HYDROCHEMISTRY OF THE WHITE ROCK CANYON SPRINGS AND RIO GRANDE, NEW MEXICO

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I. Introduction and Previous Investigations

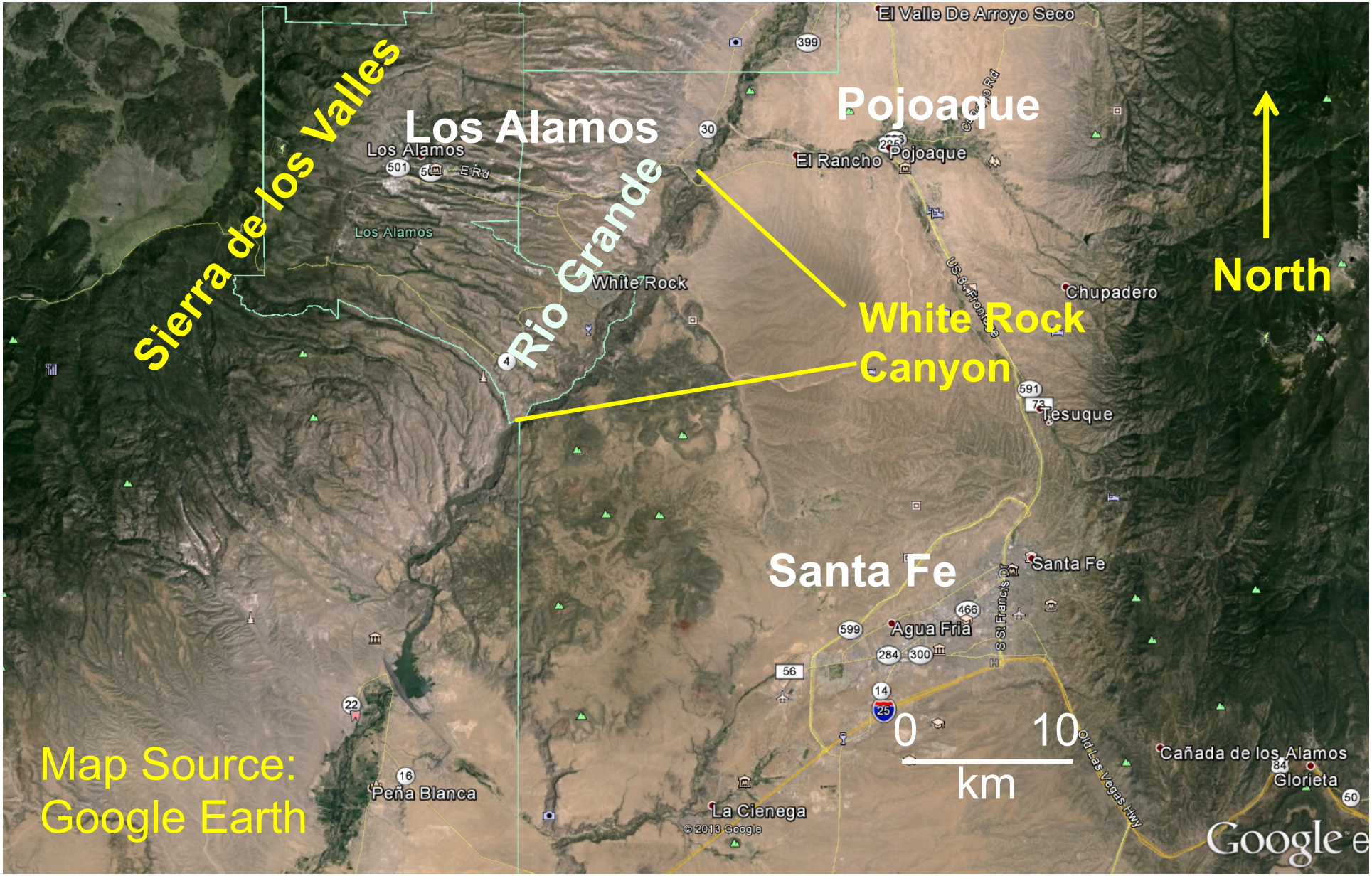
II. Hydrology

III. Solute Concentrations

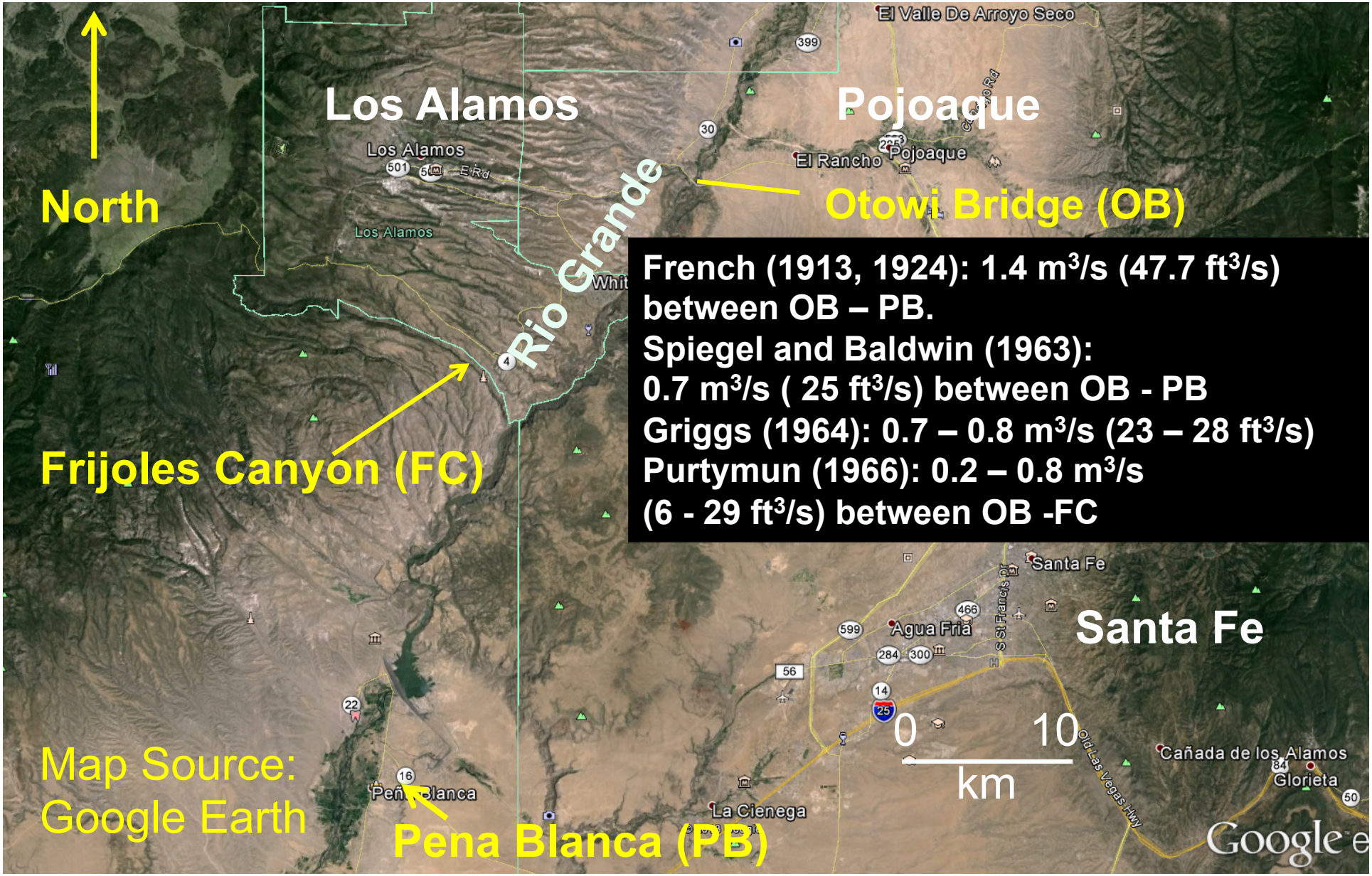
IV. Groundwater Age and Flow Paths

V. Summary and Conclusions

Map of Santa Fe-Pojoaque-Los Alamos Area, Including White Rock Canyon, North-Central New Mexico



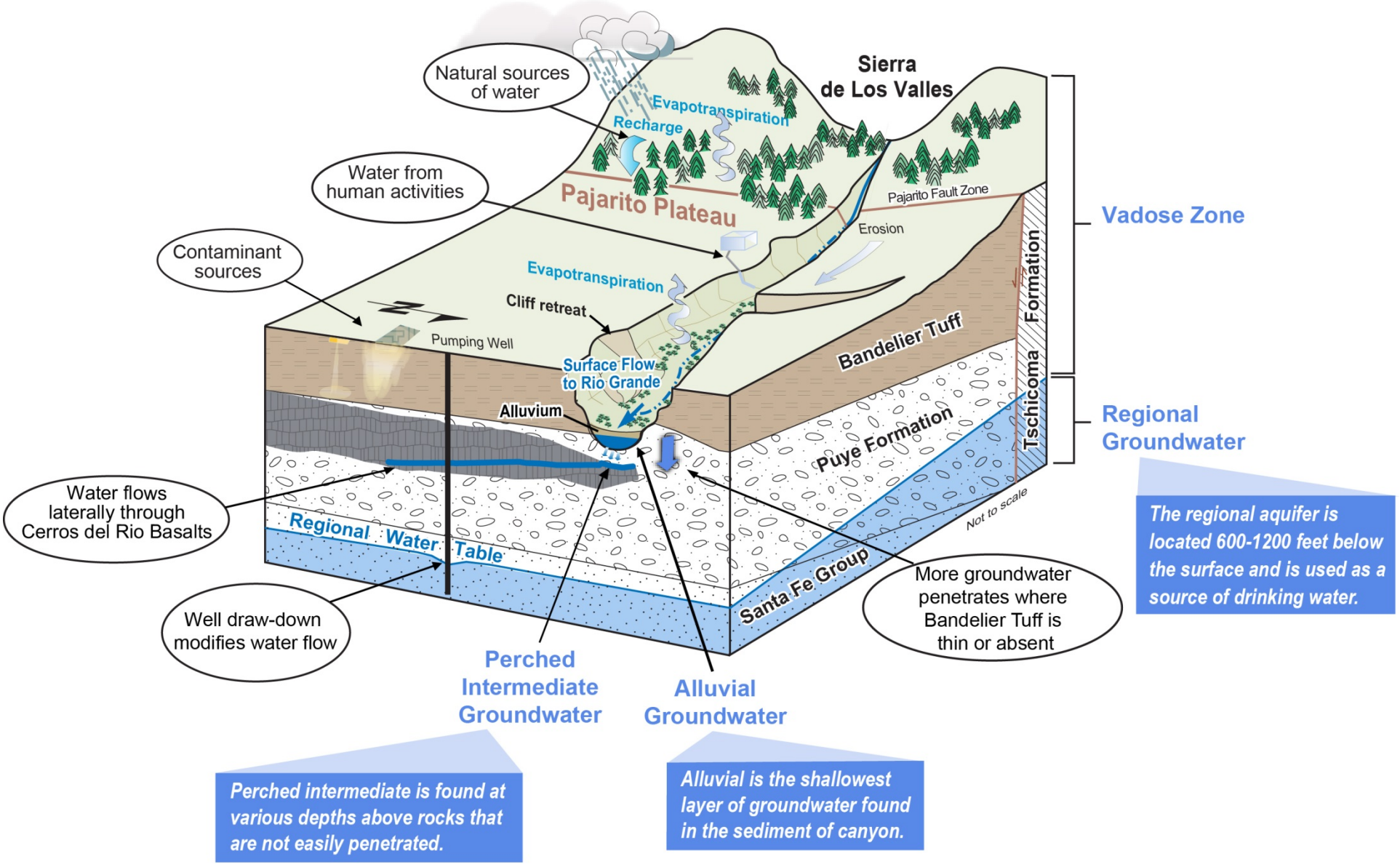
Summary of Hydrological Measurements Conducted on the Rio Grande Between Otowi Bridge and Pena Blanca



