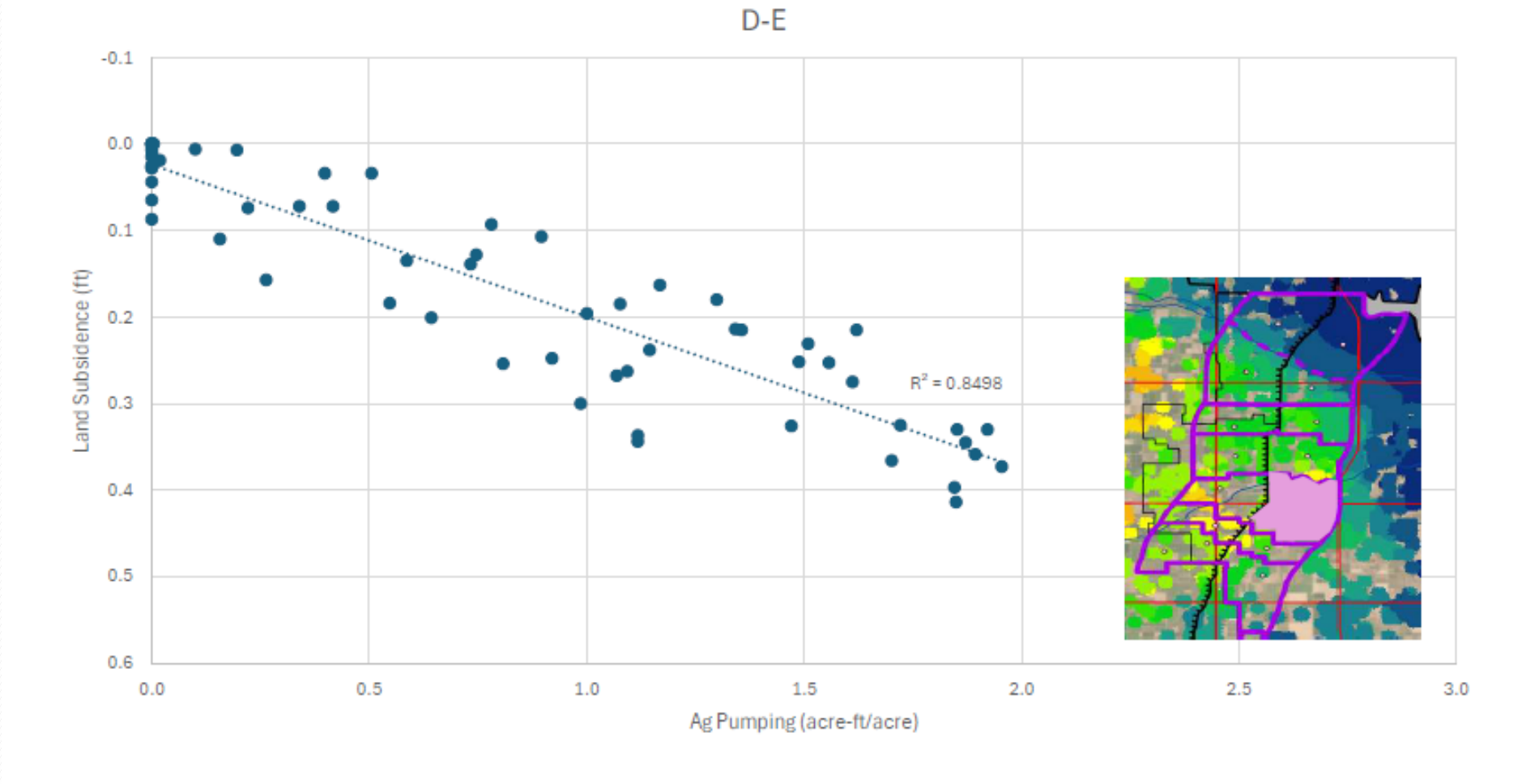
Plotted Cumulative Land Subsidence vs. Monthly Pumping for 2018 through 2024



