

A Coupled Watershed and Groundwater-Flow Model of Sonoma Valley, CA

Tracy Nishikawa

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Problem

- **Sonoma Valley relies on surface water and groundwater for water supply**
- **Groundwater challenges**
 - **Declining water levels**
 - **Water quality**
 - **Seawater intrusion**
 - **Geothermal**
 - **Surface-water/groundwater interaction**

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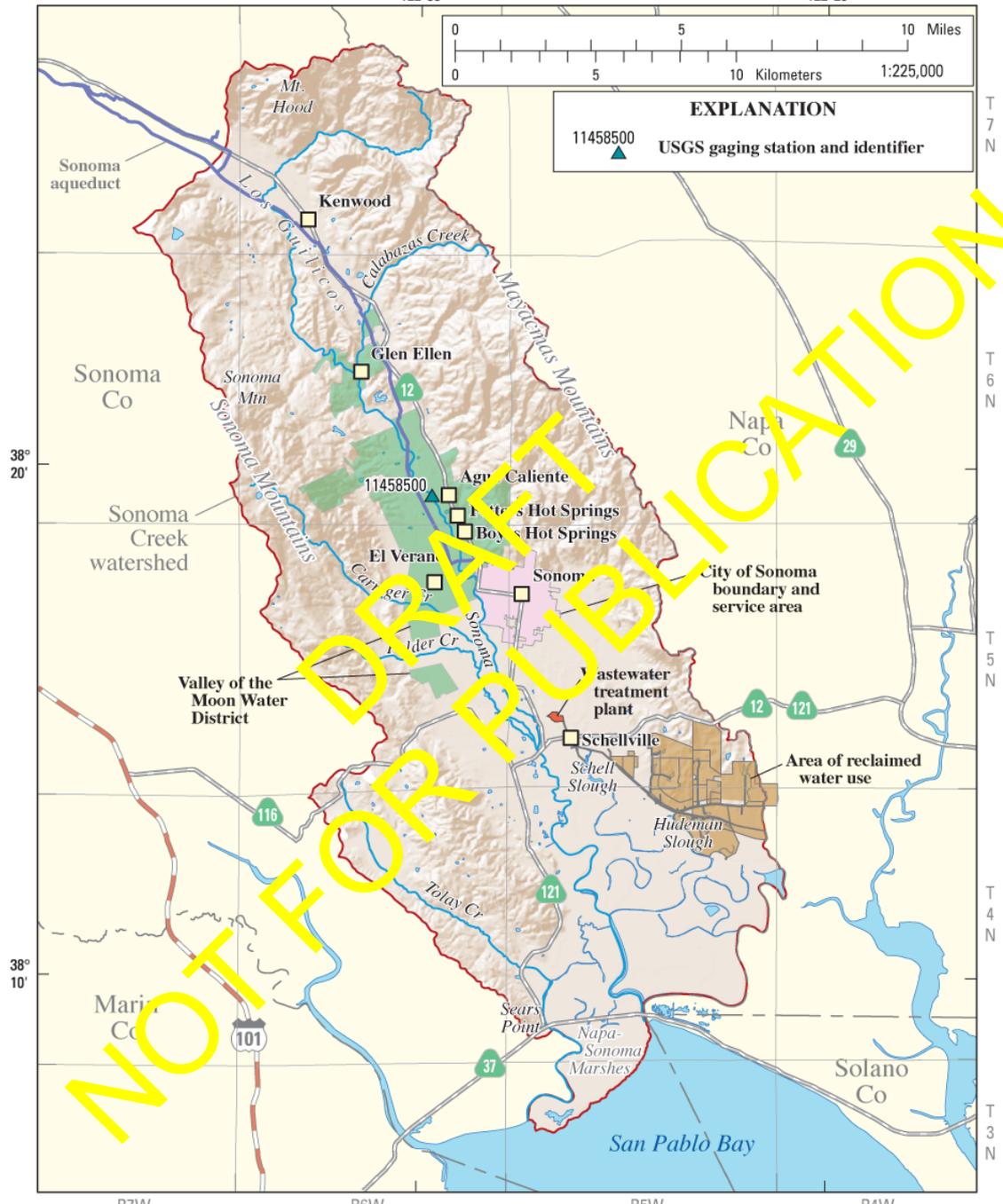
122°30'

122°20'



EXPLANATION

11458500 ▲ USGS gaging station and identifier



38° 20'

38° 10'

T 7 N
T 6 N
T 5 N
T 4 N
T 3 N

R7W R6W R5W R4W

Base from U.S. Geological Survey digital data, 1:250,000, 2003. State Plane Projection, Fipzone 402
Shaded relief base from 1:250,000 scale Digital Elevation Model: sun illumination from northwest at 30 degrees above horizon



Previous Work by Farrar et al. (2006)

- Characterized hydrogeology
- Seepage run on Sonoma Creek
- Characterized geochemistry
- Developed groundwater-flow model



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In cooperation with the
SONOMA COUNTY WATER AGENCY

Geohydrological Characterization, Water-Chemistry,
and Ground-Water Flow Simulation Model of the
Sonoma Valley Area, Sonoma County, California



Scientific Investigations Report 2006-5092

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Proposed Work

- **Compile and interpret existing data**
- **Refine hydrologic budget**
- **Refine conceptual model of groundwater-flow system**
- **Update model by Farrar et al. (2006) w/ coupled surface-water/groundwater-flow model**

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Interpret Existing Data

- **Gaging-station data to determine baseflow**
- **Complete analysis of 2010 seepage runs**
- **Develop 1900-2011 climate database**
 - **Precipitation**
 - **Air temperature**
- **Compile water-level data from local and state networks**
- **Compile available water-quality data**

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Refine Hydrologic Budget

- **Recharge-related data**
 - Precipitation
 - Water chemistry including isotopes
 - Seepage runs
- **Discharge-related data**
 - Pumping
 - Land use (estimate ag and domestic pumping)
 - Vegetation type and density (ET)

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Refine Groundwater Conceptual Model

- Reassess hydrostratigraphy
 - 3D extent of aquifers
 - 3D extent of faults
 - Define areas of water-level decline
- Distribution and quantity of recharge and discharge

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Update Existing Model

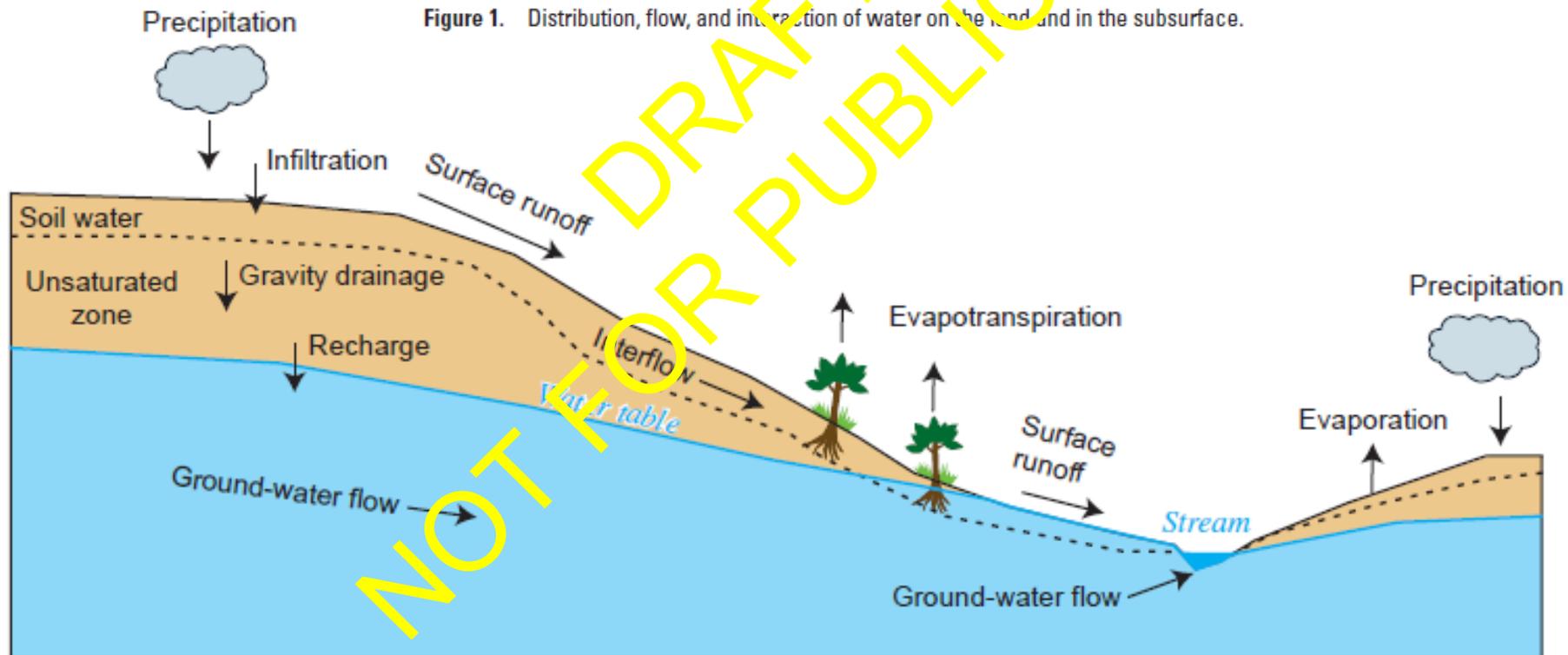
- Develop coupled watershed and groundwater-flow model using GSFLOW
 - Couples PRMS with MODFLOW
 - Currently completing model of Santa Rosa Plain
- 3 phases
 - **MODFLOW**
 - PRMS
 - GSFLOW

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GSFLOW—Coupled Ground-Water and Surface-Water Flow Model Based on the Integration of the Precipitation-Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW-2005)

By Steven L. Markstrom, Richard G. Niswonger, R. Steven Regan, David E. Prudic, and Paul M. Barlow

Figure 1. Distribution, flow, and interaction of water on the land and in the subsurface.



