3a i Sampling and Aquifer Testing

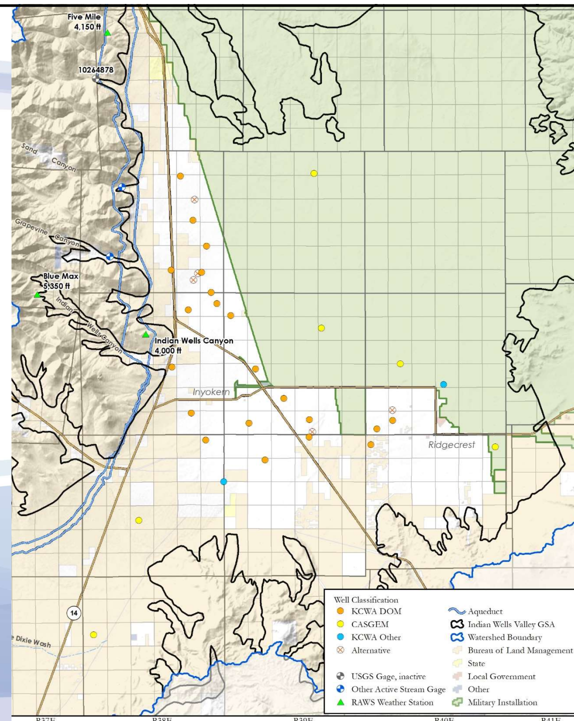
Developing work plans for Prop 1 Funding for Sampling and Aquifer Testing

- TDS and General Chemistry at Wells, Springs, and Streams
  Phase 1:
  - KCWA has contacted 5 DOM well owners for sampling
  - 10 samples with sampling rig
  - Spring and stream sampling

  Phase 2:
  - Outreach for other DOM well sampling

- Isotope Sampling
  - Subcontract with DRI

- Aquifer Testing
  - Developing work plan

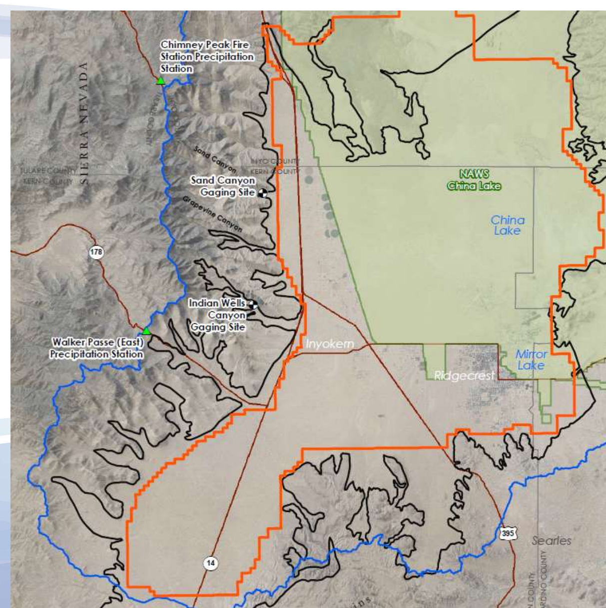


Stream Gages / Weather Stations

- Continuing permitting:
  - Meeting w BLM May 2nd

- Access/Permit Discussions with Ridgecrest BLM staff for:
  - Sand Canyon Gaging Site
  - Indian Wells Canyon Gaging Site
  - Walker Passe (east) Precipitation Station

- Access/Permit Coordination with Bakersfield BLM staff for:
  - Chimney Peak Fire Station Precipitation Station

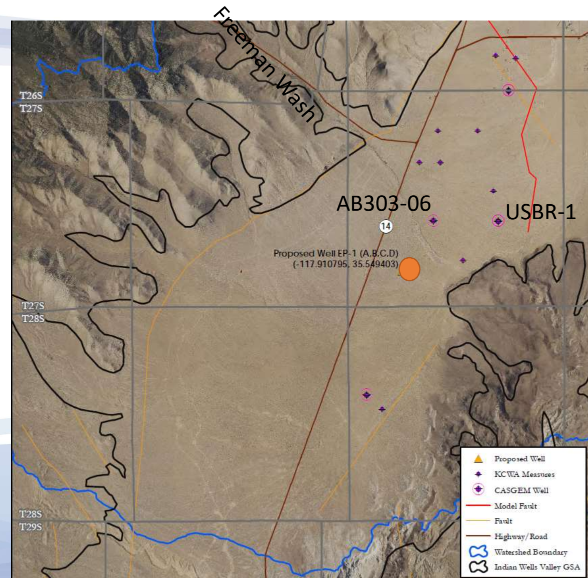


2

DWR Technical Support Service

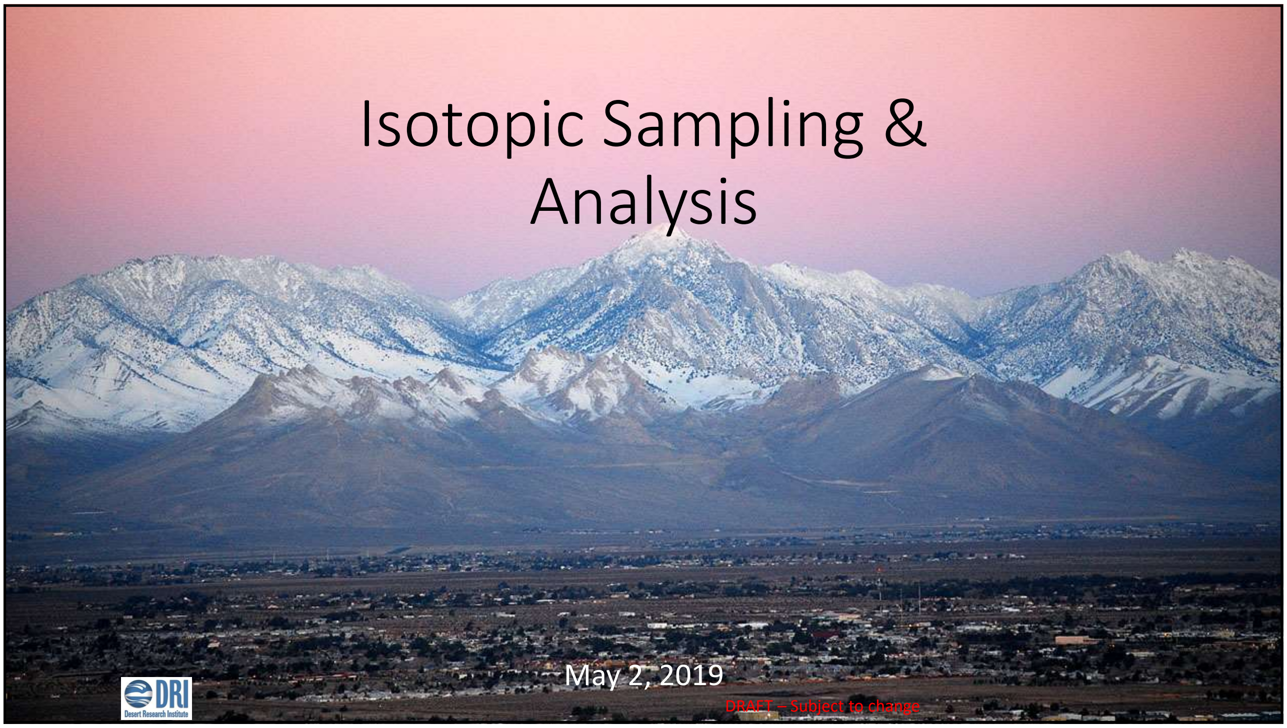
El Paso Multi-Level Well Project

- TSS Application Accepted by DWR on 3/21
- Coordinating with DWR (Jack Tung, PG) who is coordinating with drillers
  - Gregg Drilling not able to drill to 2000'
  - Sub-contract to Best Drilling
  - Not able to fund full well description.
  - Current proposal:
    - Drill/Geophysical Logging to 2000 feet
    - Install 2 or 3 (out of 4) shallower piezometers
- Need to determine water source for drilling



STETSON ENGINEERS INC.

