Cluster analysis of groundwater quality in the Sacramento Valley: a case study of type-chemistry

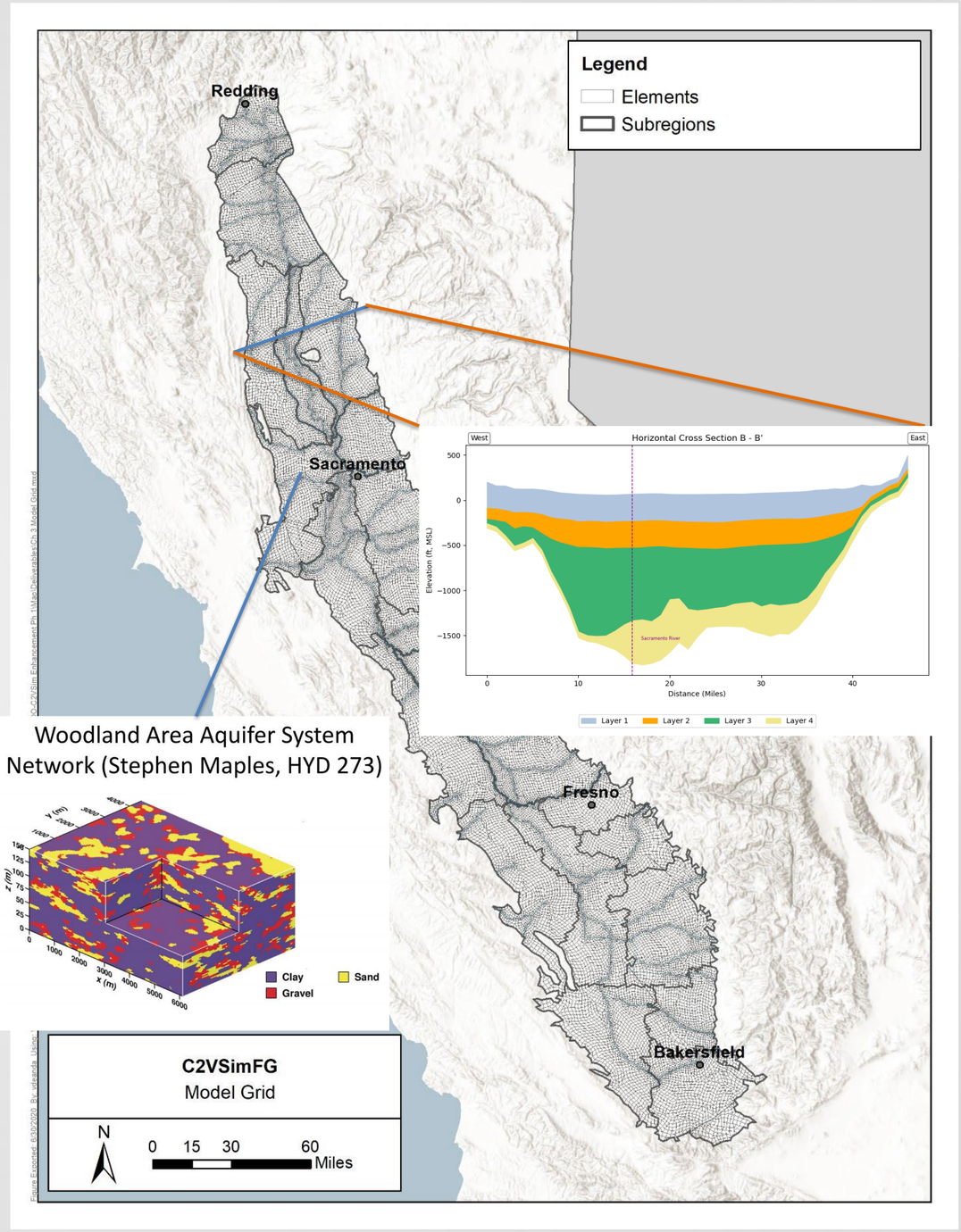
Kyle Hardage, PhD
Engineering Geologist
DWR SGMO Modeling Tools & Support

April 17, 2023

CALIFORNIA DEPARTMENT OF WATER RESOURCES
SUSTAINABLE GROUNDWATER MANAGEMENT OFFICE

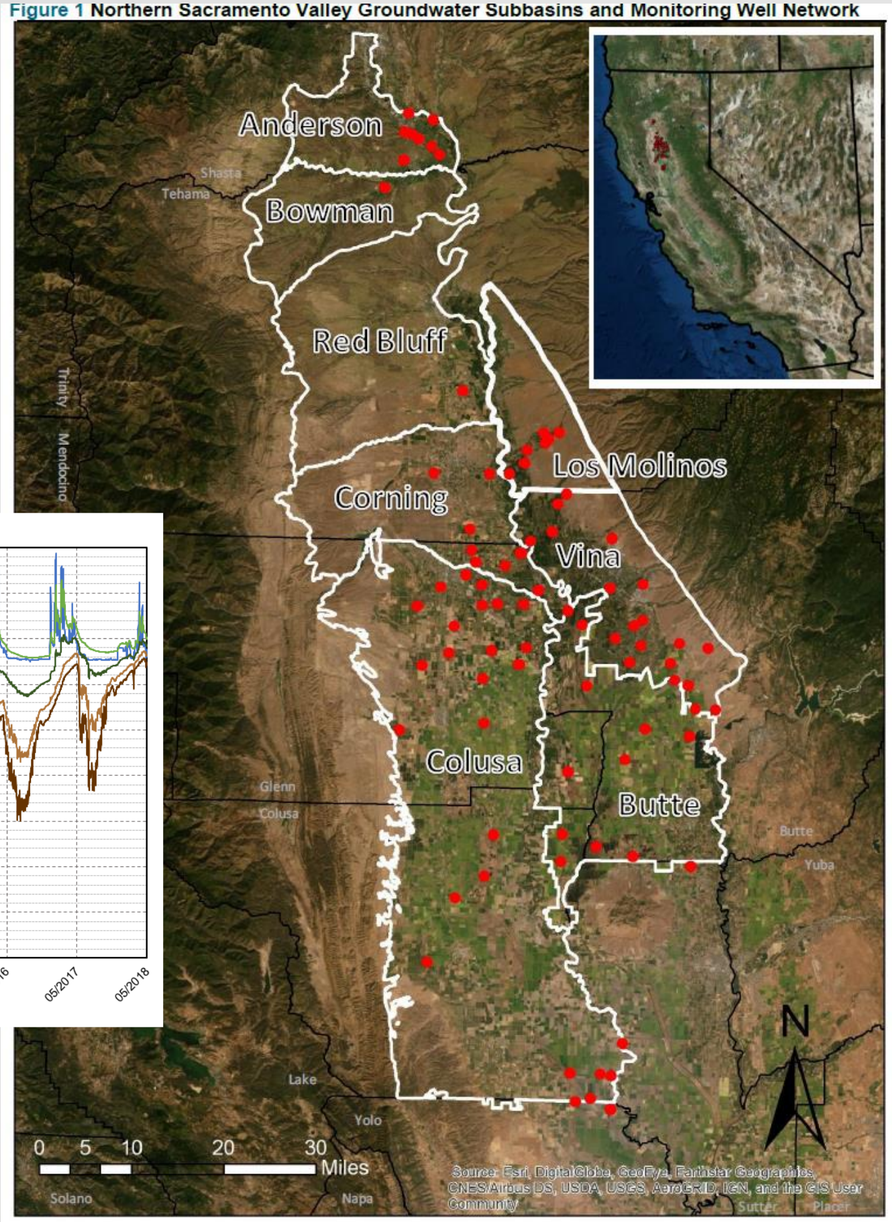
Background

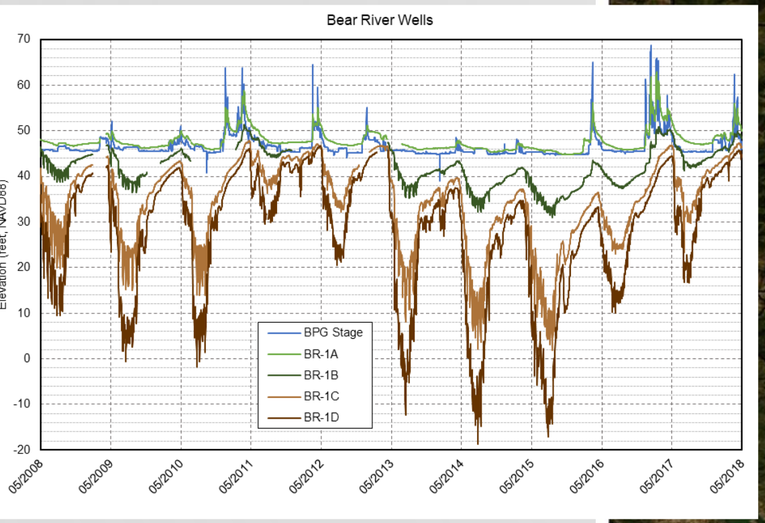
- C2VSim-FG – 4 layers
  - Miss stratigraphy complexity
- Well construction data
  - Screening intervals unknown
- Water quality of known wells to constrain unknown



Background

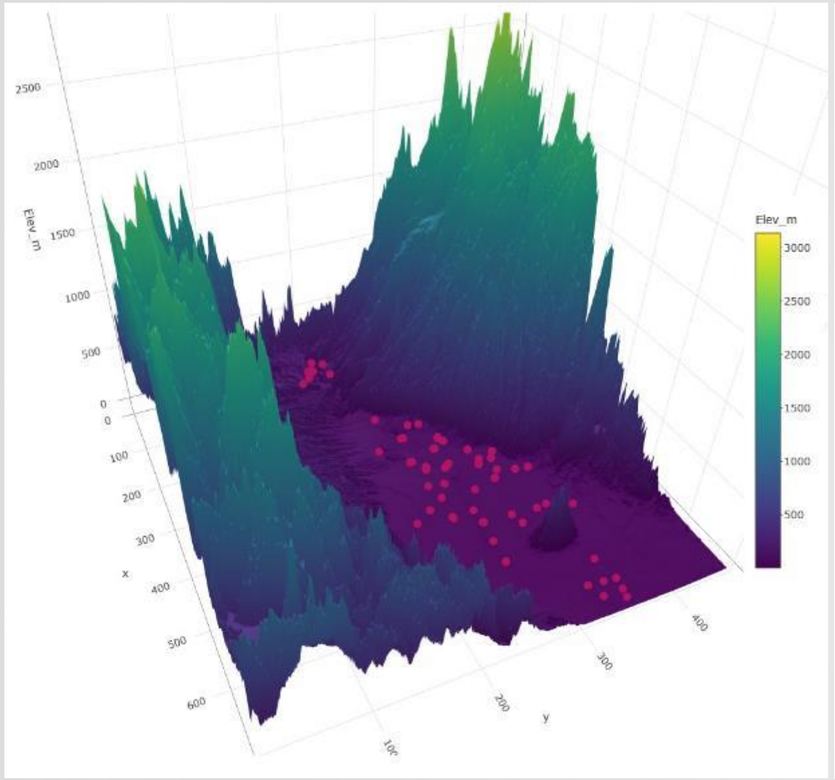
Figure 1 Northern Sacramento Valley Groundwater Subbasins and Monitoring Well Network