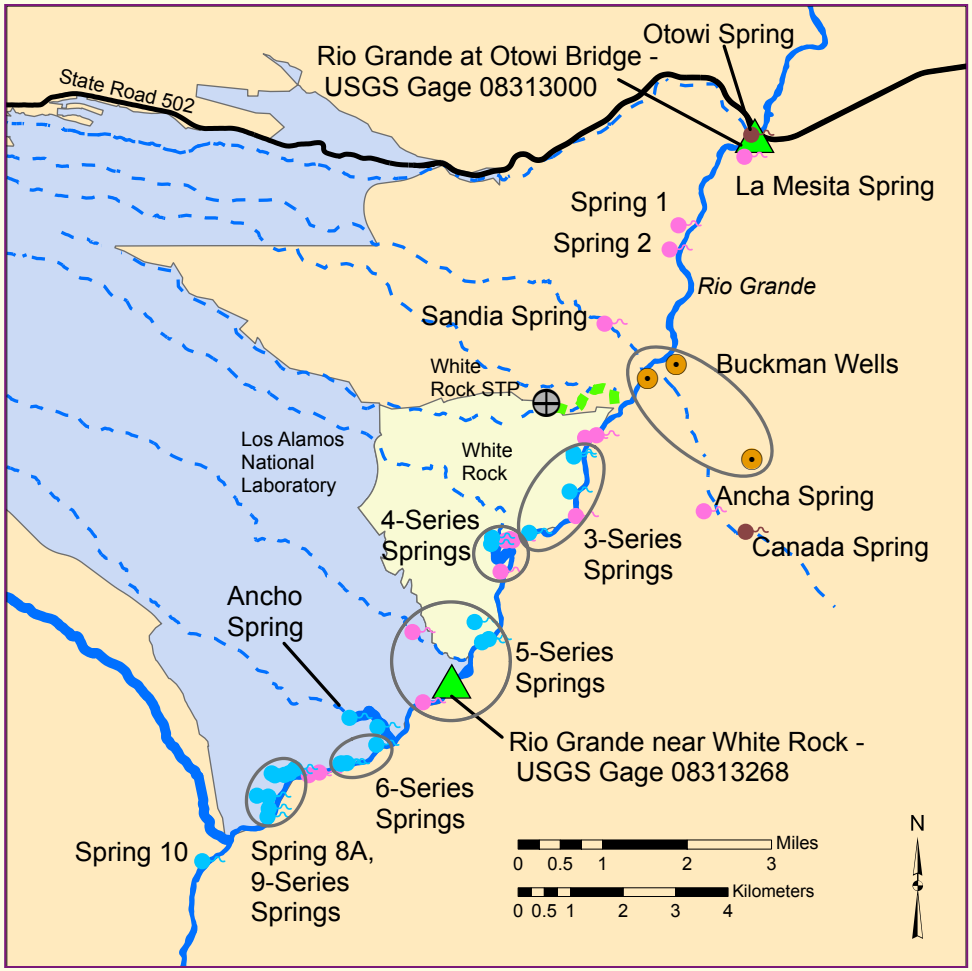
French (1913, 1924): 1.4 m^3/s (47.7 ft^3/s) between OB – PB.
Spiegel and Baldwin (1963):
0.7 m^3/s (25 ft^3/s) between OB - PB
Griggs (1964): 0.7 – 0.8 m^3/s (23 – 28 ft^3/s)
Purtymun (1966): 0.2 – 0.8 m^3/s
(6 - 29 ft^3/s) between OB -FC

GROUNDWATER

Schematic of Groundwater Processes on the Pajarito Plateau, NM



Map Showing Springs Discharging in White Rock Canyon, North Central New Mexico



A total of 36 regional aquifer springs discharge in White Rock Canyon (WRC) (33 springs discharge west of the Rio Grande).

Cumulative discharge from WRC springs west of the Rio Grande is 0.085 m^3/s (3 ft^3/s) (Purtymun, 1966). Most of the WRC springs discharge between <2.83e-05 and 0.02 m^3/s (<0.001 and 0.71 ft^3/s) (Spring 4A).

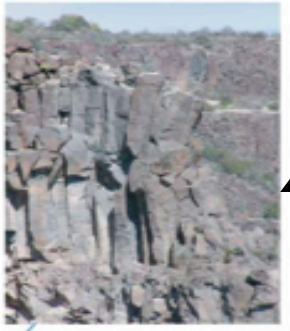
Waterfall and Pool in Pajarito Canyon
White Rock Canyon, North-Central New Mexico

LANL Hydrostratigraphy and White Rock Canyon Springs

No WRC Springs discharge from the Bandelier Tuff.

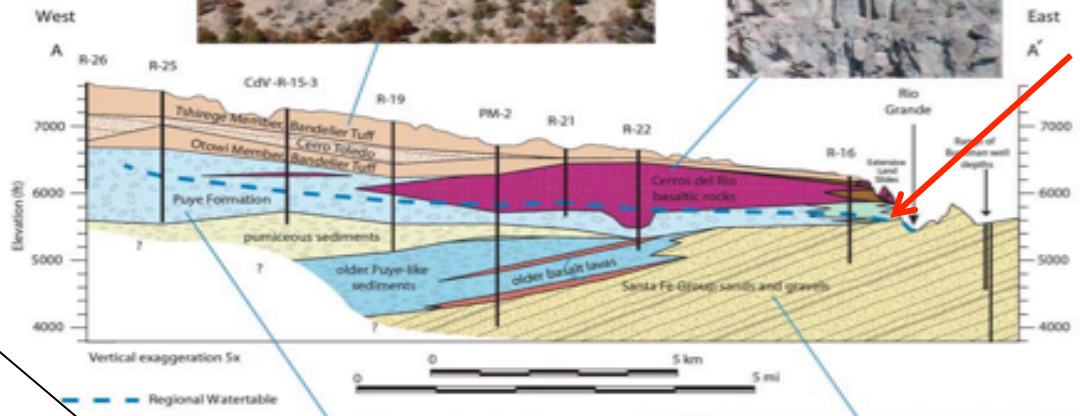
Perched Zones (Bandelier Tuff)

Perched Zones and Regional Aquifer (Cerros del Rio basalt)



Springs 6 and 9B

WRC Springs
Ancho Spring, 5 series, 6 series, 7, 8, 9 series, and 10



White Rock Canyon Springs

WRC Springs
1, 2 series, 3 series, 4 series, 5 series, 6 series, La Mesita, and Sandia

Perched Zones and Regional Aquifer (Puye Formation, Phreatomagmatic Deposits)

Regional Aquifer (Santa Fe Group)

$\delta^{18}O$ and $\delta^{2}H$ Results for Springs and Wells, Pajarito Plateau and Surrounding Areas

