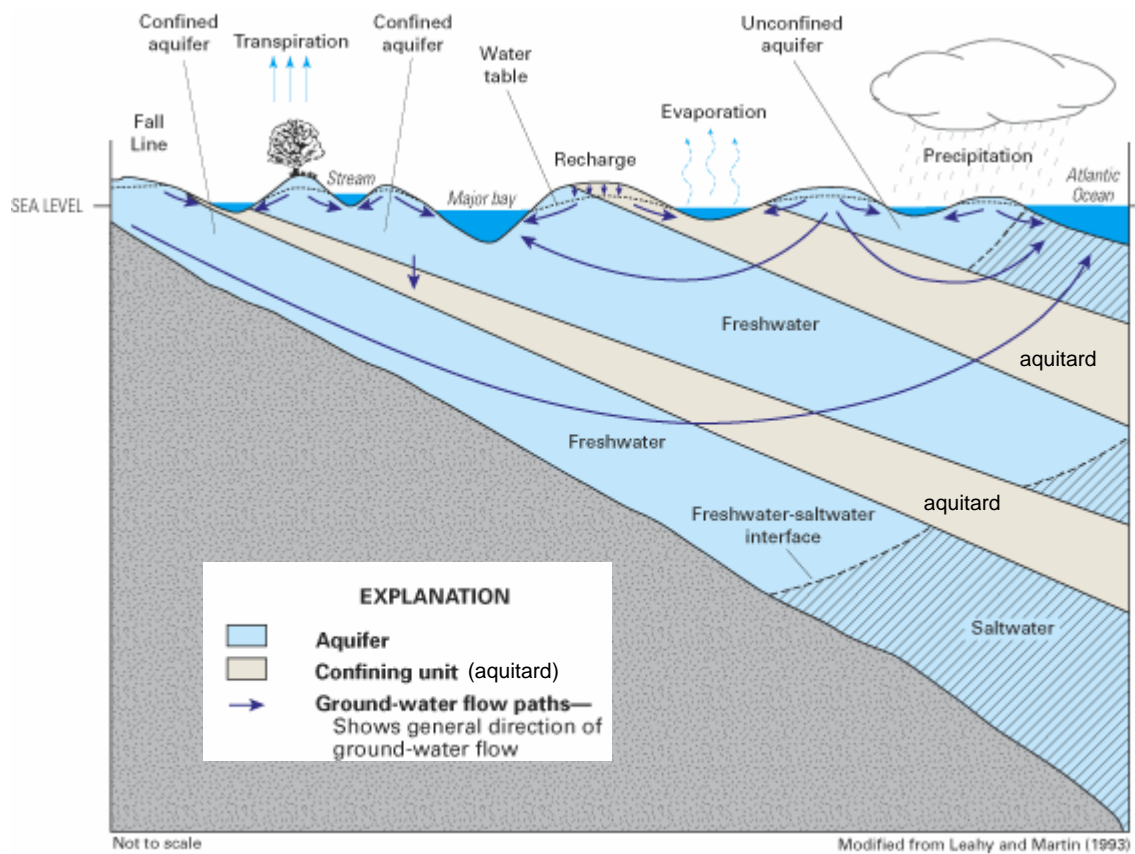
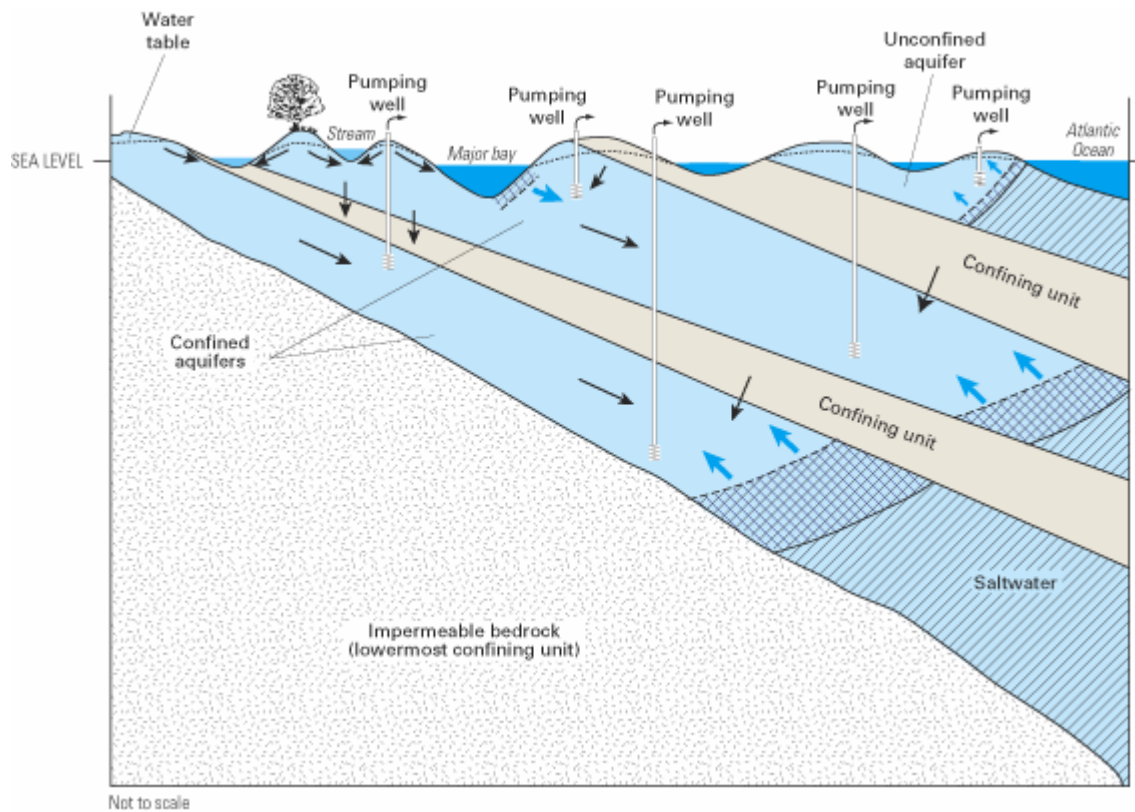


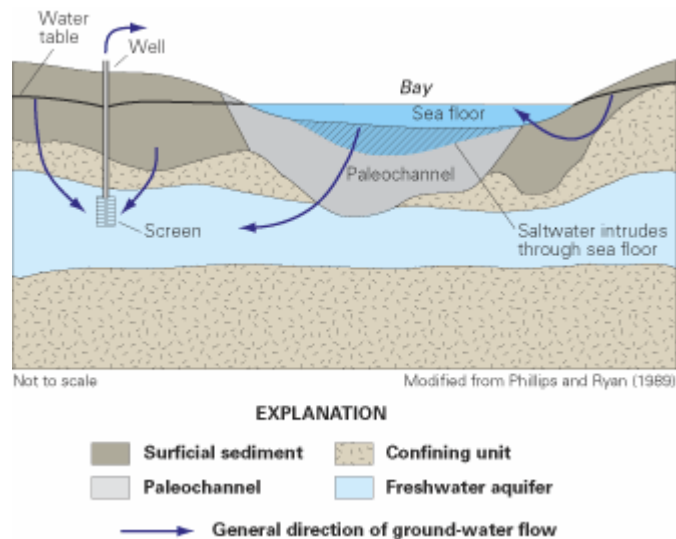
**Figure 6-1a**  
**Saltwater Wedge in a Simple Coastal Aquifer (from Barlow, 2003)**



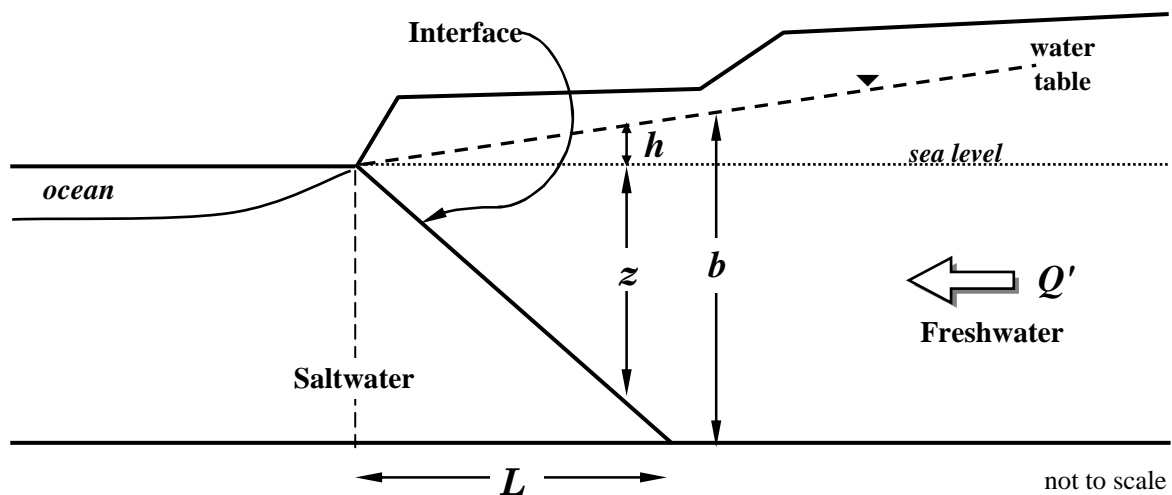
**Figure 6-1b**  
**Saltwater Interfaces in a Layered Coastal Aquifer (from Barlow, 2003)**



**Figure 6-2a**  
**Interface Migration in Response to Groundwater Pumping (from Barlow, 2003)**



**Figure 6-2b**  
**Conceptual Model of Saltwater Intrusion Through Paleochannels (from Barlow, 2003)**



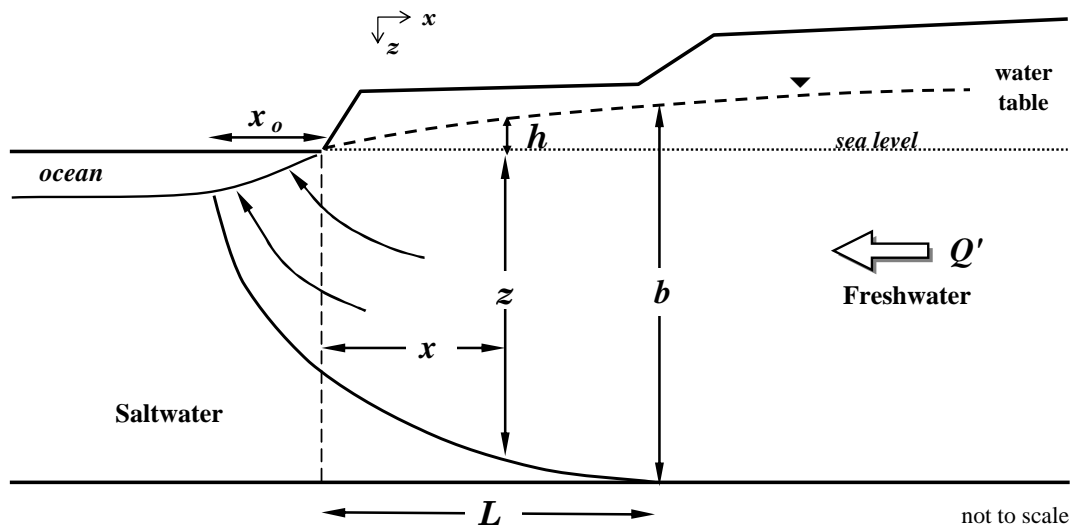
$$z = 40h$$

$$L = \frac{Kb^2}{40Q'} = \frac{b}{40i}$$

Ghyben-Herzberg Relation  
(assumes homogeneous, isotropic, and  
hydrostatic conditions, and saltwater density  
1.025 x freshwater)

- $b$  aquifer thickness (ft)
- $h$  height of the water table above sea level (ft)
- $i$  groundwater hydraulic gradient (dh/dx)
- $K$  hydraulic conductivity (ft/day)
- $L$  length that saltwater wedge protrudes inland from coastline (ft)
- $Q'$  groundwater flow per unit length of coastline (ft<sup>2</sup>/day)
- $Q' = K b i$  (Darcy's law)
- $z$  depth below sea level to a point on the interface (ft)

**Figure 6-3**  
**Ghyben-Herzberg Relation**  
(adapted from Domenico and Schwartz, 1990)



### Interface with submerged seepage face

(assumes homogeneous and isotropic conditions, and saltwater density 1.025 x freshwater)

$$z = \sqrt{\left(\frac{40 Q'}{K}\right)^2 + \frac{80 Q' x}{K}} = \sqrt{(40 ib)^2 + 80 ibx} \quad (\text{Glover, 1964})$$

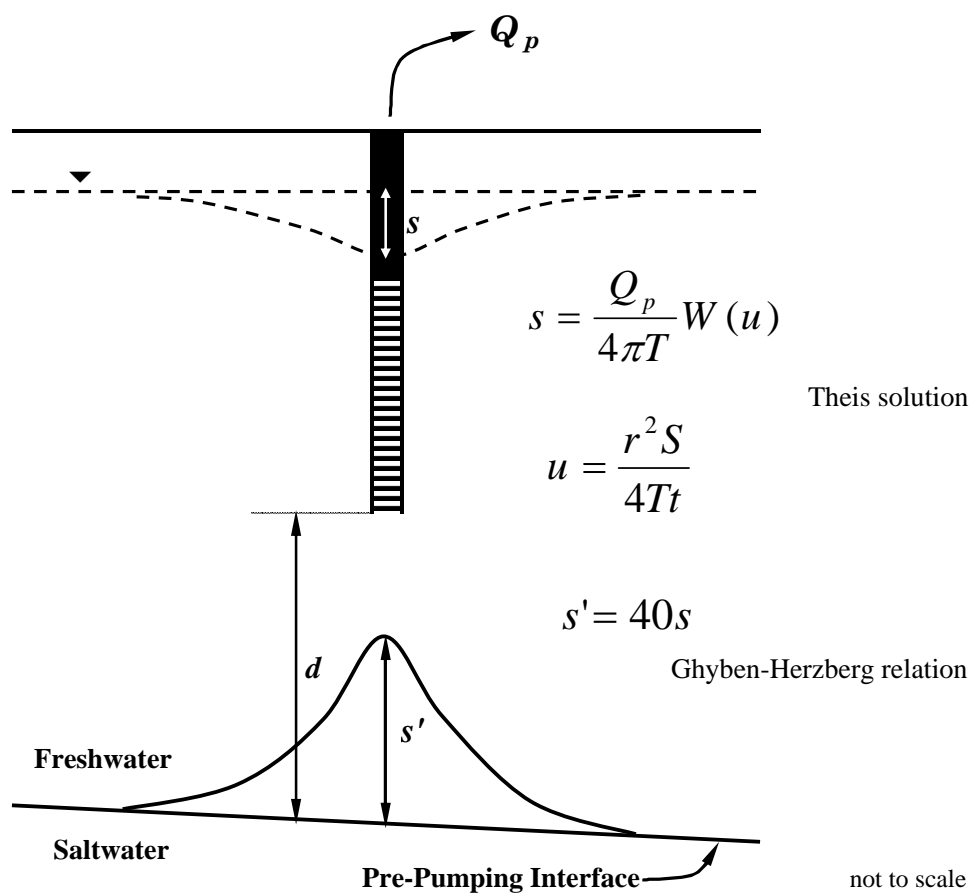
$$z_0 = \frac{40 Q'}{K} = 40 ib \quad h = \sqrt{\frac{Q' x}{20 K}} = \sqrt{\frac{ibx}{20}} \quad x_0 = -\frac{20 Q'}{K} = -20 ib$$

$$L = \frac{Kb^2}{80 Q'} - \frac{20 Q'}{K} = \frac{b}{80 i} - 20 ib$$

- $b$  aquifer thickness (ft)
- $h$  height of the water table above sea level (ft)
- $i$  groundwater hydraulic gradient (dh/dx)
- $K$  hydraulic conductivity (ft/day)
- $L$  length that saltwater wedge protrudes inland from coastline (ft)
- $Q'$  groundwater flow per unit length of coastline (ft<sup>2</sup>/day)
- $Q' = K \frac{dh}{dx} b$  (Darcy's law)
- $x$  distance inland from the coastline (ft)
- $x_0$  width of seepage face (ft)
- $z$  depth below sea level to interface (ft)
- $z_0$  depth to interface at coastline (ft)

**Figure 6-4**

**Glover Solution for Saltwater Interface**  
(adapted from Domenico and Schwartz, 1990)

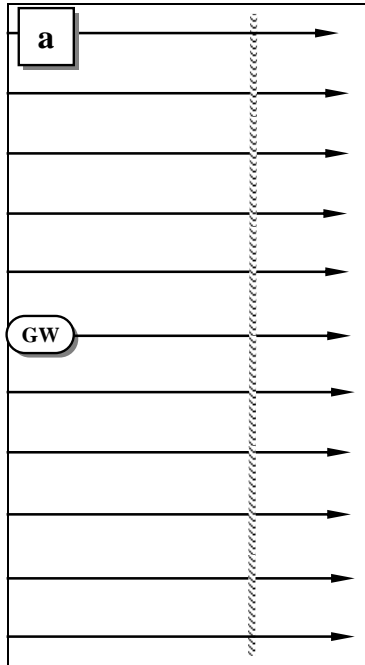
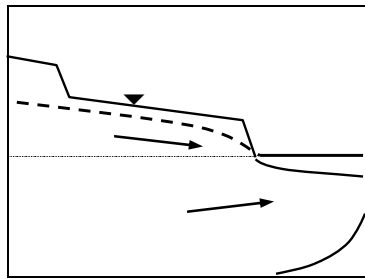


(assumes homogeneous and isotropic conditions, and saltwater density 1.025 x freshwater)

- $d$  distance from base of well to pre-pumping interface (ft)
- $Q_p$  pumping rate (ft<sup>3</sup>/day)
- $r$  distance from well (ft)
- $s$  drawdown
- $s'$  height of interface rise (i.e., cone) due to pumping (ft)
- $T$  transmissivity (ft<sup>2</sup>/day)
- $t$  time since pumping began (days)
- $W(u)$  Theis well function

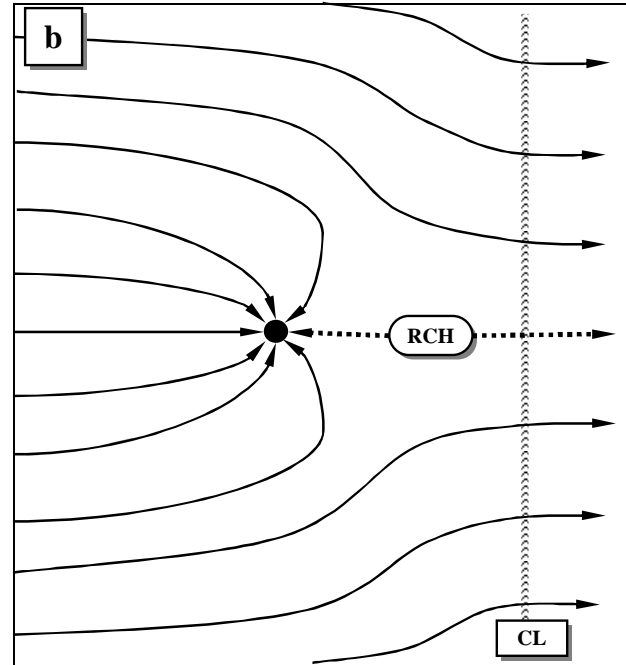
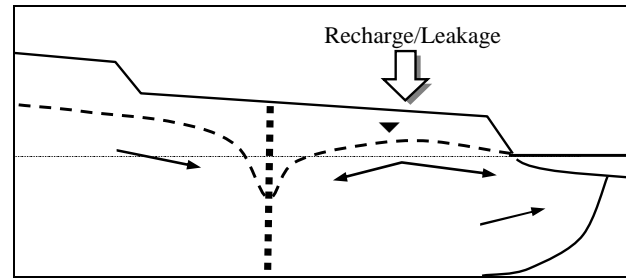
Cone estimated to remain stable if  $s'$  is less than 1/3 of  $d$ .

**Figure 6-5**  
**Upconing of Saltwater Interface**

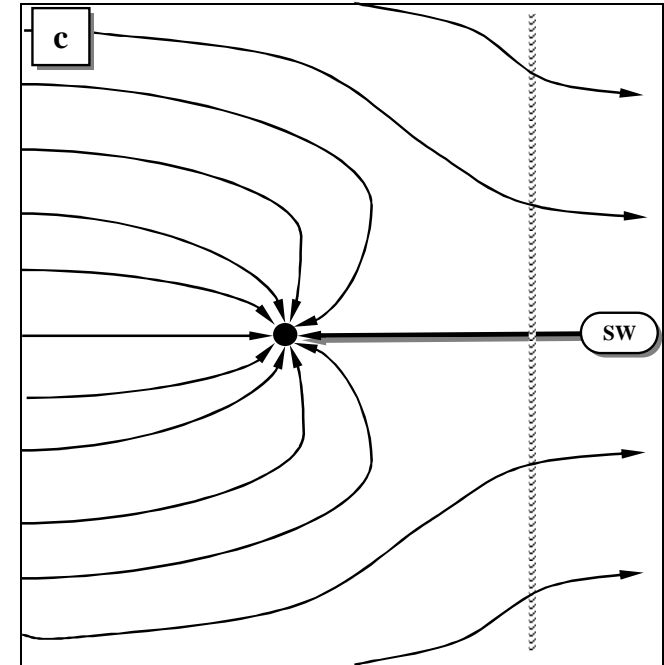
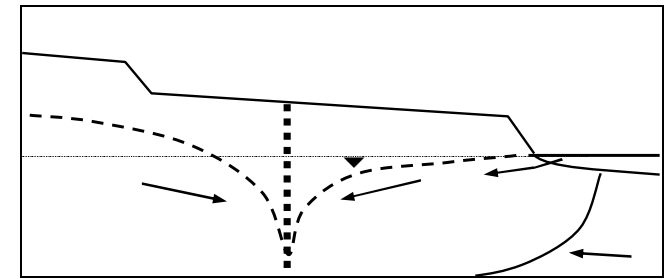


Native groundwater flow (GW) crosses under the coastline (CL) for eventual discharge to the ocean.

Conditions depicted are for an unconfined aquifer. The same situation could occur for a confined aquifer with near-shore seafloor outcrops.



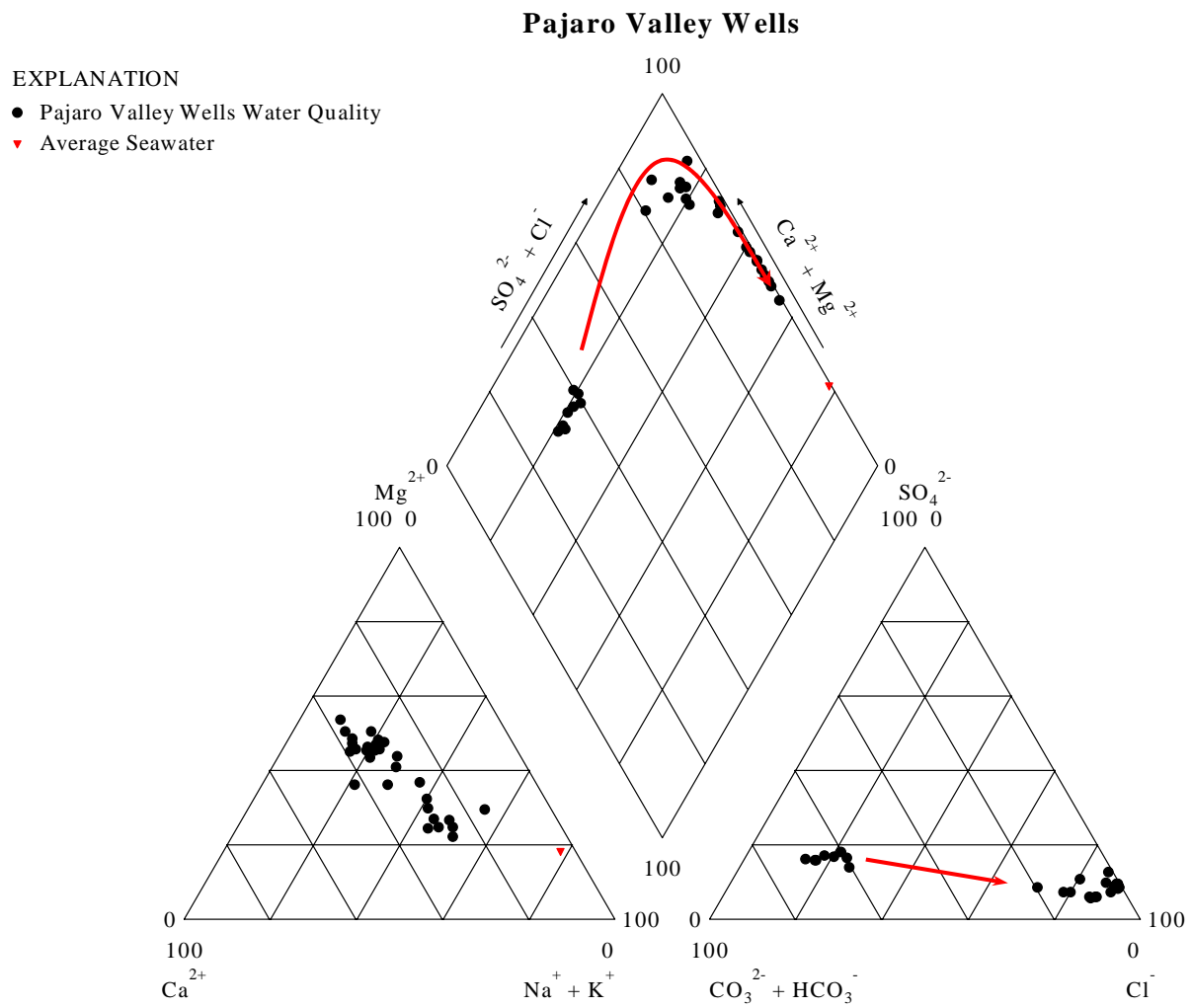
Groundwater flow toward the ocean is intercepted by well(s). Recharge or leakage from overlying layers (RCH) contributes to well yield and helps replace lost flow to the ocean, thus creating what is essentially a groundwater divide between the well and ocean discharge.



One or more wells capture such a large portion of the groundwater flow that recharge and leakage are no longer sufficient to establish a groundwater divide between the well and ocean. This allows water stored in the aquifer offshore to flow to the well. The lost groundwater storage offshore is eventually replaced by seawater. Note that the interface remains offshore.