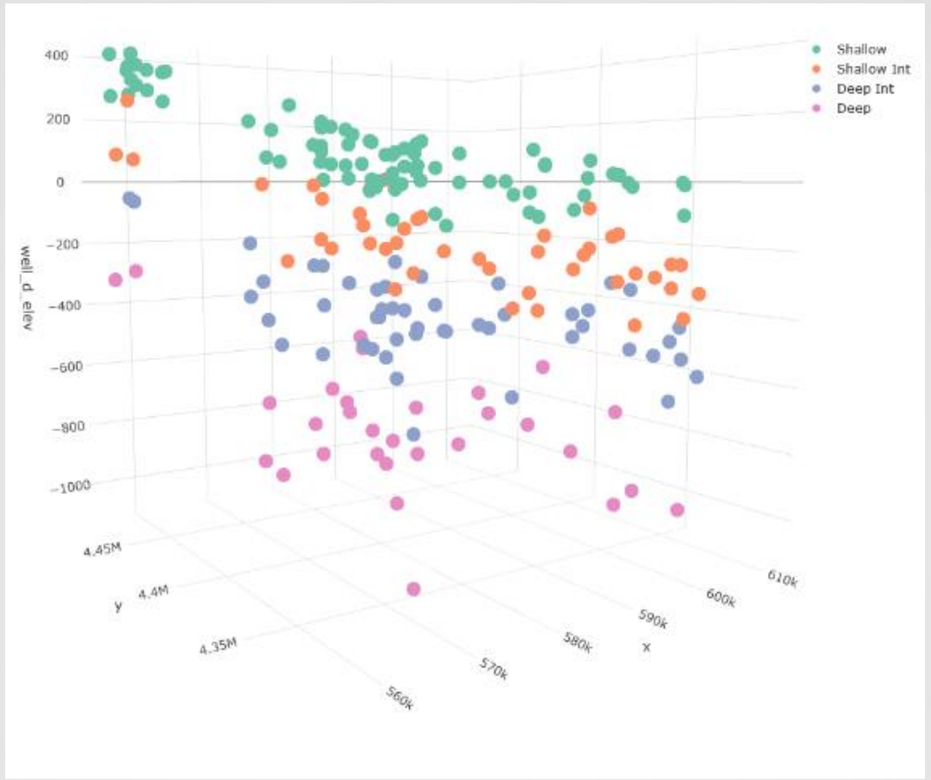


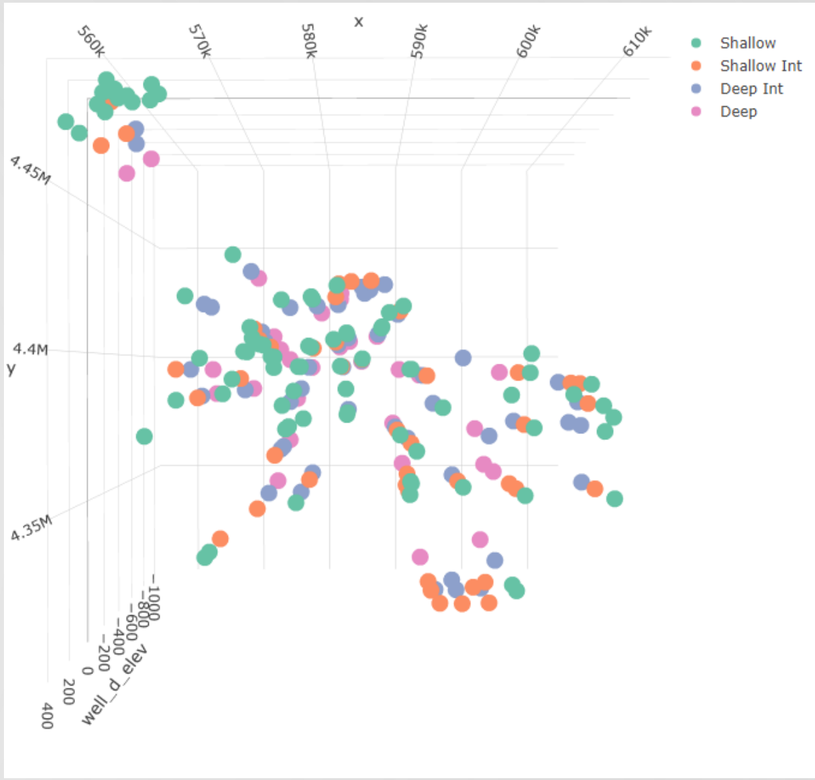


CALIFORNIA DEPARTMENT OF WATER RESOURCES
SUSTAINABLE GROUNDWATER MANAGEMENT OFFICE

Method







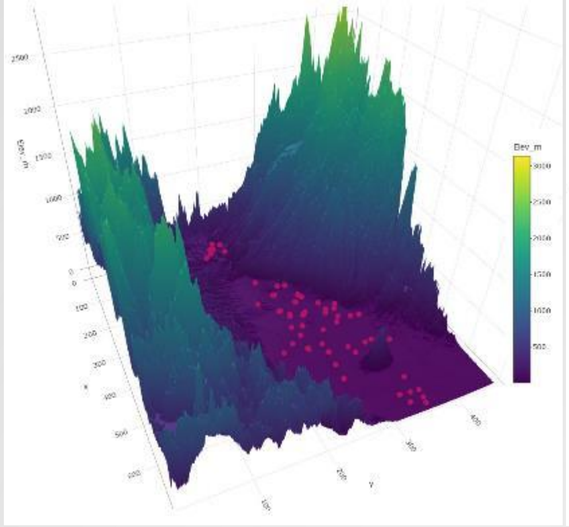
Sacramento valley (3x exaggeration)
Multi-level wells viewed from above
Multi-level wells viewed from side

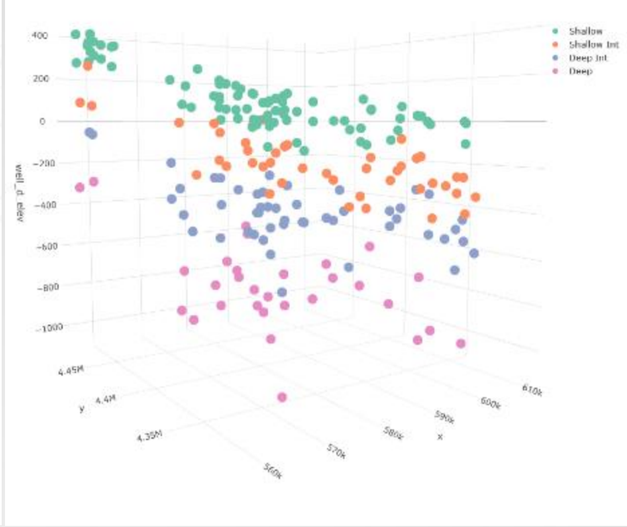
Method

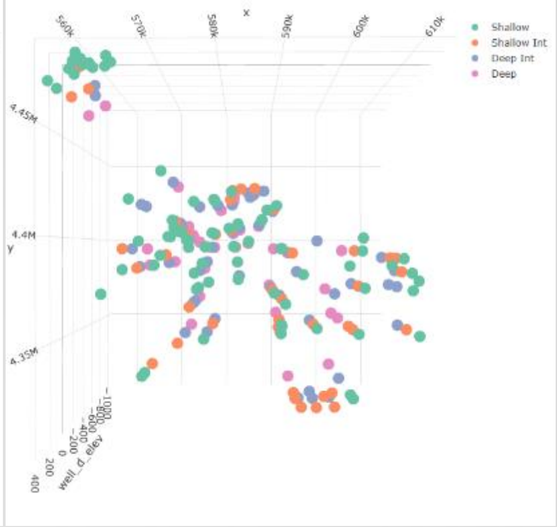
K-means, 4 clusters
All 45 parameters

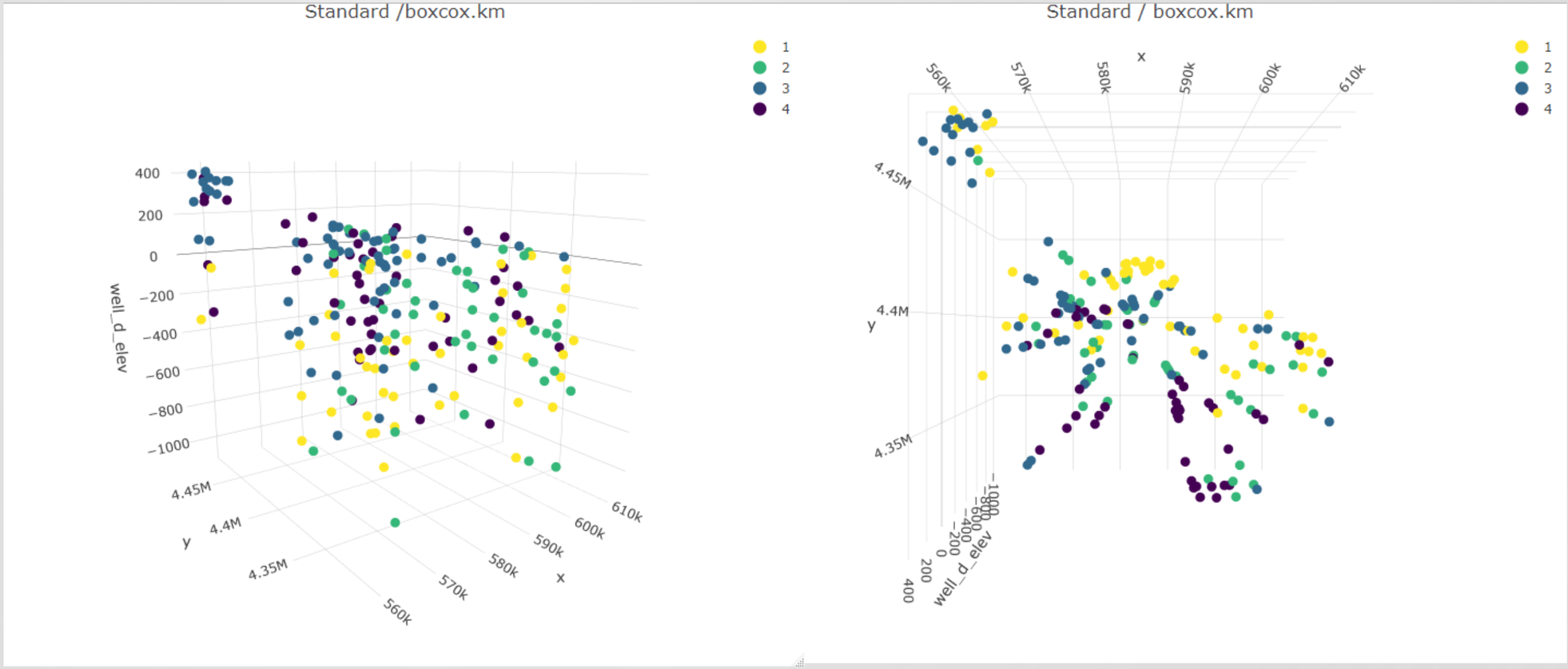
Why k-means?

