Helium-Tritium Isotope Geochemistry Insights, Pajarito Plateau and Surrounding Areas, New Mexico (LA-UR 07-1185)

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Motivation of Study

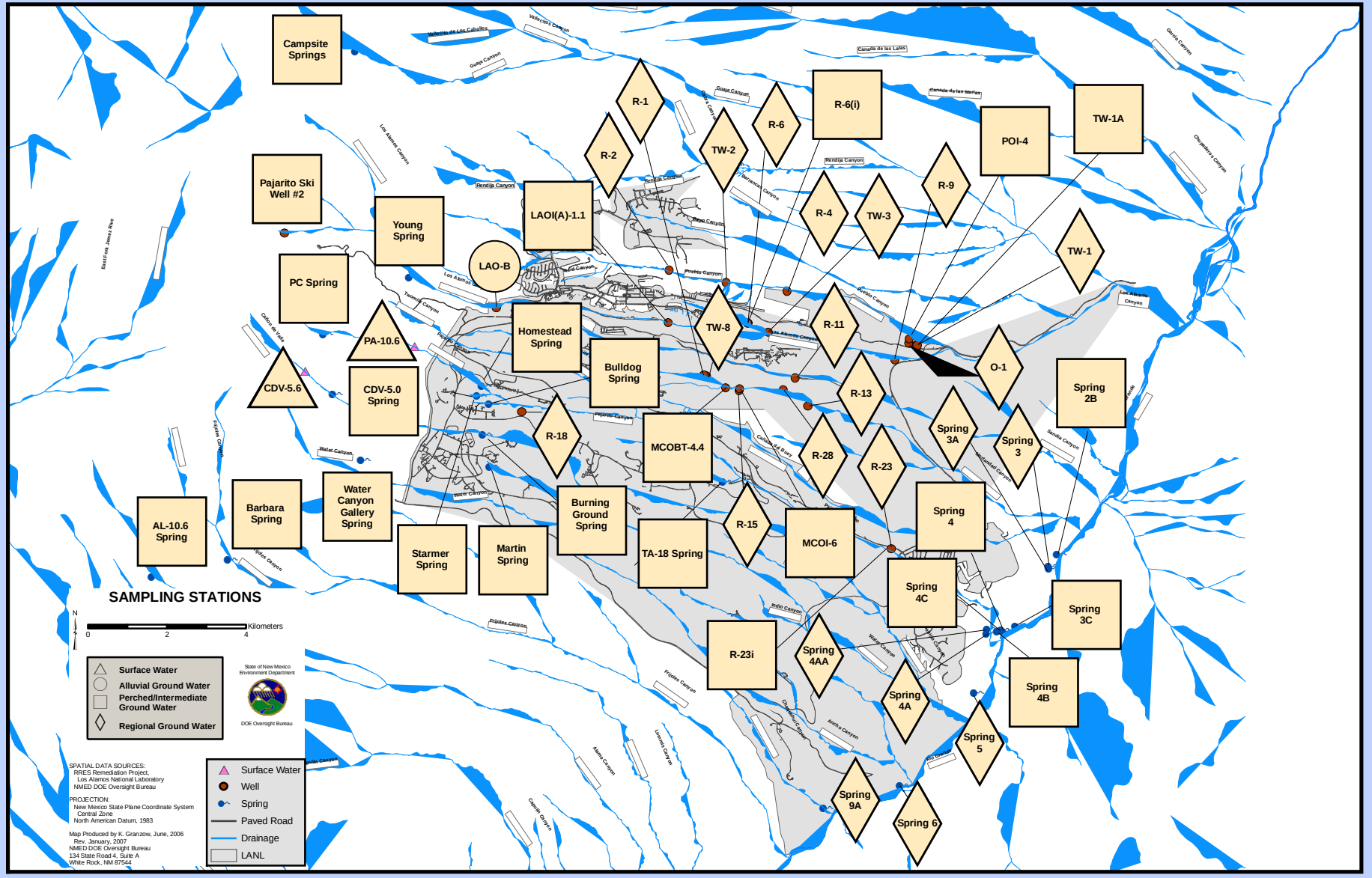
Establish an understanding of the groundwater flow system at Los Alamos (water sources, mixing relations flow paths, and travel times) that is independent of numerical models.

