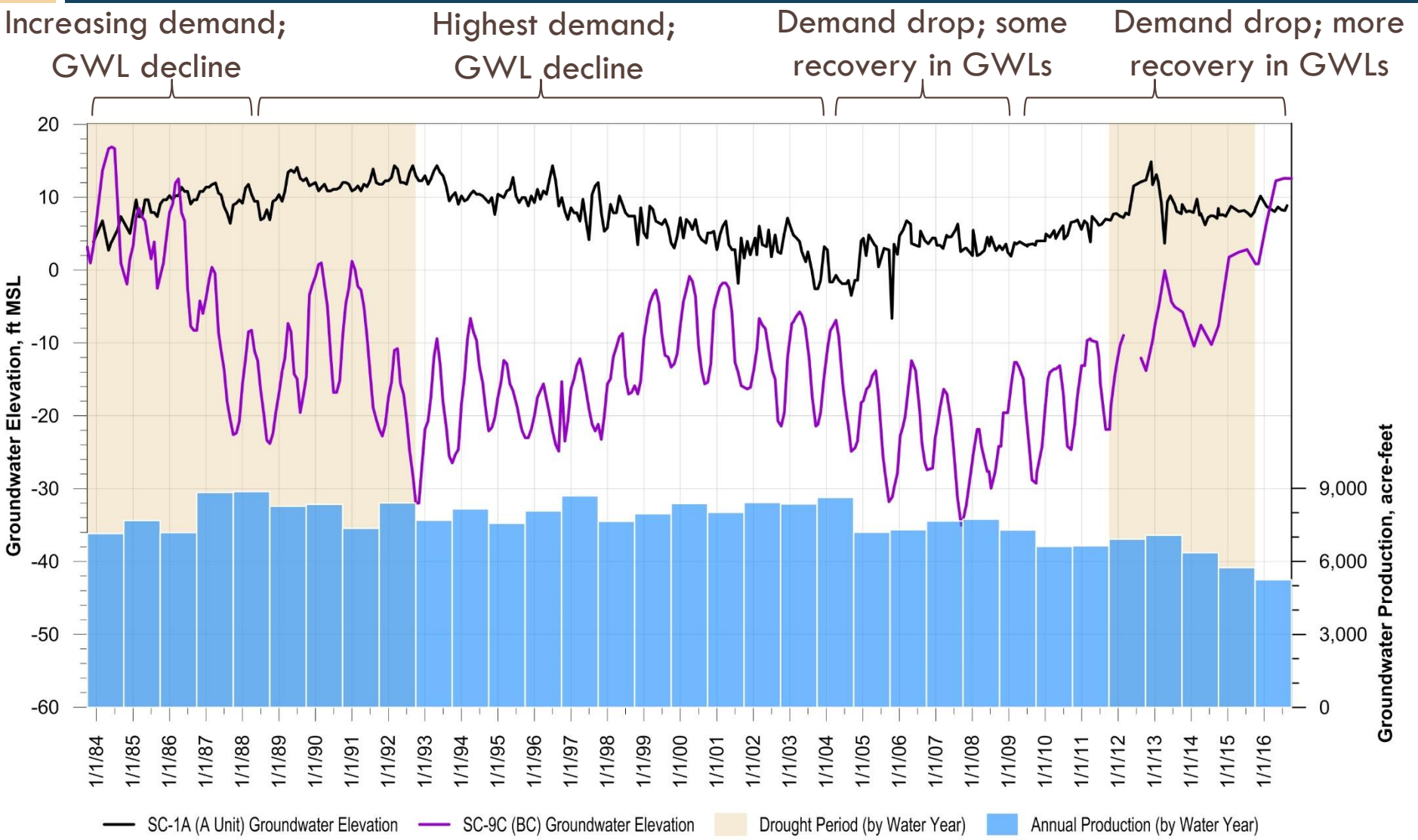
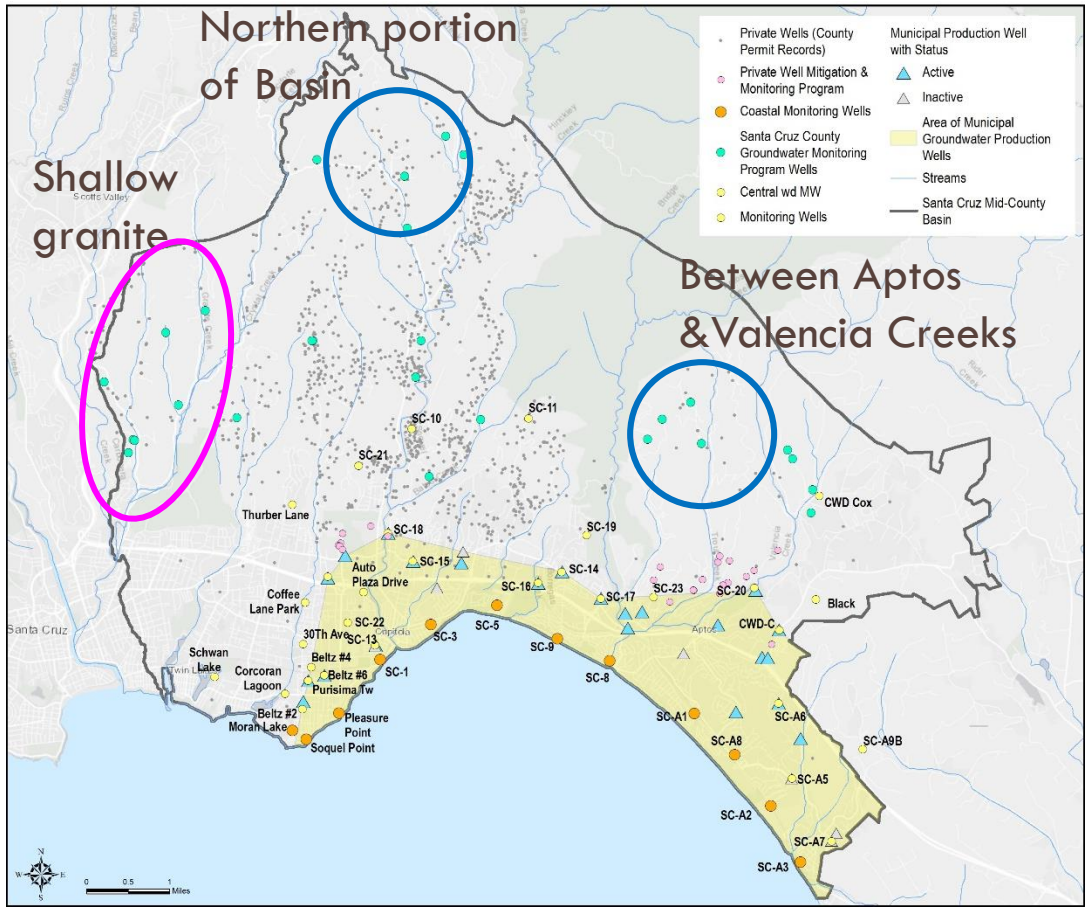
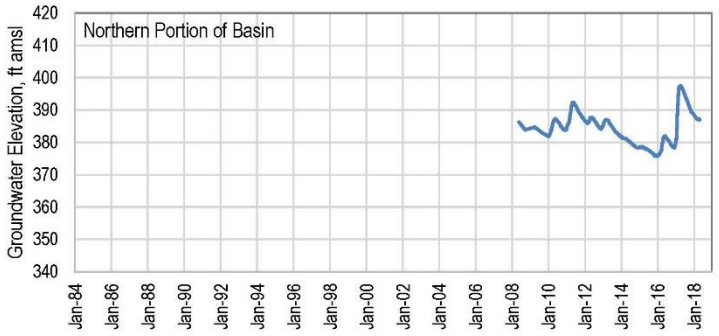
# Chronic Lowering of Groundwater Levels