Trends:
East-west,
North-south
divides rather
than depth





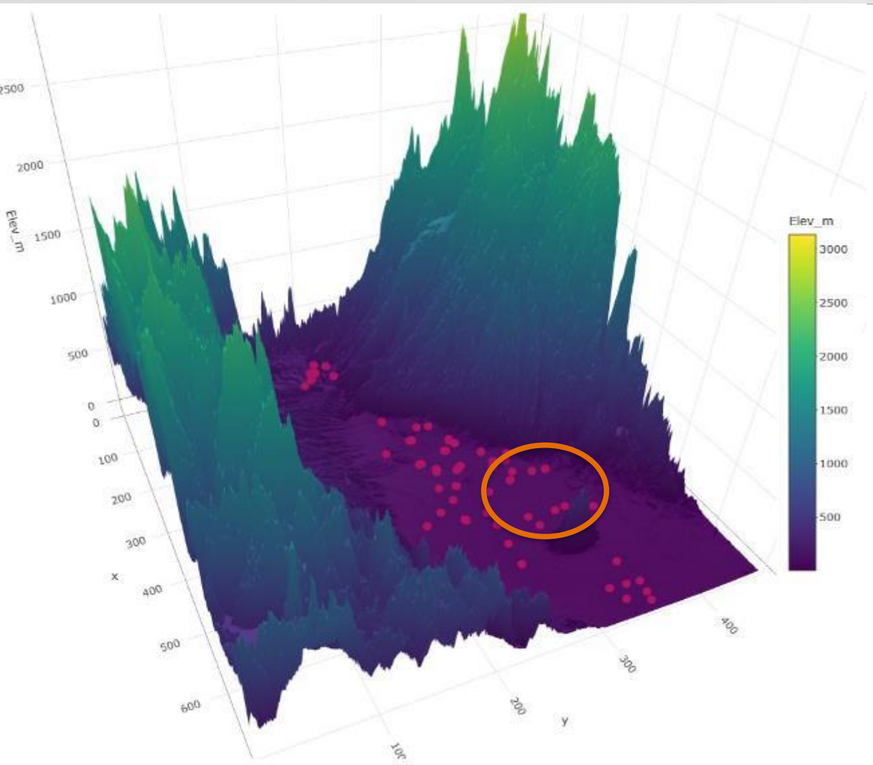


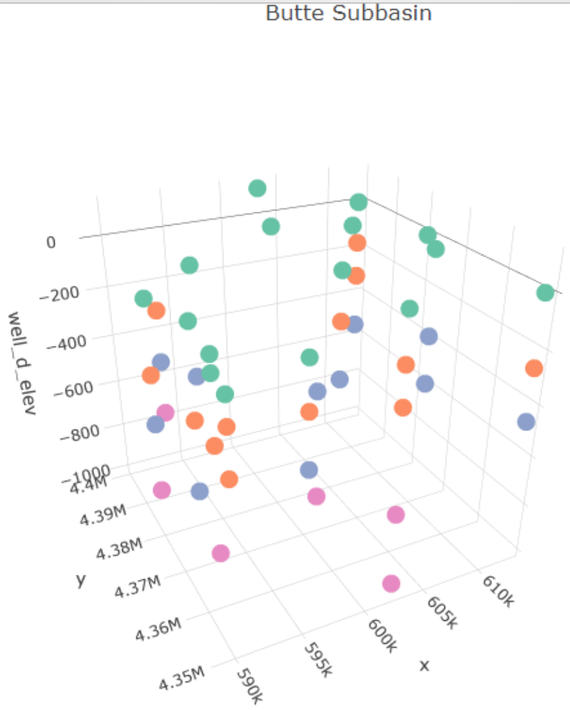


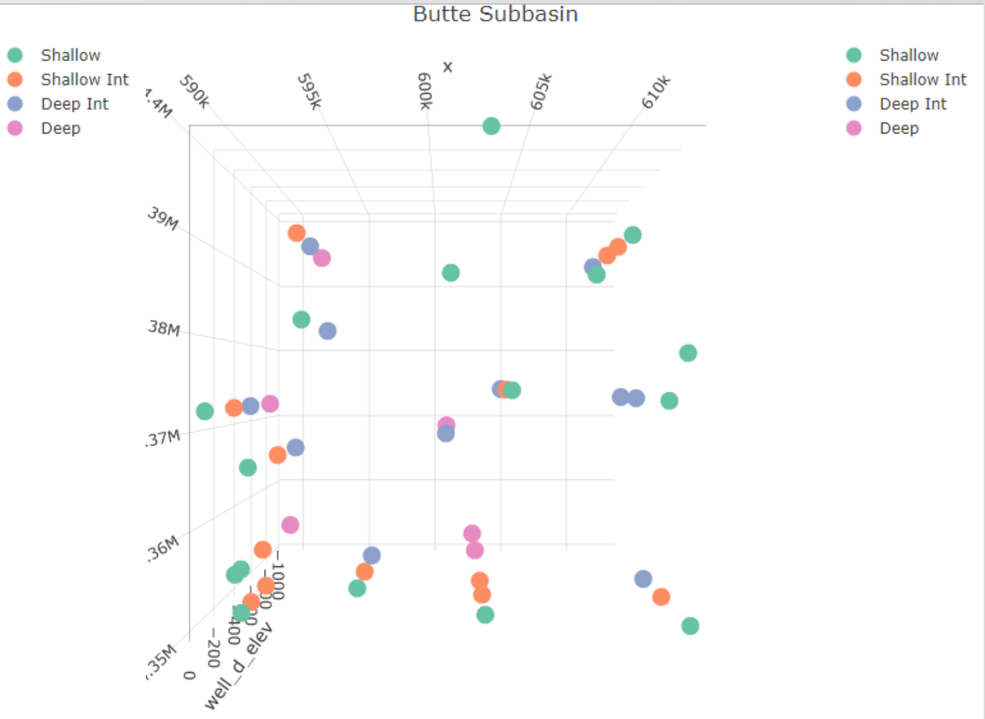
CALIFORNIA DEPARTMENT OF WATER RESOURCES
SUSTAINABLE GROUNDWATER MANAGEMENT OFFICE