Isotopic Sampling & Analysis



Objectives

- Establish baseline water quality conditions for monitoring trends and assessing performance of basin management activities
- Fill data gaps and reduce uncertainty in flow and transport model forecasts
- Refine hydrologic conceptual model for model validation and refinement: sources of groundwater, age of groundwater, flowpaths

Previous Work

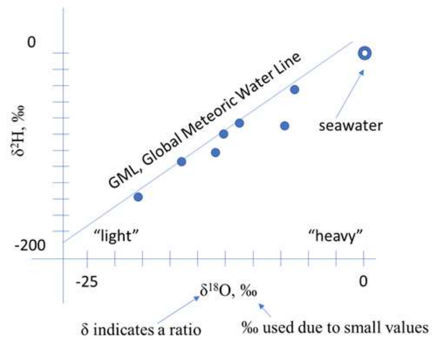
- Smith et al., 1992 (precipitation)
- Berenbrock and Schroeder, 1994
- Houghton, 1995, 1996, and other CSUB
- Tetra Tech 2003
- AB303, 2003 and 2008
- Compilations by Guler, 2000 and Williams, 2007

Prop 1 Task 8 Water quality and stable isotope sampling and analysis

- Stable isotopes of carbon, hydrogen, oxygen, sulfur, and boron. Also identifies age dating of water.
- Boron: used as a somewhat conservative tracer to compute mixing of different water sources
- Sulfur: affected by reactions with gypsum, suggested as identifying encroachment of playa water
- Hydrogen and oxygen: reflect precipitation, mixing, evaporation
- Carbon: Radioactive isotope used for dating, stable isotope for correcting age calculations

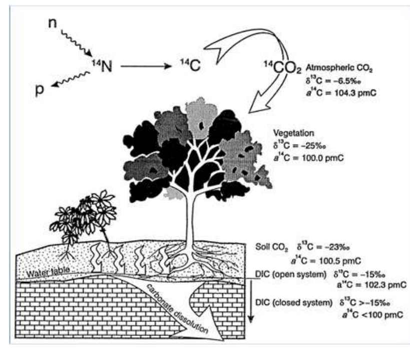
Isotopes

$\delta^{18}O$ and $\delta^{2}H$



^{14}C and $\delta^{13}C$

$a_t = a_0 * e^{-\lambda t}$



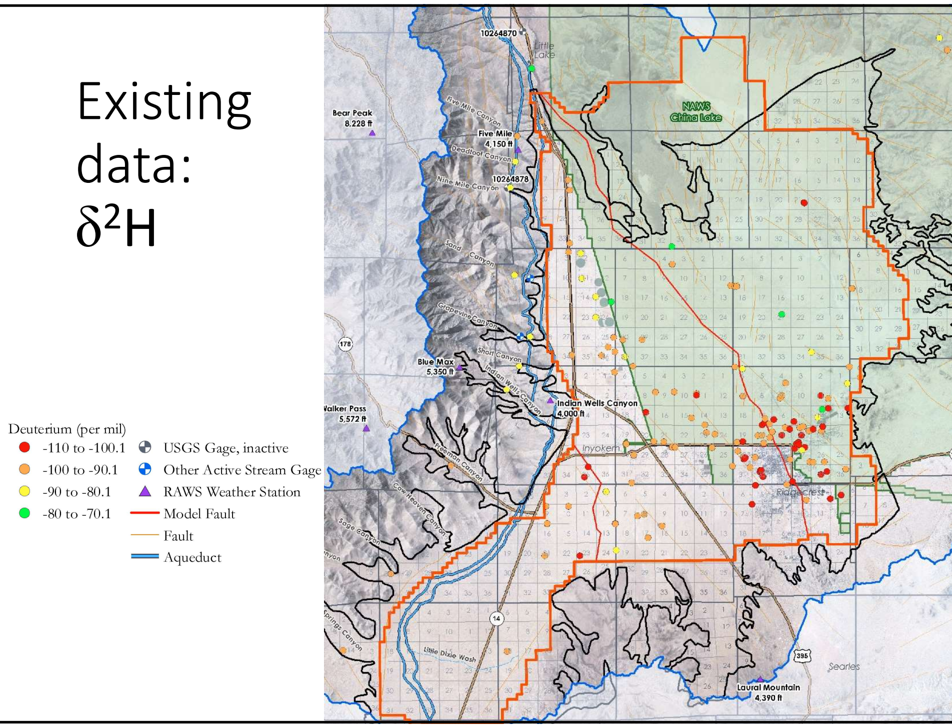
Data

- Over 200 stable isotopic analyses for groundwater samples, and almost 100 for surface waters (though some locations are imprecise)
- Almost 100 ^{14}C measurements (though some are absent ^{13}C or percent modern carbon data)

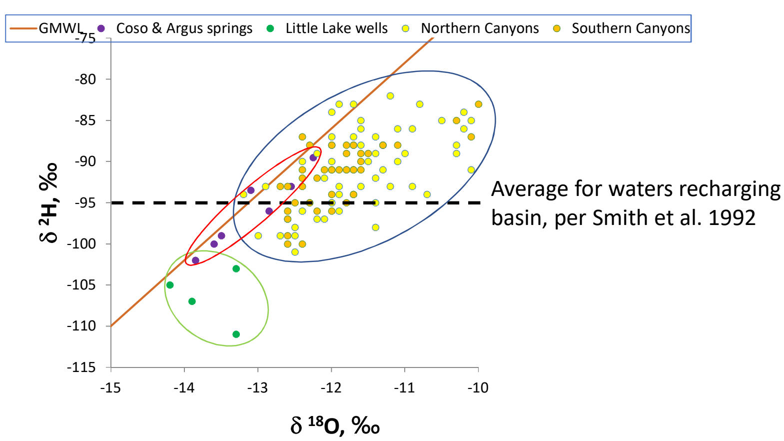
Approach

- Evaluate existing data in context of conceptual hydrogeologic model
- Identify inconsistencies & uncertainties
- Identify data gaps