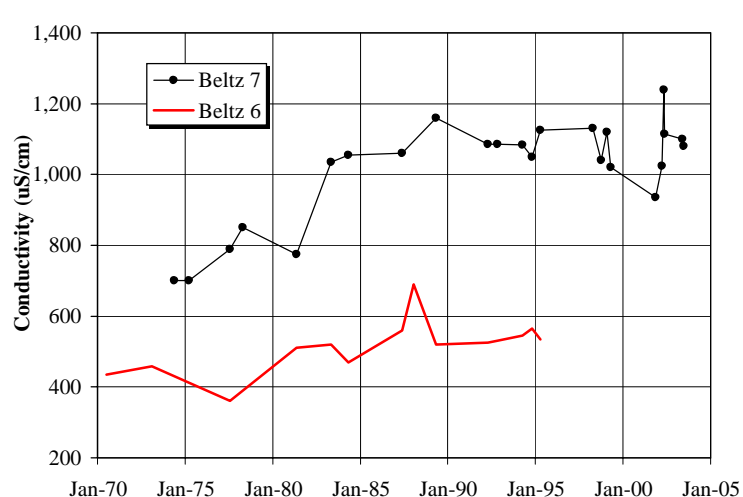
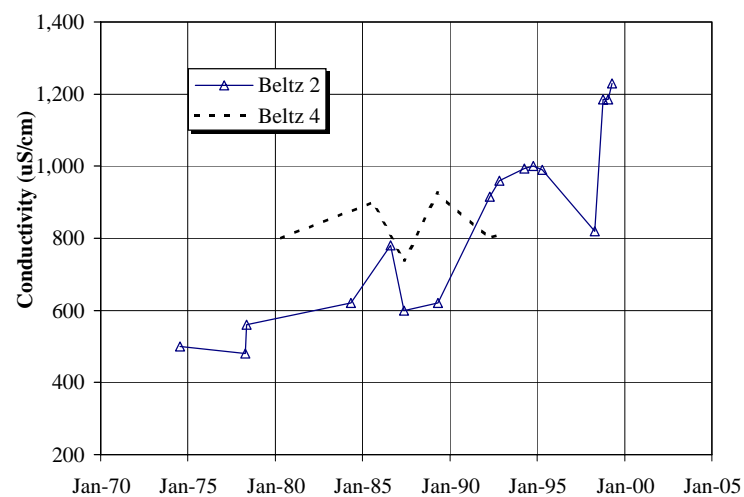
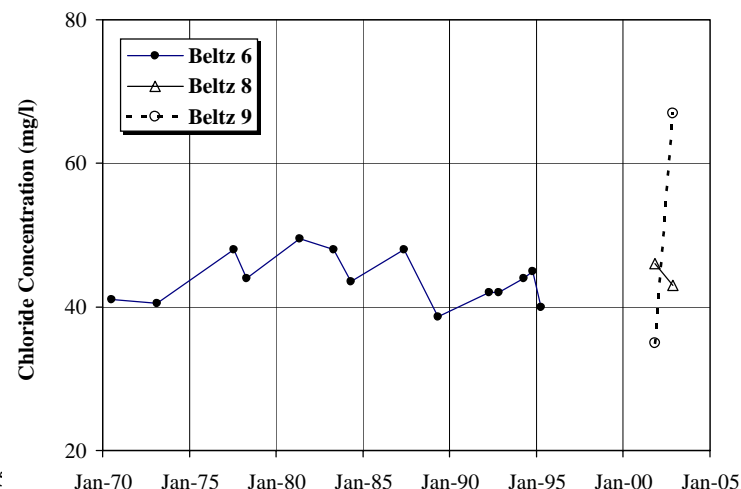
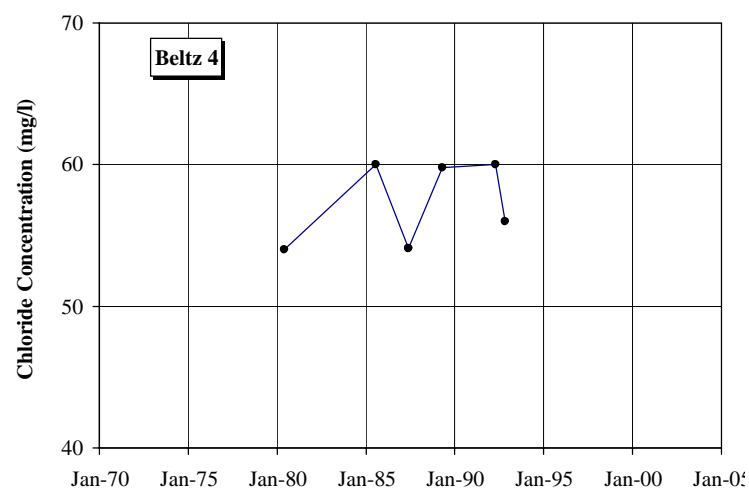
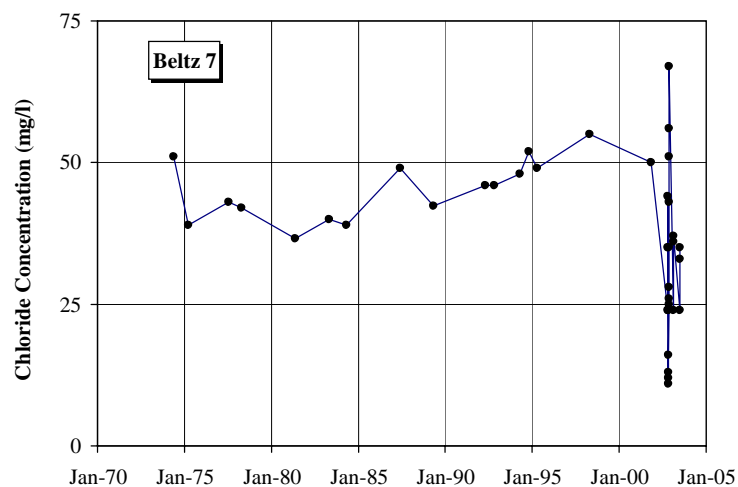
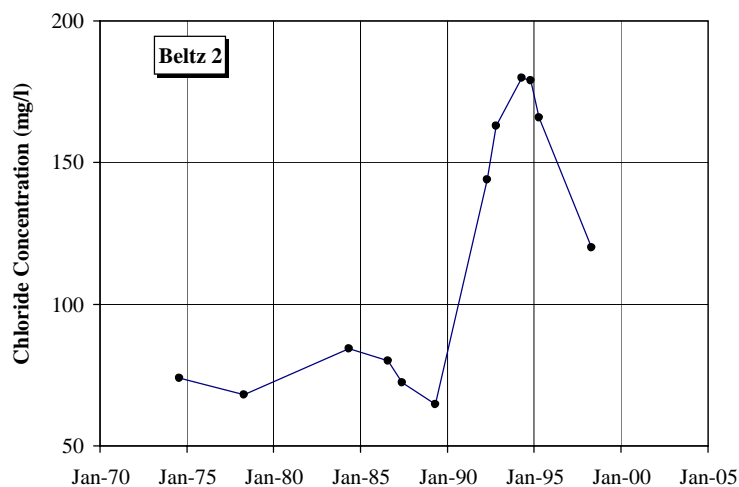
The transition from (b) to (c) also could result from drought conditions.

**Figure 6-6**  
**Seawater Capture by Cone of Depression**



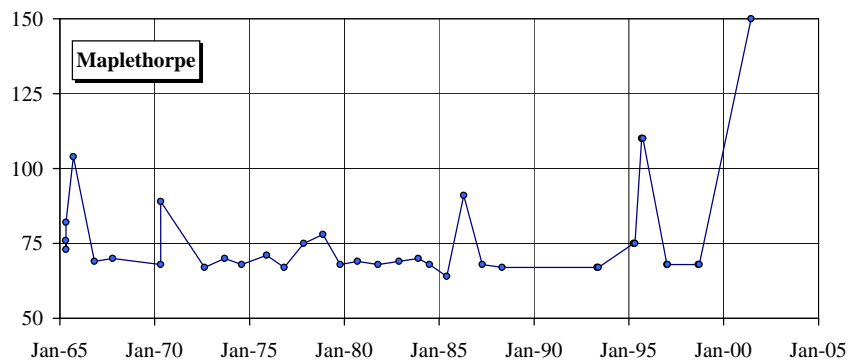
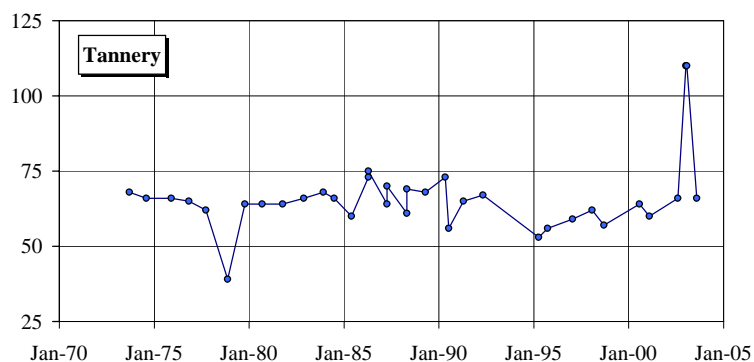
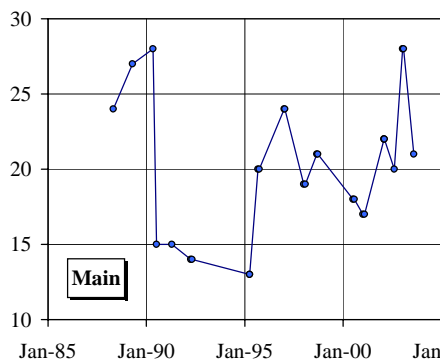
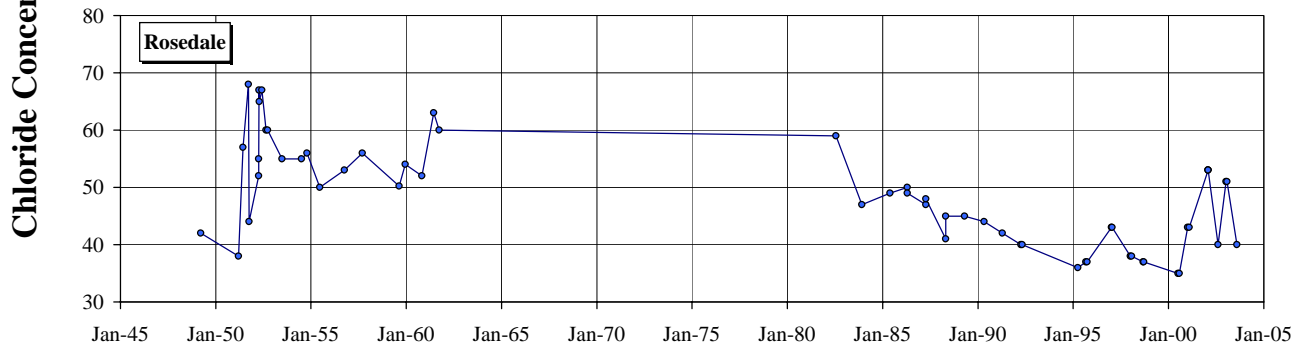
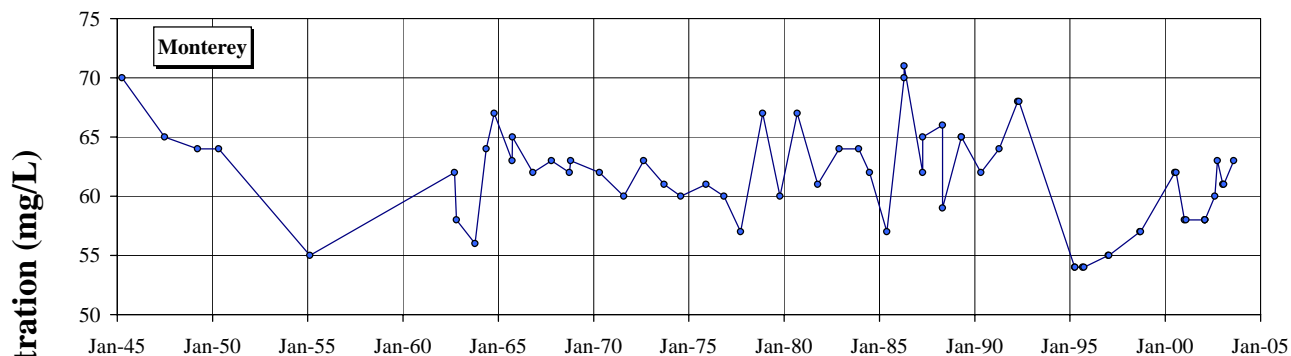
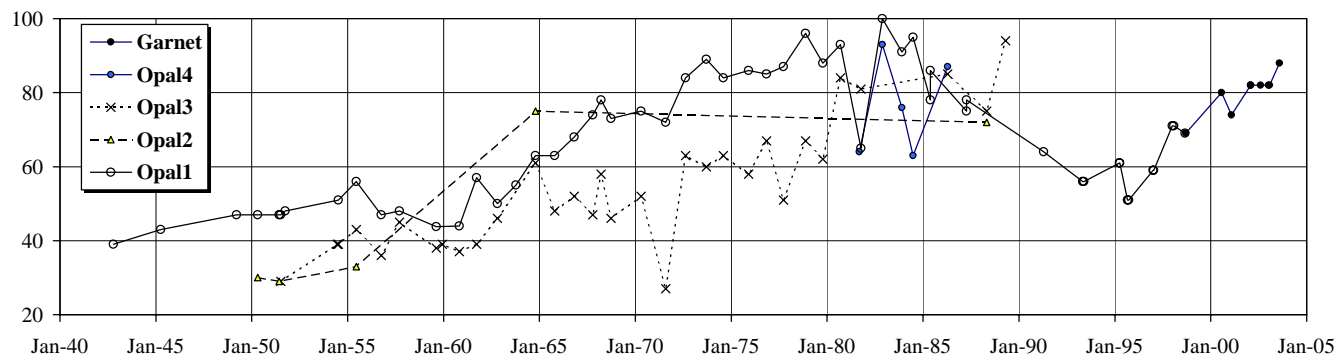
**Figure 6-7**

**Trilinear Diagram Example for Pajaro Valley Water Quality**



**Figure 6-8**  
**Chloride Concentrations and Electrical Conductivity for Beltz Wells**

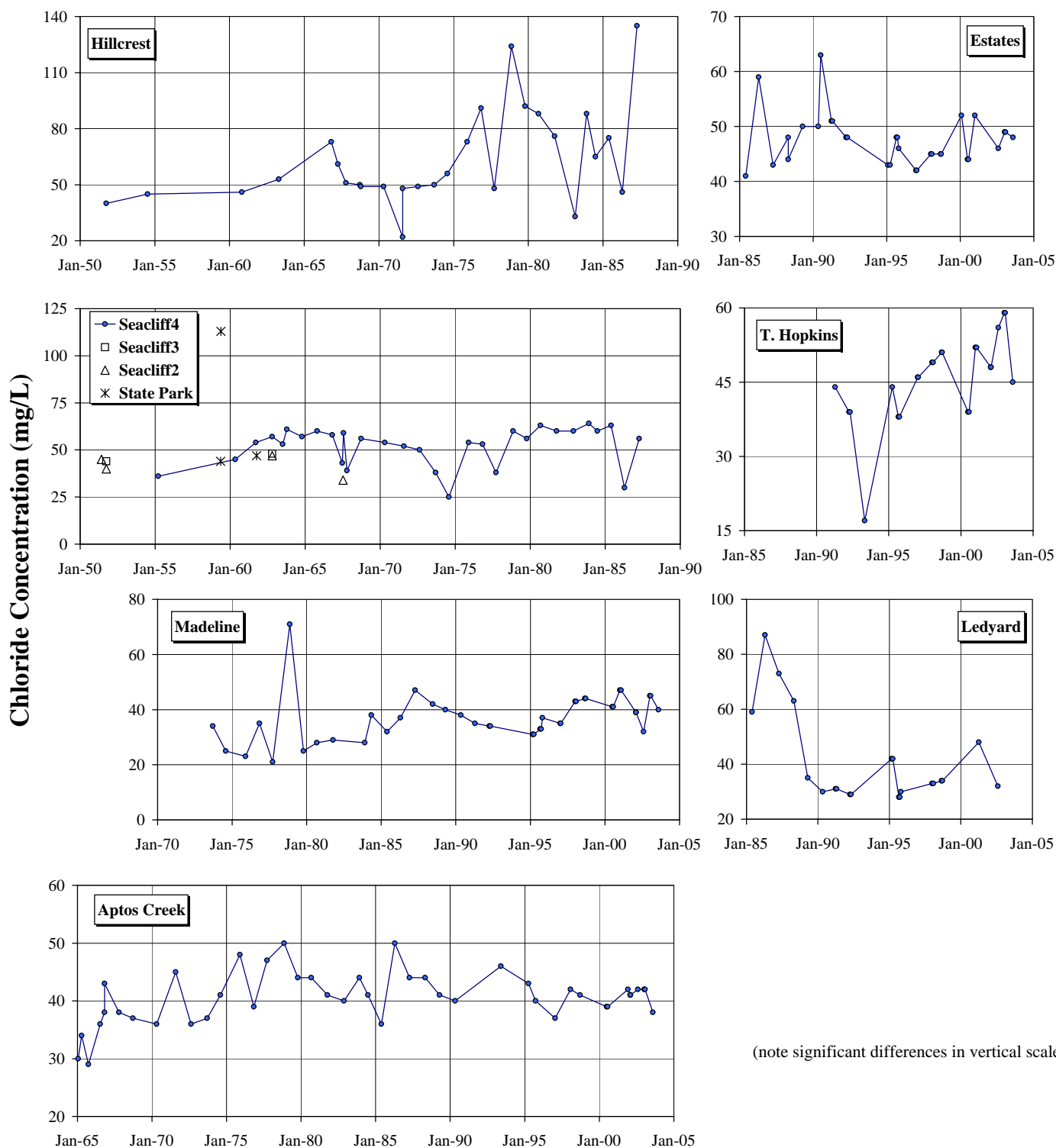




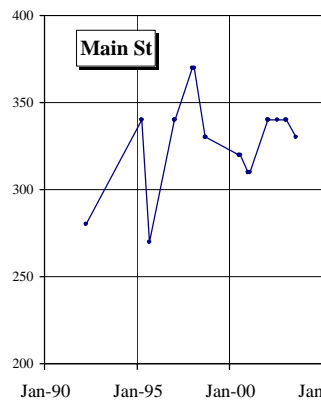
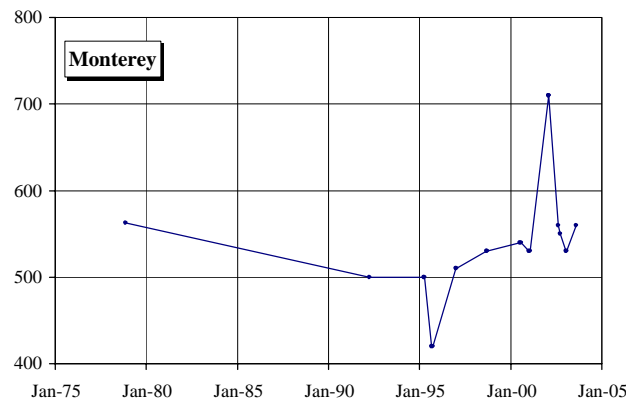
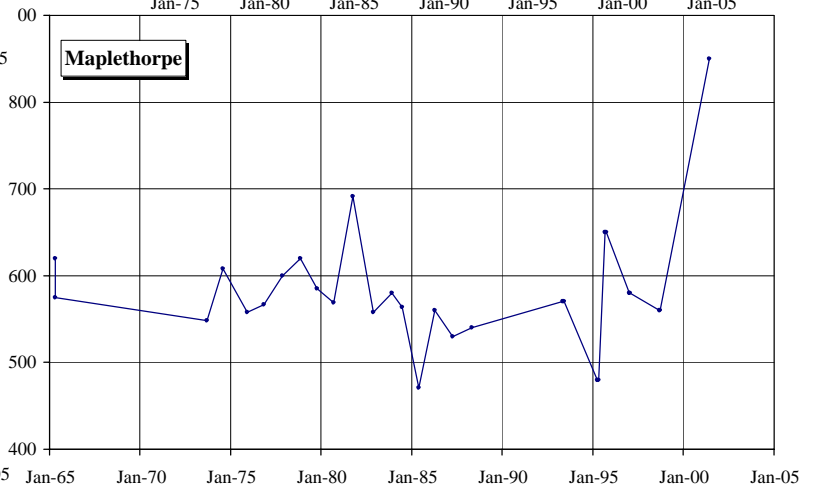
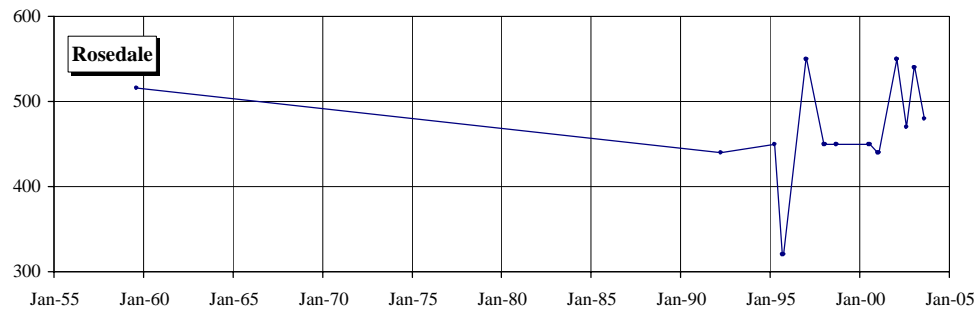
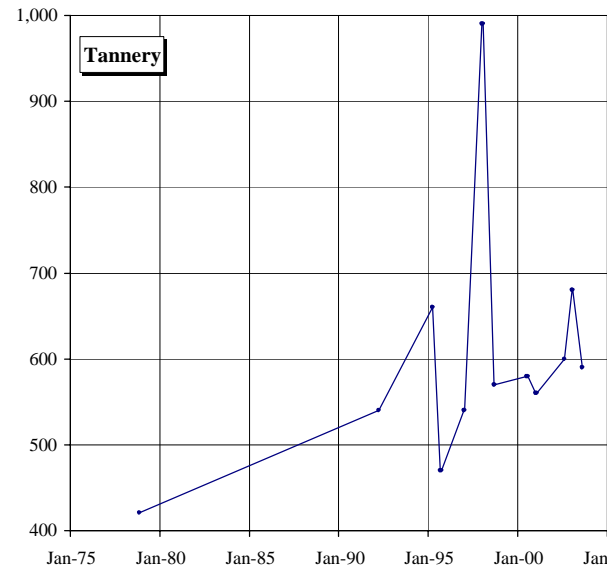
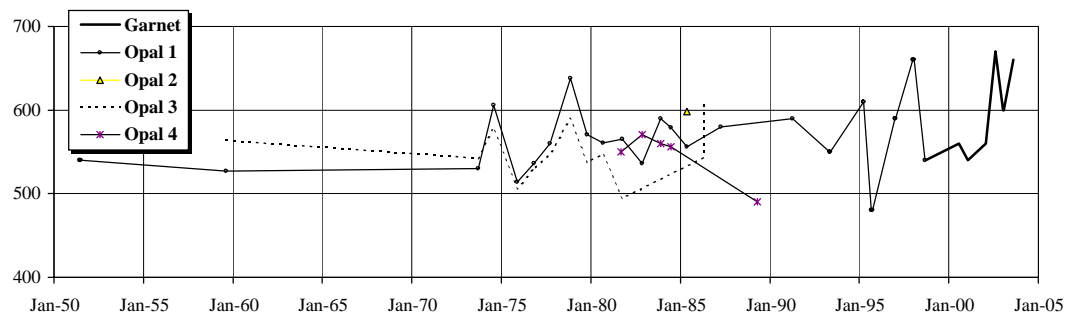
**Figure 6-9a**  
**Chloride Chemographs for**  
**Purisima Production Wells**

SCWD Service Area I

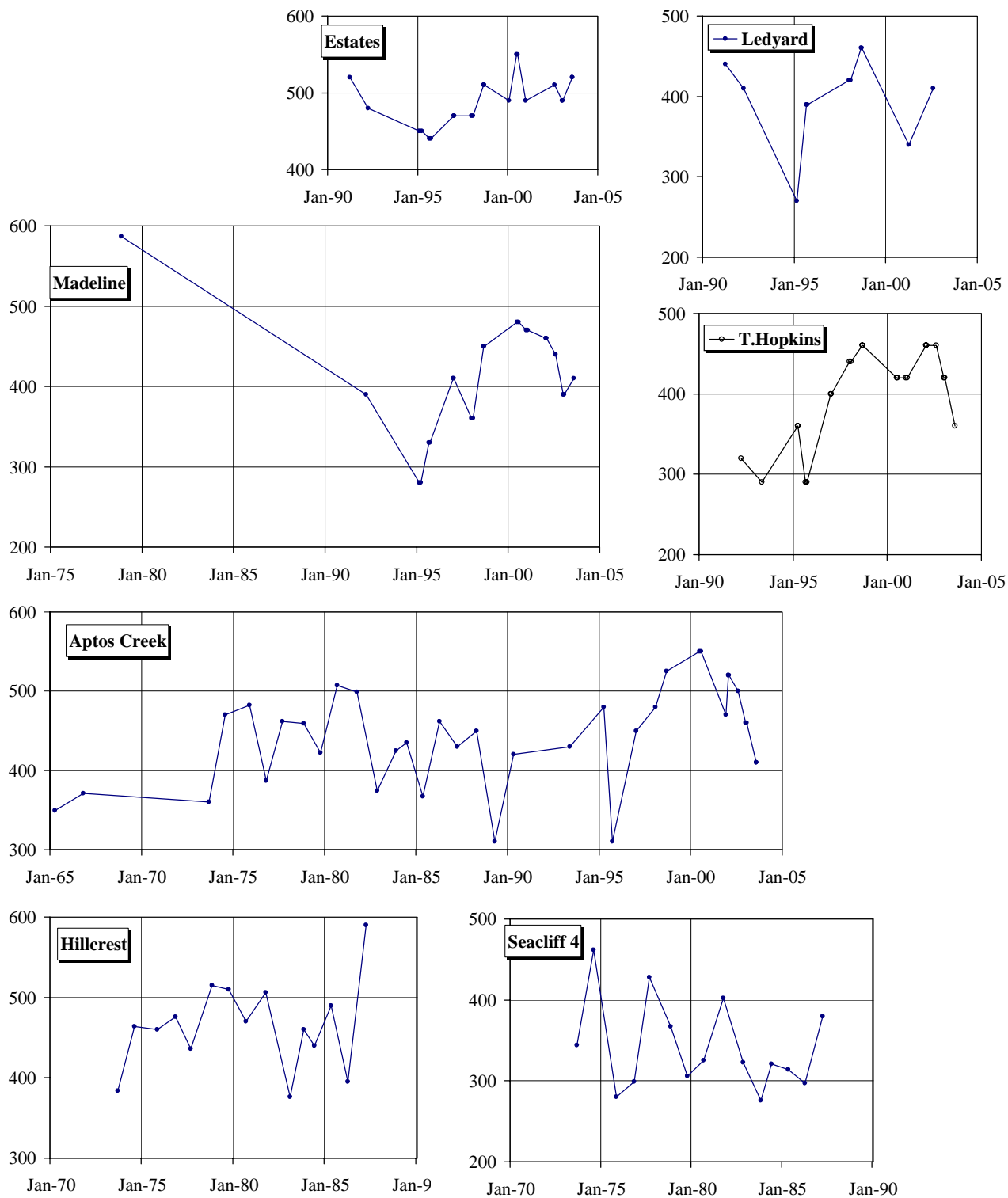
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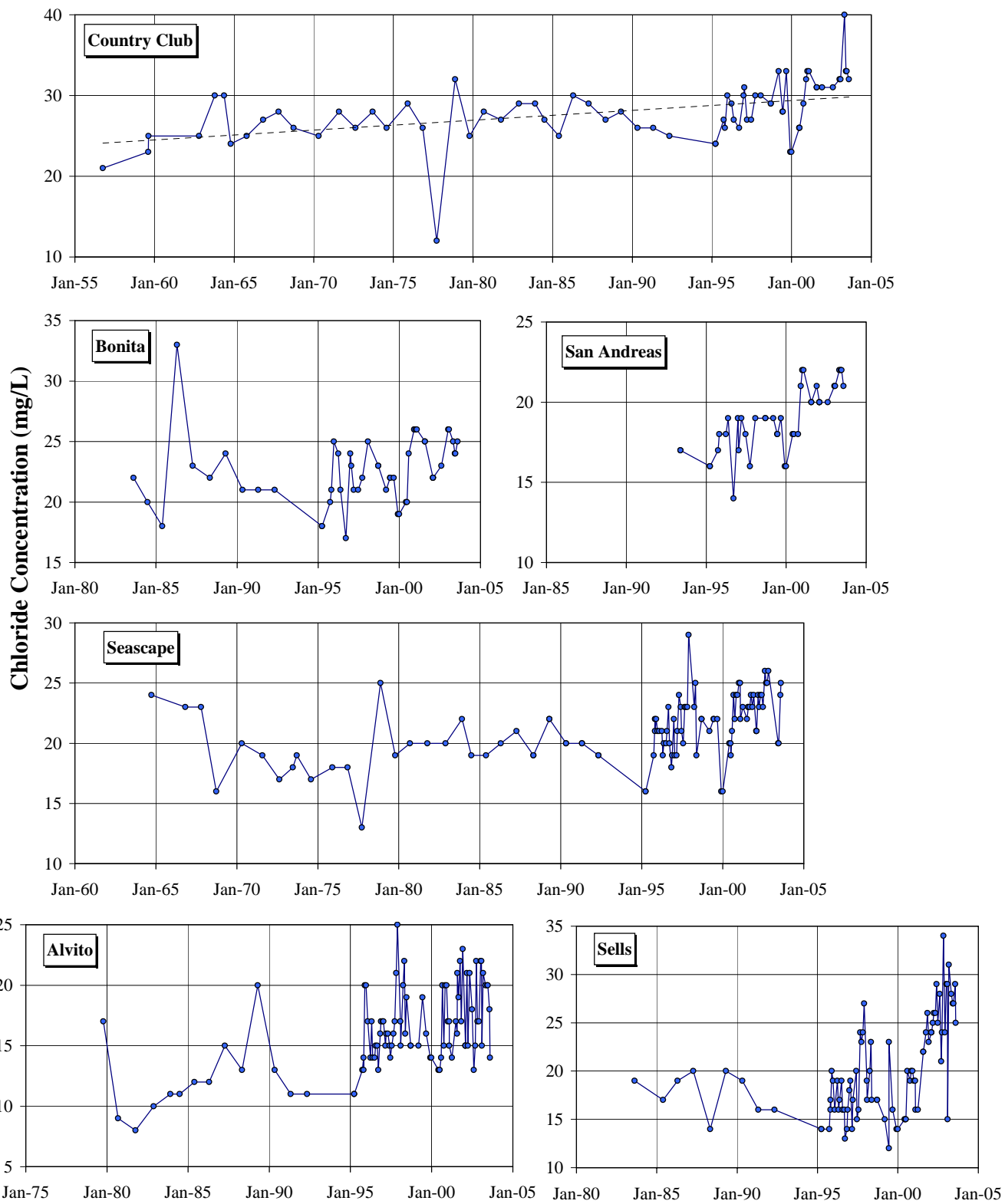
**Figure 6-9b**  
**Chloride Chemographs for Purisima Production Wells**  
 SCWD Service Area II