Results

Butte Subbasin



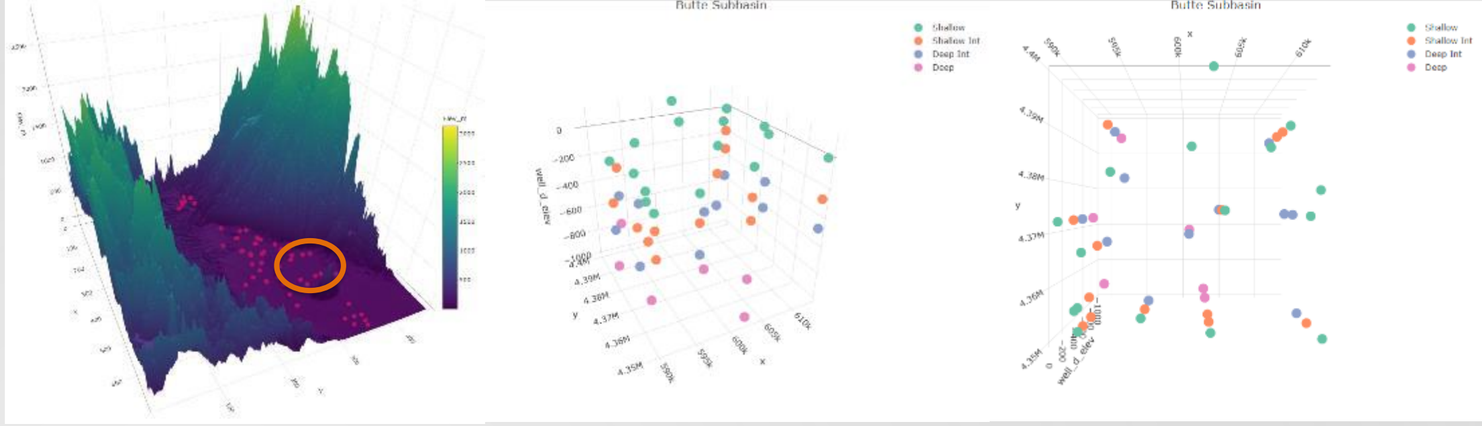


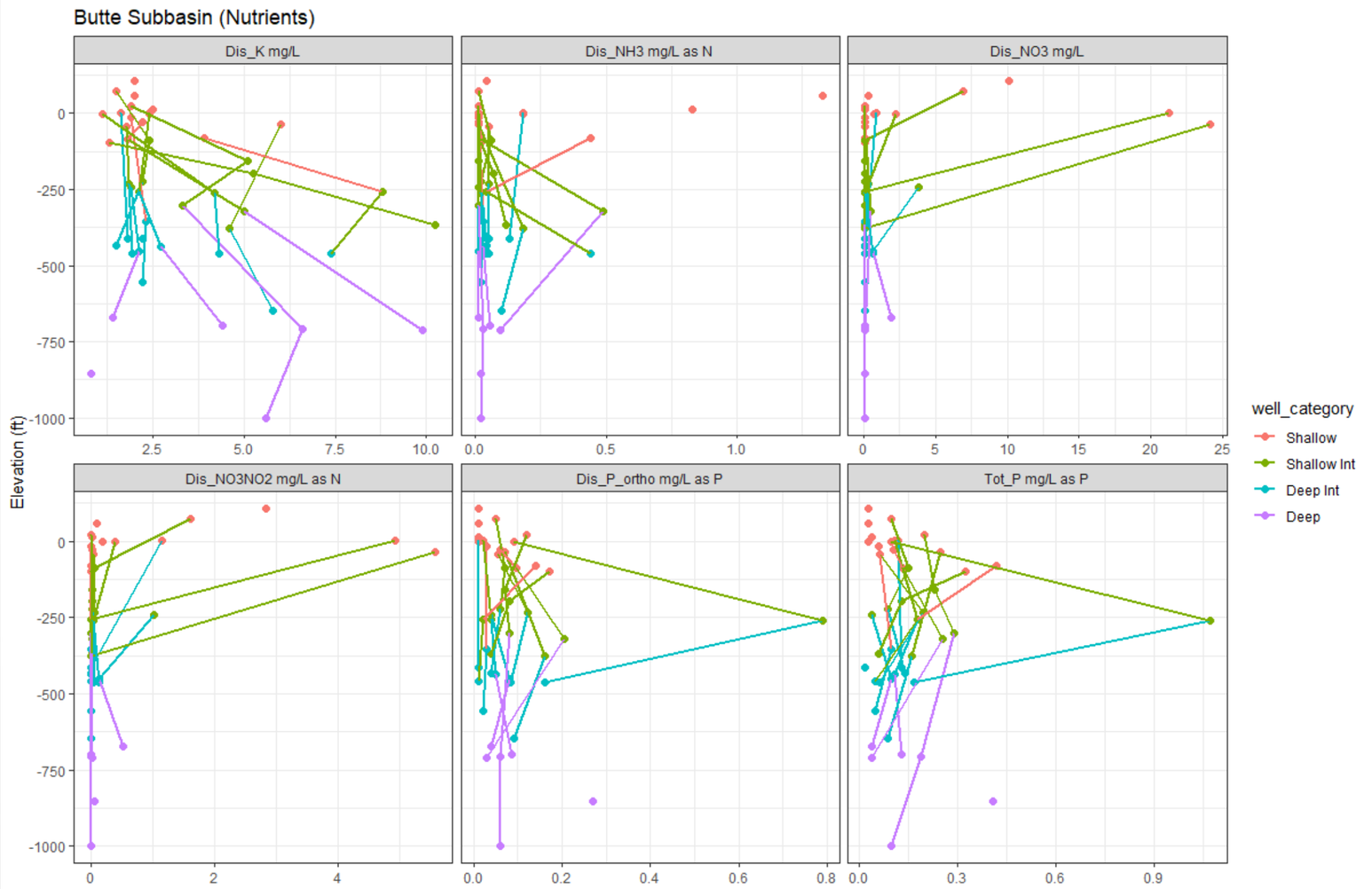


Results

Parameters by depth
Nutrients

Desirable:
Combinations of concentrations at varying depths

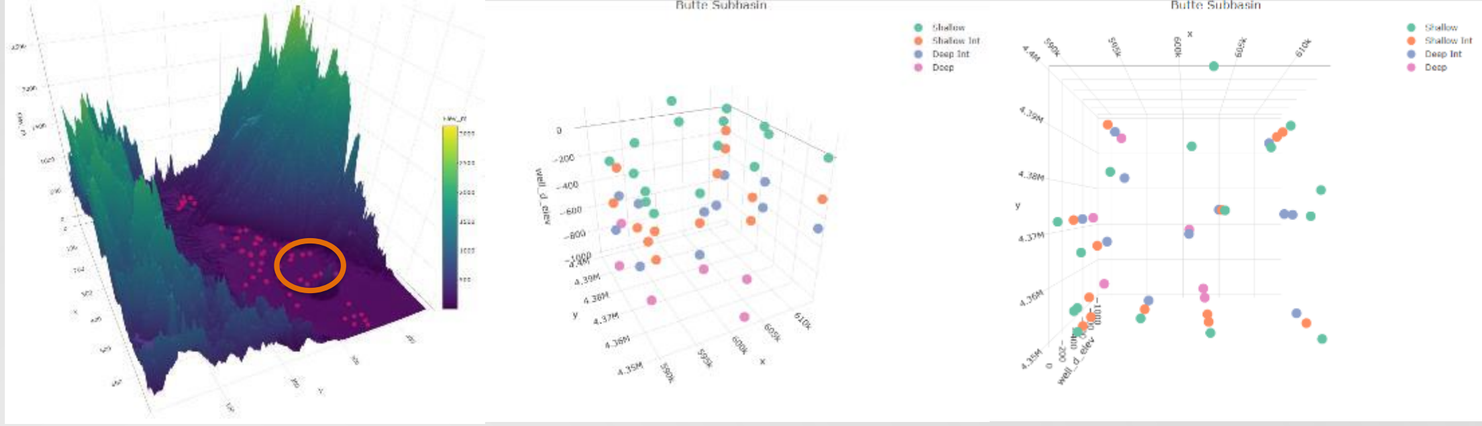


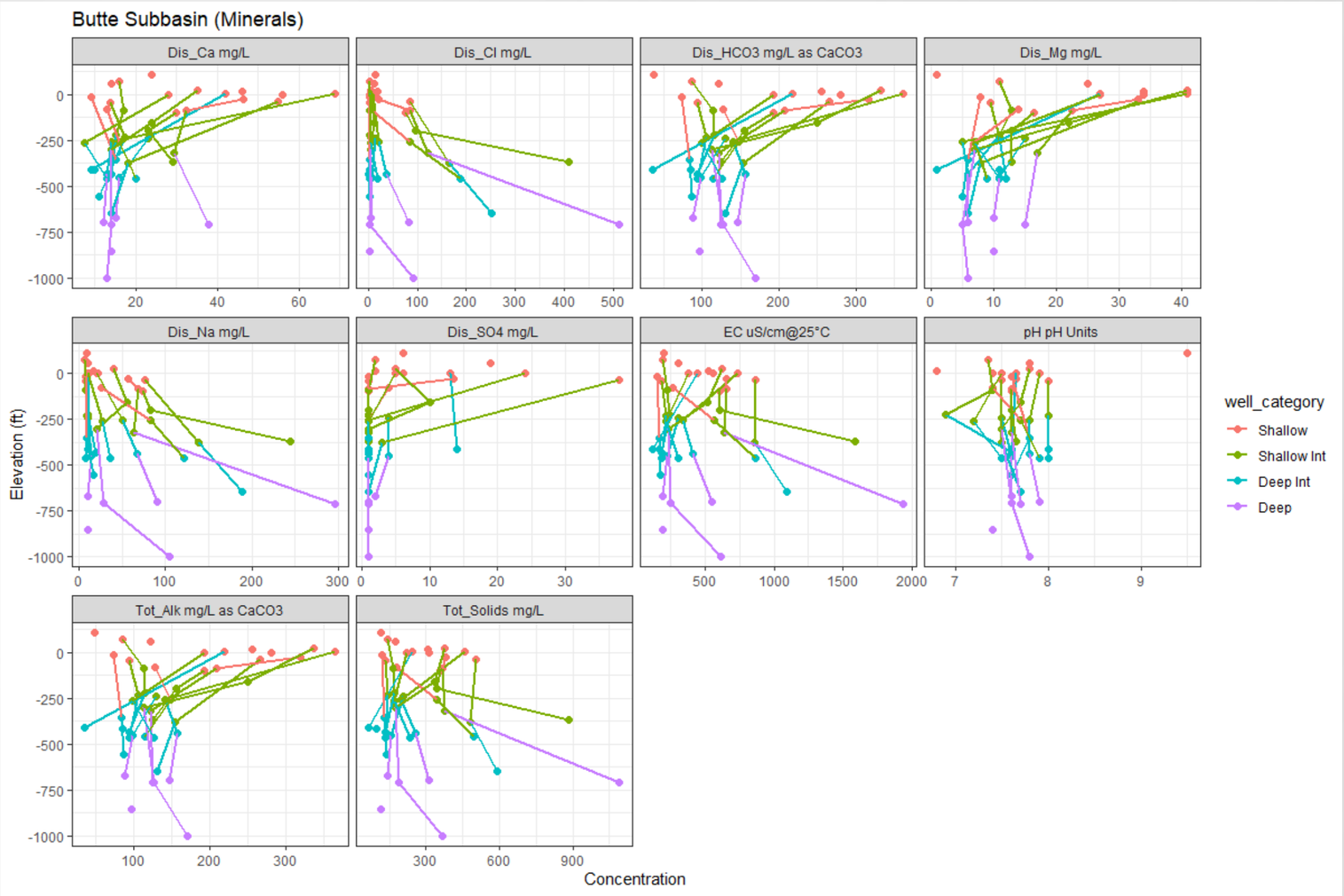


Results

Parameters by depth
Minerals

Desirable:
Combinations of concentrations at varying depths

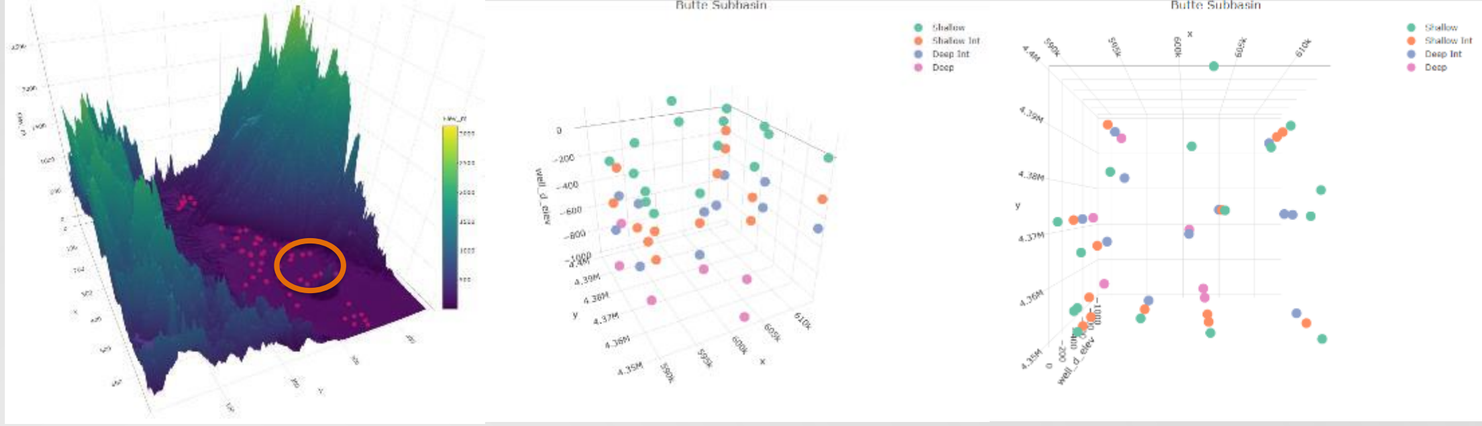


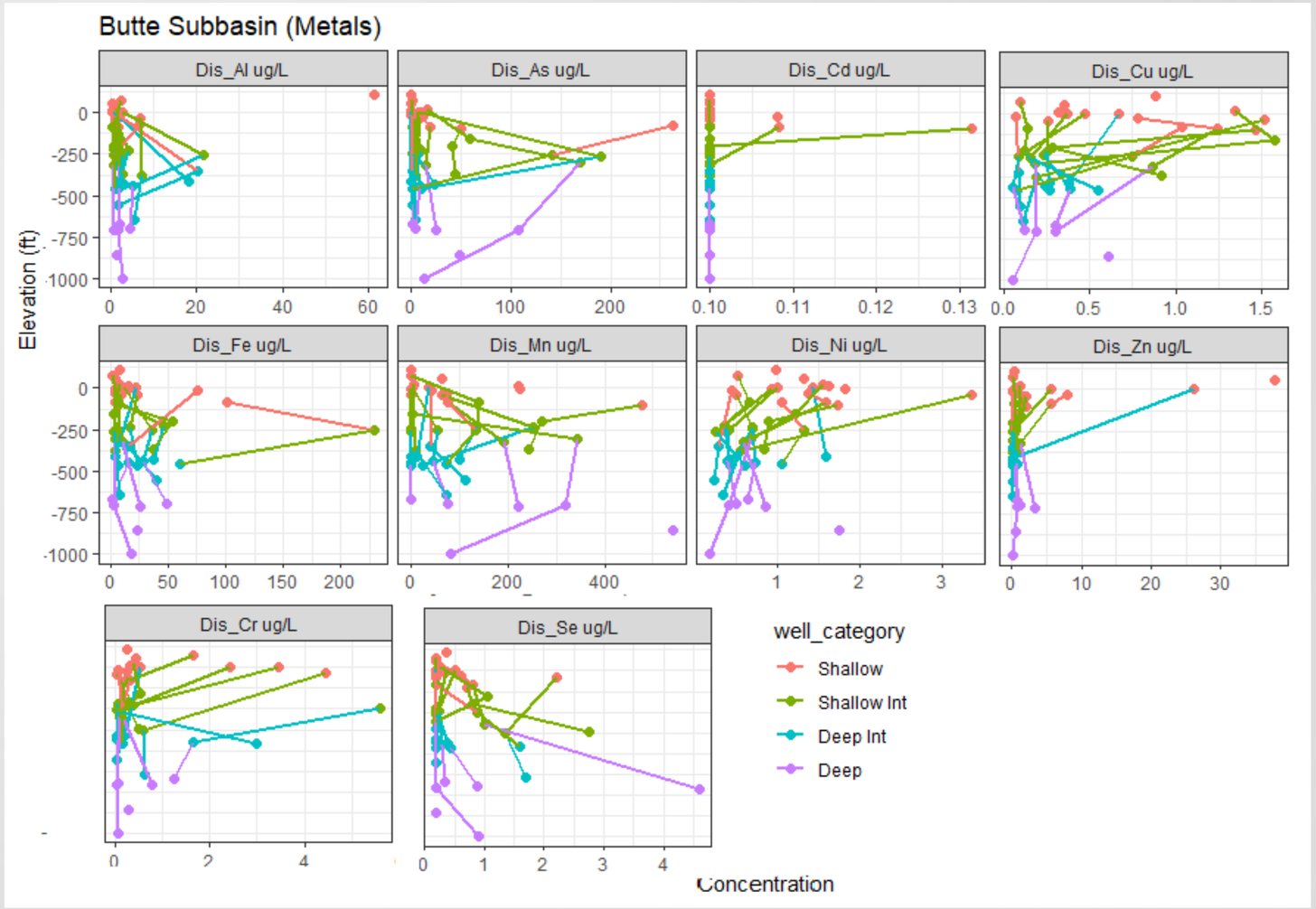


Results

Parameters by depth
Metals (dissolved, total)