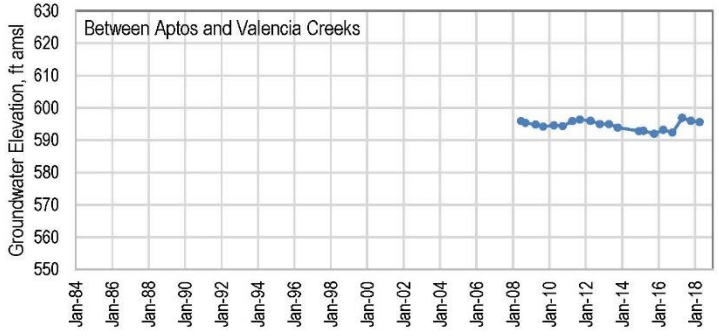
# Historical Changes in Coastal Groundwater Elevations

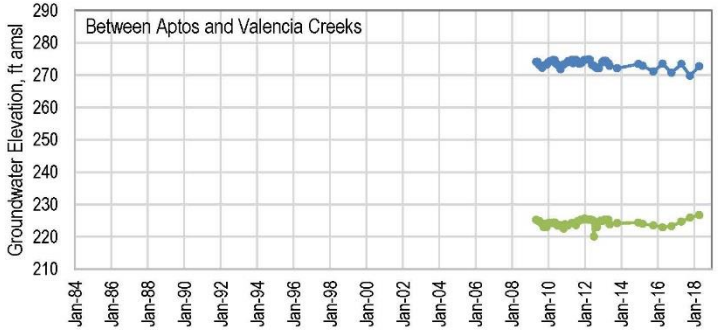


# Historical Changes in Private Well Groundwater Elevations

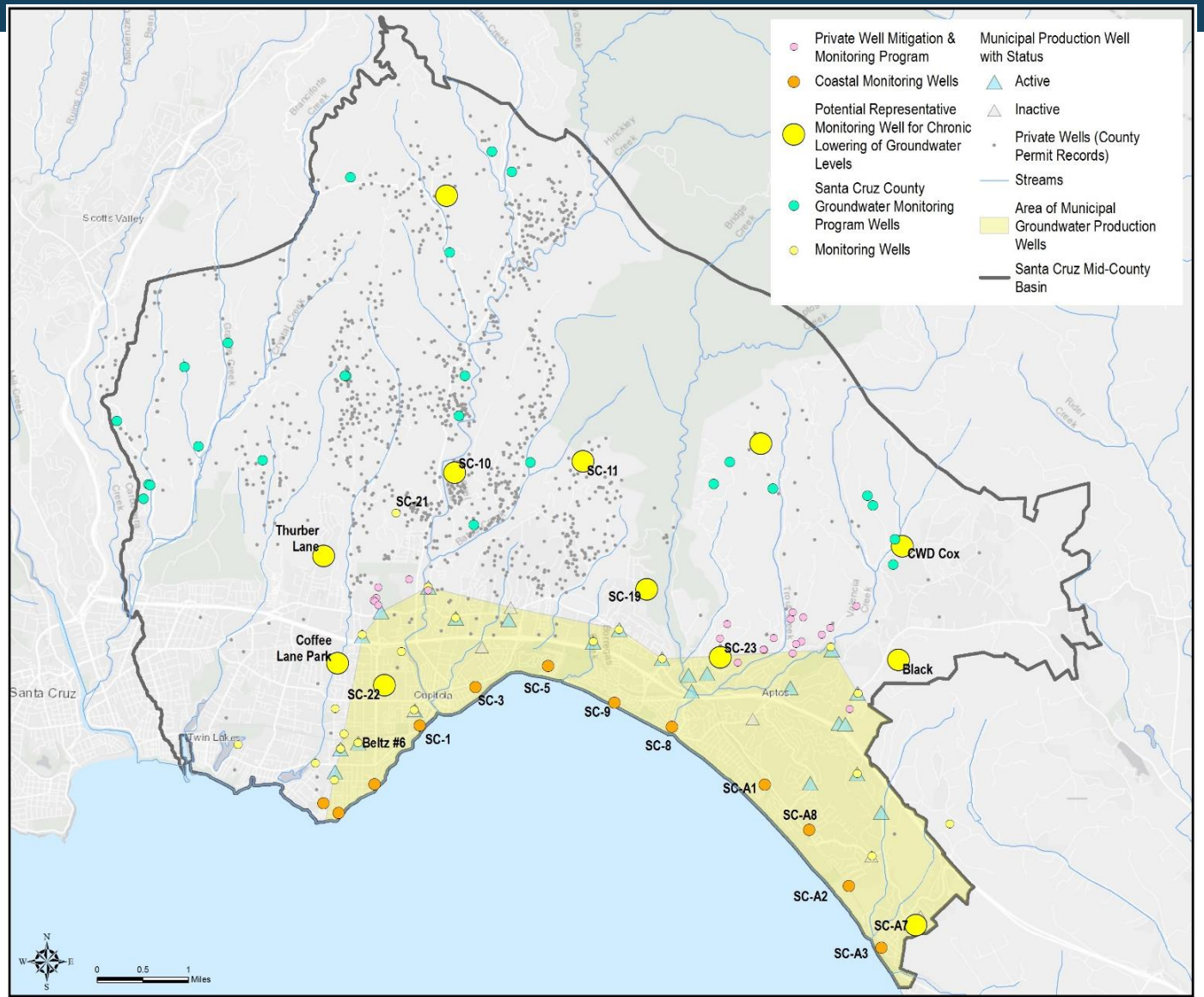


# Potential Representative Monitoring Wells



# Significant & Unreasonable Conditions

Chronic lowering of groundwater levels has potential to impact uses and users by:

- Inducing seawater intrusion.
- Reducing stream baseflow that supports groundwater dependent ecosystems & aquatic species by lowering groundwater levels beneath the streambed, or by reducing the hydraulic gradient and the rate of groundwater discharge to the stream.
- **Reducing yield of wells by causing groundwater levels to drop below well screens or the bottom of wells. Users of groundwater in the basin are agriculture, domestic, and municipal, with few industrial users.**

# Significant & Unreasonable Chronic Lowering of Groundwater Levels

**Key Variables:** Lowering of groundwater levels that cause <percentage> or more of <well use type> groundwater pumping well's to <well condition>

**<percentage>:** this variable is dependent on <well condition>.

Fall below top of screen - could be a higher number of wells that can have levels fall below top of screen (e.g., 25% of wells)

