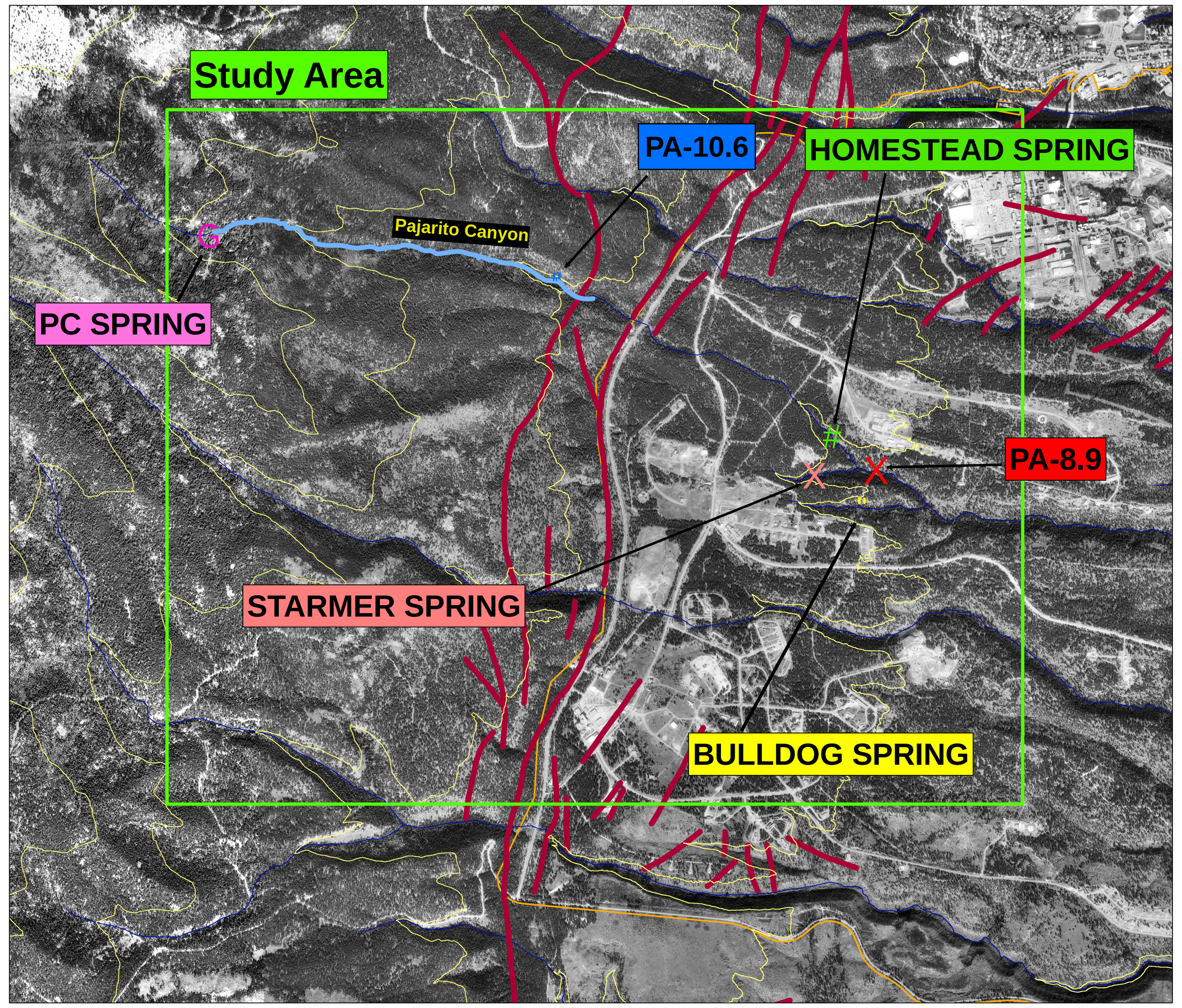

Study Area Showing PA-10.6 Surface-Water Station, Springs and Pajarito Fault Zone

Meters
0 1,000 2,000 4,000

500 ft Contour — Drainage
Fault — LANL Boundary
Extent of Perennial Flow

DATA SOURCES:
RRES Remediation Project, Los Alamos National Laboratory
NMED DOE Oversight Bureau
US Department of the Interior, US Geological Survey
Digital Orthophoto Quadrangles