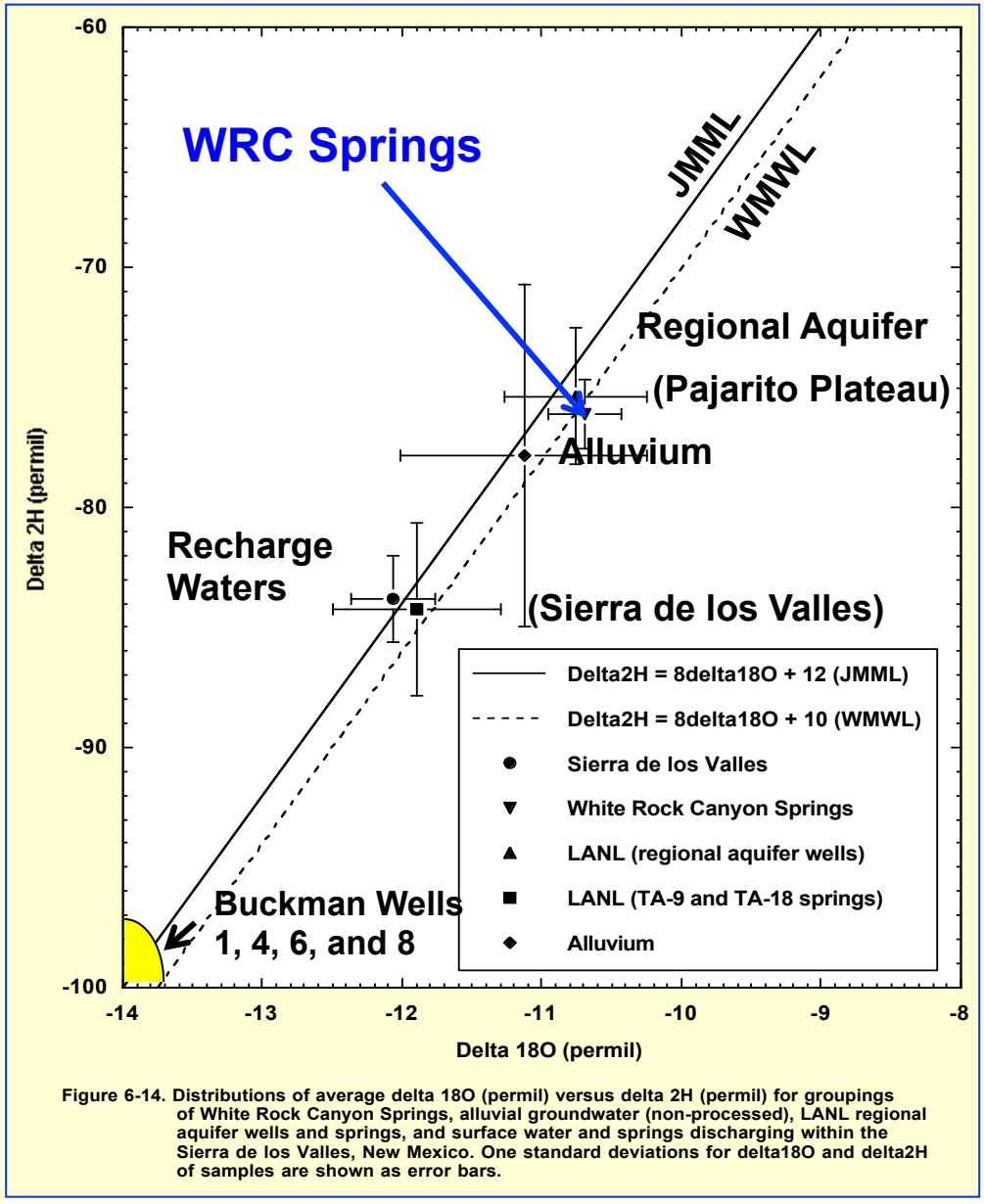
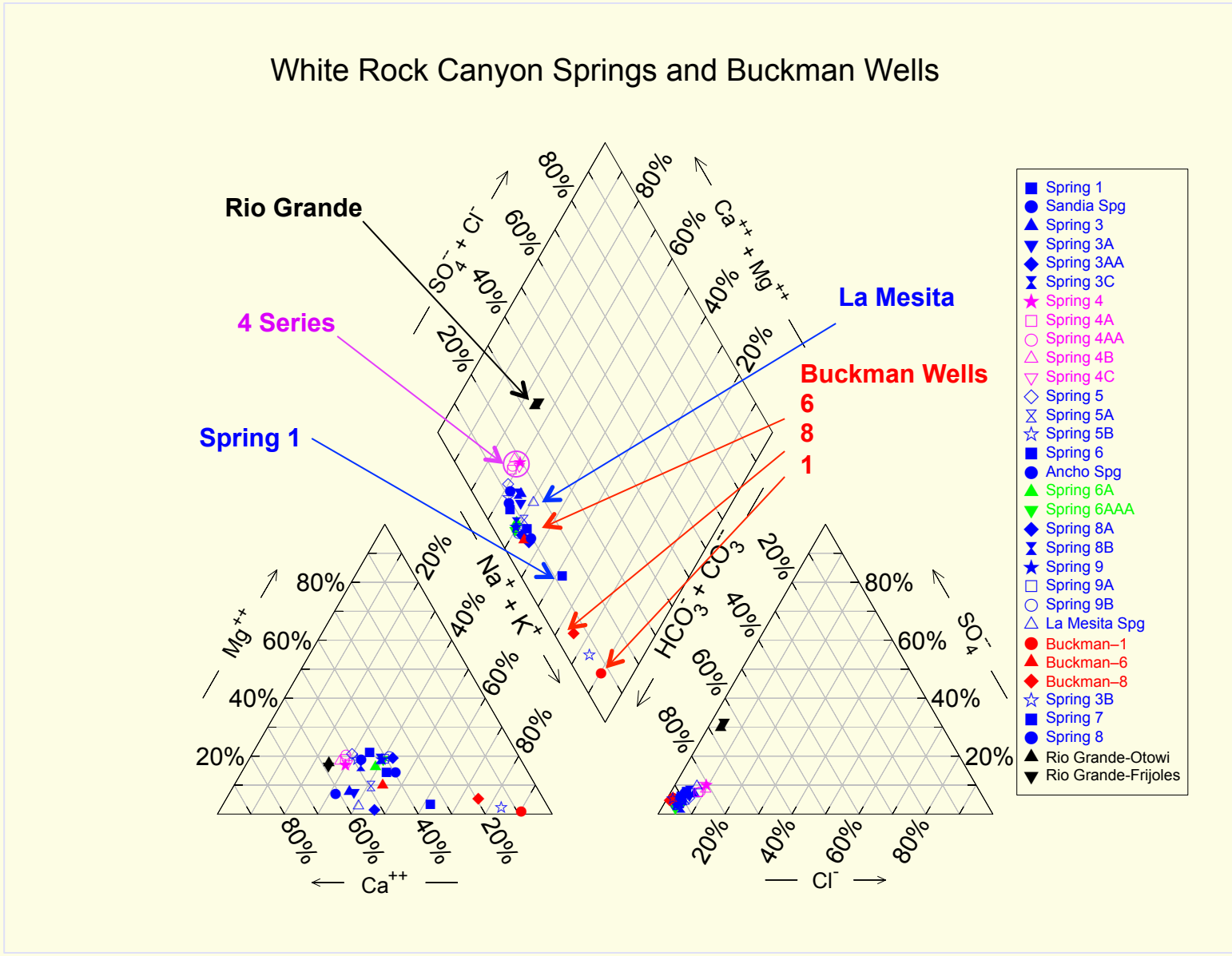
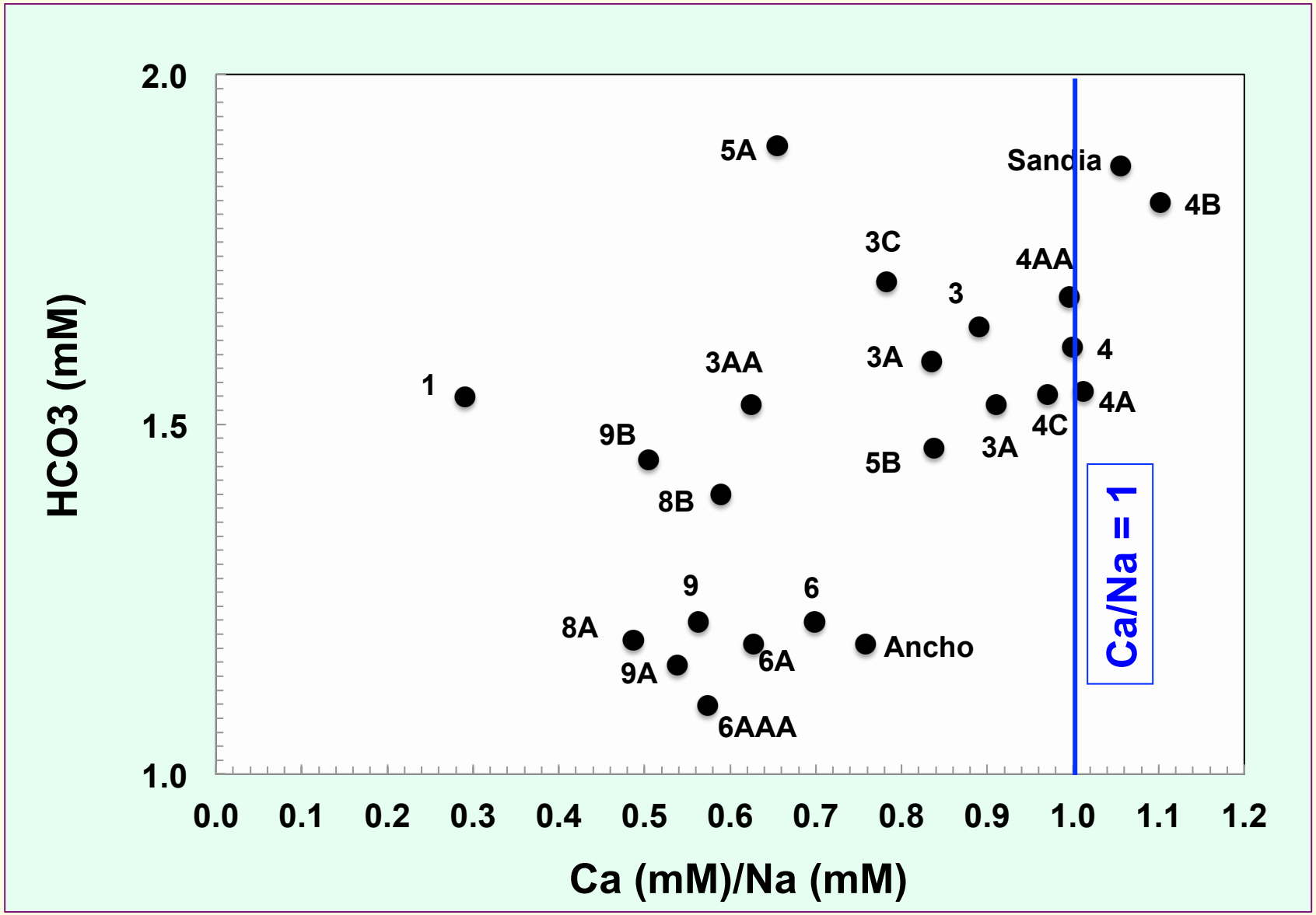


Figure 6-14. Distributions of average delta 18O (permil) versus delta 2H (permil) for groupings of White Rock Canyon Springs, alluvial groundwater (non-processed), LANL regional aquifer wells and springs, and surface water and springs discharging within the Sierra de los Valles, New Mexico. One standard deviations for delta18O and delta2H of samples are shown as error bars.

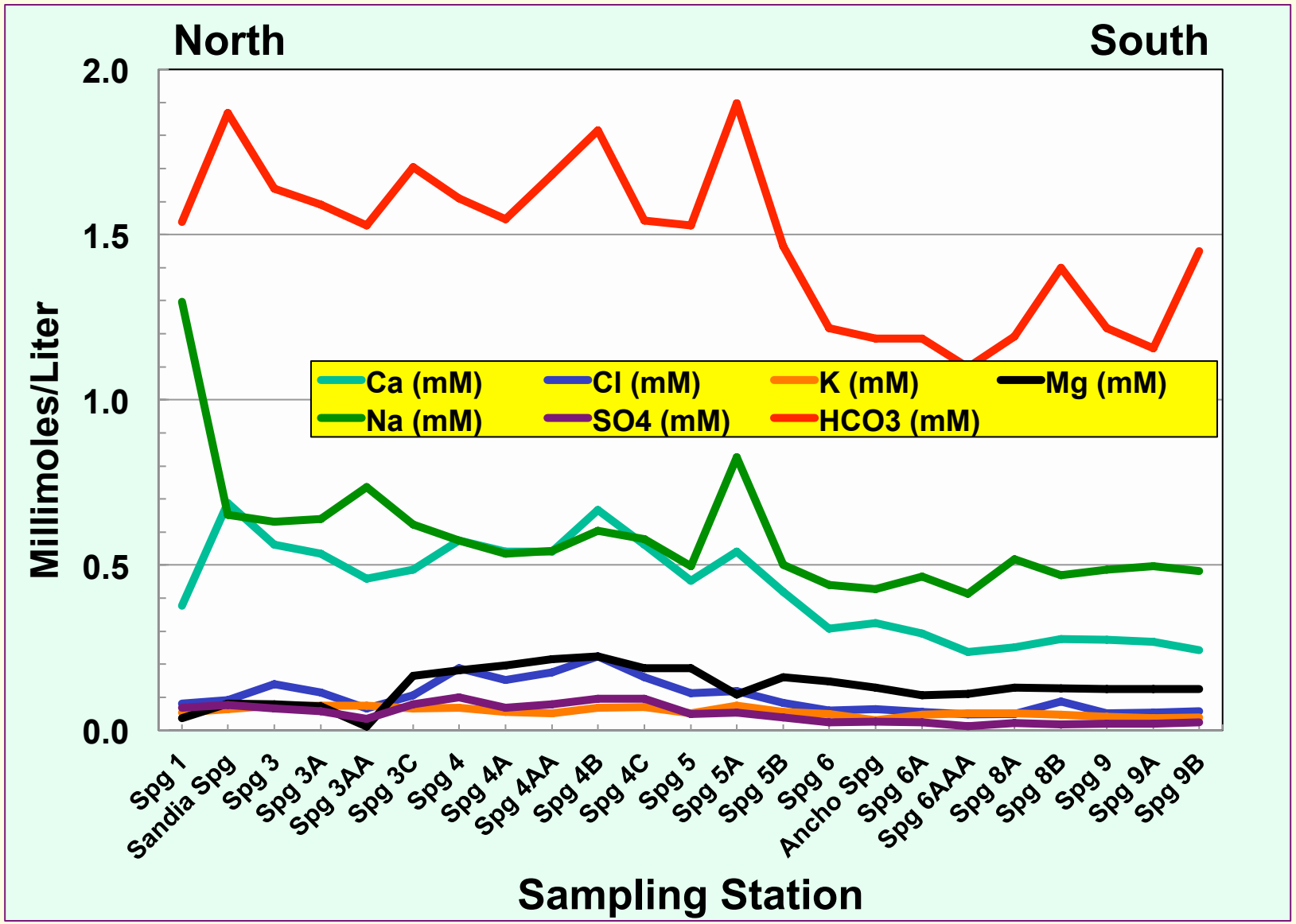
Trilinear Diagram for White Rock Canyon Springs and Buckman Wells (2012) (Prepared by June Fabryka-Martin)