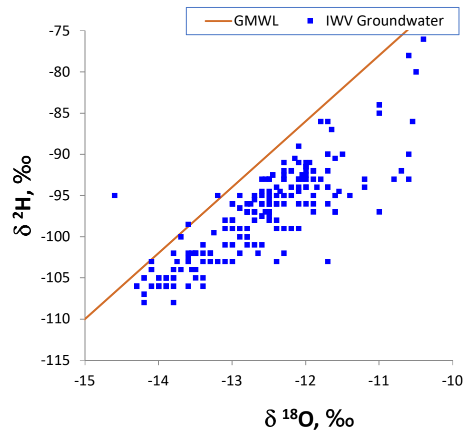
Existing data: δ^2H

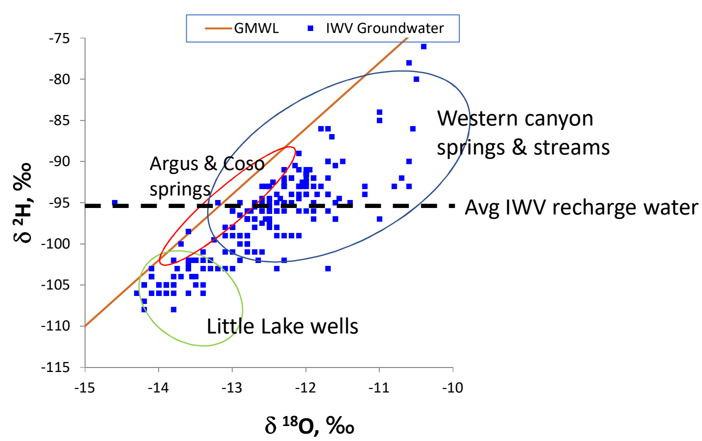


Stable Isotopic Composition of IWV recharge

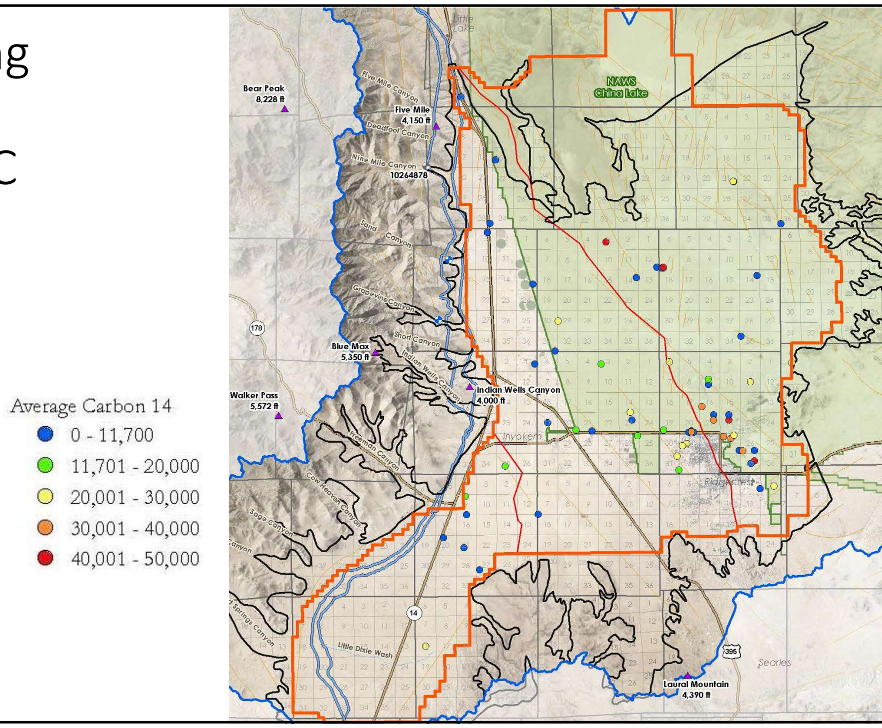


Stable Isotopic Composition of IWV groundwater

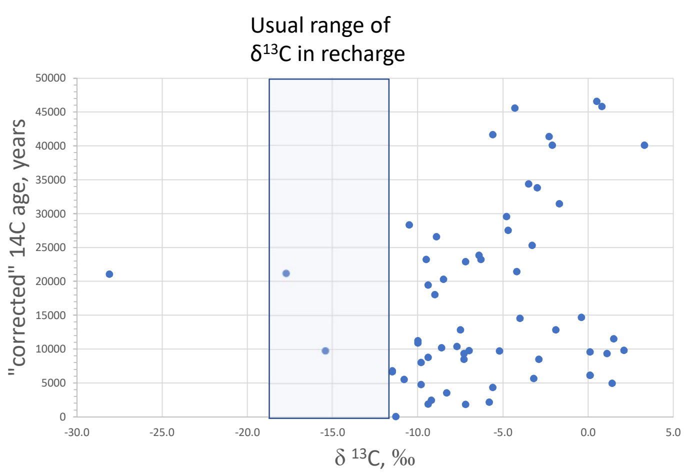




Existing Data: DIC ^{14}C



Dissolved inorganic carbon



DOC ^{14}C Groundwater Dating

- DOC does not participate in dissolution and precipitation reactions → little dilution from aquifer rocks
- Case Study: Average DOC ^{14}C age for Ash Meadows discharge is 2,900 yrs, in good agreement with hydraulic data (1,500 yrs), and Devils Hole $\delta^{18}O$ calcite record (<2,000), and much less than DIC ^{14}C ages (>10,000 yrs)

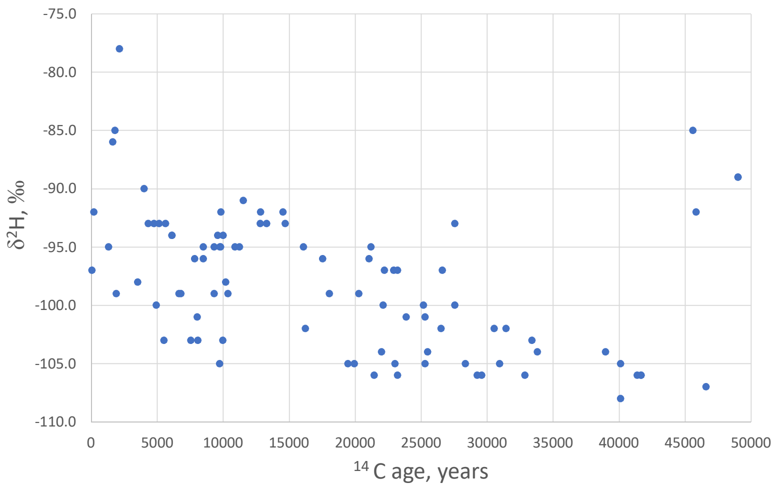
Another Case Study: Nevada National Security Site Groundwater

Frenchman Flat

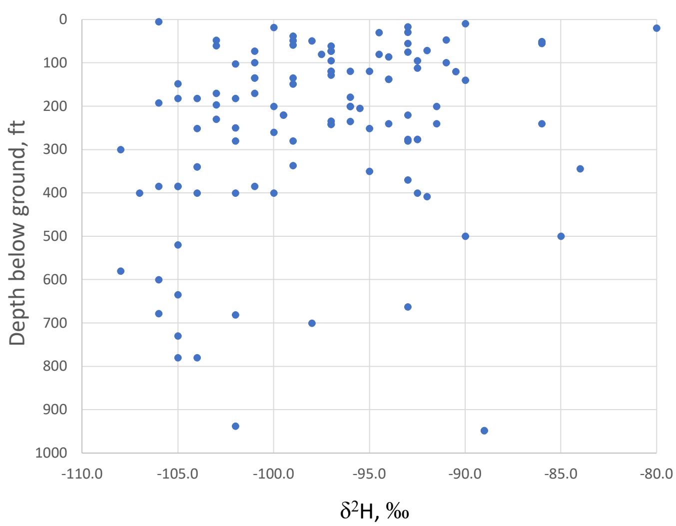
Comparison of DIC ^{14}C ages and DOC ^{14}C ages

	Well	DIC ^{14}C (yrs)	DOC ^{14}C (yrs)
Alluvial aquifer	Water Well 5A	22,800	8,100
	Water Well 5B	16,800	3,700
	Water Well 5C	23,000	3,700
	ER-5-4	27,900	3,300
Volcanic aquifer	Water Well 4A	14,000	12,000
	ER-5-4 #2	32,300	10,000
	UE-5c Water Well	22,500	5,800
	UE-5 PW-3	14,200	3,900