Map Produced by K. Granzow, Sept, 2005
NMED DOE Oversight Bureau
134 State Road 4, Suite A
White Rock, NM 87544

PROJECTION:
New Mexico State Plane Coordinate System
Central Zone
North American Datum, 1983

State of New Mexico Environment Department
DOE Oversight Bureau

ASSESSING GROUND-WATER RECHARGE THROUGH THE PAJARITO FAULT ZONE, UPPER PAJARITO CANYON, LOS ALAMOS, NEW MEXICO

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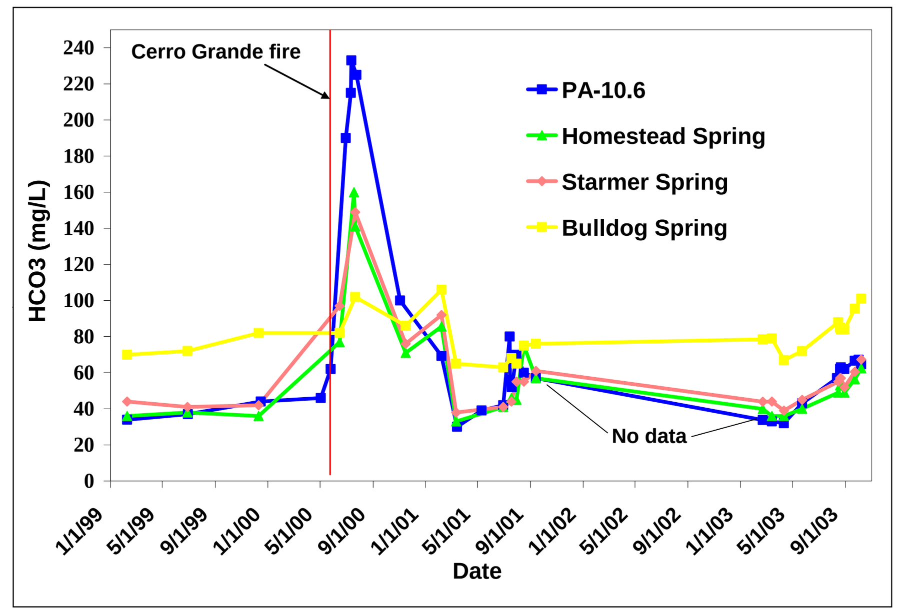
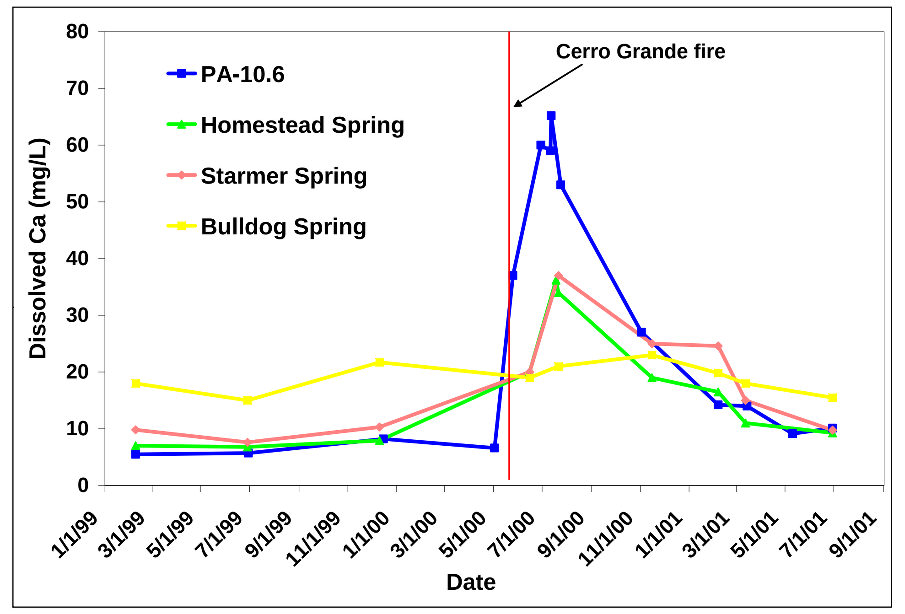
Physical processes of ground-water recharge to aquifers beneath the Los Alamos region are not well understood. In particular, there is limited knowledge concerning the role of the Pajarito fault zone as a ground-water recharge mechanism (conduit and/or barrier). The present conceptual hydrogeologic model for the Pajarito fault zone is incomplete because of the paucity of data. The New Mexico Environment Department's Department of Energy Oversight Bureau (the Bureau) has initiated a study to determine if surface water loss in the upper reach of Pajarito Canyon is occurring within the Pajarito fault zone. Hydrologic, hydrochemical, and isotopic constituents (?D, ?^{18}O, and ^{3}H) are being analyzed for samples collected at the fault expression (PA-10.6) and from downgradient springs. General hydrologic conditions include a perennial surface-water reach that flows west to east for approximately 2.4 km upstream of the Pajarito fault zone. This reach is supplied by seep and spring discharges at an elevation of about 2,740 m. Under baseflow conditions, the reach abruptly terminates at PA-10.6 at an elevation of 2,470 m. Approximately 1.9 km downstream of PA-10.6, three perennial springs discharge from horizontal fractures and/or surge beds at an elevation of about 2,330 m. Various rock units of the upper Bandelier Tuff crop out at PA-10.6 and the springs. From 1997 through 2001, periodic bucket-and-stopwatch-flow measurements were made at PA-10.6 and below the springs. Recharge and discharge (water balance) measurements were nearly equivalent. Isotopic data collected in 1999 suggest that two of the three aforementioned springs (Homestead and Starmer Springs) are chemically and isotopically similar to the PA-10.6 waters. Some chemical differences were noted, however, including elevated concentrations of Cl, SO_4, and Na, which may be attributed to salt-laden-runoff infiltration along State Road 501. The third spring (Bulldog Spring) contains elevated concentrations of ^{3}H and major ions, and is slightly enriched in ?D and ?^{18}O compared to water at PA-10.6, suggesting a different recharge source. Solutes produced from the Cerro Grande fire in May 2000 introduced chemical tracers that showed a direct link between water at PA-10.6 and the downgradient springs. Subsequent summer-monsoon flooding in the upper reach of Pajarito Canyon impacted water quality at PA-10.6. Hydrochemical changes at PA-10.6 included an approximate four-fold increase in dissolved HCO_3, SO_4, Ca, K, Mg, Mn, Sr, and total dissolved solids. In less than one month, these tracers were observed at Homestead and Starmer Springs. Slight hydrochemical changes observed at Bulldog Spring indicated that some connection in ground-water flow was established. Lower concentrations of these tracers were also measured during the summers of 2001 and 2003. During 2005, Los Alamos National Laboratory investigators and the Bureau will finalize this project by collecting and analyzing additional samples for ^{3}H, ^{4}He, Ar, Ne, ?D, ?^{18}O, and major ions to better define the hydraulic connectivity between waters at PA-10.6 and the springs. These findings will provide additional insights to the role of the Pajarito fault zone controlling ground-water recharge in the study area.