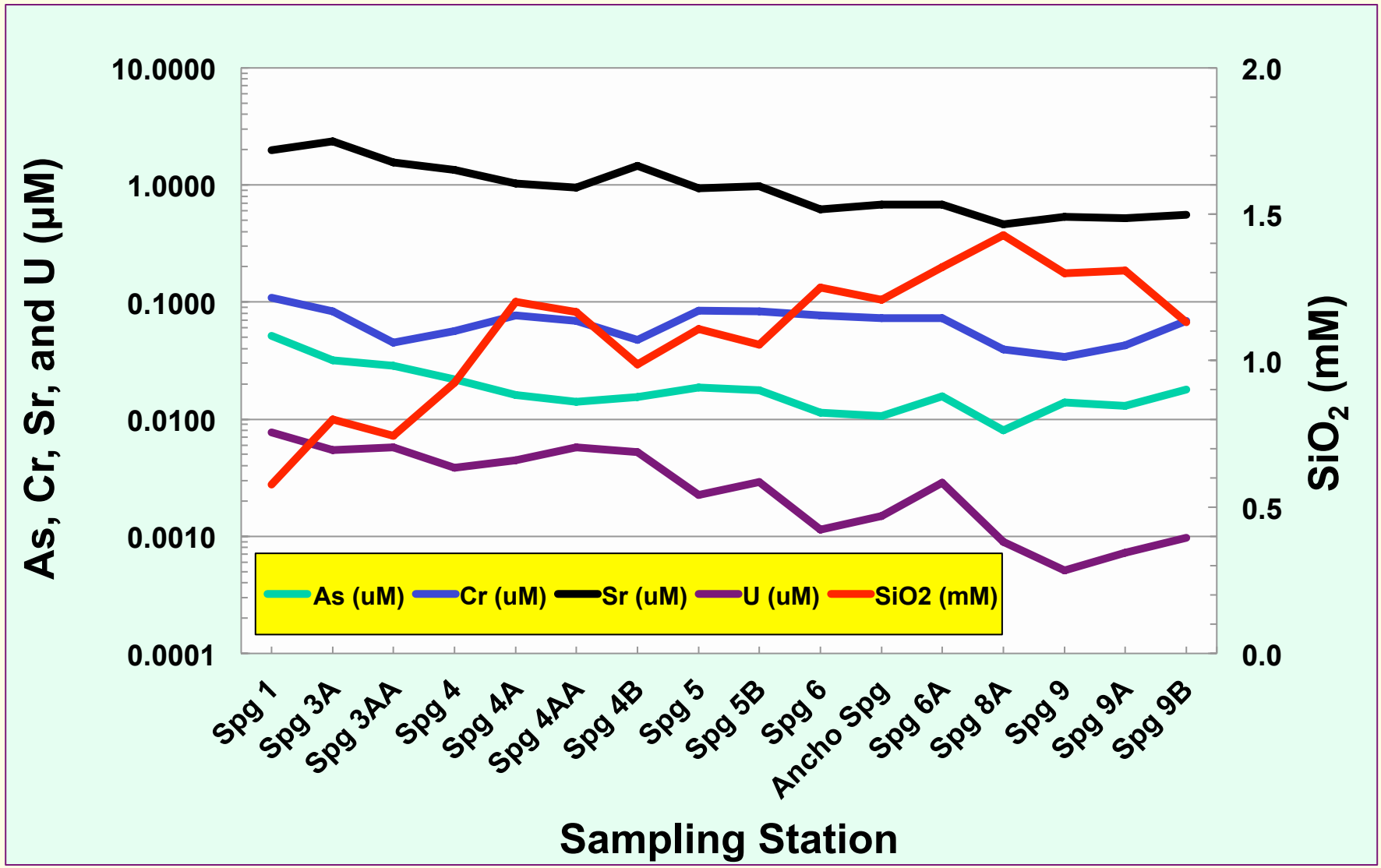
Dissolved Calcium/Sodium Versus Bicarbonate at White Rock Canyon Springs Discharging West of the Rio Grande (2012)



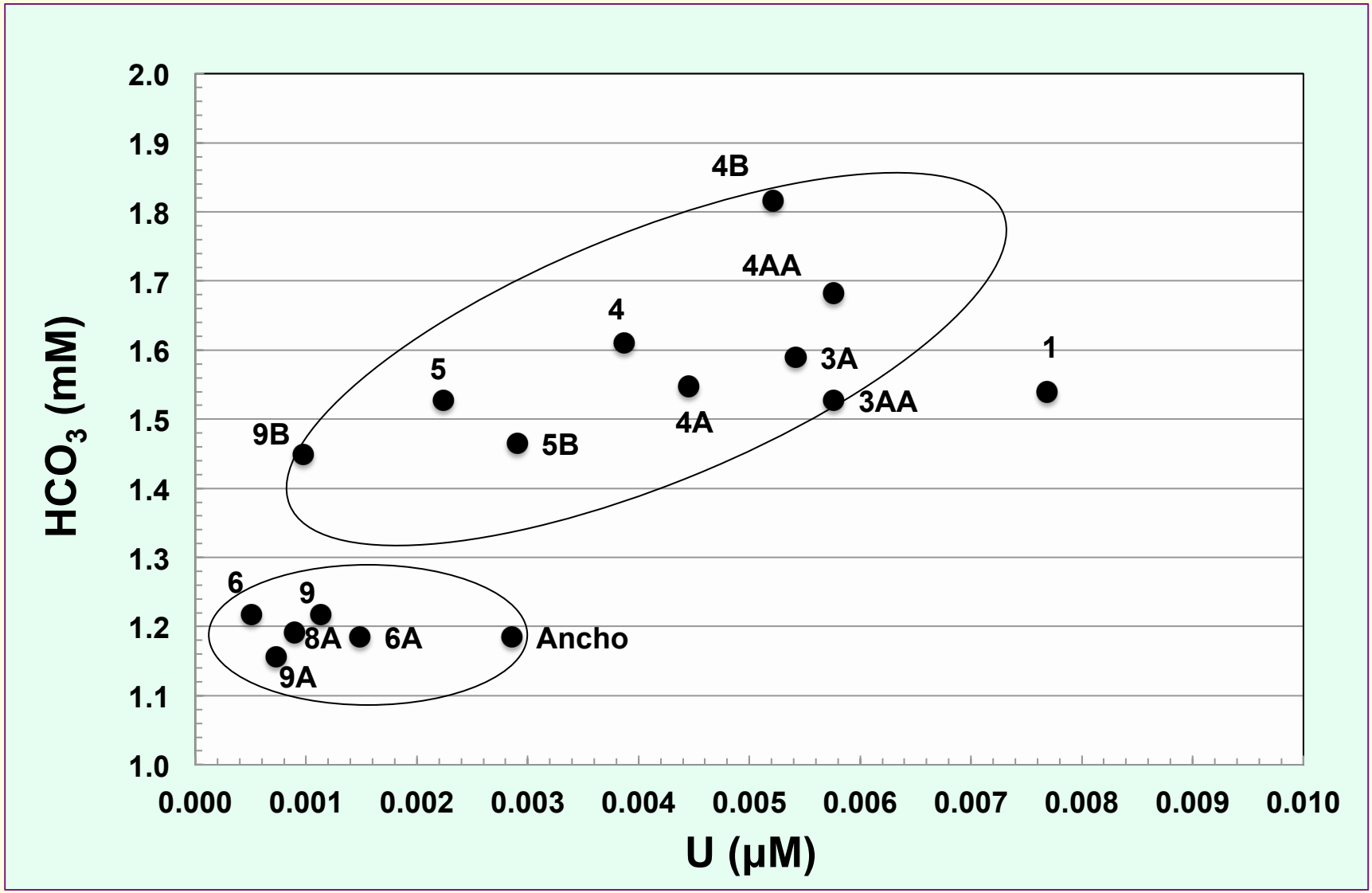
Dissolved Concentrations of Major Ions at White Rock Canyon Springs Discharging West of the Rio Grande (2012)



