

A decorative graphic in the background consisting of a large, light blue water drop shape and a thick, light blue line that forms a stylized mountain range or a series of peaks and valleys.

WDWA Subsidence Review

Area of Interest (AOI) 2

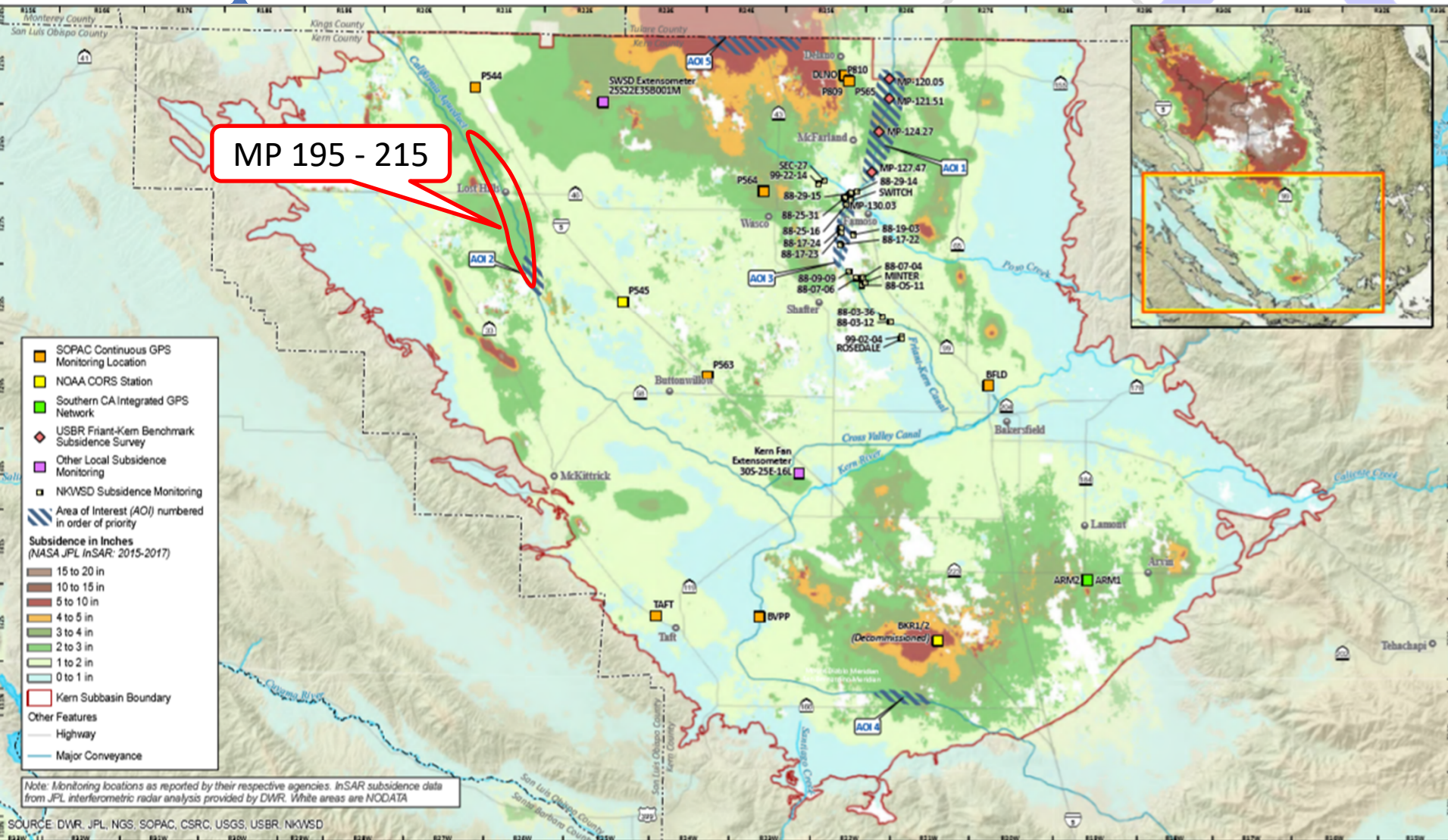
Aqueduct Milepost 195-215

January 2020
Revised April 2020

Background

- Inelastic land subsidence identified as undesirable result
- Area of Interest (AOI) 2 – Aqueduct Mileposts (MP) 195 – 215
- 2011 Embankment failure MP 208
- DWR concludes geology and groundwater pumping as cause of subsidence
- Data indicates alternative interpretations should be considered

AOI 2 (MP 195 – 215)



Kern Groundwater Authority
Basin Setting

Kern County, California

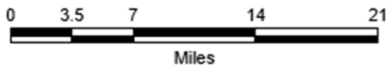
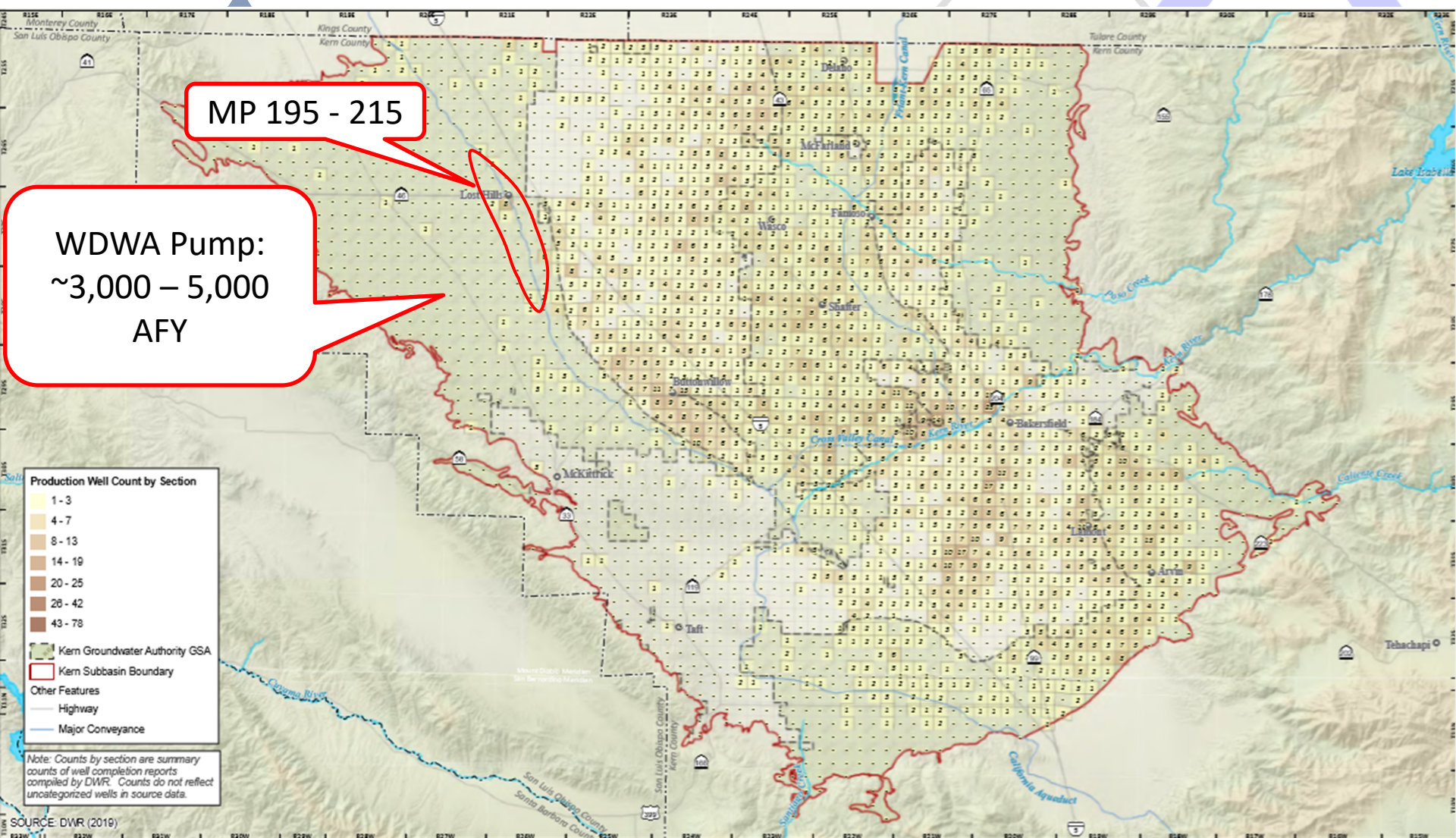