View of south wall at fault.

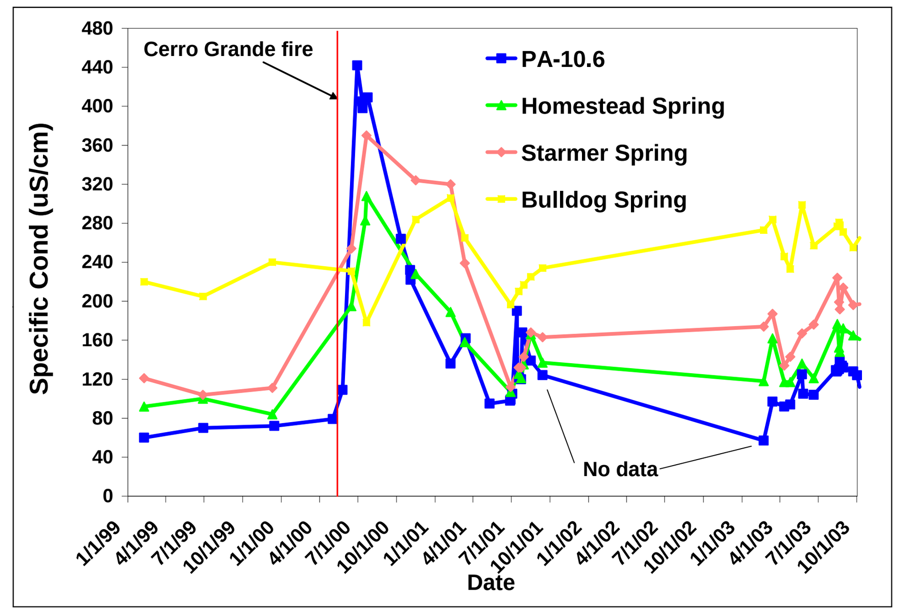
View of Homestead Spring.