Why GSFLOW? 2 Words: “Natural Recharge”

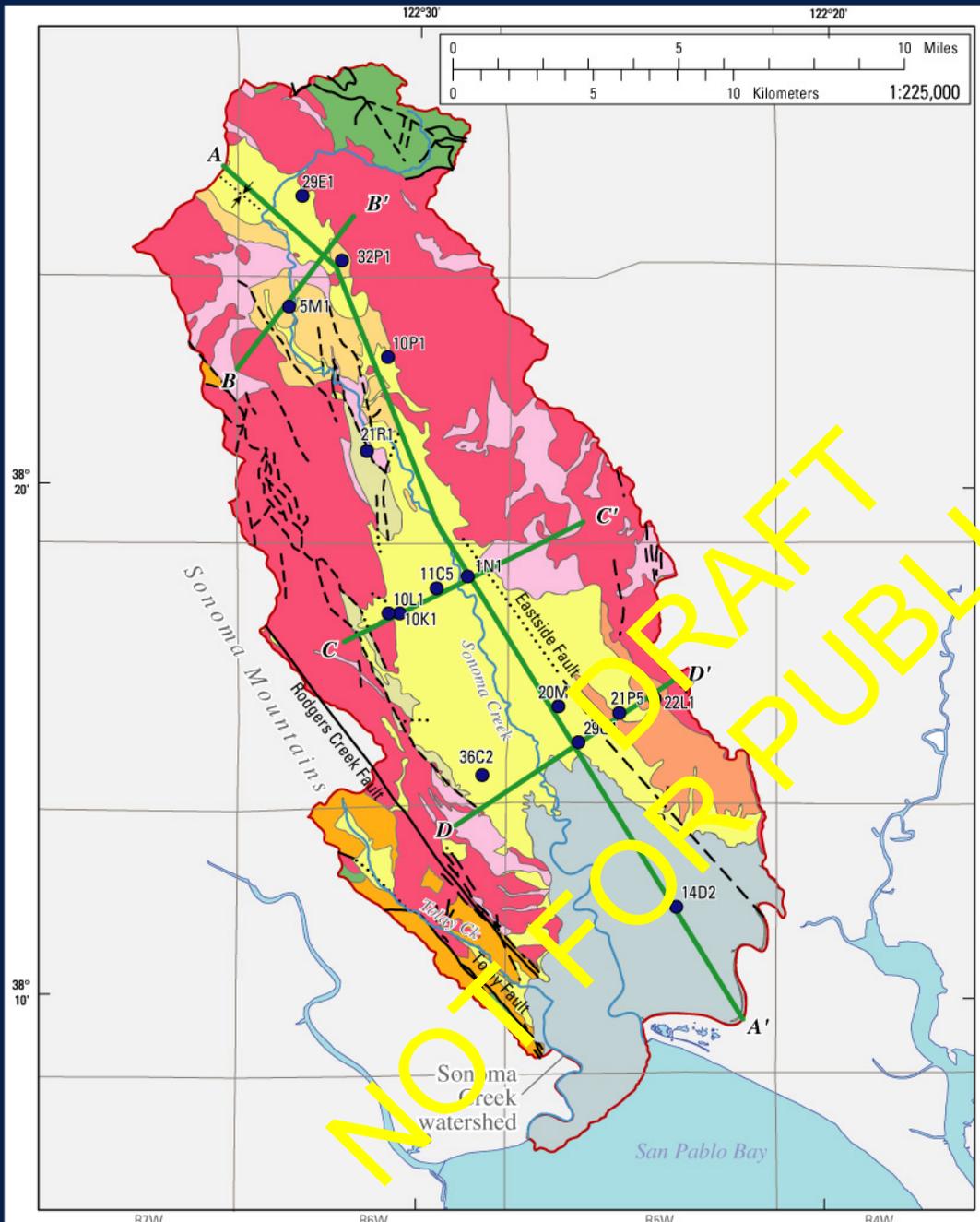
- Estimate based on precipitation record or surrogate
- Simulate recharge using a watershed model and use as input for groundwater-flow model
- Coupled approach, e.g., GSFLOW

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Proposed Work: MODFLOW

	Original	Updated
Model	MODFLOW-2000	MODFLOW-2005
Domain	Alluvial fill	Entire watershed
# of layers	8	???
Grid size	1,320 x 1,320 ft	???
Simulation horizon	1975-2000	???
Natural recharge	Estimated using zones	Bauer (2008) approach, SCWA/SEC recharge map, or BCM

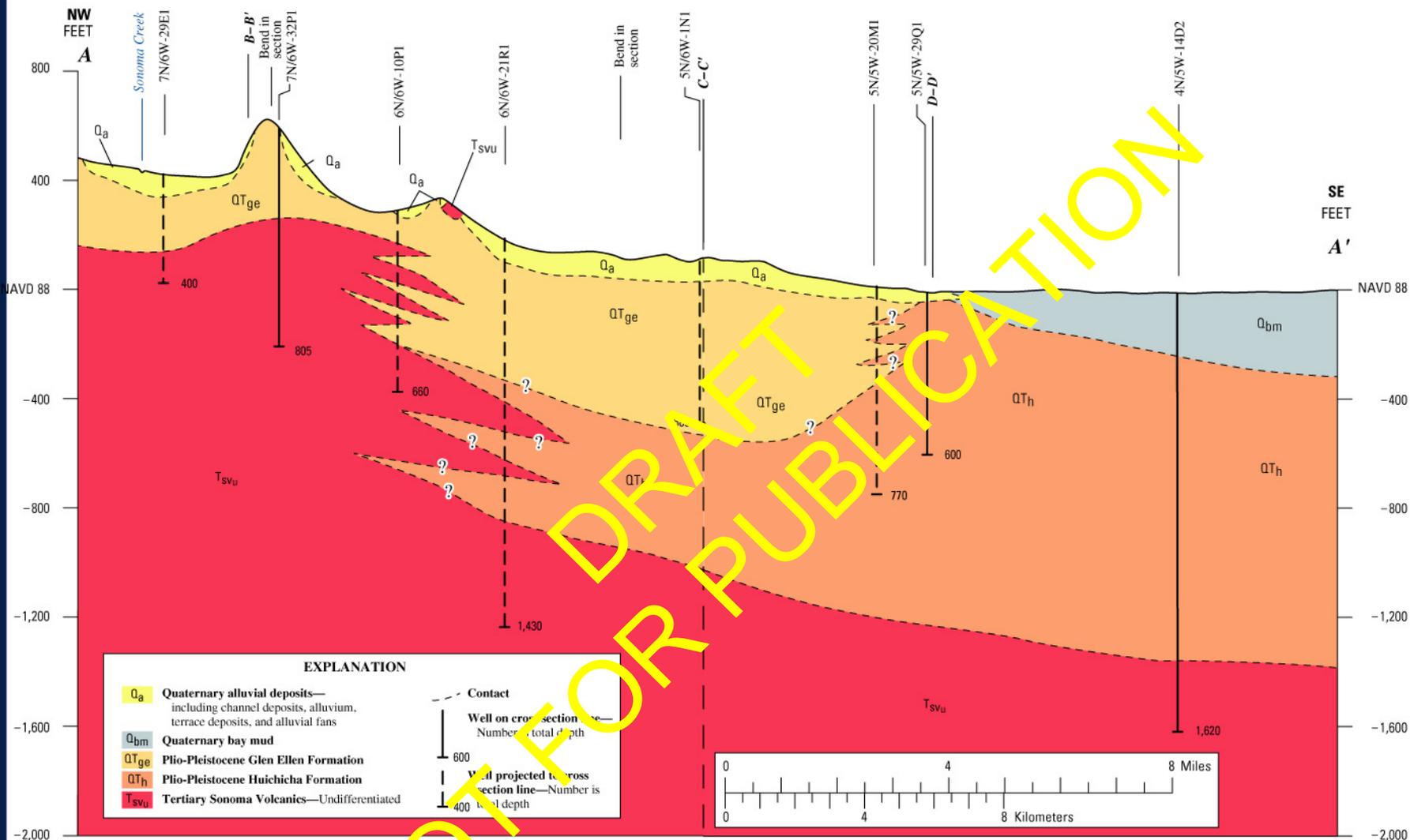
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EXPLANATION