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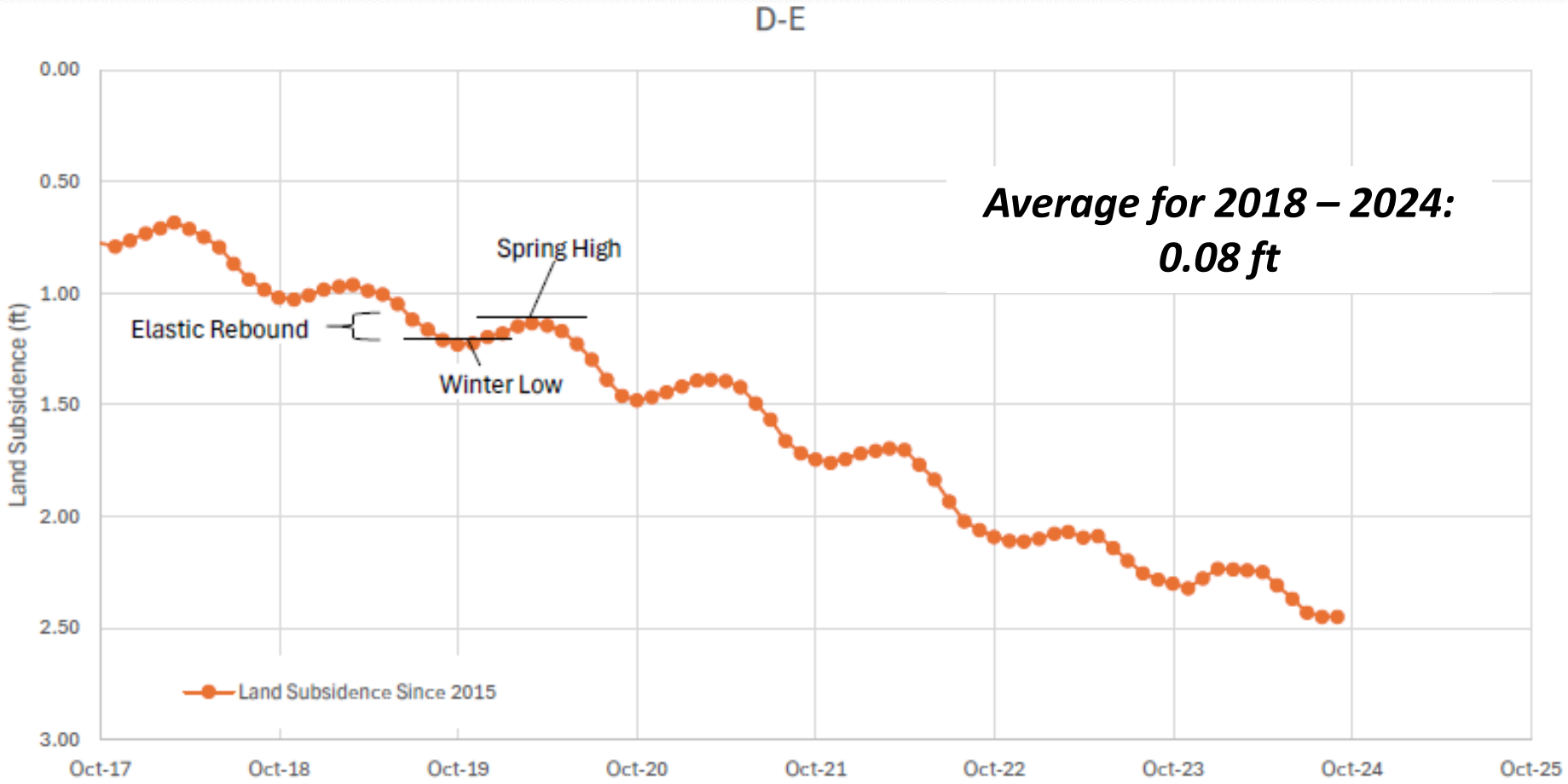
Identified the Elastic Component of Subsidence