REGIONAL SUBSIDENCE
MONITORING NETWORK

OCTOBER 2019

FIGURE 3-6

Production Well Density



Kern Groundwater Authority
Basin Setting

Kern County, California

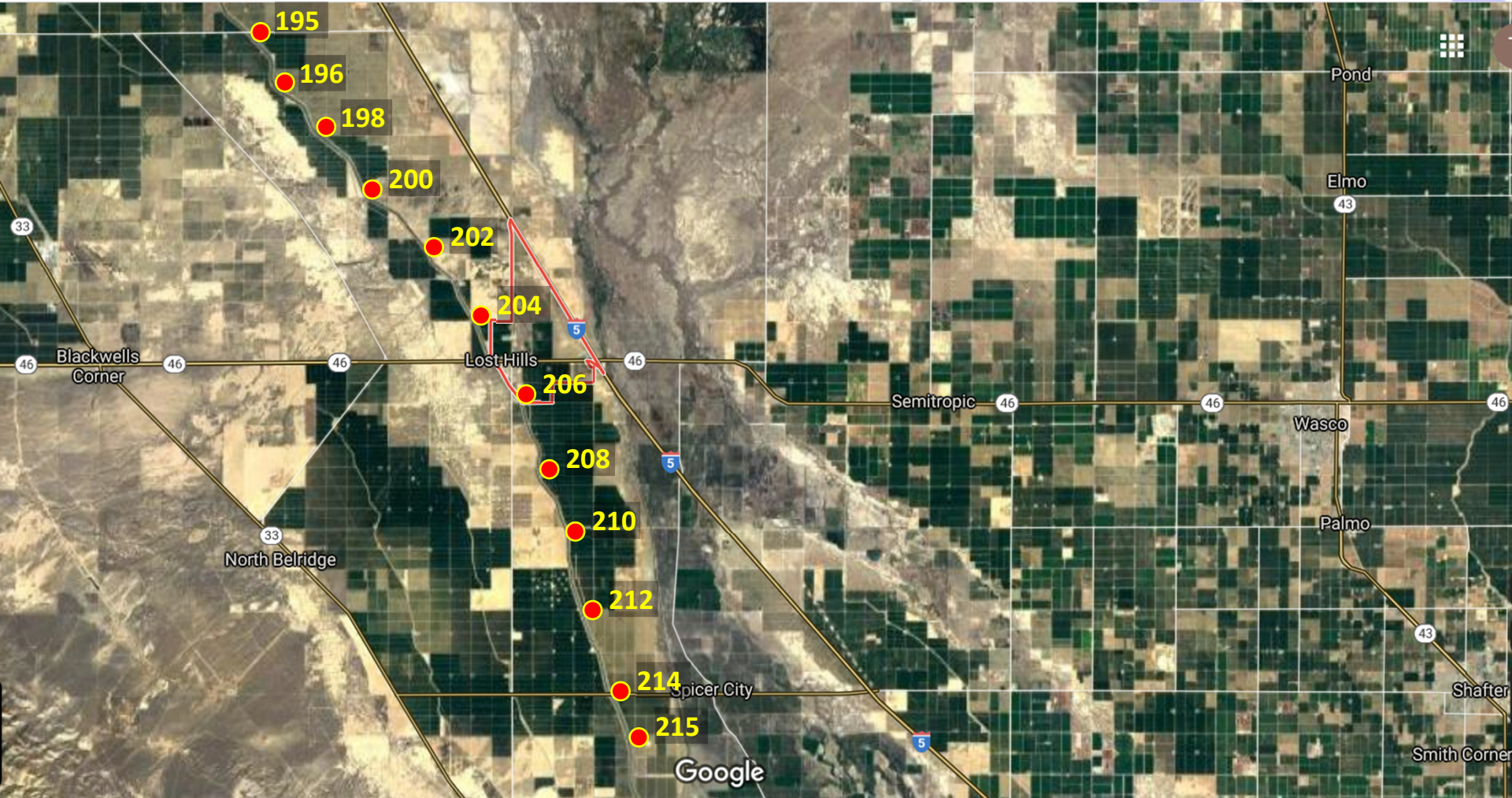


DENSITY OF WELLS PER SQUARE MILE
(PRODUCTION)