Desirable:
Combinations of concentrations at varying depths

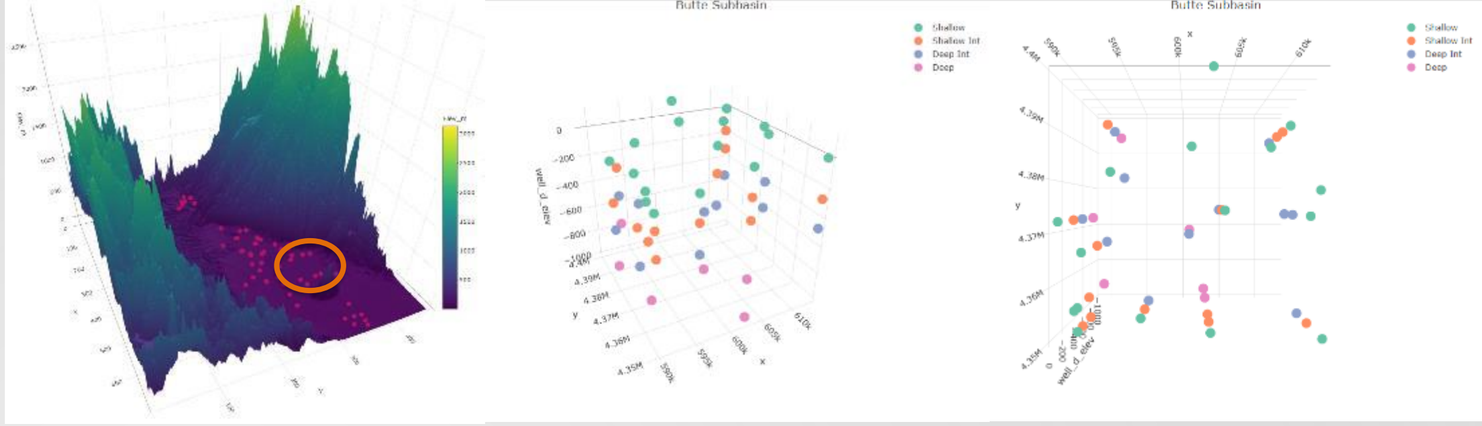


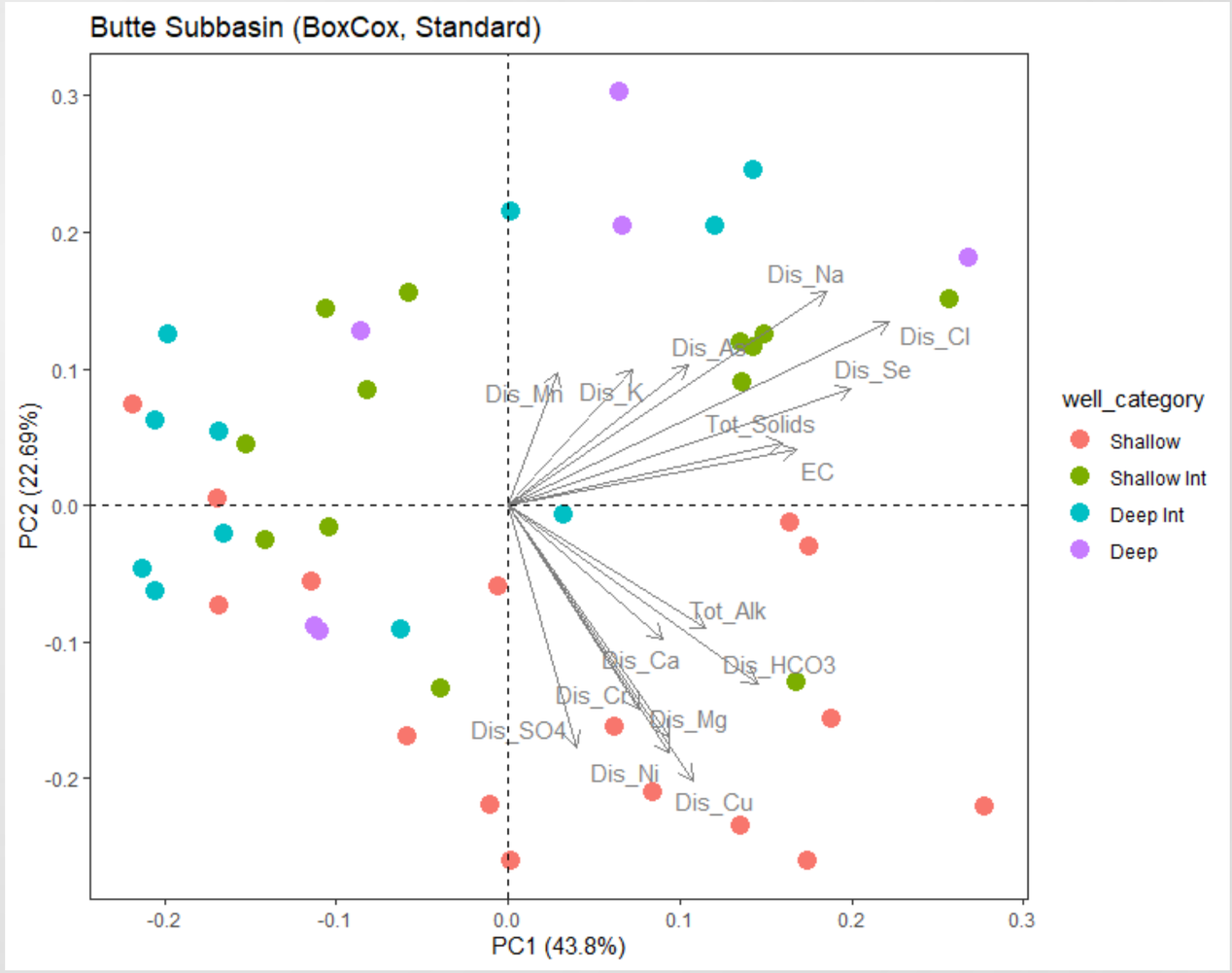


Results

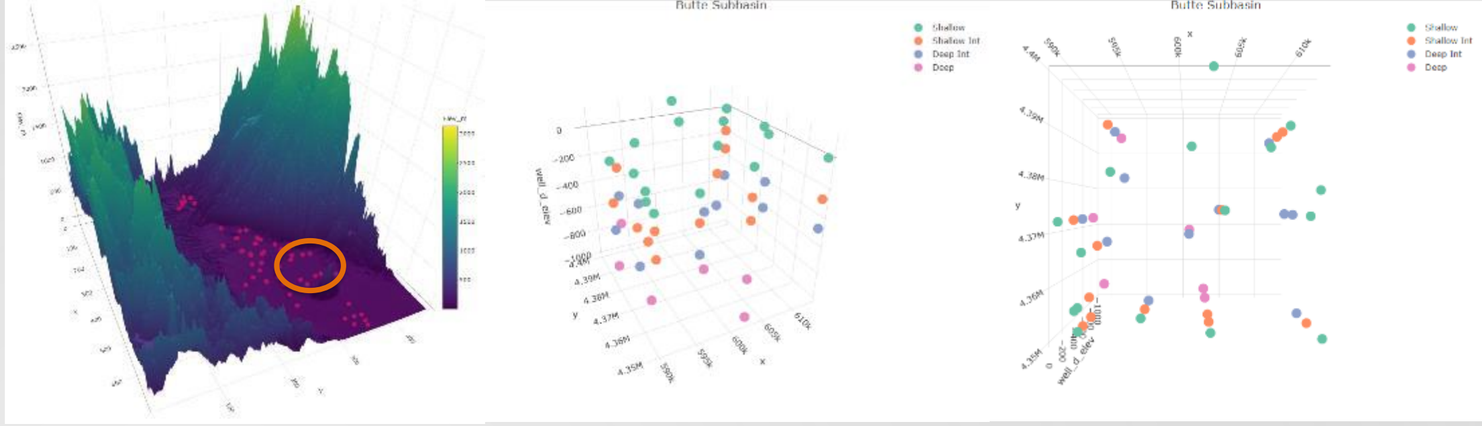
Principle component analysis

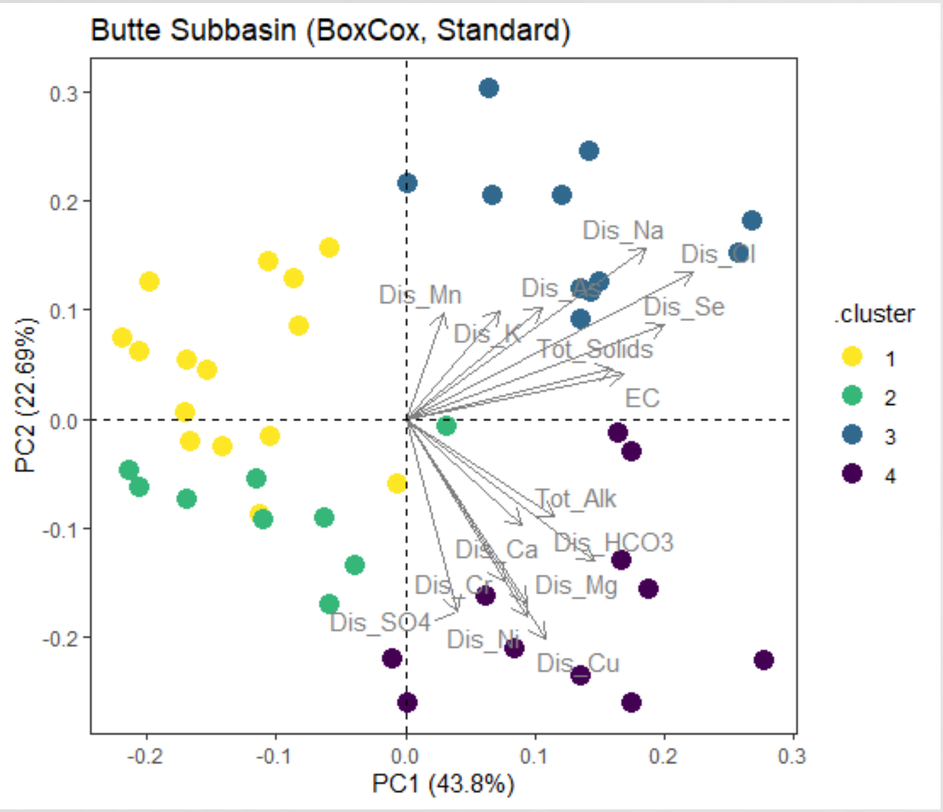
Is depth a principle component?

