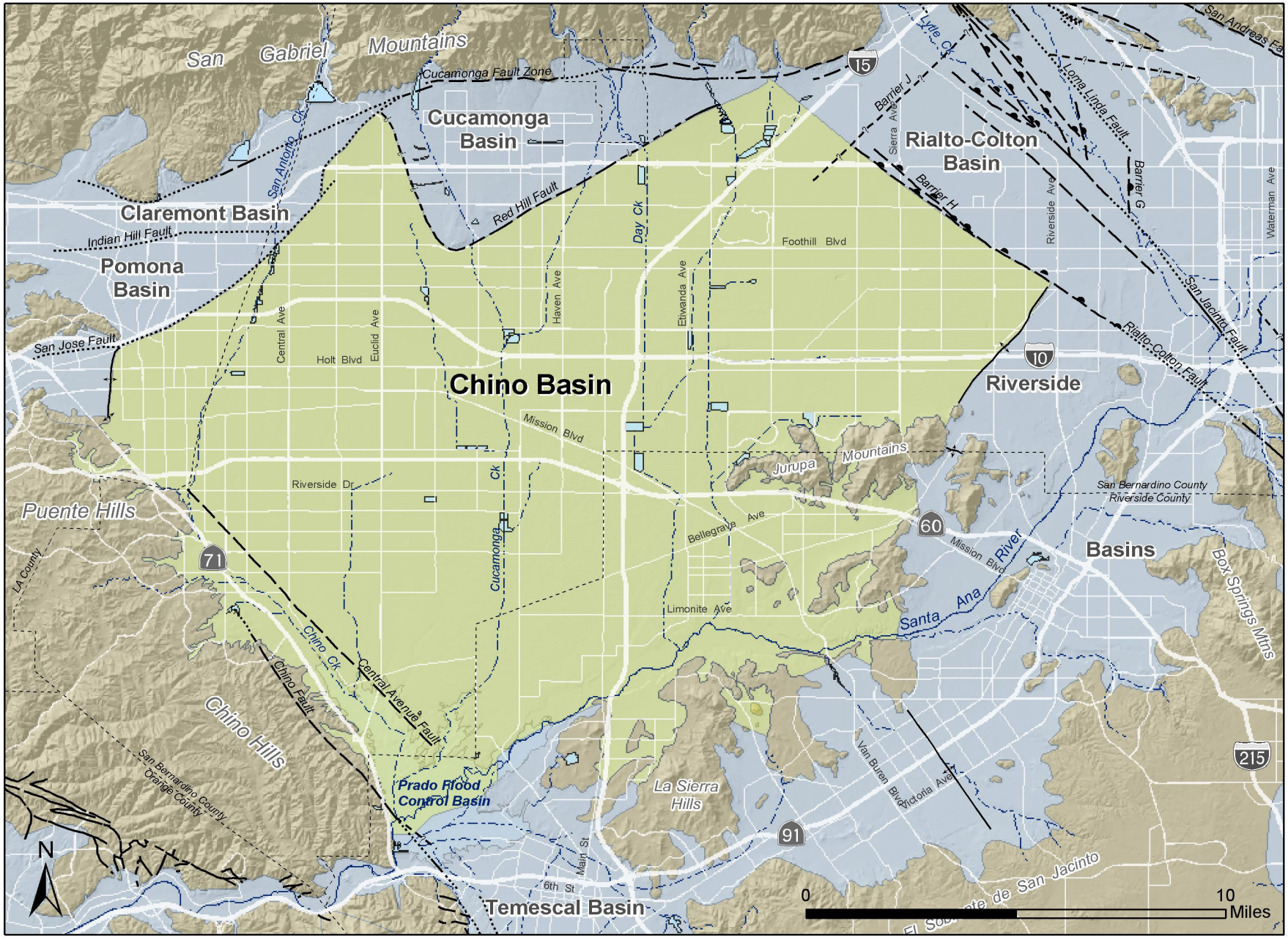
Hydrogeology Fundamentals of the Chino Basin

- General Setting
- Geology
- Recharge and Discharge
- Groundwater Quality
- Groundwater Desalting
- Groundwater Levels and Flow
- Land Subsidence



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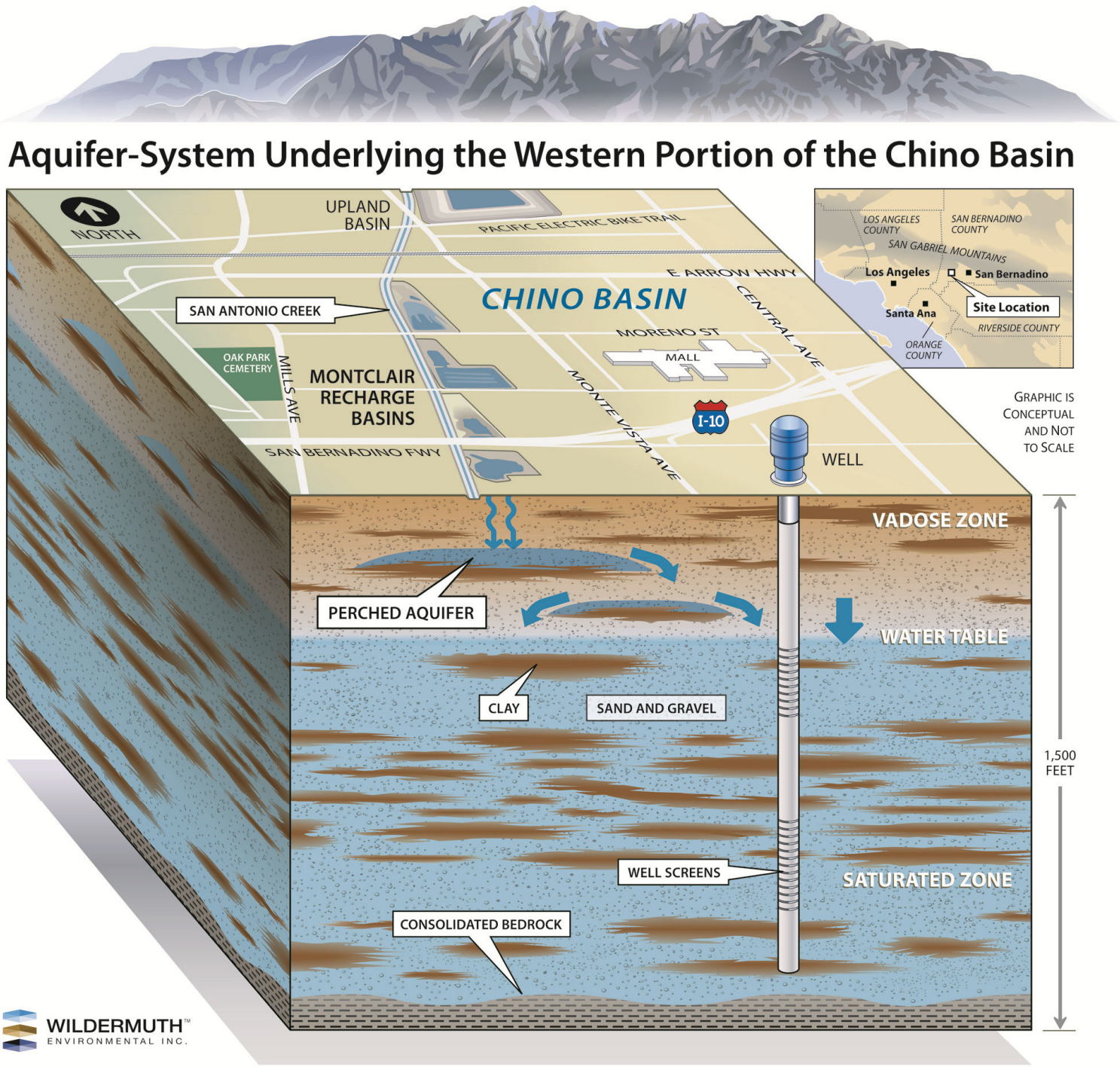
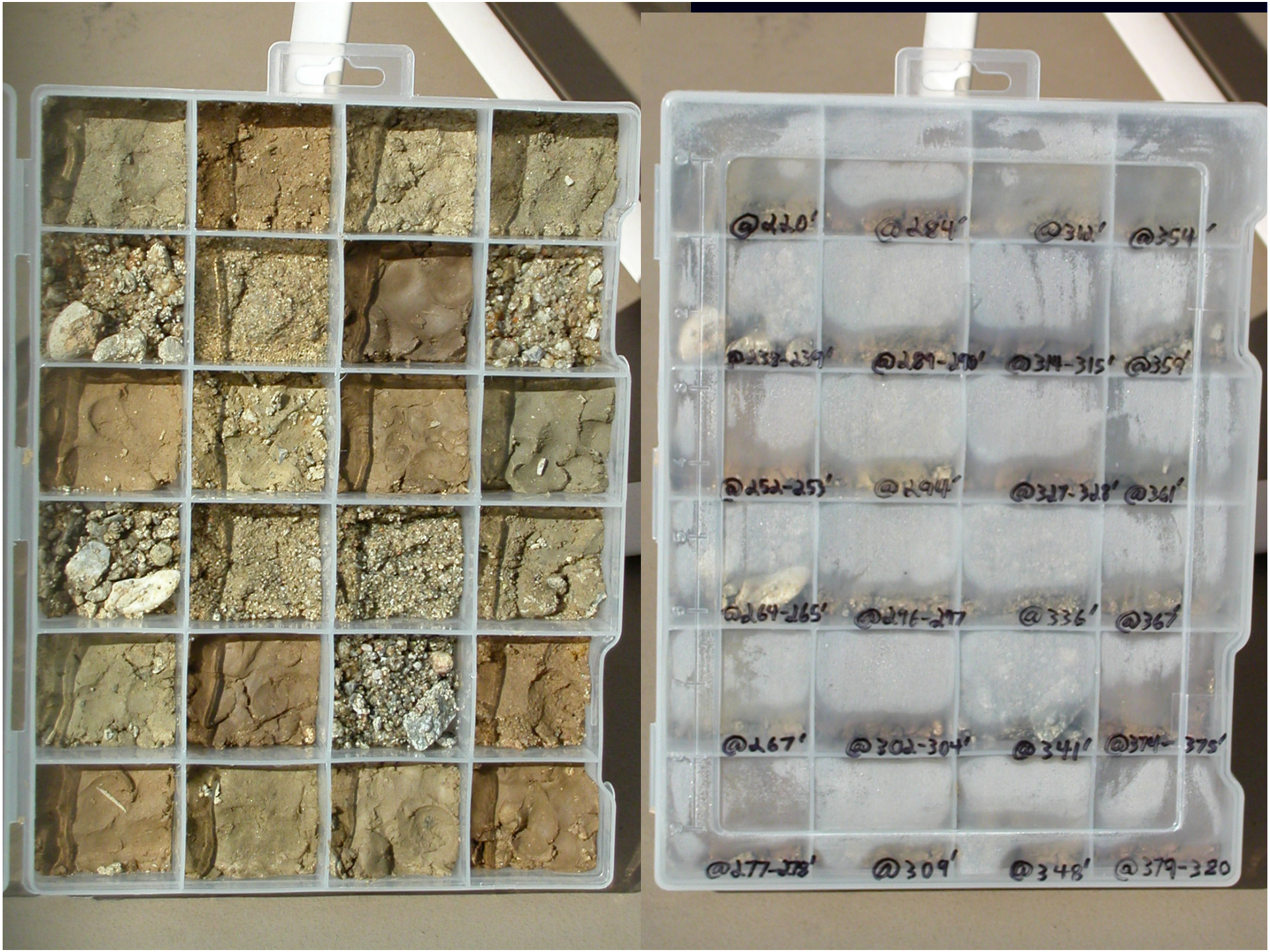
Chino Basin Stats

- Area is about 220 square miles
- Contains about 6.0 million acre-ft
- Pumpers
  - 24 appropriators (cities, districts, etc)
  - ~300 overliers (mostly agricultural)
- Safe yield is 140,000 acre-ft/yr

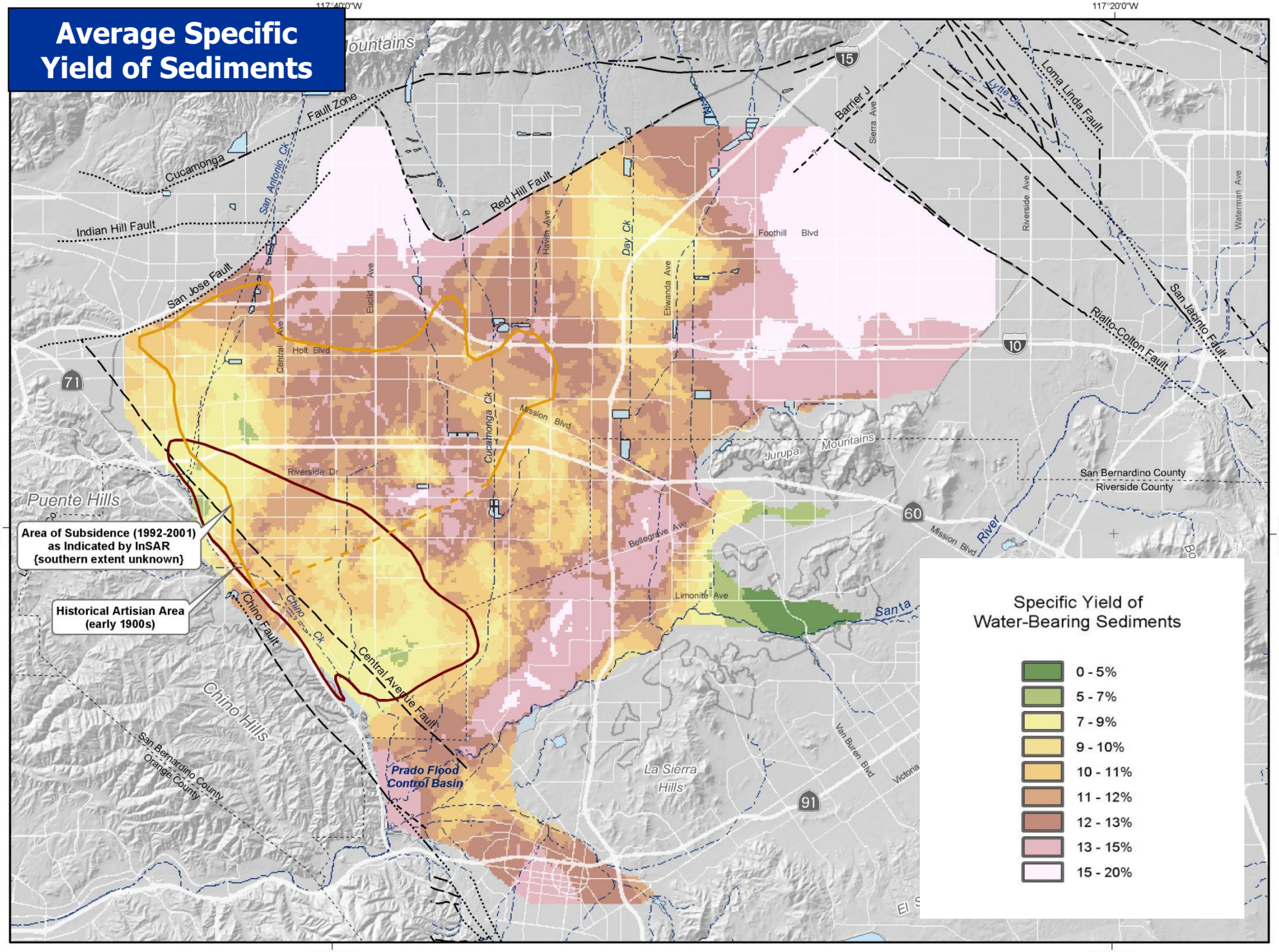
Aquifer-System Underlying the Western Portion of the Chino Basin



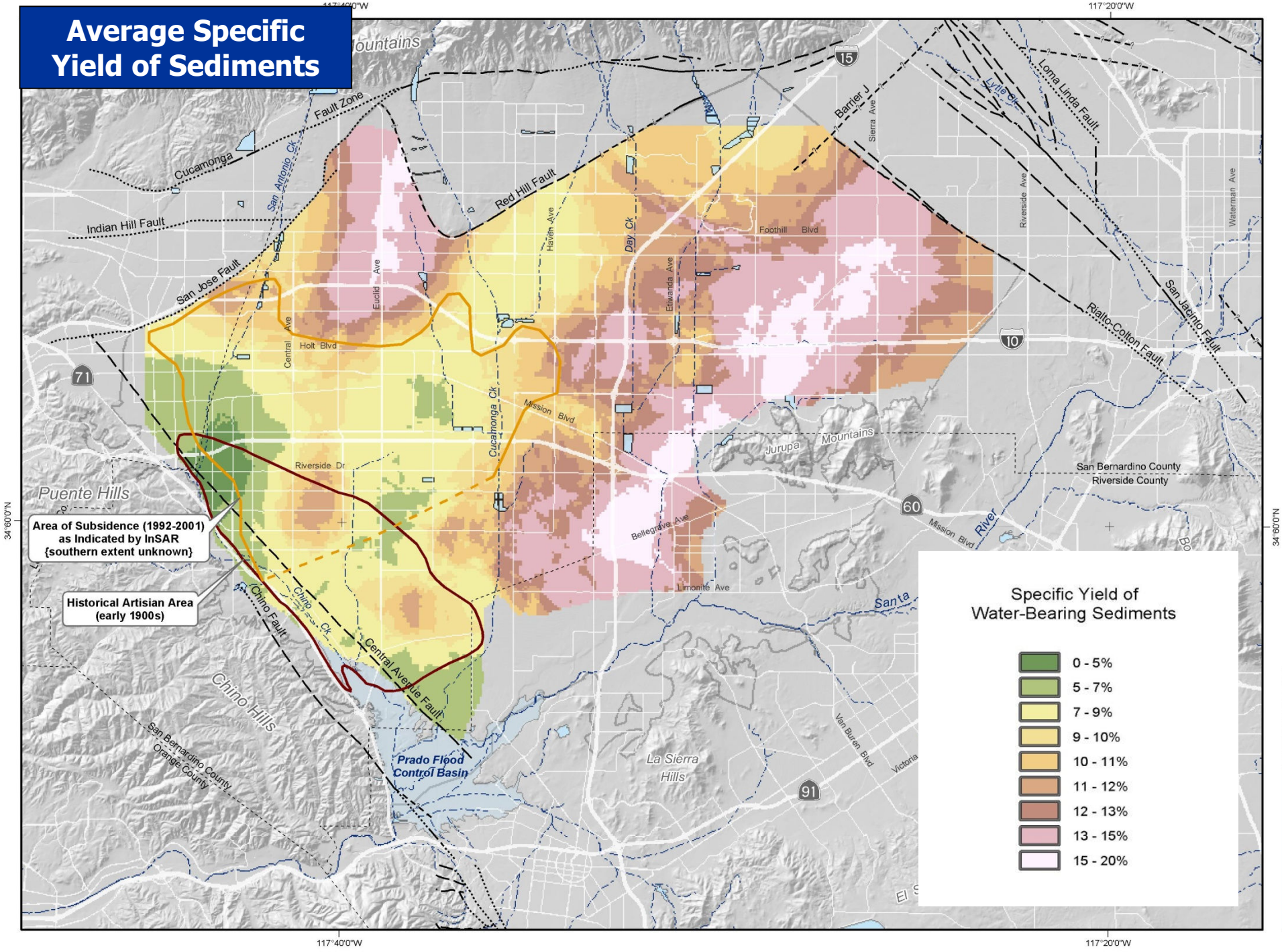
WILDERMUTH™
ENVIRONMENTAL INC.