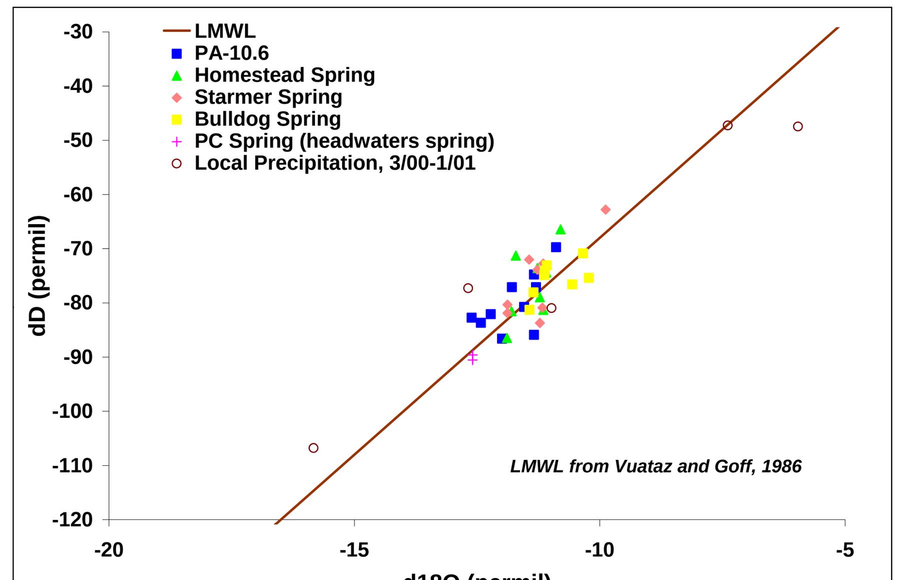
Bicarbonate concentrations during the period 1999 through 2003 at PA-10.6 and the springs Homestead, Starmer, and Bulldog.



Dissolved calcium concentrations during the period 1999 through 2001 at PA-10.6 and the springs Homestead, Starmer, and Bulldog.



Specific conductance during the period 1999 through 2003 at PA-10.6 and the springs Homestead, Starmer, and Bulldog.



Stable-isotope comparison of local meteoric water, PA-10.6 (recharge), discharge (springs), and local precipitation.

Additional Post-Fire Hydrochemical Changes

? Increases in dissolved chloride and sodium at PA-10.6 were not observed.

? Dissolved sulfate and potassium increased at PA-10.6 by factors of about 10 and five, respectively. Slight increases were observed at Homestead and Starmer Springs.