Working the isotopes together



Combining with hydrogeology



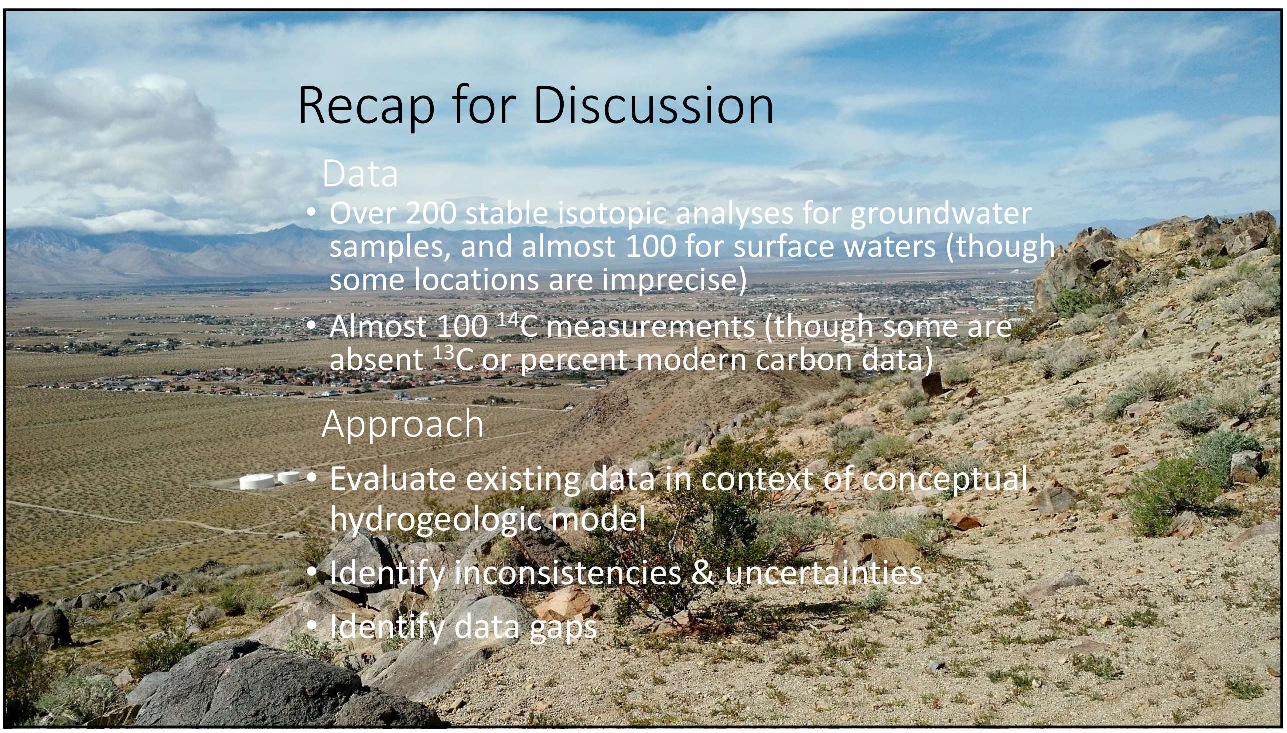
Recommendations from AB303 reports

2003

- ^{18}O, ^{2}H, and ^{14}C most informative isotopes
- Sample in western, SW, and NE IWV (USBR wells and select production wells)
- Sample from recharge areas in watershed

2008

- Determine ^{13}C and ^{14}C in canyon groundwater
- Resample wells with spurious ^{34}S and ^{13}C results
- Sample shallow aquifer to identify modern recharge
- Sample potential recharge areas from El Paso Mountains
- Sample in Little Lake and southern Rose Valley
- Sample in northeastern valley along Argus canyons



Recap for Discussion

Data

- Over 200 stable isotopic analyses for groundwater samples, and almost 100 for surface waters (though some locations are imprecise)
- Almost 100 ^{14}C measurements (though some are absent ^{13}C or percent modern carbon data)

Approach

- Evaluate existing data in context of conceptual hydrogeologic model
- Identify inconsistencies & uncertainties
- Identify data gaps

GSP Monitoring Network for Sustainable Management Criteria

Agenda Item 3b

1

Sustainable Management Criteria Review

- 6 Sustainability Indicators:
  - Chronic Lowering of Groundwater Levels
  - Reduction of Groundwater Storage
  - Seawater Intrusion
  - Degraded Water Quality
  - Land Subsidence
  - Depletion of Interconnected Surface Water

2

Sustainable Management Criteria Review

- Sustainable Management Criteria
  - Undesirable Results: Occurs when any of the 6 Sustainability Indicators become "significant and unreasonable"
  - Minimum Thresholds: Quantitative limit where exceedances produce undesirable results
  - Interim Milestones: Quantitative goals set in five-year increments at each representative monitoring site
  - Measurable Objectives: Quantitative goals that reflect the basin's desired groundwater conditions
  - Sustainability Goal: Qualitative description of how Undesirable Results are avoided and the basin is operated within its sustainable yield

3

Minimum Thresholds: Metrics

Sustainability Indicators	Lowering GW Levels	Reduction of Storage	Seawater Intrusion	Degraded Quality	Land Subsidence	Surface Water Depletion
Metric(s) Defined in GSP Regulations	• Groundwater Elevation	• Total Volume	• Chloride concentration isocontour	• Migration of Plumes • Number of supply wells • Volume • Location of isocontour	• Rate and Extent of Land Subsidence	• Volume or rate of surface water depletion

Source: DWR

4

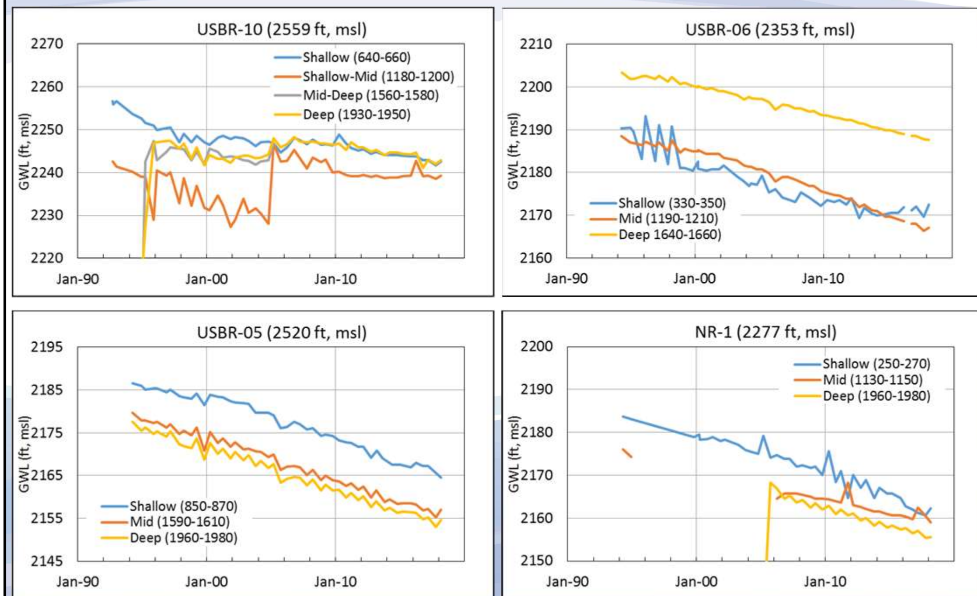
Minimum Thresholds: Groundwater Levels as Proxy

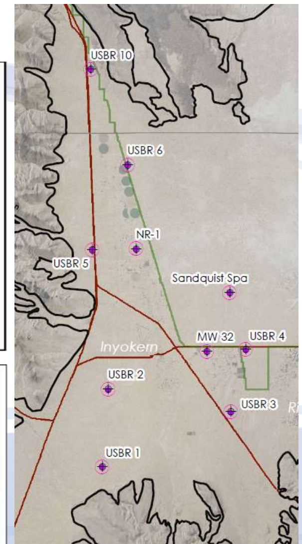
- Groundwater elevations can be used as a proxy metric for any (or potentially all) of the sustainability indicators when setting minimum thresholds
- Significant correlation between groundwater levels and the other metrics must be demonstrated
- Two Options:
  1. Demonstrate that setting a groundwater level minimum threshold satisfies the minimum threshold requirements for both chronic lowering of groundwater levels and other sustainability indicators at a given site.
  2. Use a groundwater level minimum threshold solely for establishing a threshold for another sustainability indicator, but not to satisfy the minimum threshold requirements for chronic lowering of groundwater.