@220'
@284'
@340'
@354'
@238-239'
@289-290'
@314-315'
@359'
@252-253'
@294'
@327-328'
@361'
@264-265'
@296-297
@336'
@367'
@267'
@302-304'
@341'
@374-375'
@277-278'
@309'
@348'
@379-380

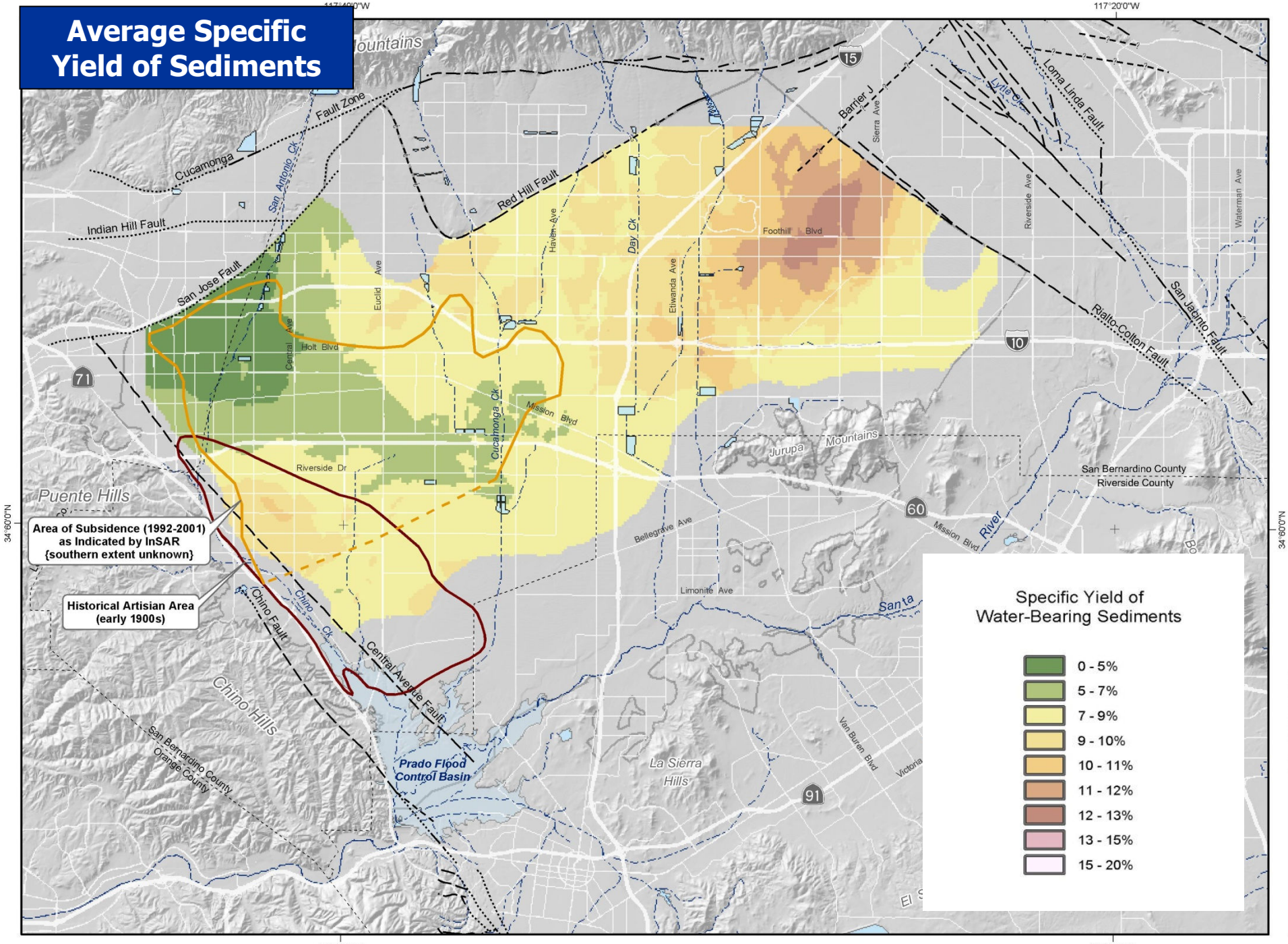
Average Specific Yield of Sediments



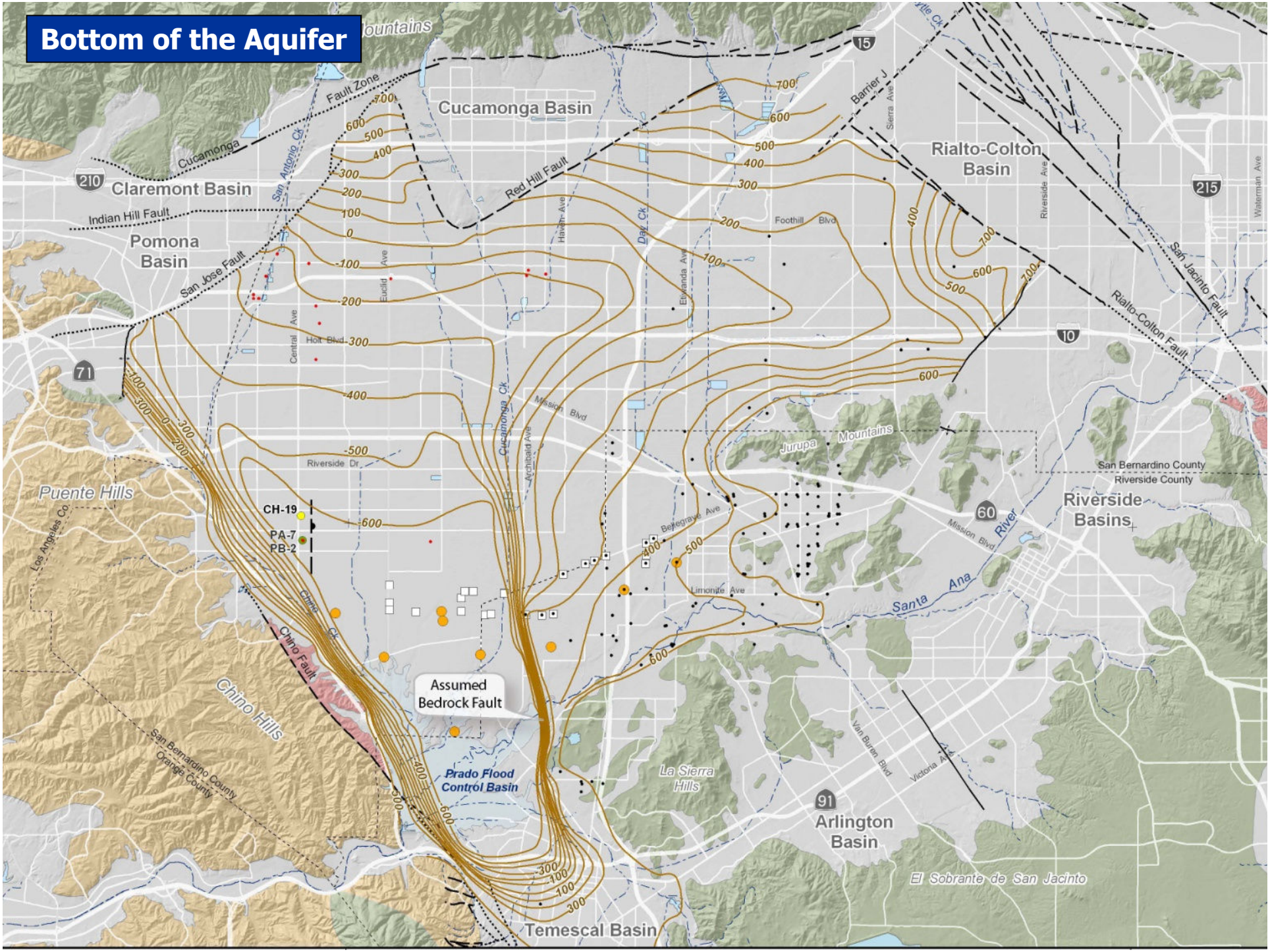
Average Specific Yield of Sediments



Average Specific Yield of Sediments

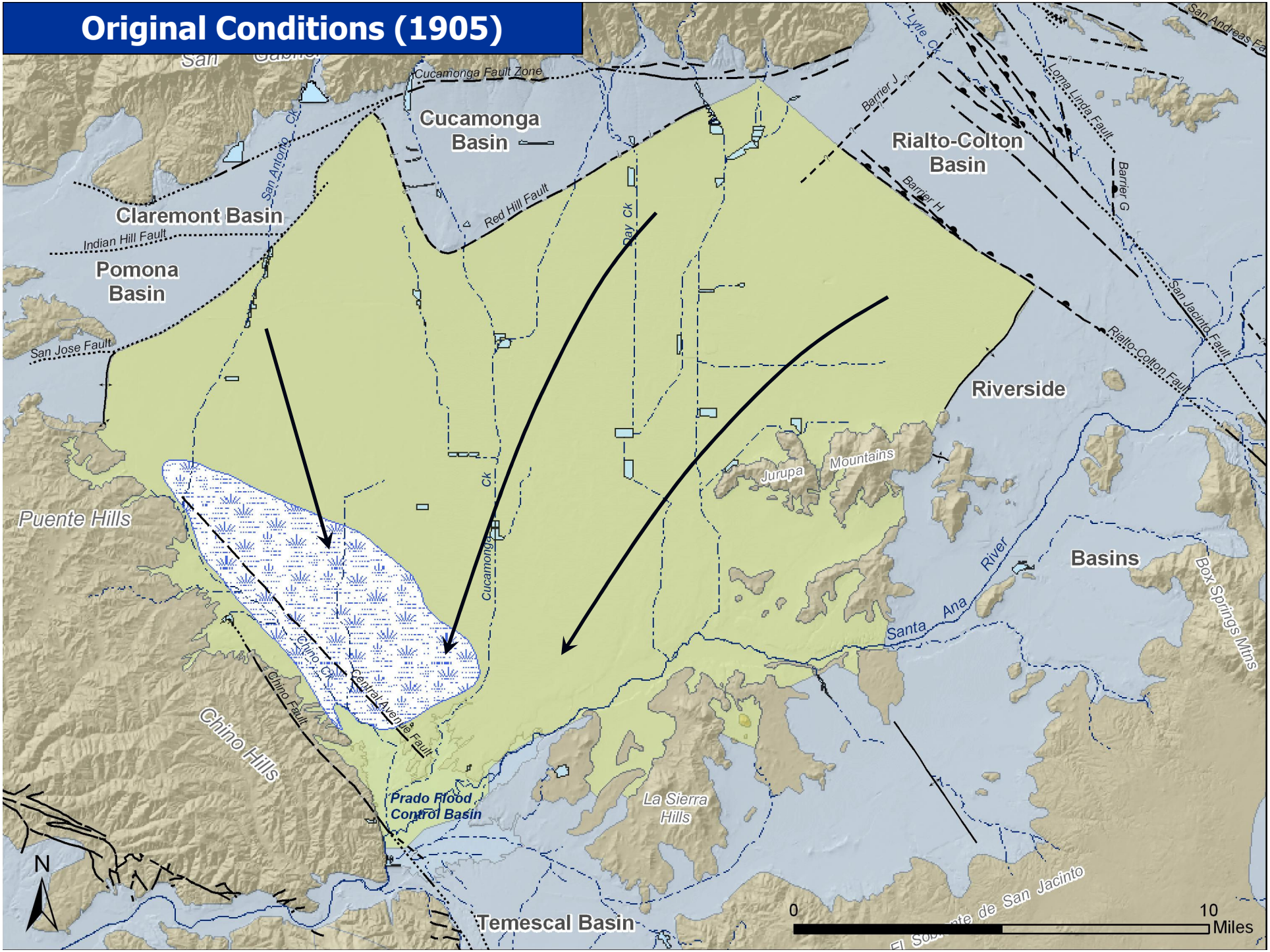


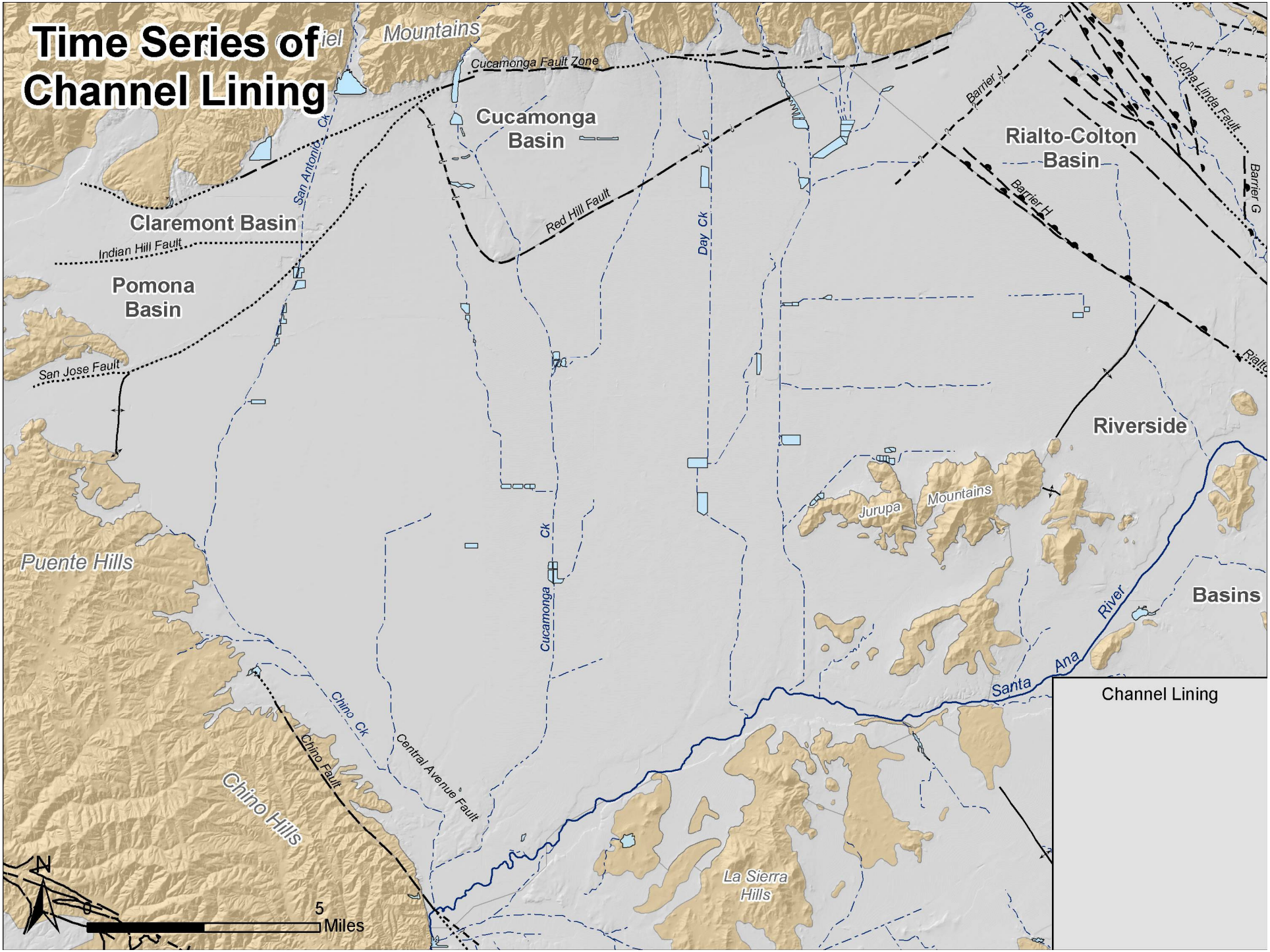
Bottom of the Aquifer

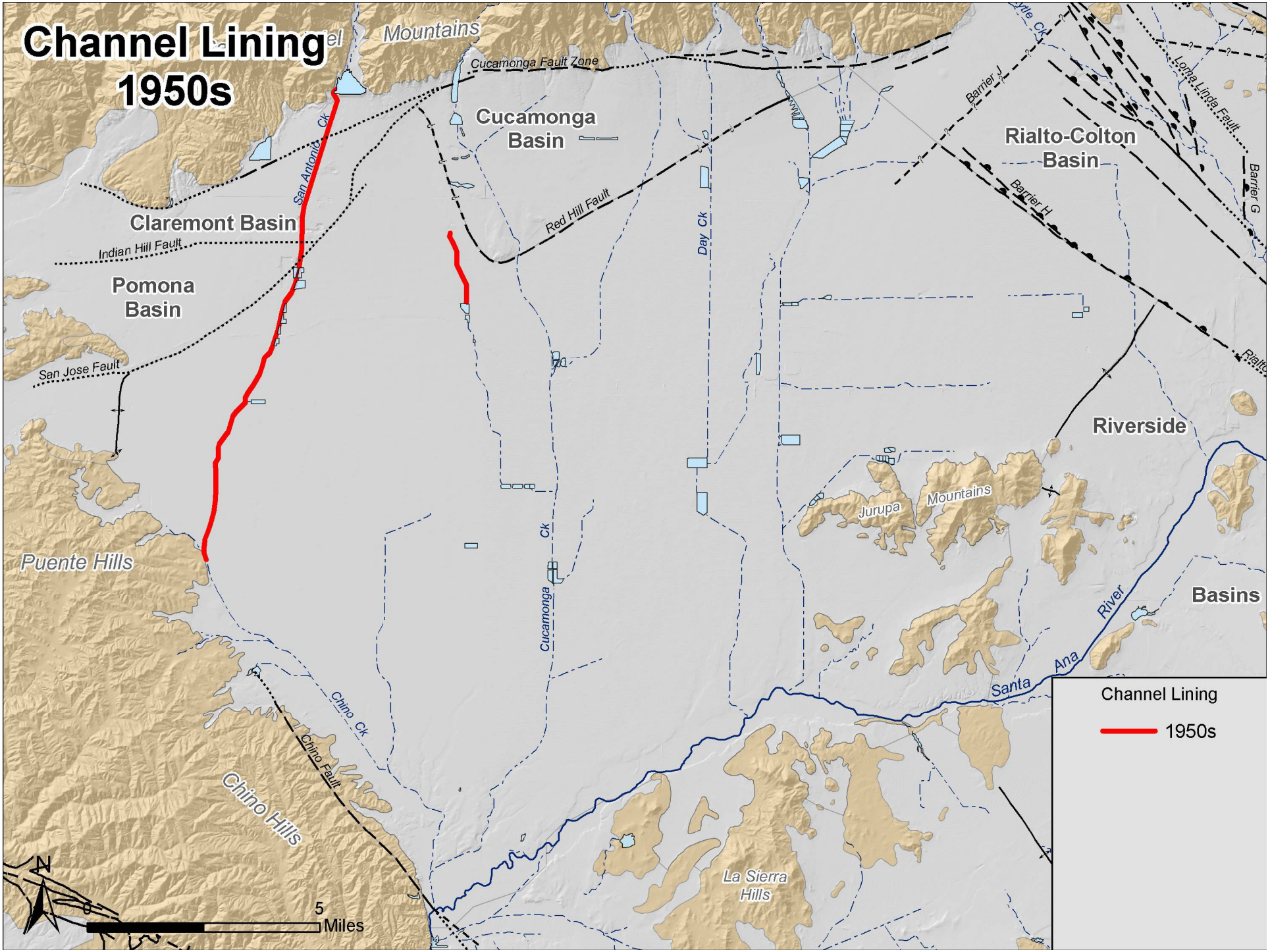


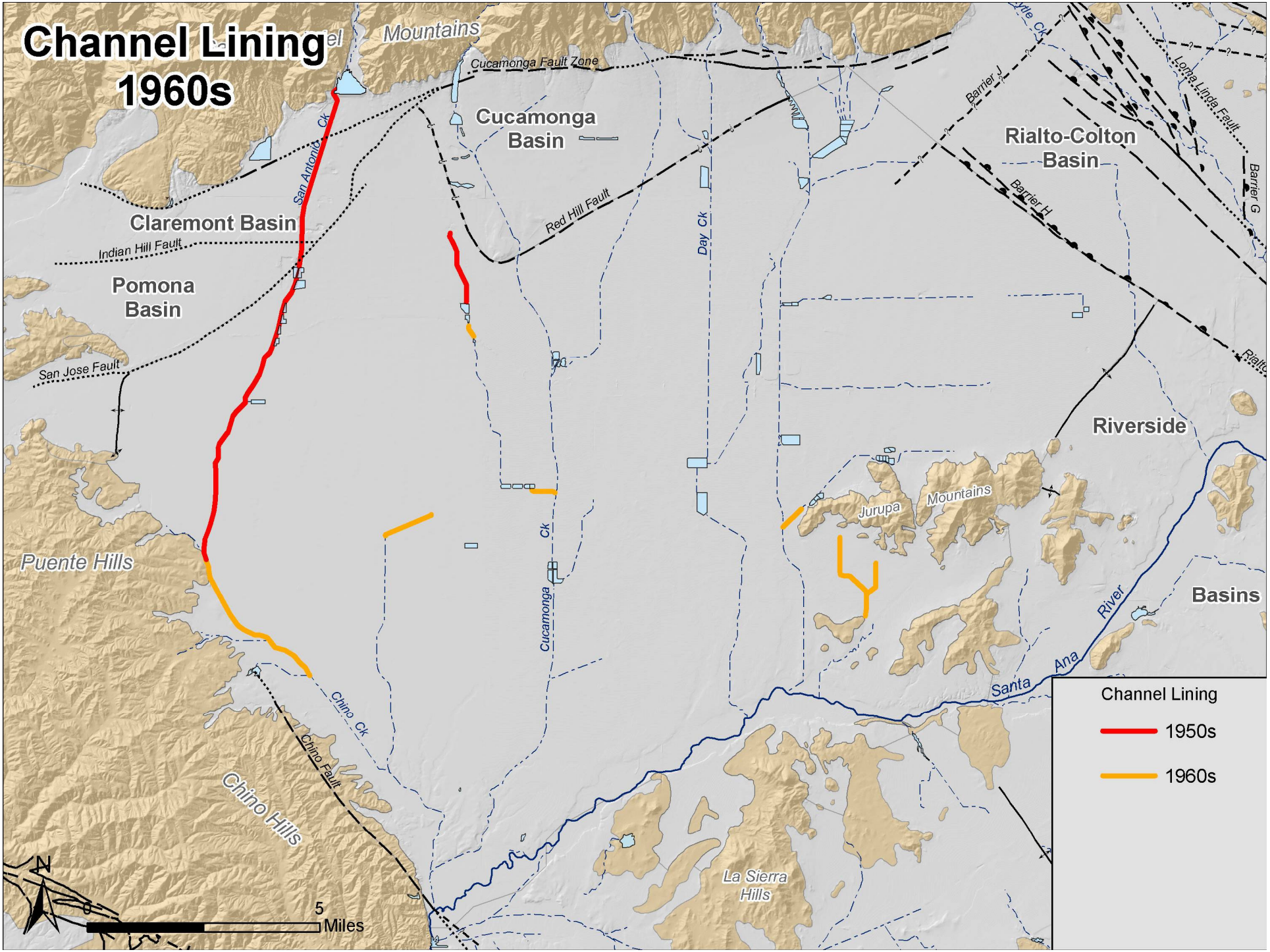
Recharge and Discharge

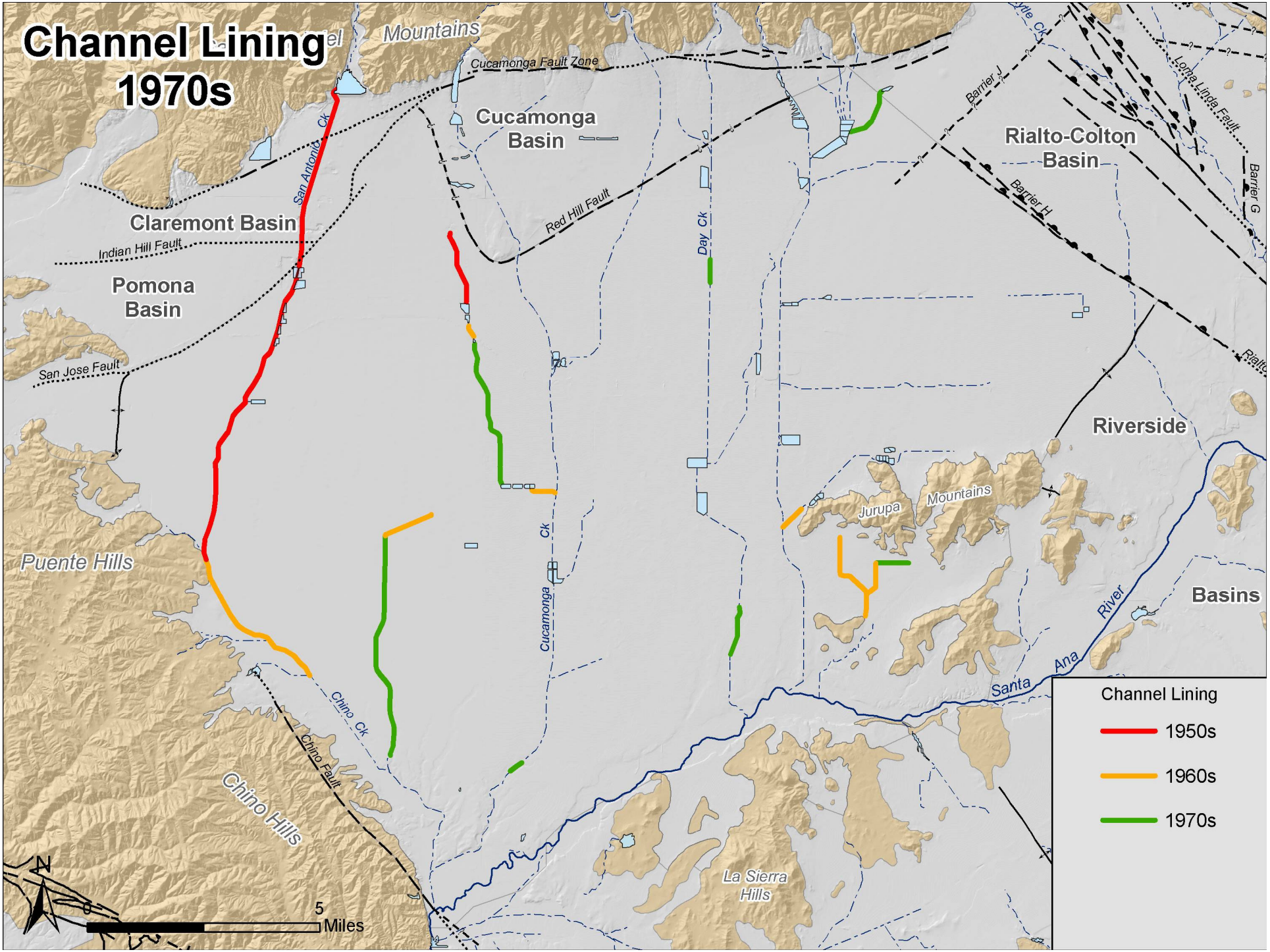
- Recharge
  - Sub-surface inflow from bounding basins
  - Deep infiltration from precipitation and applied water
  - Artificial recharge
  - Santa Ana River
- Discharge
  - Pumping
  - Evapotranspiration of shallow groundwater
  - Outflow of rising groundwater (Santa Ana River)

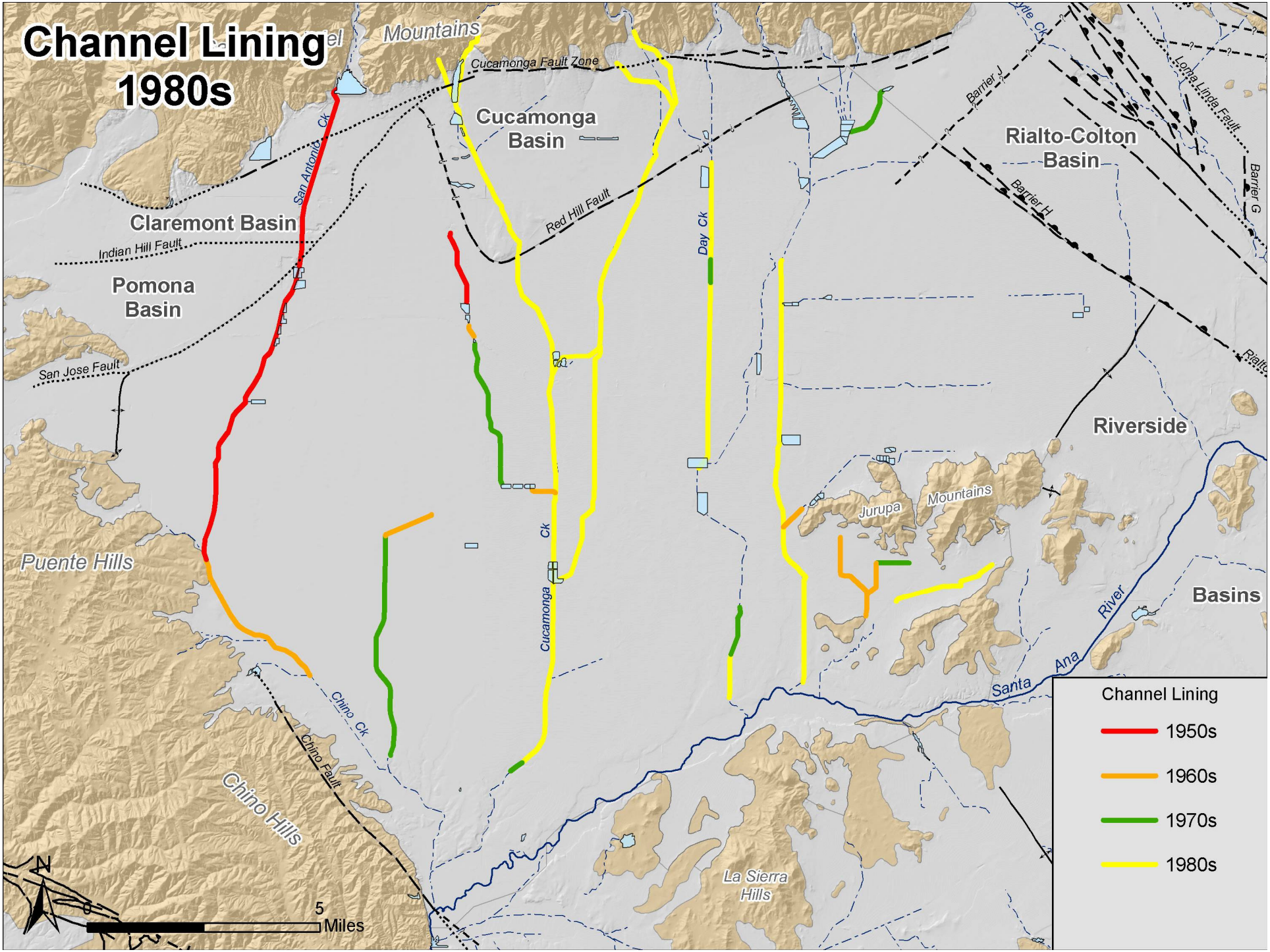

Original Conditions (1905)
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Pomona Basin
Indian Hill Fault
San Jose Fault
San Antonio Ck
Red Hill Fault
Day Ck
Barrier J
Barrier H
Barrier G
Lytle Ck
Loma Linda Fault
San Andreas Fault
San Jacinto Fault
Rialto-Colton Fault
Riverside
Jurupa Mountains
Puente Hills
Chino Ck
Central Avenue Fault
Chino Fault
Chino Hills
Cucamonga Ck
Santa Ana River
Basins
Box Springs Mtns
Prado Flood Control Basin
La Sierra Hills
Temescal Basin
N
0
10
Miles

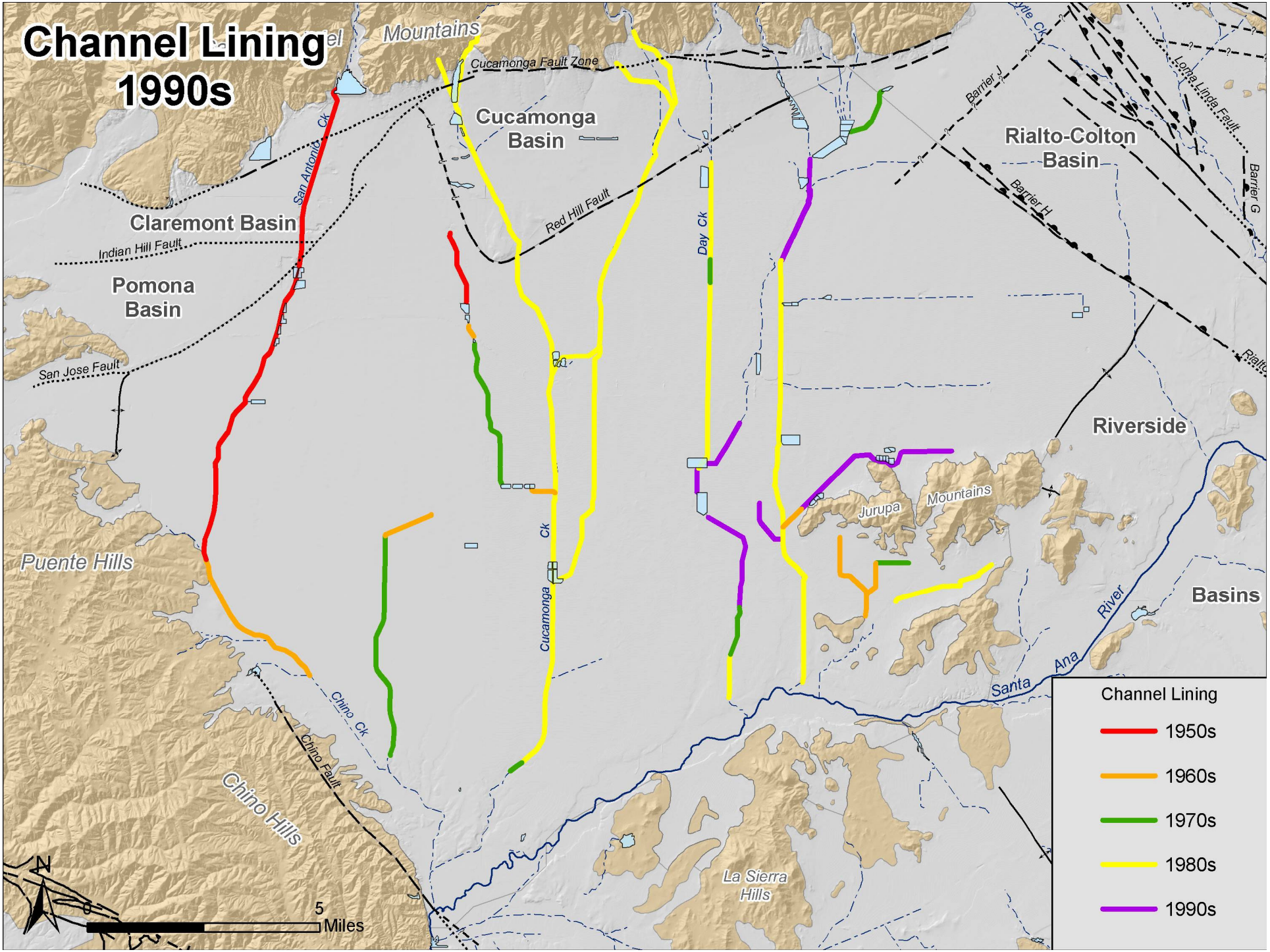

Time Series of Channel Lining
Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Indian Hill Fault
Red Hill Fault
San Antonio Ck
Day Ck
Barrier J
Barrier H
Barrier G
Lorna Linda Fault
Pomona Basin
San Jose Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Basins
Santa Ana River
Chino Ck
Chino Fault
Central Avenue Fault
Chino Hills
La Sierra Hills
N
5 Miles
Channel Lining


Channel Lining