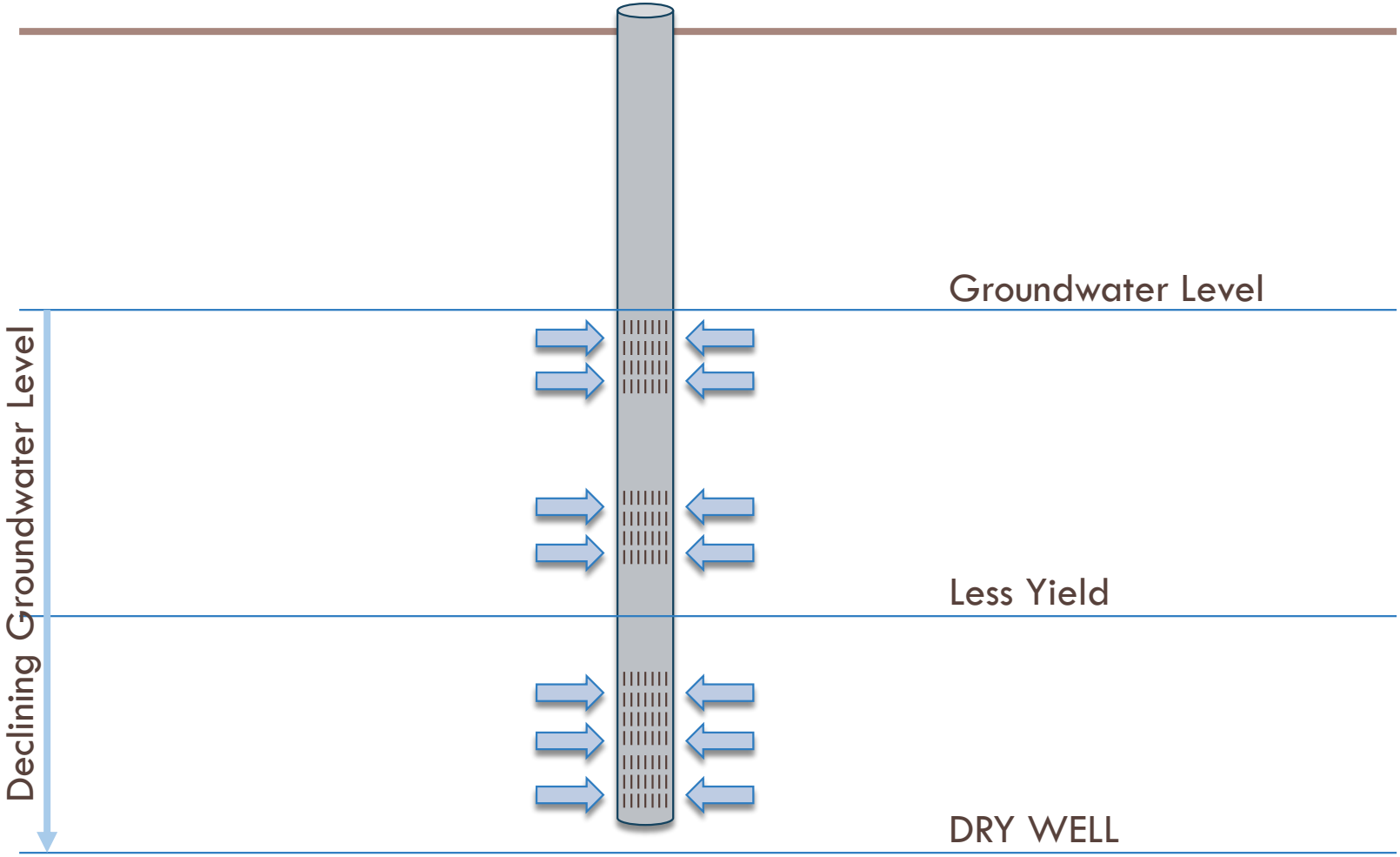
Certain distance from bottom of well – e.g., 20 feet allows for some production capacity (e.g., 5% of wells, excludes very shallow wells)

Go dry – fewer wells should be allowed to go dry (e.g., 1% of wells)

**<well use type>:** Should there be a distinction between user types? (agricultural, domestic, industrial, municipal).

**<well condition>:** go dry (below bottom of well), a certain distance from the bottom of the well, or fall below top screen?

# Impacts of Lowered Groundwater Levels on Wells



# Significant & Unreasonable

## Chronic lowering of groundwater we want to avoid

Technical staff proposal:

Lowering of groundwater levels that cause 5% or more of all groundwater pumping well's to fall below 20 feet from the bottom of wells

**RATIONALE:** having groundwater levels fall below 20 feet from the bottom of a well is clearly significant and unreasonable. Groundwater levels falling below this depth will certainly reduce the wells' ability to pump groundwater. Groundwater levels falling below the top of well screens is not significant and unreasonable as it occurs commonly. A low percentage such as 5% covers the population of wells that are very shallow (< 100 feet).

# Discussion

# and

# Selection of Significant & Unreasonable Chronic Lowering of Groundwater Level Conditions

# Significant & Unreasonable Chronic Lowering of Groundwater Levels

**Key Variables:** Lowering of groundwater levels that cause <percentage> or more of <well use type> groundwater pumping well's to <well condition>

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**<well condition>:** go dry (below bottom of well), a certain distance from the bottom of the well, or fall below top screen?

# Undesirable Results for Chronic Lowering of Groundwater Elevations

## What set of conditions are significant & unreasonable

**Key Variables:** The <statistic> Representative Monitoring Well groundwater elevation over <time period> falls below the <Minimum Threshold>

# What happens when you change <variables>?

- <statistic>
  - **Minimum** elevation measured. This absolute number makes it more difficult to stay above the Minimum Threshold and the more difficult it will be to avoid Undesirable Results (less flexibility)
  - **75th Percentile** elevation measured. This statistic requires three-quarters of the groundwater elevations to be above the Minimum Threshold, making it easier to be above the Minimum Threshold than using the minimum but more stringent than using average groundwater elevations
  - **Average** elevation measured. This statistic allows for some groundwater levels to go below the Minimum Threshold, making it easier to exceed the threshold (more flexibility)

# What happens when you change <variables>?

- <time period>
  - Monthly ⇨ data logger needed. More data to average
  - Quarterly ⇨ data needs to be collected at least monthly
  - One year ⇨ data needs to be collected at least quarterly

# What happens when you change <variables>?

- <Minimum Threshold>
  - Numeric value set for every Representative Monitoring Well by technical staff
  - The aim is to set the Minimum Threshold at a level that reflects what is considered a chronically lowered groundwater elevation. Levels below this level will cause impacts to a significant number of wells
  - The lower the groundwater elevation set for Minimum Thresholds, the easier it will be to stay above the threshold, but there is a chance other wells may be impacted (more flexibility)
  - The higher the groundwater elevation set for Minimum Thresholds, the more difficult it will be to stay above it and ultimately may cause undesirable results (less flexibility)

# Undesirable Results
# Technical Staff Proposal

- The average Representative Monitoring Well groundwater elevation over one month falls below the <Minimum Threshold>

**Rationale:** monthly average will identify seasonal low levels

More flexibility in avoiding Undesirable Results: average elevation over one year

Less flexibility in avoiding Undesirable Results: 75th percentile elevation over one month