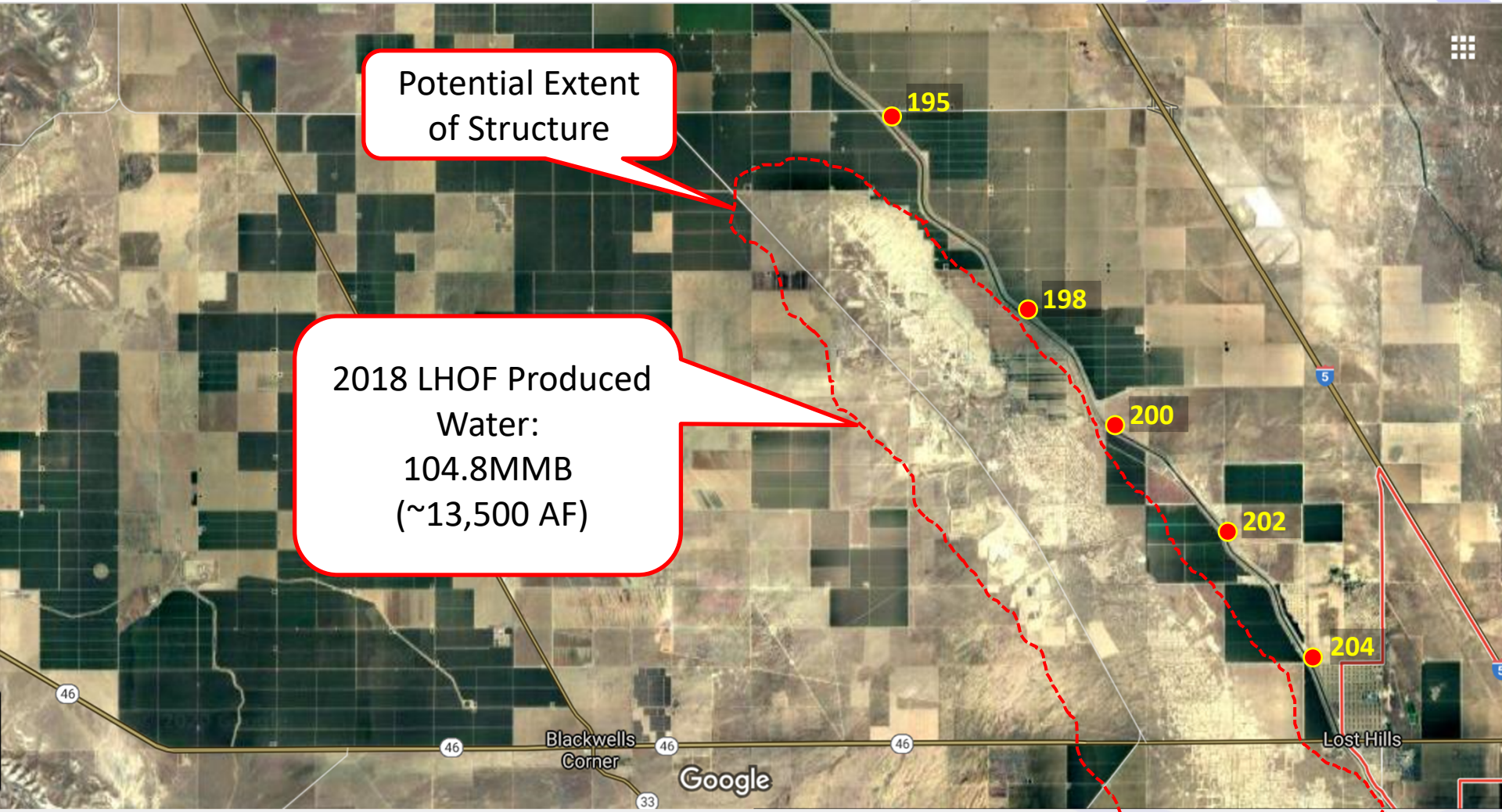
JULY 2019

FIGURE 2-4

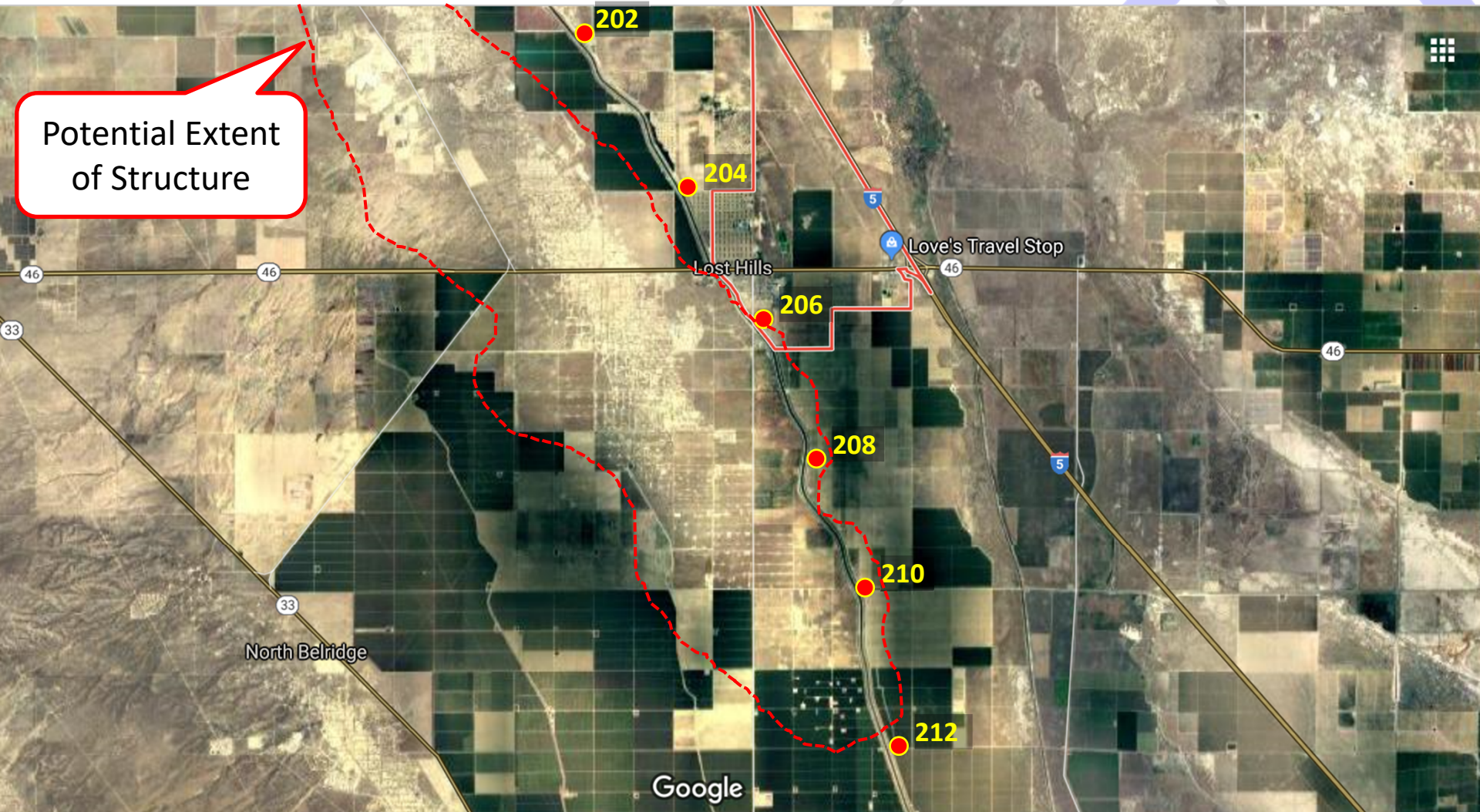
AOI 2 (MP 195 – 215)