Average for 2018 – 2024: 0.08 ft

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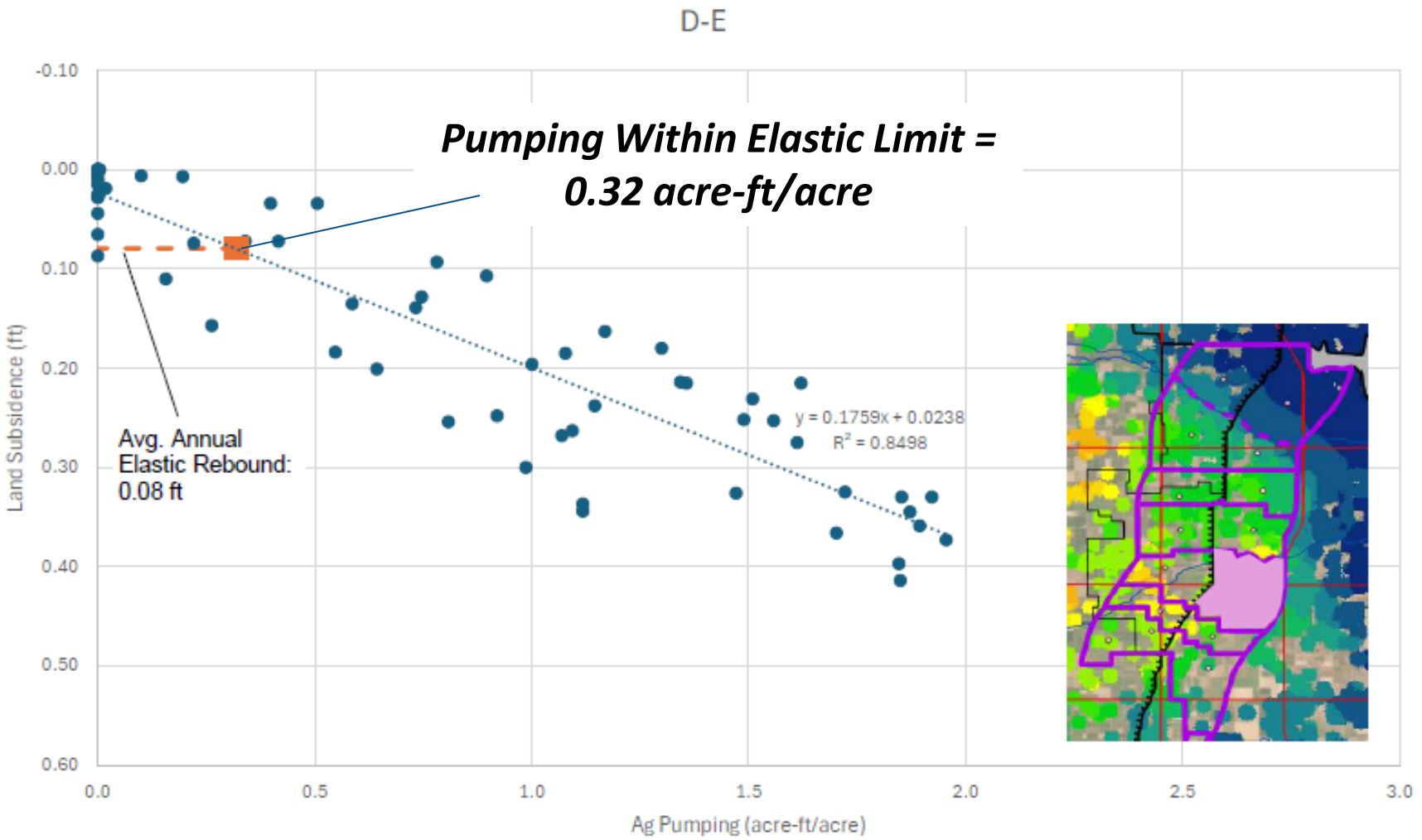
Identified the Pumping that Can Occur Within the Elastic Limit of Subsidence