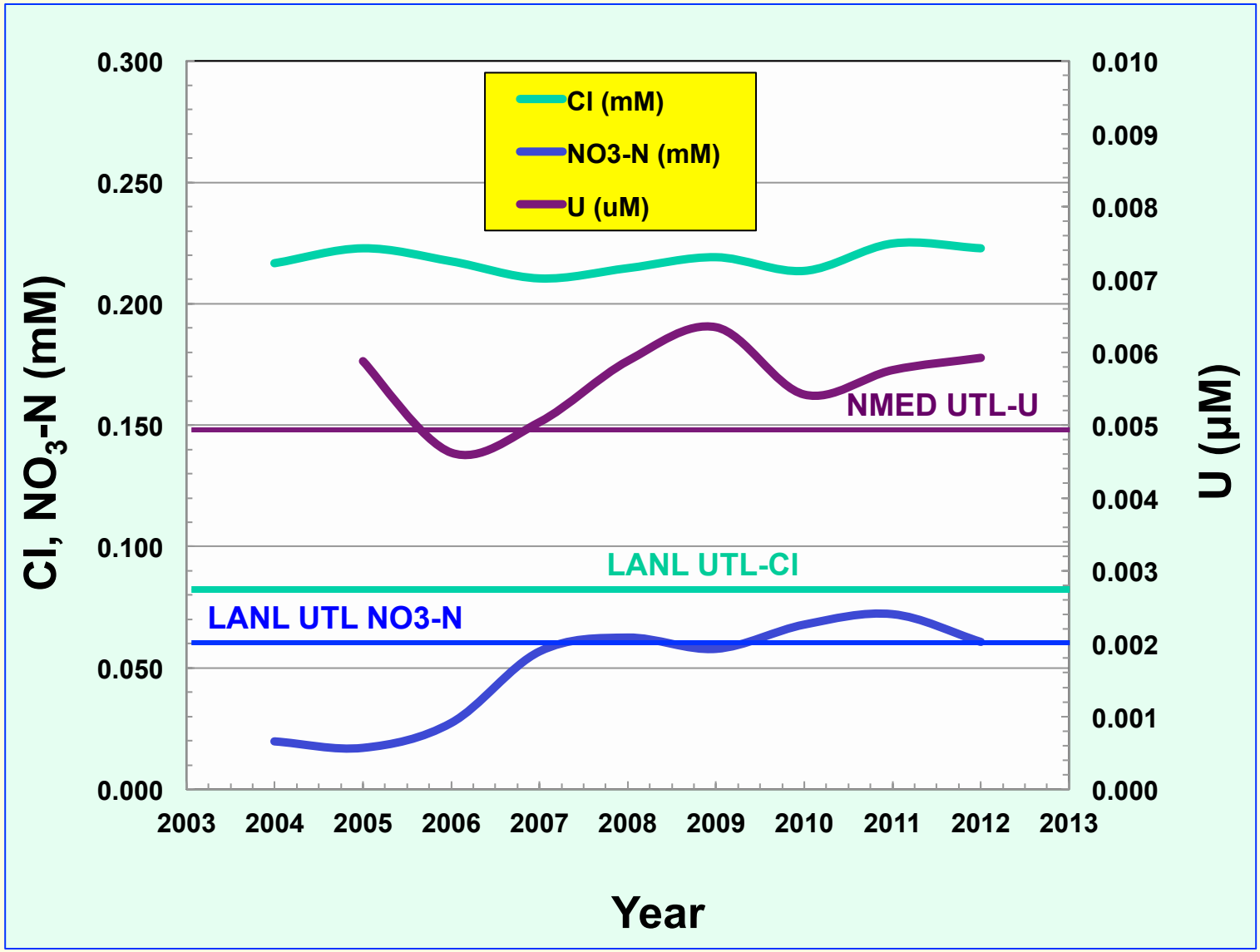
Dissolved Concentrations of Arsenic, Chromium, Silica, Strontium, and Uranium at White Rock Canyon Springs Discharging West of the Rio Grande (2012)



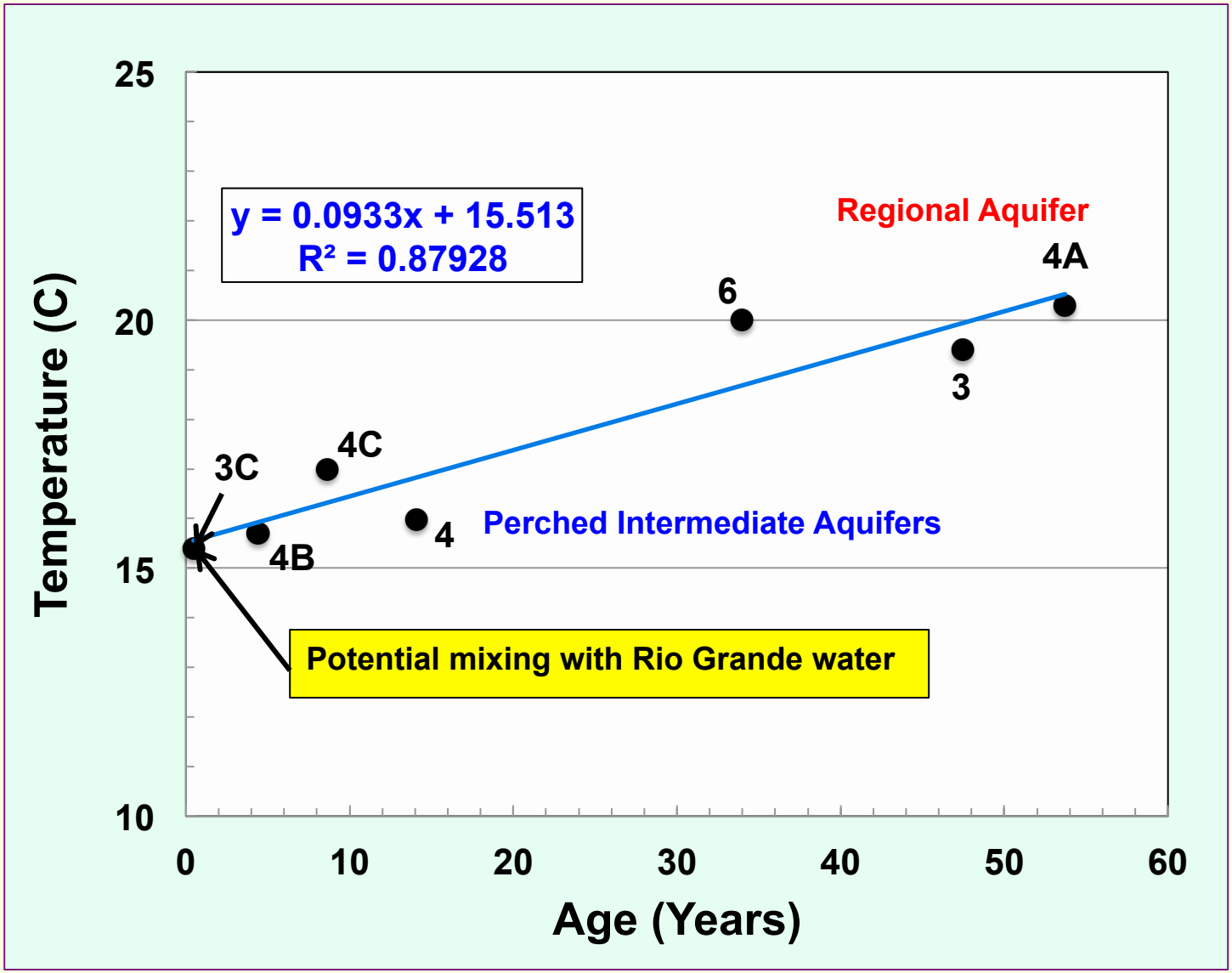
Dissolved Concentrations of Uranium Versus Bicarbonate at White Rock Canyon Springs Discharging West of the Rio Grande (2012)



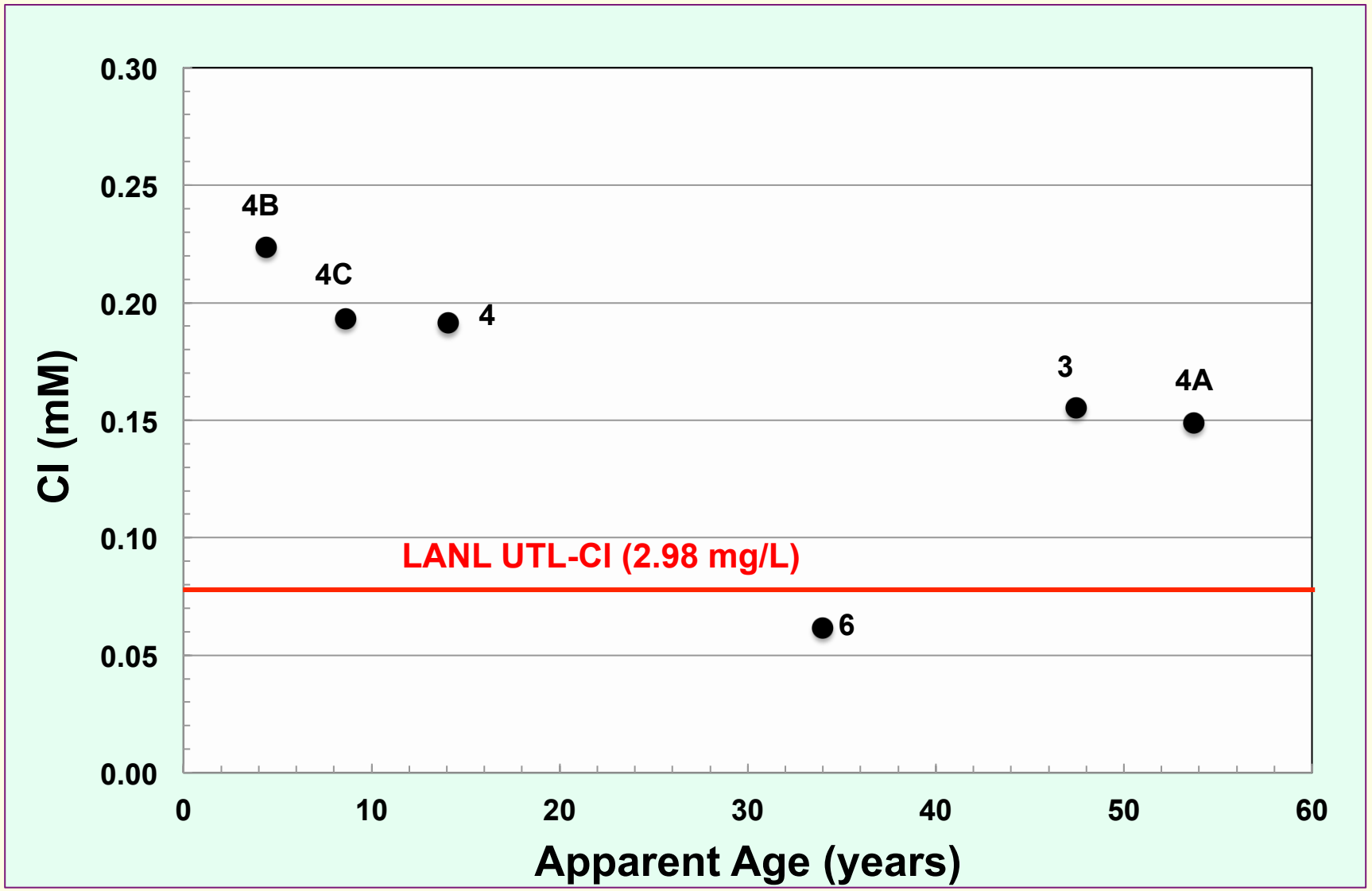
Dissolved Concentrations of Chloride, Nitrate-N, and Uranium at Spring 4B From 2004 Through 2012, White Rock Canyon, NM