Northern Lost Hills MP 195 – 204

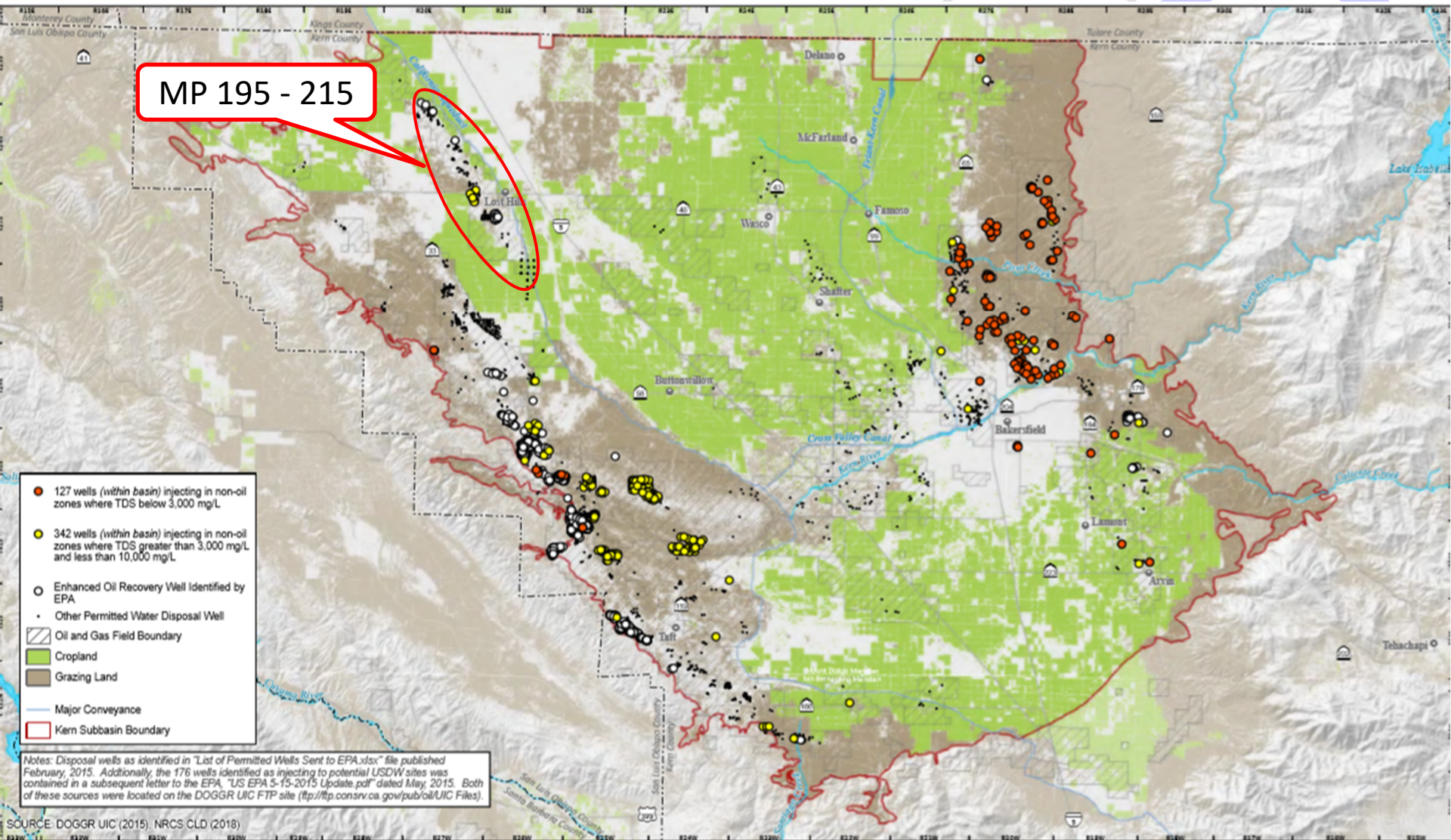


Southern Lost Hills MP 202 - 212



Summary: Slides # 1- 7

- 2015-2017 InSAR: 2 – 4 inches of subsidence concomitant with Aqueduct, Lost Hills Oil Field (LHOF) and Agriculture
- Shift to permanent crops and drip/micro-irrigation in ~1996
- Sparse irrigation well density in AOI 2
- 2018 LHOF produced water volume (all sources): ~104.8MMB (i.e., ~13,500 AF)
- WDWA pumping is limited by poor quality: ~3,000 – 5,000 AFY
- LHOF structure appears to extend beneath the Aqueduct in places (e.g., MP 208)

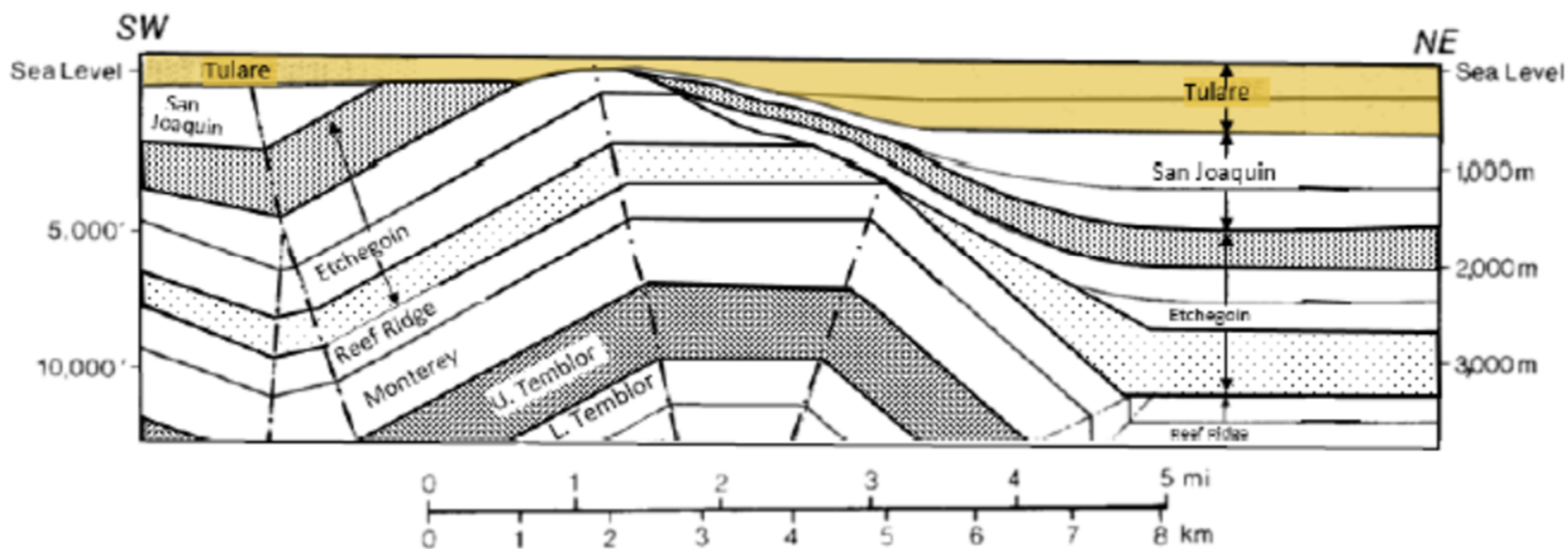


Kern Groundwater Authority
Basin Setting
Kern County, California



OIL AND GAS WELLS IN THE
UNDERGROUND INJECTION CONTROL PROGRAM
AUGUST 2019
FIGURE 2-39

Figure 8 : Structural cross section over Lost Hills anticline from Medwedeff (1989)