The Average of All Sectors was 0.4 acre-ft/acre

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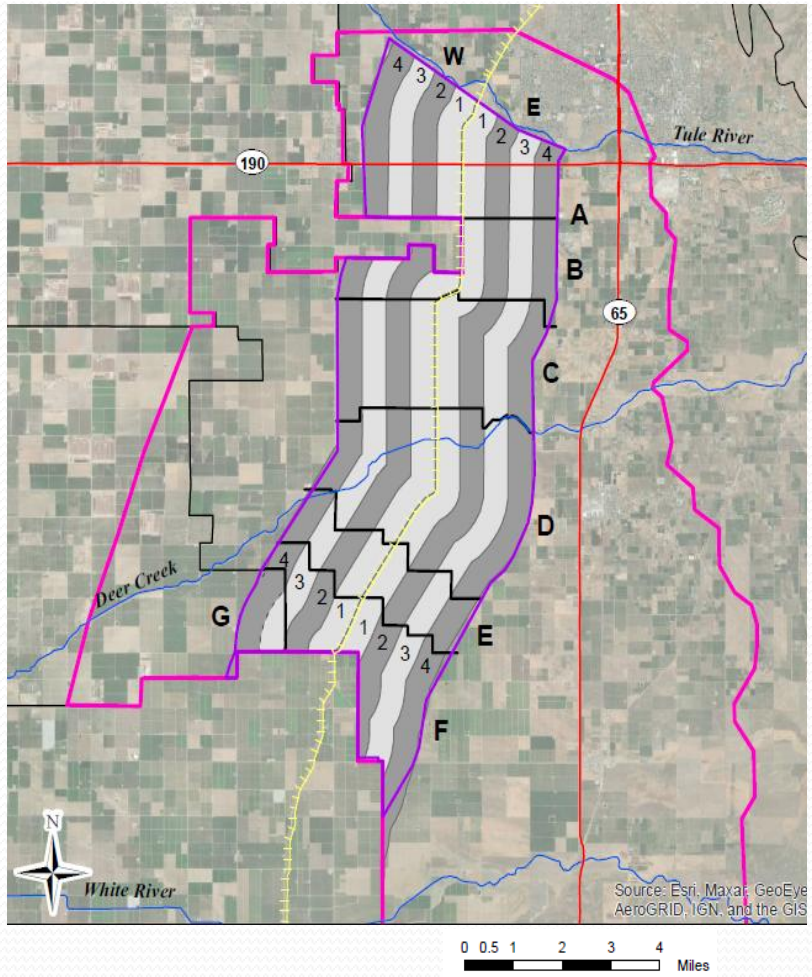
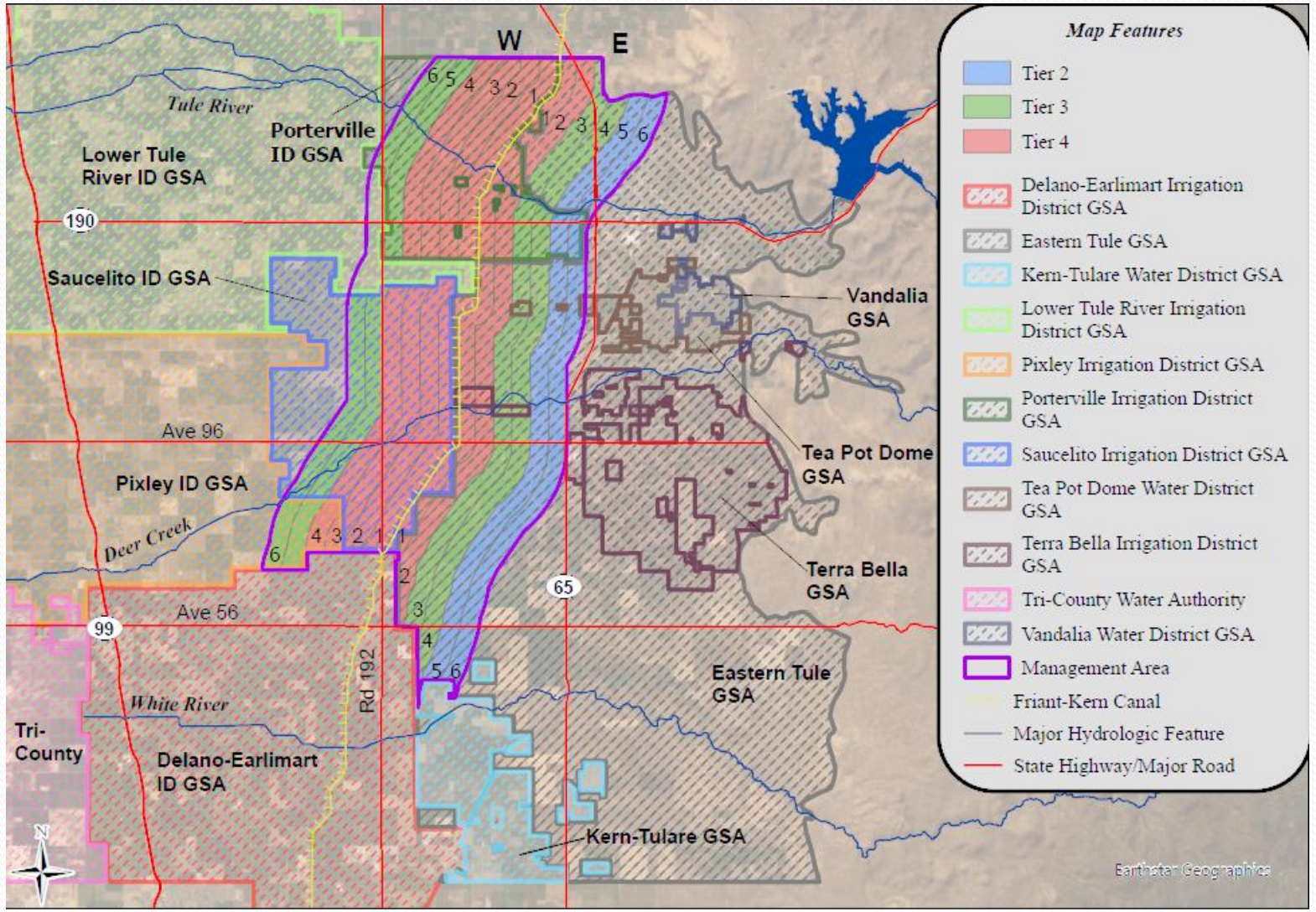
Expansion of Land Subsidence Management Area