# Discussion
# and
# Selection of Undesirable Results
# for
# Chronic Lowering of
# Groundwater Levels

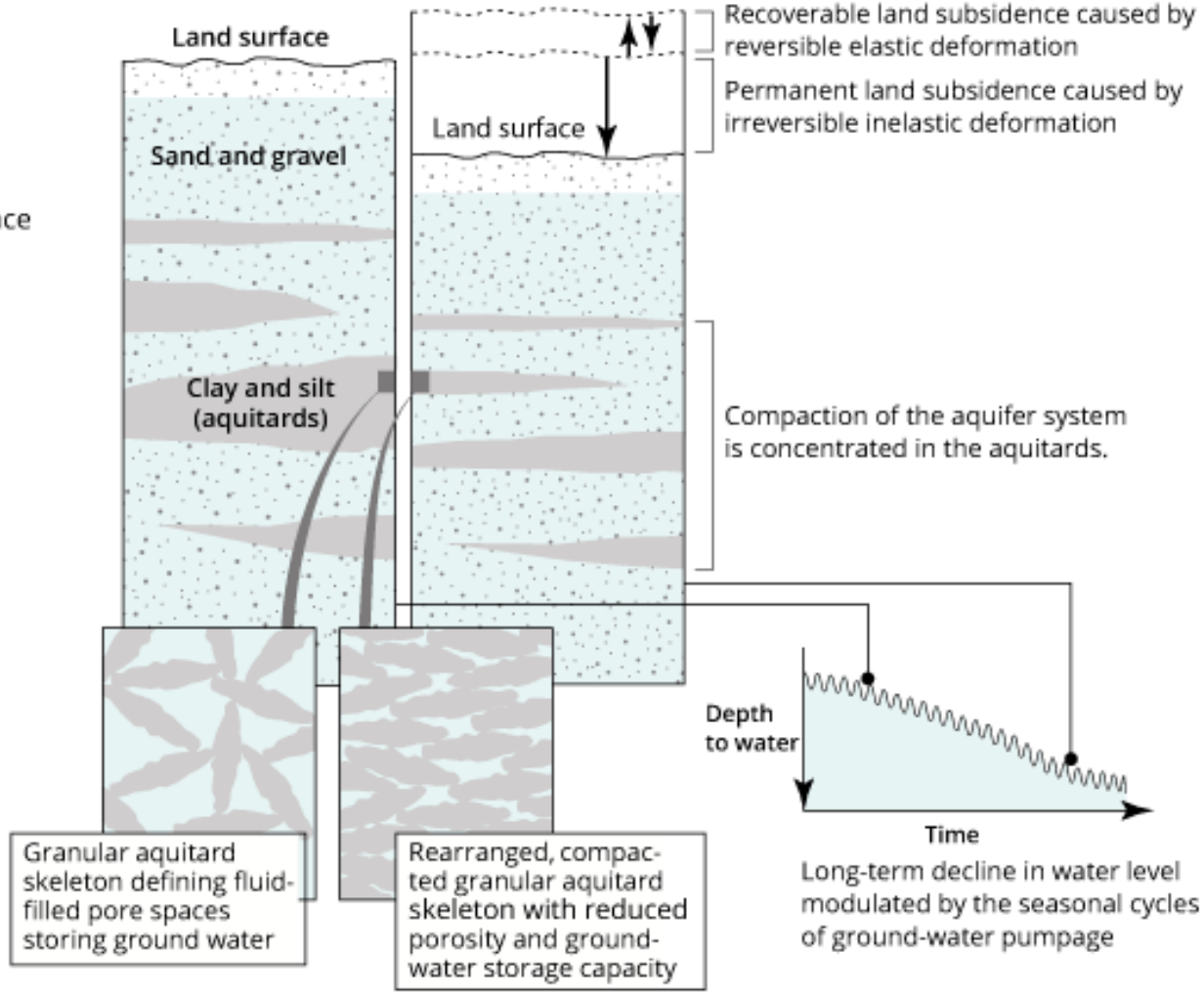
# Land Subsidence

# What is Land Subsidence

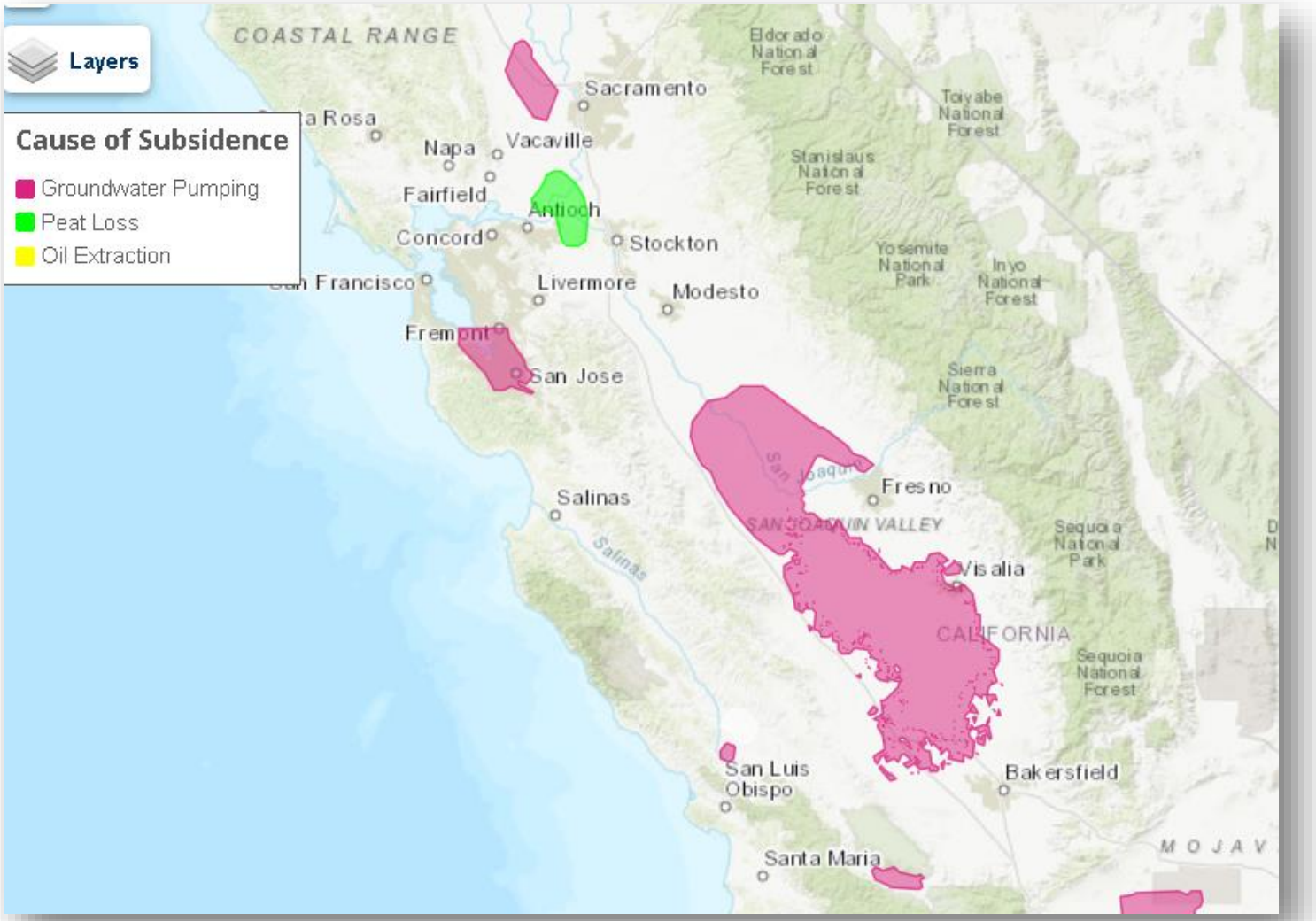
- Land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials.
- The principal causes are:
  - Aquifer-system compaction,
  - Drainage and decomposition of organic soils
  - Underground mining, oil and gas extraction, hydrocompaction, natural compaction, sinkholes, and thawing permafrost

# Aquifer-System Compaction

When long-term pumping lowers groundwater levels and raises stresses on the aquitards beyond the preconsolidation-stress thresholds, the aquitards compact adn the land surface subsides permanently.