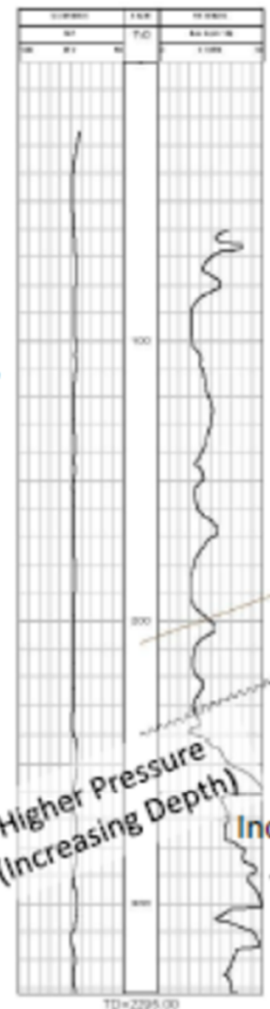


Structural cross section over Lost Hills anticline modified after Medwedeff (1989) showing asymmetric fold with erosion of Etchegoin and San Joaquin Formations with eastward deposition of Tulare Formation thinning onto the structure and thickening to the east.

A

A'

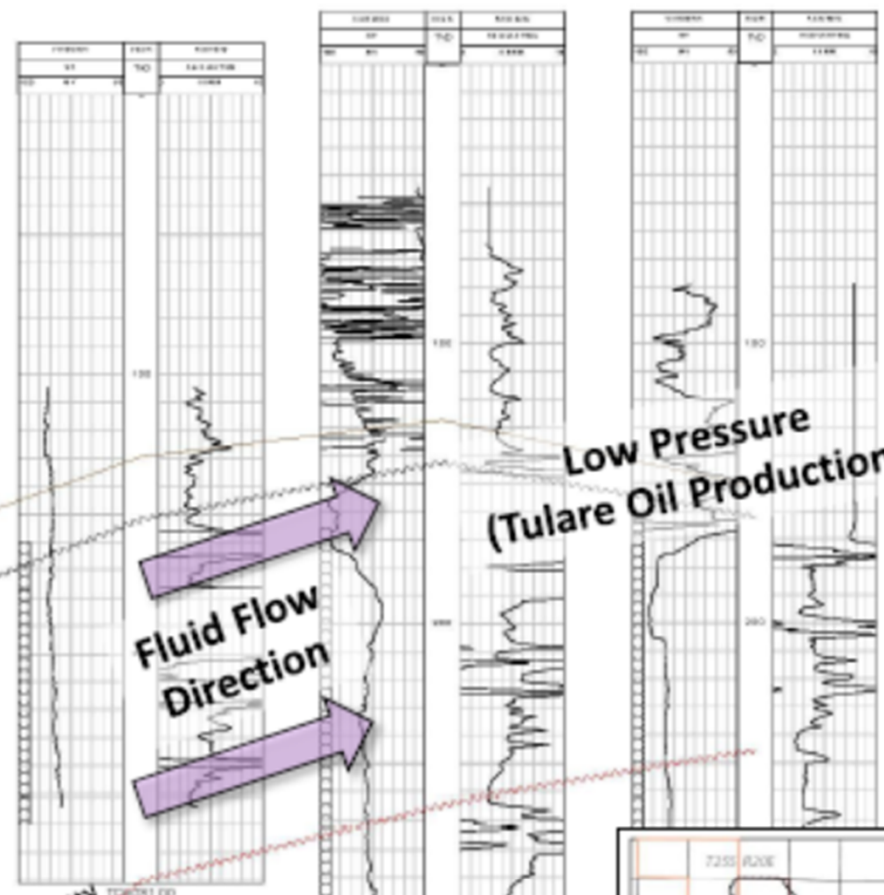
Measured Depth



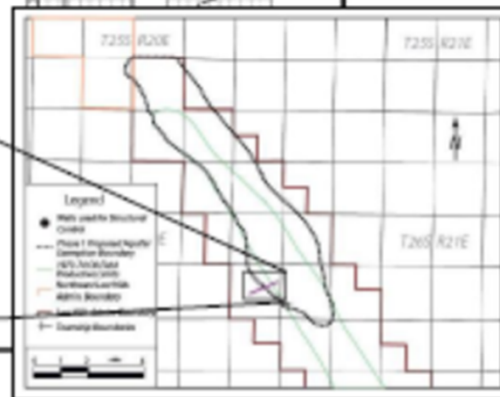
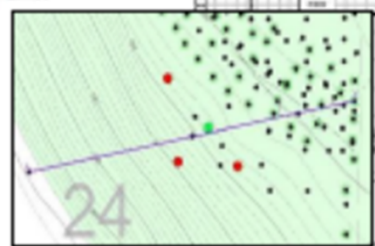
Mudstone Containment Layer
Top Tulare Disposal Interval (idle)

Higher Pressure (Increasing Depth)