GSP Monitoring Network

- GSP Network comprised of CASGEM Wells
- Minimum of one “key well” representative site per modeling zone area (but likely more required)
- Considerations for Establishing Sustainable Management Criteria for Groundwater Levels
  - Natural Recharge
  - Induced Recharge
  - Recharge Areas
  - Pumping Depressions
  - Flow Barriers
  - Groundwater Dependent Ecosystems requirements

GWL Trends at Northwest IWV CASGEM Wells





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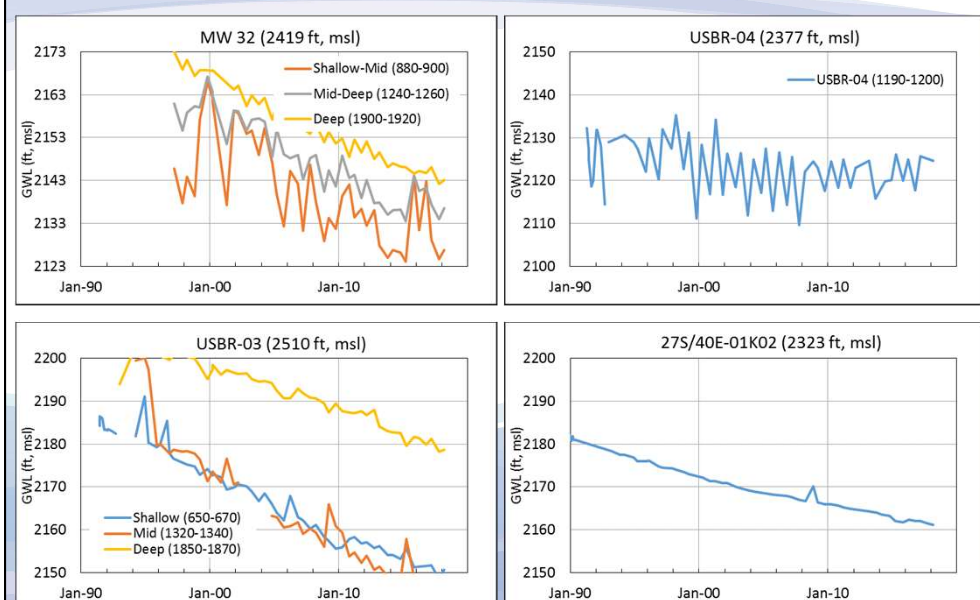
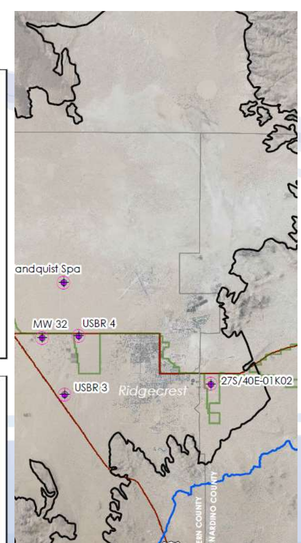
GWL Trends at Southeast IWV CASGEM Wells





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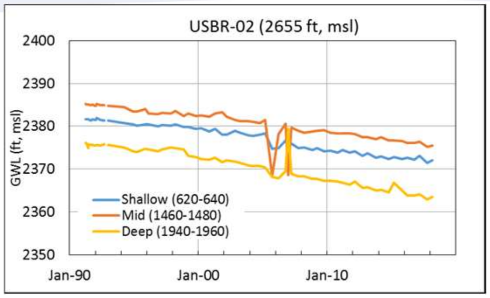
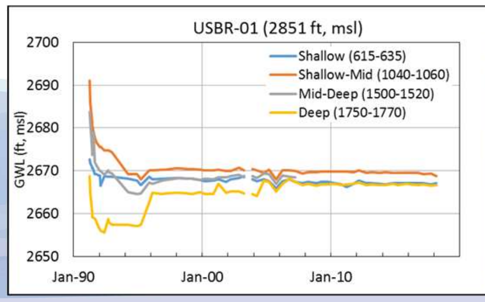
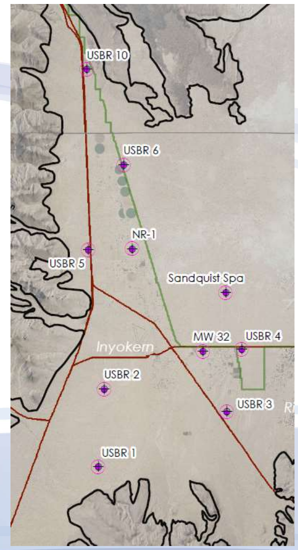
GWL Trends at El Paso CASGEM Wells