Geologic unit		Age
Q _{bm}	Bay mud—Silt, clay, and peat	Holocene
Q _a	Quaternary alluvial units—Stream channel deposits, stream terrace deposits, alluvial fan deposits, and flood plain deposits	Holocene to Pleistocene
QT _{ge}	Glen Ellen Formation—Fluvial deposits of gravels, sand, and clay	Early Pleistocene to Pliocene
QT _h	Huichila Formation—Fluvial deposits of gravels, sand, and clay with interbedded tuffs	Pliocene
T _s	Unnamed sedimentary unit	Pliocene
T _{sv}	Sonoma Volcanics—Volcaniclastic rocks	Pliocene to Miocene
T _{sv}	Sonoma Volcanics—Lavas, tuffs and breccias (figure 9)	Pliocene to Miocene
T _{svu}	Sonoma Volcanics—Undifferentiated shown in cross-sections (figure 10)	Pliocene to Miocene
T _p	Petaluma Formation—Lacustrine and fluvial deposits of siltstone, sandstone, shale, and conglomerate with interbedded tuffs	Miocene
KJ _f	Franciscan Complex—Mélange with blocks of graywacke, chert, greenstone, and metamorphic rocks	Cretaceous to Jurassic
— Faults—Solid where accurately located, dashed where approximate, queried where uncertain, dotted where concealed		
⋯⋯⋯? Syncline—Dotted where concealed		
B—B' Line of geologic section—See figures 10A–10D		
● Well and identifier		





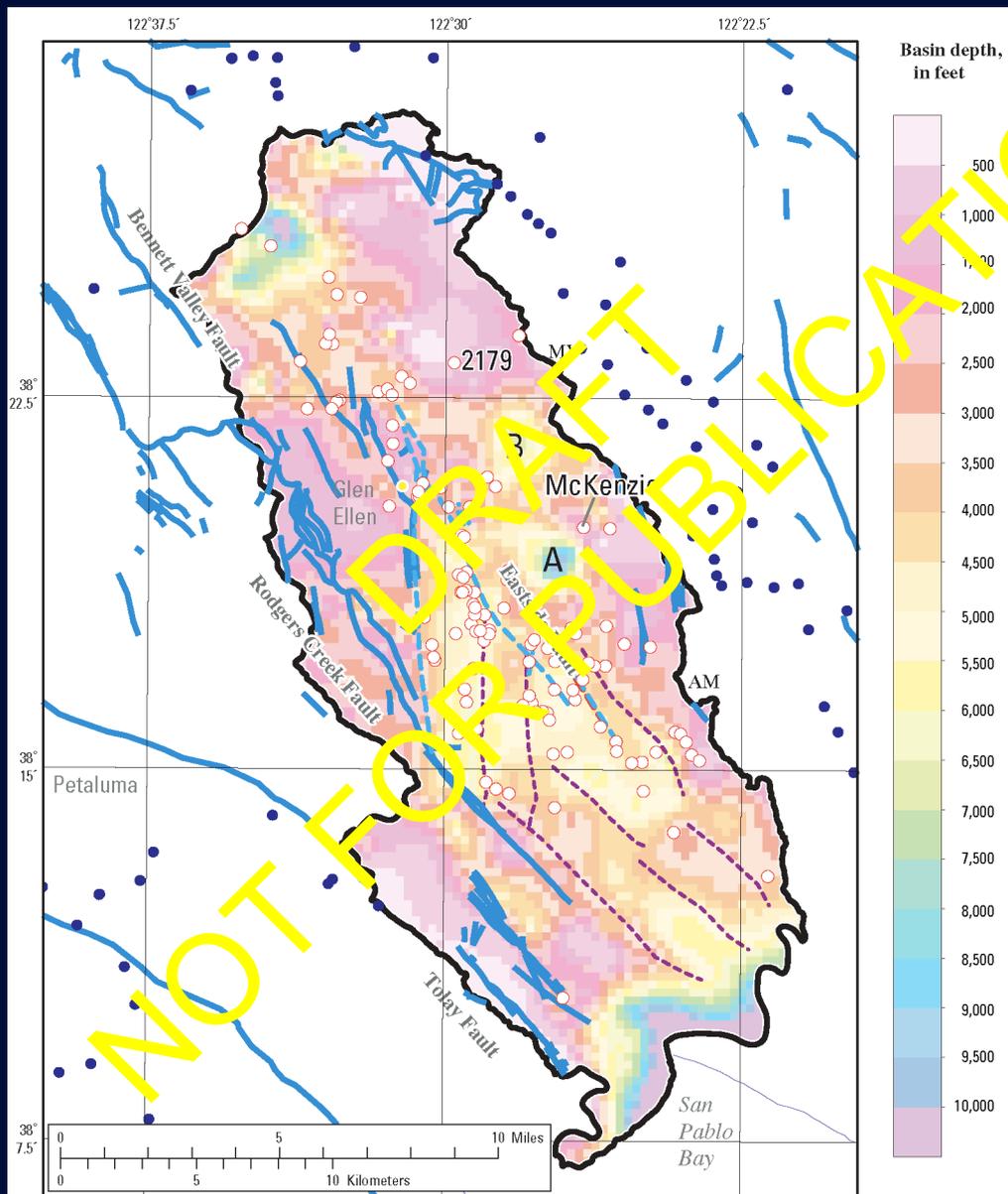
EXPLANATION	
Q_a	Quaternary alluvial deposits— including channel deposits, alluvium, terrace deposits, and alluvial fans
Q_{bm}	Quaternary bay mud
Q_{Tge}	Plio-Pleistocene Glen Ellen Formation
Q_{Th}	Plio-Pleistocene Huichicha Formation
T_{svu}	Tertiary Sonoma Volcanics—Undifferentiated
	Contact
	Well on cross section— Number is total depth
	Well projected to cross section line—Number is well depth