Increasing Cementation of Tulare Sands

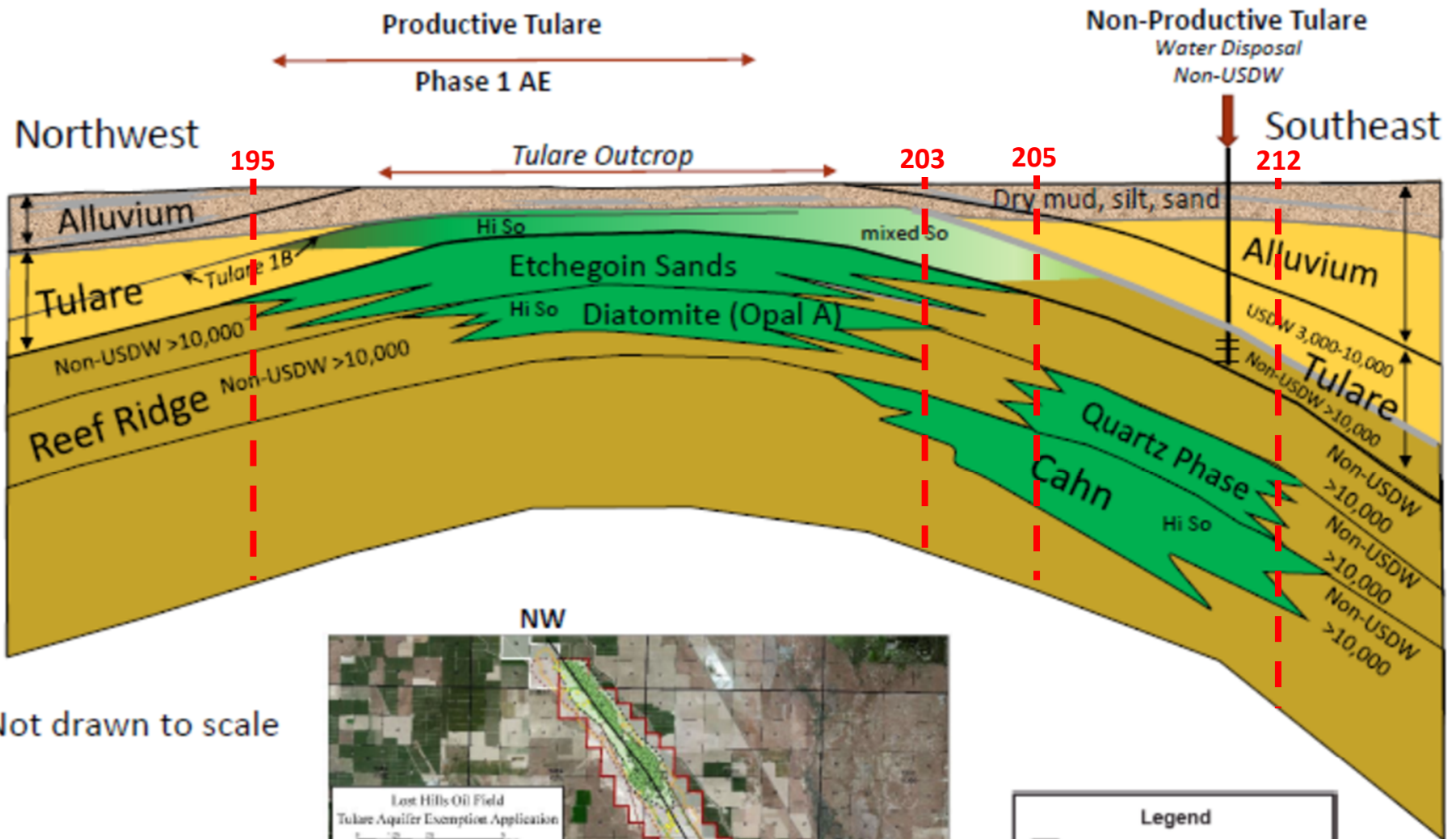


Tulare Unconformity
Top Etchegoin

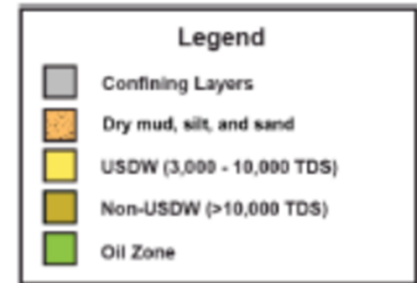
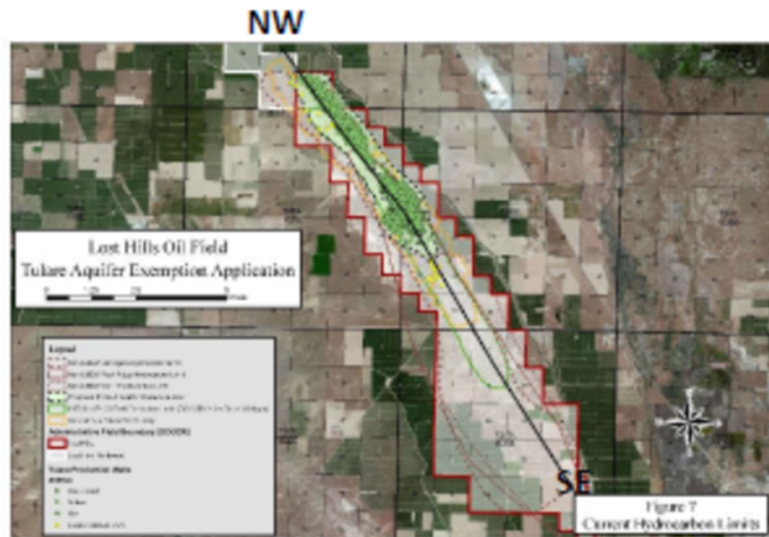


S24, T26S R20E

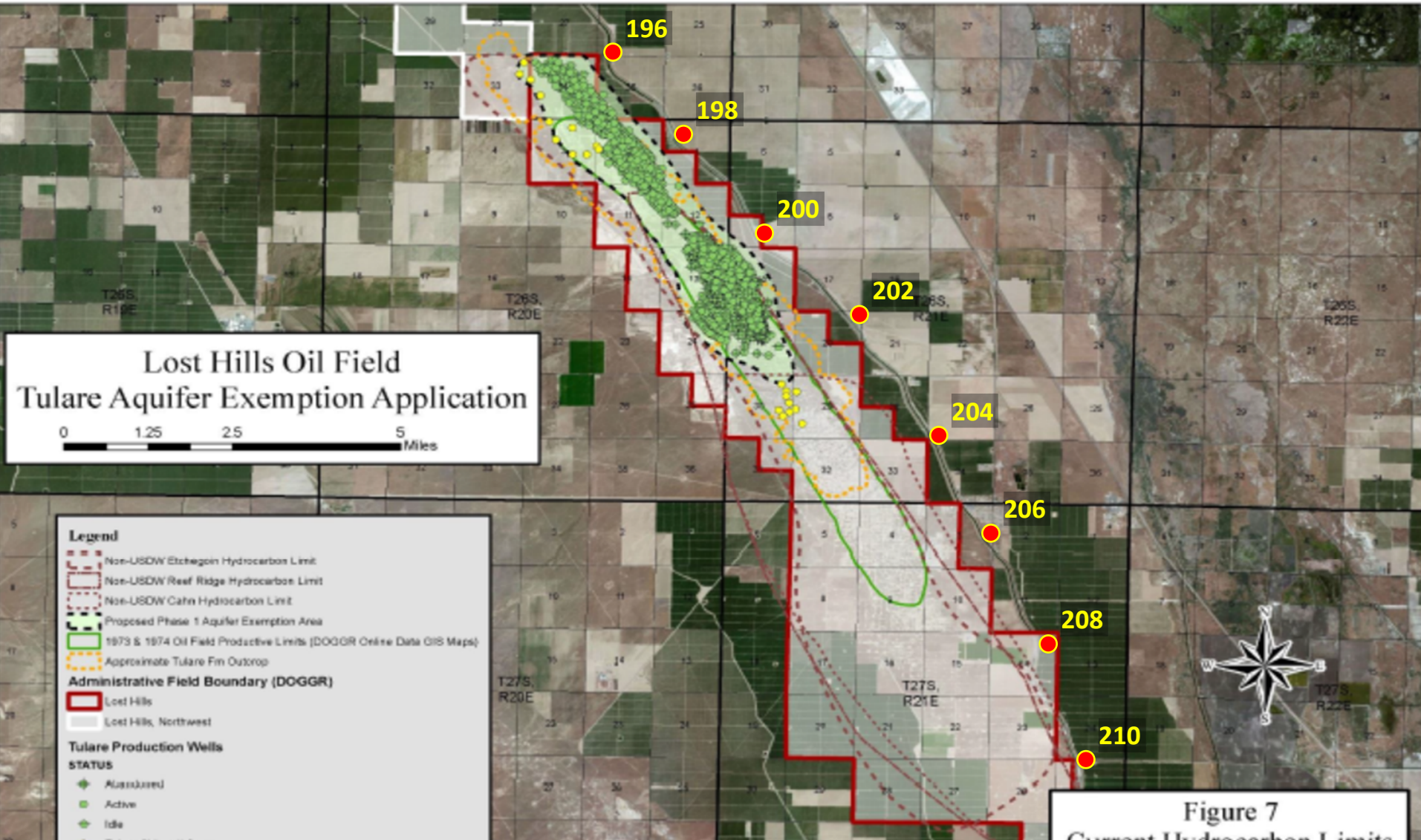
Figure 10: Conceptual strike cross section; Lost Hills Oil Field