1950s
Mountains
Cucamonga Fault Zone
Cucamonga Basin
San Antonio Ck
Claremont Basin
Indian Hill Fault
Red Hill Fault
Day Ck
Rialto-Colton Basin
Barrier J
Lorna Linda Fault
Barrier G
Barrier H
Pomona Basin
San Jose Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Basins
Santa Ana River
Chino Ck
Chino Fault
Chino Hills
La Sierra Hills
N
5
Miles
Channel Lining
1950s


Channel Lining
1960s
Mountains
Cucamonga Fault Zone
Cucamonga Basin
San Antonio Ck
Claremont Basin
Indian Hill Fault
Pomona Basin
San Jose Fault
Red Hill Fault
Day Ck
Rialto-Colton Basin
Barrier J
Barrier H
Lorna Linda Fault
Barrier G
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Chino Ck
Chino Fault
Chino Hills
Santa Ana River
Basins
La Sierra Hills
N
5
Miles
Channel Lining
1950s
1960s


Channel Lining
1970s
Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Indian Hill Fault
Pomona Basin
San Jose Fault
Red Hill Fault
San Antonio Ck
Day Ck
Barrier J
Barrier H
Barrier G
Lorna Linda Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Chino Ck
Chino Fault
Chino Hills
La Sierra Hills
Santa Ana River
Basins
N
5
Miles
Channel Lining
1950s
1960s
1970s


Channel Lining
1980s
Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Indian Hill Fault
Pomona Basin
San Jose Fault
Red Hill Fault
San Antonio Ck
Day Ck
Barrier J
Barrier H
Barrier G
Lorna Linda Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Chino Ck
Chino Fault
Chino Hills
La Sierra Hills
Santa Ana River
Basins
N
5
Miles
Channel Lining
1950s
1960s
1970s
1980s


Channel Lining
1990s
Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Indian Hill Fault
Pomona Basin
San Jose Fault
Red Hill Fault
San Antonio Ck
Day Ck
Barrier J
Barrier H
Barrier G
Lorna Linda Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Chino Ck
Chino Fault
Chino Hills
La Sierra Hills
Santa Ana River
Basins
N
5
Miles
Channel Lining
1950s
1960s
1970s
1980s
1990s