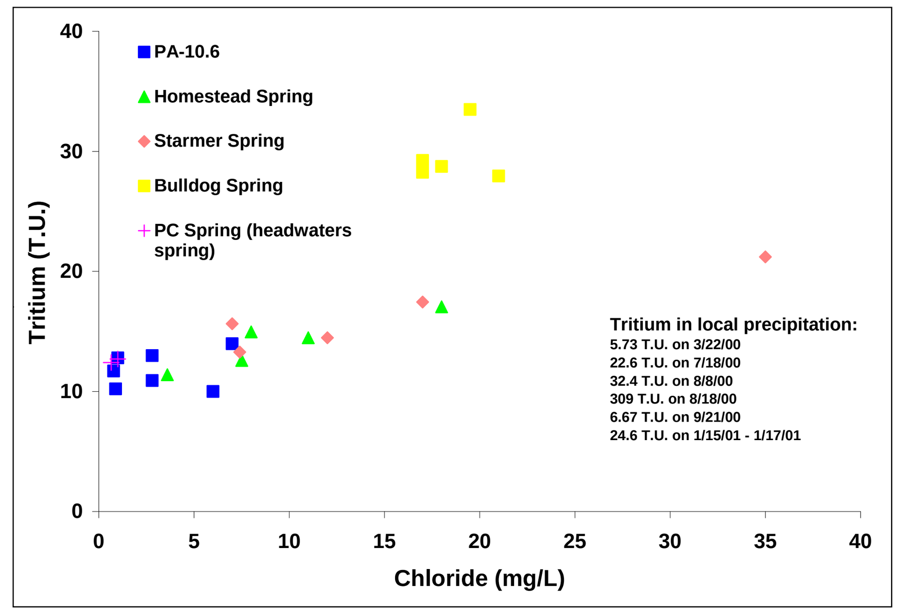
? Dissolved strontium (Sr) and magnesium (Mg) increased at PA-10.6 by factors of about seven and five, respectively. Dissolved Sr and Mg at Homestead and Starmer Springs increased by a factor of about four to five.

? Dissolved manganese increased at PA-10.6 by a factor of about 500 but did not increase at Homestead and Starmer Springs.

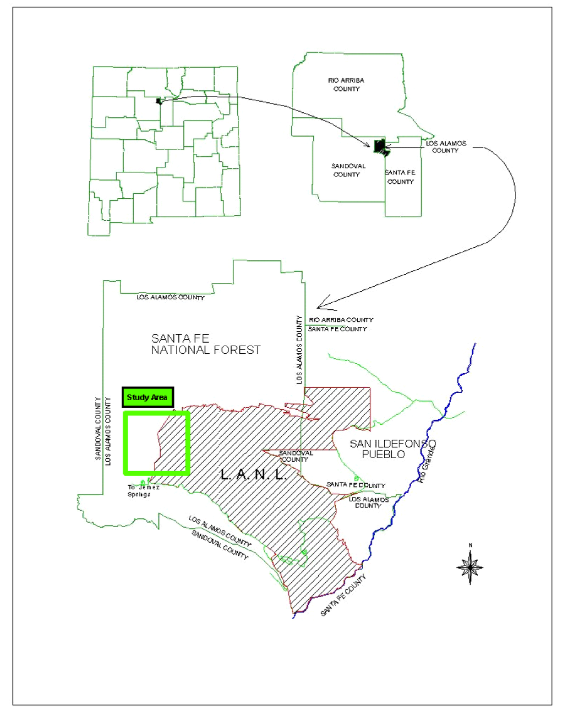
? In most cases, solute concentrations were greater at PA-10.6 than the springs. This suggests that:

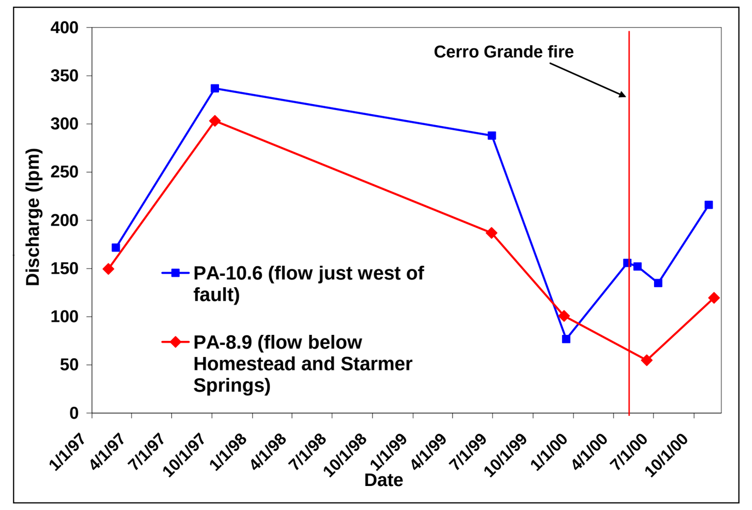
(1) the springs may have experience local recharge that diluted the PA-10.6 fire-impacted recharge waters and/or;

(2) the spring waters are mixing along the flow path with respect to age, i.e., pre-fire with post-fire waters.



Tritium activity plotted against chloride concentrations for PA-10.6 and the springs Homestead, Starmer, Bulldog, and PC (headwaters spring).