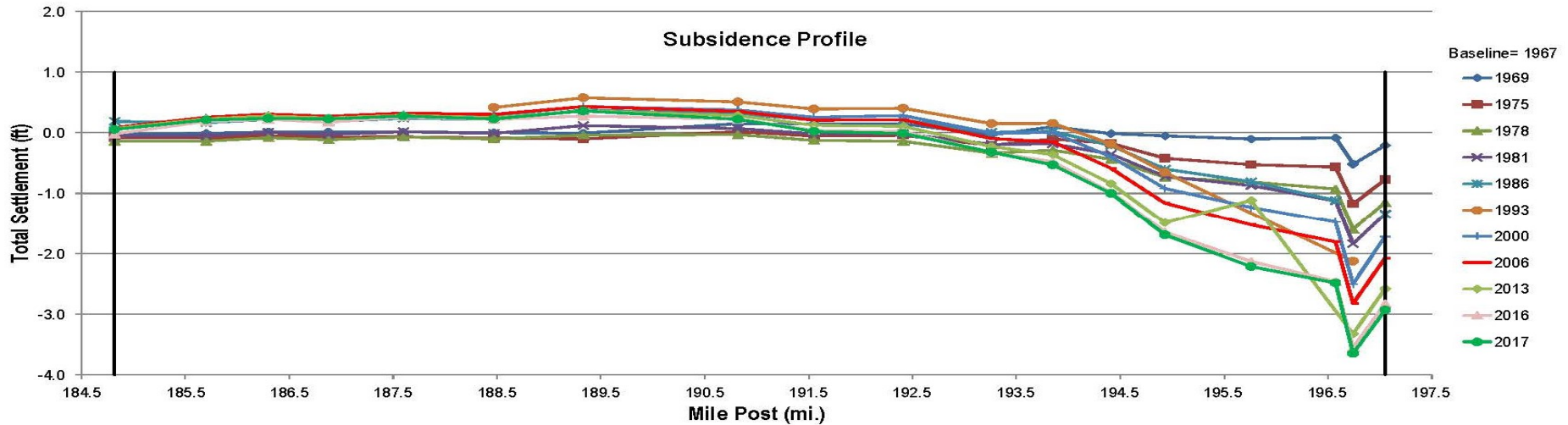
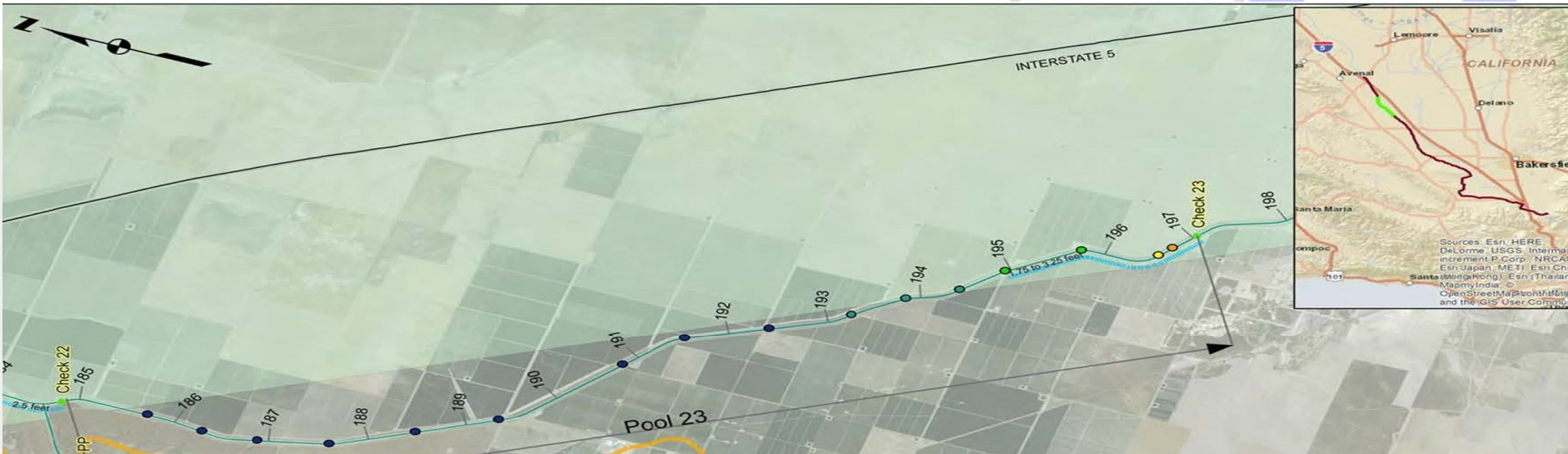
Not drawn to scale



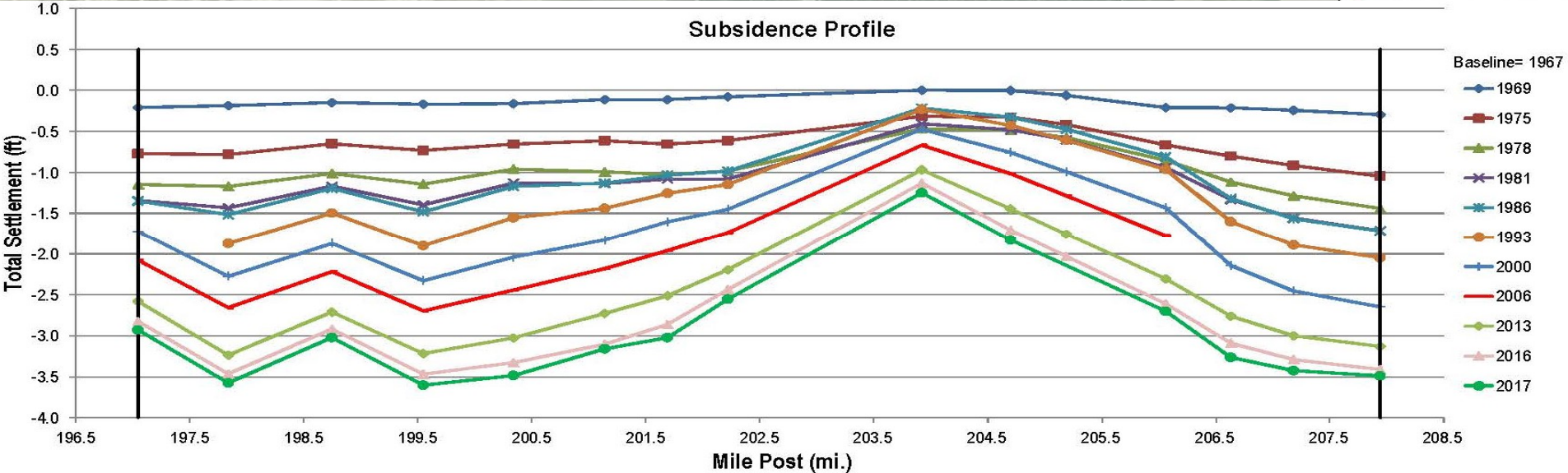
LHOF Distribution of Oil Production Intervals