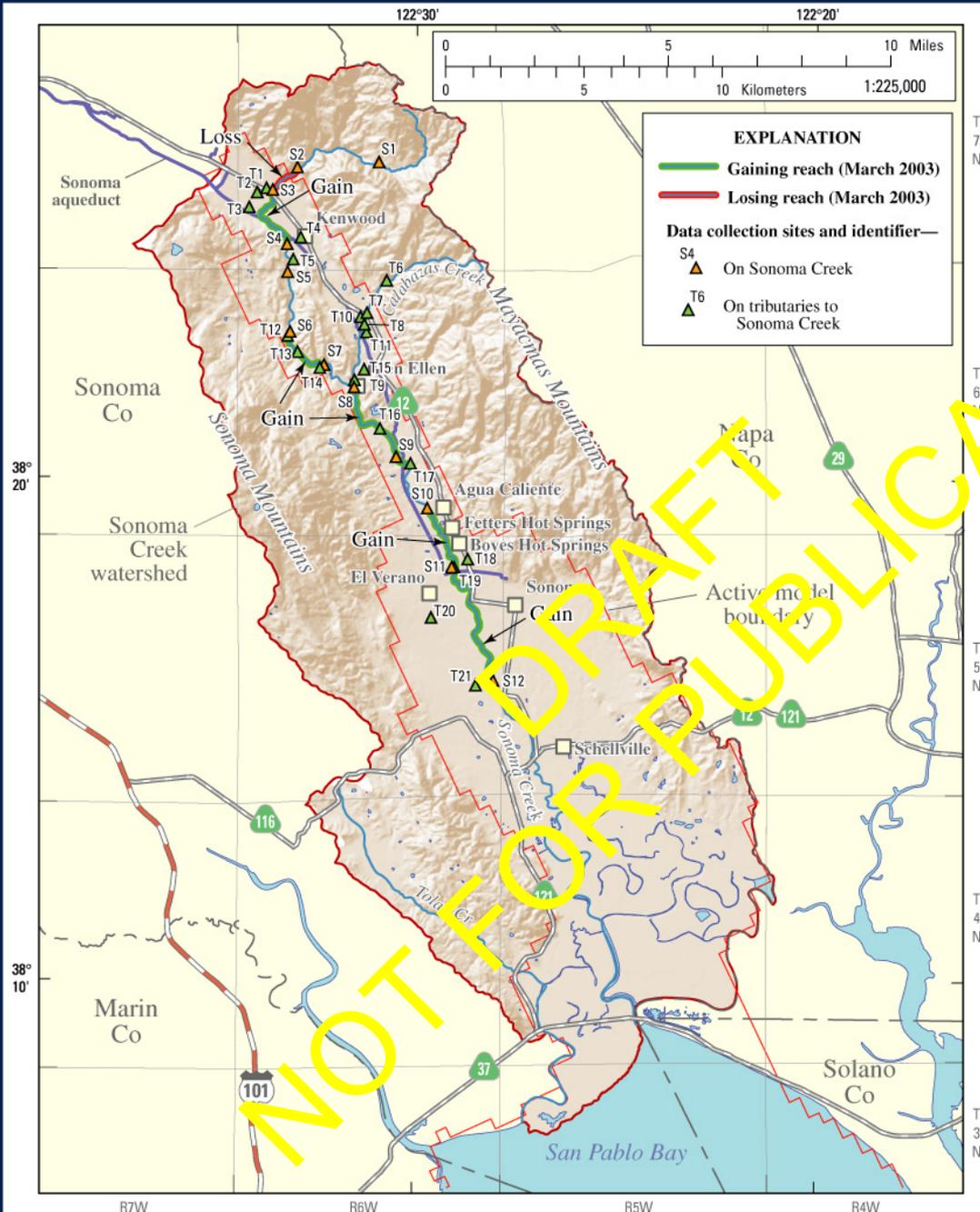
Trace of section shown on figure 9

VERTICAL SCALE GREATLY EXAGGERATED



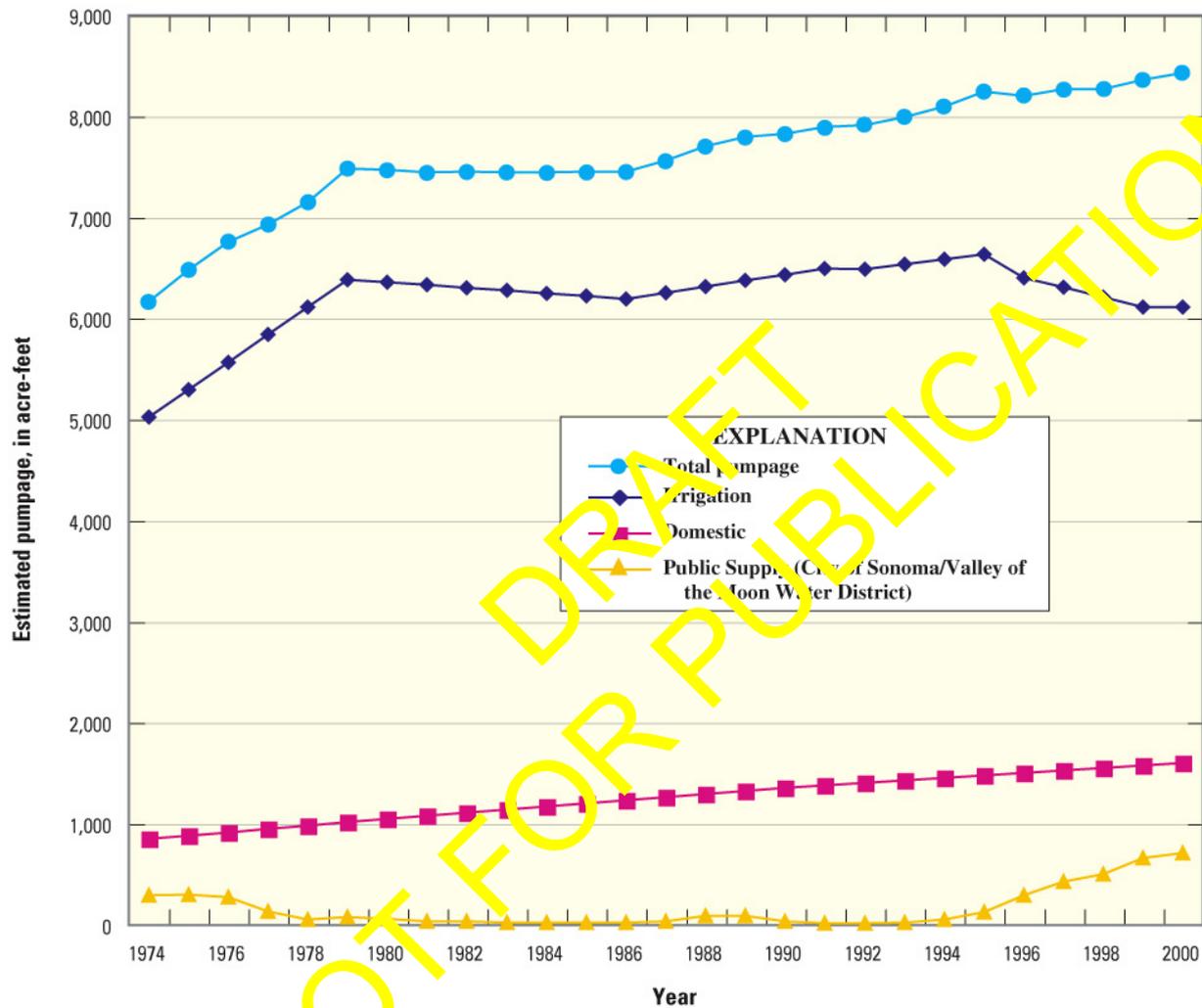
Depth to Basement





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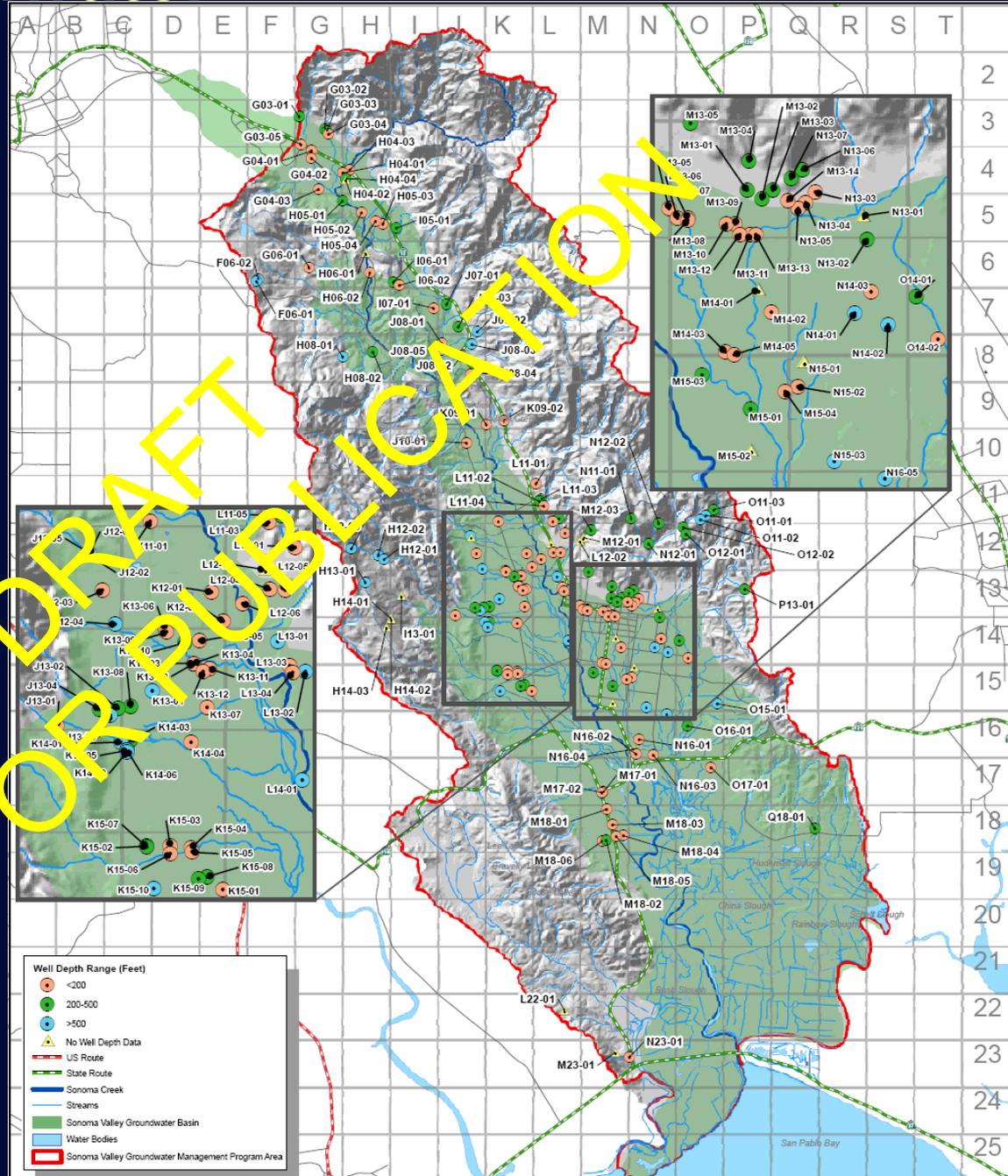
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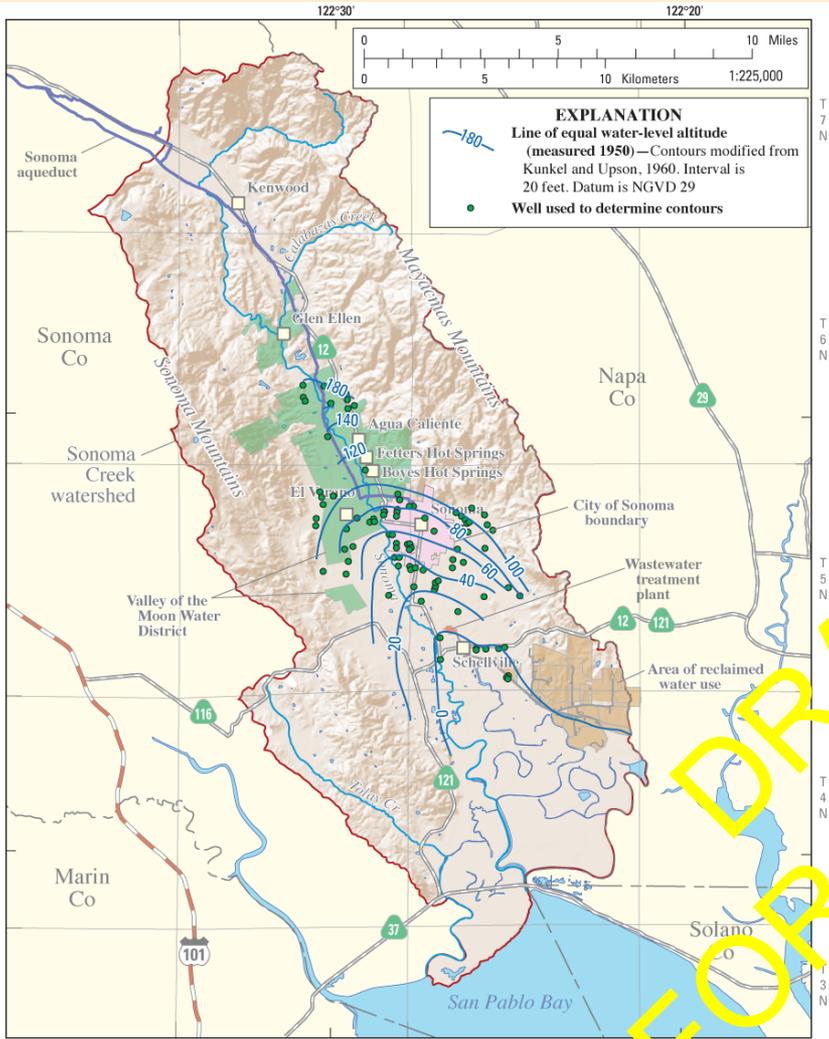
Voluntary Groundwater-Level Monitoring