**Figure 6-10a**  
**TDS Concentrations for Purisima Production Wells**  
**SCWD Service Area I (mg/L)**

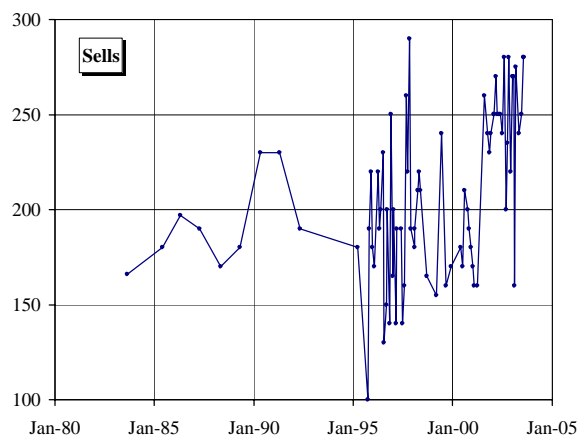
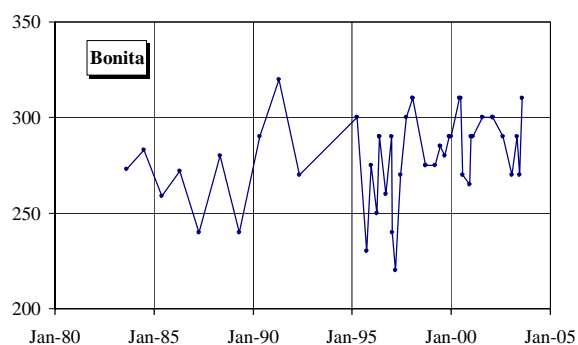
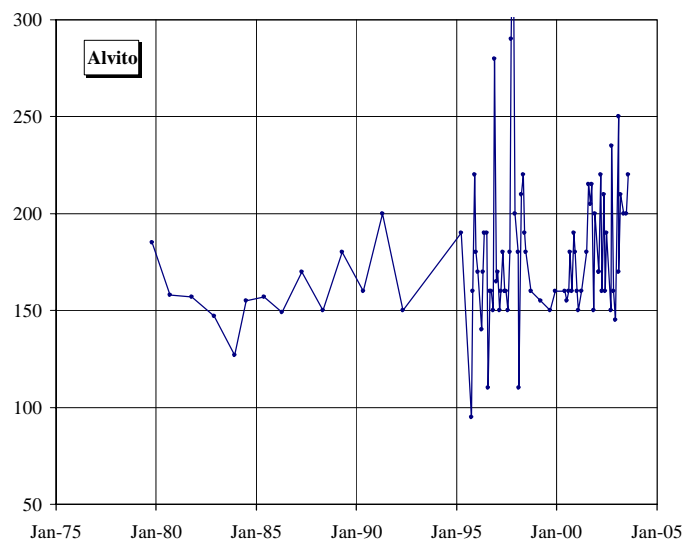
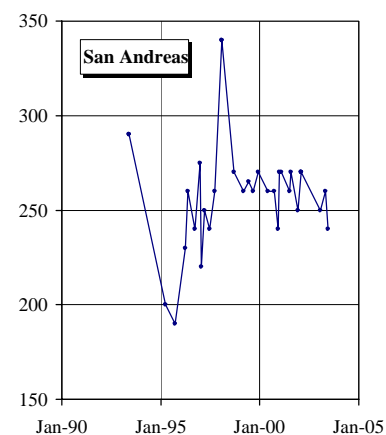
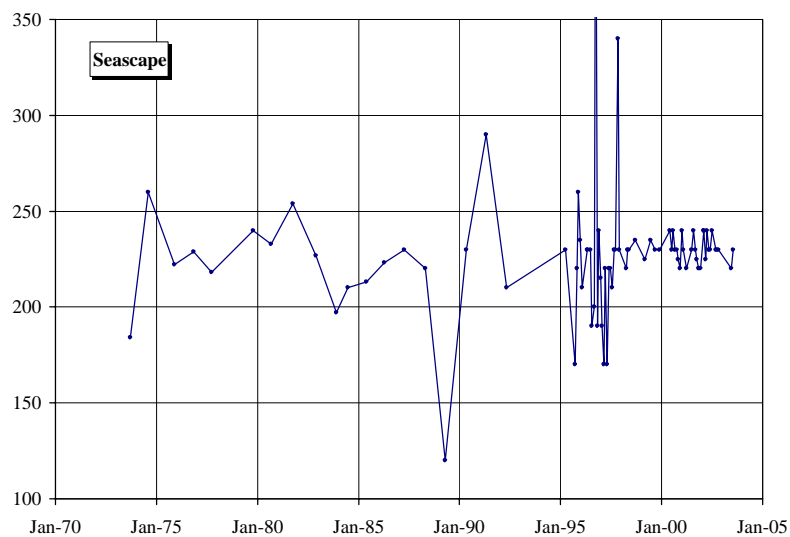
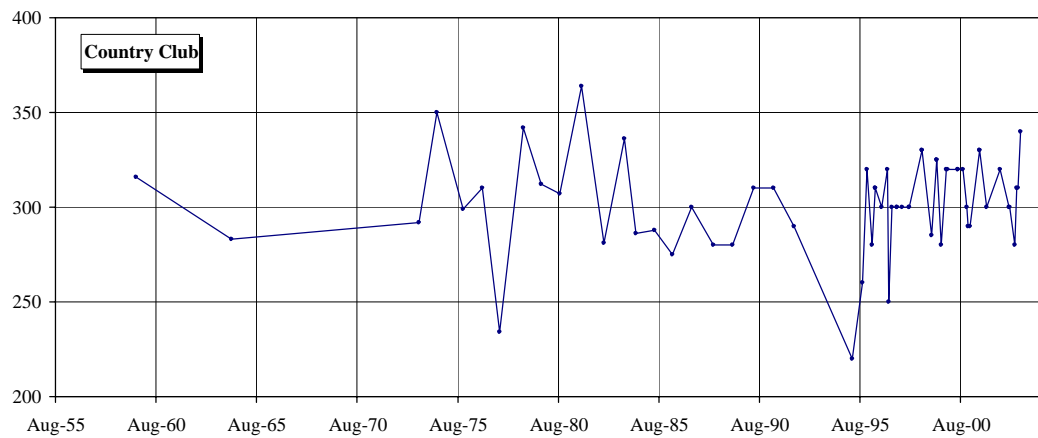


**Figure 6-10b**  
**TDS Concentrations for Purisima Production Wells**  
**SCWD Service Area II (mg/L)**



(note significant differences in vertical scale)

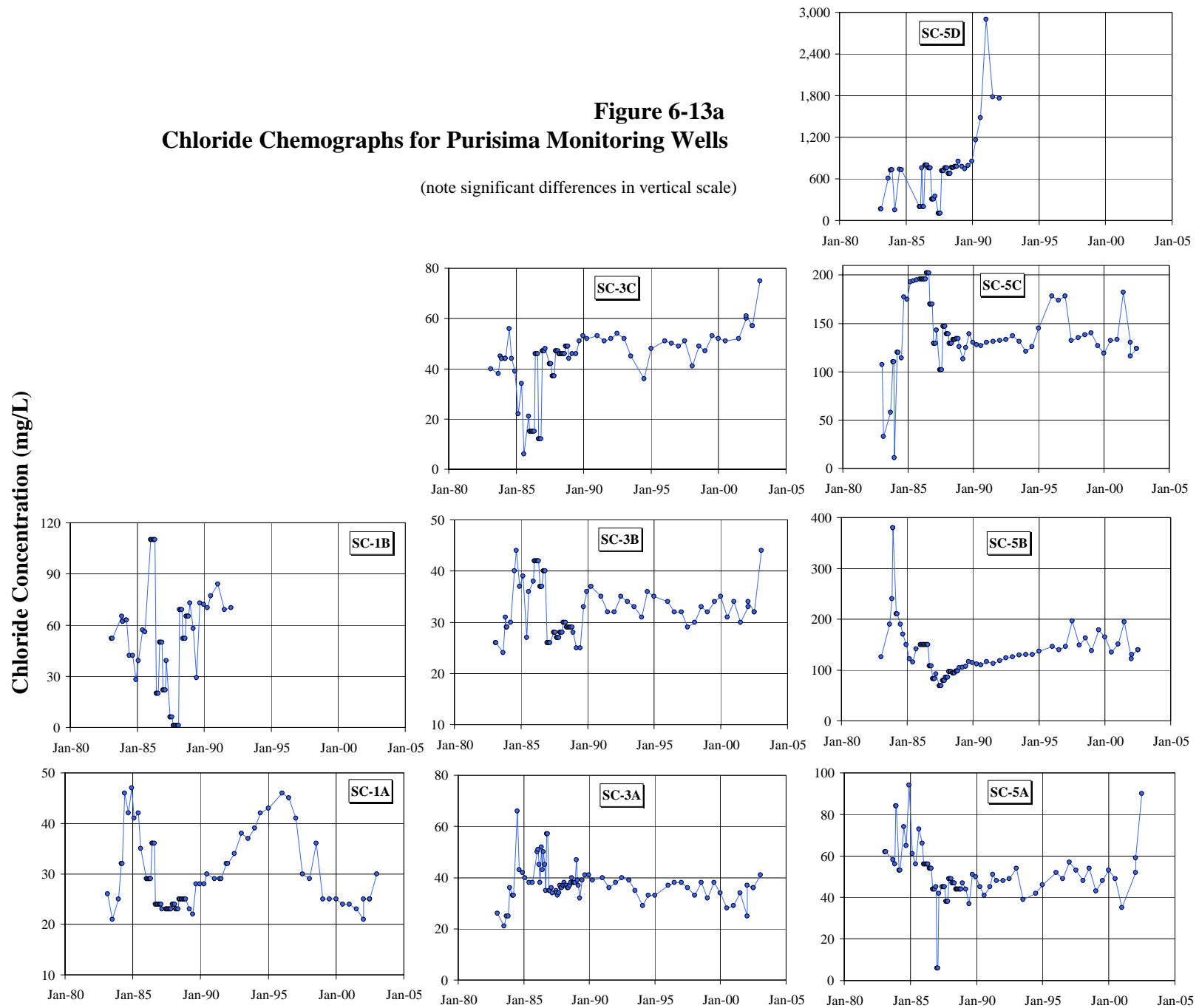
**Figure 6-11**  
**Chloride Chemographs for Aromas Production Wells**



**Figure 6-12**  
**TDS Concentrations for Aromas**  
**Production Wells (mg/L)**

**Figure 6-13a**  
**Chloride Chemographs for Purisima Monitoring Wells**

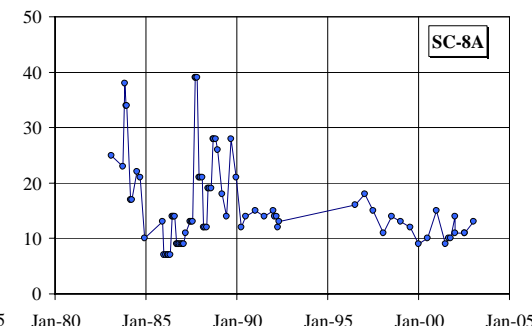
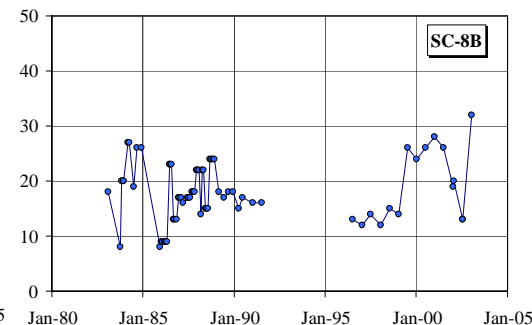
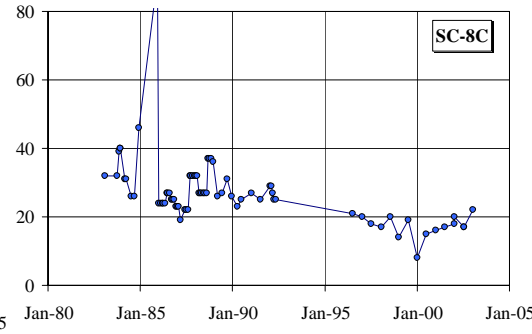
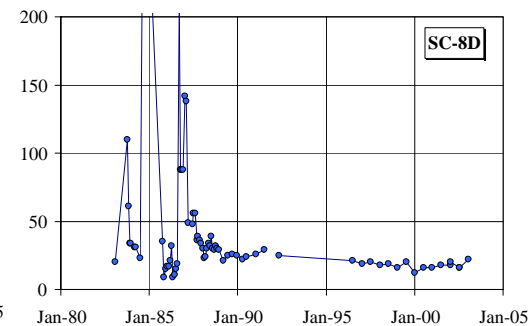
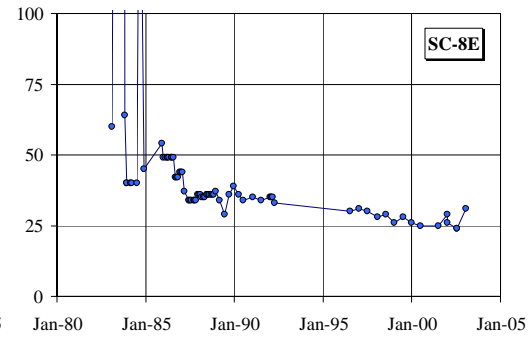
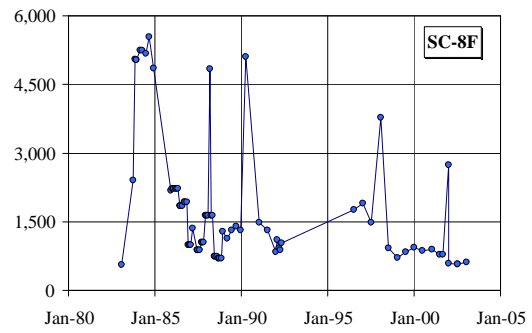
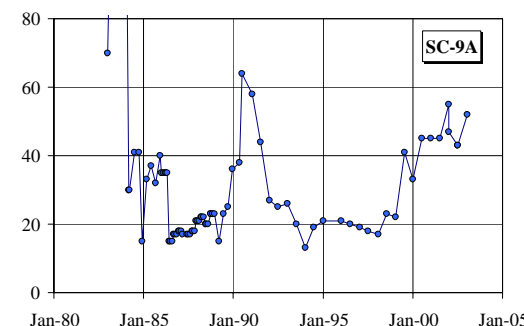
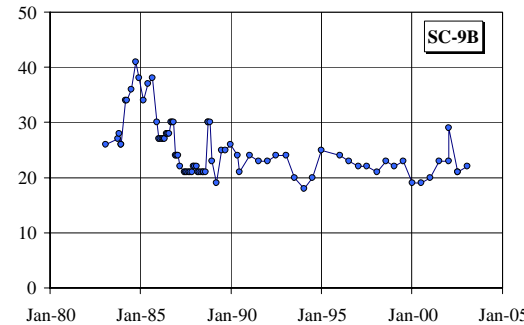
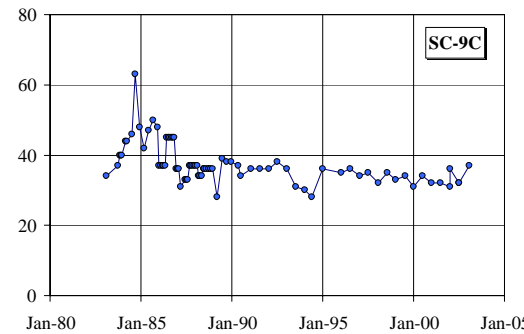
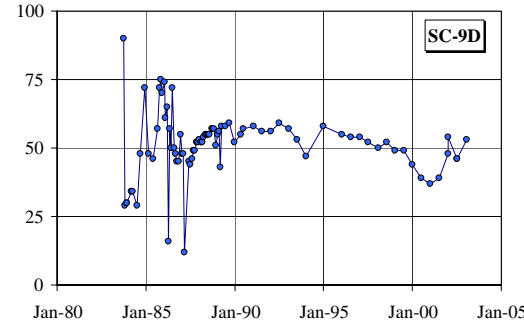
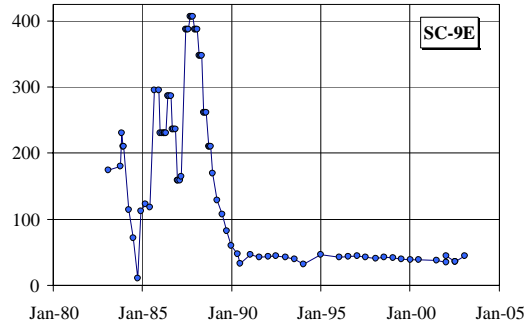
(note significant differences in vertical scale)



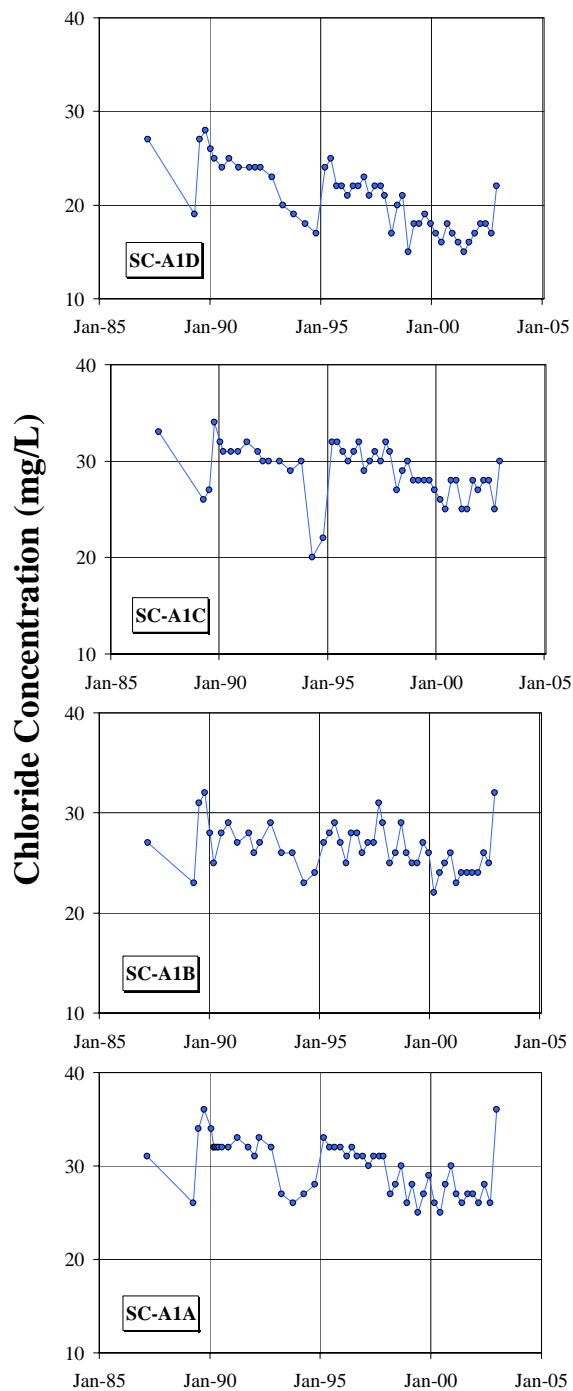
**Figure 6-13b**  
**Chloride Chemographs for**  
**Purisima Monitoring Wells**

(note significant differences in vertical scale)

Chloride Concentration (mg/L)

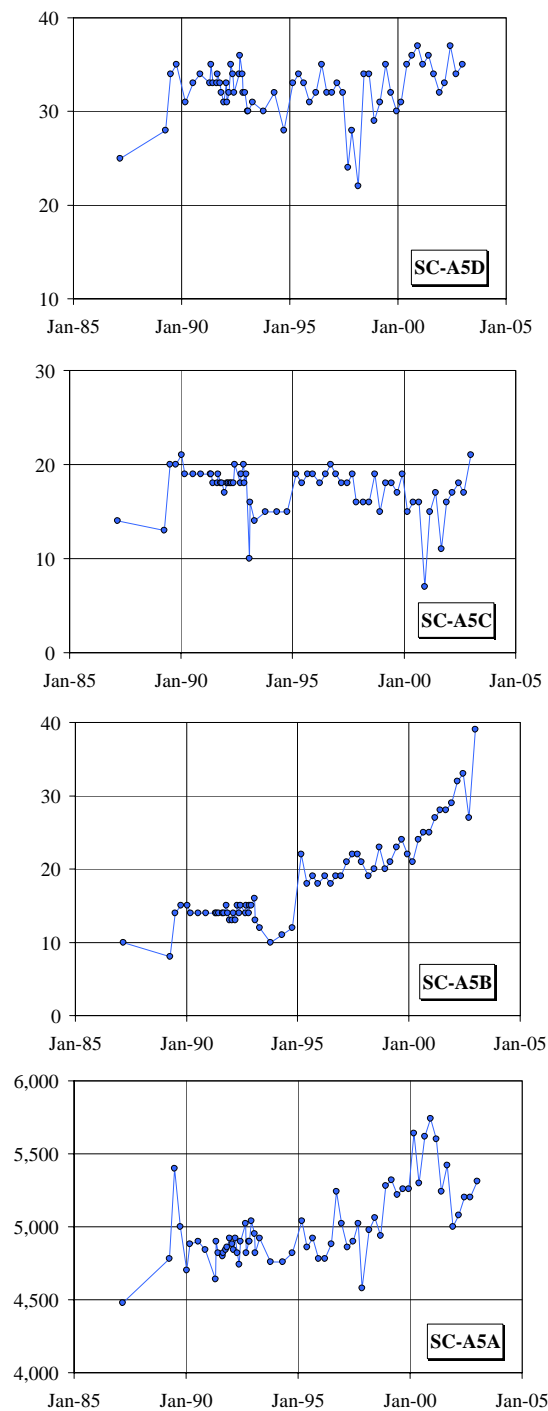
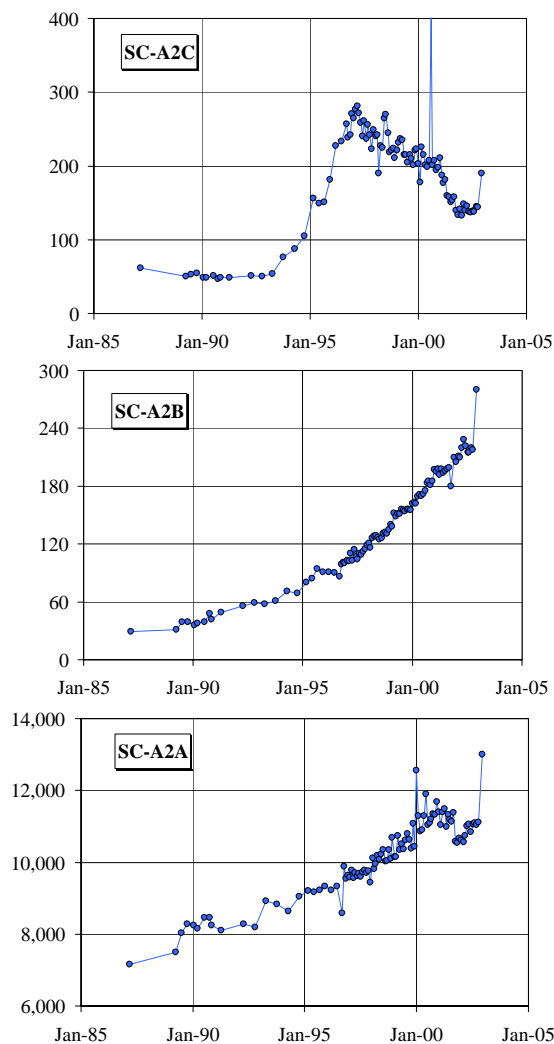