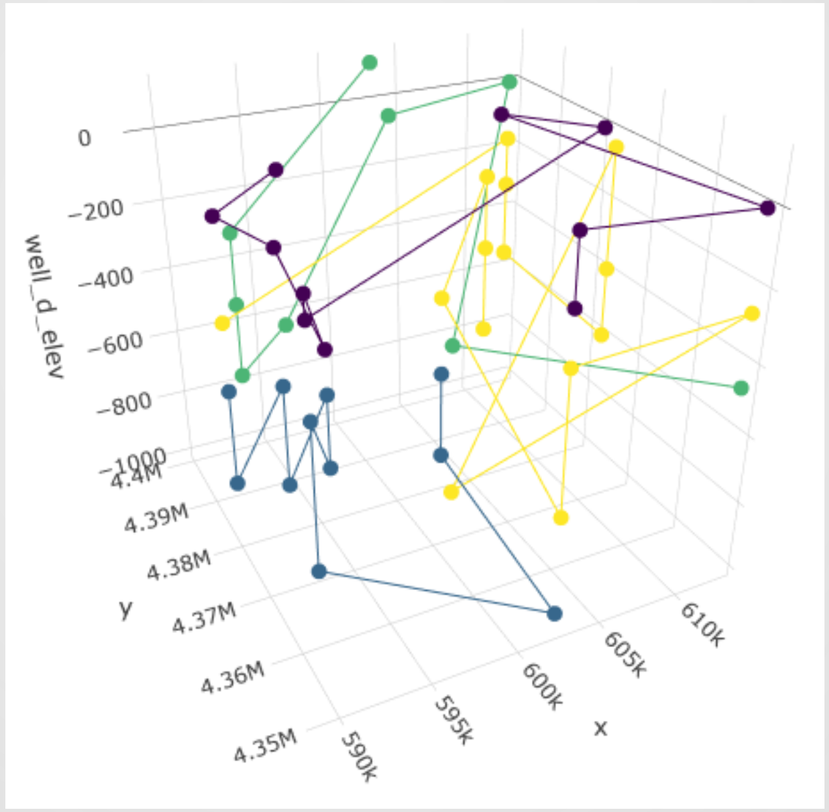


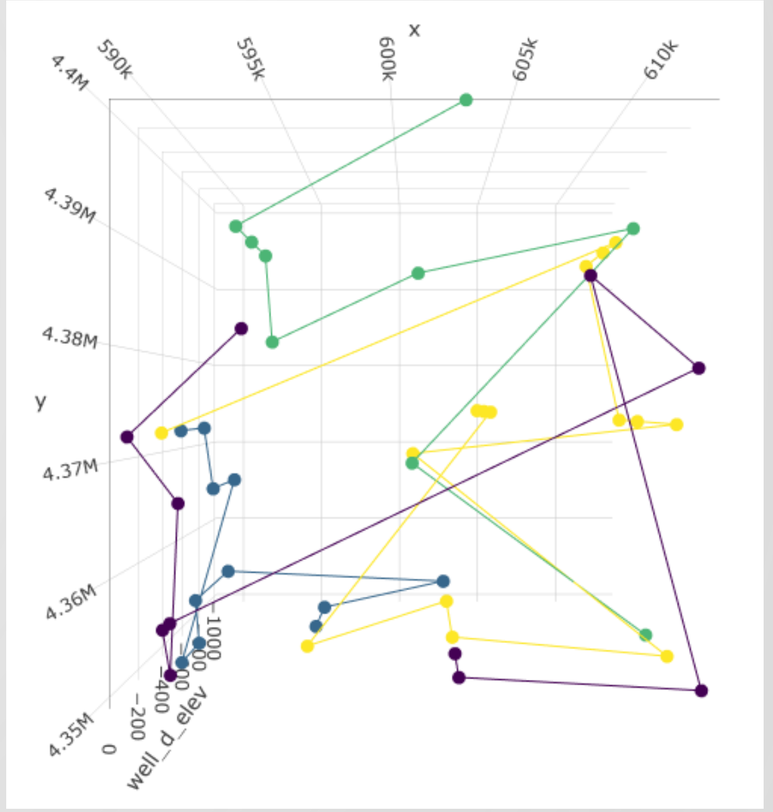


Results
4 clusters

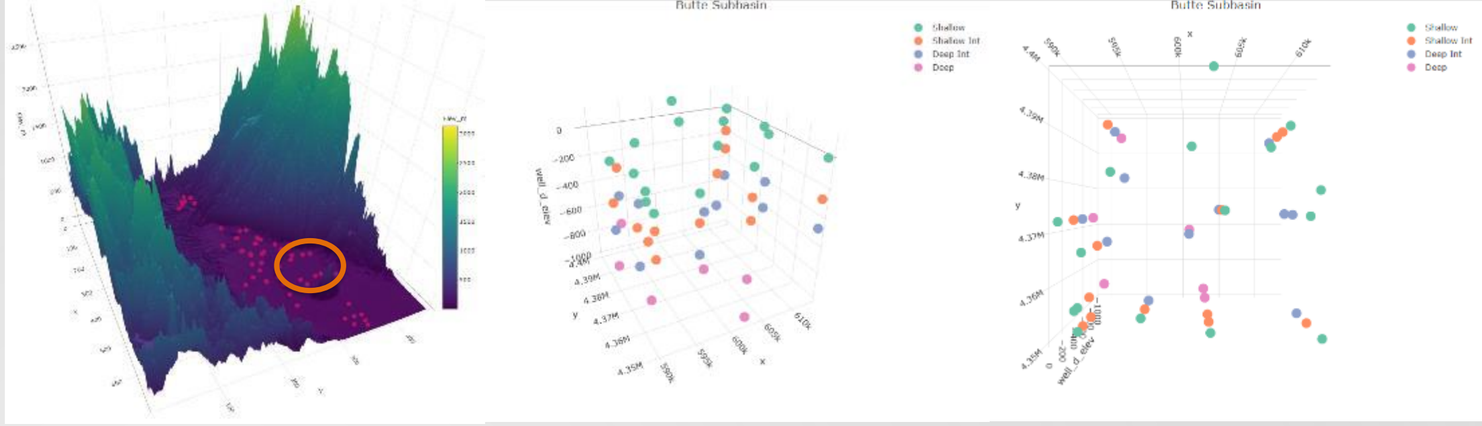


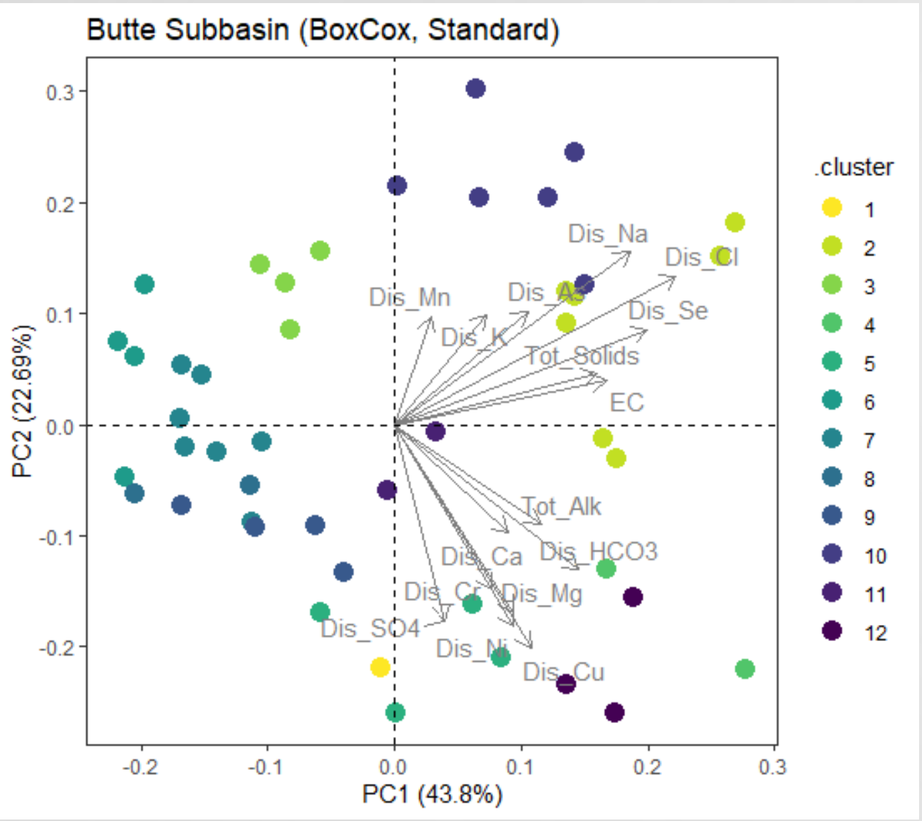


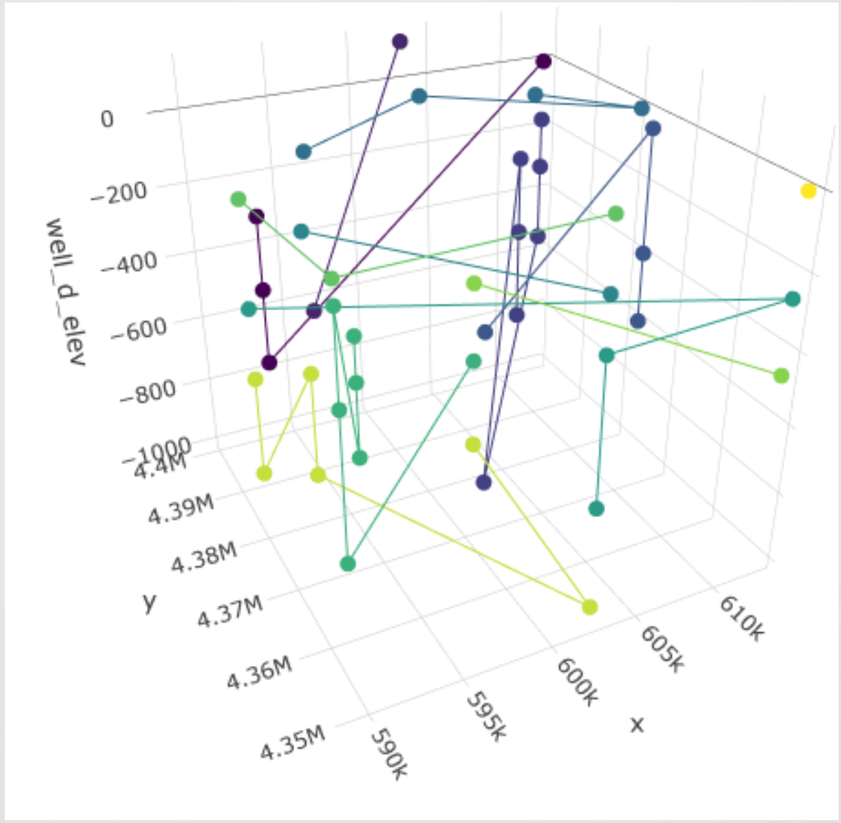


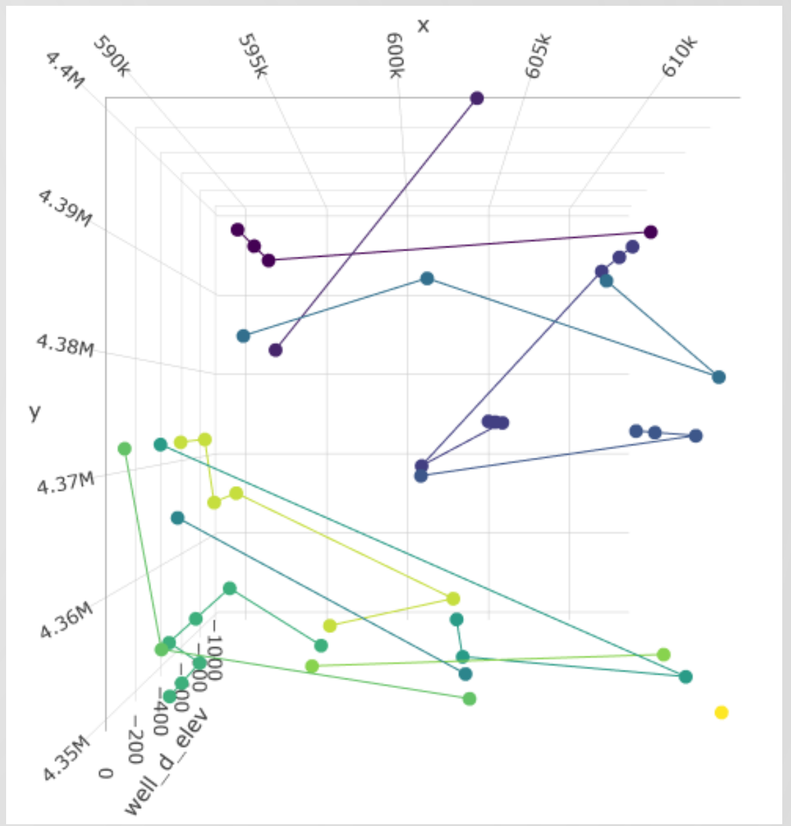


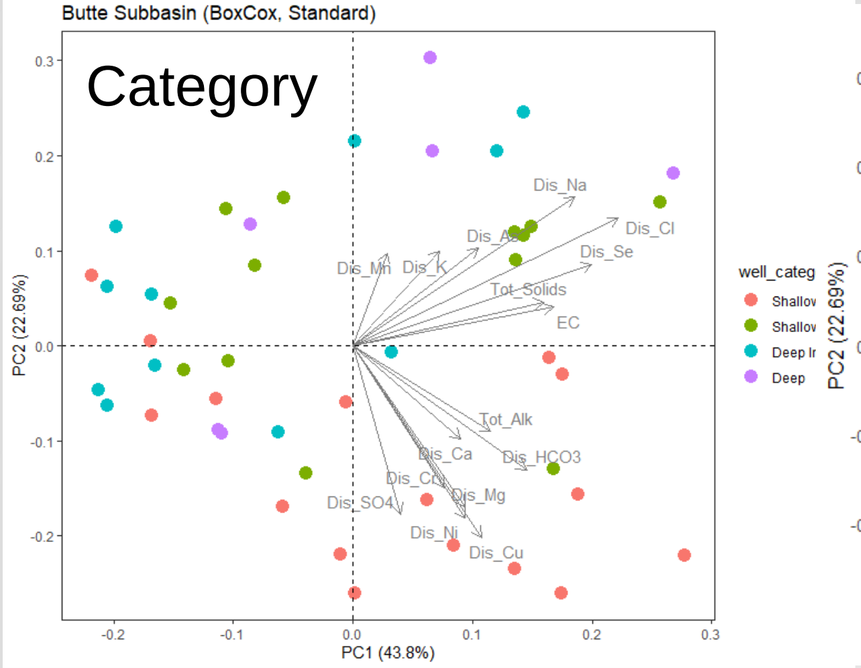
Results
12 clusters

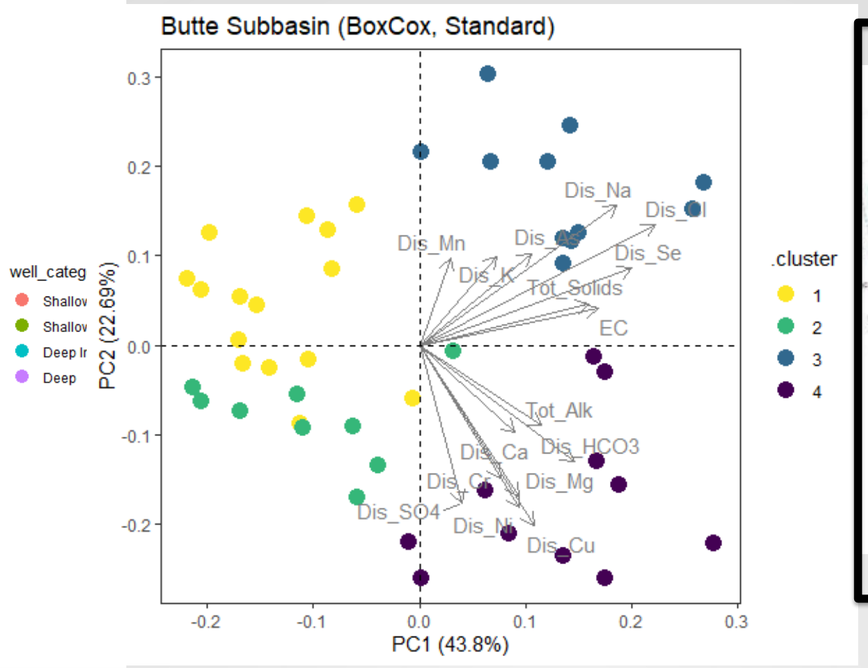


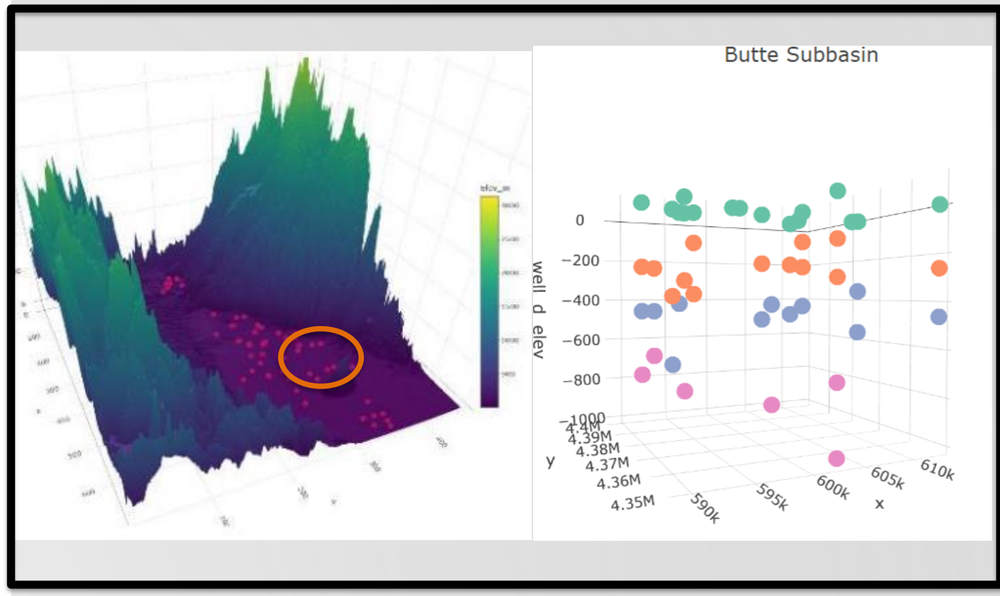




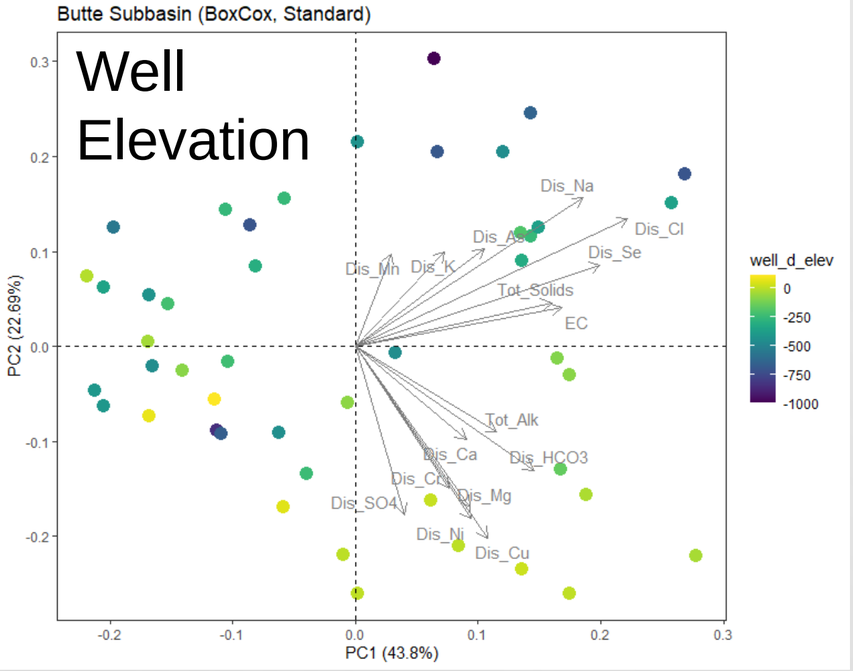


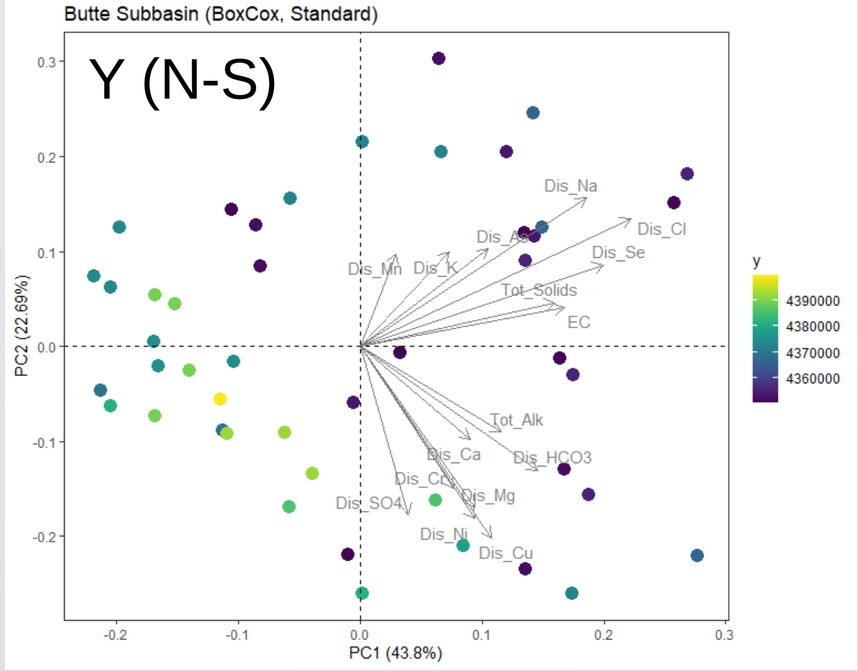