11 30 2007 13 53


01 12 2007 08 54

Artificial Recharge Facilities

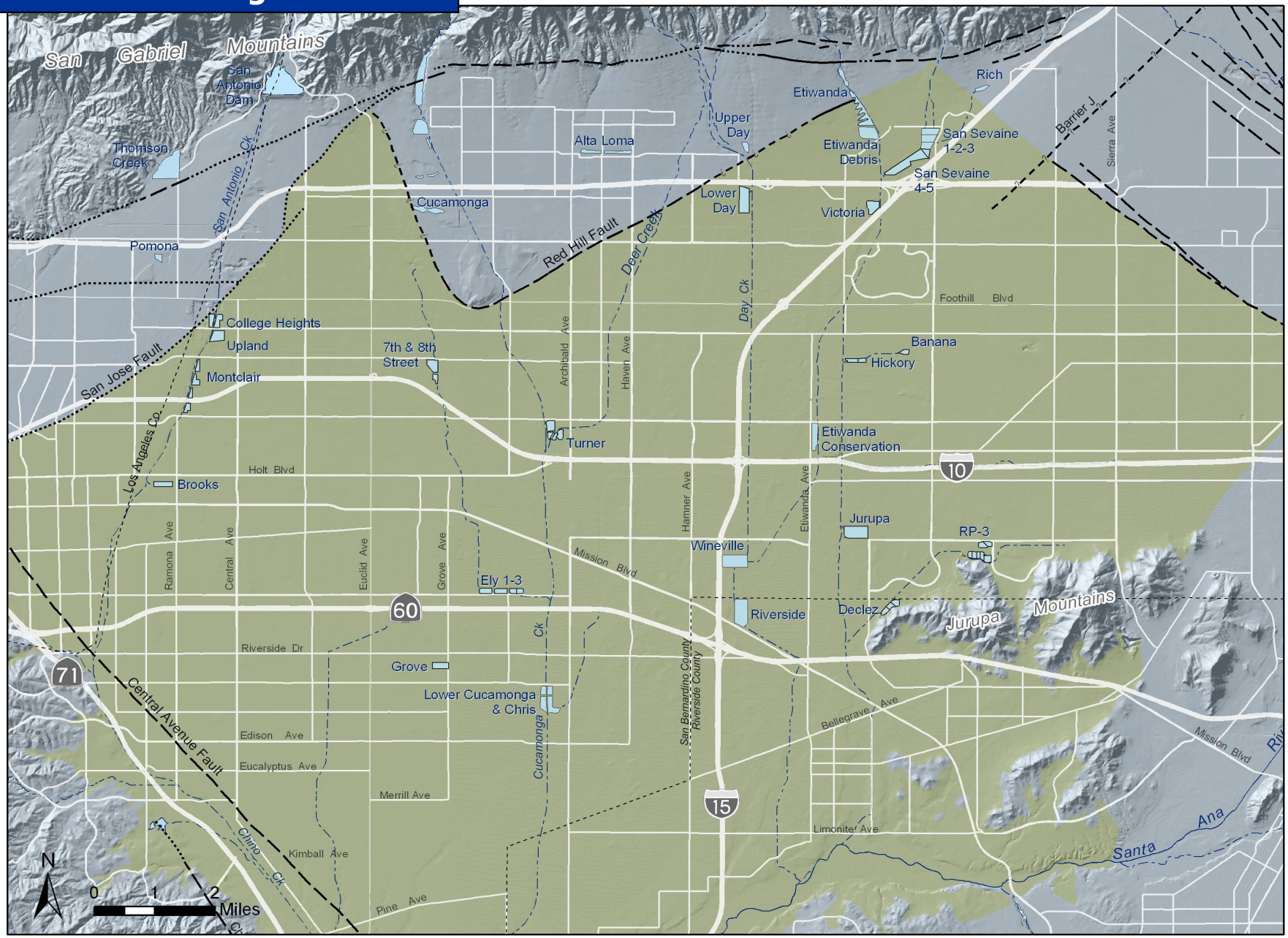


Figure_2-1_PP.mxd

Imported Water Facilities

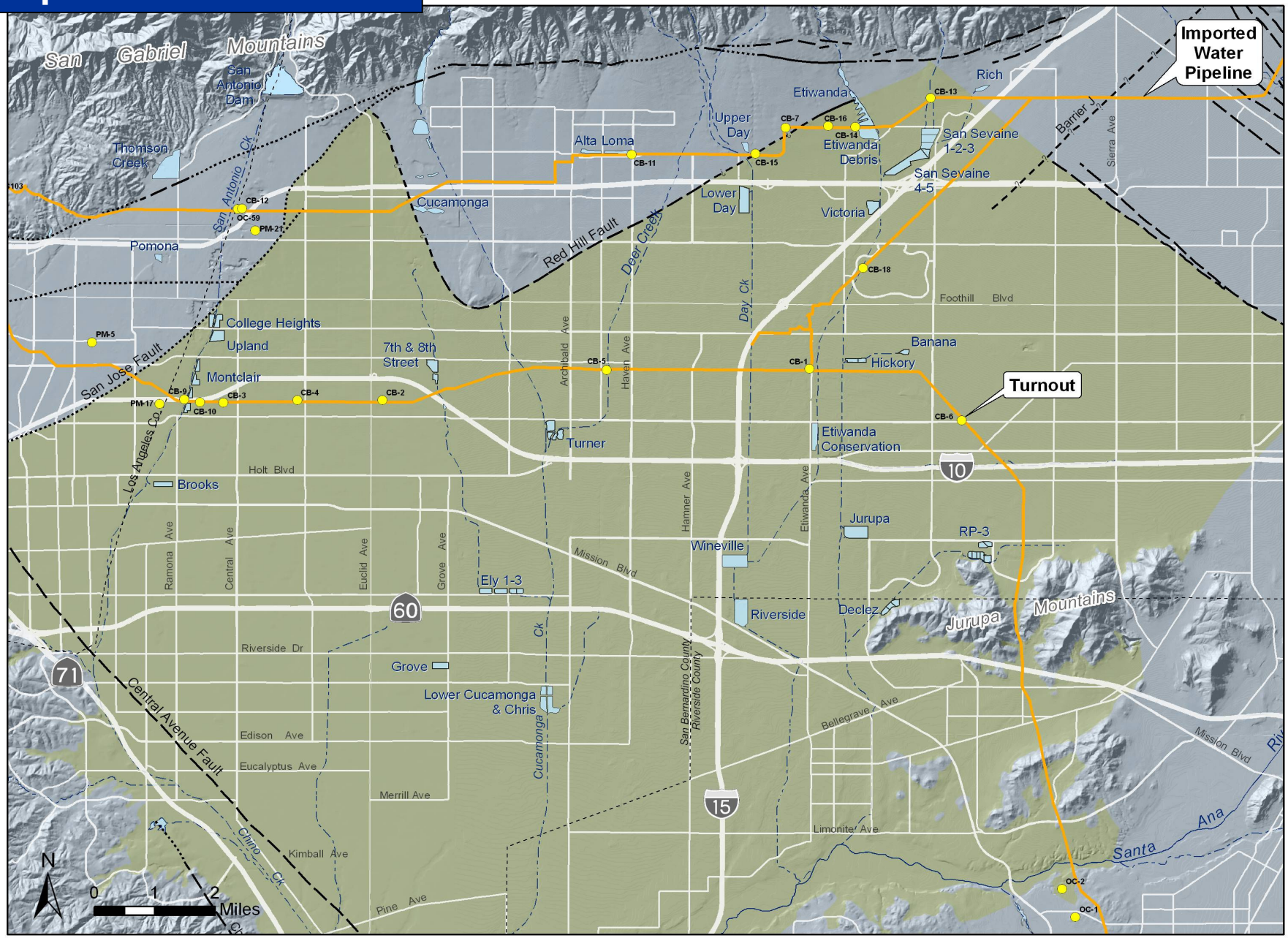


Figure_2-1_PP.mxd

Recycled Water Facilities

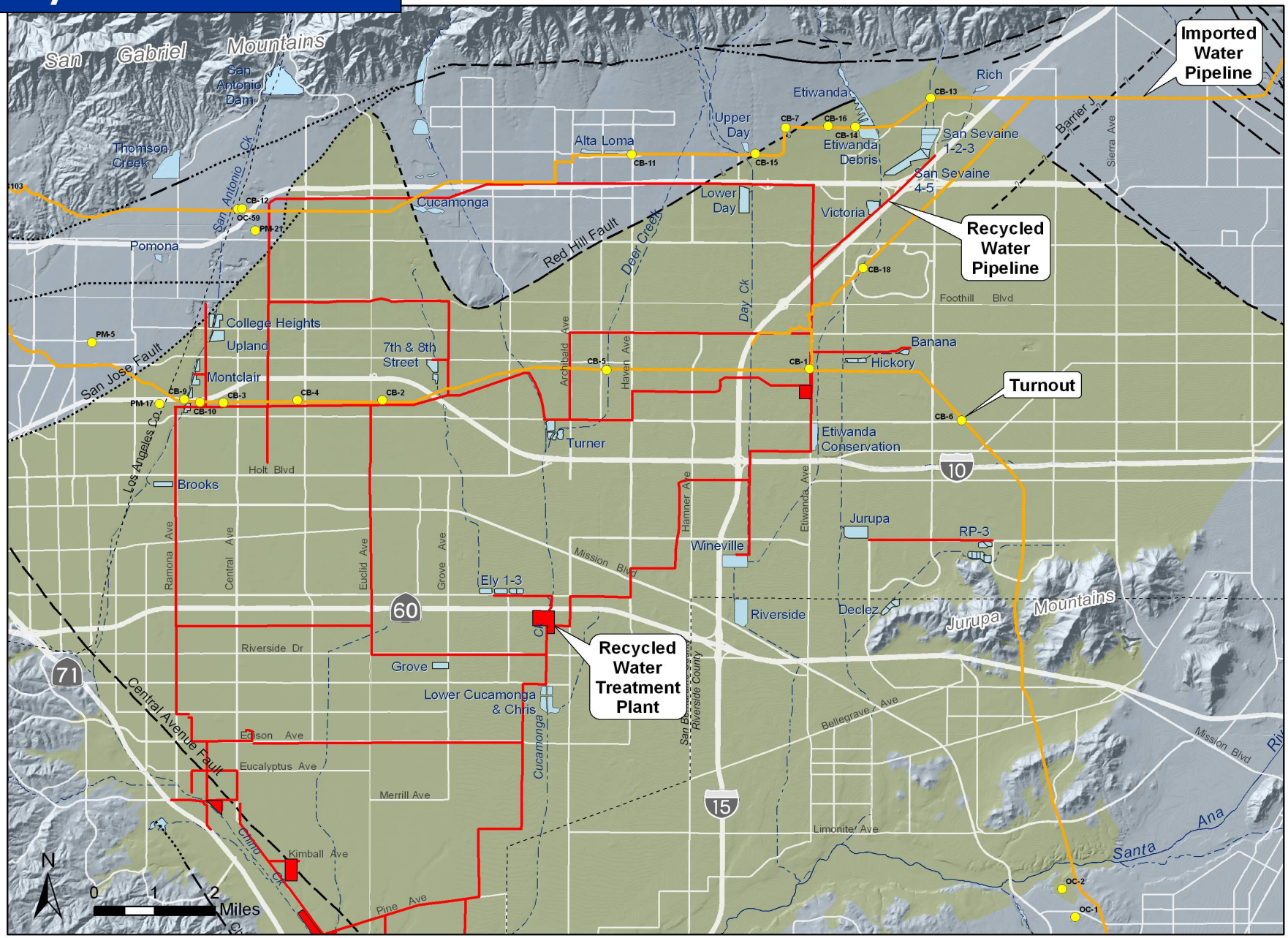
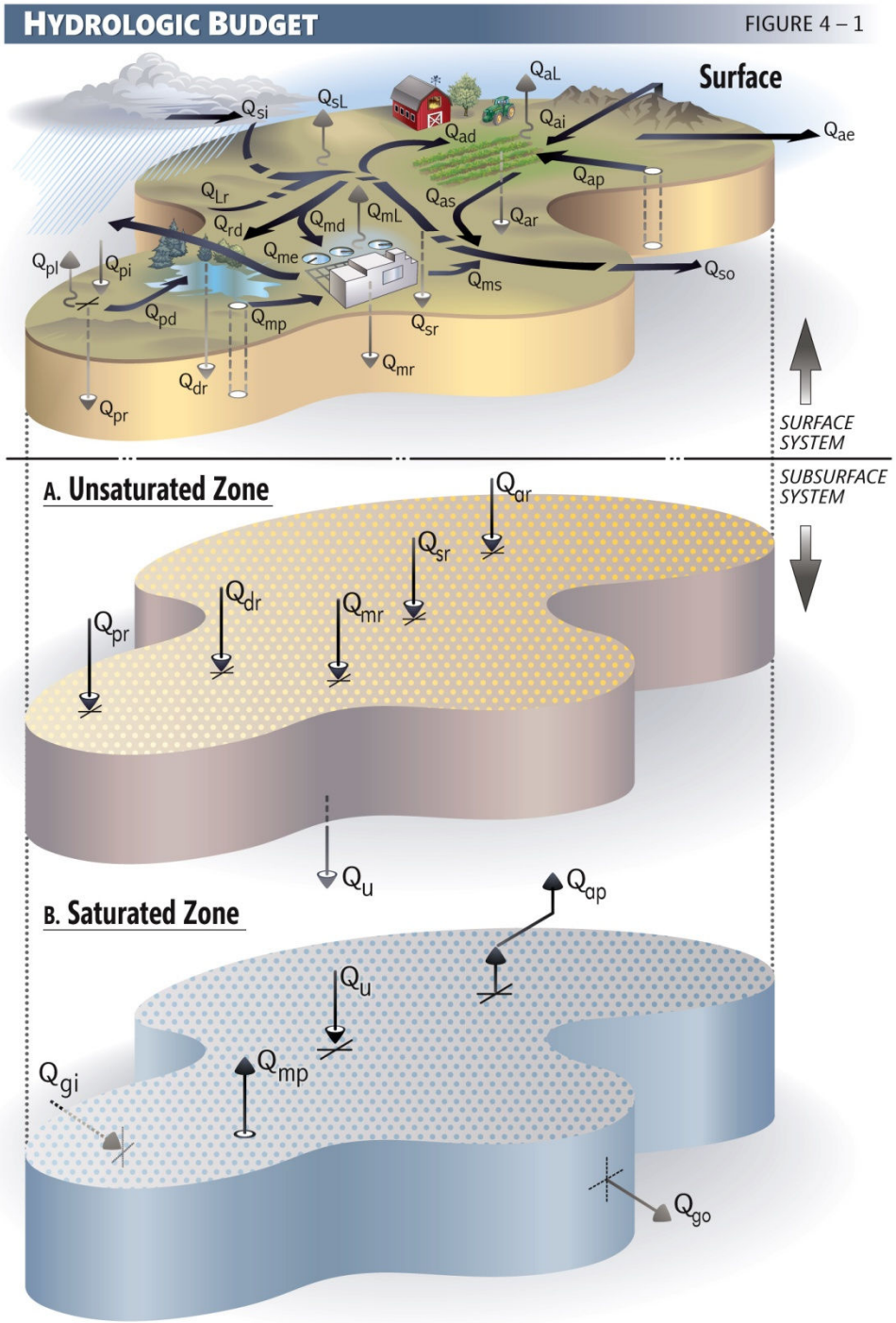
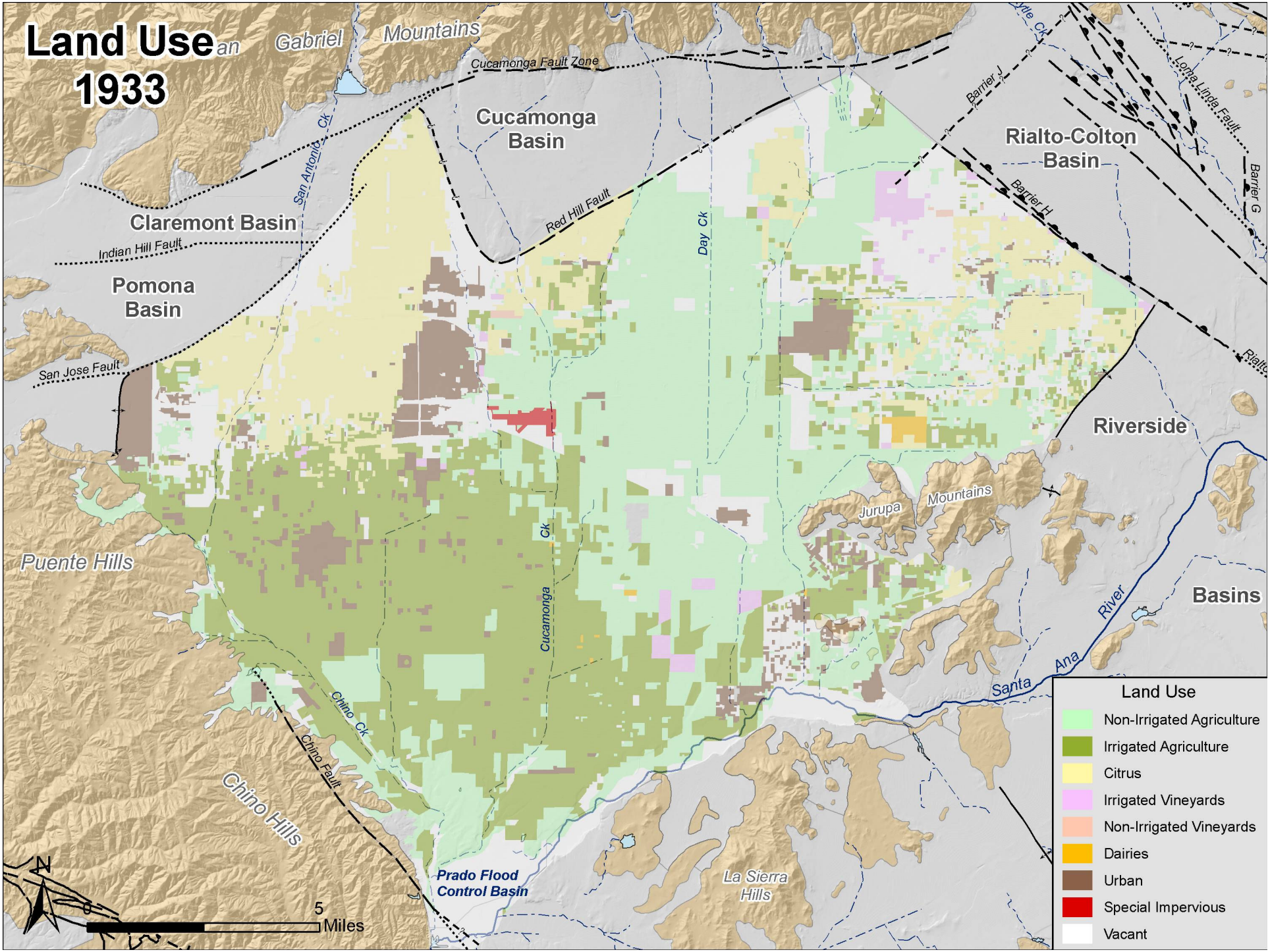
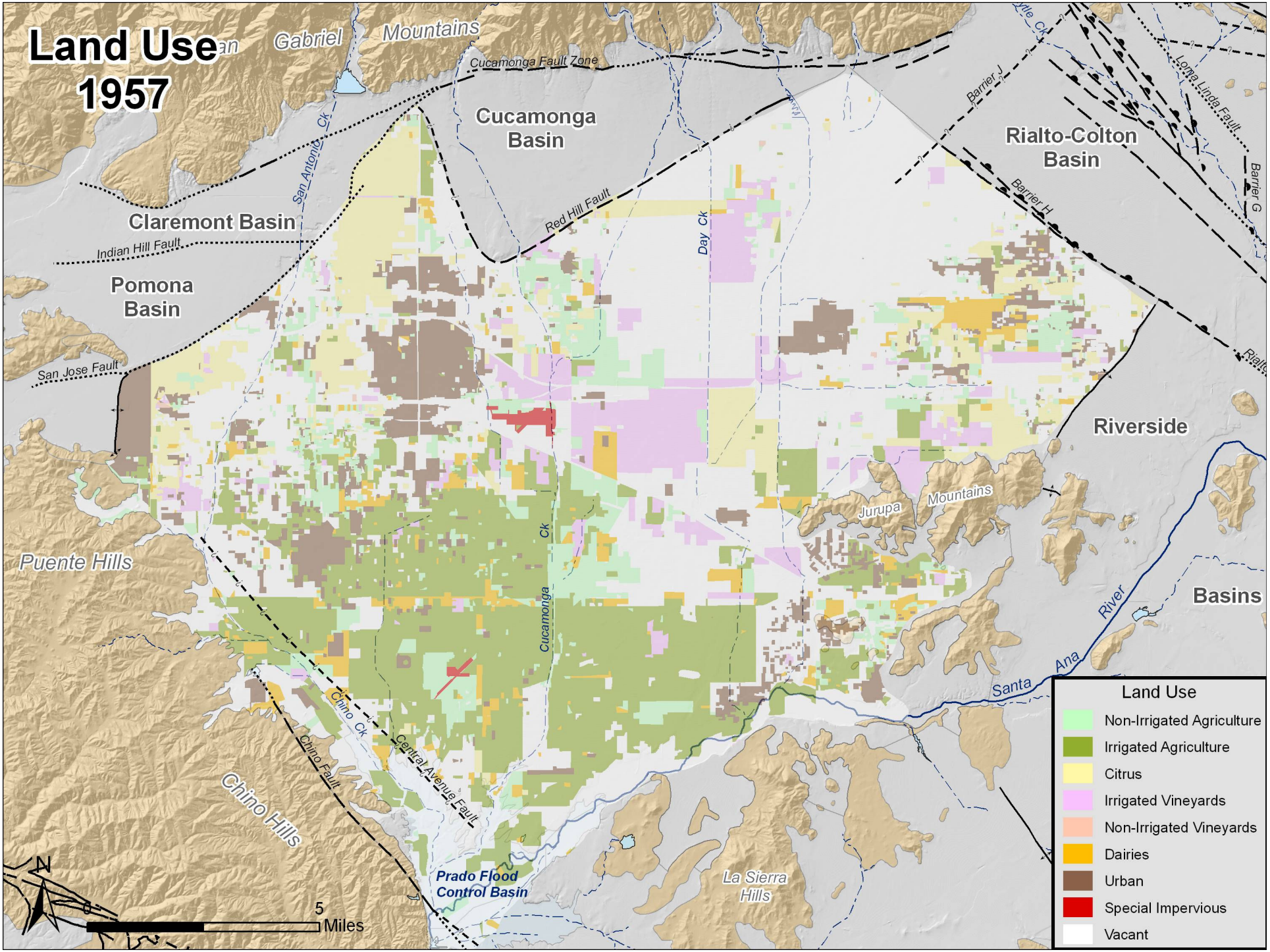