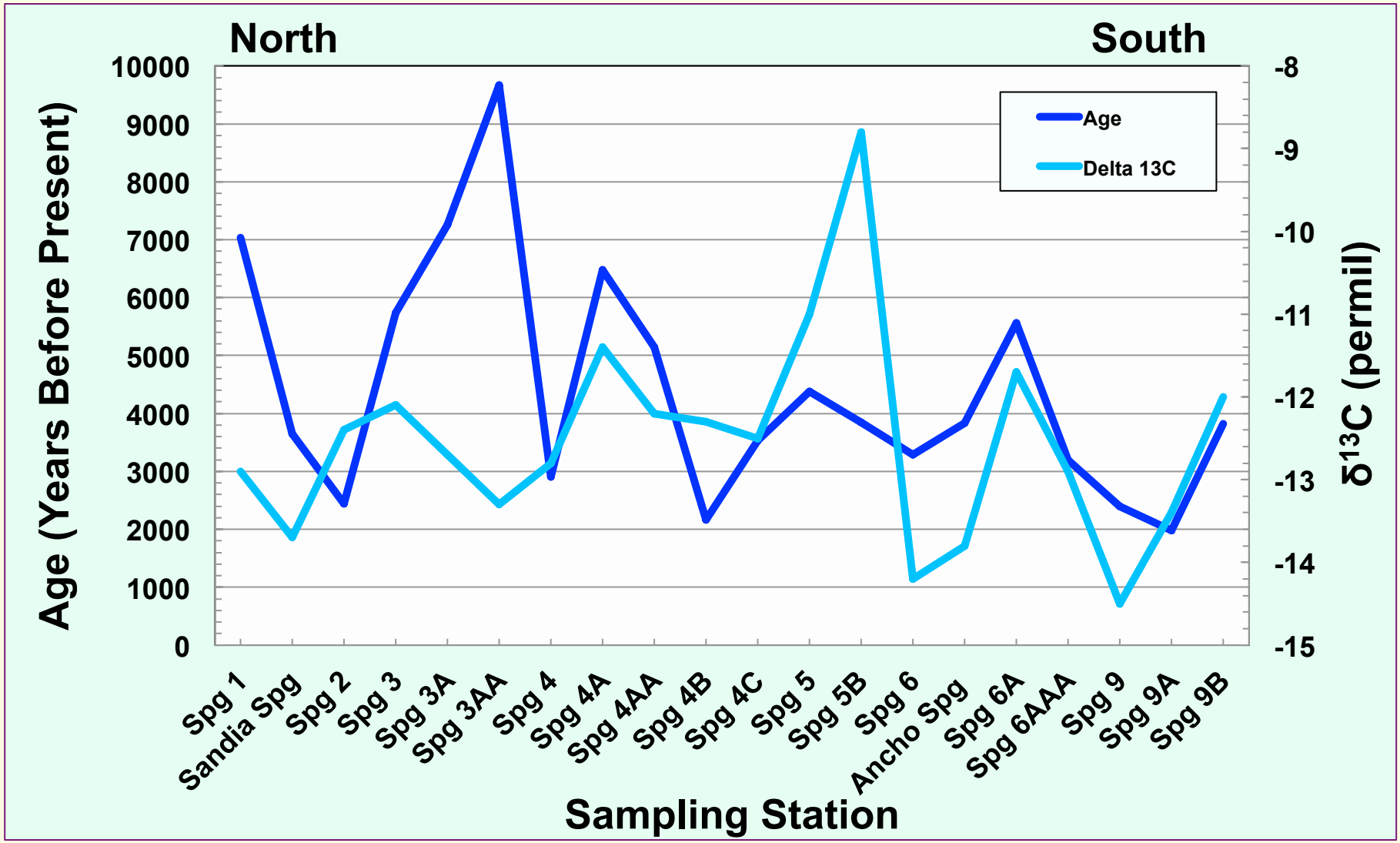
Apparent Age ($^3H/^3He$) Versus Groundwater Temperature at Selected White Rock Canyon Springs, North-Central New Mexico



Apparent Age ($^3H/^3He$) Versus Chloride Concentrations at Selected White Rock Canyon Springs, North-Central New Mexico



Unadjusted Carbon-14 Ages and δ^{13}Carbon Values for White Rock Canyon Springs Discharging West of the Rio Grande



Summary and Conclusions

- **The White Rock Canyon (WRC) springs represent discharge zones for the deep vadose zone and upper portion of the regional aquifer beneath the Pajarito Plateau, New Mexico.**
- **Results of stable isotope analyses ($\delta^{18}O$ and $\delta^{2}H$) suggest that recharge to the WRC springs occurs within the Sierra de los Valles and along canyon bottoms within several watersheds dissecting the Pajarito Plateau.**
- **The WRC springs vary in flow ranging from less than 1.16e-05 to 0.015 m^3/s (<0.4e-3 to 0.53 ft^3/s), discharging from the Chamita Formation, Cerros del Rio basalt, and Puye Formation aquifers. Total discharge for the WRC springs west of the Rio Grande is 0.03 m^3/s (1.06 ft^3/s).**
- **Groundwater sampled from the WRC springs is characterized by sodium-calcium-bicarbonate, calcium-sodium-bicarbonate, and mix cation-anion compositions. Concentrations of TDS range between 170 to 480 mg/L.**

Summary and Conclusions

- **Several of the WRC springs contain elevated above background concentrations of chloride, nitrate, perchlorate, tritium, and uranium derived from industrial and municipal sewage outfalls and deicing salt.**
- **Results of tritium/helium dating of several WRC springs discharging west of the Rio Grande suggest that groundwater-flow paths are controlled by complex lithological and hydraulic properties of the vadose zone and regional aquifer.**
- **Unadjusted carbon-14 ages for the WRC springs range from 2100 to 9700 years before present and generally decrease in age from north to south.**
- **Monitoring the WRC springs provides data essential for evaluating long-term sustainability and contaminant vulnerability of the regional aquifer and Rio Grande.**

Supplemental Material

Analytical Methods (LANL and NMED)

Major Ions

Ion chromatography, titration, and inductively coupled plasma-optical emission spectroscopy

Trace Elements

Inductively coupled plasma-optical emission spectroscopy and (high resolution) inductively coupled plasma-mass spectrometry

Field Parameters

Dissolved oxygen, pH, ORP, temperature, specific conductance, and turbidity

Analytical Methods (LANL and NMED)

Stable Isotopes

Isotope ratio mass spectrometry ($\delta^{2}H$, $\delta^{18}O$, $\delta^{15}N$, and $^{13}\delta C$)

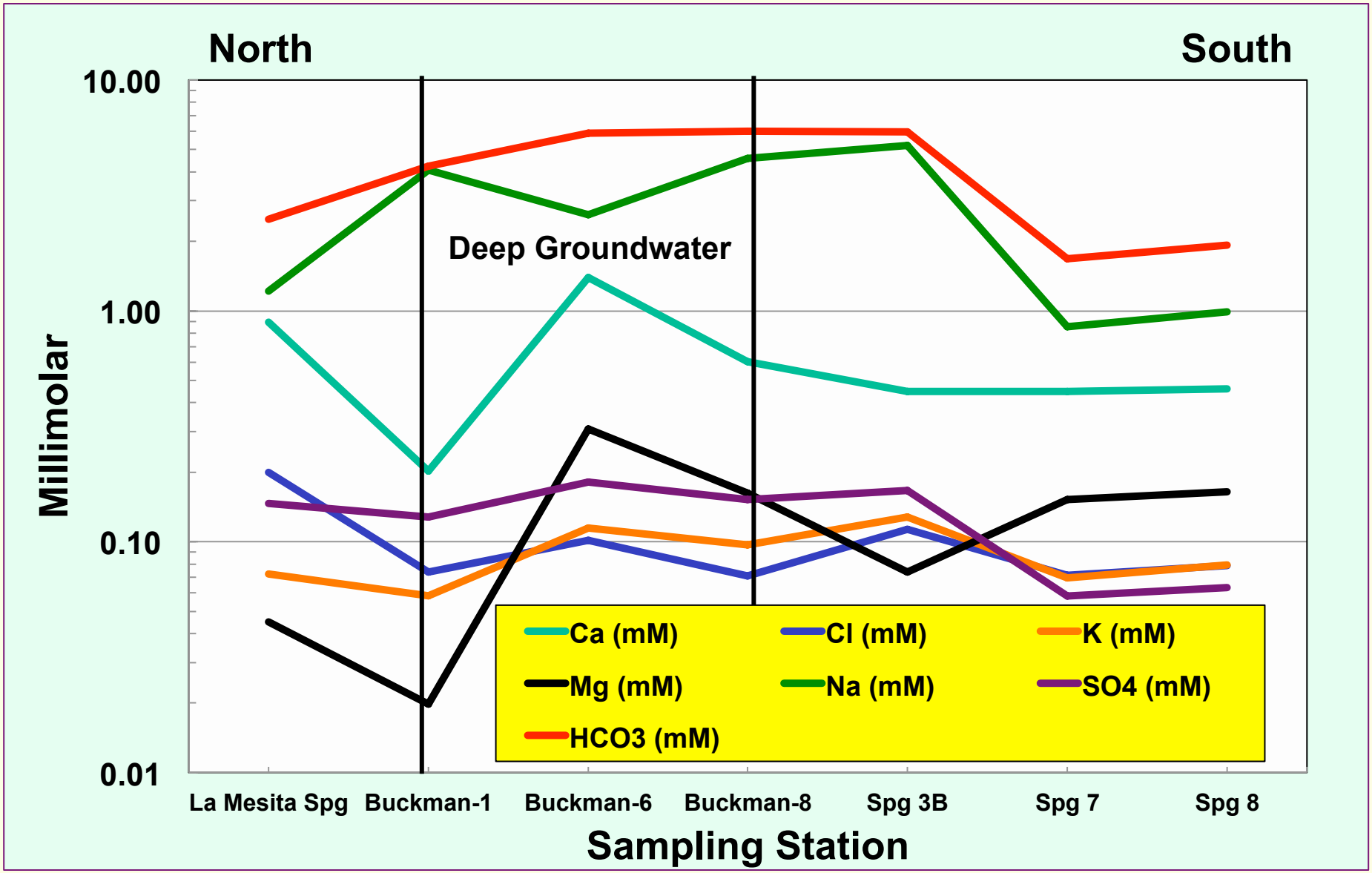
Carbon 14 (NMED)

Accelerator mass spectrometry

Tritium-Helium

Electrolytic enrichment (^{3}H) and mass spectrometry ($^{3,4}He$) for He ingrowth

Dissolved Concentrations of Major Ions at Buckman Wells and White Rock Canyon Springs Discharging East of the Rio Grande (2012)