Original LSMA



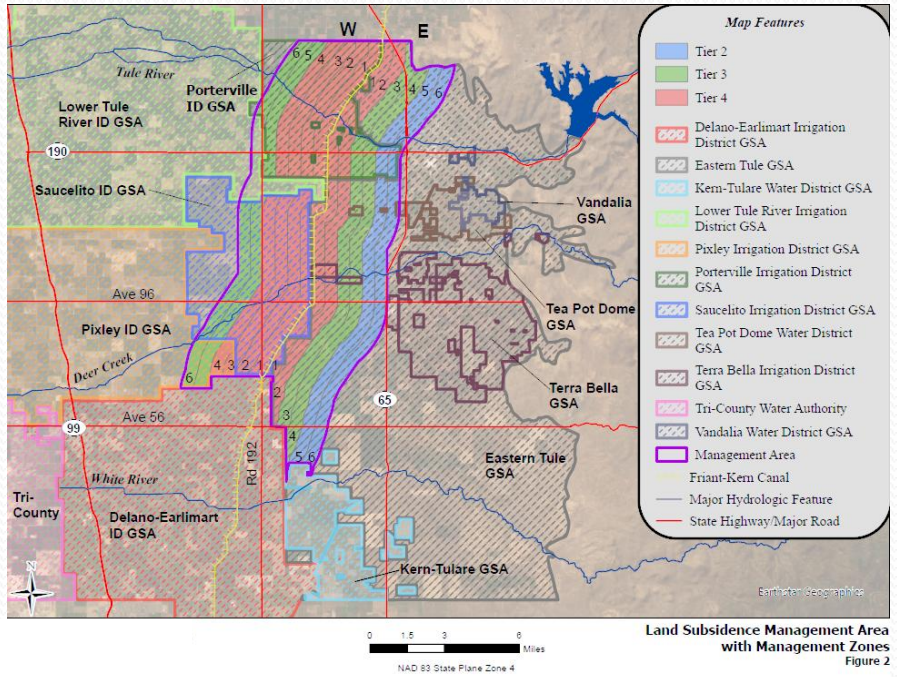
Recommended Revised LSMA



Land Subsidence Management Area with Management Zones
Figure 2

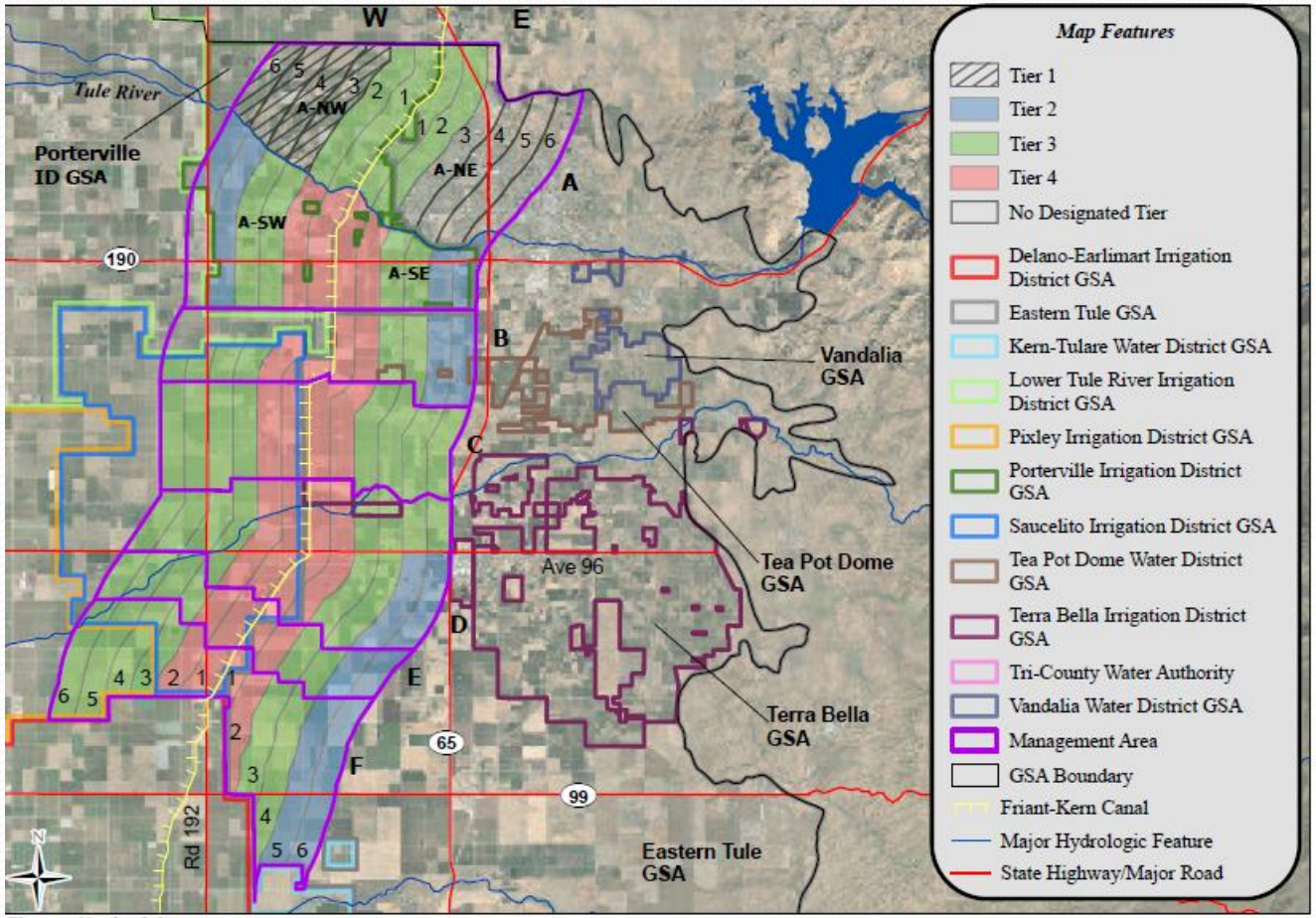
Zones Within the LSMA Have Been Revised to Reflect Comments Received and the New Allowable Pumping Limits

July 2025 LSMA



Land Subsidence Management Area with Management Zones
Figure 2

Recommended Revised LSMA



Land Subsidence Management Area with Management Zones
Figure 2

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Recommended Changes in Land Subsidence Management Criteria

Current Criteria Dictate Management Actions when Subsidence Thresholds are Exceeded

Tier 1 - Land Subsidence Between 0 ft and 1.49 ft
Tier 2 - Land Subsidence Between 1.50 ft and 2.00 ft
Tier 3 - Land Subsidence Between 2.00 ft and 2.49 ft
Tier 4 - Land Subsidence Between 2.50 ft and 2.99 ft

Effective January 1, 2026 →

- The Tiers are no longer based on the amount of land subsidence that has occurred in any given management zone but rather allowable groundwater pumping that will avoid and minimize land subsidence within the LSMA.
- Groundwater pumping in all zones will now be limited to the Native Yield (0.27 acre-ft/acre/year) except for extractions of Surface Water Recharge Credits, subject to annual pumping limits specified herein.
- Differences in management actions between the Tiers will now be based on different limits (i.e. "caps") on pumping of Surface Water Recharge Credits.
- Caps on extraction of Surface Water Recharge Credits will be based on analyses of groundwater pumping limits needed to limit land subsidence, as described in Section 4.3.2 herein.