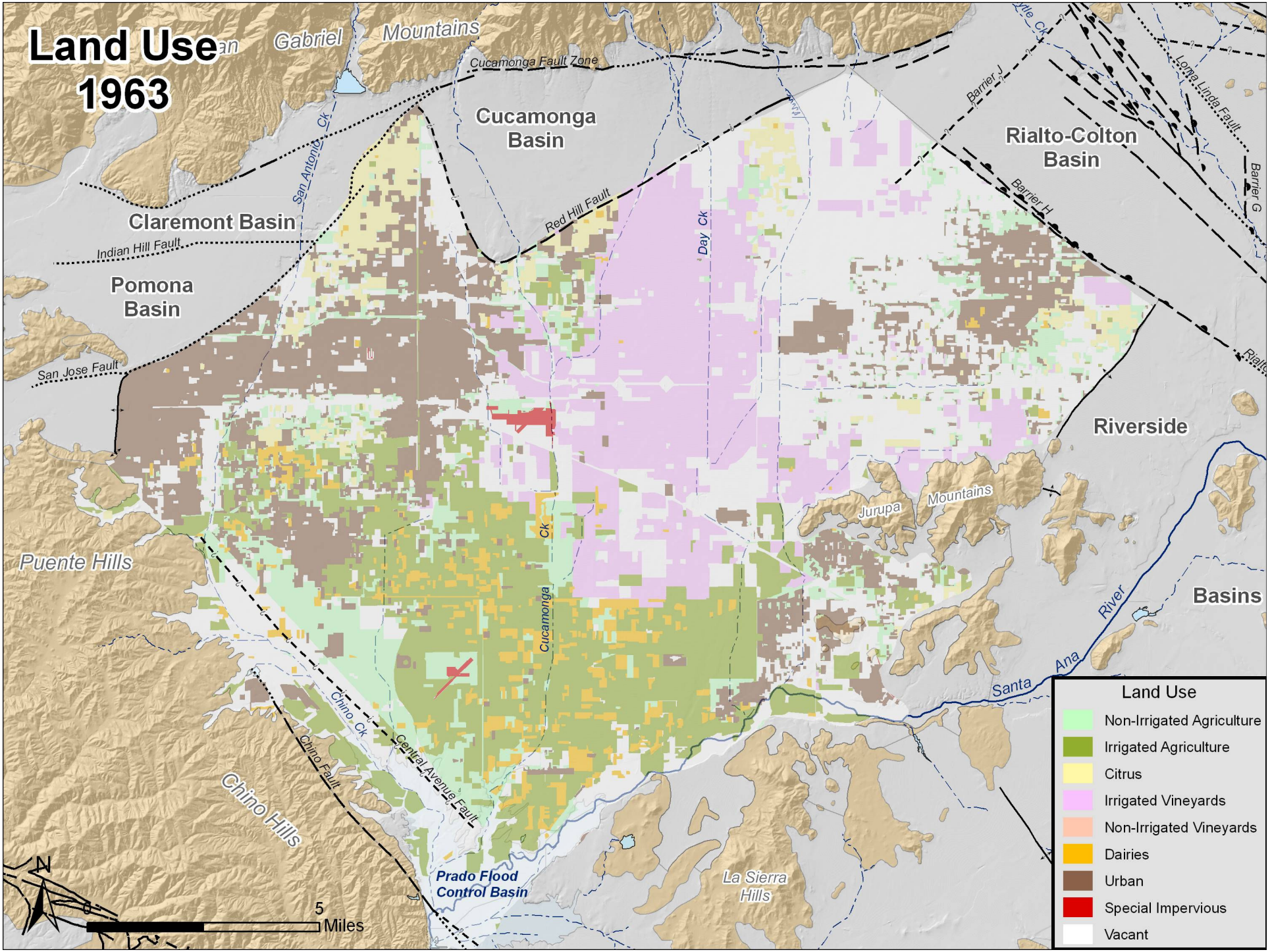
Figure_2-1_PP.mxd

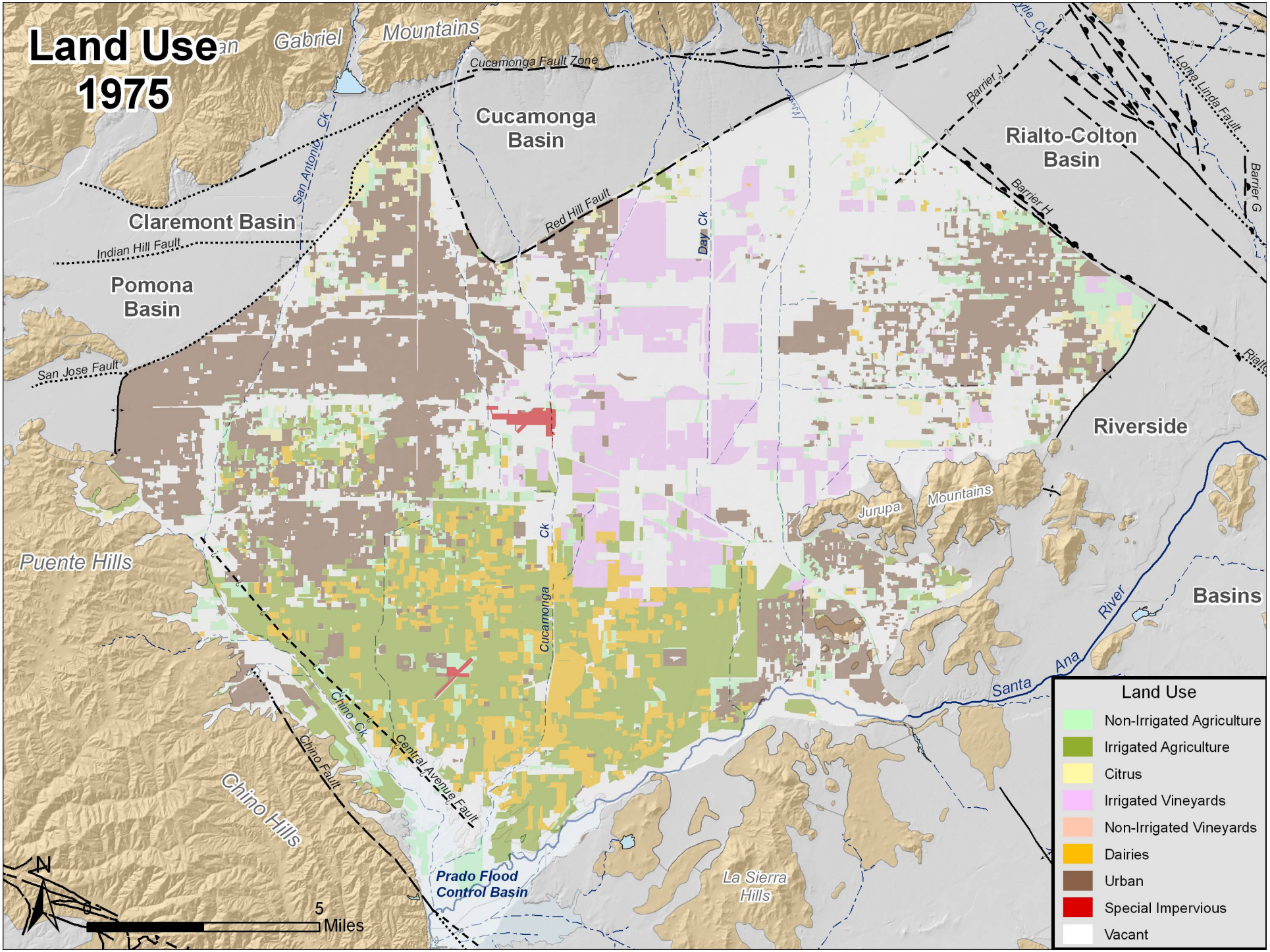

Recycled Water Recharge
Lysimeters at Ely Basin

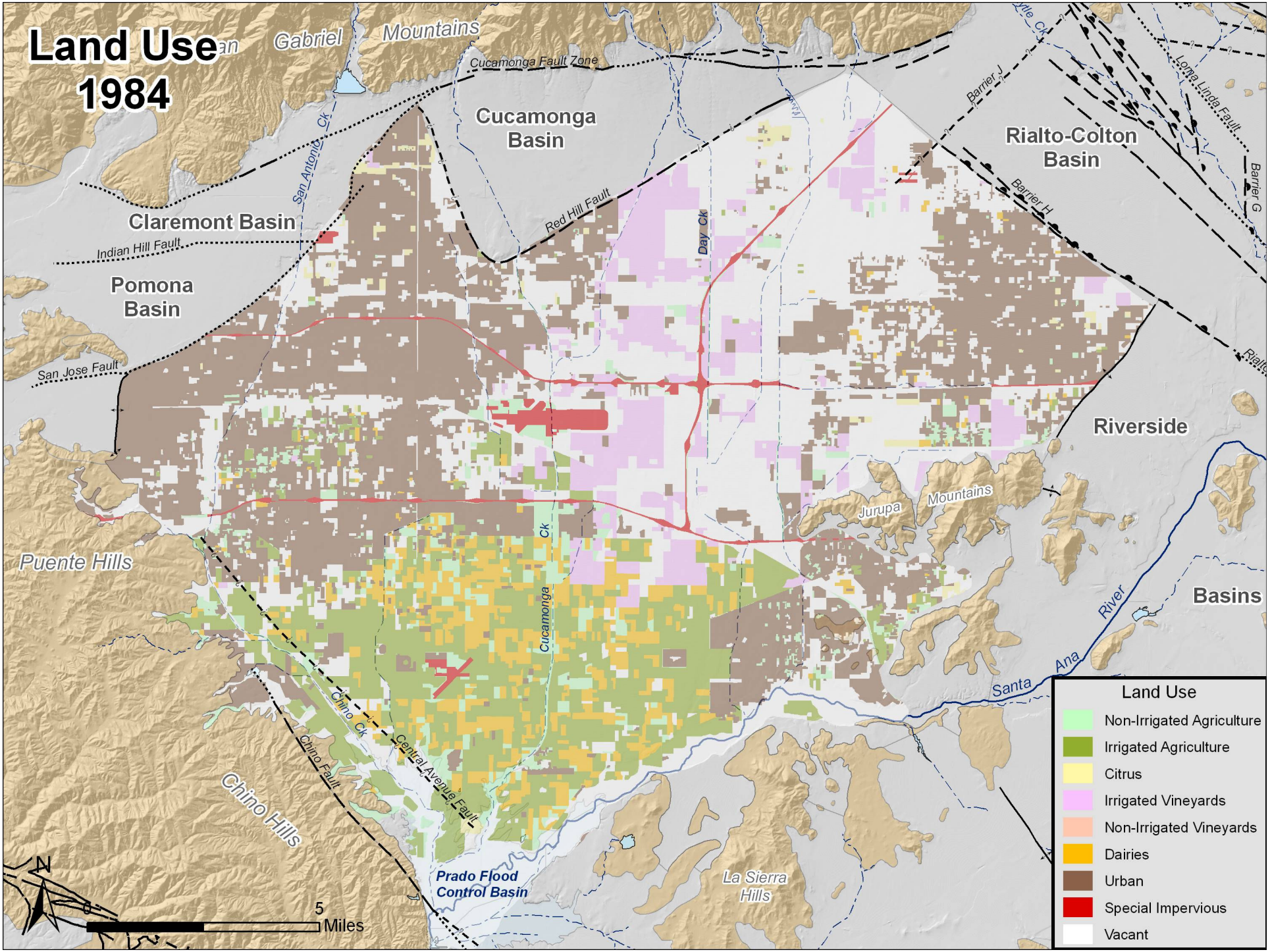

HYDROLOGIC BUDGET
FIGURE 4 – 1
Surface
Q_{si}
Q_{sL}
Q_{aL}
Q_{ai}
Q_{ae}
Q_{ad}
Q_{ap}
Q_{as}
Q_{ar}
Q_{Lr}
Q_{rd}
Q_{md}
Q_{mL}
Q_{me}
Q_{pl}
Q_{pi}
Q_{pd}
Q_{mp}
Q_{ms}
Q_{so}
Q_{sr}
Q_{mr}
Q_{dr}
Q_{pr}
SURFACE SYSTEM
SUBSURFACE SYSTEM
A. Unsaturated Zone
Q_{ar}
Q_{sr}
Q_{dr}
Q_{mr}
Q_{pr}
Q_u
B. Saturated Zone
Q_{ap}
Q_u
Q_{gi}
Q_{mp}
Q_{go}

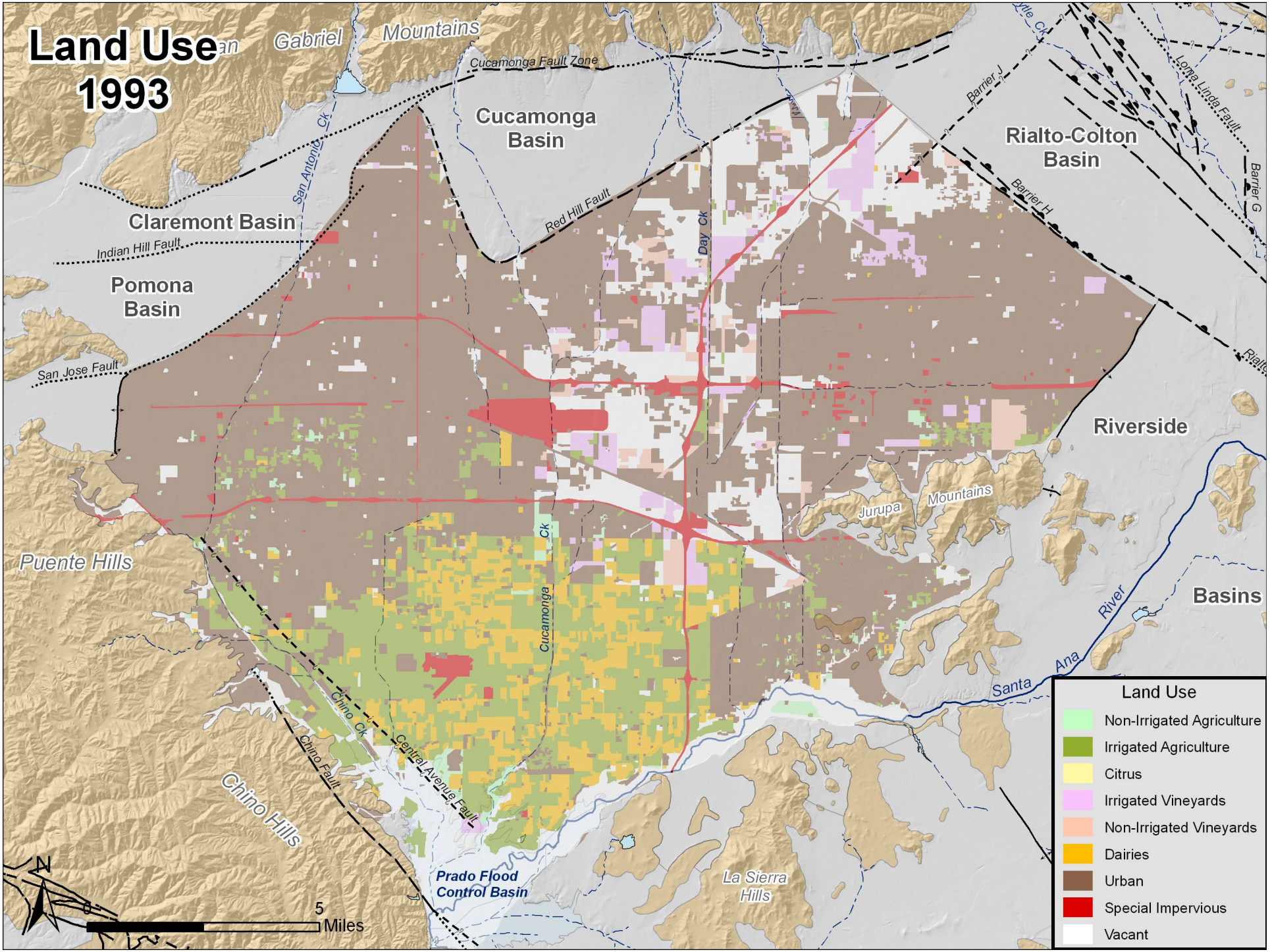

Land Use
1933
an Gabriel Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Pomona Basin
San Antonio Ck
Red Hill Fault
Day Ck
Barrier J
Barrier H
Barrier G
Lorna Linda Fault
Indian Hill Fault
San Jose Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Chino Ck
Chino Fault
Chino Hills
Santa Ana River
Basins
Prado Flood Control Basin
La Sierra Hills
N
0
5
Miles
Land Use
Non-Irrigated Agriculture
Irrigated Agriculture
Citrus
Irrigated Vineyards
Non-Irrigated Vineyards
Dairies
Urban
Special Impervious
Vacant