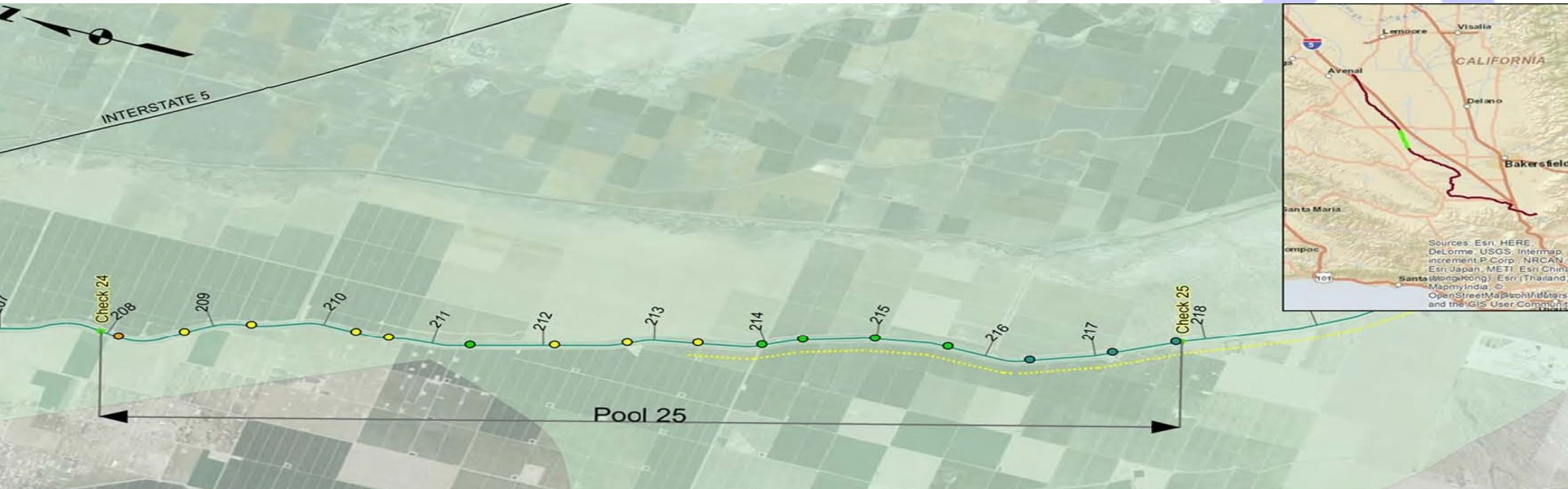
2019 DWR Report Plate: 12 MP 185-197



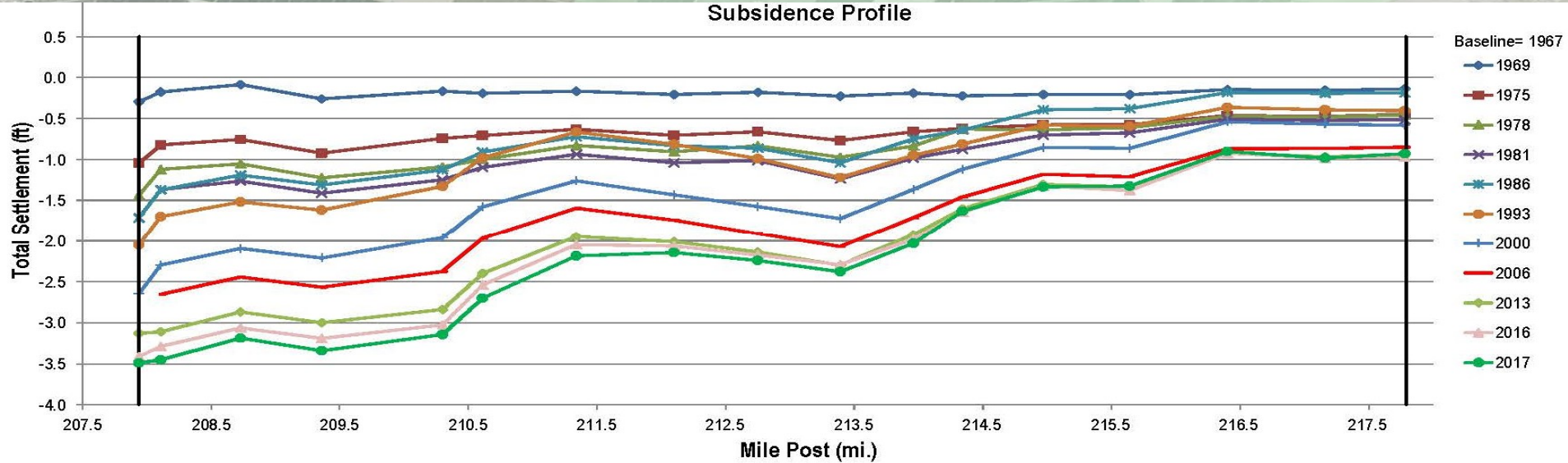
2019 DWR Report: Plate 13 MP 197-208



2019 DWR Report: Plate 14 MP 208-218



Subsidence Profile



Summary: Slides # 9 - 17

- LHOA Aquifer Exemption Application (AEA): shows up-flank migration of groundwater towards crest of the geologic structure due to pressure gradient
- LHOA Administrative Area and flanks of the geologic structure extend to the east beyond the Aqueduct in places (e.g., MP 208)
- Tulare oil zone extends from ~ MP 195 - MP 204
 - DWR data shows land surface “high point”: MP 202.5-MP 205.5
 - High Point concomitant with pinchout of Tulare zone production
- Agriculture pumping not the principal cause of subsidence

Conclusions and Recommendations

- Eastern flank of anticline likely extends beneath Aqueduct in places
- Oil production causes groundwater to move up-flank towards anticline crest
- MP 208: anticline flank potentially beneath Aqueduct
- MP 204: “high point” corresponds to pinchout of Tulare Zone production
- MP 212: marks the current end of Reef Ridge/Cahn production
- Causes of subsidence complex, further study needed

Conclusions and Recommendations (Cont.)

- Subsidence in AOI 2 is complex and has multiple potential causes
 - Geology/Soils/Aqueduct
 - Produced Water/ SGMA-Groundwater Extraction
- Coordination between all stakeholders (DWR, Agriculture and Oil) is necessary to comprehensively assess causes and solutions - **ON GOING!**
- Recommend additional monitoring (InSAR, pumping and geodetic) in coordination with GSP, CalGEM (DOGGR) and DWR – **ON GOING!**