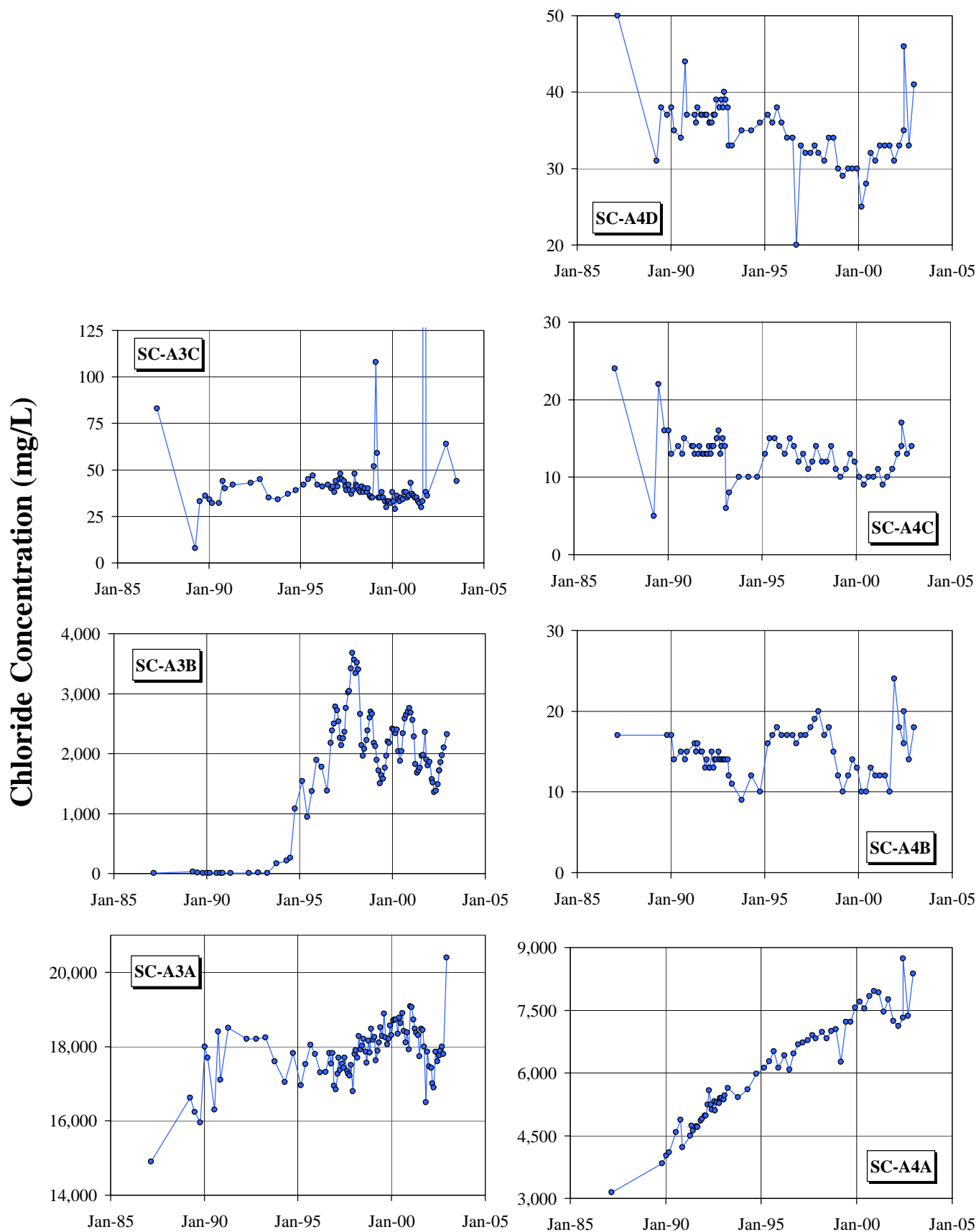




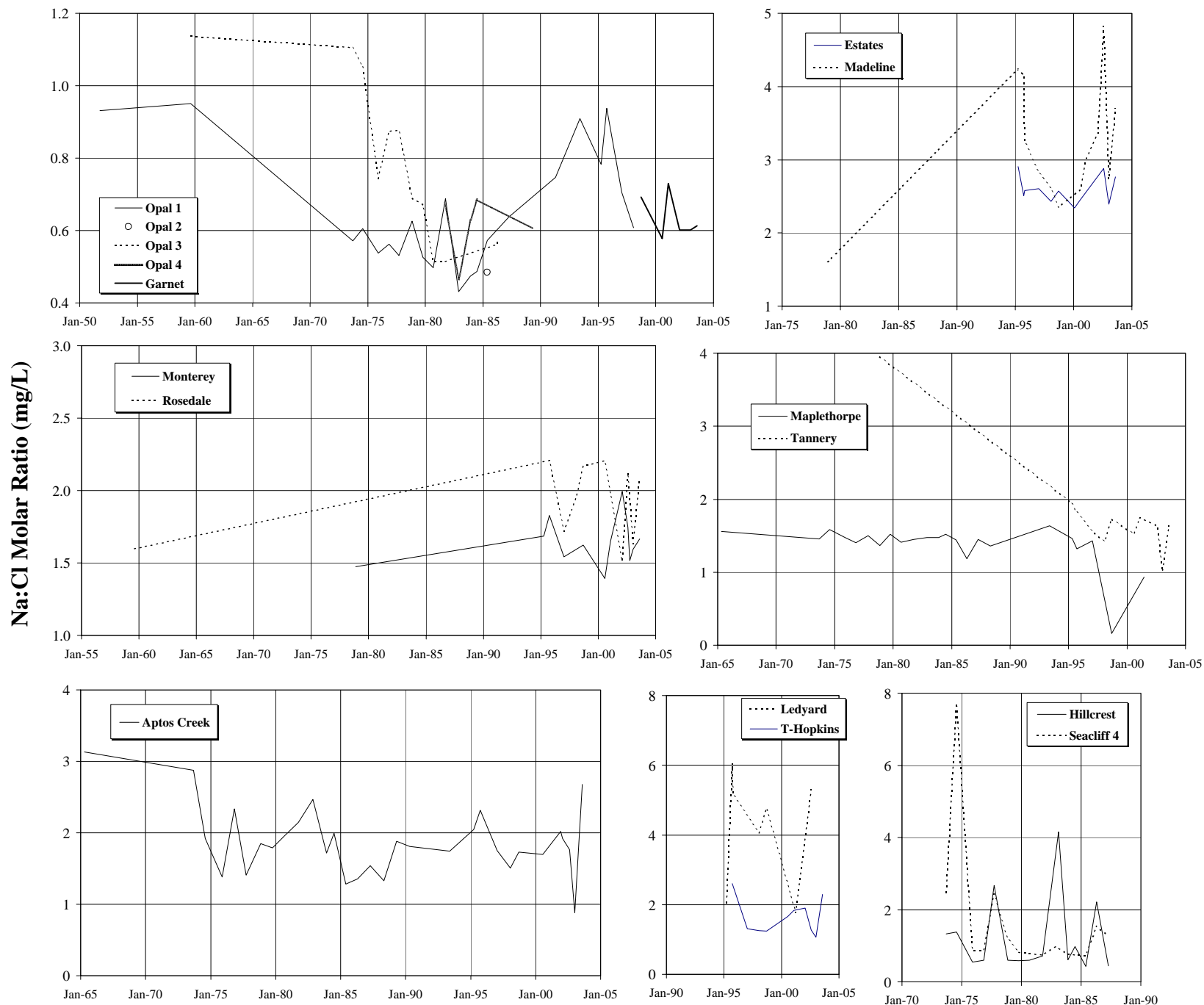
**Figure 6-14a**  
**Chloride Chemographs for**  
**Aromas Monitoring Wells**

(note significant differences in vertical scale)



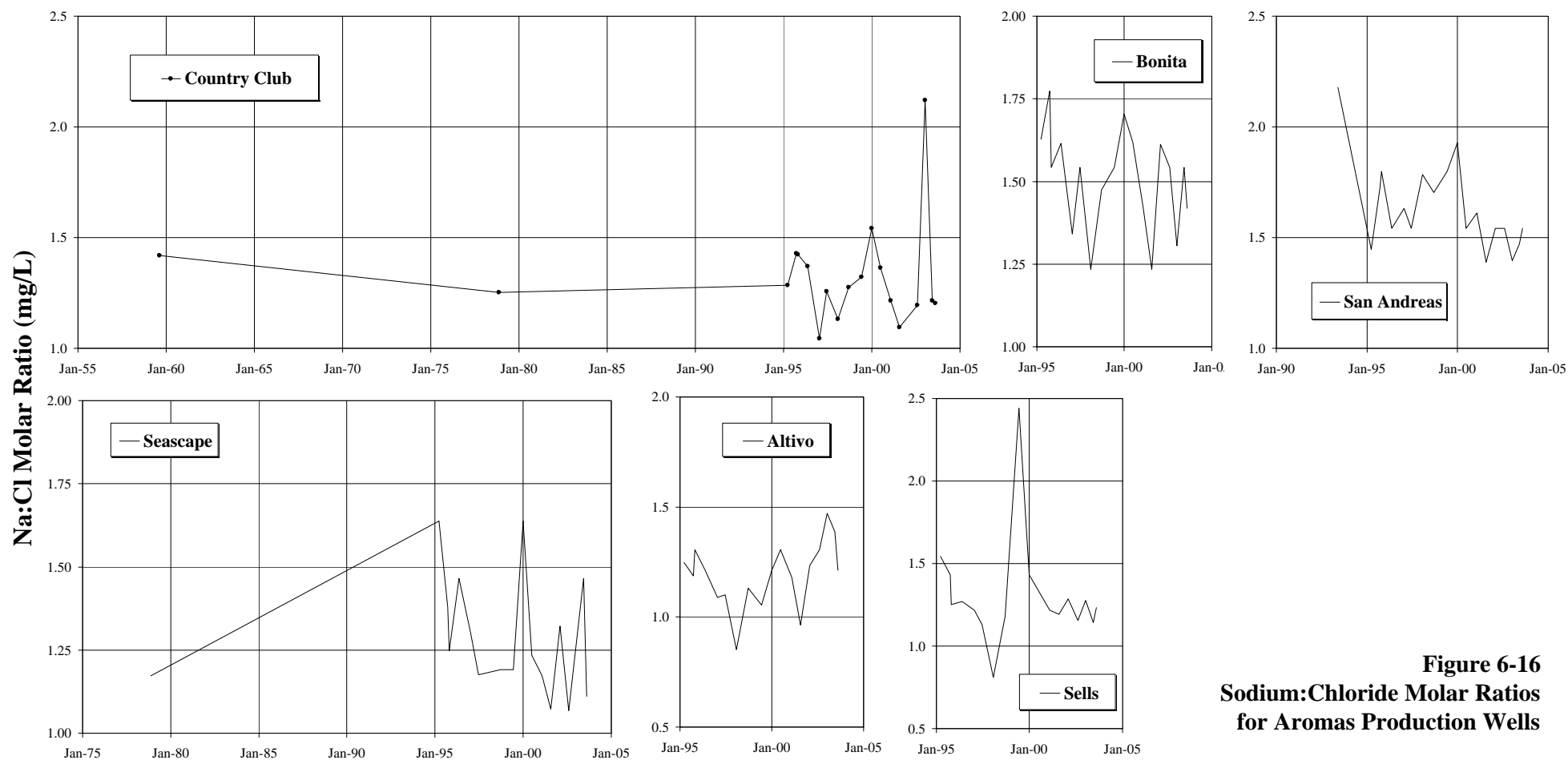


**Figure 6-14b**  
**Chloride Chemographs for Aromas Monitoring Wells**  
 (note significant differences in vertical scale)

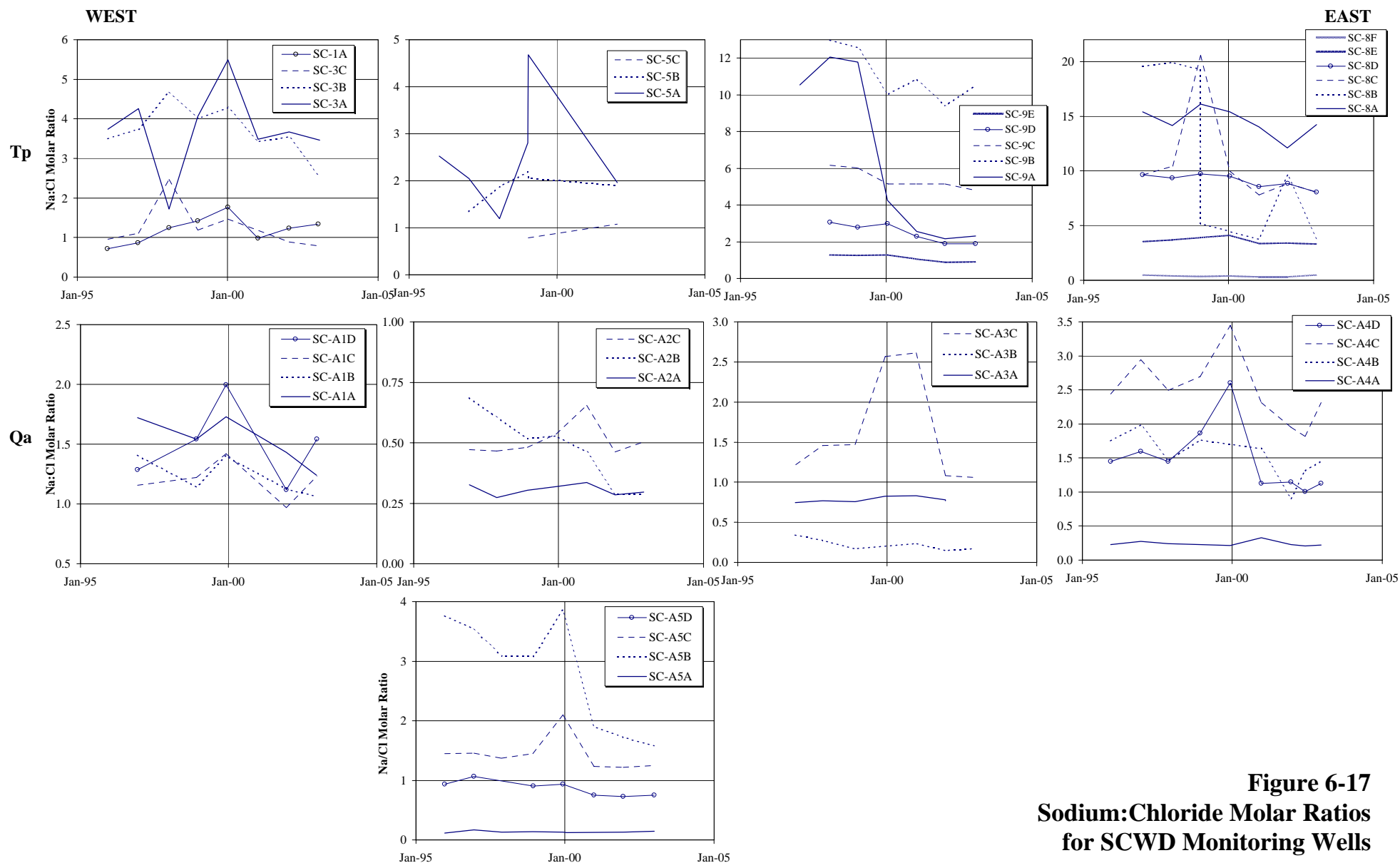


(note significant differences in vertical scale)

**Figure 6-15**  
**Sodium:Chloride Molar Ratios for Purisima Production Wells**



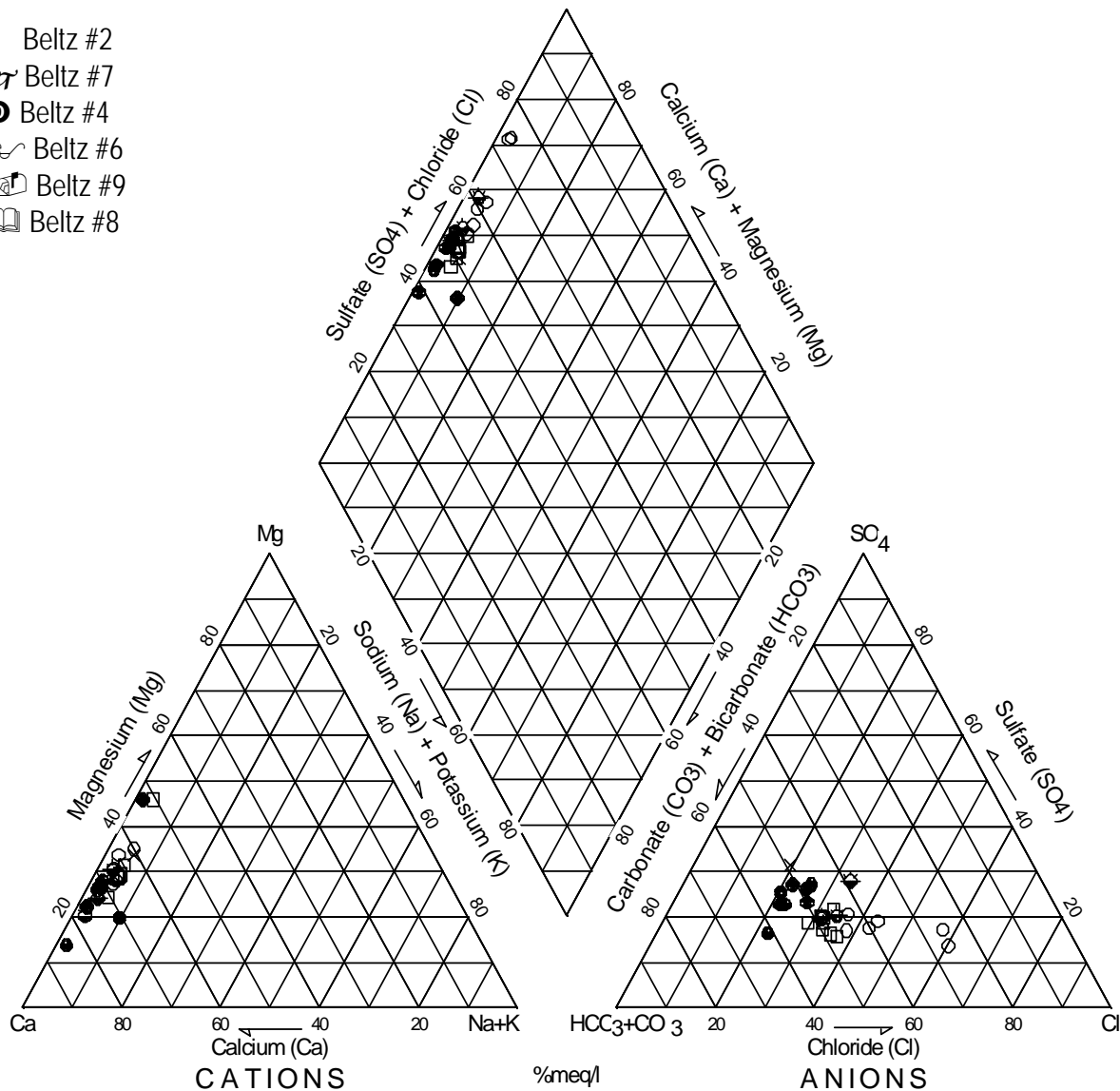
**Figure 6-16**  
**Sodium:Chloride Molar Ratios**  
**for Aromas Production Wells**



**Figure 6-17**  
**Sodium:Chloride Molar Ratios**  
**for SCWD Monitoring Wells**

# City of Santa Cruz Beltz Wells

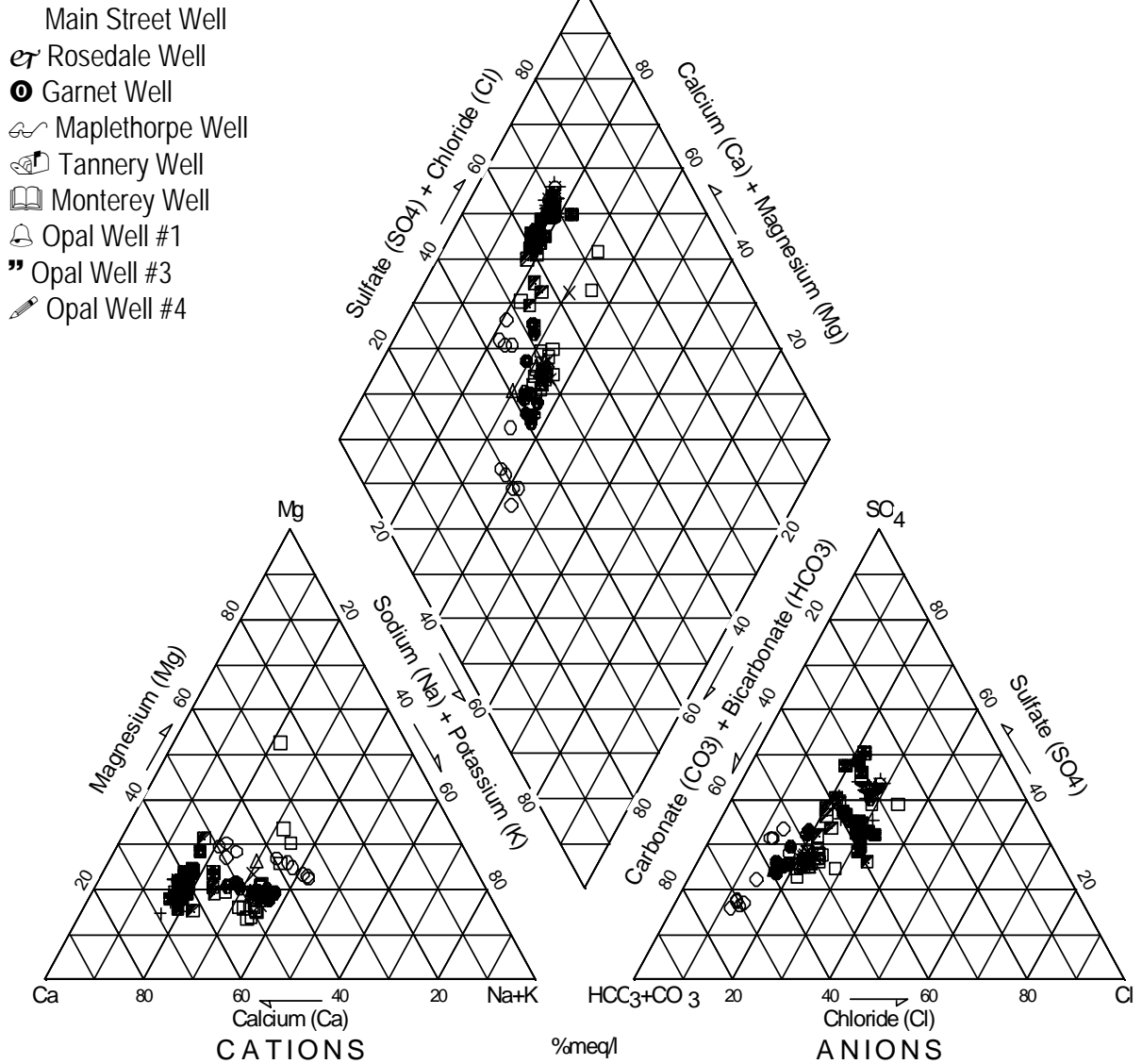
- Beltz #2
-  Beltz #7
-  Beltz #4
-  Beltz #6
-  Beltz #9
-  Beltz #8