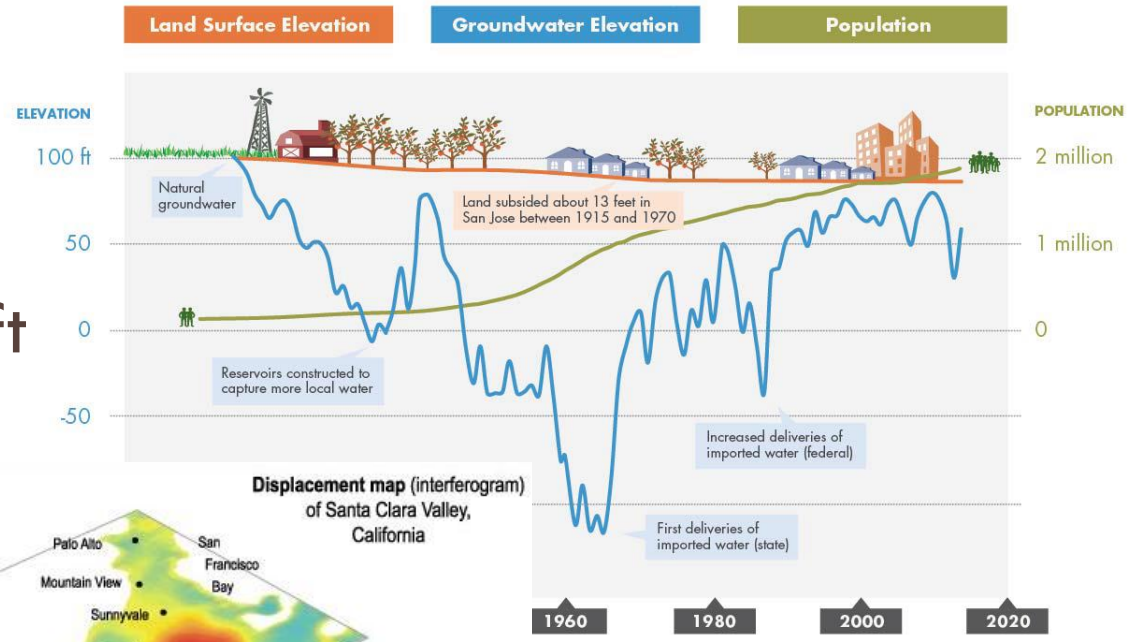


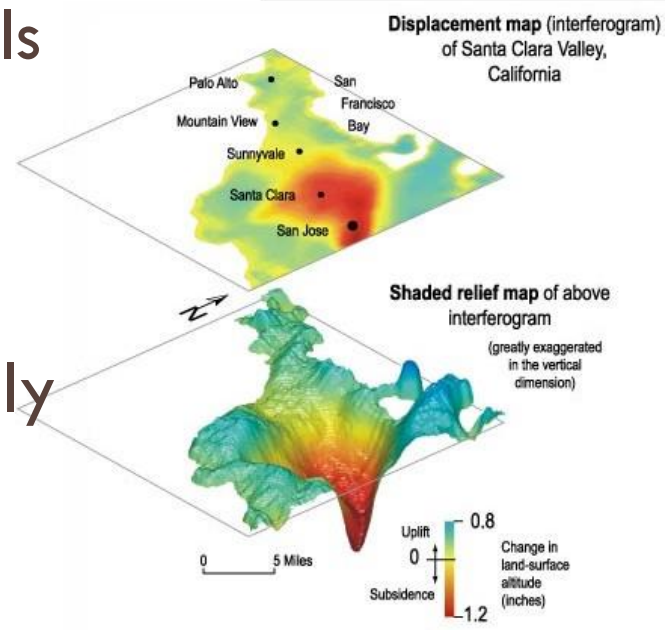
# Nearby Documented Land Subsidence



# Santa Clara Valley Land Subsidence

- Started in 1933
- Up to 8 feet of subsidence
- After 1992 some uplift occurred as groundwater levels recovered
- Currently, elastic subsidence that recovers seasonally



# San Joaquin Valley Land Subsidence


Impacted area = 5,200 $mi^2$

# Monitoring Land Subsidence

- Level surveying tied to known stable benchmarks;
- Borehole extensometers;
- Continuous GPS tracking; or
- Satellite derived Interferometric Synthetic Aperture Radar (InSAR) data

NONE OF THESE ARE CURRENTLY DONE IN THE BASIN

# Effects of Land Subsidence

## Manmade Infrastructure

- Changes to gradients of water conveyance structures causing reductions in designed flow capacity
- Damage to roads & railways
- Damage to bridges & buildings
- Damage to pipelines & wells

NONE OF THESE HAVE BEEN REPORTED IN THE BASIN

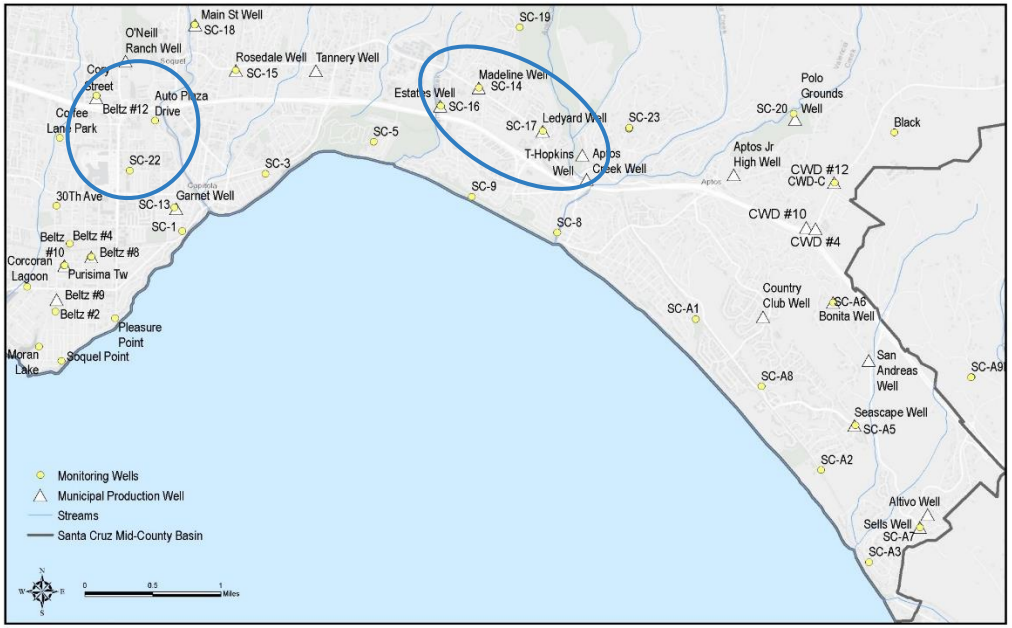
## Natural Systems

- Permanently decreased capacity to store groundwater
- Topography changes, causing low areas, such as wetlands, to change size and shape, migrate to lower elevations, or disappear
- Rivers changing course or erosion/deposition patterns changing to reach a new equilibrium