- 80 - New Wells since 2007

- 140 - Wells with Synchronized Monitoring

- Track and Assess Seasonal and Long-term Trends

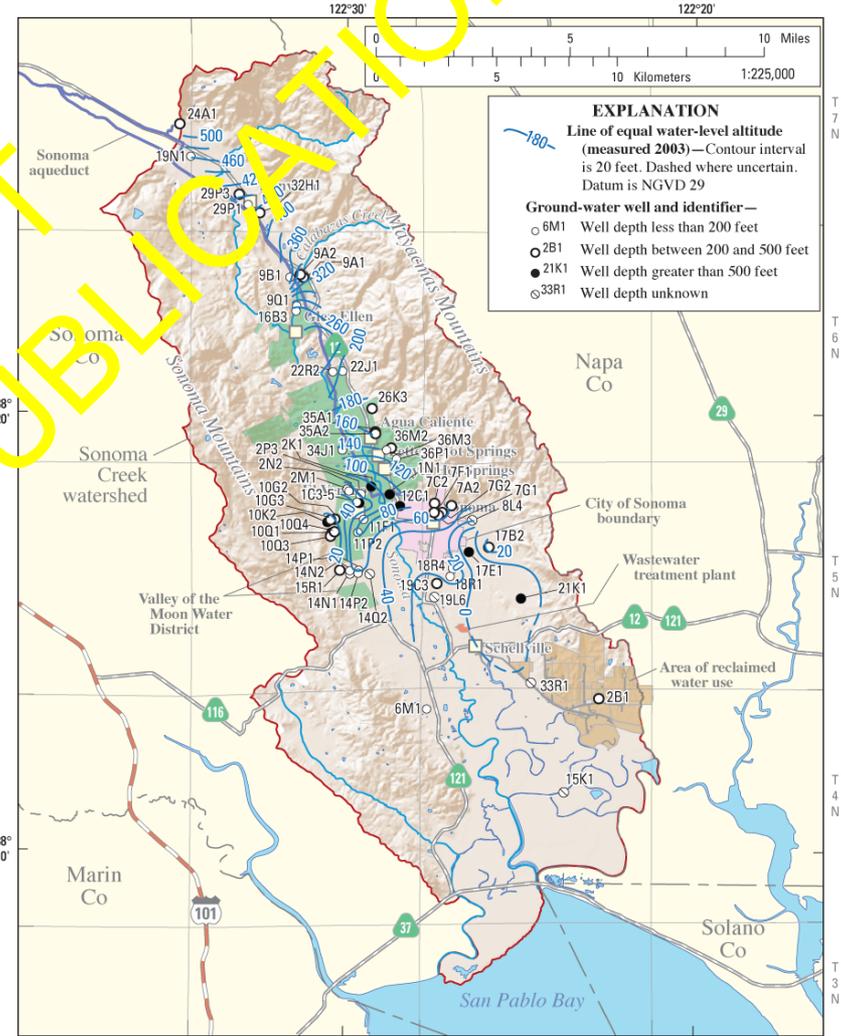




EXPLANATION
 Line of equal water-level altitude (measured 1950)—Contours modified from Kunkel and Upson, 1960. Interval is 20 feet. Datum is NGVD 29
 Well used to determine contours

Base from U.S. Geological Survey digital data, 1:250,000, 2003. State Plane Projection, Fipzone 402
 Shaded relief base from 1:250,000 scale Digital Elevation Model; sun illumination from northwest at 30 degrees above horizon

2003



EXPLANATION
 Line of equal water-level altitude (measured 2003)—Contour interval is 20 feet. Dashed where uncertain. Datum is NGVD 29
 Ground-water well and identifier—
 ○ 6M1 Well depth less than 200 feet
 ○ 2B1 Well depth between 200 and 500 feet
 ● 21K1 Well depth greater than 500 feet
 ○ 33R1 Well depth unknown

Base from U.S. Geological Survey digital data, 1:250,000, 2003. State Plane Projection, Fipzone 402
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1950



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Recent Groundwater Conditions

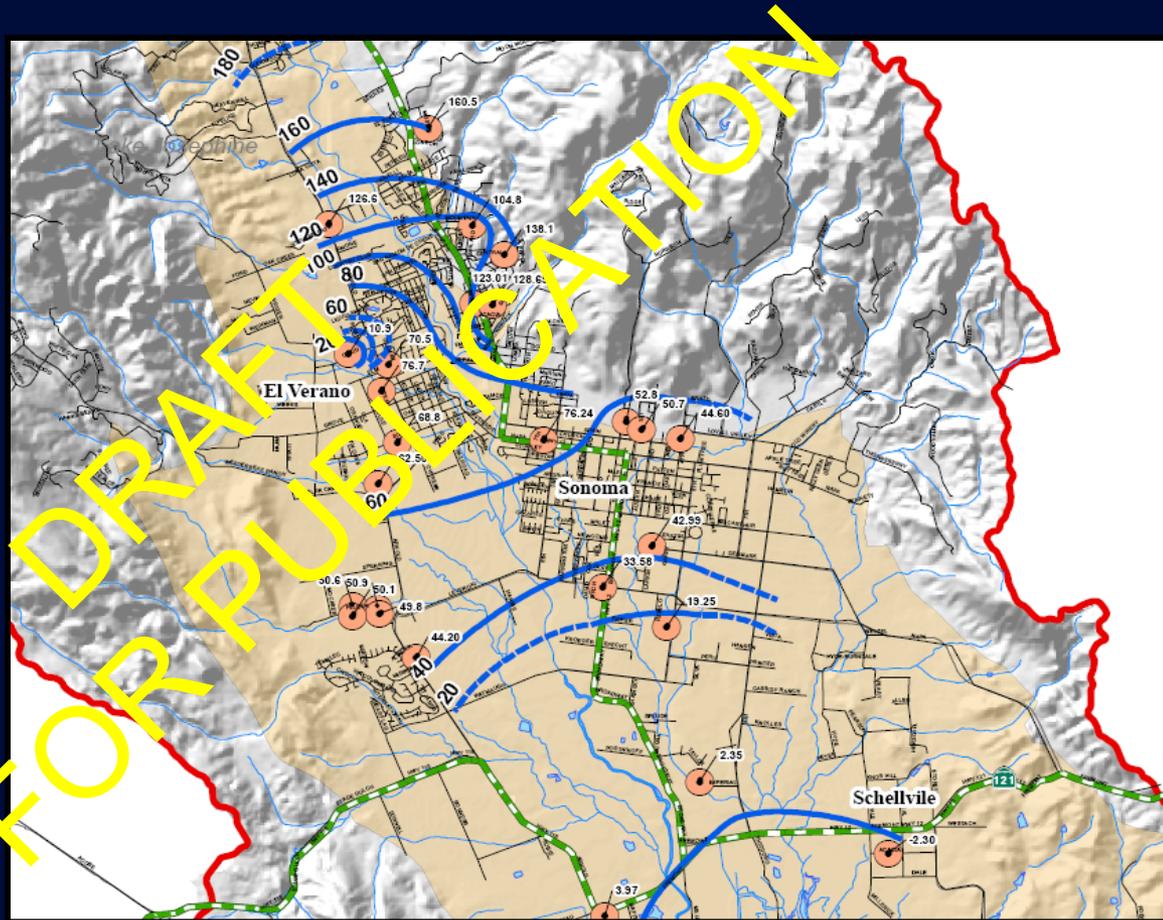
Shallow-Zone wells generally stable and above sea level

➤ Localized areas of declining groundwater levels mainly observed in Deeper-Zone wells