Management Actions That Apply to All Tiers

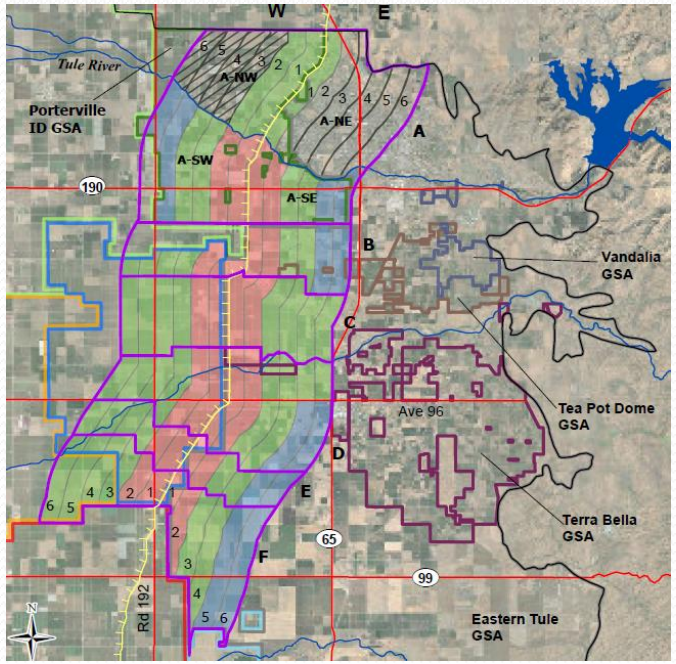
- All groundwater pumpers will be required to register their wells with the ETGSA.
- All wells pumping groundwater within the LSMA will require a meter and reporting of monthly pumping data to ETGSA staff.
- There will be no allowed carryover of unused Sustainable Yield Allocation from prior to 2025, including precipitation, in the LSMA.
- There will be no allowed allocation of pre-purchased Tier 1 penalty allocation or Groundwater Credits in the LSMA, regardless of when they were purchased in relation to the Determination Date (Attachment I; Section 4.05).
- There will be no allowed transfers of Groundwater Credits associated with unused Sustainable Yield Allocation from outside the LSMA into the LSMA.
- Unused sustainable yield and/or Groundwater Credits from Tier 1 zones are available to be extracted and or transferred outside of the LSMA, provided such use and transfer is otherwise consistent with the ETGSA Rules and Regulations (Attachment I).

Recommended Tier 1 Land Subsidence Management Criteria

Groundwater Extractions will be Limited to:

- Native Sustainable Yield of 0.27 acre-ft/acre
- Surface Water Recharge Credits Up To 1 acre-ft/acre

Total Groundwater Extractions Limited to 1.27 acre-ft/acre



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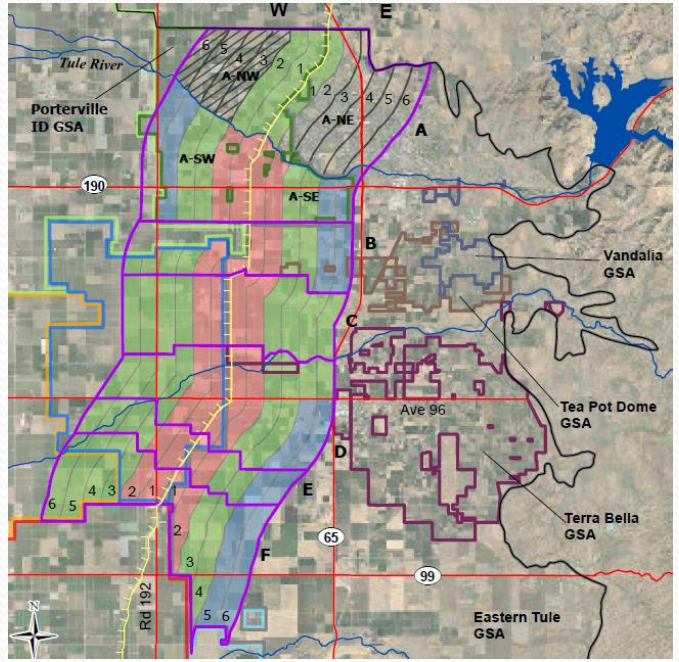
Recommended Tier 2 Land Subsidence Management Criteria

Groundwater Extractions will be Limited to:

- Native Sustainable Yield of 0.27 acre-ft/acre
- Surface Water Recharge Credits Up To 0.53 acre-ft/acre