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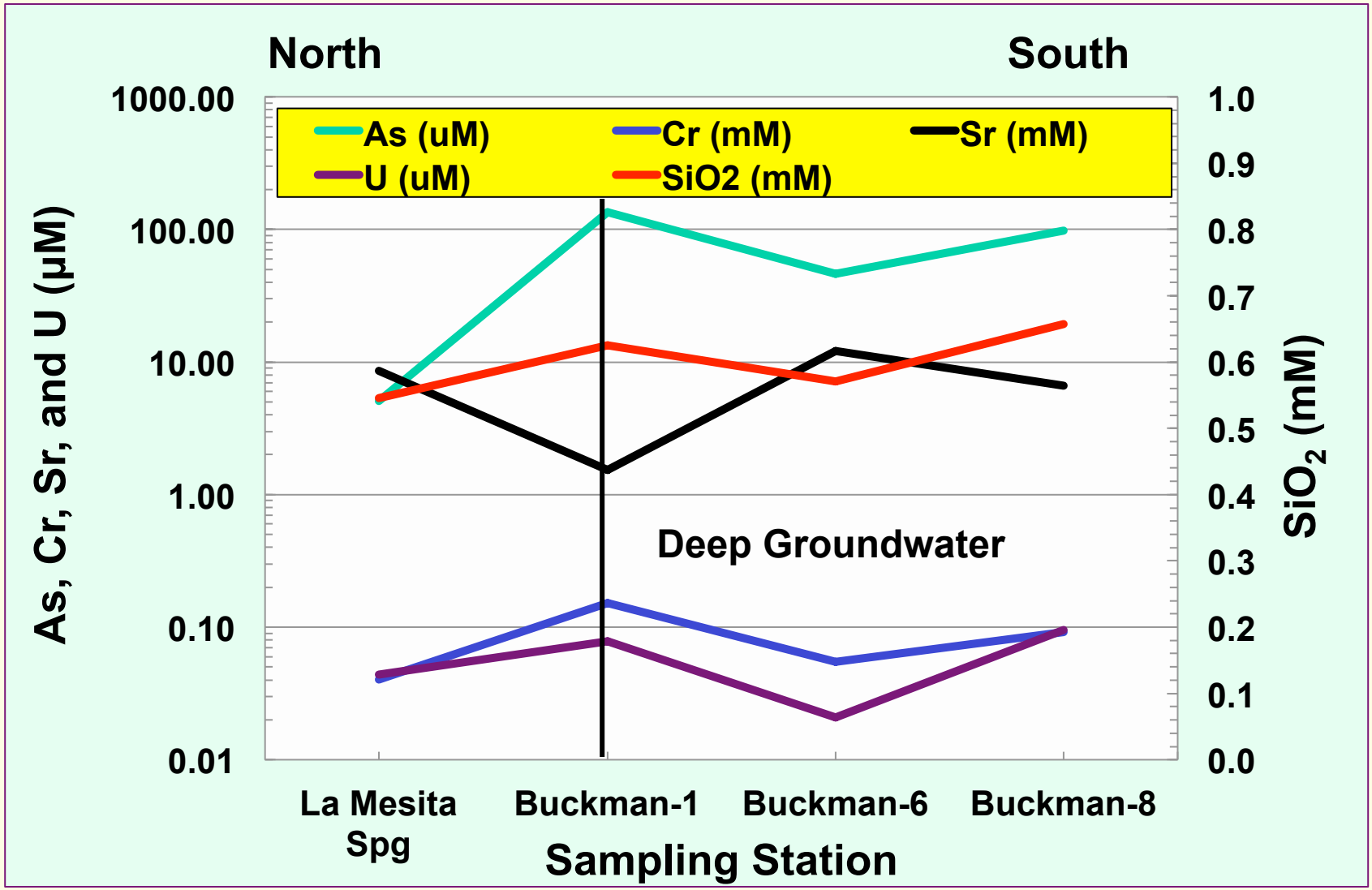

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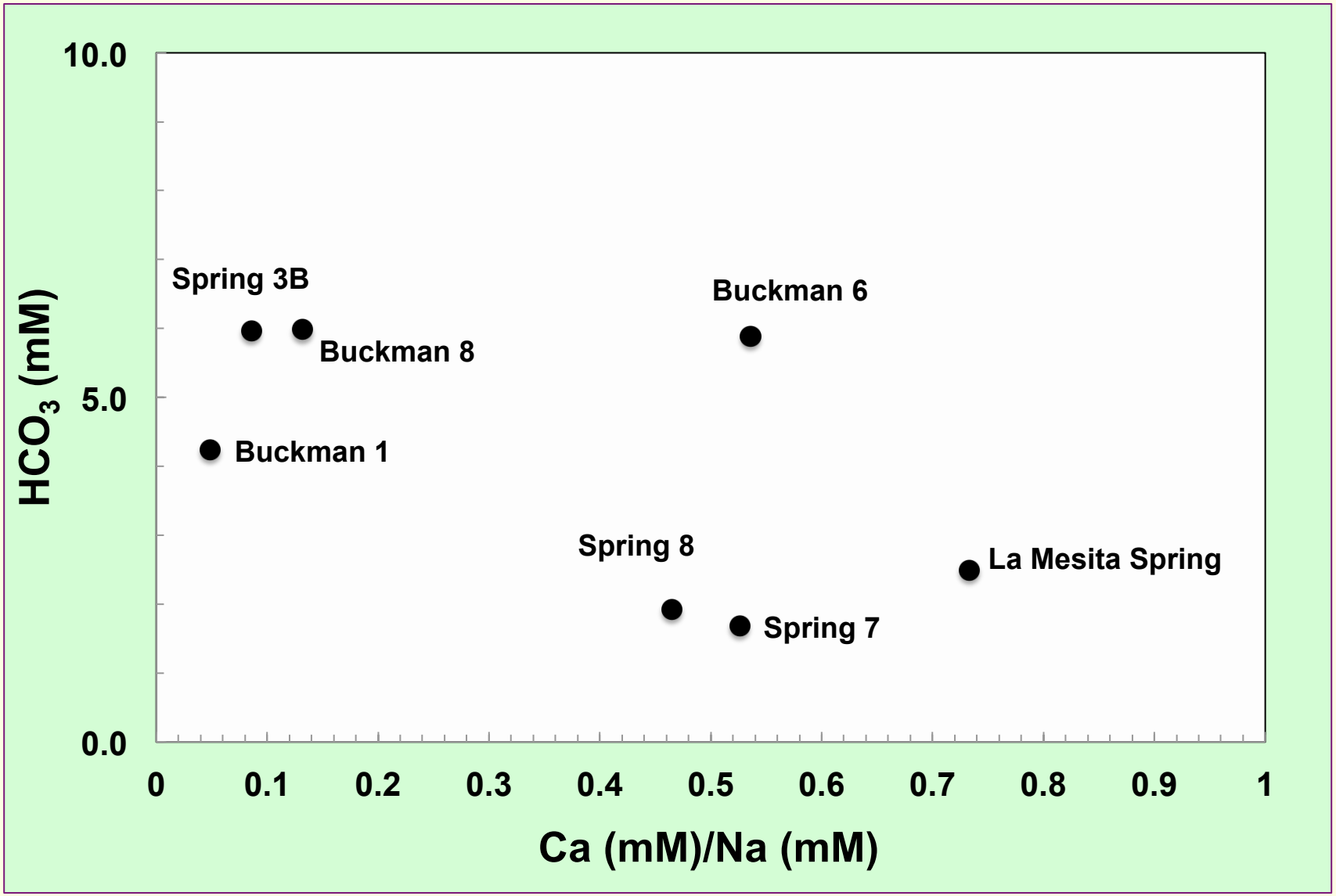
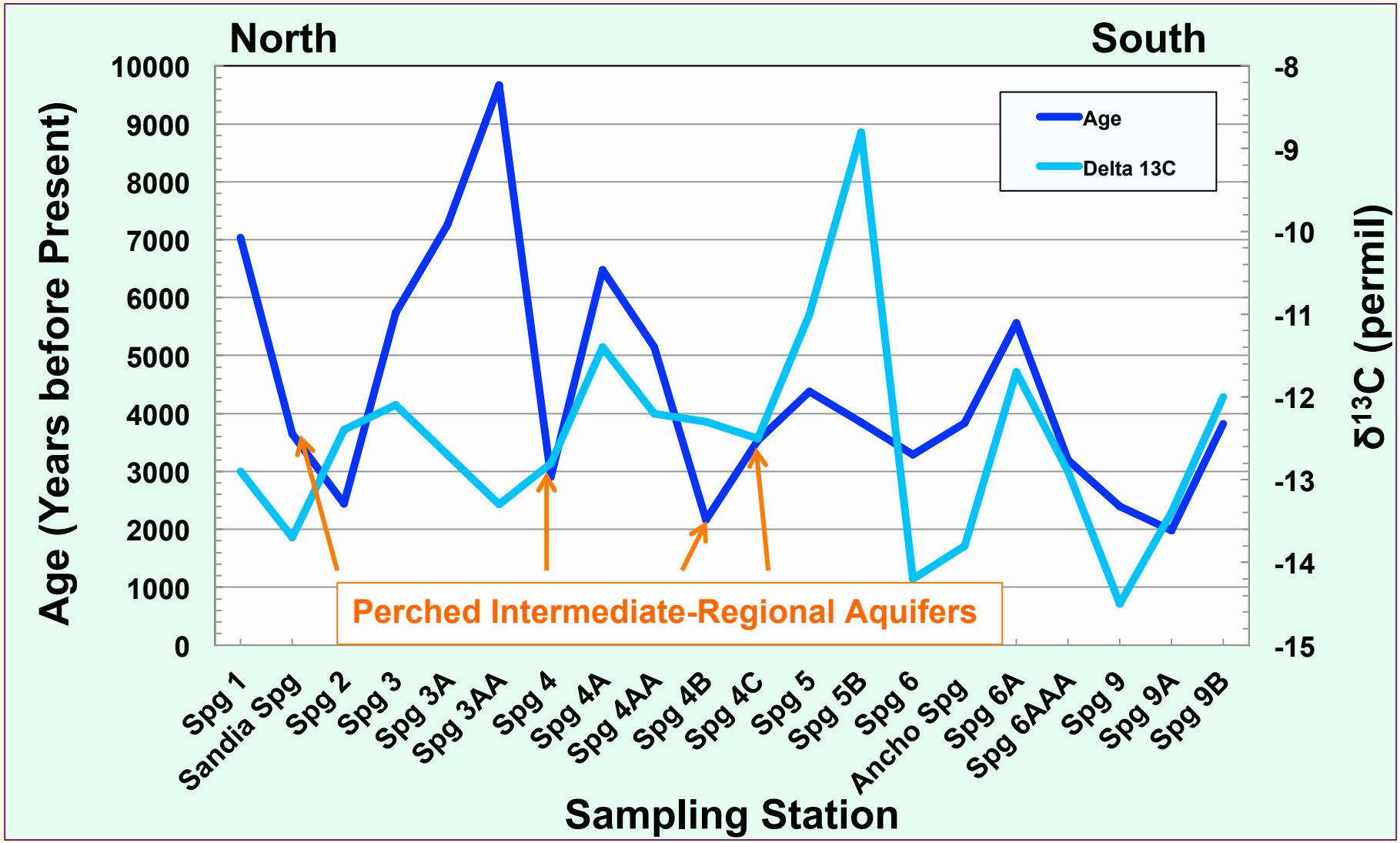
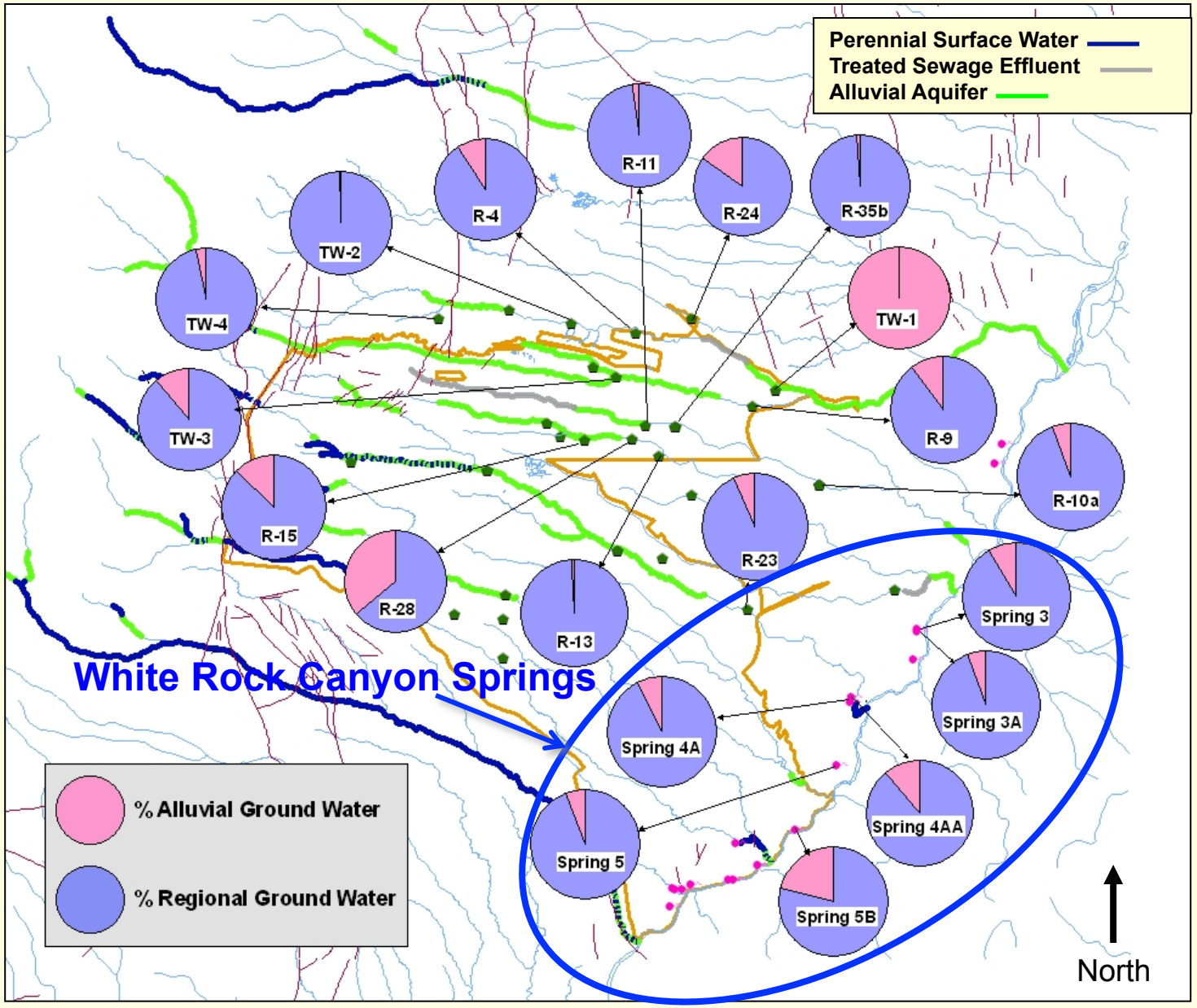