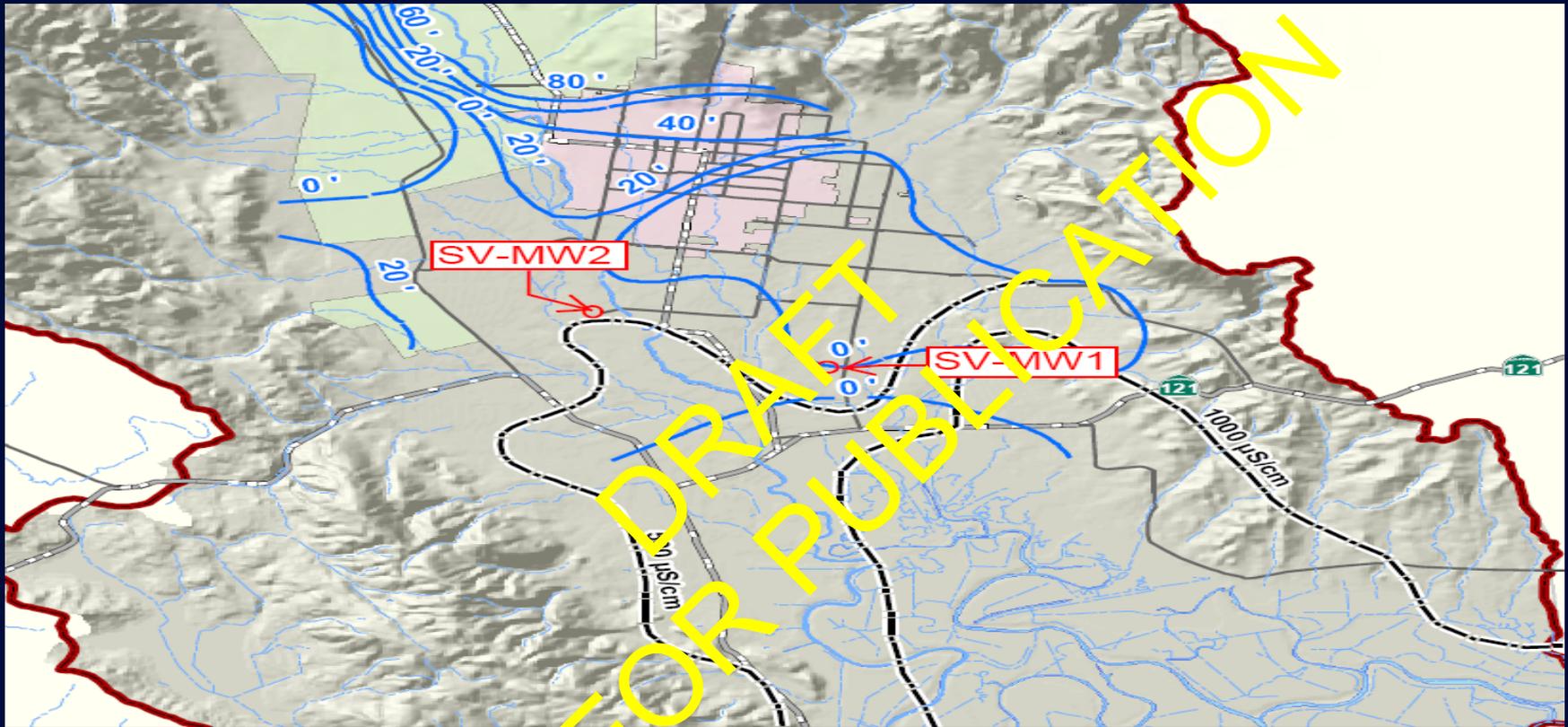
➤ El Verano Area

➤ Southeast of City of Sonoma

➤ Groundwater-levels are locally below sea level



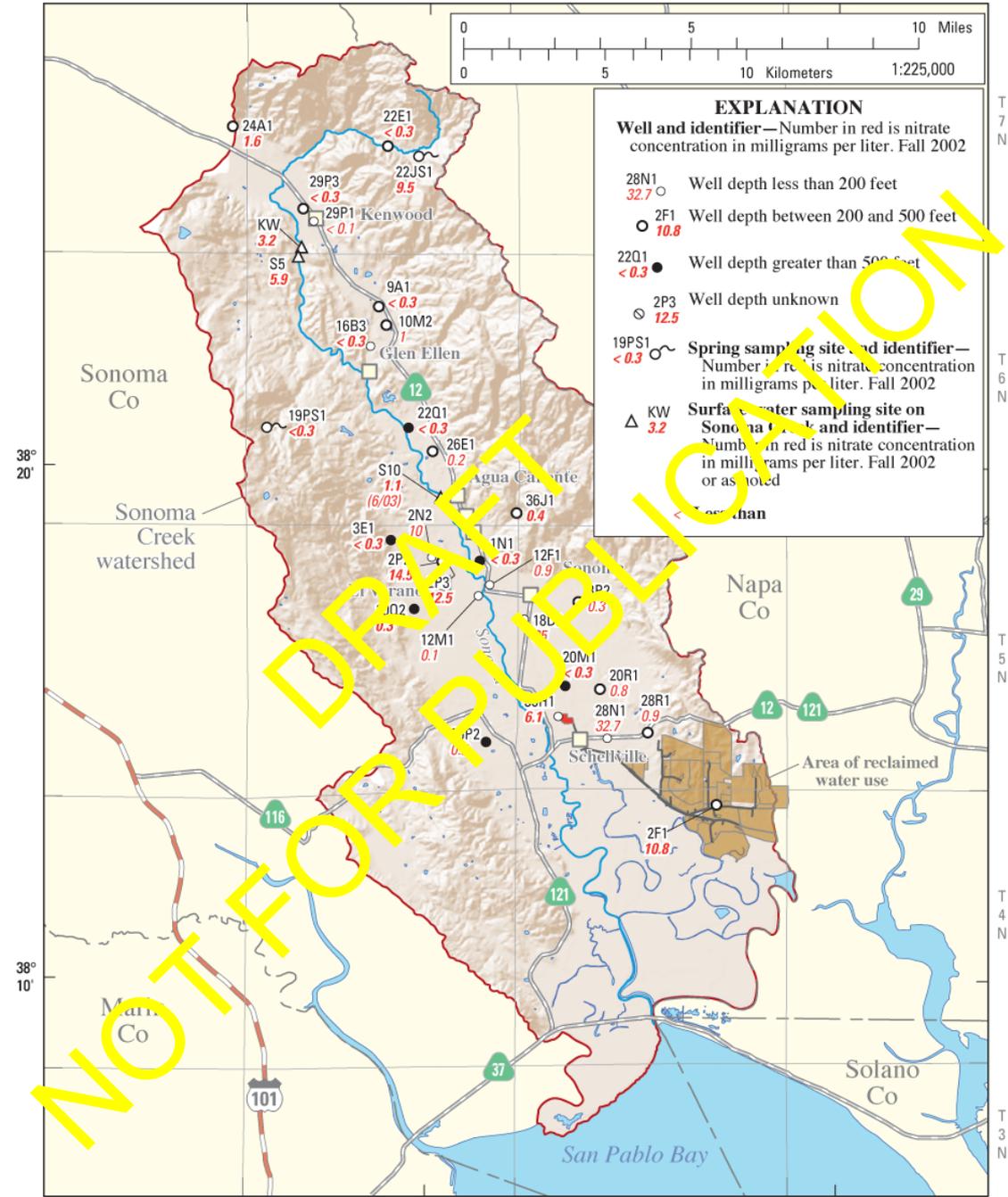
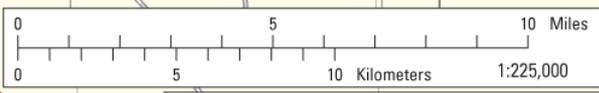
Incorporate New Nested Groundwater Monitoring Wells



- Geologic logs for hydrostratigraphy
- Water levels for characterization and model calibration
- Water quality for characterization and model calibration

122°30'

122°20'



EXPLANATION

Well and identifier—Number in red is nitrate concentration in milligrams per liter. Fall 2002

- 28N1 32.7 Well depth less than 200 feet
- 2F1 10.8 Well depth between 200 and 500 feet
- 22Q1 <0.3 Well depth greater than 500 feet
- 2P3 12.5 Well depth unknown

Spring sampling site and identifier—Number in red is nitrate concentration in milligrams per liter. Fall 2002

- 19PS1 <0.3

Surface water sampling site on Sonoma Creek and identifier—Number in red is nitrate concentration in milligrams per liter. Fall 2002 or as noted

- △ KW 3.2

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T 7 N
T 6 N
T 5 N
T 4 N
T 3 N