**Figure 6-18a**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

## Purisima Production Wells

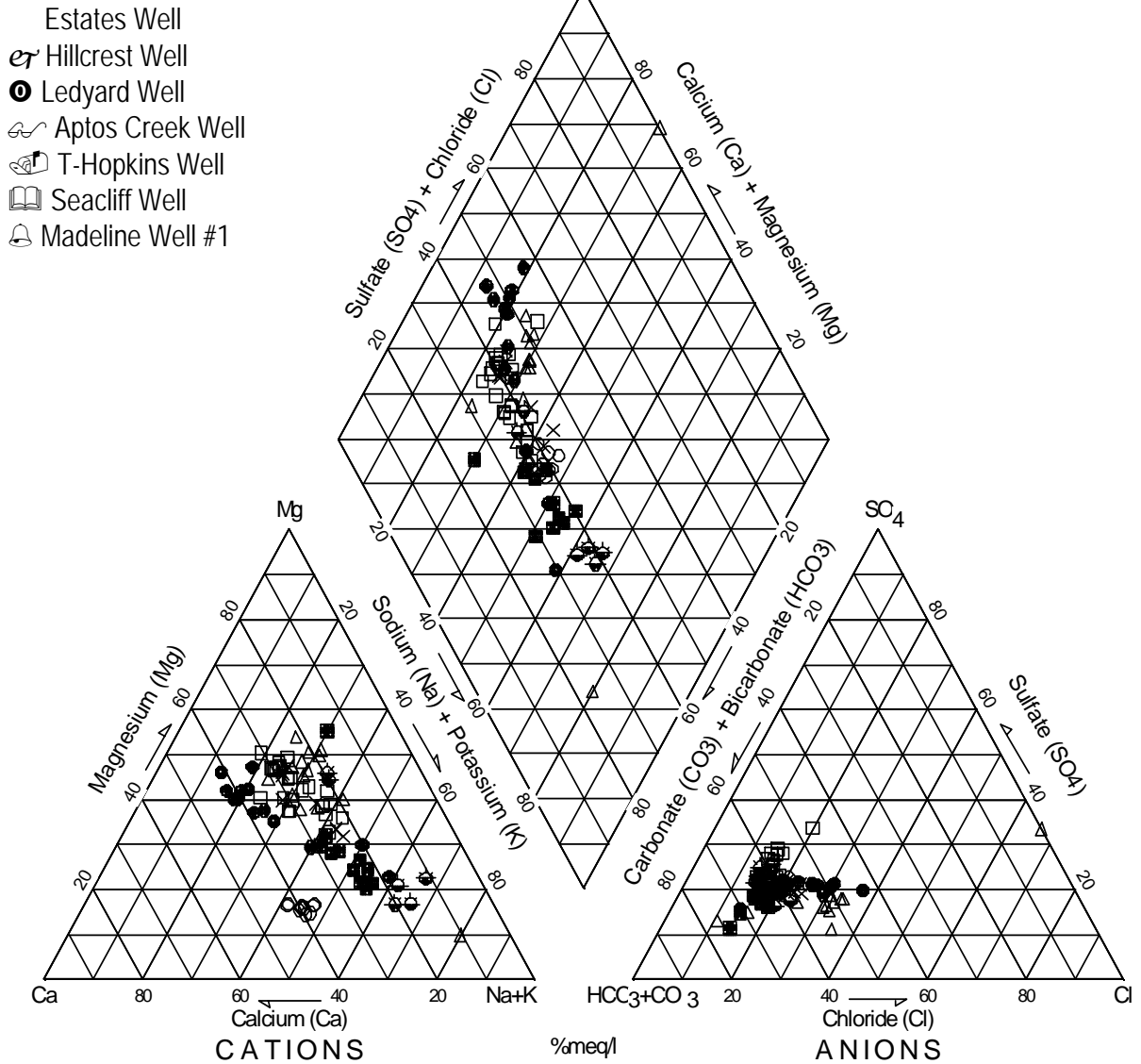
A and AA Sub-Units



**Figure 6-18b**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

## Purisima Production Wells

A through E Sub-Units

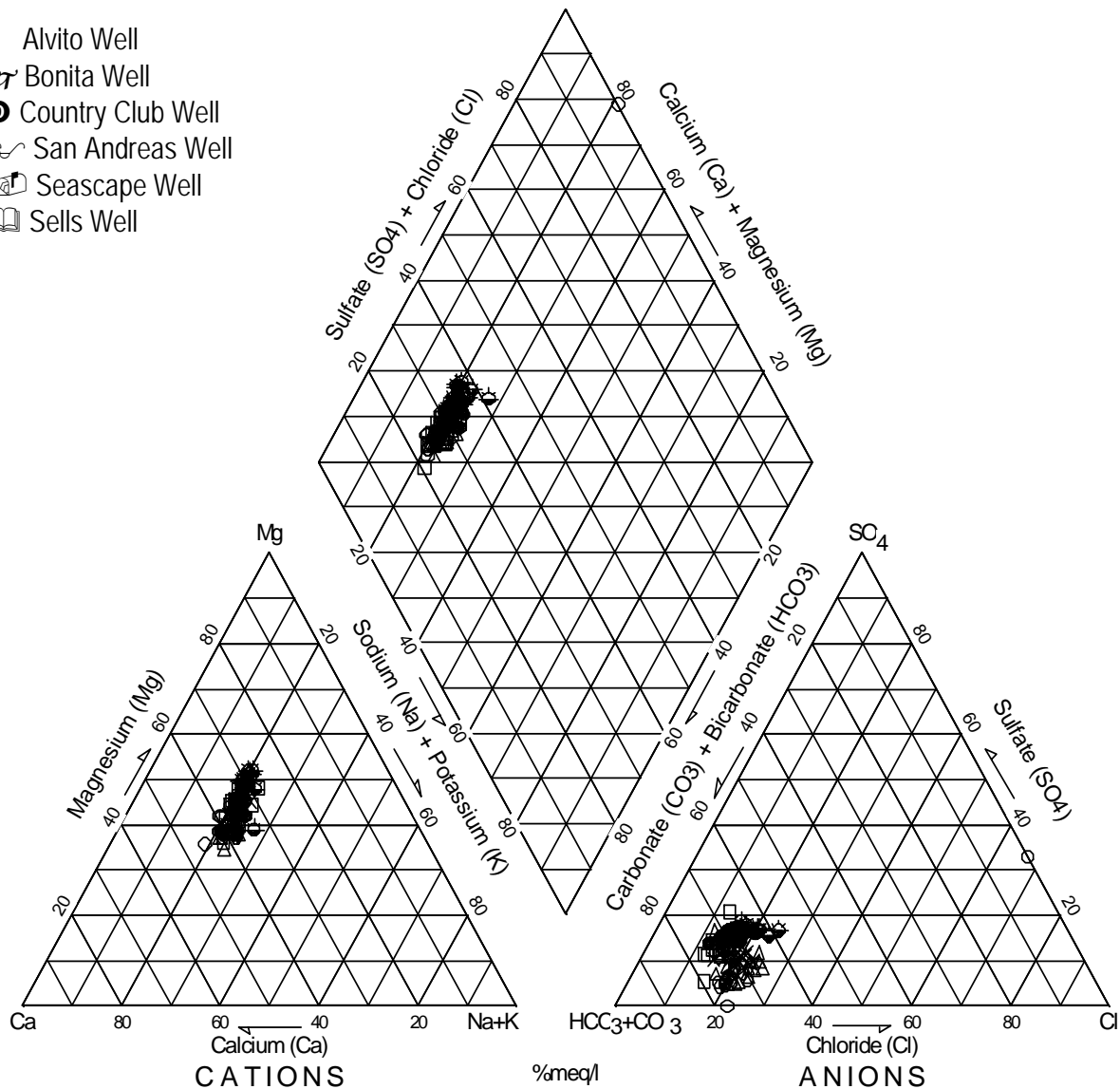


**Figure 6-18c**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**



## Aromas Production Wells

- Alvito Well
- Bonita Well
- Country Club Well
- San Andreas Well
- Seascape Well
- Sells Well

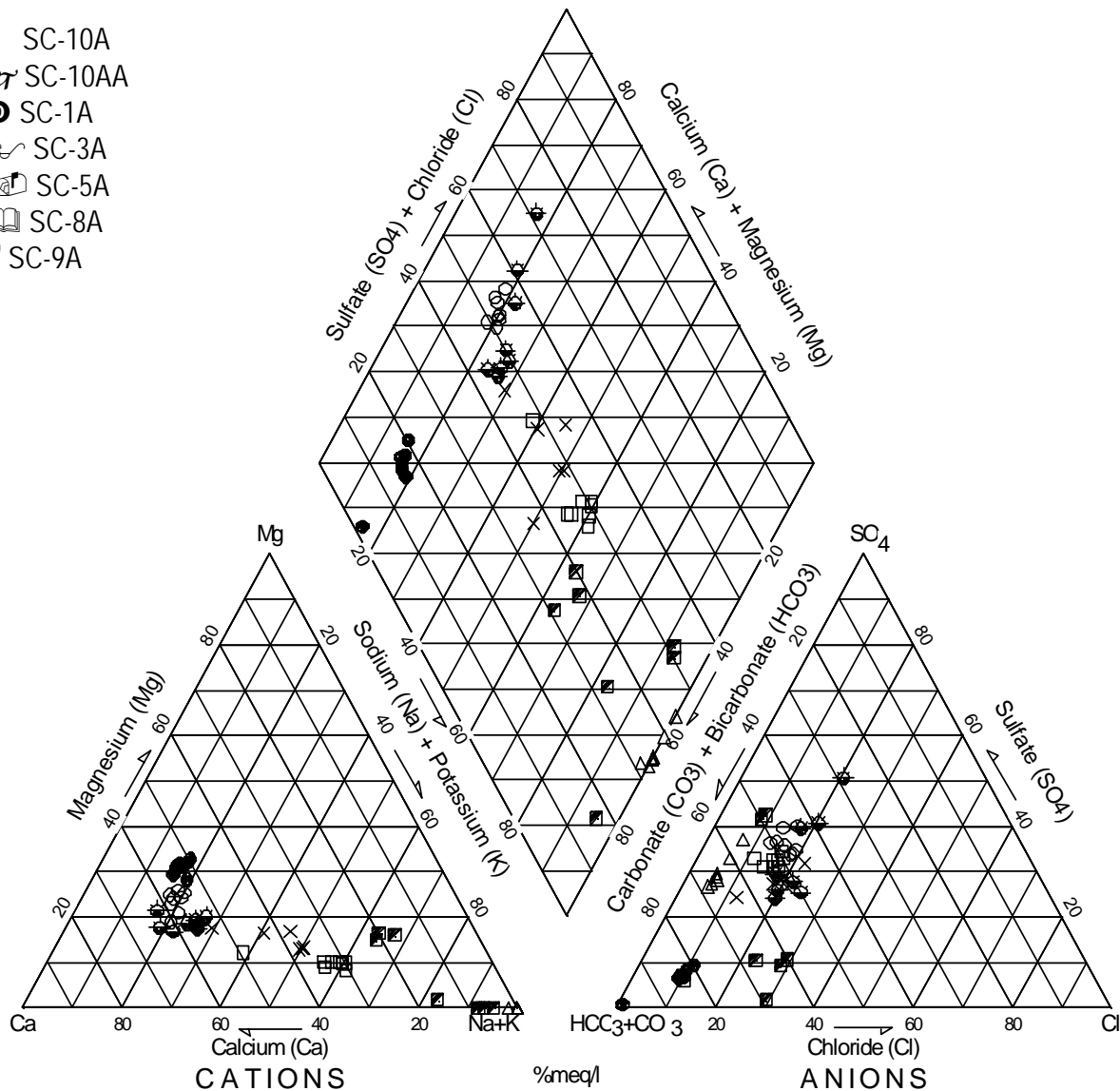


**Figure 6-18d**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

# Purisima Monitoring Wells

A and AA Sub-Units

- SC-10A
- SC-10AA
- SC-1A
- SC-3A
- SC-5A
- SC-8A
- SC-9A



**Figure 6-18e**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

# Purisima Monitoring Wells

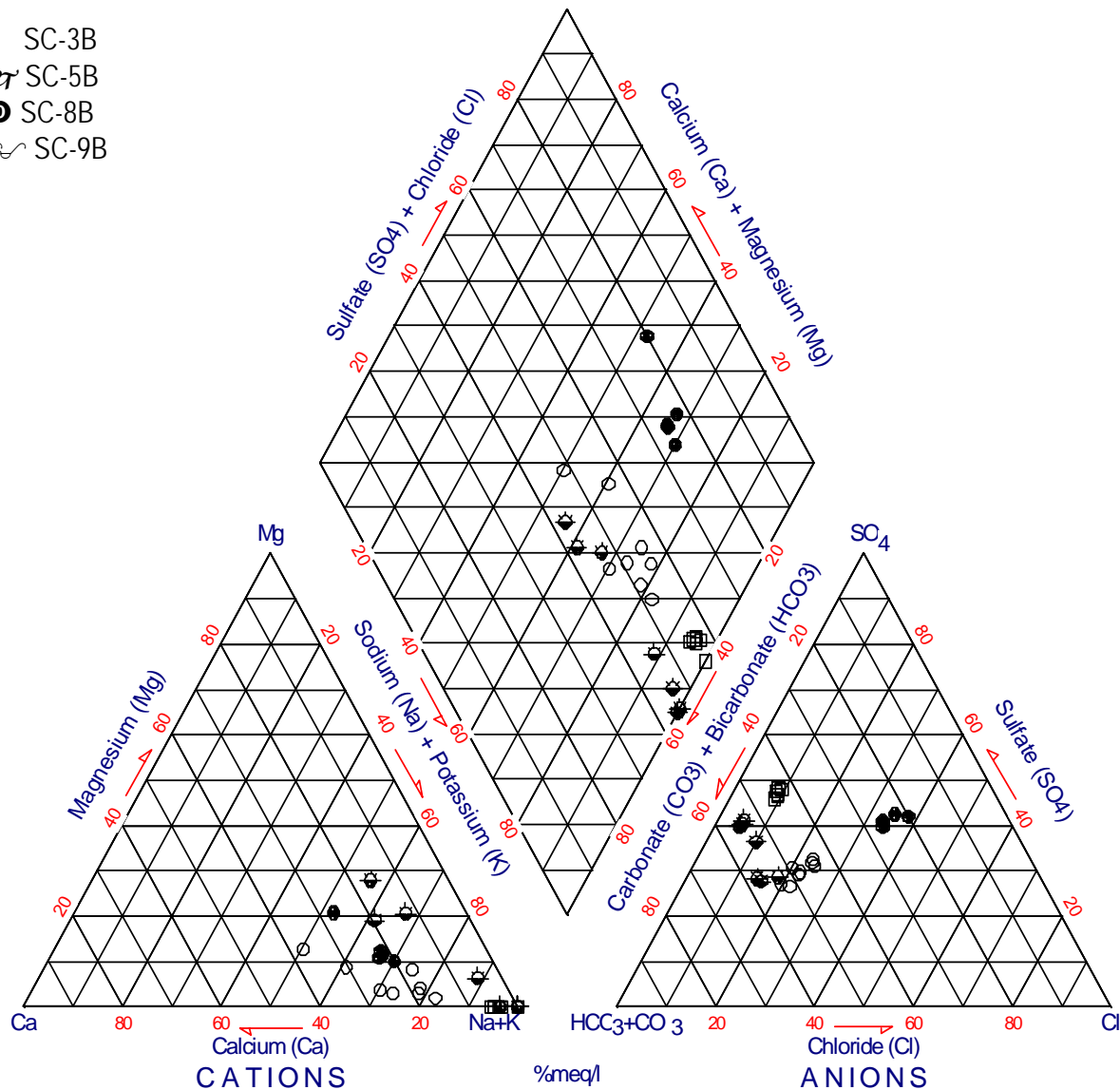
B Sub-Unit

SC-3B

SC-5B

SC-8B

SC-9B

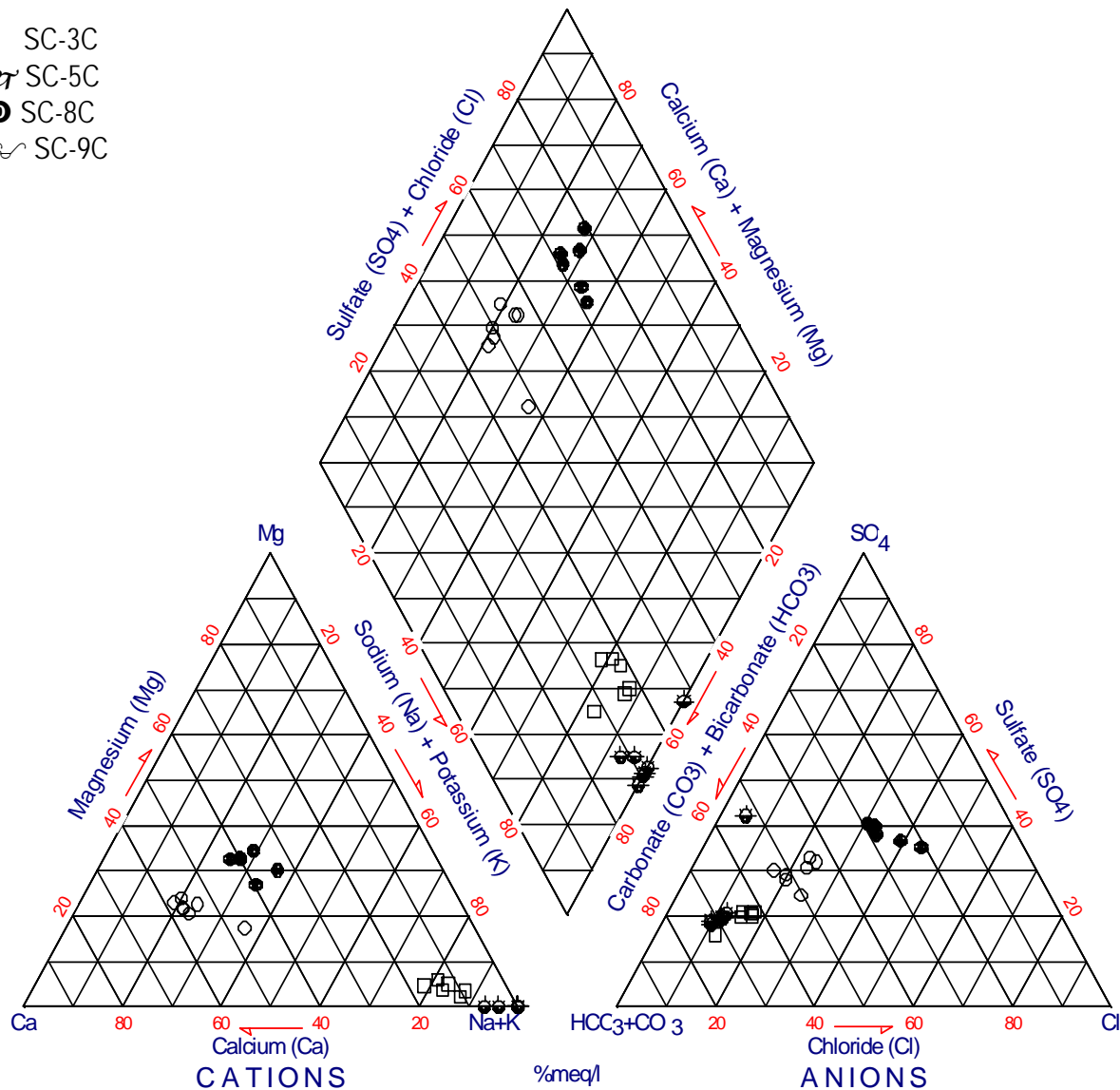


**Figure 6-18f**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

# Purisima Monitoring Wells

C Sub-Unit

- SC-3C
- SC-5C
- SC-8C
- SC-9C

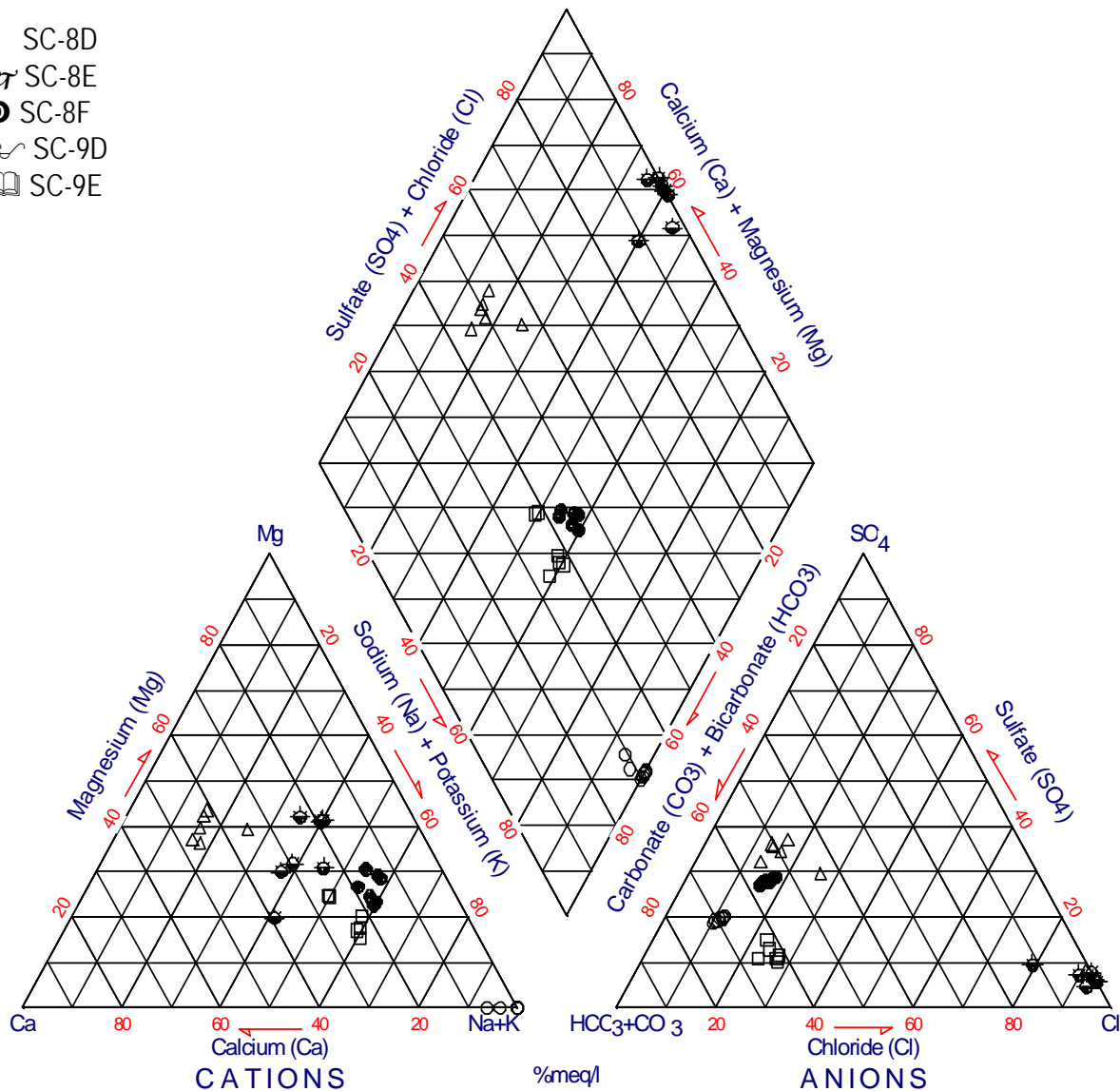


**Figure 6-18g**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

# Purisima Monitoring Wells

D, E, and F Sub-Units

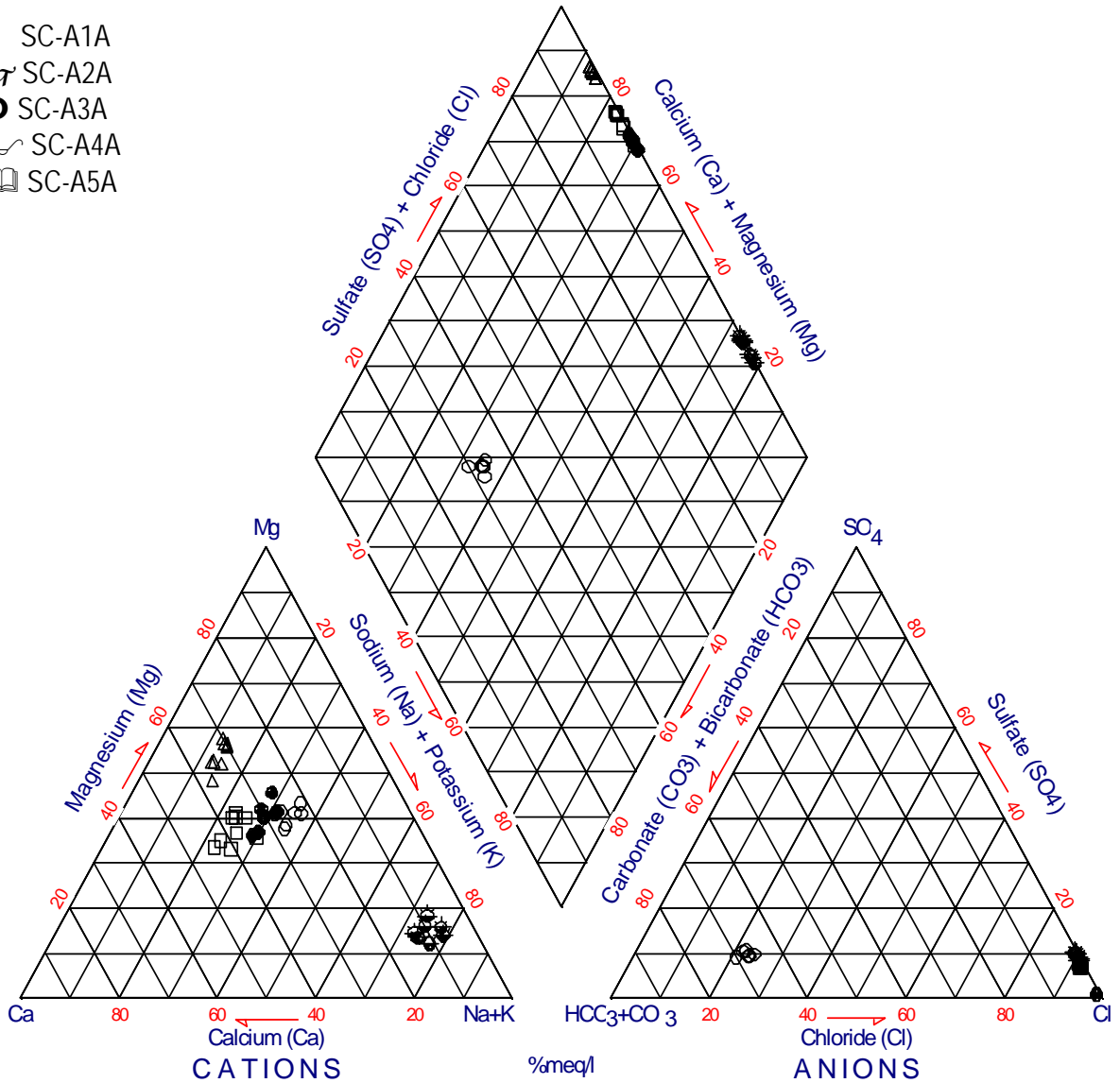
- SC-8D
- SC-8E
- SC-8F
- SC-9D
- SC-9E



**Figure 6-18h**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

# Aromas Monitoring Wells

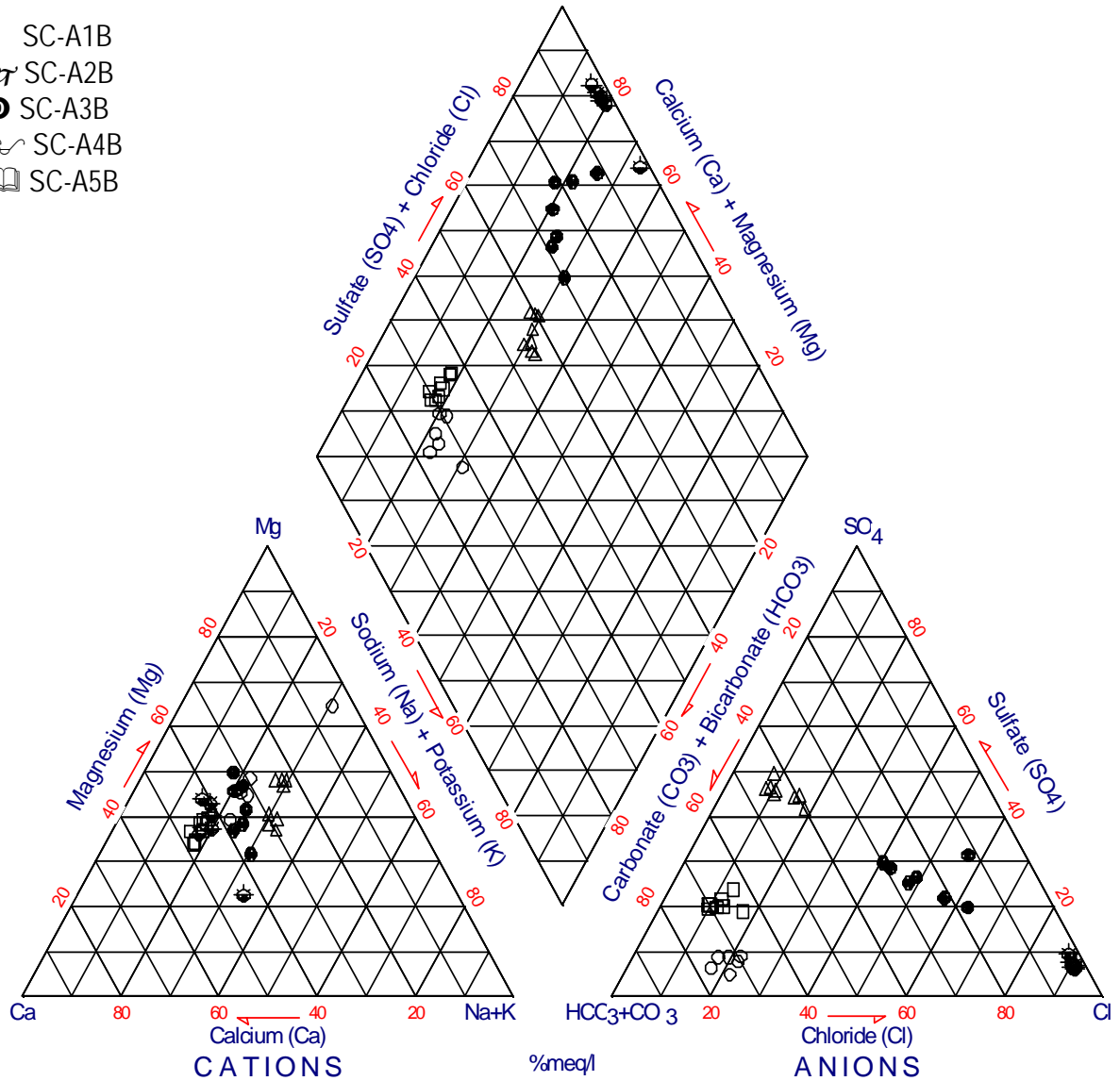
- SC-A1A
- SC-A2A
- SC-A3A
- SC-A4A
- SC-A5A