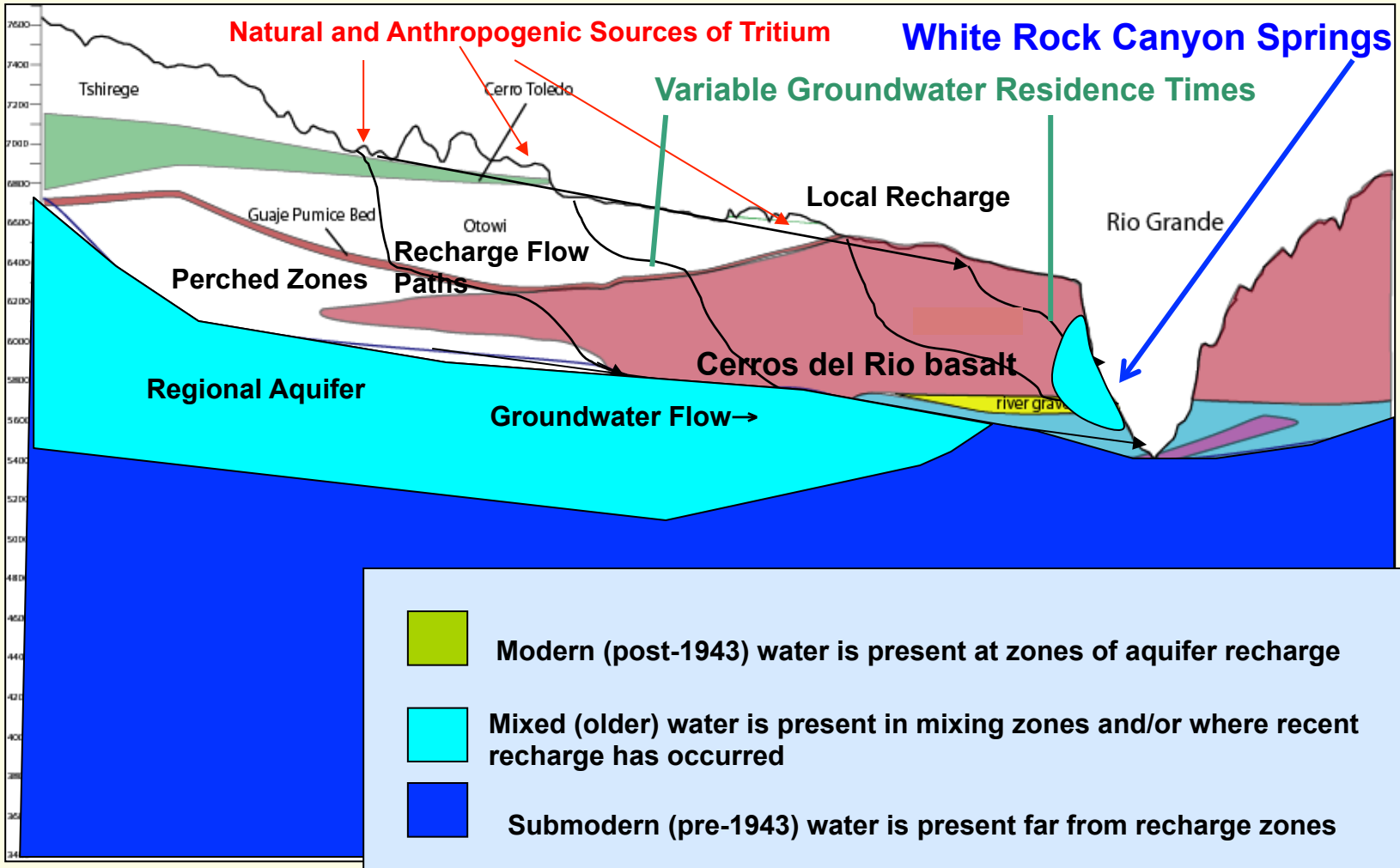
Unadjusted Carbon-14 Ages and δ^{13}Carbon Values for White Rock Canyon Springs Discharging West of the Rio Grande



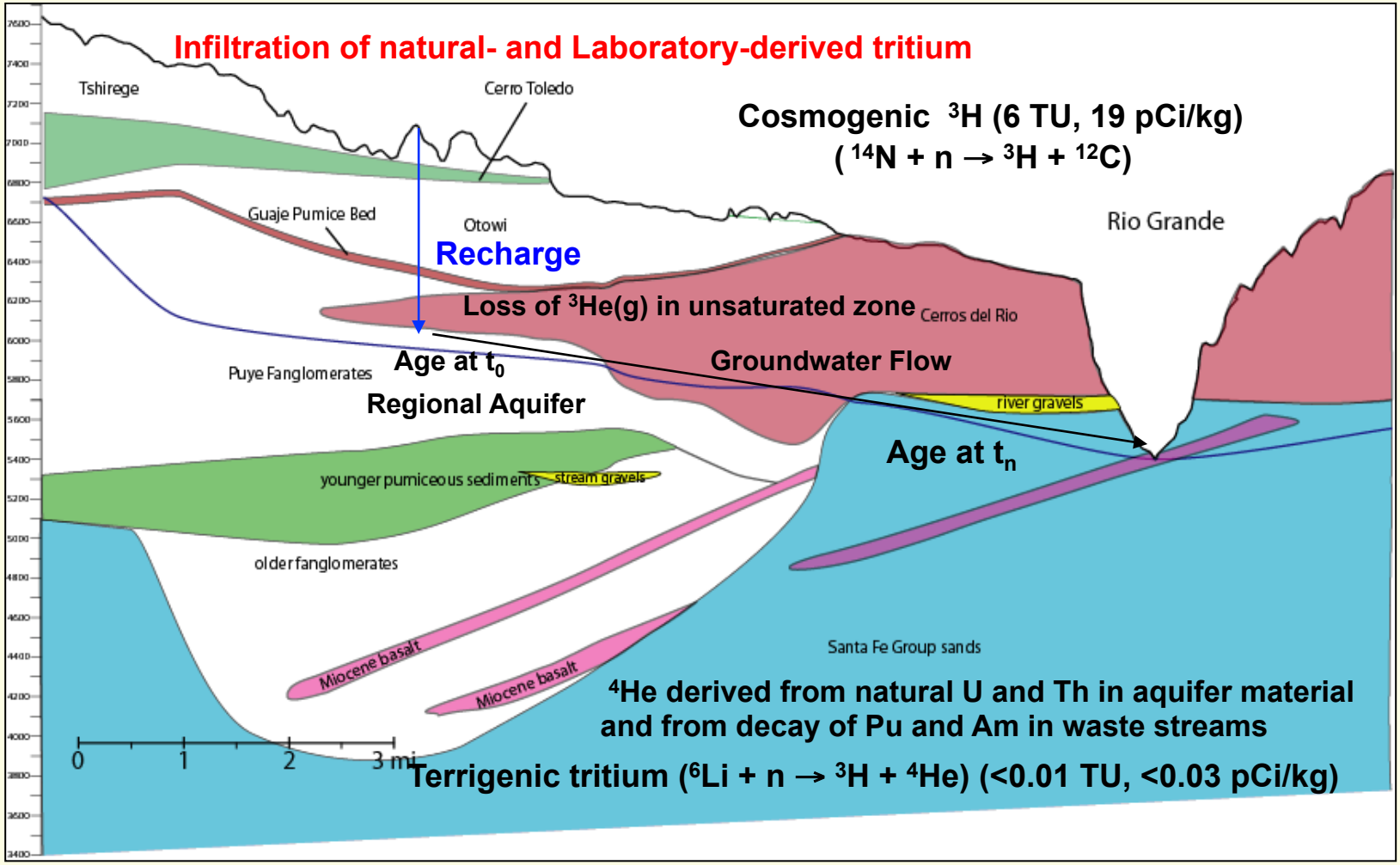
Average Mixing Ratios for the Regional Aquifer Containing Chloride Derived From Alluvial Ground Water, Pajarito Plateau, New Mexico



Generalized Trends in Groundwater Age for Conceptual Model of Groundwater Flow



Conceptual Model for Tritium and Helium



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