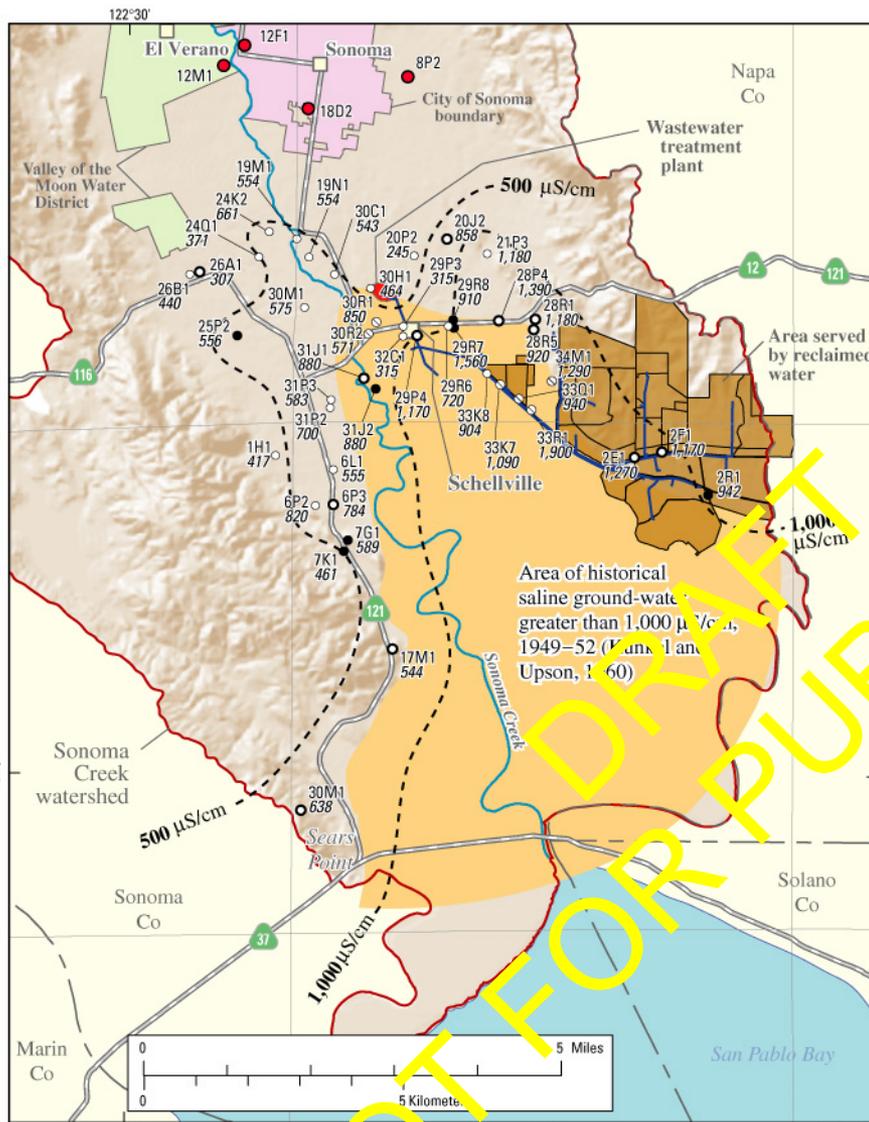
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Shaded relief base from 1:250,000 scale Digital Elevation Model; sun illumination from northwest at 30 degrees above horizon





Base from U.S. Geological Survey digital data, 1:250,000, 2, 3, State Plane Projection, Fipzone 402. Shaded relief base from 1:250,000 scale Digital Elevation Model; sun illumination from northwest at 30 degrees above horizon.

EXPLANATION

- Reclaimed water distribution system
- Line of equal specific conductance (field) for September 2003, in microSiemens per centimeter
- 18D2 Well and identifier—Near City of Sonoma with specific conductance greater than 500 microSiemens per centimeter, as measured by CADWR 2002–04

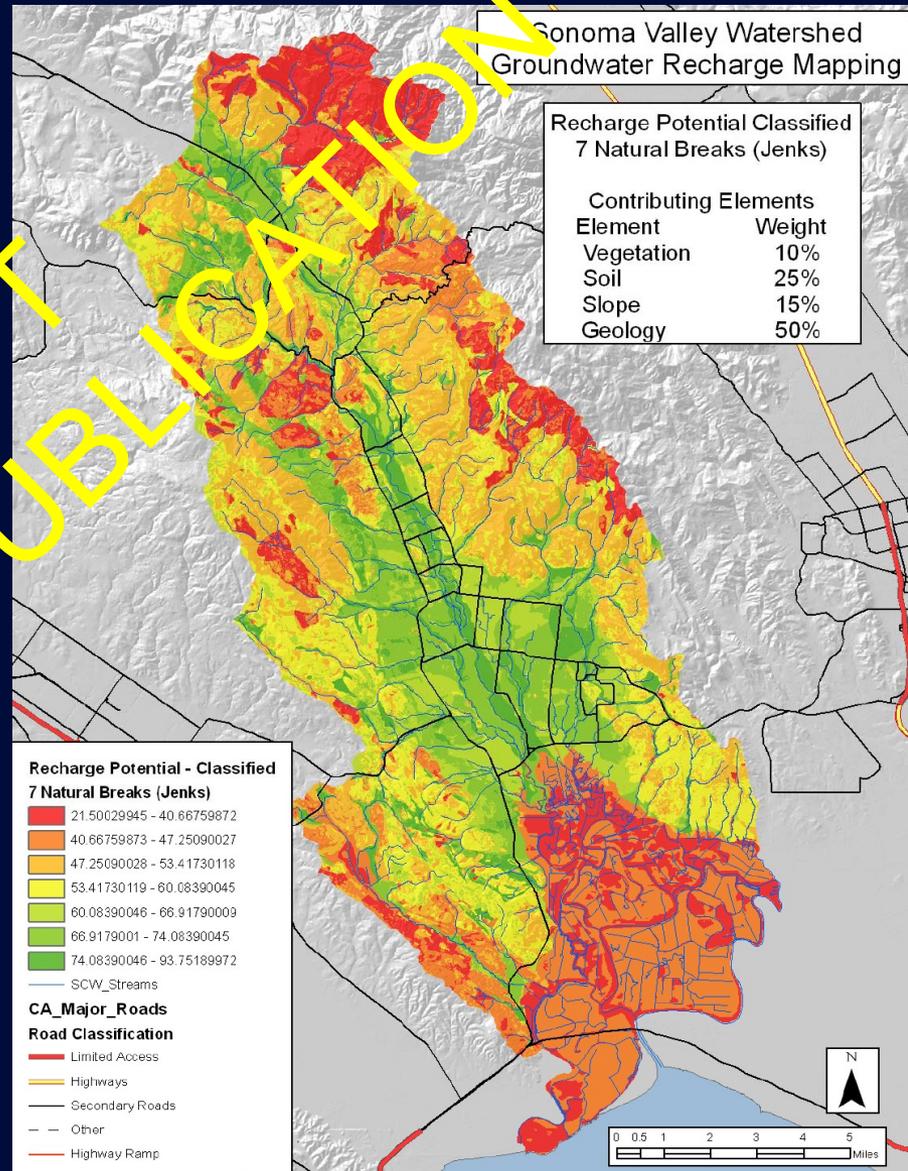
- Well and identifier**—Number in italics is specific conductance in microSiemens per centimeter, measured by USGS 2003
- 30H1 Well depth less than 200 feet
- 464 Well depth less than 200 feet
- 17M1 Well depth between 200 and 500 feet
- 544 Well depth between 200 and 500 feet
- 31J2 Well depth greater than 500 feet
- 880 Well depth greater than 500 feet
- 33K7 Well depth unknown
- 1,090 Well depth unknown



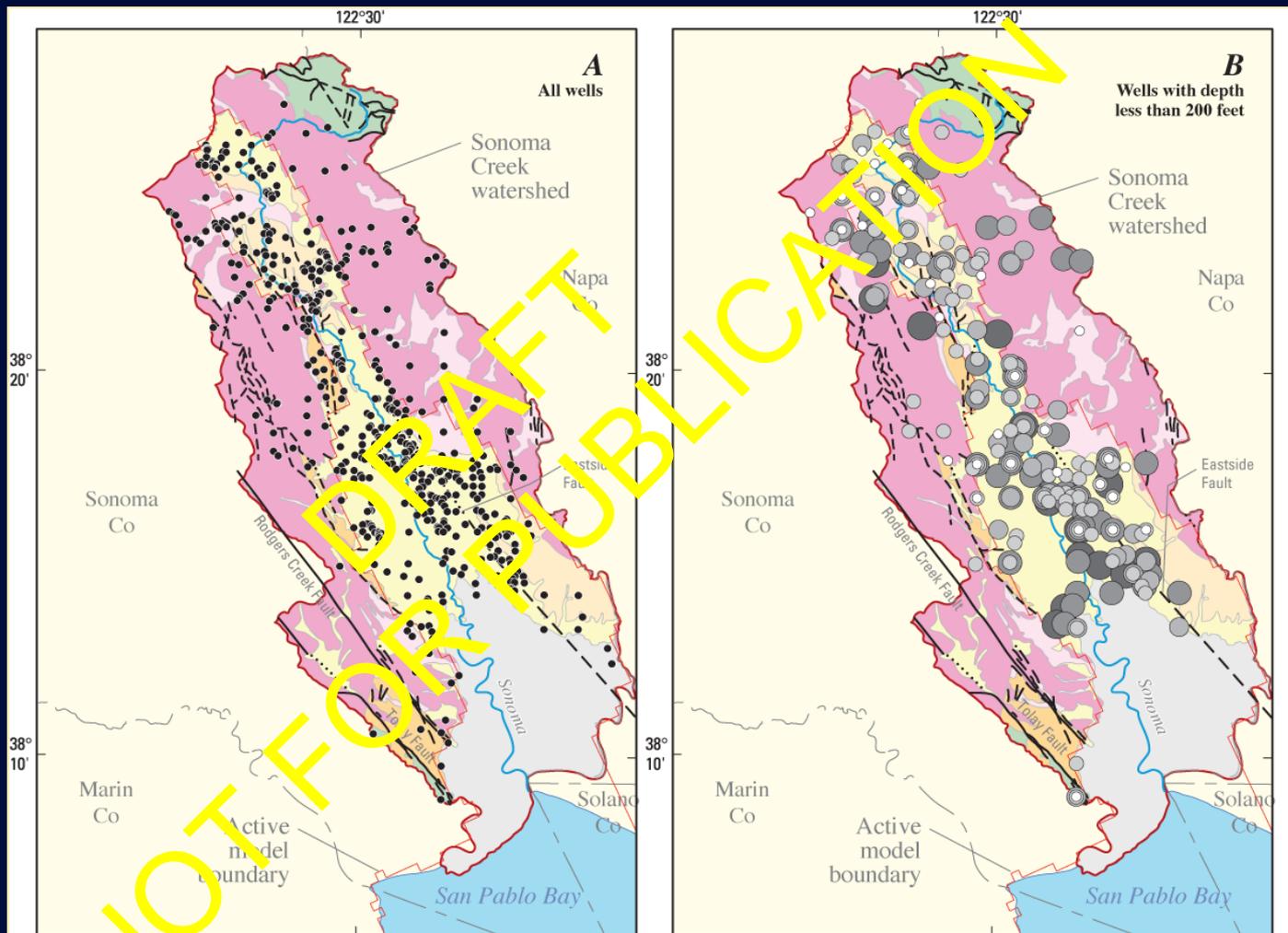
Groundwater Recharge Potential Mapping by SEC