Total Groundwater Extractions Limited to 0.8 acre-ft/acre



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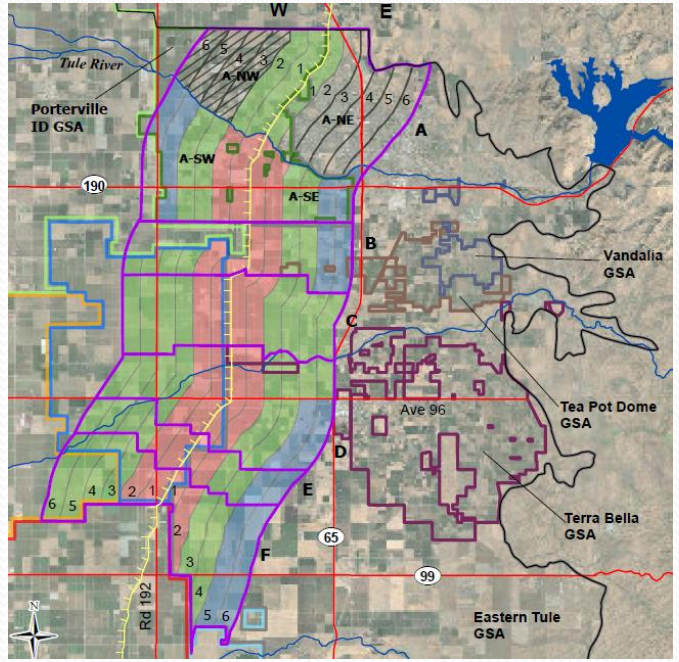
Recommended Tier 3 Land Subsidence Management Criteria

Groundwater Extractions will be Limited to:

- Native Sustainable Yield of 0.27 acre-ft/acre
- Surface Water Recharge Credits Up To 0.13 acre-ft/acre

Total Groundwater Extractions Limited to 0.4 acre-ft/acre



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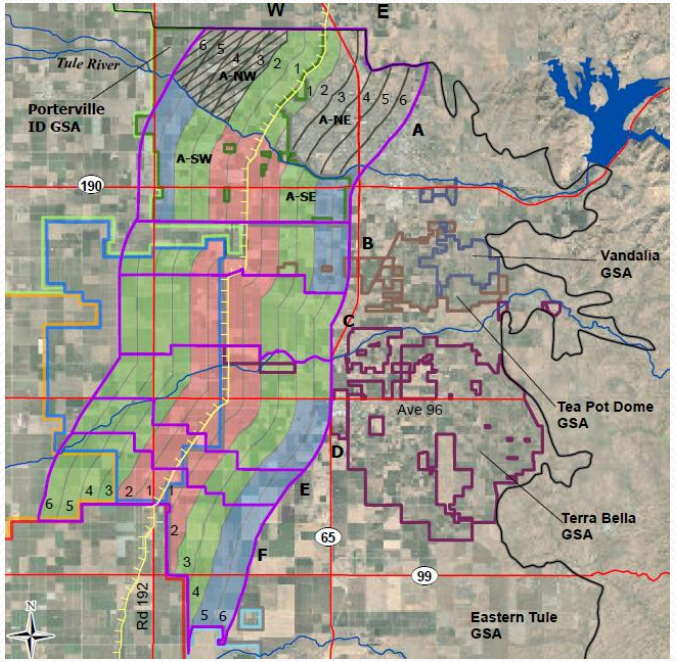
Recommended Tier 4 Land Subsidence Management Criteria

Groundwater Extractions will be Limited to:

- Native Sustainable Yield of 0.27 acre-ft/acre

Total Groundwater Extractions Limited to 0.27 acre-ft/acre



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Recommendations for Adaptive Management

- Changes in pumping restrictions in individual zones (could be reduced or increased based on data and observations of land subsidence response and groundwater elevation changes),
- Implementation of localized pumping restrictions,
- Changes to transfer policy,
- Changes to LSMA,
- Changes to criteria for determining allowable pumping in the LSMA (e.g. future land subsidence management may be based on groundwater level management)

Increased Meetings of the Land Subsidence Monitoring and Management Committee to Quarterly

Other Recommendations

- Mandatory Well Registration and Metering
- Recommend Coordination of Management Actions with Neighboring GSAs

Questions/Discussion