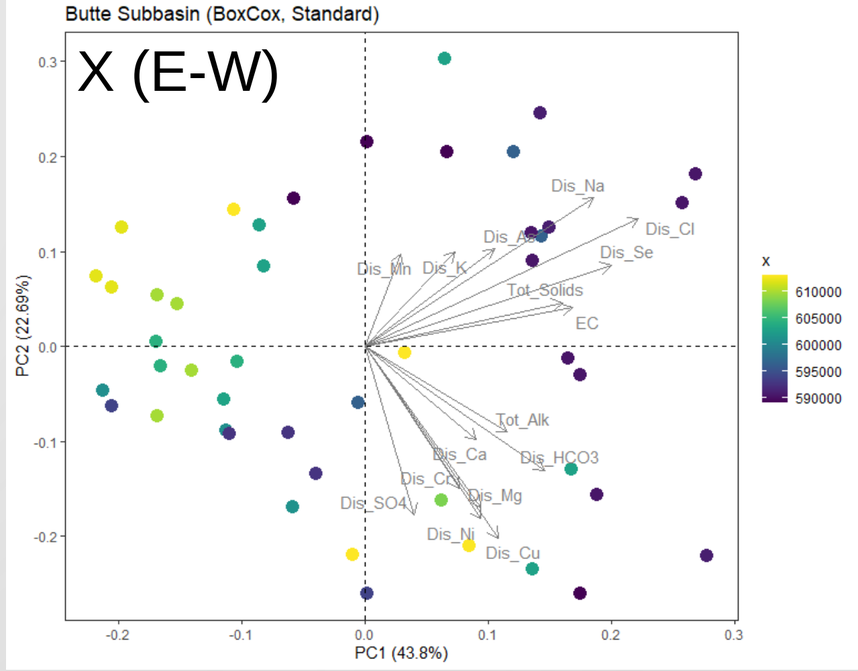




Redox: Mn, As | Cr, Cu, SO4

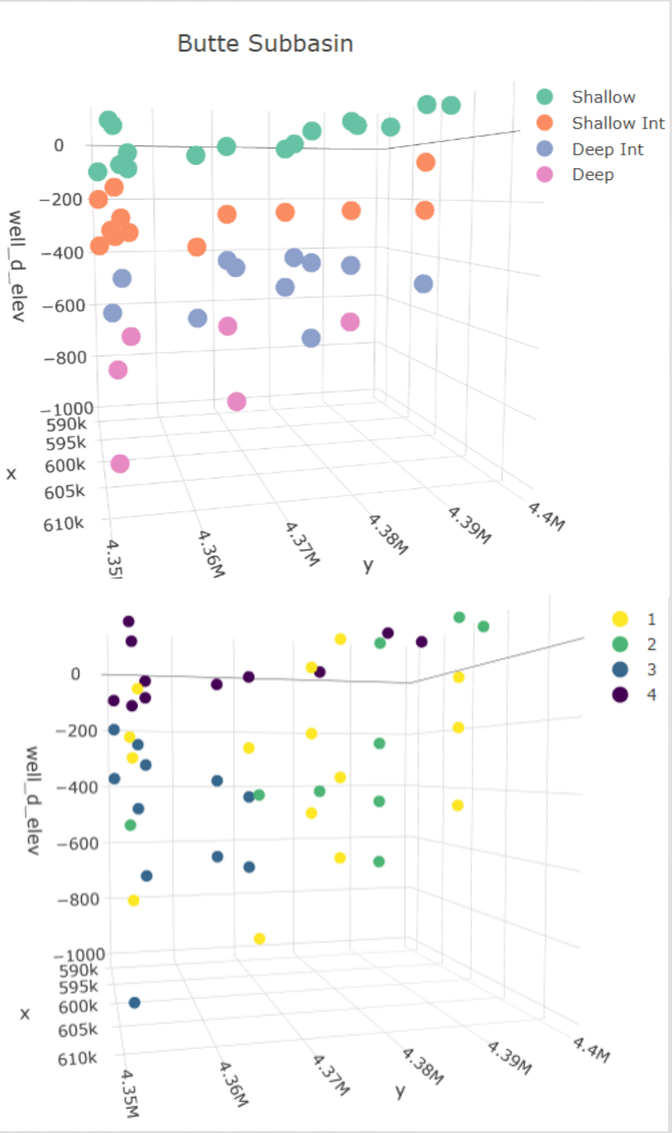


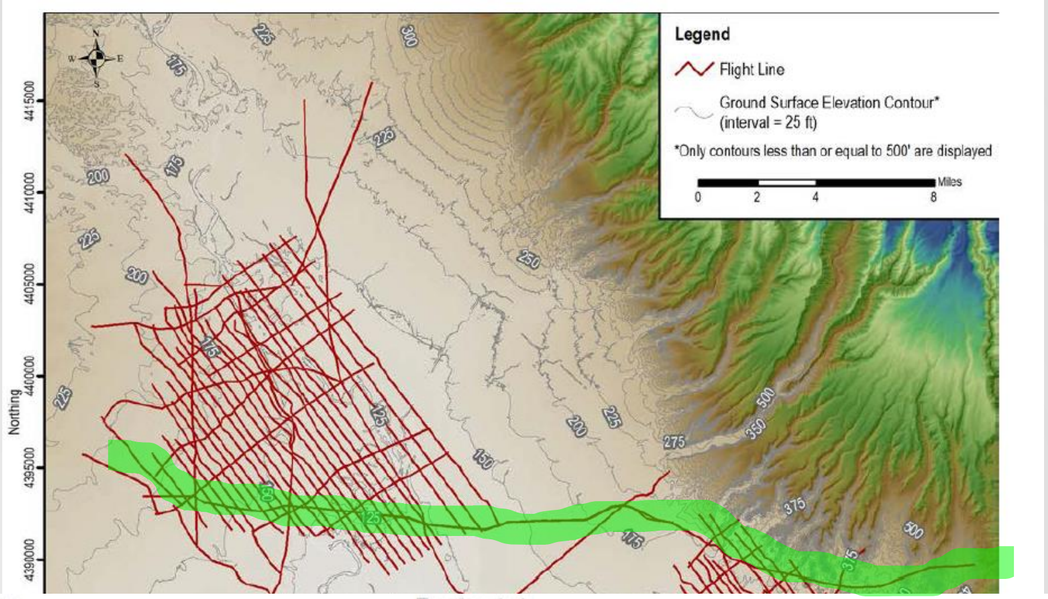




AEM Pilot Study

XY directional geology





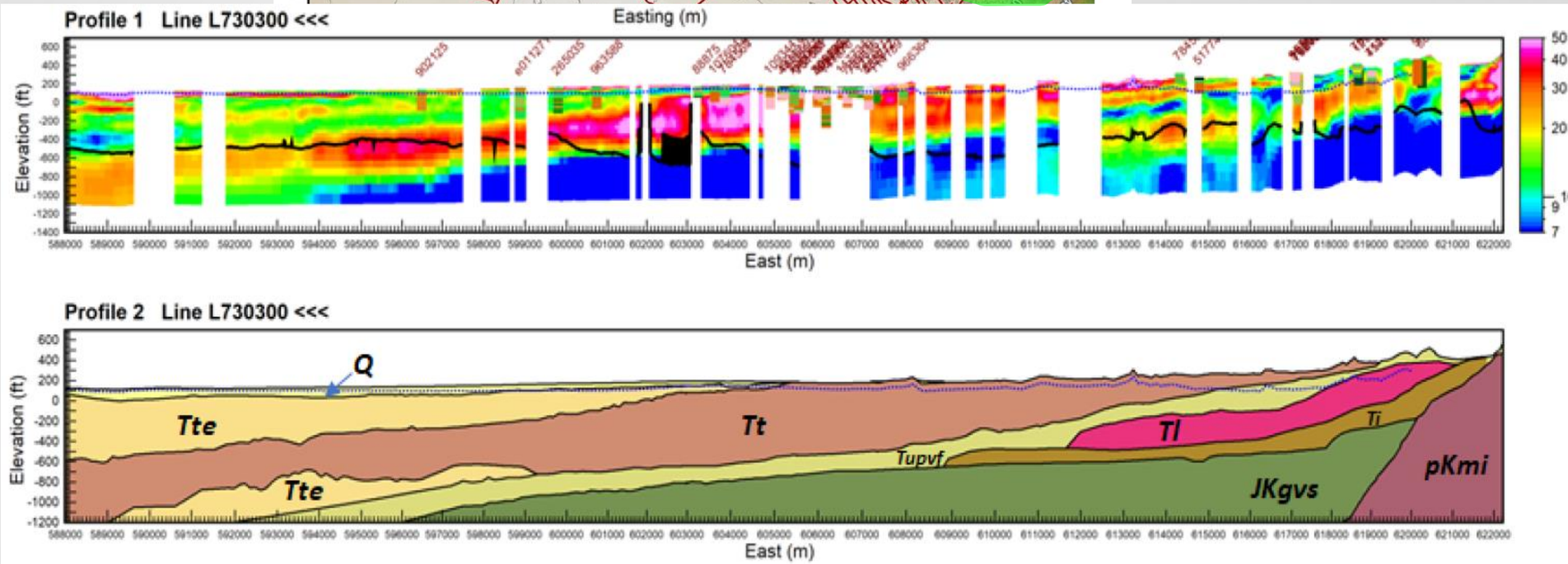


Figure 5-4. Example digitization of stratigraphic contacts for AEM flight line L730300.Stratigraphic units indicated: Quaternary (*Q*), Tehama FM (*Tte*), Tuscan FM (*Tt*), Upper Princeton Valley Fill (*Tupvf*), Lovejoy Basalt (*Tl*), Ione FM (*Ti*), Great Valley Sequence (JKgvs), and Granite (*pKmi*).