**Figure 6-18i**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

# Aromas Monitoring Wells

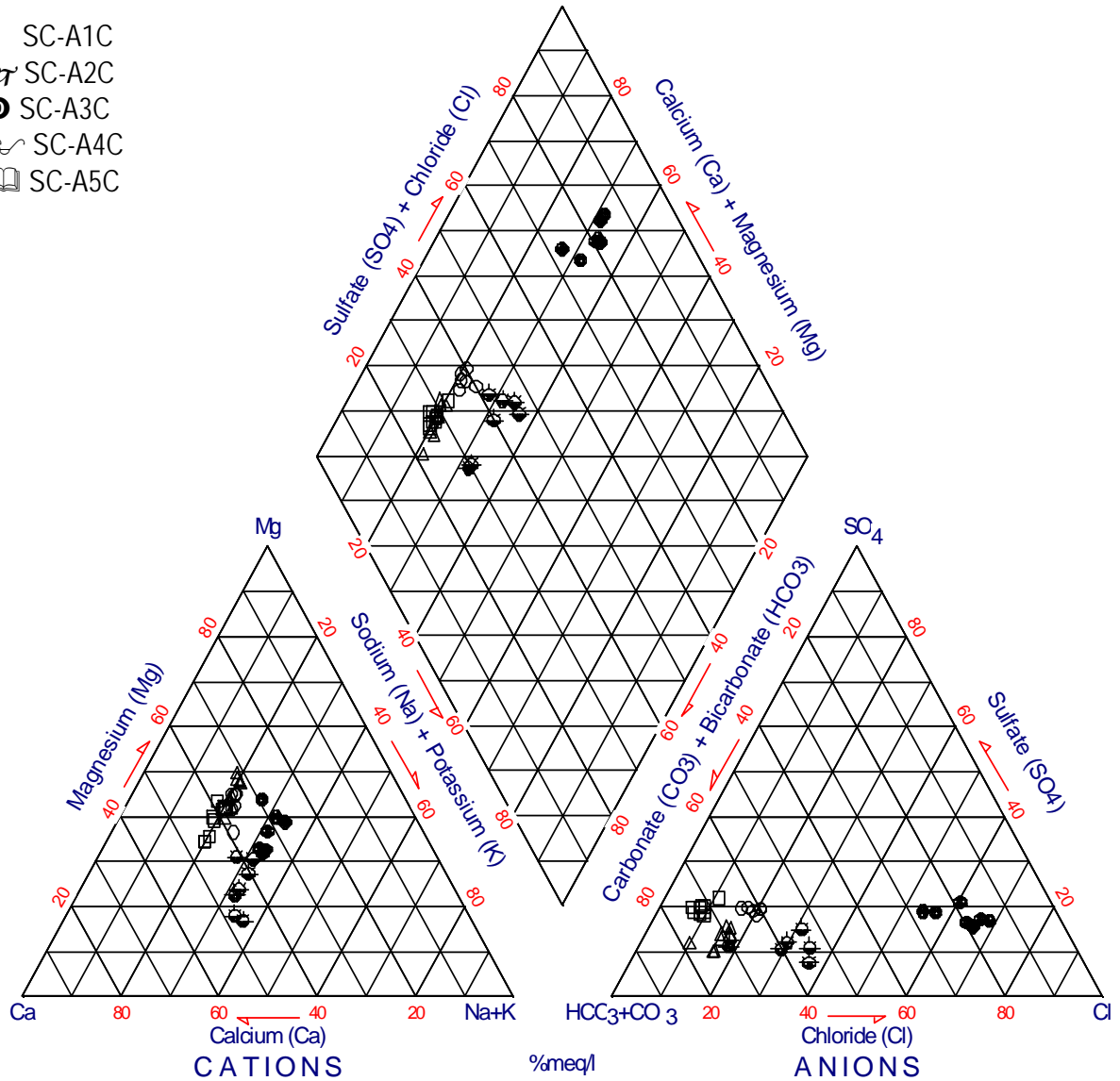
- SC-A1B
- SC-A2B
- SC-A3B
- SC-A4B
- SC-A5B



**Figure 6-18j**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

# Aromas Monitoring Wells

- SC-A1C
- SC-A2C
- SC-A3C
- SC-A4C
- SC-A5C

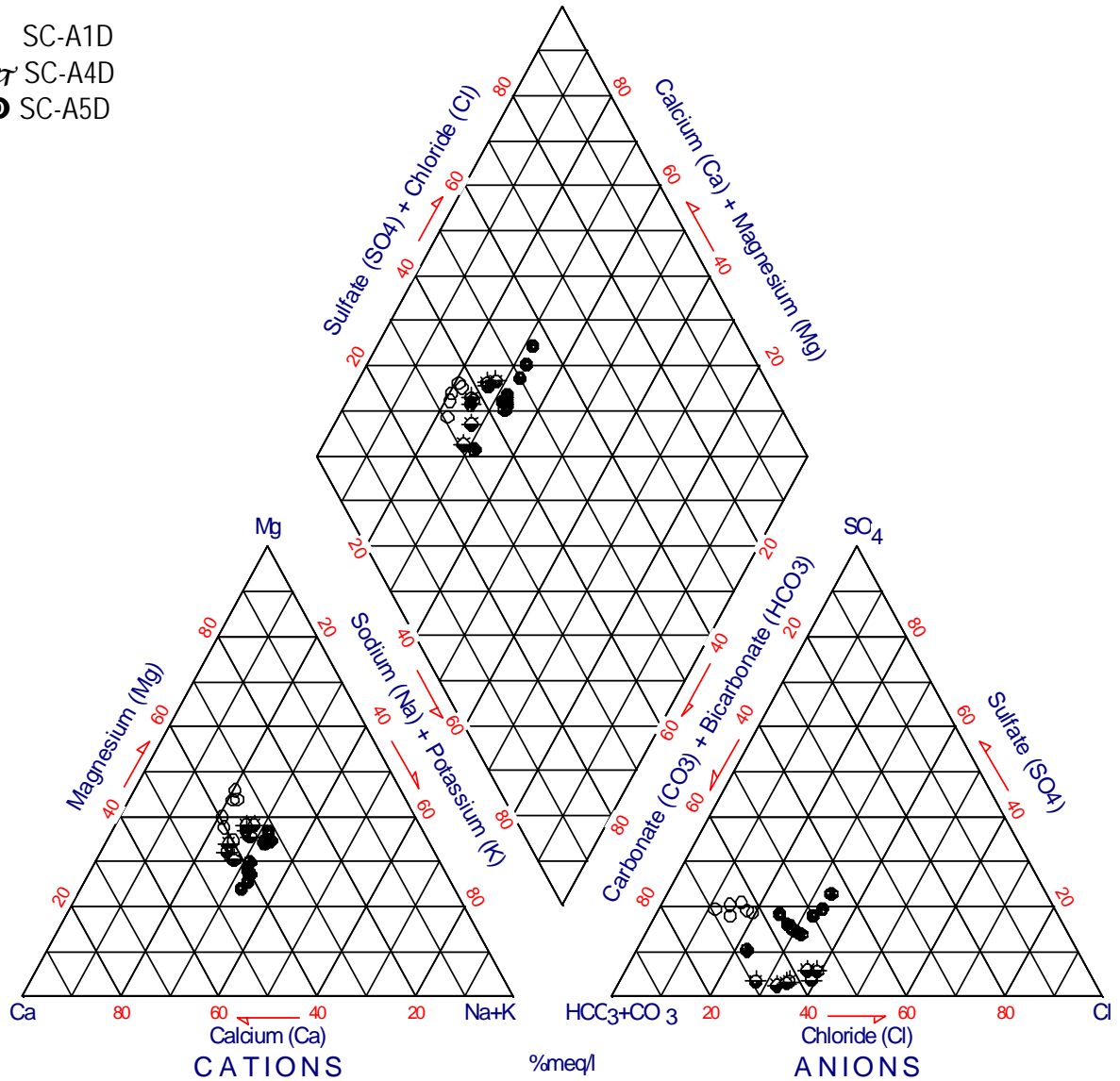


**Figure 6-18k**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

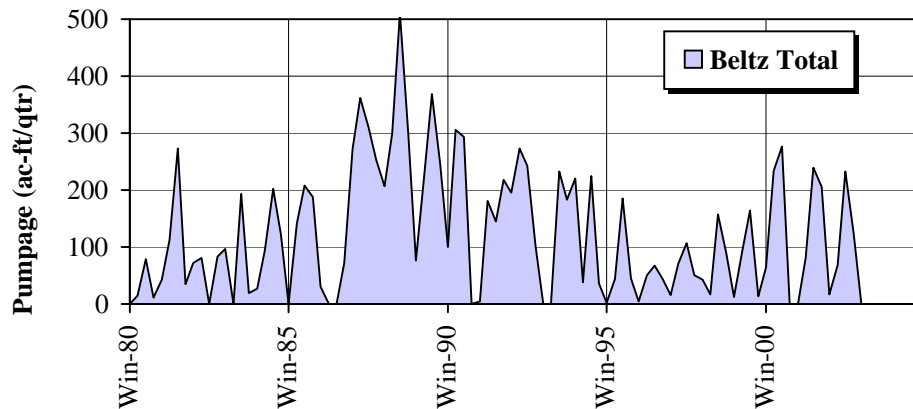
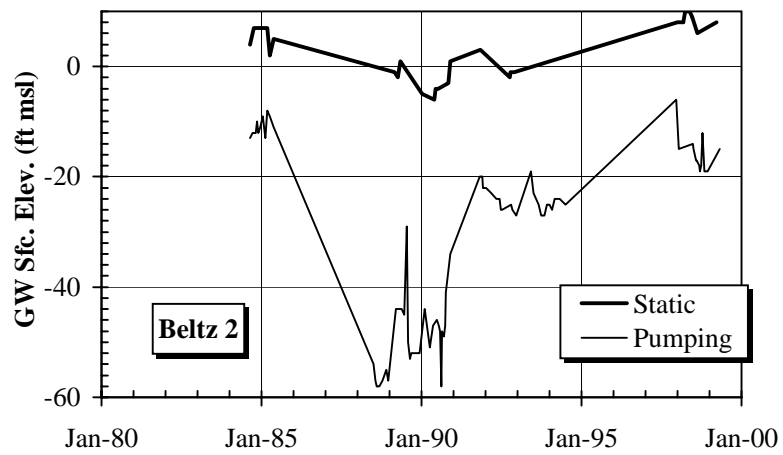
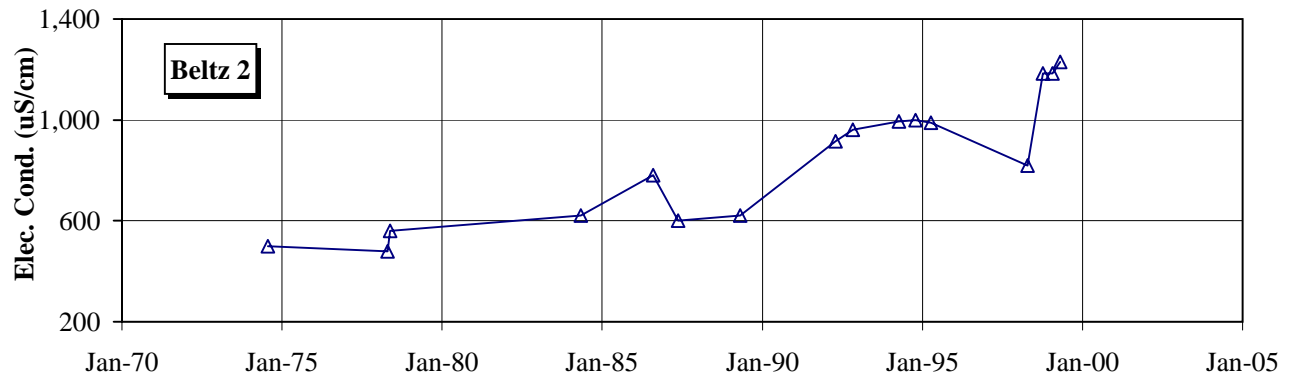
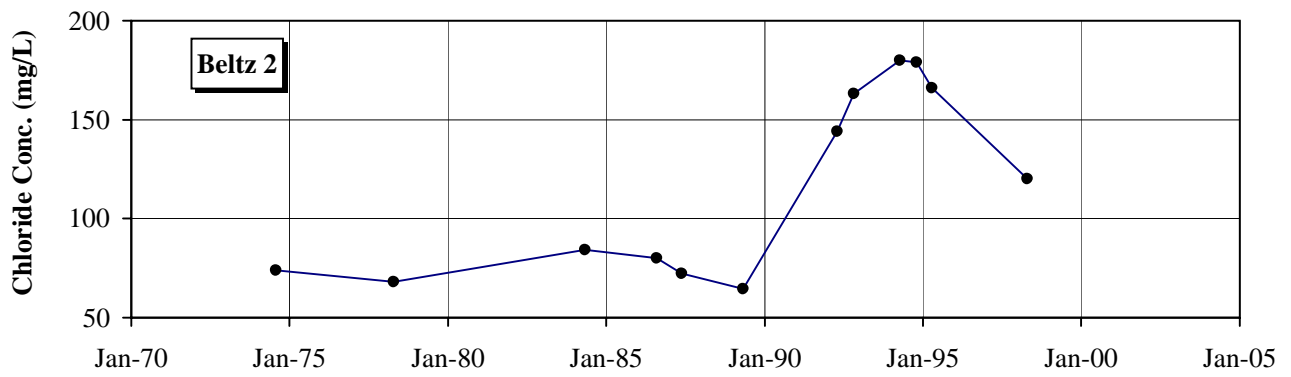


# Aromas Monitoring Wells

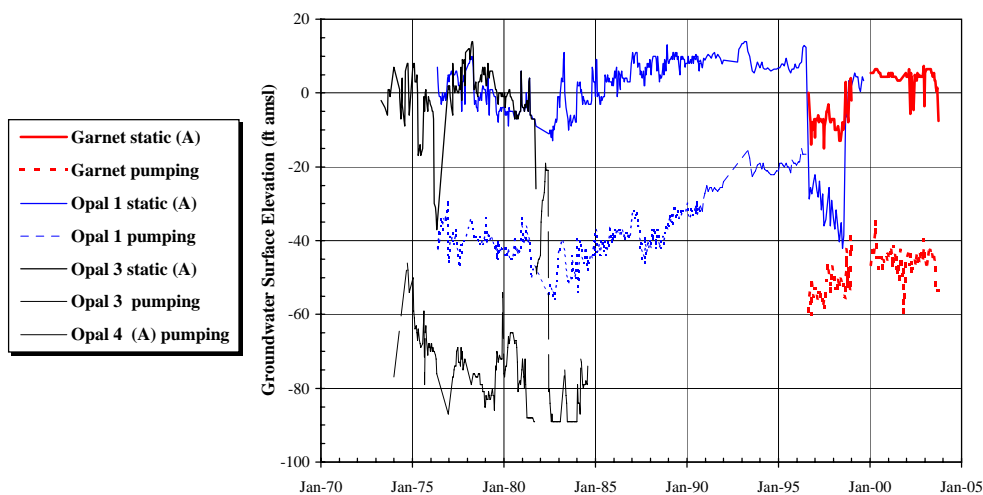
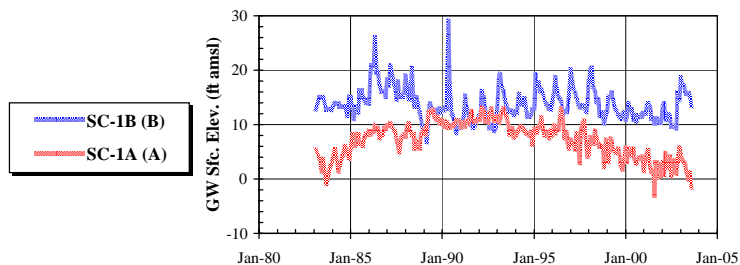
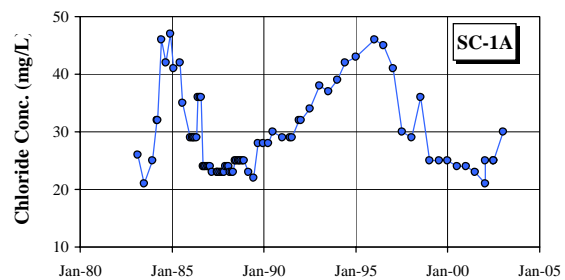
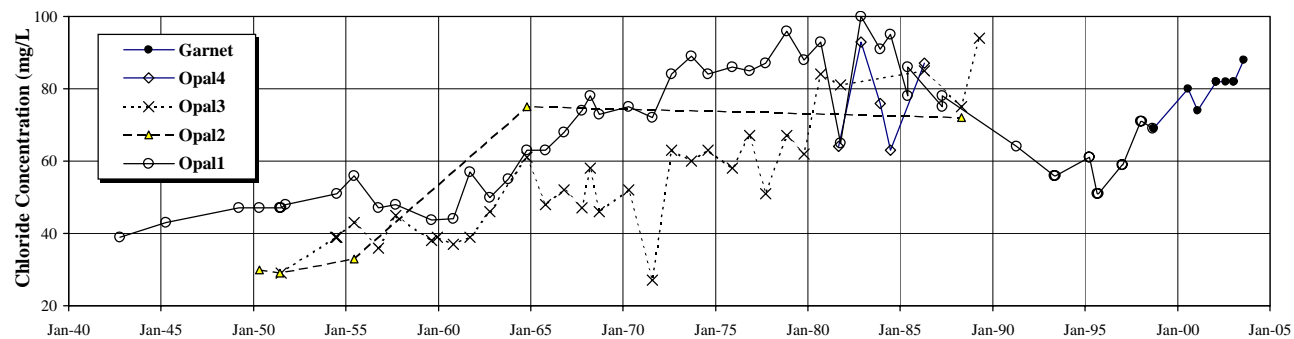
- SC-A1D
- SC-A4D
- SC-A5D



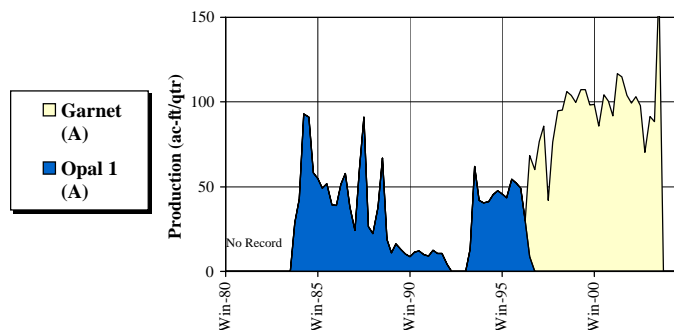
**Figure 6-18I**  
**Trilinear Diagrams for Selected**  
**Production and Monitoring Wells**

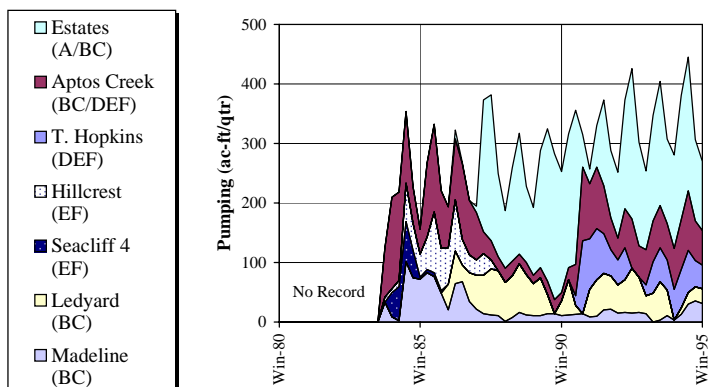
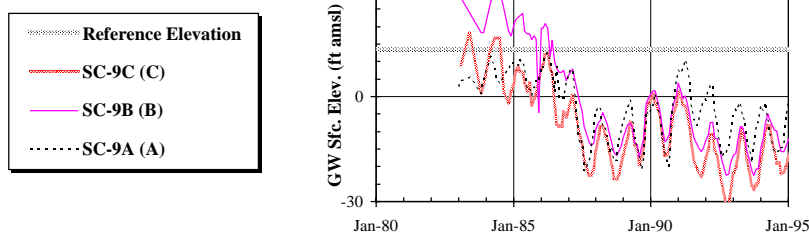
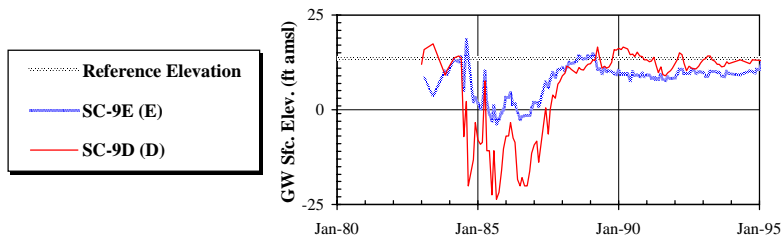
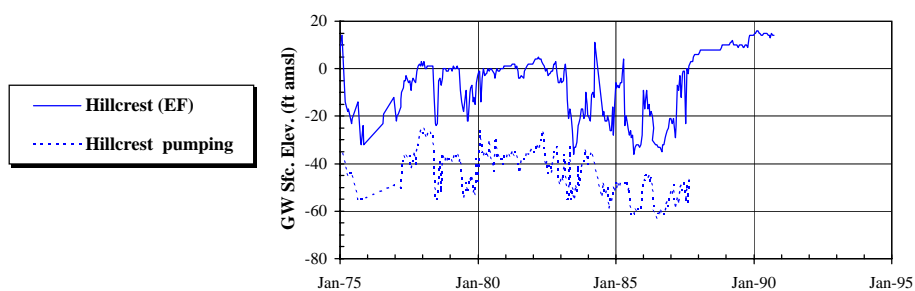
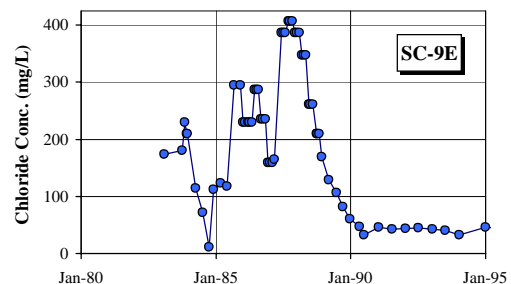
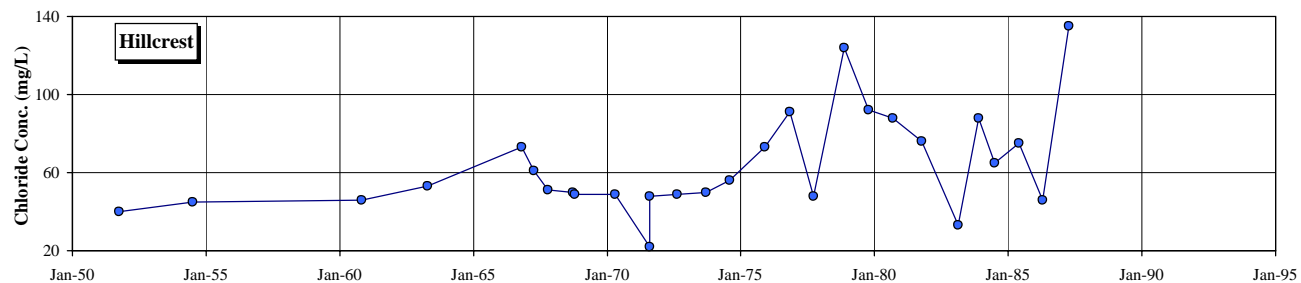