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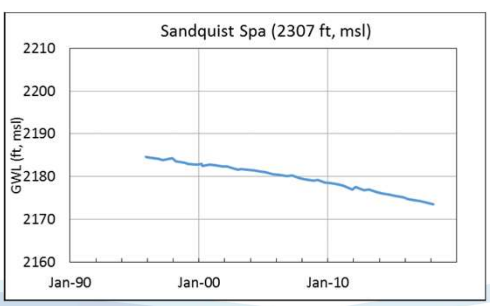
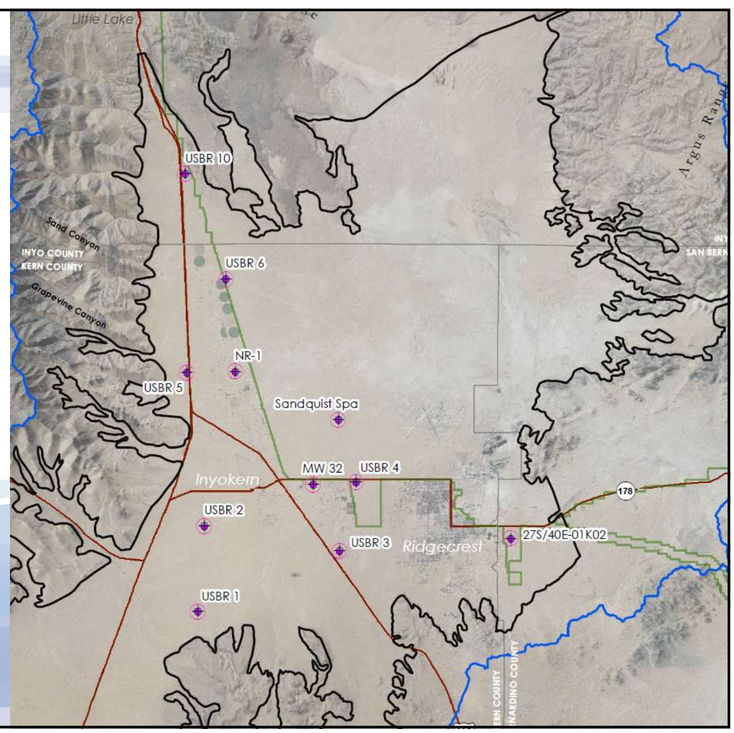
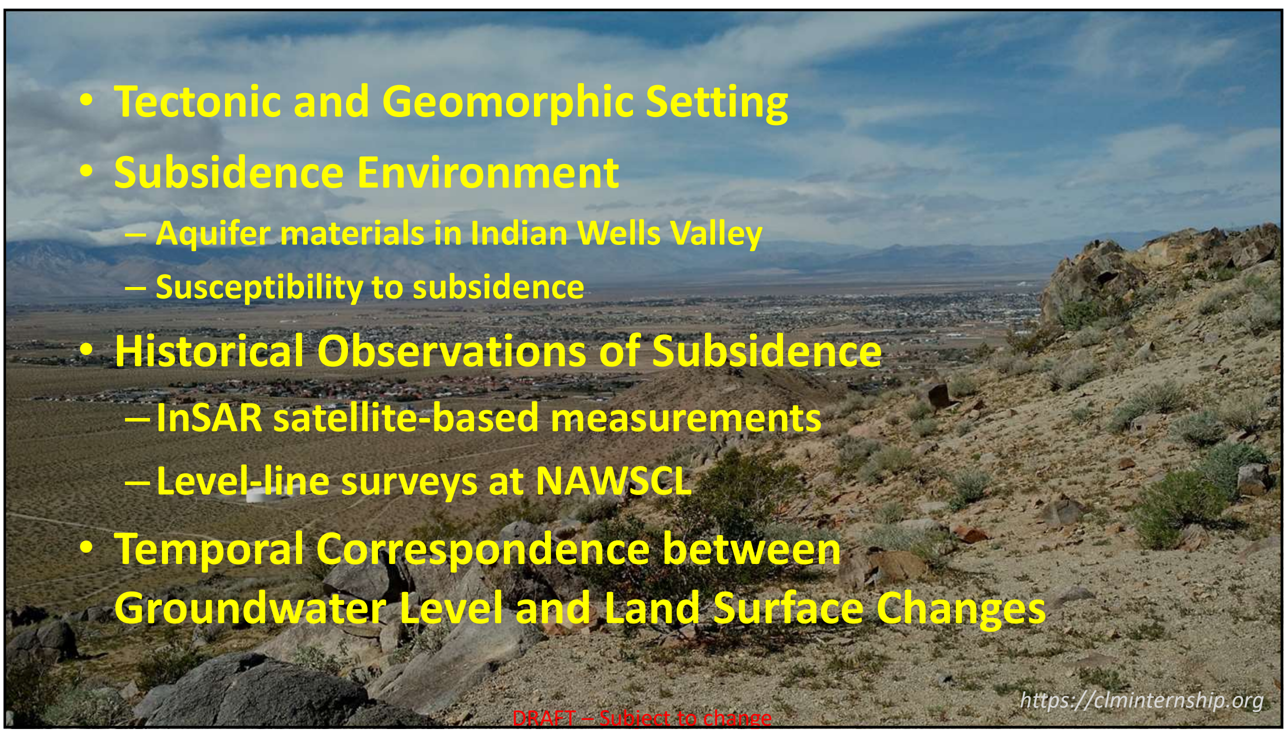
GWL Trends at Navy CASGEM Wells



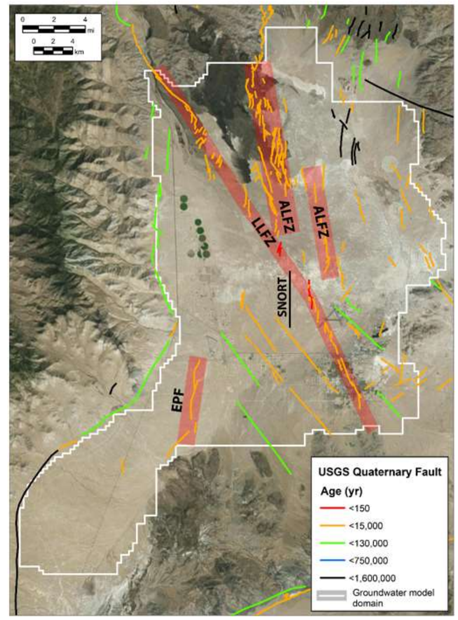



Indian Wells Valley
Land Subsidence Conditions
May 2, 2019
DRI
Desert Research Institute
DRAFT – Subject to change


• Tectonic and Geomorphic Setting
• Subsidence Environment
– Aquifer materials in Indian Wells Valley
– Susceptibility to subsidence
• Historical Observations of Subsidence
– InSAR satellite-based measurements
– Level-line surveys at NAWSCL
• Temporal Correspondence between Groundwater Level and Land Surface Changes
https://clminternship.org
DRAFT – Subject to change

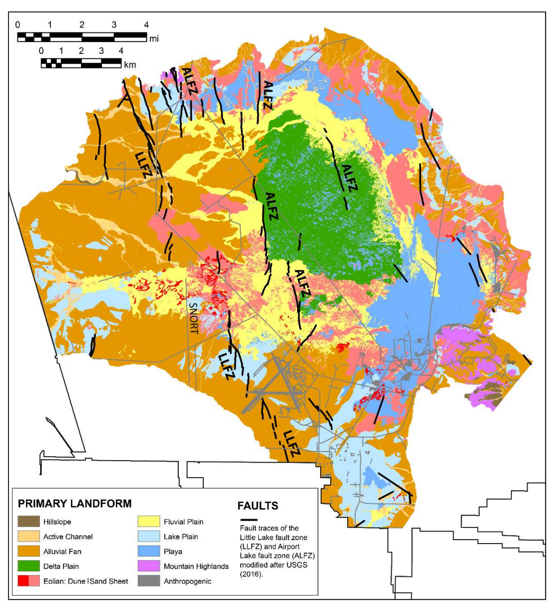
Tectonic Setting of Indian Wells Valley Groundwater Basin

- Tectonically active
  - Little Lake fault zone (LLFZ) – Historical rupture 1982
  - Airport Lake fault zone (ALFZ) - Historical rupture 1995
  - El Paso fault (EPF) – Latest Pleistocene to Holocene
  - Sierra Nevada frontal fault – Late Pleistocene
  - Quaternary bedrock faults
- Volcanically active
  - Coso Volcanic center



Geomorphic Setting of Indian Wells Valley Groundwater Basin

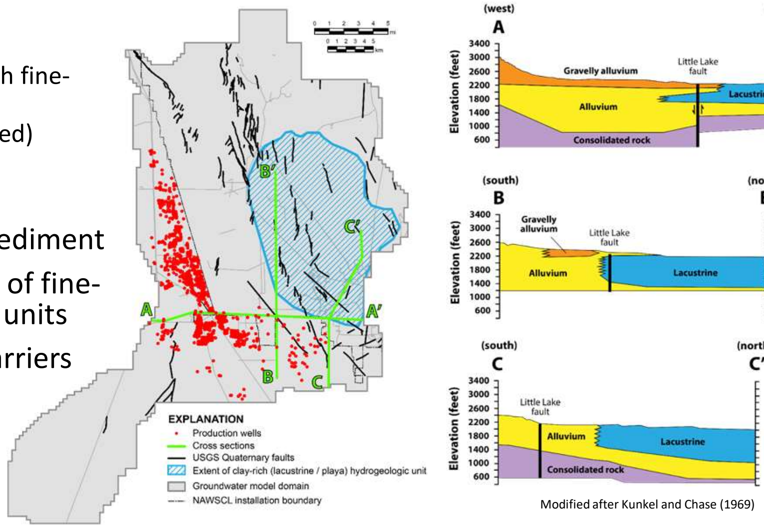
- Landforms typical of Basin and Range Province
  - Alluvial fans (gravelly to sandy)
  - Alluvial plains (sandy to silty)
  - Lacustrine / playa (silty to clayey)
  - Deltaic (sandy)
  - Sand dunes (sandy)
- Complex mosaic of landforms
- Faults commonly control distribution of landforms