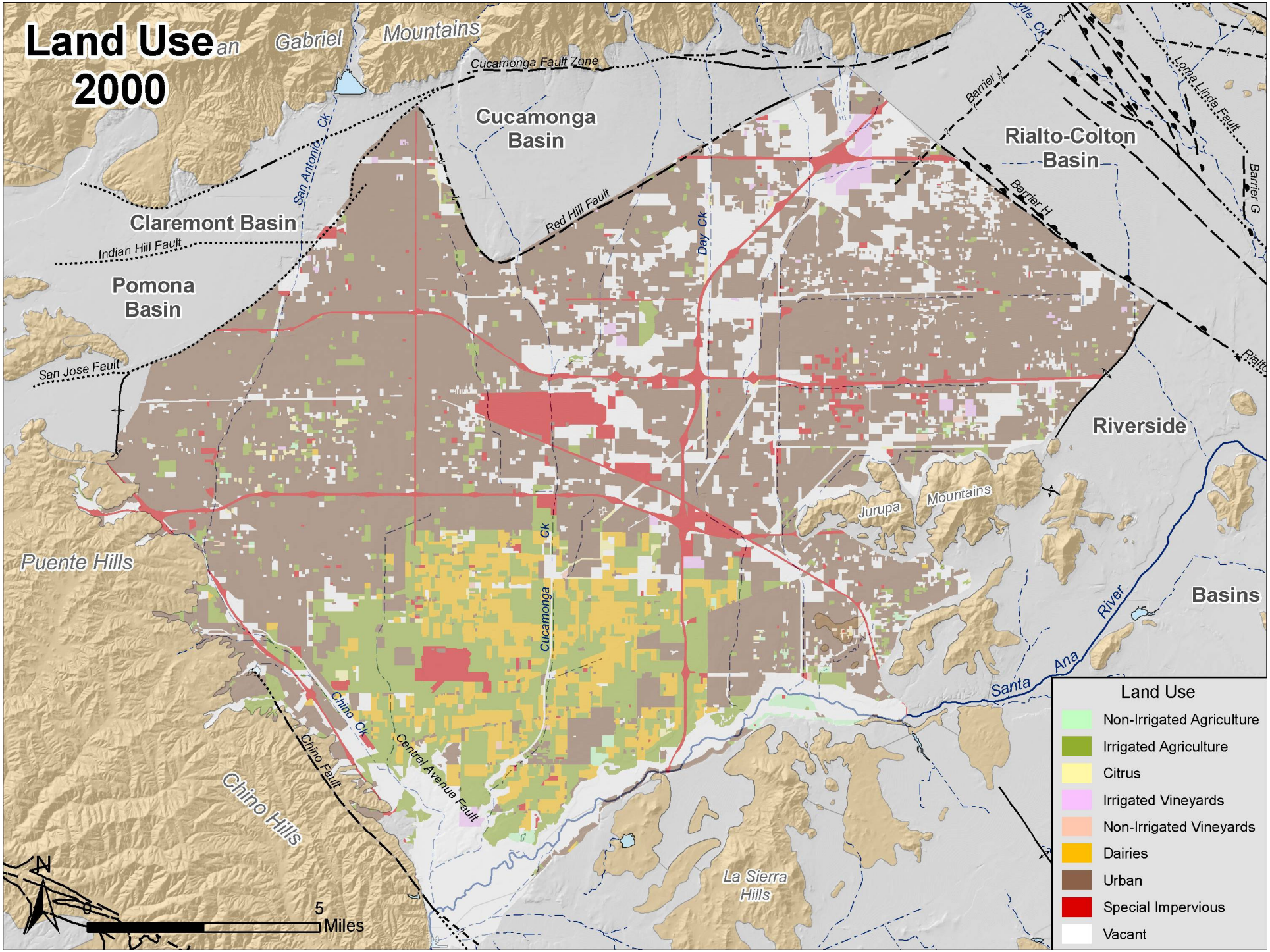

Land Use
1957
Gabriel
Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Pomona Basin
San Antonio Ck
Red Hill Fault
Day Ck
Barrier J
Barrier H
Barrier G
Lorna Linda Fault
Indian Hill Fault
San Jose Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Santa Ana River
Basins
Chino Ck
Chino Fault
Central Avenue Fault
Chino Hills
Prado Flood Control Basin
La Sierra Hills
N
5 Miles
Land Use
Non-Irrigated Agriculture
Irrigated Agriculture
Citrus
Irrigated Vineyards
Non-Irrigated Vineyards
Dairies
Urban
Special Impervious
Vacant


Land Use
1963
Gabriel
Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Pomona Basin
San Antonio Ck
Red Hill Fault
Day Ck
Barrier J
Barrier H
Barrier G
Lorna Linda Fault
Indian Hill Fault
San Jose Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Santa Ana River
Basins
Chino Ck
Chino Fault
Central Avenue Fault
Chino Hills
Prado Flood Control Basin
La Sierra Hills
N
5 Miles
Land Use
Non-Irrigated Agriculture
Irrigated Agriculture
Citrus
Irrigated Vineyards
Non-Irrigated Vineyards
Dairies
Urban
Special Impervious
Vacant


Land Use
1975
Gabriel
Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Pomona Basin
San Antonio Ck
Red Hill Fault
Day Ck
Barrier J
Barrier H
Barrier G
Lorna Linda Fault
Indian Hill Fault
San Jose Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Santa Ana River
Basins
Chino Ck
Chino Fault
Central Avenue Fault
Chino Hills
Prado Flood Control Basin
La Sierra Hills
N
5
Miles
Land Use
Non-Irrigated Agriculture
Irrigated Agriculture
Citrus
Irrigated Vineyards
Non-Irrigated Vineyards
Dairies
Urban
Special Impervious
Vacant


Land Use
1984
Gabriel
Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Pomona Basin
San Antonio Ck
Red Hill Fault
Indian Hill Fault
San Jose Fault
Day Ck
Barrier J
Barrier H
Barrier G
Lorna Linda Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Santa Ana River
Basins
Chino Ck
Chino Fault
Central Avenue Fault
Chino Hills
Prado Flood Control Basin
La Sierra Hills
N
5
Miles
Land Use
Non-Irrigated Agriculture
Irrigated Agriculture
Citrus
Irrigated Vineyards
Non-Irrigated Vineyards
Dairies
Urban
Special Impervious
Vacant


Land Use
1993
Gabriel Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Pomona Basin
San Antonio Ck
Red Hill Fault
Indian Hill Fault
San Jose Fault
Day Ck
Barrier J
Barrier H
Barrier G
Lorna Linda Fault
Riverside
Jurupa Mountains
Puente Hills
Cucamonga Ck
Chino Ck
Chino Fault
Central Avenue Fault
Chino Hills
Prado Flood Control Basin
La Sierra Hills
Santa Ana River
Basins
N
5
Miles
Land Use
Non-Irrigated Agriculture
Irrigated Agriculture
Citrus
Irrigated Vineyards
Non-Irrigated Vineyards
Dairies
Urban
Special Impervious
Vacant


Land Use 2000
an Gabriel Mountains
Cucamonga Fault Zone
Cucamonga Basin
Rialto-Colton Basin
Claremont Basin
Pomona Basin
Riverside
Basins
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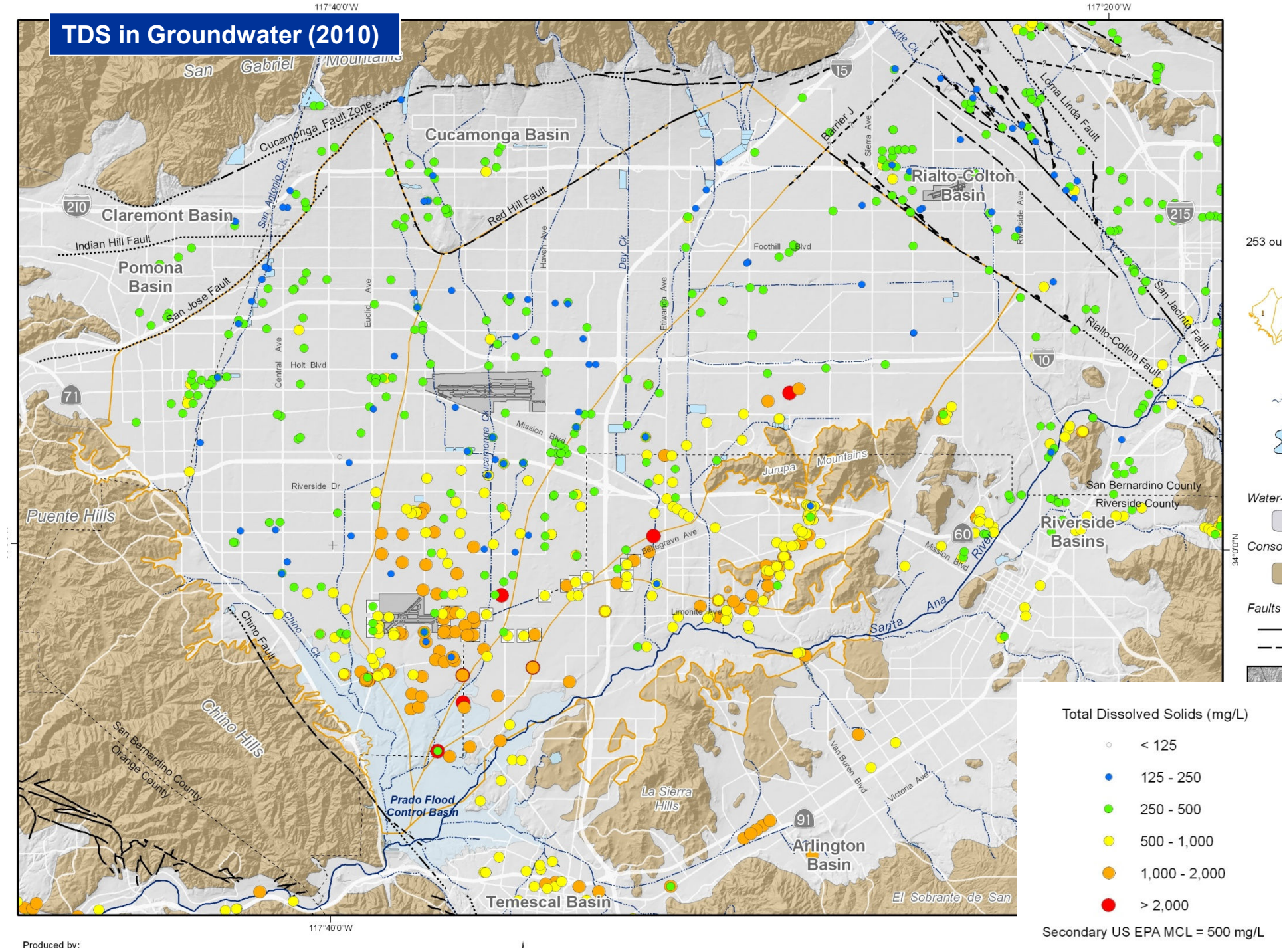
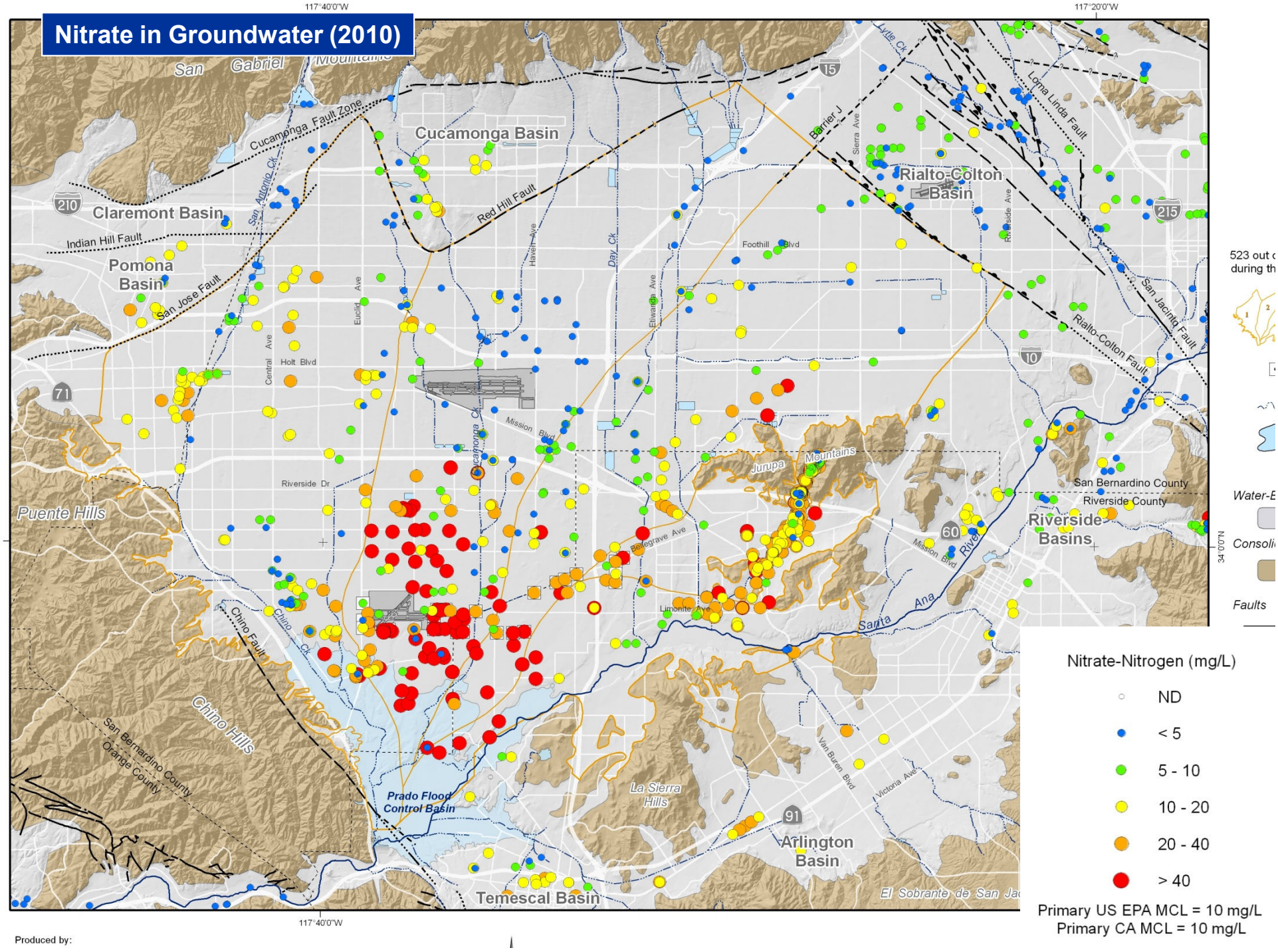
Chino Hills
La Sierra Hills
Jurupa Mountains
San Antonio Ck
Red Hill Fault
Indian Hill Fault
San Jose Fault
Day Ck
Barrier J
Barrier H
Barrier G
Lytle Ck
Lorna Linda Fault
Cucamonga Ck
Chino Ck
Chino Fault
Central Avenue Fault
Santa Ana River
N
5
Miles
Land Use
Non-Irrigated Agriculture
Irrigated Agriculture
Citrus
Irrigated Vineyards
Non-Irrigated Vineyards
Dairies
Urban
Special Impervious
Vacant

TDS in Groundwater (2010)

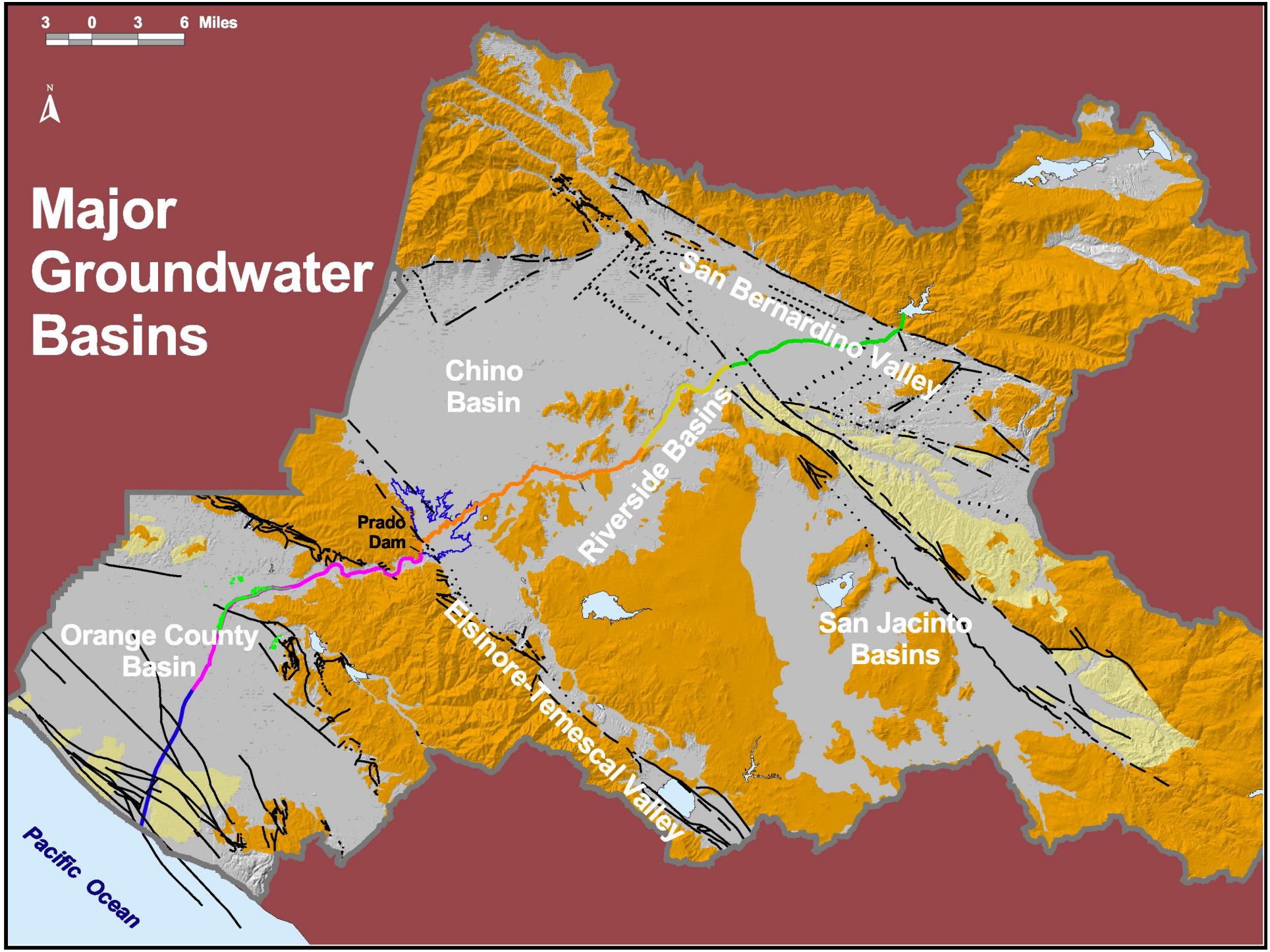


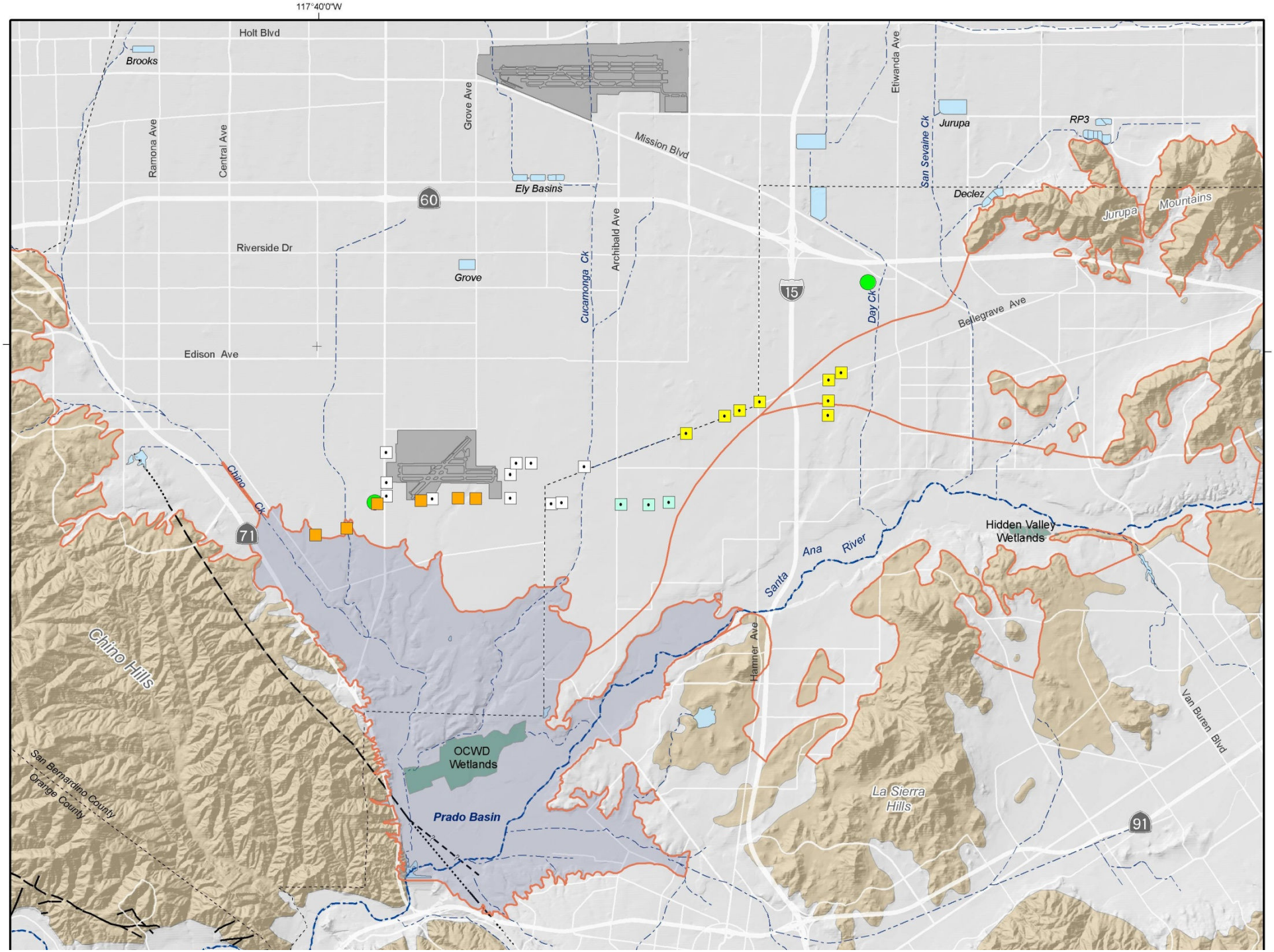
Produced by:

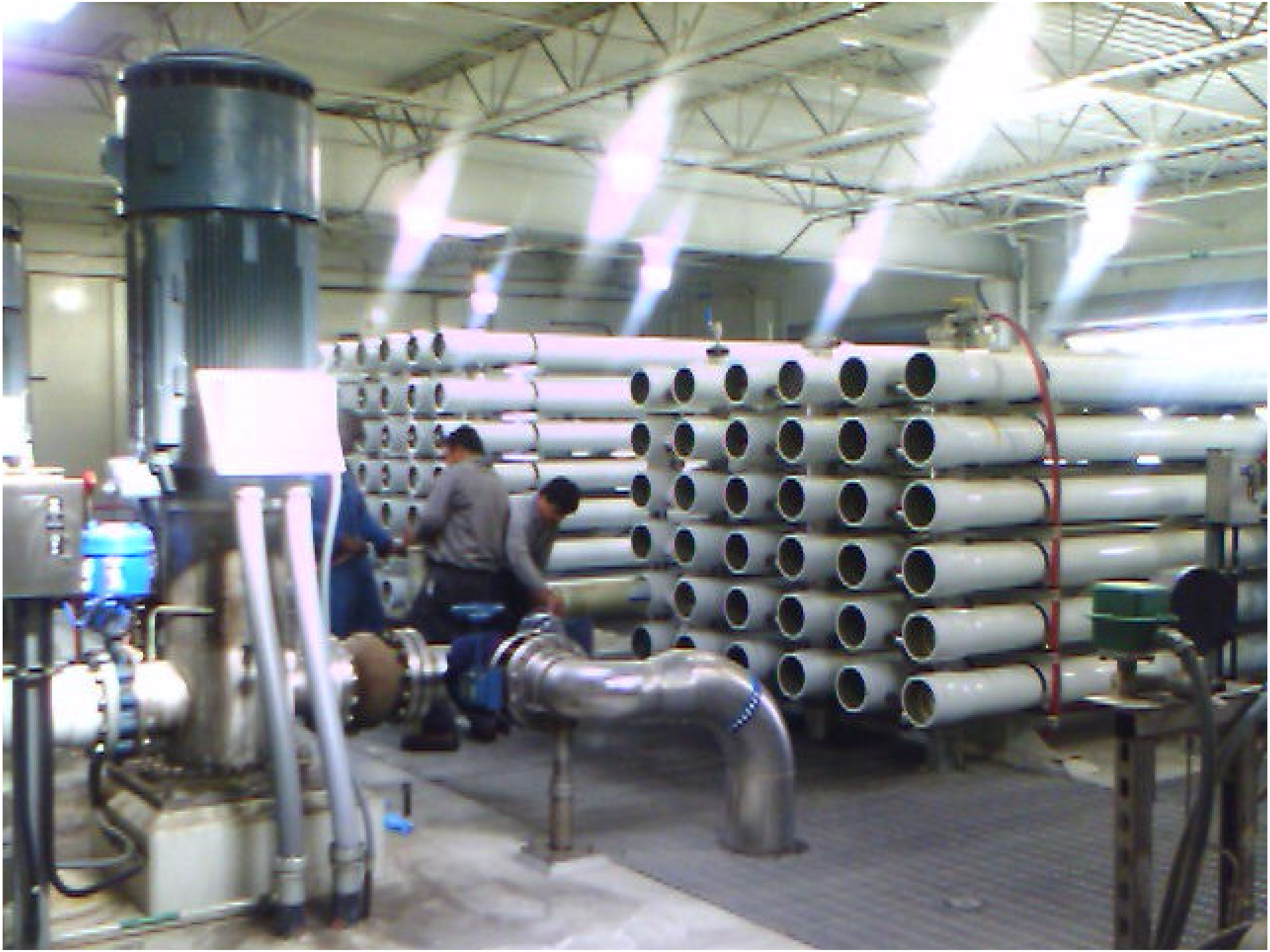
Nitrate in Groundwater (2010)



Produced by:


3 0 3 6 Miles
N
Major Groundwater Basins
Chino Basin
San Bernardino Valley
Riverside Basins
Prado Dam
Orange County Basin
Elsinore-Temescal Valley
San Jacinto Basins
Pacific Ocean


117°40'0"W
Holt Blvd
Brooks
Ramona Ave
Central Ave
Grove Ave
Ely Basins
Mission Blvd
Etiwanda Ave
San Sevaine Ck
Jurupa
RP3
Declez
Jurupa Mountains
60
Riverside Dr
Grove
Cucamonga Ck
Archibald Ave
15
Day Ck
Bellegrave Ave
Edison Ave
Chino Ck
71
Hidden Valley Wetlands
Santa Ana River
Hamner Ave
Chino Hills
OCWD Wetlands
Prado Basin
San Bernardino County
Orange County
La Sierra Hills
Van Buren Blvd
91



Water Level Decline (1933-2000)

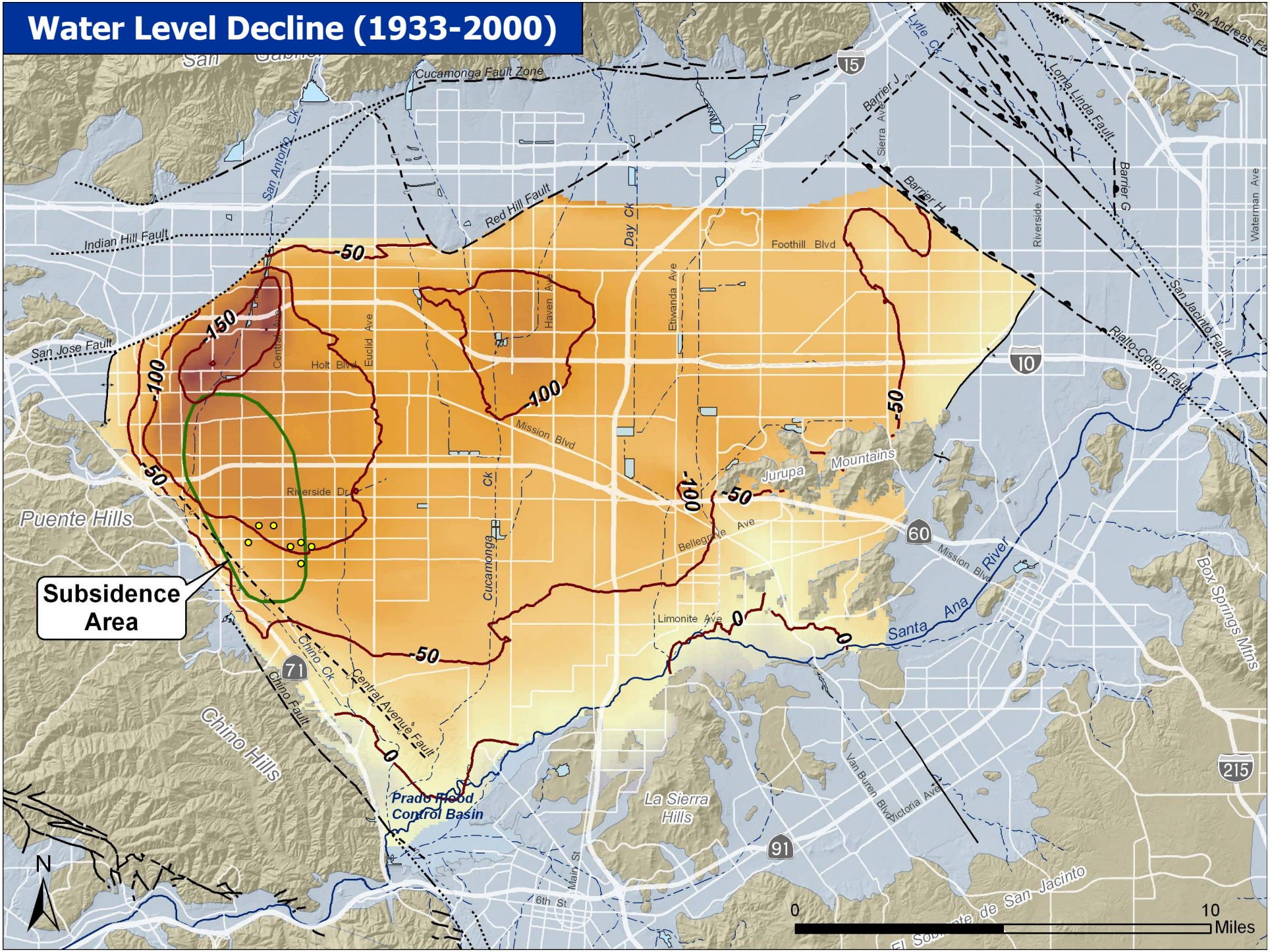
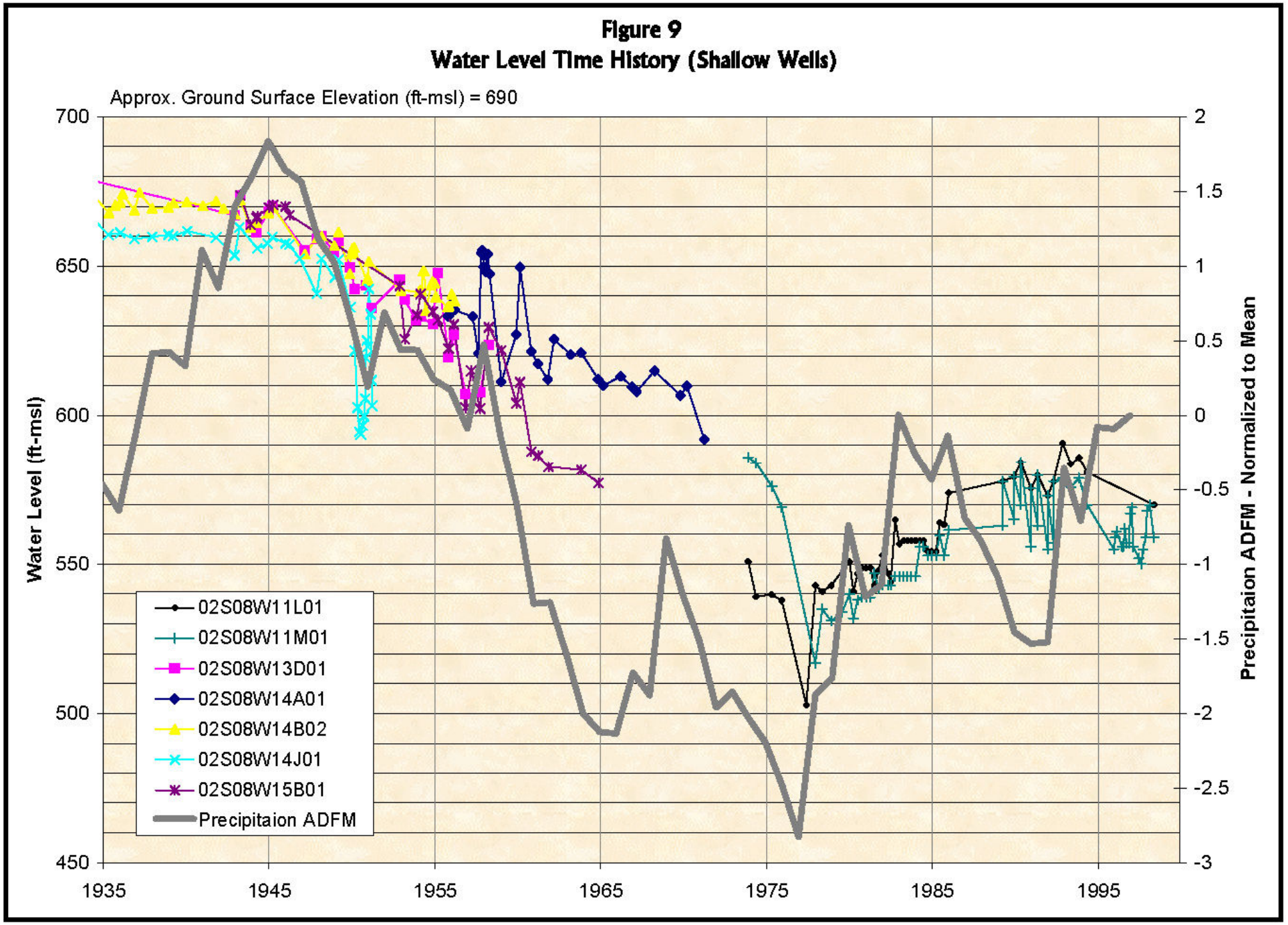
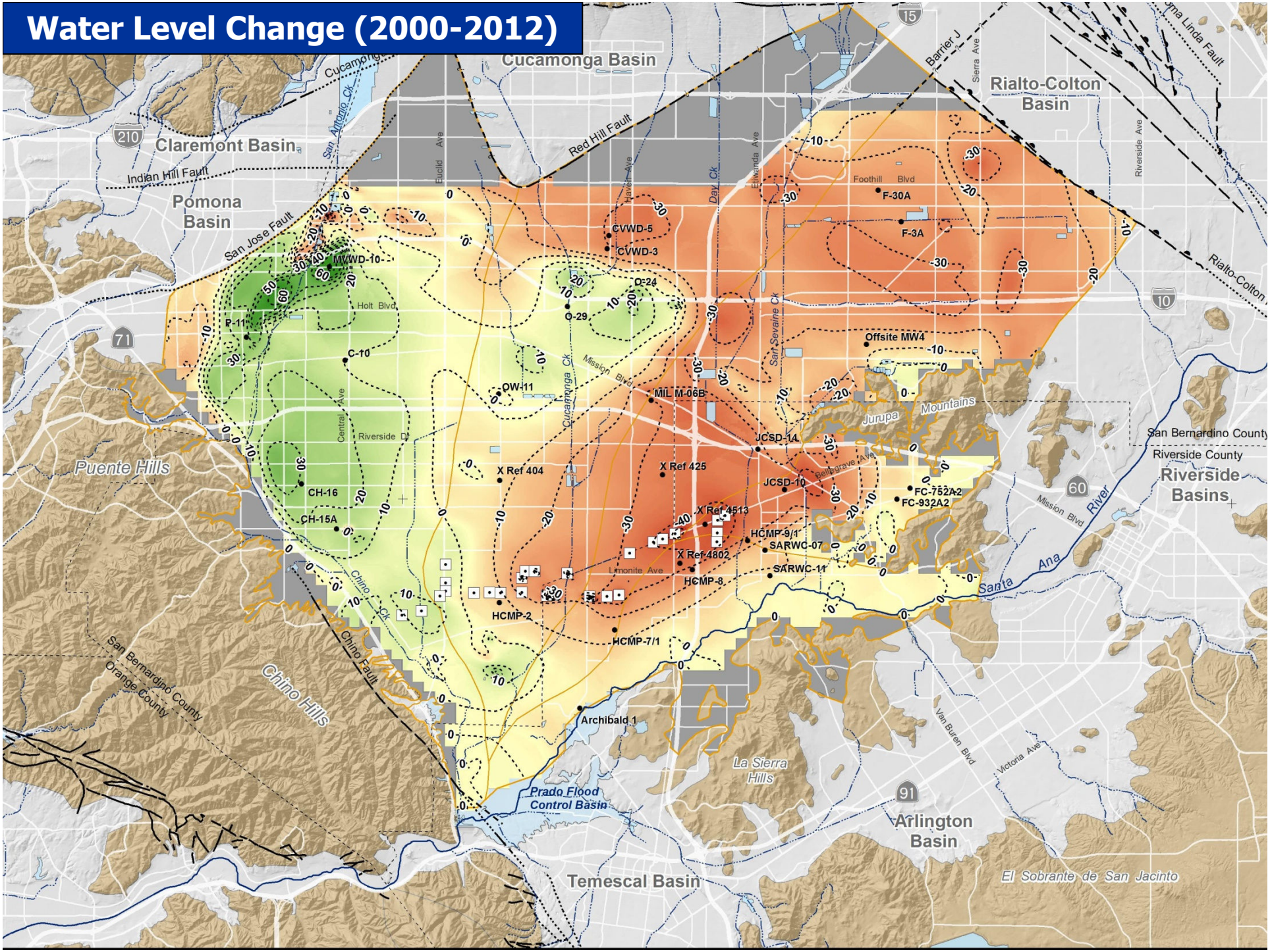
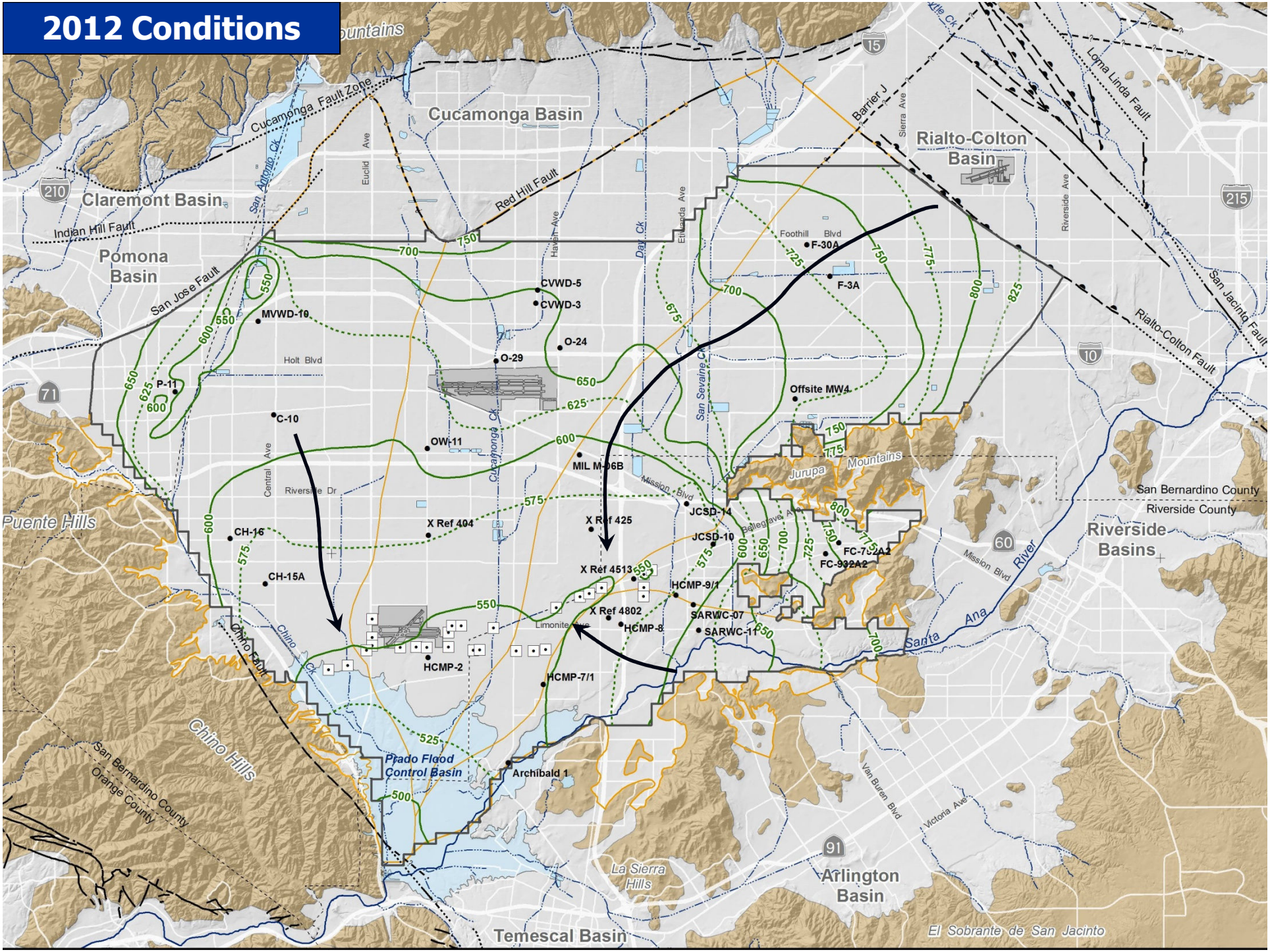