**Figure 6-19**  
**Beltz 2 Chloride, Water Levels, and Pumping**

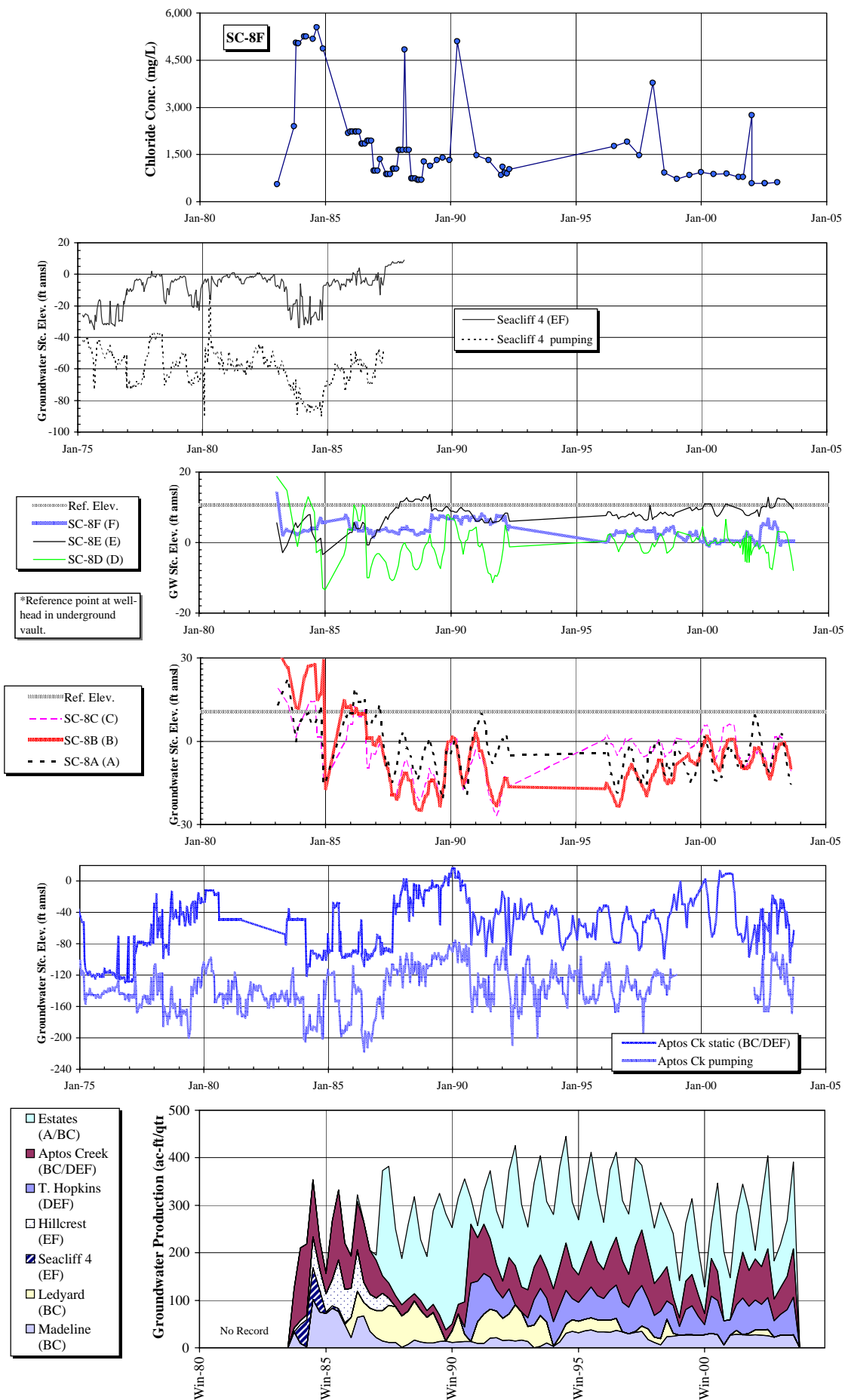


**Figure 6-20**  
**Opal, Garnet, and SC-1**  
**Chloride Concentrations,**  
**Water Levels, and Pumping**

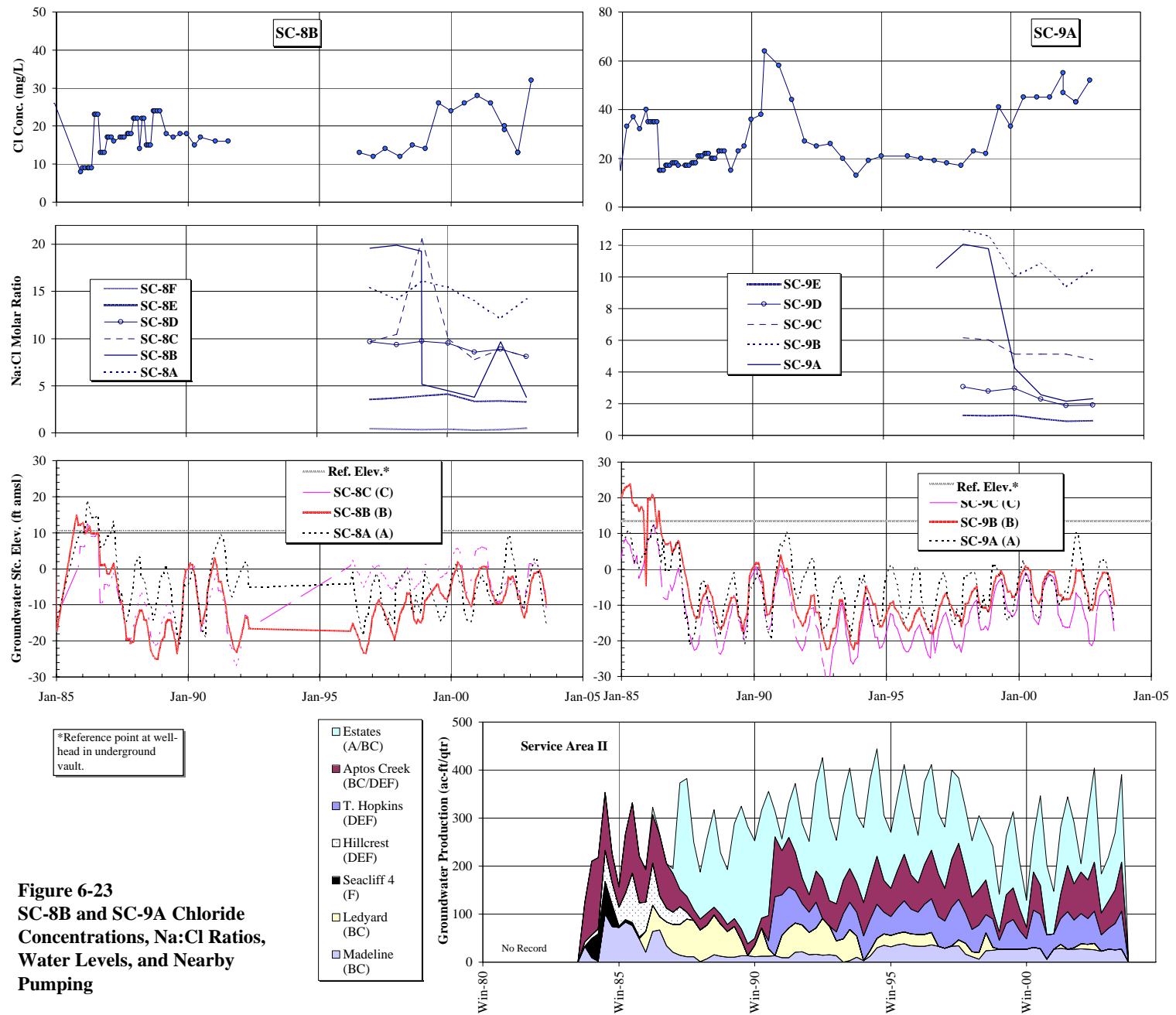


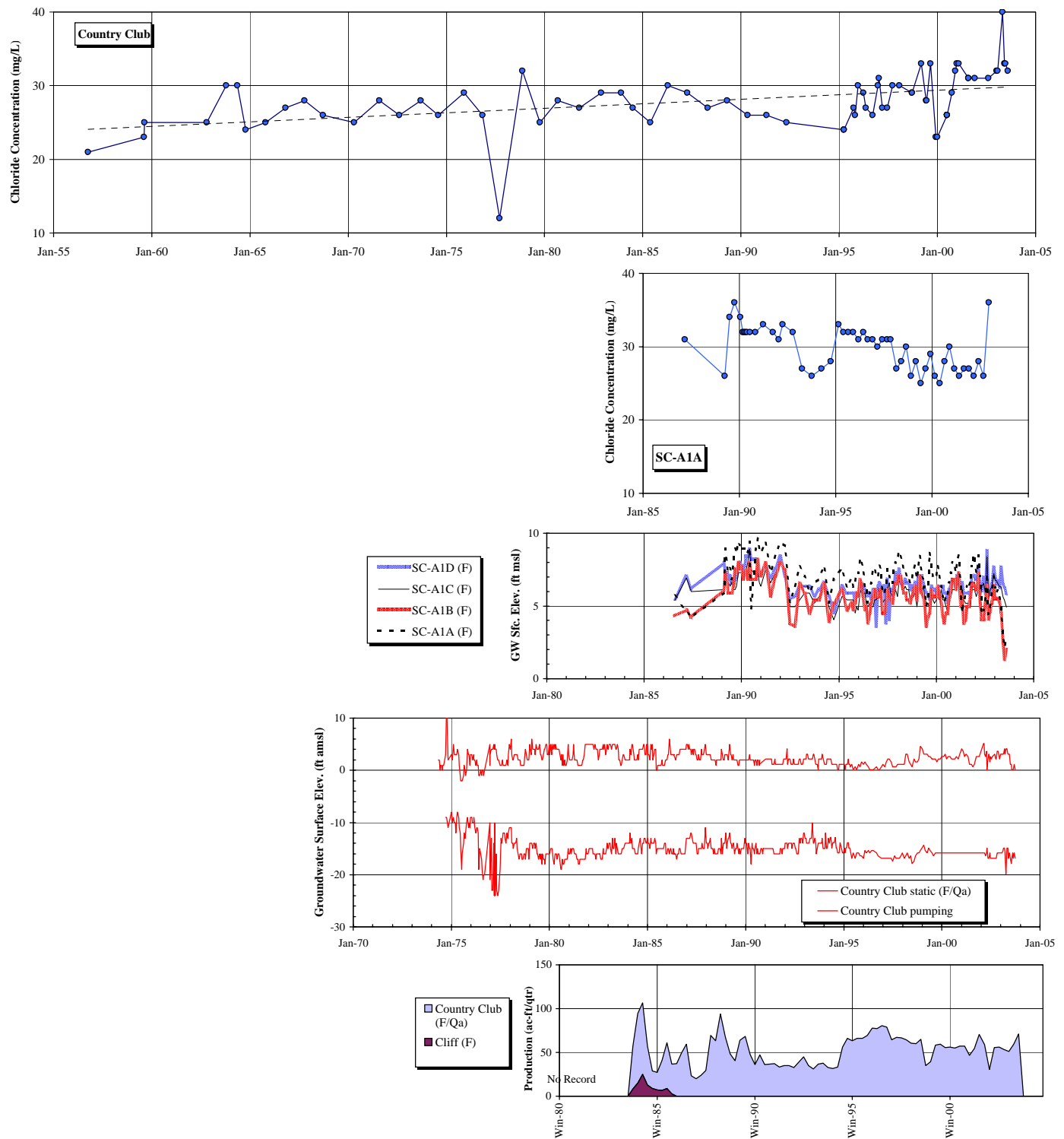


**Figure 6-21**  
**Hillcrest and SC-9E Chloride**  
**Concentrations, Water Levels,**  
**and Nearby Pumping**

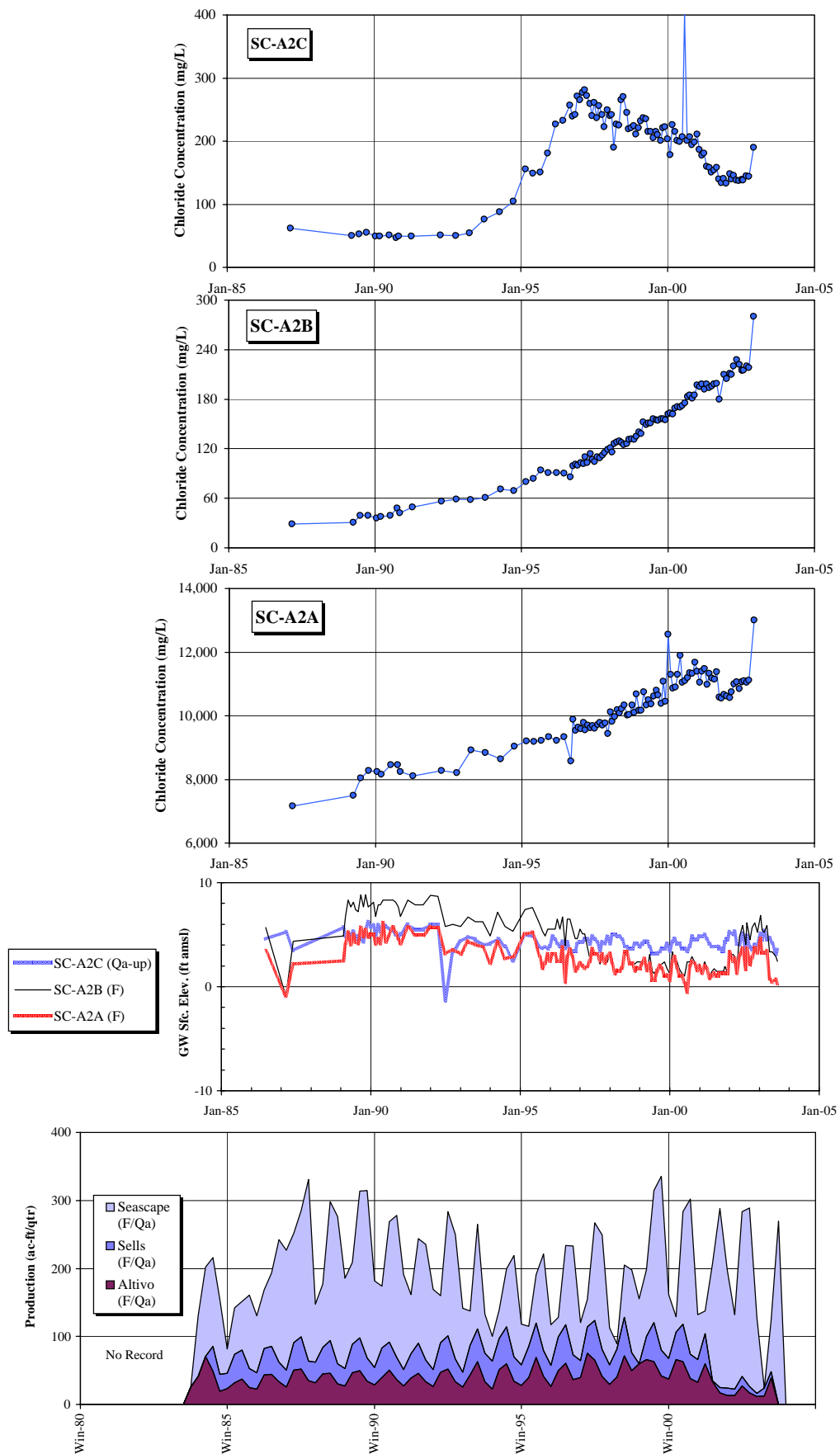


**Figure 6-22**  
**Seacliff 4, Aptos Creek, and SC-8 Chloride Concentrations, Water Levels, and Nearby Pumping**



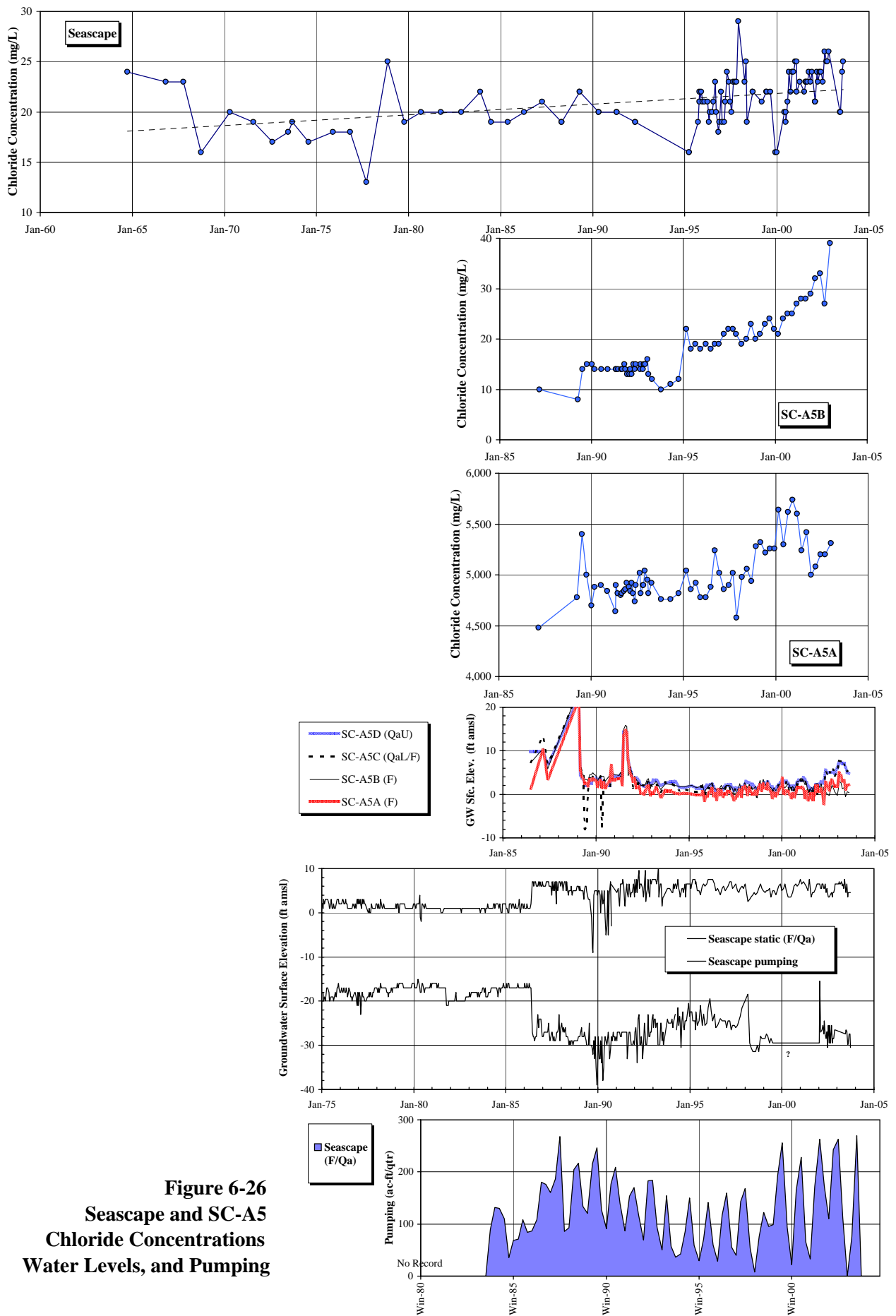


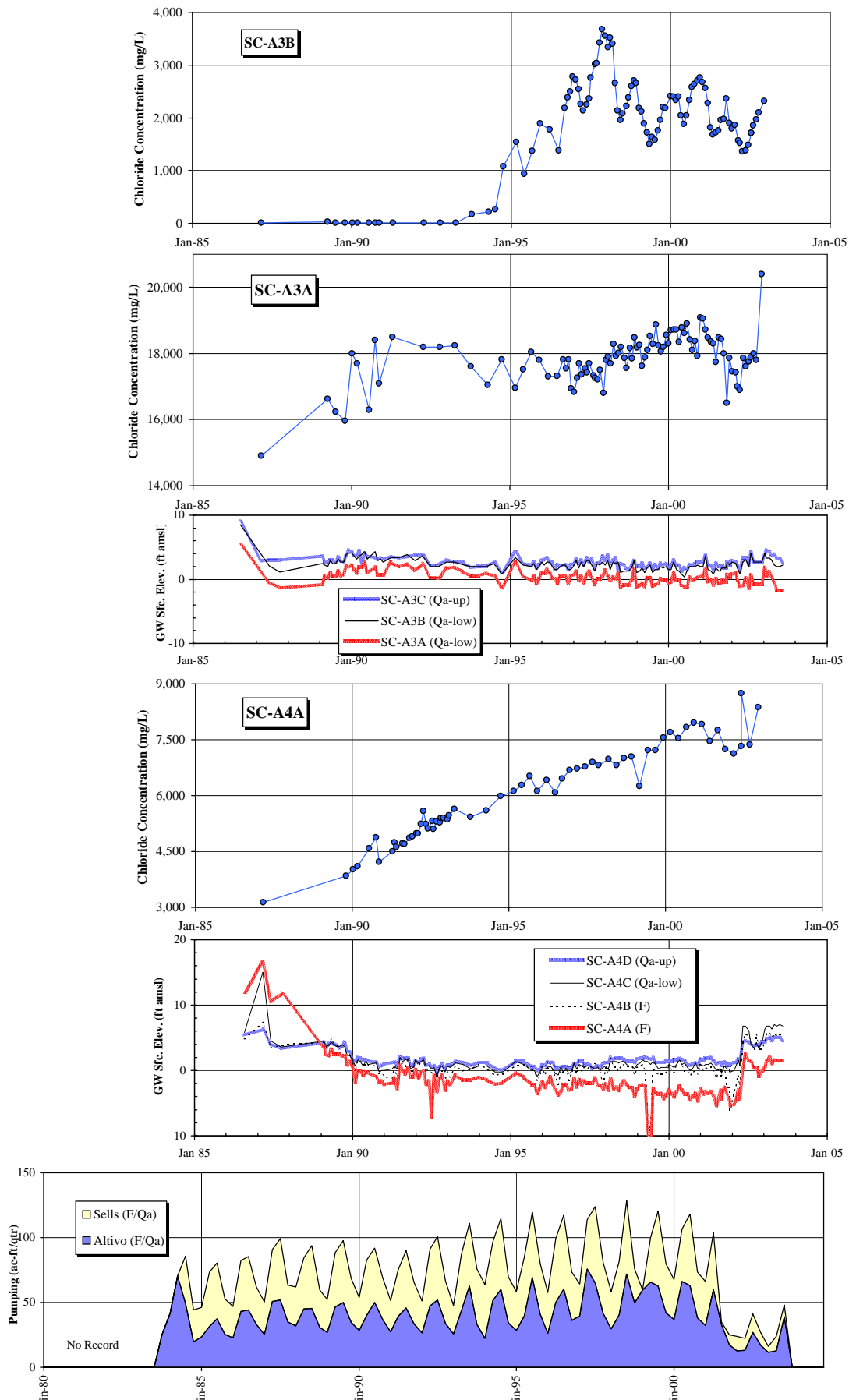
**Figure 6-24**  
**Country Club and SC-A1 Chloride Concentrations, Water Levels, and Pumping**



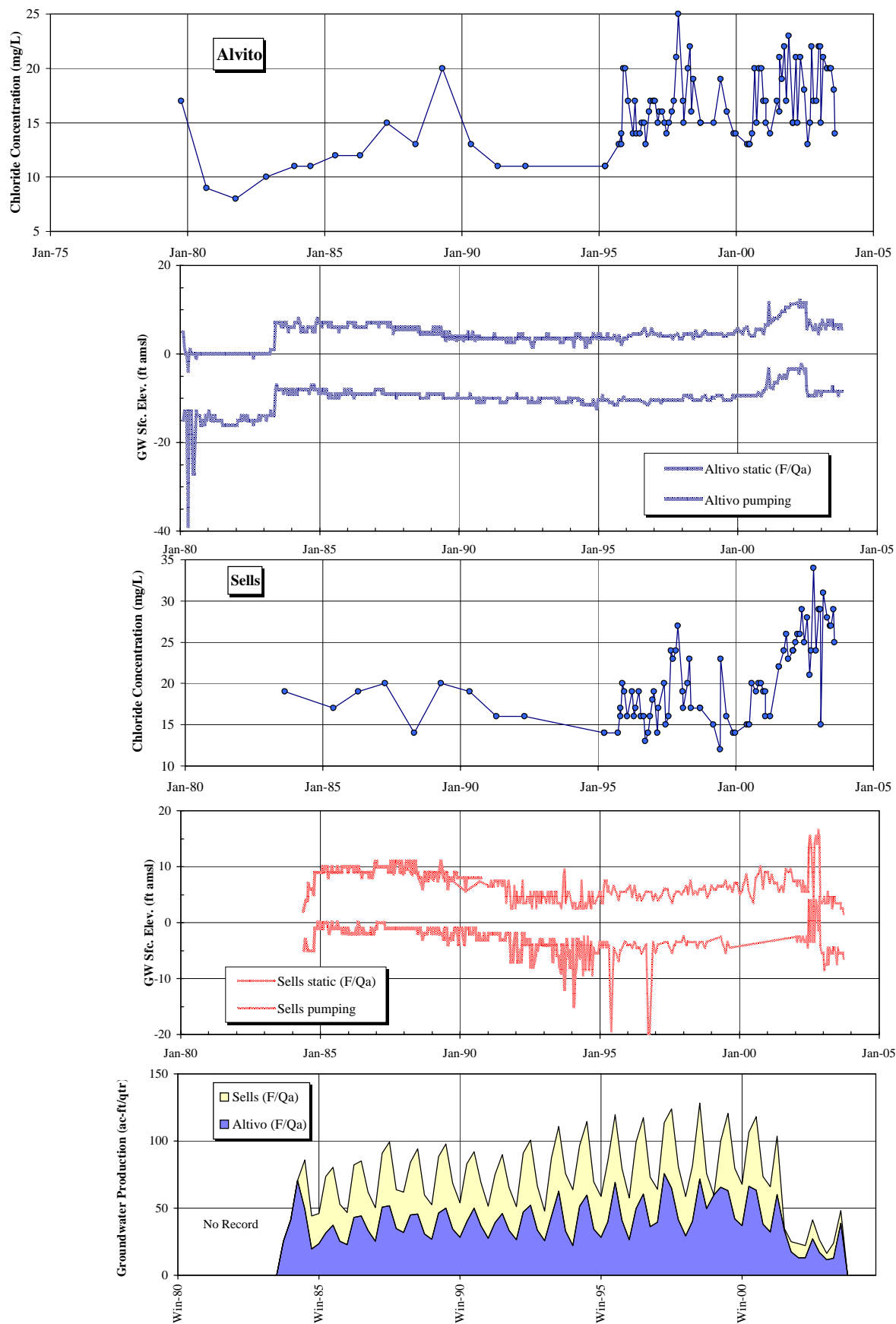
**Figure 6-25**  
**SC-A2 Chloride Concentrations, Water Levels, and Nearby Pumping**