Bacon et al. (2016)

Subsidence Environment: Aquifer Materials

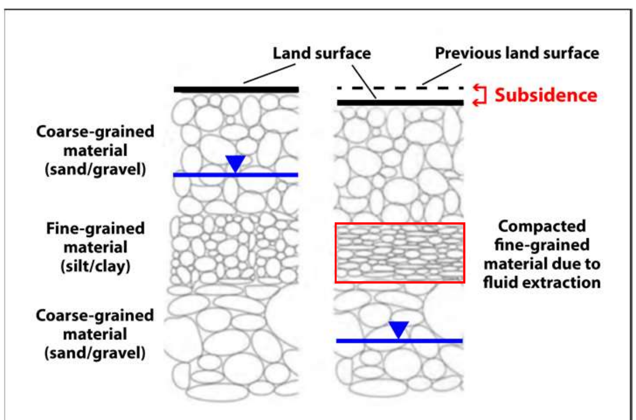
- Hydrogeologic units
  - Alluvial fans (coarse-grained)
  - Alluvium (coarse-grained with fine-grained layers)
  - Lacustrine / playa (fine-grained)
  - Deltaic (coarse-grained)
  - Sand dunes (coarse-grained)
- Large area of fine-grained sediment
- Overlapping lateral margins of fine-grained and coarse-grained units
- Faults form groundwater barriers



Modified after Kunkel and Chase (1969)

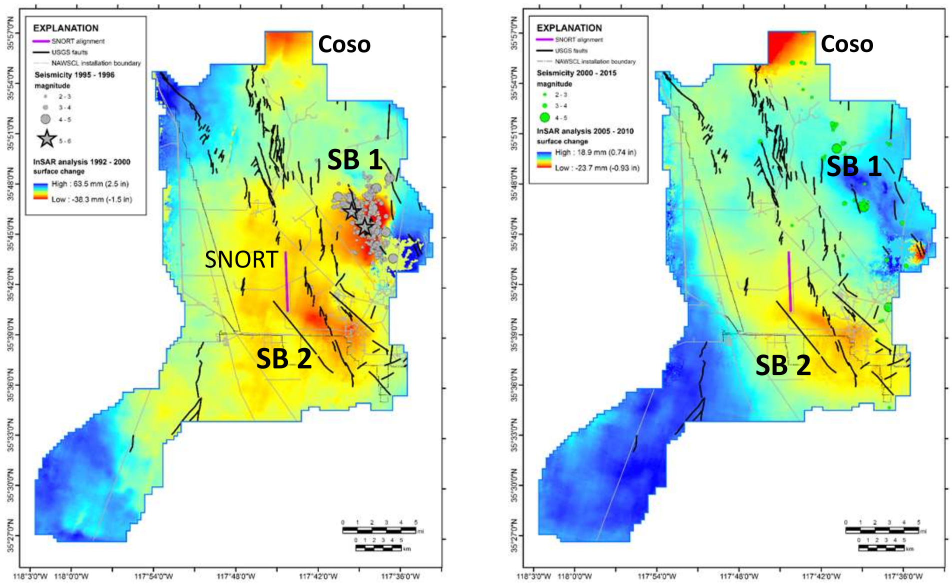
Subsidence Environment: Susceptibility to Subsidence

- Hydrogeologic units
  - Alluvial fans (coarse-grained)
  - **Alluvium (coarse-grained with fine-grained layers)**
  - **Lacustrine / playa (fine-grained)**
  - Deltaic (coarse-grained)
  - Sand dunes (coarse-grained)
- Fine-grained sediment prone to compaction from groundwater lowering
- Result is land subsidence
- Interbedded coarse- and fine-grained sediment are highly susceptible
- Fault contacts and discontinuous interbedded fine-grained layers commonly produce differential subsidence



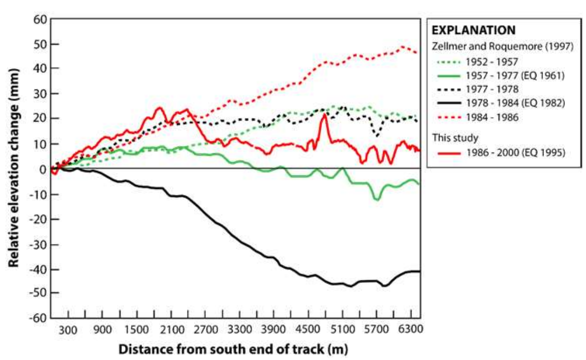
Adapted from Borchers and Carpenter (2014)

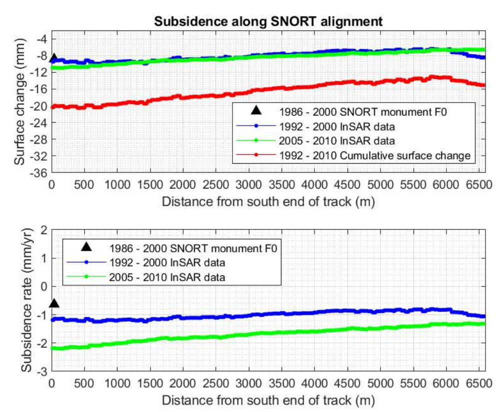
Historical Observations of Subsidence: 1992 – 2000 & 2005 – 2010



Modified after Katzenstein (2015)