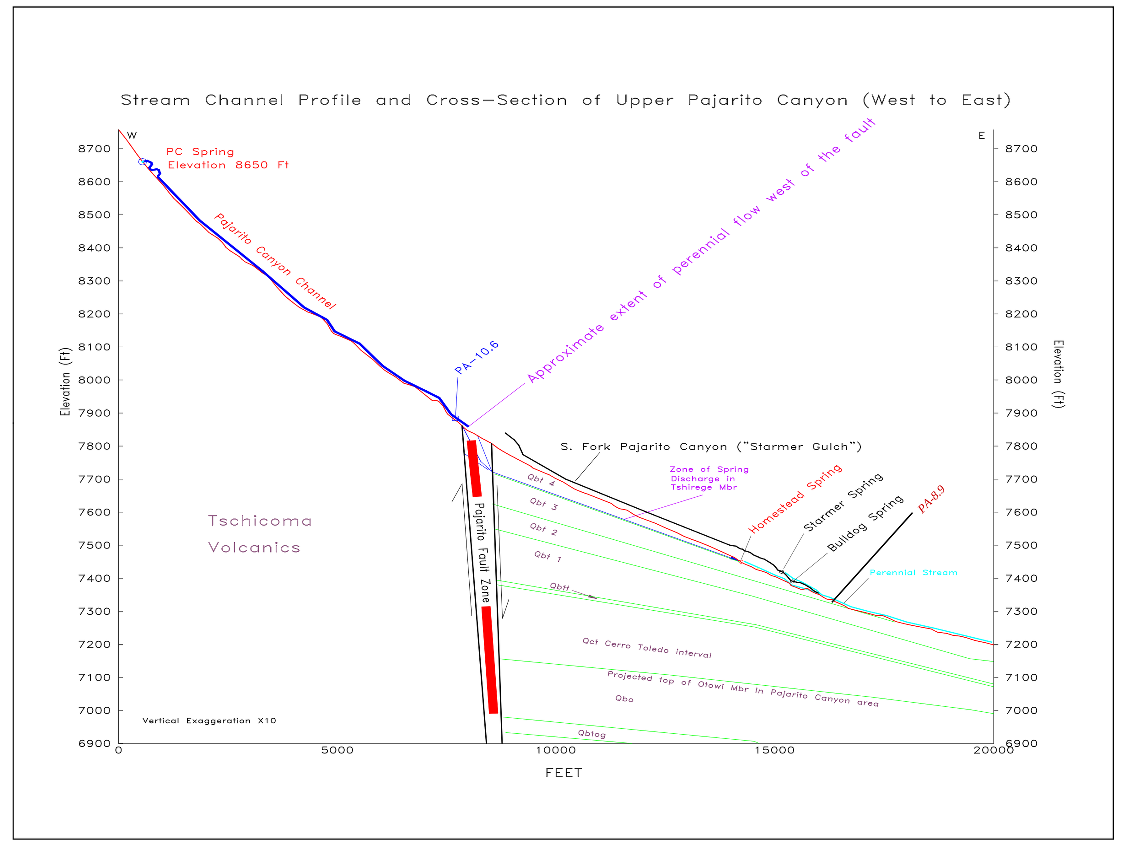


Discharge measurements at PA-10.6 and downstream of Homestead and Starmer Springs

Seepage Run Data

Seepage measurements/runs across the Pajarito fault (PA-10.6 and gage E240) on October 7, 1997 and June 29, 1999 resulted in a loss of 114 lpm and 134 lpm, respectively.

View at the fault looking upstream/west.



Conclusions

? Seepage-run data show loss of 114 and 134 lpm across the PFZ.

? Water-balance measurements at PFZ (PA-10.6) and below springs nearly equivalent.

? Localized snowmelt provides some recharge to the springs.

? **Hydrogeochemical data collected from 1997 through 2003 indicate the PFZ is a recharge conduit between PA-10.6 and some springs (Homestead and Starmer).**

? Water quality at PA-10.6 impacted by monsoonal flooding after the Cerro Grande fire; impacts traced to Homestead and Starmer Springs in less than one month.

? Bulldog Spring, which contains LANL derived contaminants, is recharged by a nearby source with minor contributions from PA-10.6.