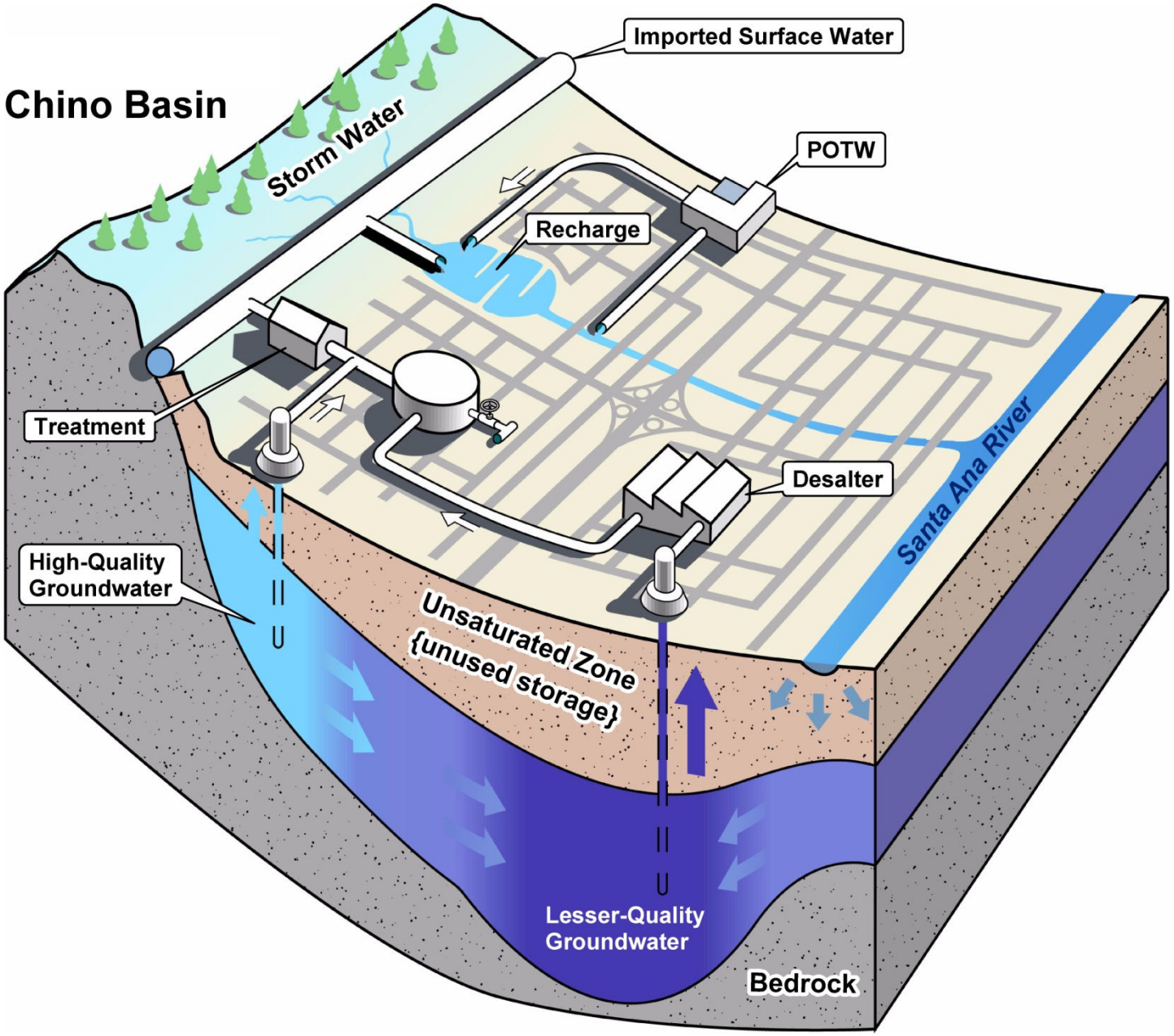
Figure 9
Water Level Time History (Shallow Wells)

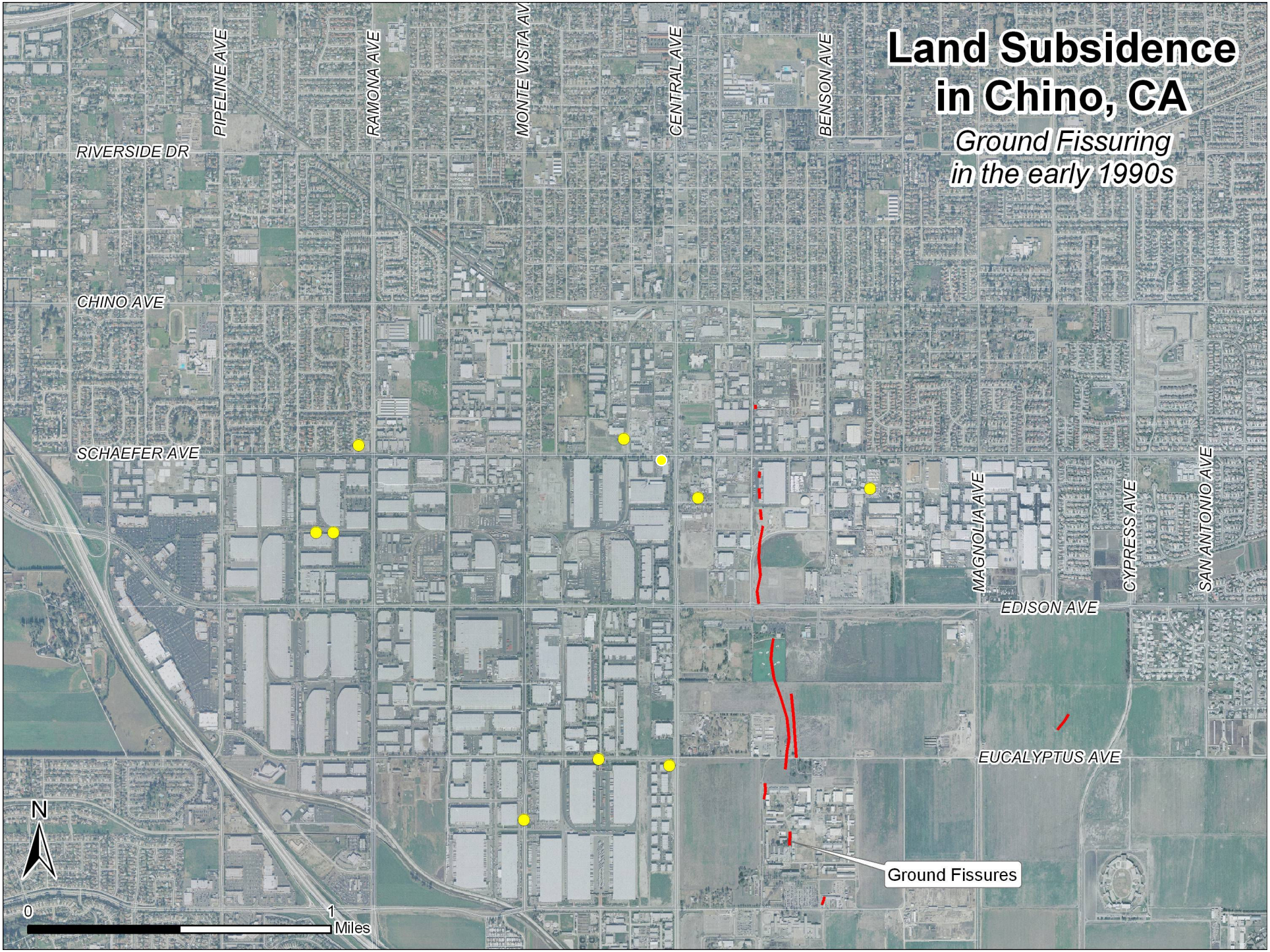


Water Level Change (2000-2012)




2012 Conditions
Cucamonga Basin
Claremont Basin
Pomona Basin
Rialto-Colton Basin
Arlington Basin
Temescal Basin
Riverside Basins
Puente Hills
Chino Hills
La Sierra Hills
El Sobrante de San Jacinto
Jurupa Mountains
Prado Flood Control Basin
Cucamonga Fault Zone
Red Hill Fault
Indian Hill Fault
San Jose Fault
Chino Fault
Rialto-Colton Fault
Loma Linda Fault
San Jacinto Fault
Barrier J
San Bernardino County
Riverside County
Orange County
Santa Ana River
Mission Blvd
Foothill Blvd
Holt Blvd
Riverside Dr
Limonite Ave
Victoria Ave
Van Buren Blvd
Euclid Ave
Haven Ave
Etiwanda Ave
Sierra Ave
Riverside Ave
Central Ave
Archibald 1
C-10
CH-15A
CH-16
CVWD-3
CVWD-5
F-30A
F-3A
FC-732A2
FC-932A2
HCMP-2
HCMP-7/1
HCMP-8
HCMP-9/1
JCSD-10
JCSD-14
MIL M-06B
MVWD-10
O-24
O-29
OW-11
Offsite MW4
P-11
SARWC-07
SARWC-11
X Ref 404
X Ref 425
X Ref 4513
X Ref 4802
15
210
215
10
60
71
91


Chino Basin
Imported Surface Water
Storm Water
POTW
Recharge
Treatment
Desalter
Santa Ana River
High-Quality Groundwater
Unsaturated Zone {unused storage}
Lesser-Quality Groundwater
Bedrock


Land Subsidence in Chino, CA
Ground Fissuring in the early 1990s
PIPELINE AVE
RAMONA AVE
MONTE VISTA AVE
CENTRAL AVE
BENSON AVE
RIVERSIDE DR
CHINO AVE
SCHAEFER AVE
MAGNOLIA AVE
CYPRESS AVE
SAN ANTONIO AVE
EDISON AVE
EUCALYPTUS AVE
Ground Fissures
N
0
1
Miles

View of a fissure that developed beneath CIM facility in December 1992

GEOMATRIX


Pipe Extensometer at Ayala Park

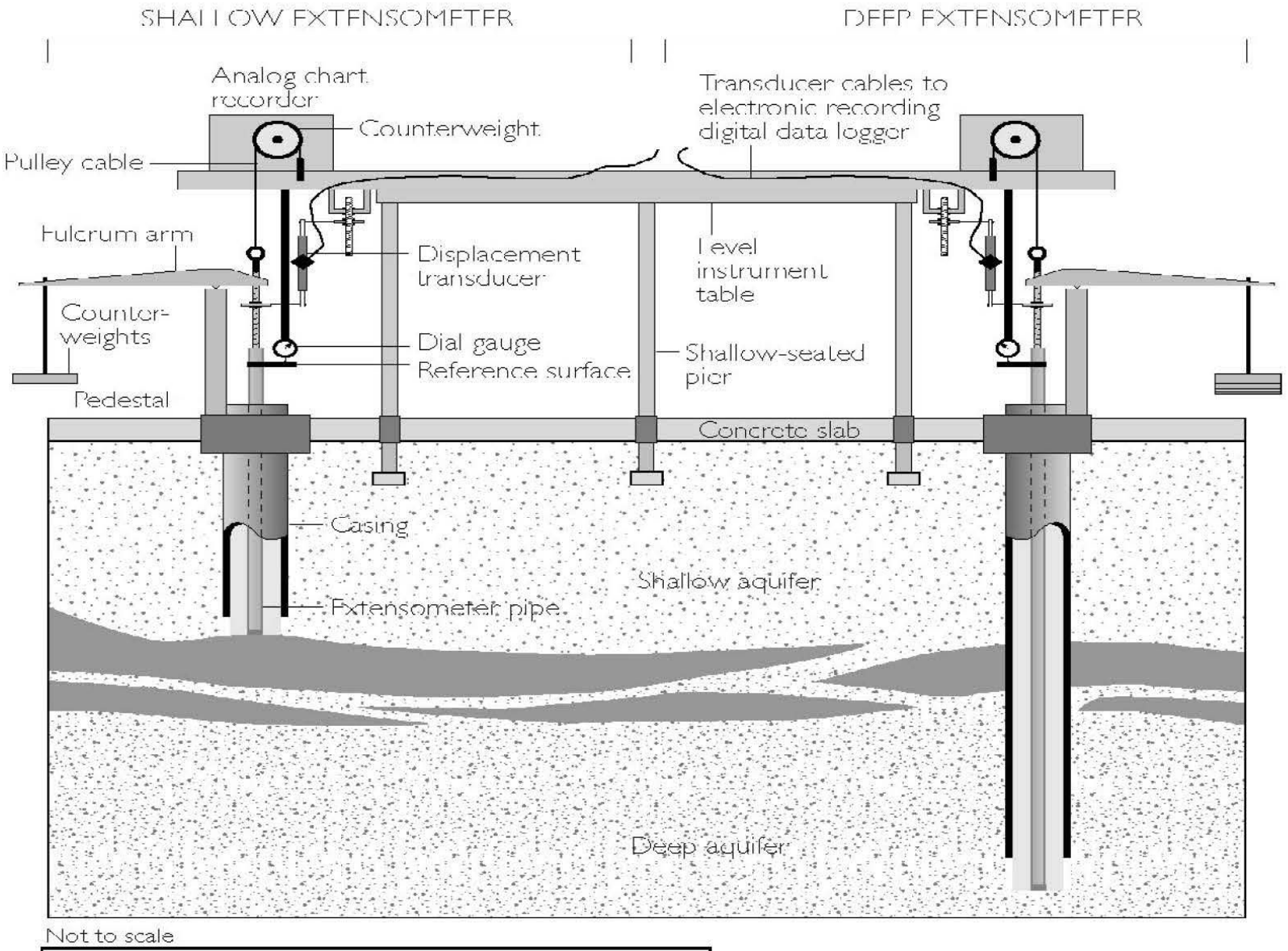
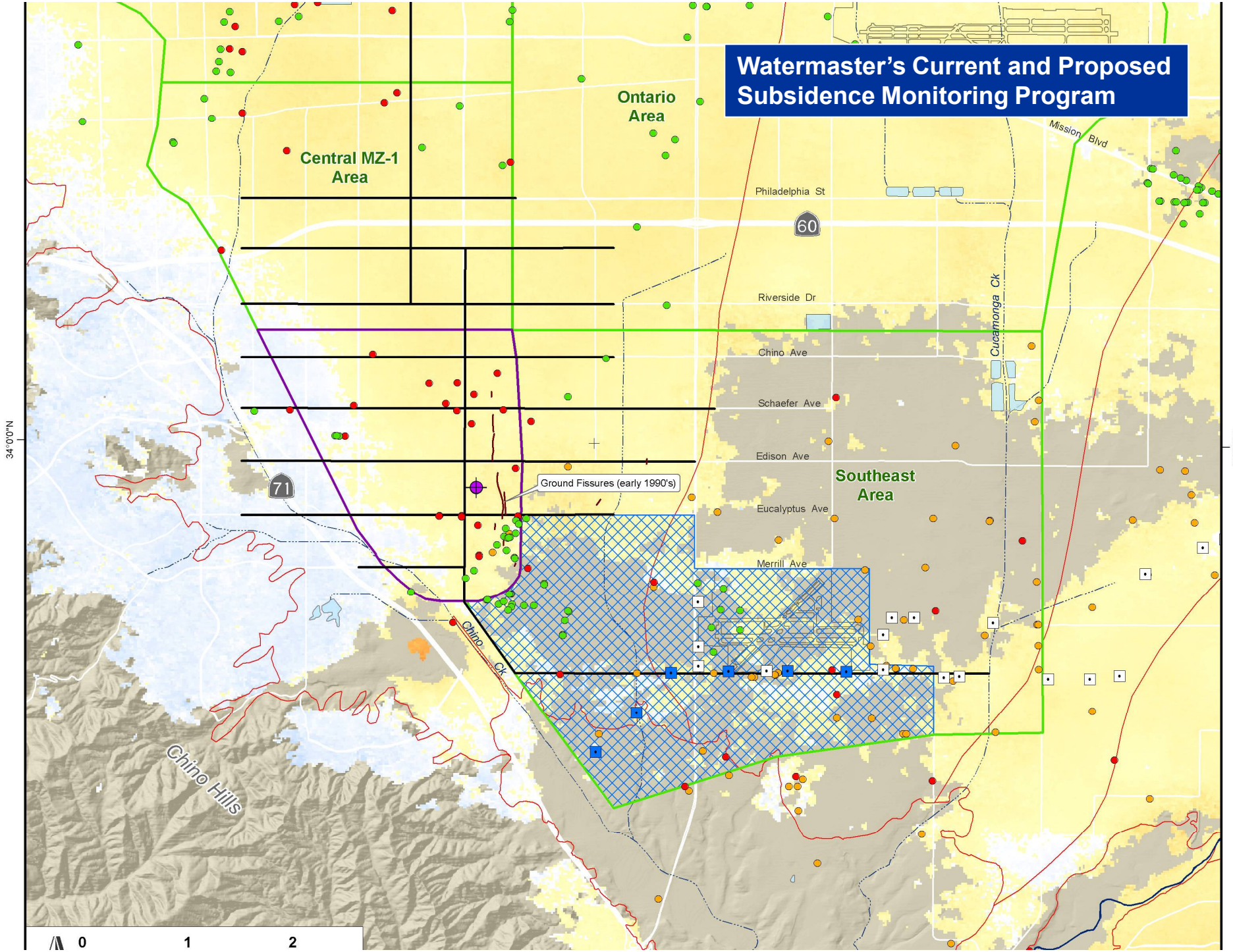


Figure 4
Schematic of Dual-Borehole Extensometer


Watermaster's Current and Proposed Subsidence Monitoring Program
Ontario Area
Central MZ-1 Area
Southeast Area
Ground Fissures (early 1990's)
Philadelphia St
Riverside Dr
Chino Ave
Schaefer Ave
Edison Ave
Eucalyptus Ave
Merrill Ave
Mission Blvd
Cucamonga Ck
Chino Ck
Chino Hills
60
71
34°0'0"N
0
1
2