# Has any Subsidence Occurred during Historic Low Groundwater Levels?

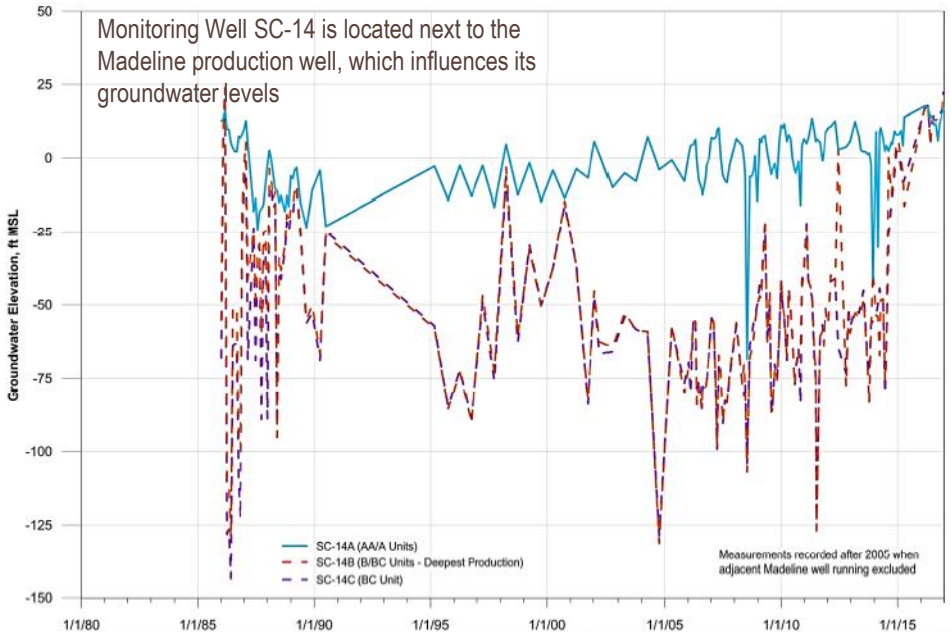
| Unit | Maximum Decline, feet | Year of Historic Low |
|---|---|---|
| Aromas/Purisima F | 5 (SC-A2A) | 2000 |
| Purisima DEF | 100 (SC-17C) | 1988 |
| Purisima BC | 140 (SC-14B) | 1986 |
| Purisima A | 80 (SC-16A) | 1988 |
| Purisima AA/Tu | 35 (SC-22AAA) | 2017 |