General flow and radioisotope age

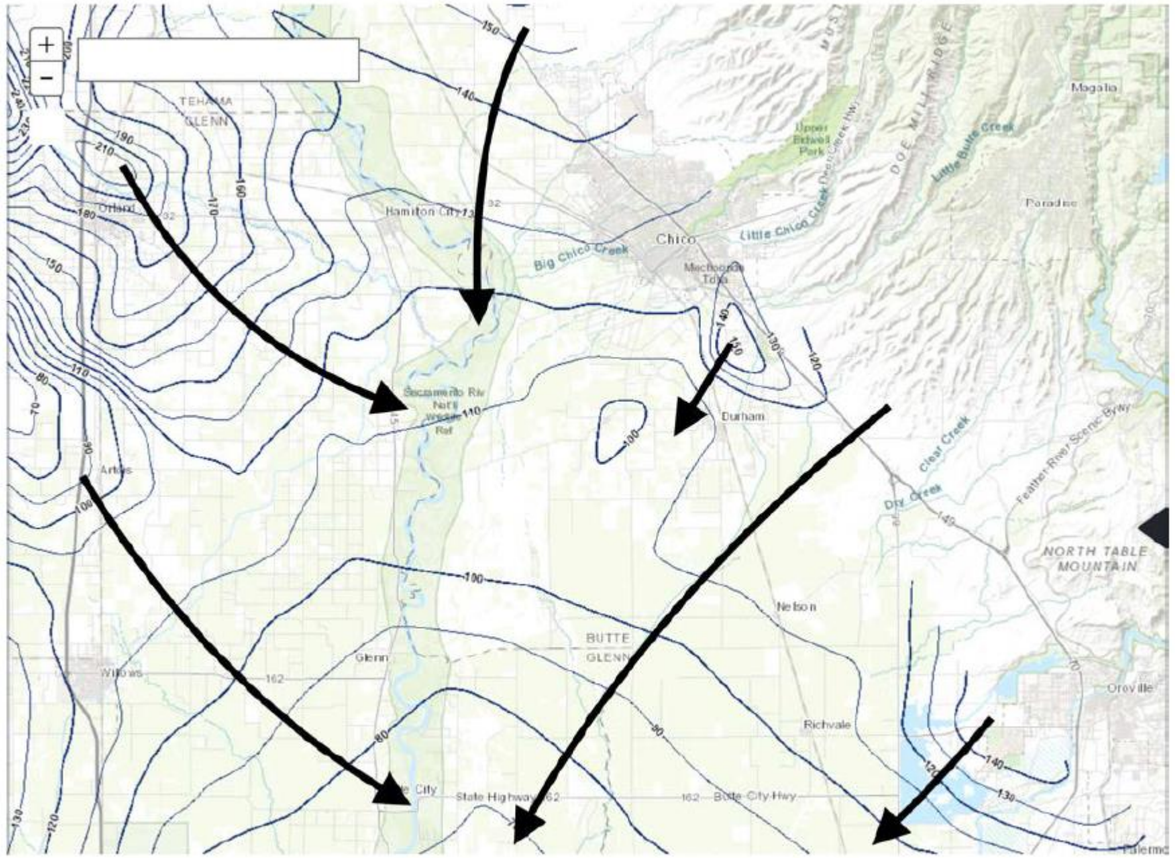
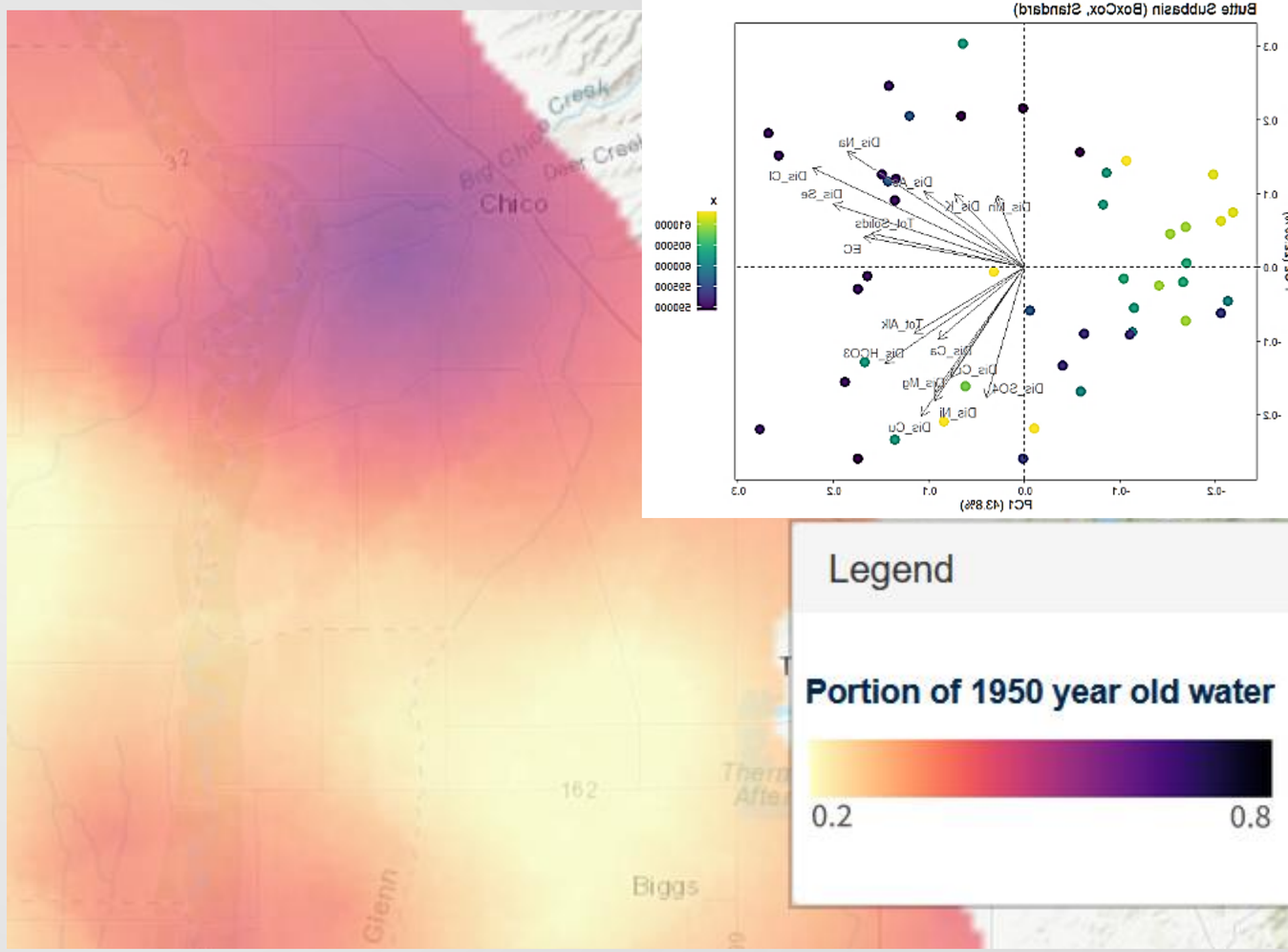
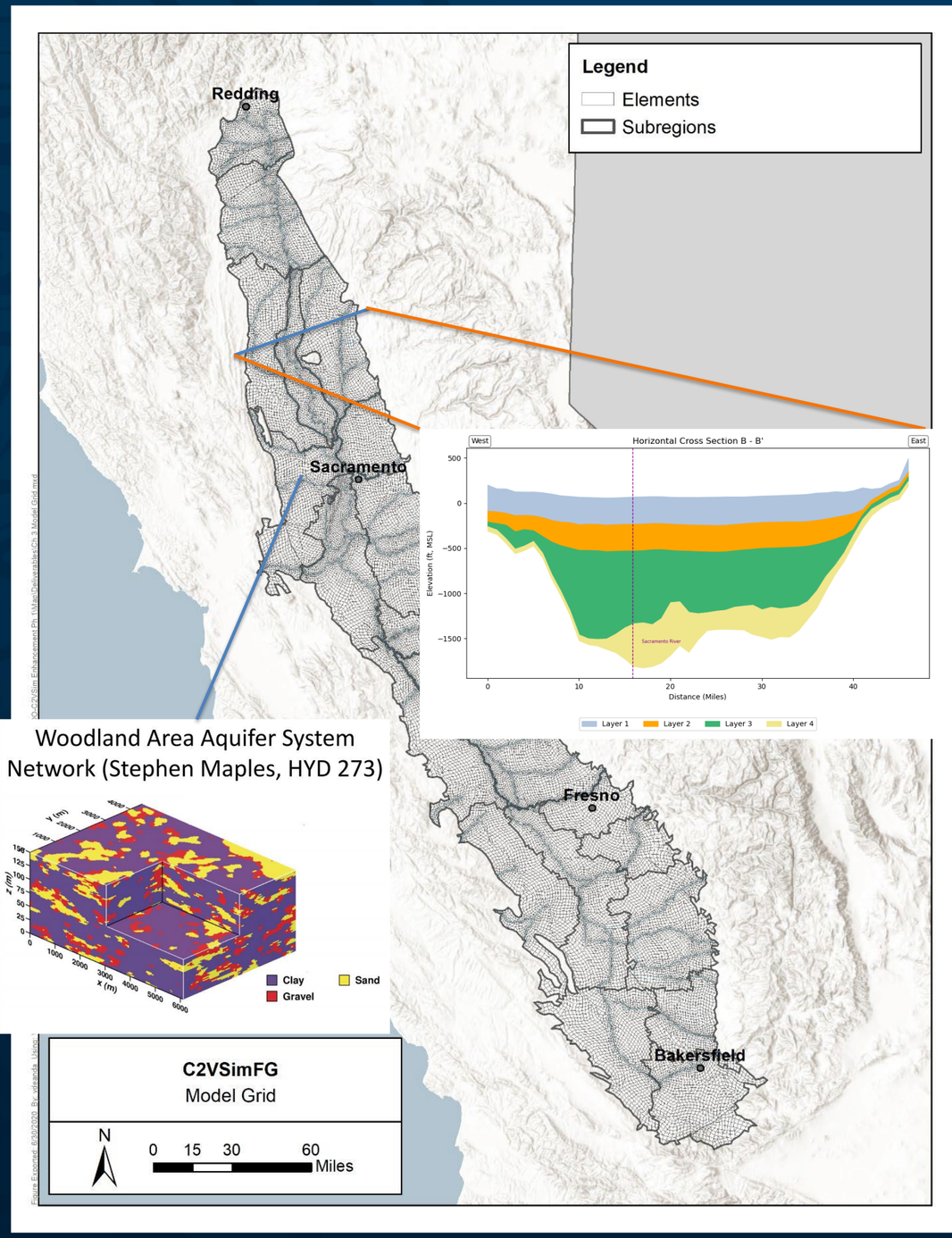


Figure 2-8. Map showing highly generalized regional groundwater flow paths around the project area (Modified from CA-DWR, 2018). Arrows indicate general groundwater flow directions. Contour interval 10 ft. (https://gis.water.ca.gov/app/gicima/).



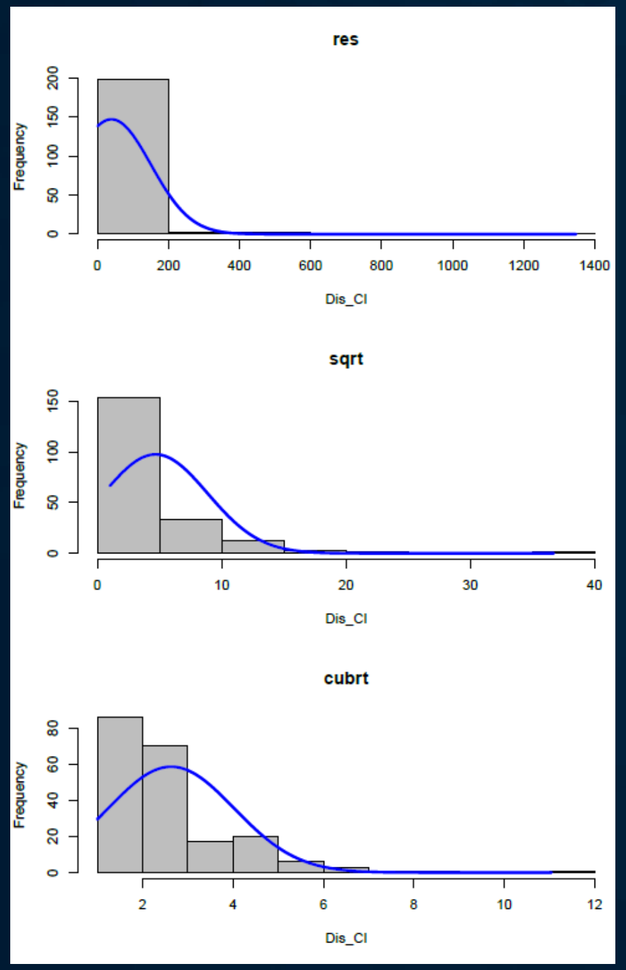
Conclusions

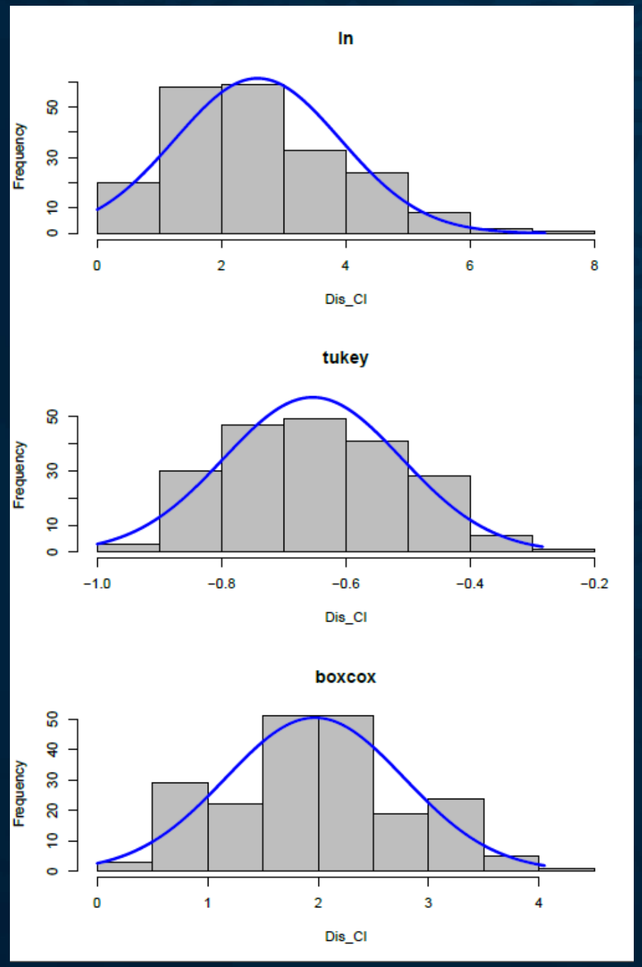
- Valley alluvium may be too complex for type-chemistry of aquifers
  - Discrete locations (confined)
- Residence time, flow direction may matter more
- Interconnection between formations



Method

45 water quality parameters





Transformation, then standardization (scaling)

Metals	Minerals	Nutrients
Dis_B	Dis_Na	Tot_N_kjeldahl
Dis_Al	Dis_Mg	Dis_P_ortho
Tot_Al	Dis_Cl	Tot_P
Dis_Cr	Dis_Ca	Dis_K
Tot_Cr	Dis_CO3	Dis_NH3
Dis_Mn	Dis_HCO3	Dis_NO3
Tot_Mn	Dis_Hard	Dis_NO3NO2
Dis_Fe	Dis_OH	
Tot_Fe	Dis_SO4	
Dis_Ni	EC	
Tot_Ni	Tot_Alk	
Dis_Cu	Tot_Solids	
Tot_Cu	pH	
Dis_Zn		
Tot_Zn		
Dis_As		
Tot_As		
Dis_Se		
Tot_Se		
Dis_Ag		
Tot_Ag		
Dis_Cd		
Tot_Cd		
Dis_Pb		
Tot_Pb		