Historical Observations of Land Surface Change: 1952 – 2010

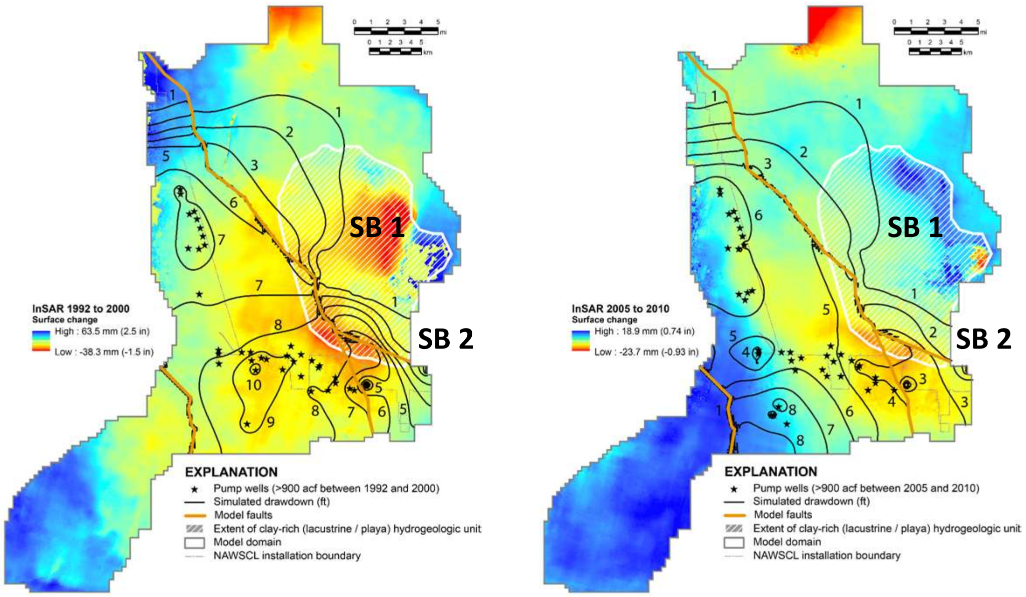




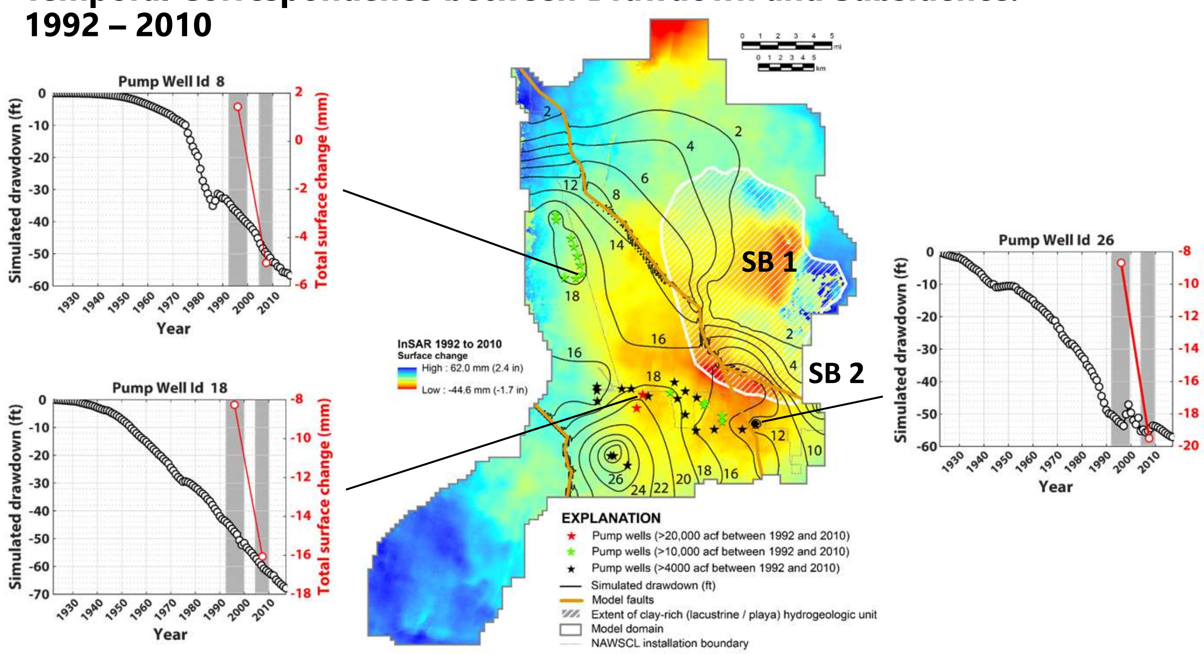
- Level-line surveys along SNORT
  - Relative tectonic uplift during stress build up during periods with no seismic activity
  - Relative tectonic subsidence during stress drops after nearby ~M5 earthquakes in 1961, 1982, 1995

- InSAR data along SNORT alignment
  - Progressive subsidence
  - Greater values on southern end near subsidence bowl 2
  - Tectonic signal on northern end

Simulated Drawdown and Observed Subsidence: 1992 – 2000 & 2005 – 2010



Temporal Correspondence between Drawdown and Subsidence: 1992 – 2010



Summary

- Tectonically and geomorphically active area of Basin and Range Province
- Fine-grained (lacustrine / playa) & interbedded fine-grained (alluvial) units prone to compaction when groundwater levels fall below historical levels
- Spatial distribution of greatest subsidence coincides with overlapping lateral margins of interbedded fine-grained units and location of faults
- Subsidence up to 45 mm (1.8 in) occurred between 1992 and 2010 in areas with up to 18 ft of drawdown
- Subsidence rate up to 5.6 mm/yr (0.23 in/yr) corresponded to a drawdown rate of up to 2.3 ft/yr between 1992 and 2010
- Good temporal correspondence between subsidence and drawdown across Indian Wells Valley groundwater basin

Land Subsidence Monitoring

- Existing Monitoring Networks in Indian Wells Valley
  - SNORT level-line surveys (land surface change)
  - National Geodetic Survey (NGS) benchmarks (land surface change)
  - Interferometric Synthetic Aperture Radar (InSAR) surveys: 1992–2000 & 2005–2010
- Possible Future Monitoring Approaches
  - Establish continuous Global Positioning (GPS) monitoring stations (land surface change)
  - New InSAR surveys (land surface change: 2010–2019)
  - Level-line surveys (land surface change)
  - Install extensometers (depth-specific intervals for compaction monitoring)

Photos from USGS


Questions
DRAFT – Subject to change
https://clminternship.org

GSP Sustainable Management Actions Modeling Scenarios

MAY 2, 2019

GSP Sustainable Management Action Modeling Scenarios

- WRM Review and Update

WRM Review – Modeling Scenarios

- Coordination of Technical/Legal Allocation Groups
- Impasse in March/April – Factors
- WRM concerns at April TAC Meeting
- Suspension of Attorney's Allocation and Modeling Ad Hoc

WRM Review – Impasse Factors

- Need to Maximize Conservation of Basin Storage
- Uncertainty of Imported Water/Replacement of Storage
- Owens Valley – LADWP: Opposition is more likely if imported water is used to support agriculture
- Potential Irreversible Loss of Basin Storage
  - High cost of replacement water
- Reserve Storage Needed for Potential Base Demand Increase (Emergency)
- Actual and Potential Impacts to Shallow Wells, Water Quality, Pumping Costs and Subsidence
- <u>IF</u> AG Must Fallow – Why Allow Removal of Reserve Water Supply?

WRM Review – Minimum Water Uses

- Estimated "Basic Health and Safety" Plus Navy Exceeds 7,650 AFY
- Current "Domestic Only" Plus Navy Uses (2016)

Navy	2,041 AFY
IWVMD	6,412 AFY
De Minimis	800 AFY
Domestic Mutuals	300 AFY
Inyokern	102 AFY
City	373 AFY
Searles/Trona	225 AFY
	10,253 AFY (Deficit ~2,600 AFY)

- Navy Reserved Rights Extended Off-Base Exceeds 7,650 AFY

WRM Update - Model Run No. 3

(Discussion/White Paper Basin Management)

- Start of Management Action – January 2022
- 2022: Total Pumping 28,600 AF
- 2022 through 2029: Total Annual Pumping ~28,600 AFY
- 2030 through 2039 (10 years): Reduce Pumping By Equal Increments Each Year to Reach 7,650 AFY
- 2039 through 2070: Total Annual Pumping 7,650 AFY
- Evaluate Impacts to Water Levels, Water Quality, Shallow Wells and Loss of Basin Storage

WRM Update - Model Run No. 4
(Coordinated AG Pumping with Allocation Transfers)

- Start of Management Action – January 2022
- 2022: Pumping Includes Reduced Pumping for Unprotected Allocation Plus Protected Pumping
- 2023 through 2027: Unprotected Allocations Reduced by Equal Increments Each Year for Total Pumping of ~12,000 AFY in 2027
- 2025: Recycled Water is available to help reduce overdraft
- 2028 through 2070: Total Annual Pumping of ~12,000 AFY
- 2035 through 2070: Total Pumping is Augmented by Imported Water Supply for basin to be sustainable
- Evaluate Impacts to Water Levels, Shallow Wells and Loss of Basin Storage

WRM Update – Model Run No. 5
(Immediate Action on Pumping Reduction)

- Start of Management Actions – January 2022
- Negotiate/Fallow All AG Pumping to Zero
- Searles to Find New Supply-Recycle Water?
- Total Annual Pumping 2022 through 2034: ~10,000 AFY
  - Includes IWVWD, Navy, De Minimis, Domestic Mutuals, Inyokern, City and Searles/Trona.
- 2025: Recycled Water is available to help reduce overdraft
- 2035 through 2070: Total Pumping is Augmented by Imported Water Supply for basin to be sustainable
- Evaluate Impacts to Water Levels, Shallow Wells and Loss of Basin Storage.