Areas of historic low groundwater levels > 50 feet



# Historic Low Groundwater Levels

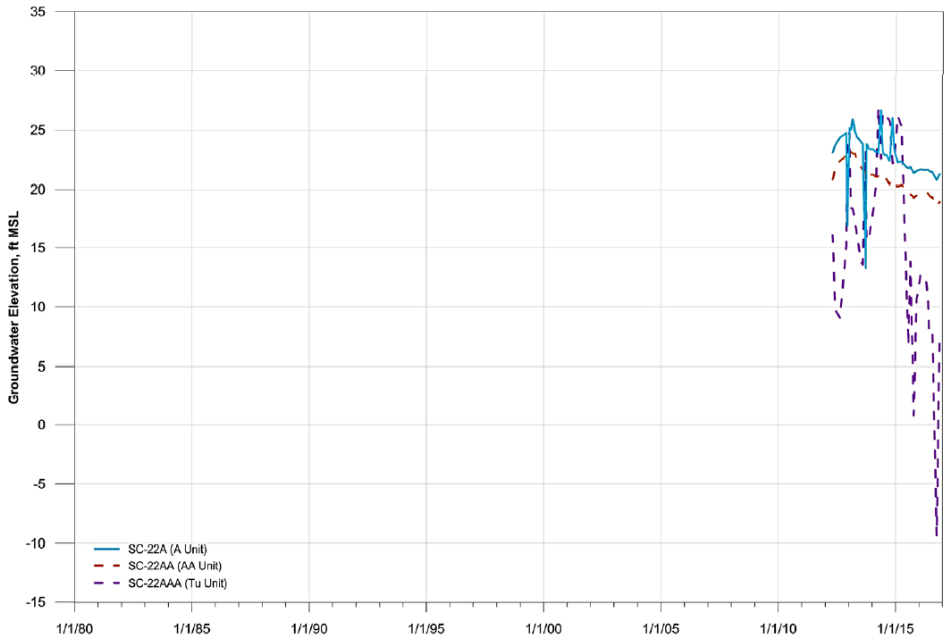
## Purisima Aquifer




More historical declines in groundwater levels

NO SUBSIDENCE EFFECTS OBSERVED

## Tu Aquifer




More recent declines in groundwater levels

TOO SOON TO OBSERVE SUBSIDENCE EFFECTS

# Groundwater Levels as a Proxy for Land Subsidence Minimum Thresholds

## DWR Guidance

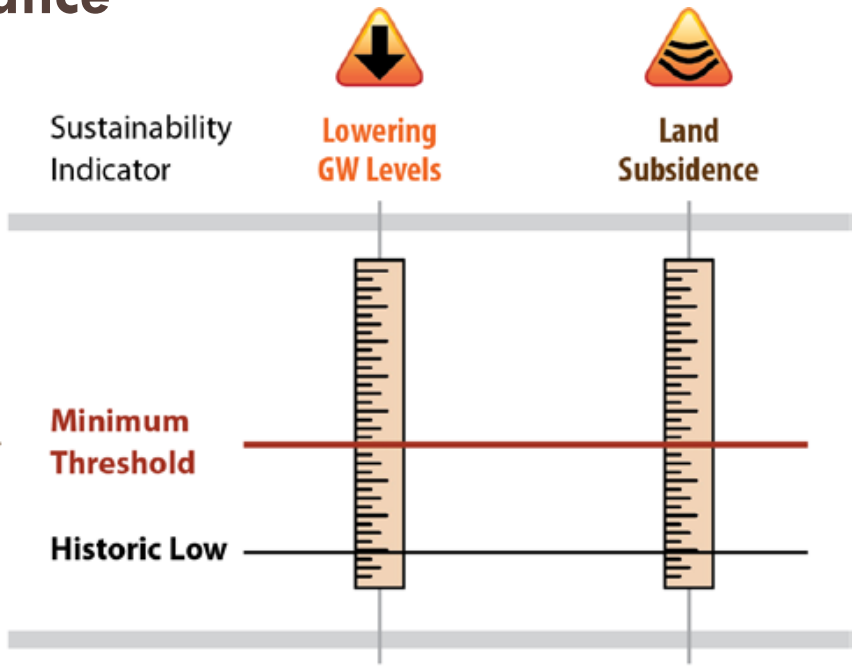
**EXAMPLE 1**

*Groundwater elevation as a proxy for land subsidence*


○ = Groundwater Level Representative Monitoring Site

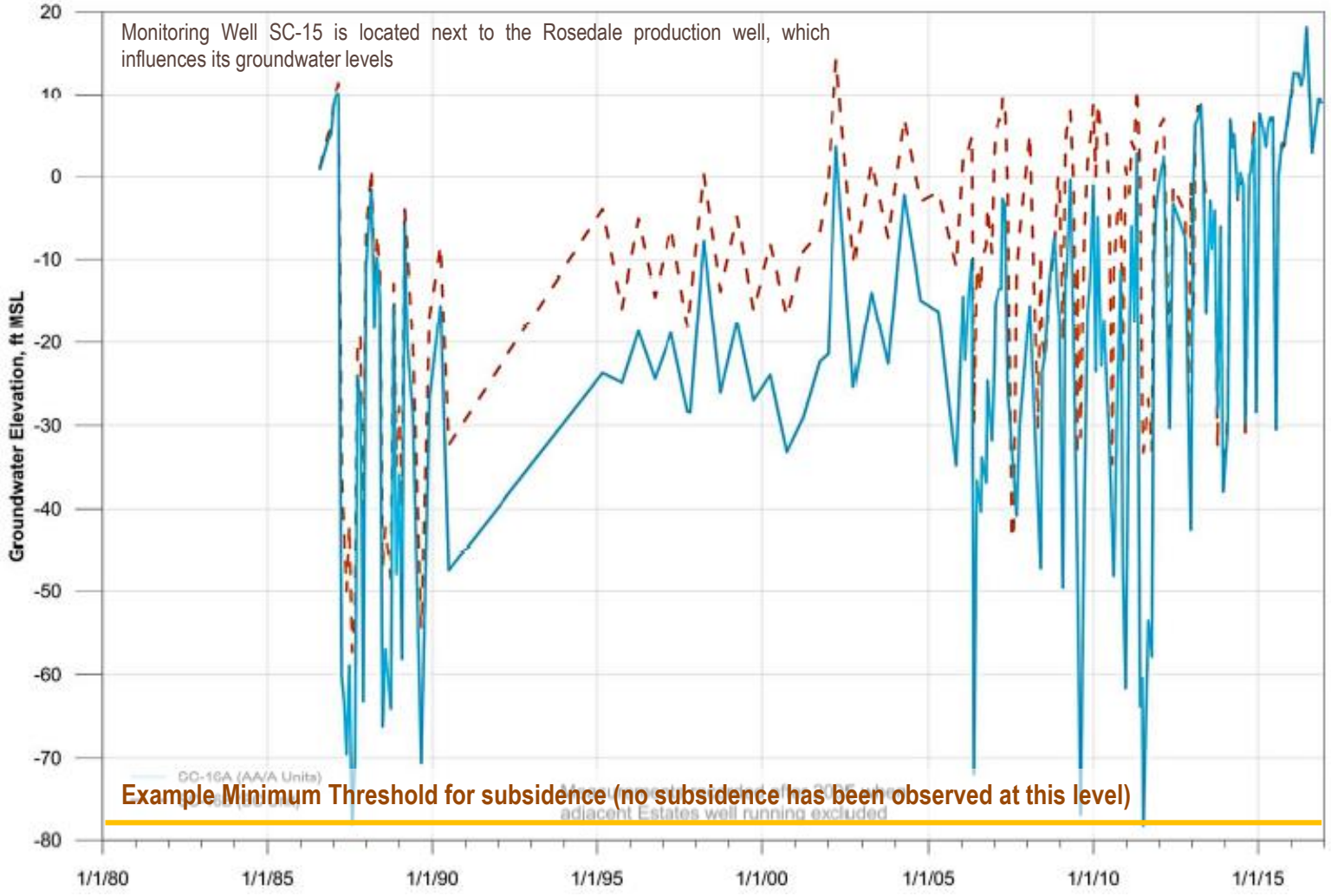
○ = Land Subsidence Representative Monitoring Site

MA = Management Area




| Metric | • **Groundwater Elevation** *(metric defined in GSP Regulations)* | • **Groundwater Elevation as a proxy** *(with demonstration of significant correlation between groundwater elevation and land subsidence)* |
|---|---|---|

# Groundwater Levels as a Proxy for Land Subsidence Minimum Thresholds



# Significant & Unreasonable

## Subsidence conditions we want to avoid having

### Technical staff's proposal

- Any land subsidence occurring

**Rationale:** Based on historical lack of subsidence

### Allow Some Subsidence

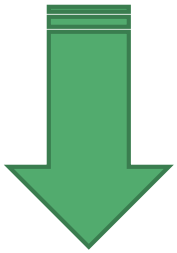
- Land subsidence occurring in developed areas only (ok if it occurs in undeveloped areas)

Note: Undeveloped areas are not likely to have changes in groundwater levels which could potentially cause subsidence

# Discussion
# and
# Selection of Significant & Unreasonable Land Subsidence Conditions

# Undesirable Results
# Proposed Metrics for Different Aquifers

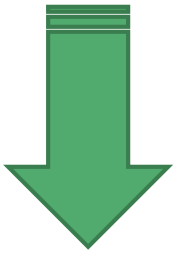
Aromas
Purisima A, BC, DEF



Groundwater Levels

Use groundwater levels as a proxy for Subsidence

Purisima AA/Tu



Groundwater Surface Elevation

Use rate of change of land surface (inches/year)

# Undesirable Results – Land Subsidence

## What set of conditions are significant & unreasonable?

**Aromas, and Purisima A, BC, DEF Units**

Use historic low groundwater levels at Representative Monitoring Wells in areas of greatest groundwater level fluctuations

**Key Variables:** <Number of wells > Representative Monitoring Wells in the Aromas and Purisima A, BC, and DEF units with <statistic> <time period> groundwater elevations below their <Minimum Threshold> in <extent>

# What happens when you change <variables>?

- <Number of wells>
  - More wells ⇨ easier to avoid Undesirable Results but higher risk of potential subsidence
  - Less wells ⇨ less flexibility in avoiding Undesirable Results but lower risk of potential subsidence
- <statistic>
  - Average – groundwater levels need to be below the <Minimum Threshold> for extended periods of time for there to be a risk of potential subsidence
  - Certain percentile – the more often a groundwater level is below the <Minimum Threshold> the greater the risk of potential subsidence

# What happens when you change <variables>?

- <time period>
  - Quarterly
  - Annual
- <Minimum Threshold>
  - Historic low
  - An elevation either higher or lower than the historic low
- <Extent>
  - This represents the area of subsidence concern

# Undesirable Results in Aromas, Purisima A, BC, and DEF Units

Technical Staff's Proposal:

- Any Representative Monitoring Well in the Aromas and Purisima A, BC, and DEF units with average annual groundwater elevations below their historic lows in any part of the basin

**Rationale:** no subsidence occurred at historical lows. Staying above those lows will ensure land subsidence does not happen in the future

# Discussion of

# Use of Groundwater Level Proxy for Subsidence

## Selection of Undesirable Results for Land Subsidence in Aromas, Purisima A, BC and DEF units

# Undesirable Results – Land Subsidence

## What set of conditions are significant & unreasonable?

**Purisima AA/Tu Units**

Using Land Surface Elevation as the metric

**Key Variables:** <Rate of subsidence, inches per year> occurring in <extent>

# What happens when you change <variables>?

- <Rate of subsidence>
  - Higher rate ⇨ easier to avoid Undesirable Results but higher risk of subsidence
  - Lower rate ⇨ less flexibility in avoiding Undesirable Results but lower risk of subsidence

- <Extent>
  - This should represent the area of subsidence concern

# Undesirable Results in Purisima AA/Tu

## Using Land Surface Elevation as the metric

Technical Staff's Proposal:

- Any land subsidence occurring in the area where the Purisima AA/Tu unit is being pumped or injected into

More flexibility:

- Land subsidence exceeding threshold rates that are higher in undeveloped areas than in developed areas