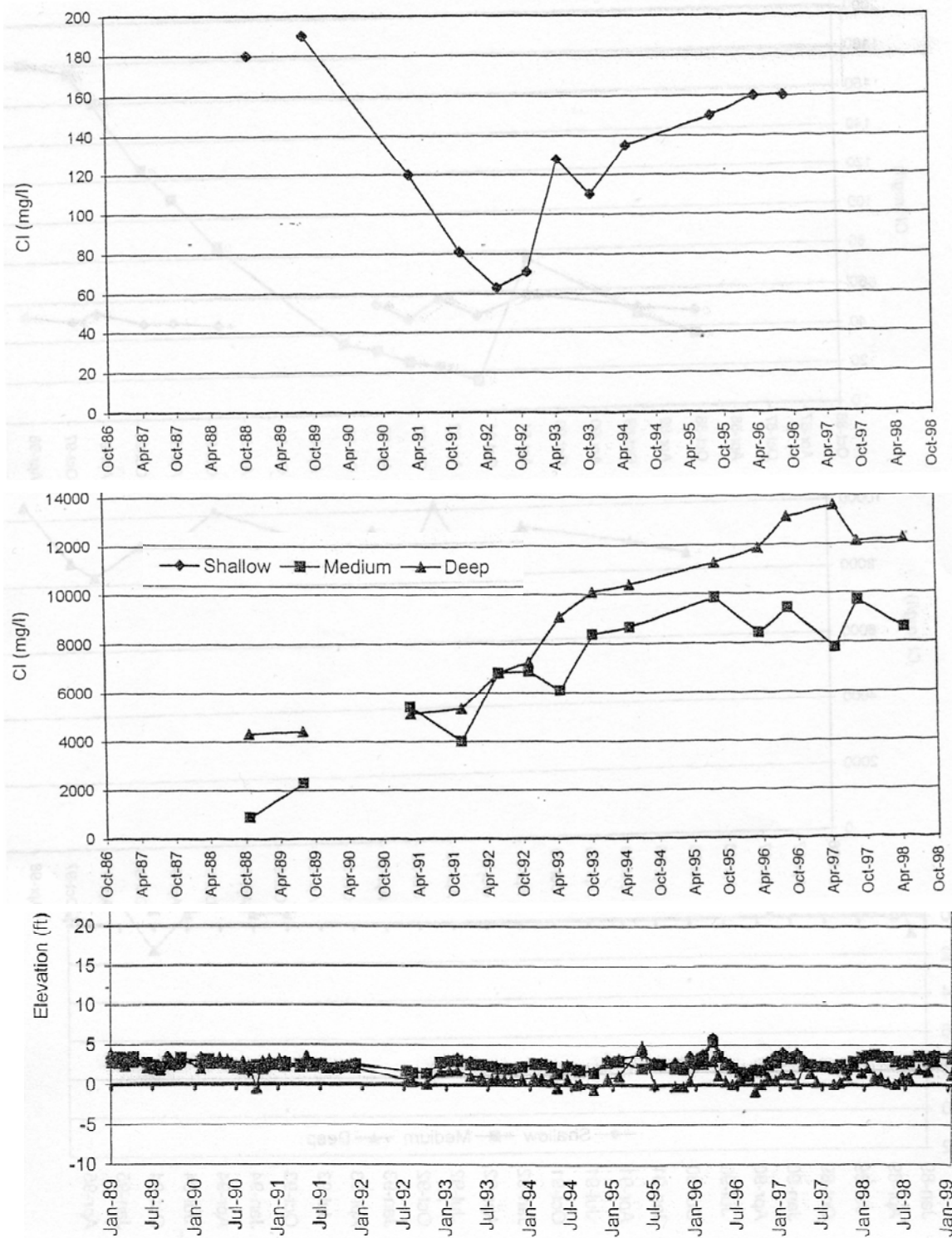




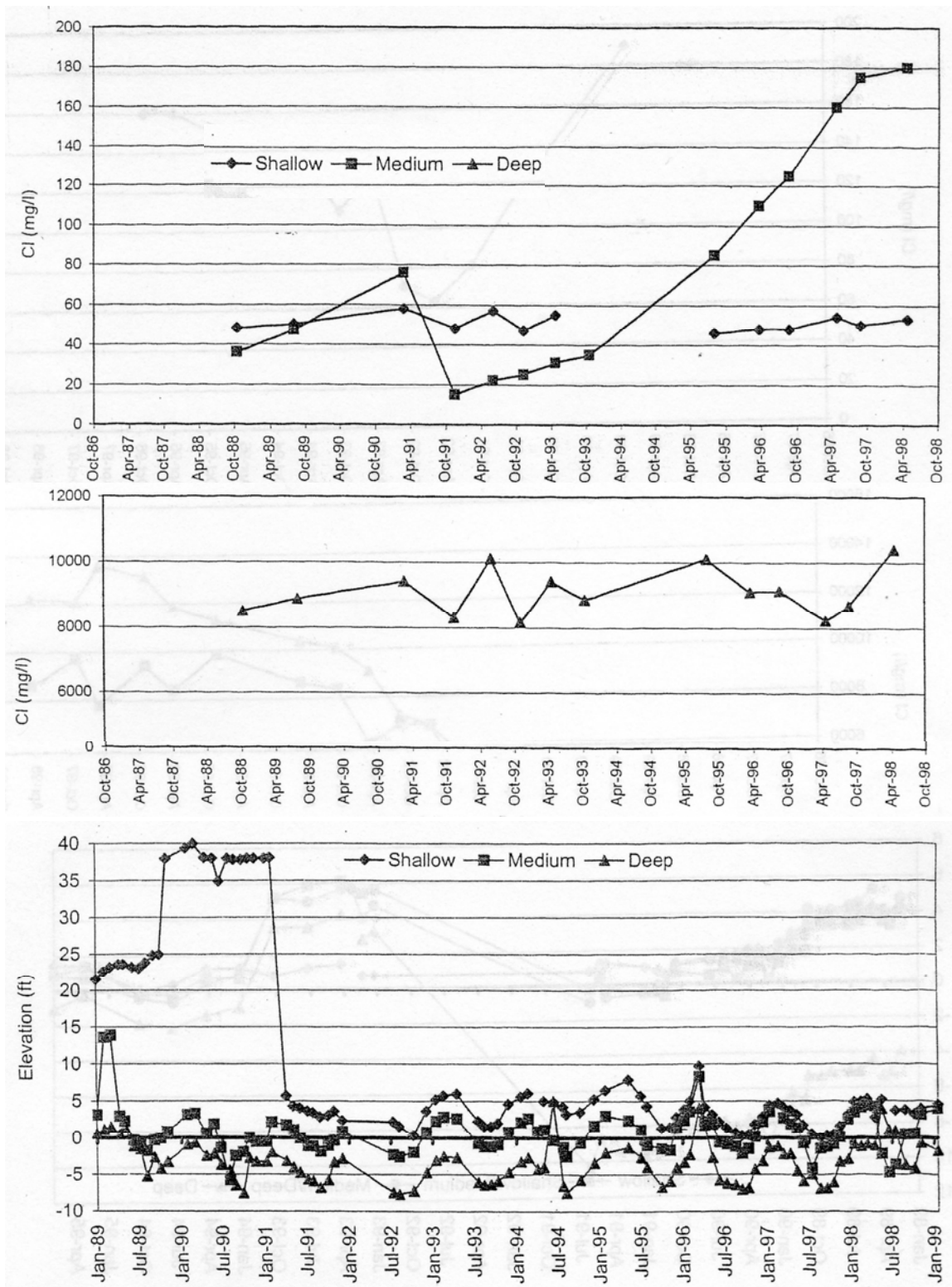
**Figure 6-27**  
**SC-A3 and SC-A4 Chloride Concentrations, Water Levels, and Nearby Pumping**



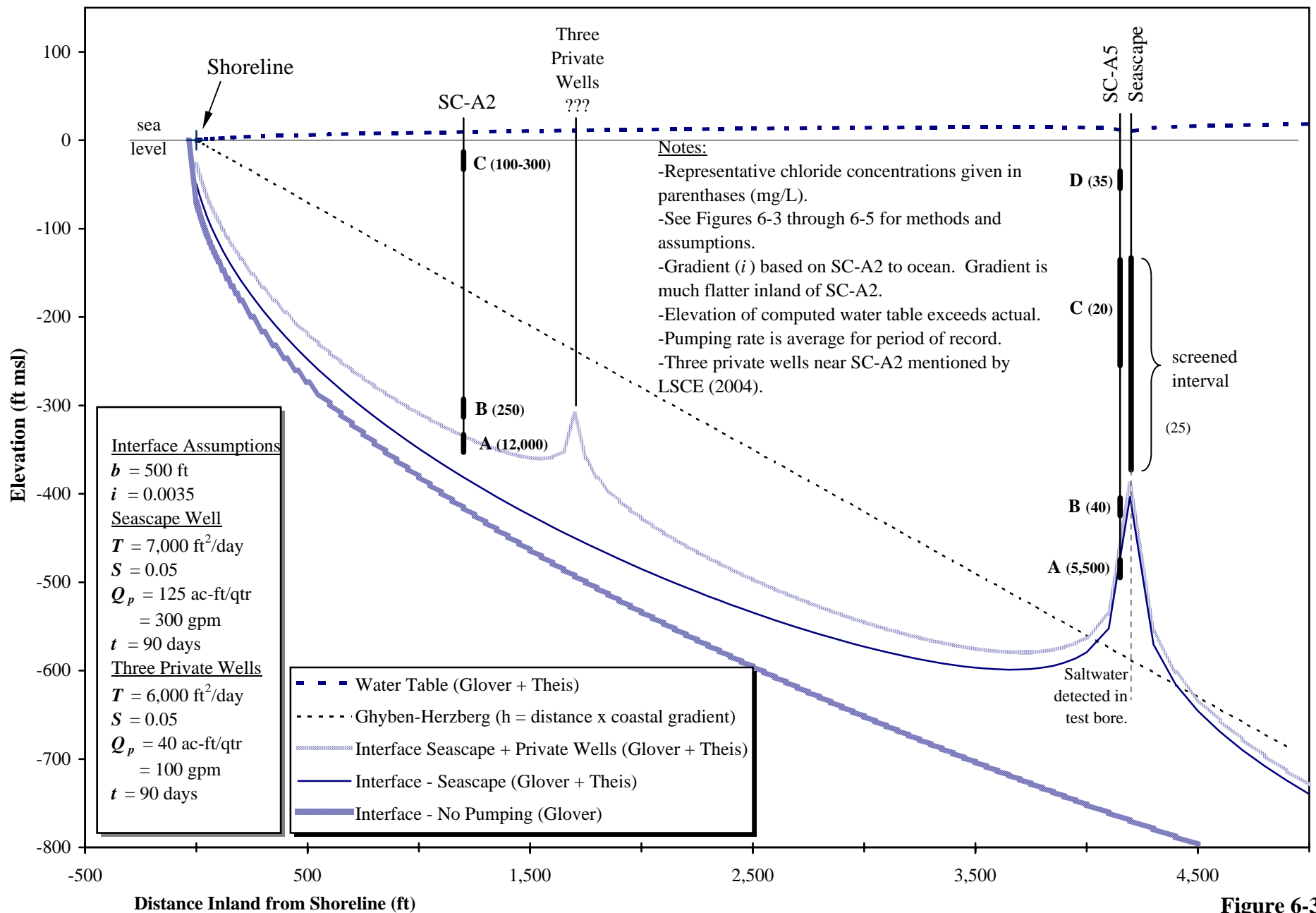
**Figure 6-28**  
**Alvito and Sells Chloride Concentrations, Water Levels, and Pumping**



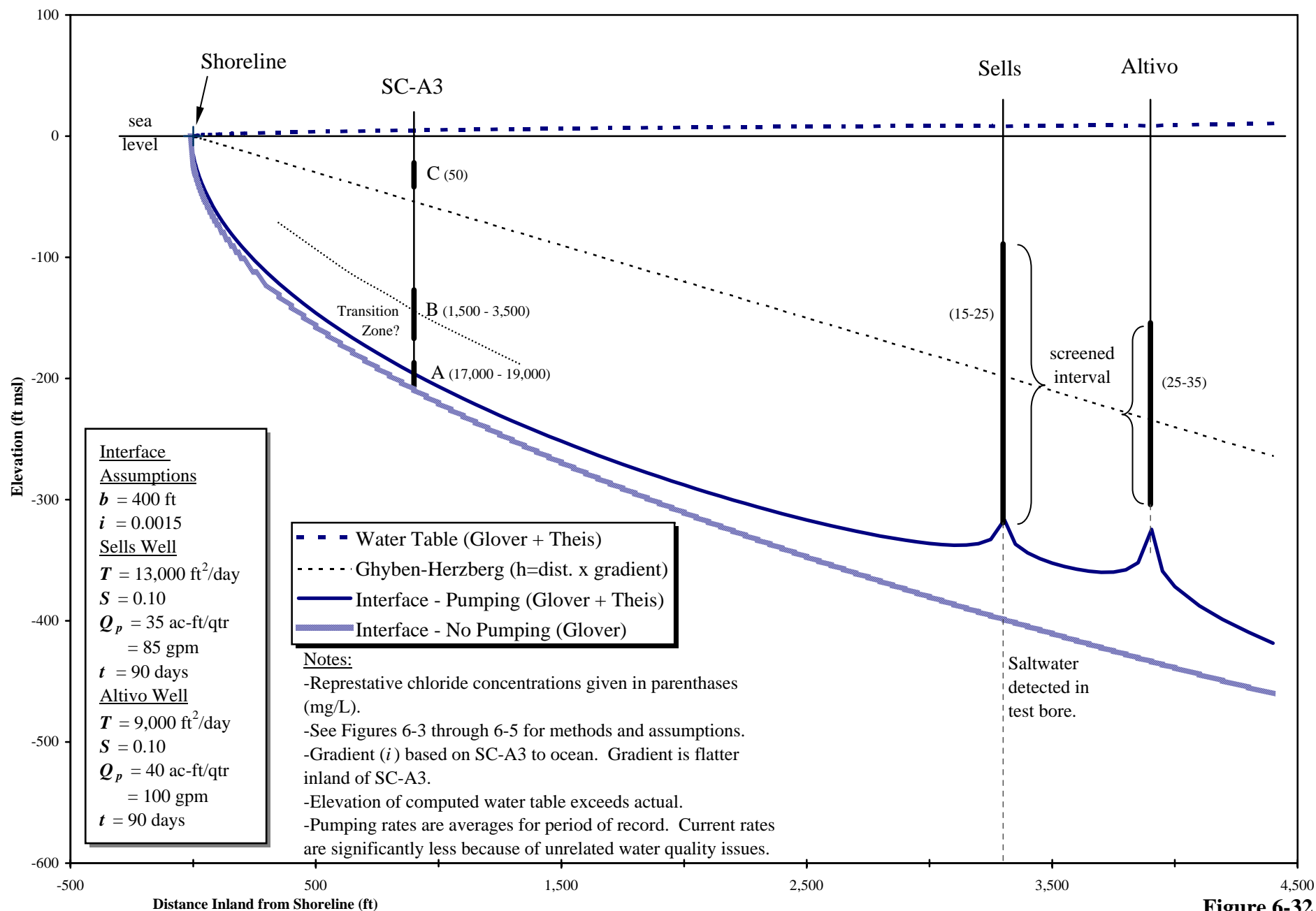
**Figure 6-29**  
**PV-1 Chloride Concentrations and Water Levels**  
 (from PVWMA, 2001)



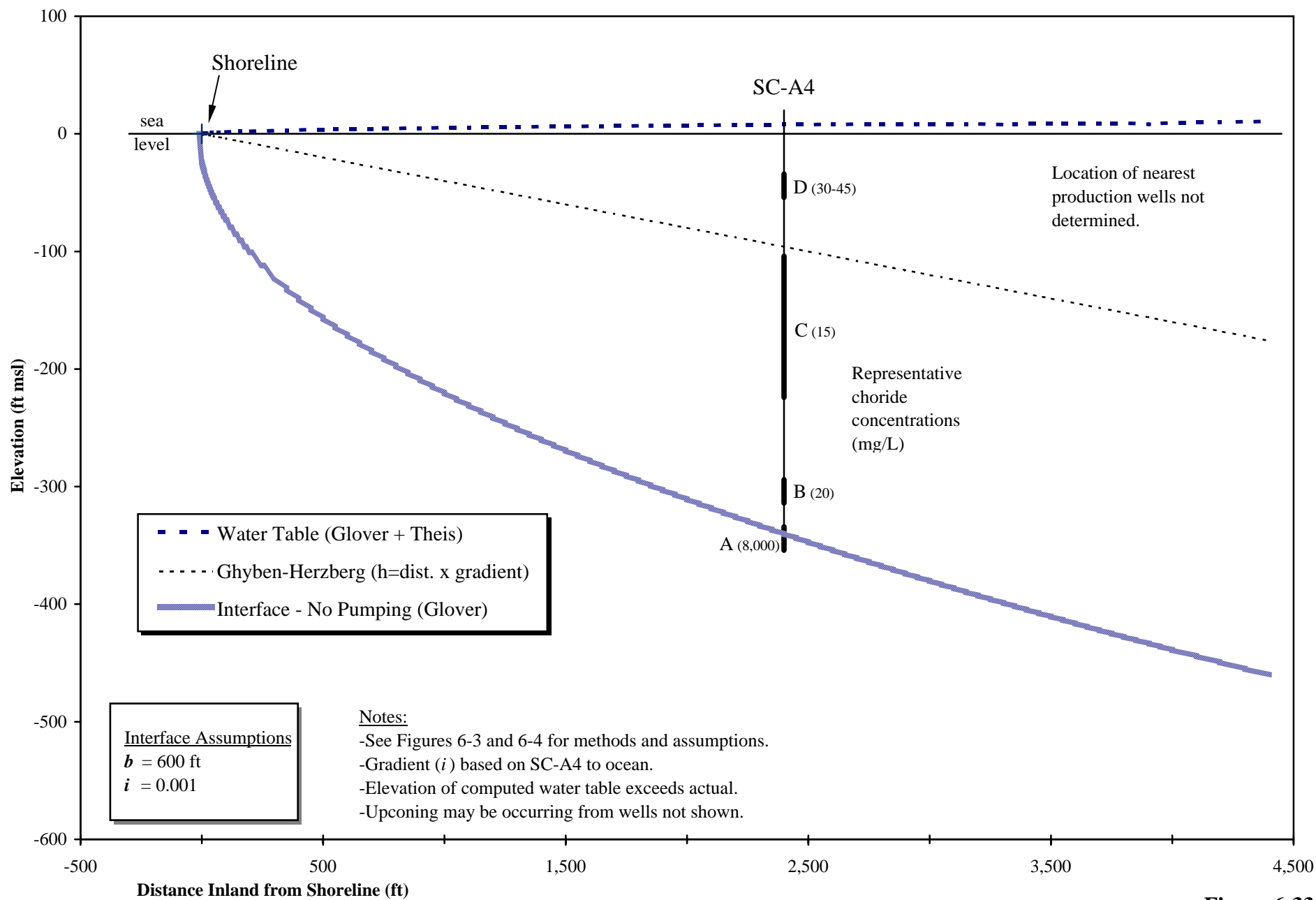
**Figure 6-30**  
**PV-8 Chloride Concentrations and Water Levels**  
 (from PVWMA, 2001)



**Figure 6-31**  
**Estimated Interface and Upconing near SC-A2, SC-A5, and Seascope Well**

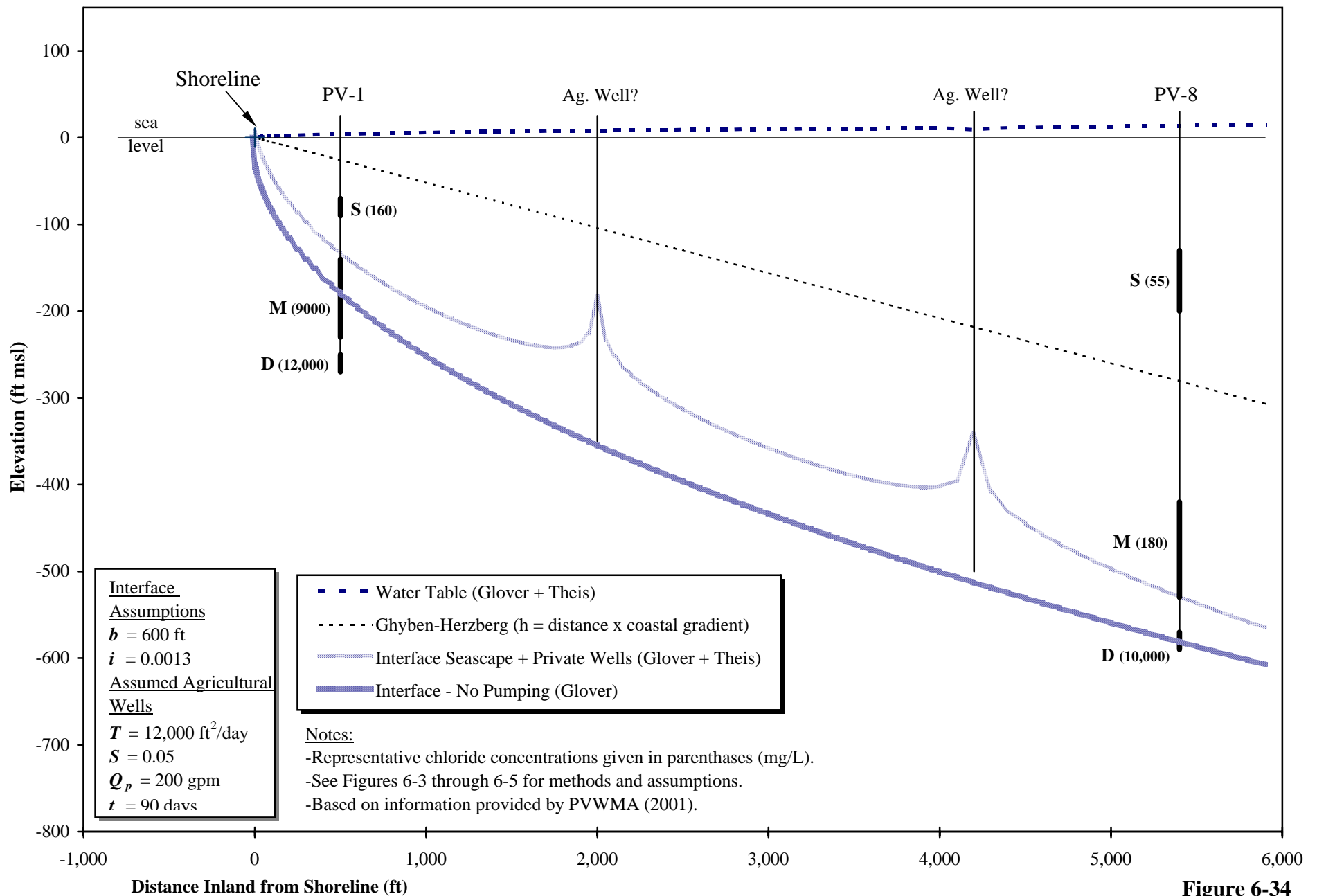


**Figure 6-32**  
**Estimated Interface and Upconing near SC-A3, Sells, and Altivo Wells**

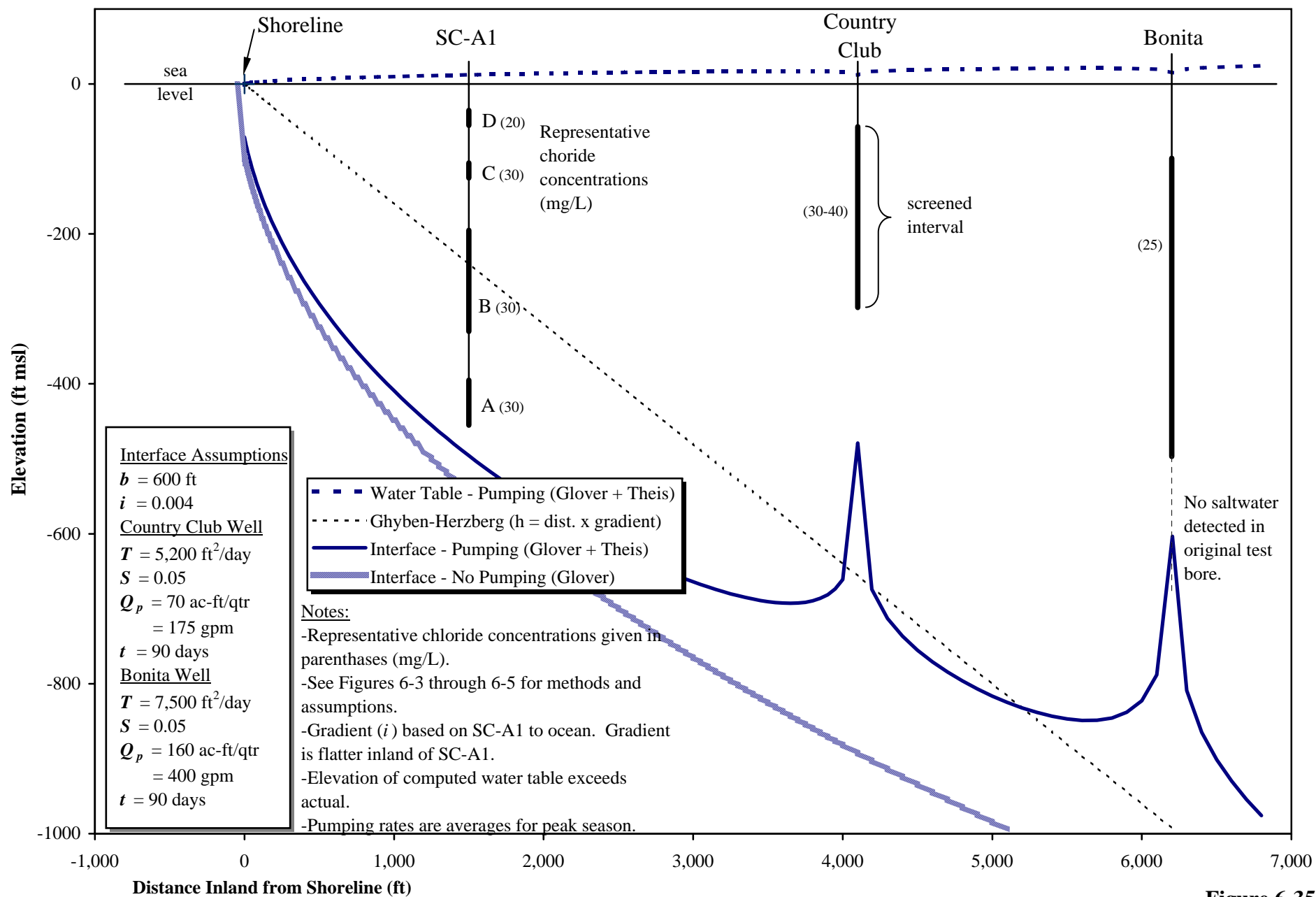


**Figure 6-33**  
**Estimated Interface near SC-A4**

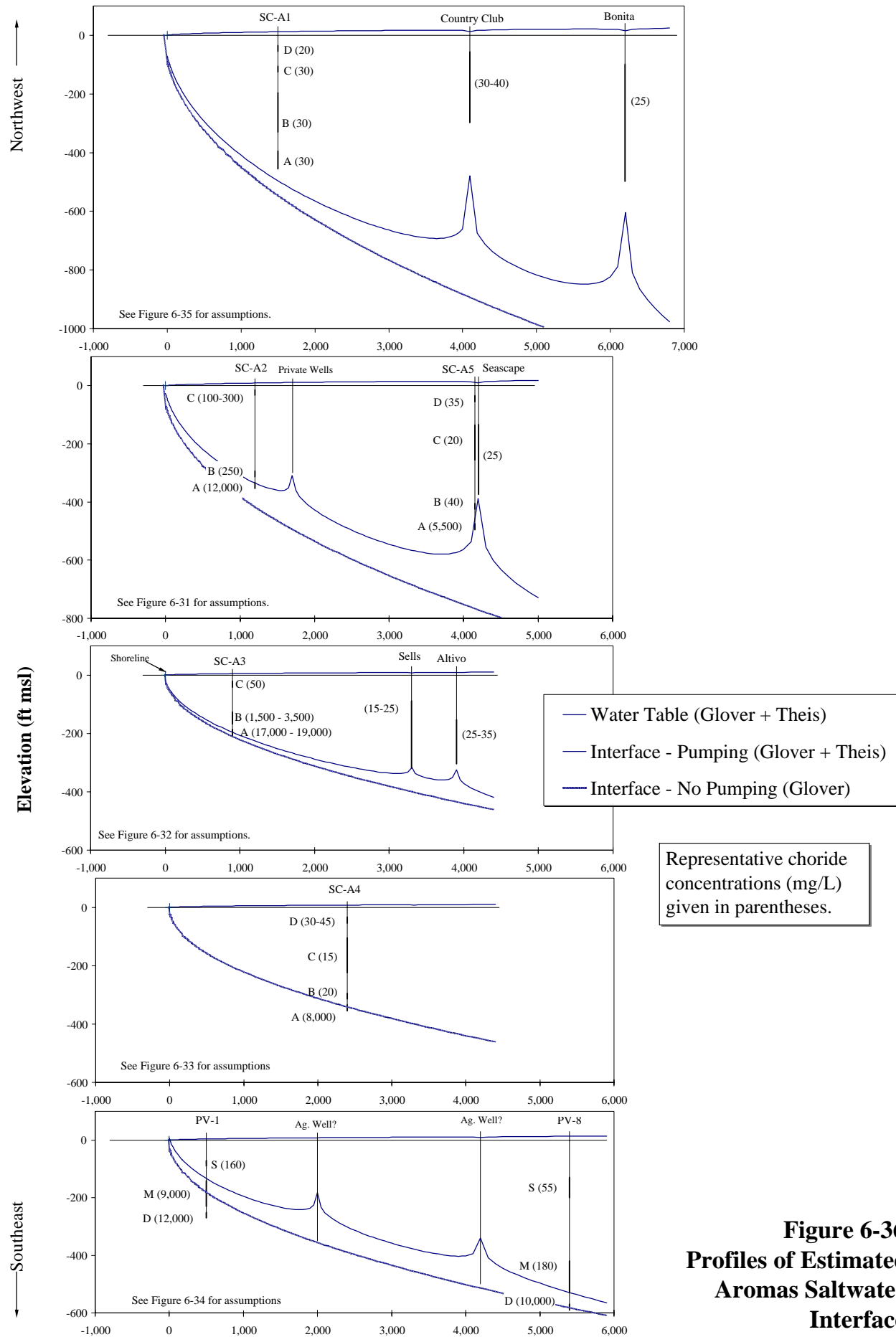




**Figure 6-34**  
Estimated Interface and Upconing near PV-1 and PV-8



**Figure 6-35**  
**Estimated Interface and Upconing near SC-A1, Country Club, and Bonita Wells**



**Figure 6-36**  
**Profiles of Estimated**  
**Aromas Saltwater**  
**Interface**