- Conducted by Sonoma Ecology Center using California DWR grant funds
- Integrating and ranking recharge components including, Geology, Soil, Slope, and Vegetation
- Identify potential groundwater recharge areas and locations suitable for multiple-scale groundwater recharge enhancement projects

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Specific-Capacity

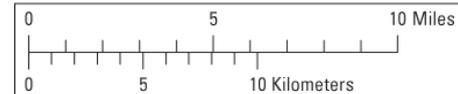


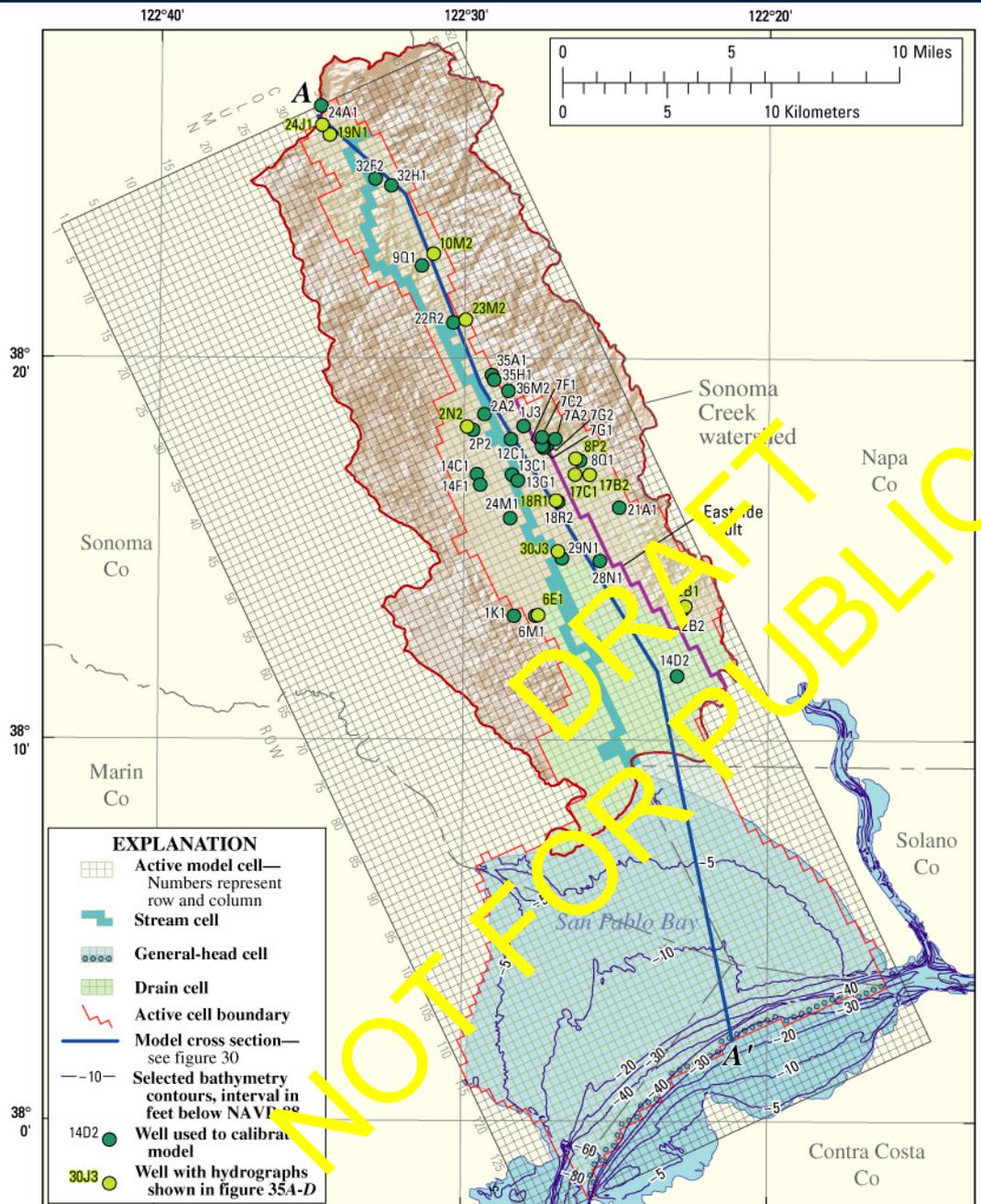
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EXPLANATION

- Faults— Solid where accurately located, dashed where approximate, dotted where concealed
- Wells
- Less than 0.2
- 0.2 to 0.5
- Greater than 0.5 to 1.0
- Greater than 1.0 to 5.0
- Greater than 5.0

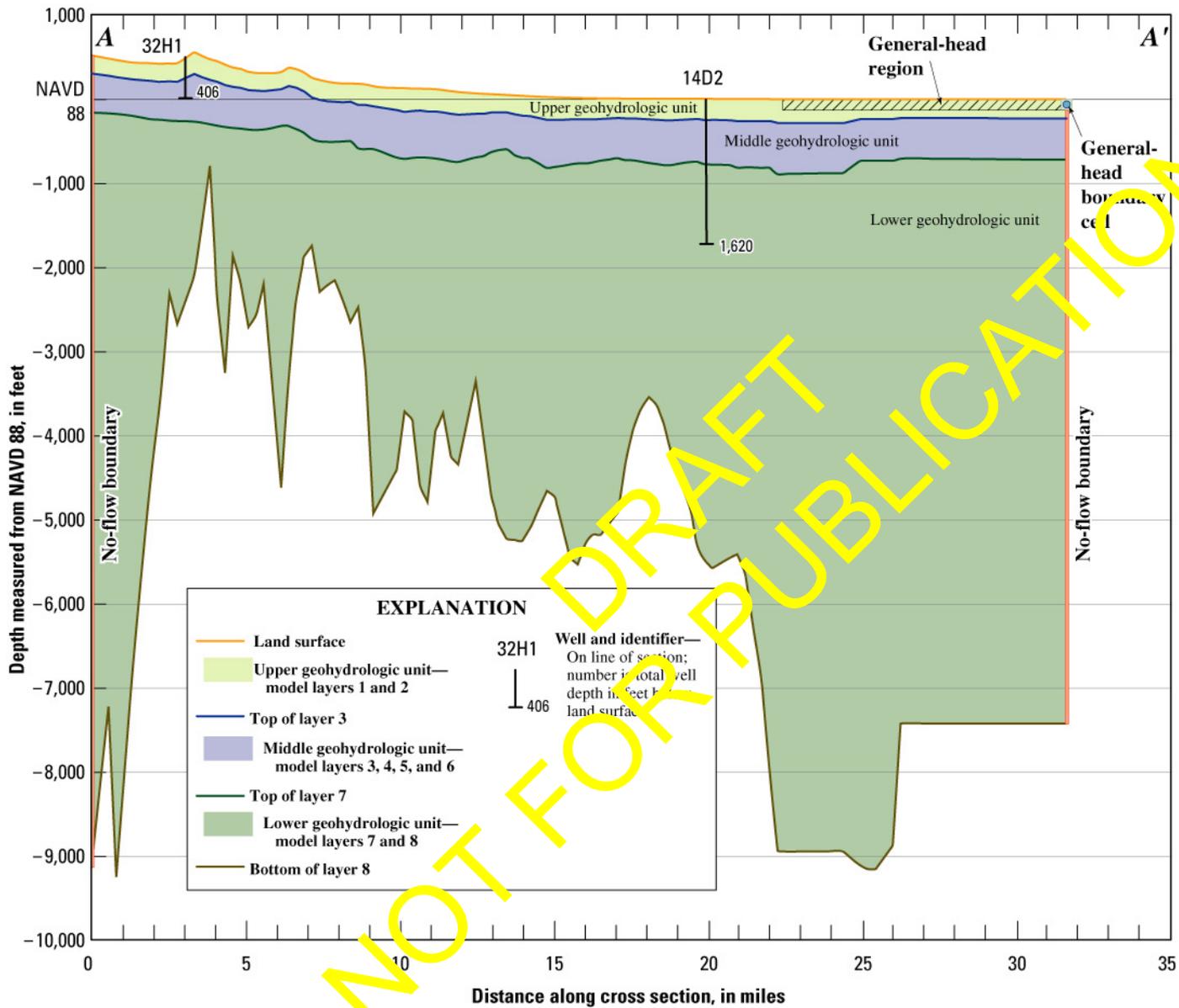
See figure 9 for explanation of geology





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Work Plan

Task	2012	2013	2014	2015	2016
1. Data interpretation	X	X			
2.1 MODFLOW	X	X			
2.2 PRMS		X	X		
2.3 GSFLOW			X	X	X
3. Reports				X	X

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Questions?