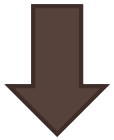
# Discussion
# and
# Selection of Undesirable Results
# for Land Subsidence in
# Purisima AA/Tu unit
# Subsidence Rate Metric

# Proposed Draft

## Seawater Intrusion Minimum Thresholds

# Proposed Draft Document format

- Recap the initial staff proposal
- Provide a summary of Committee input
- Provide revised technical recommendations to original staff proposals, with a rationale for each specific recommendation



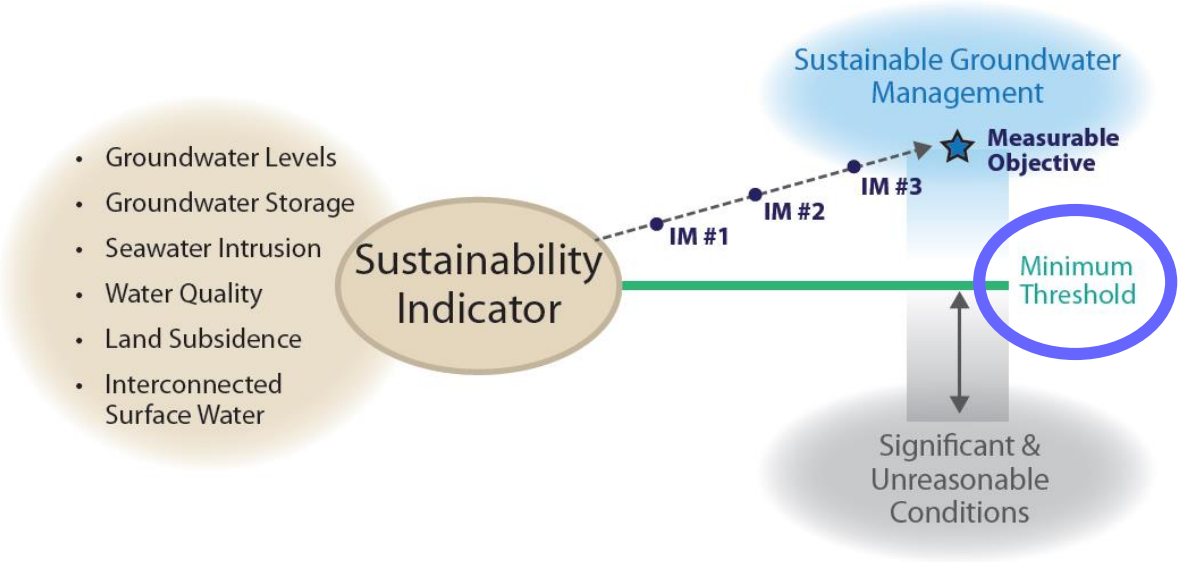
- Minimum Thresholds

# Preliminary Development of Sustainable Management Criteria for GSP

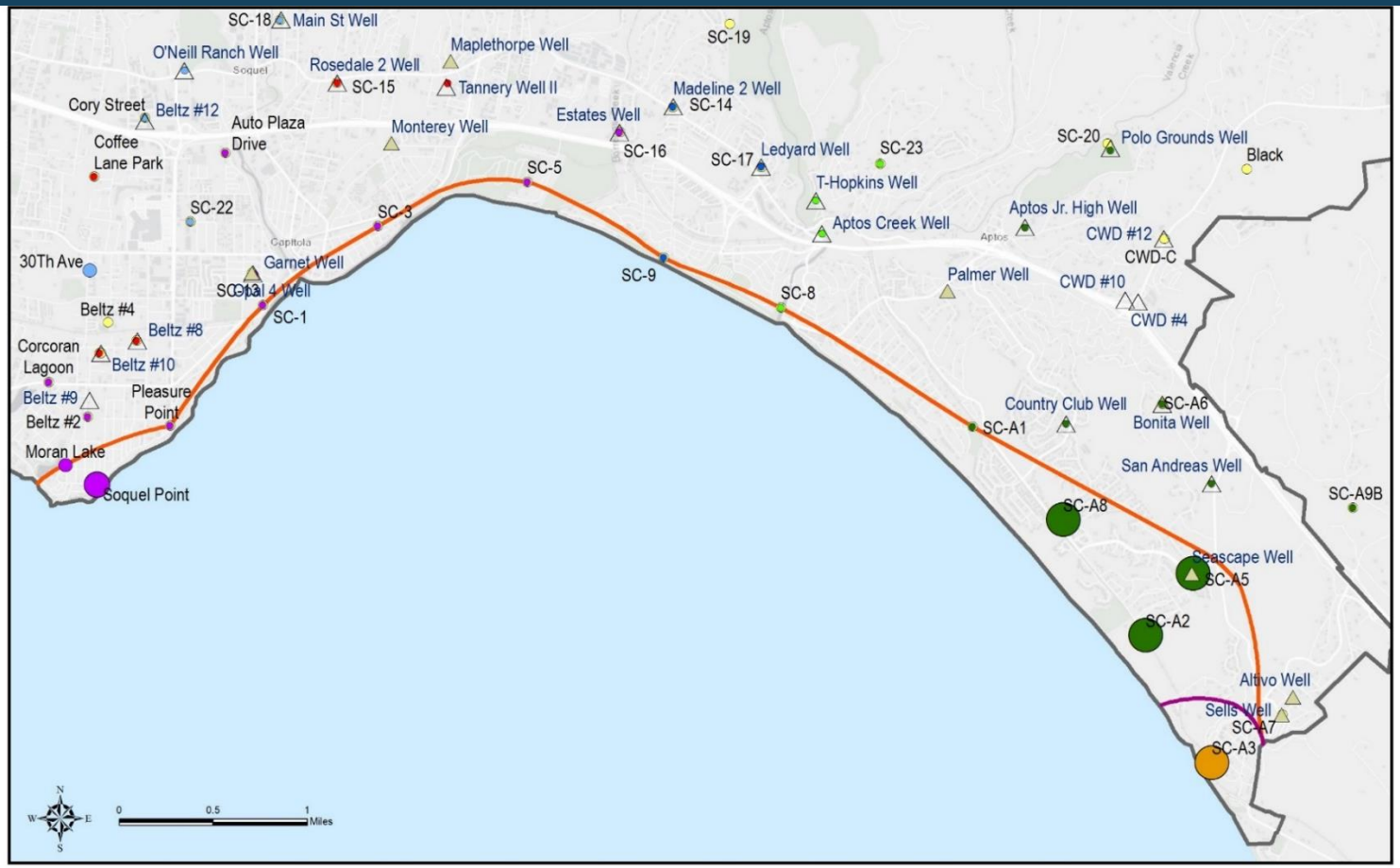
- Statement of Significant and Unreasonable
- Undesirable Results

metrics

- Minimum Thresholds



# Chloride Isocontours



# Protective Elevations as a Proxy for Seawater Intrusion

| Coastal Monitoring Well | Protective Elevation (feet mean seal level) |
|---|---|
| Moran Lake Medium | 5 |
| Soquel Point Medium | 6 |
| Pleasure Point Medium | 6.1 |
| SC-1A | 6.2 |
| SC-3A | 10 |
| SC-5A | 13 |
| SC-9C | 10 |
| SC-8D | 10 |
| SC-A1B | 3 |
| SC-A8A | 6 |
| SC-A2A | 3 |
| SC-A3A | 3 |