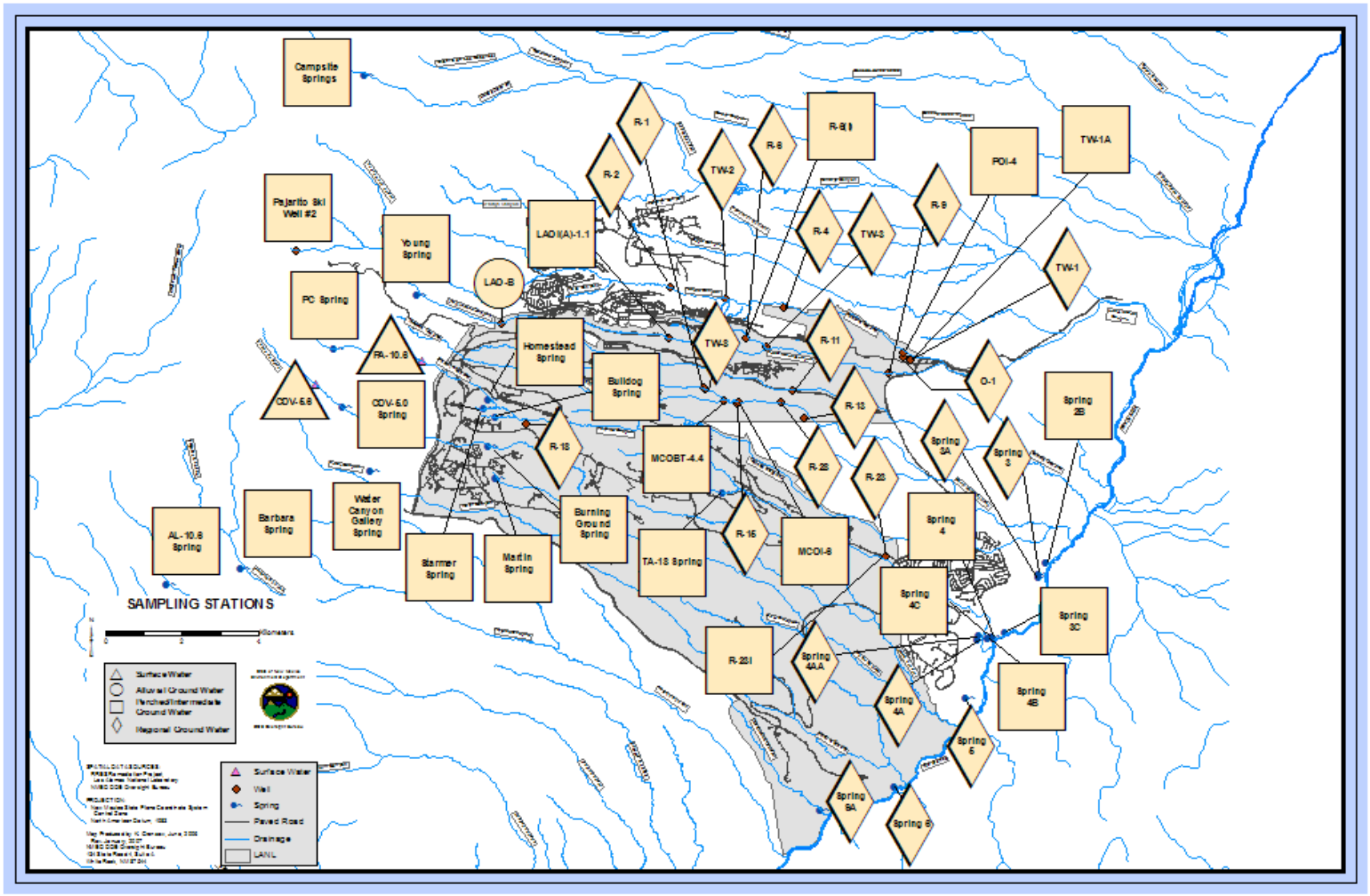
This understanding can be used either to guide the development or evaluate results of corresponding flow models.

Of particular interest is the vulnerability of water supply wells and natural discharge areas near the Rio Grande to contamination.

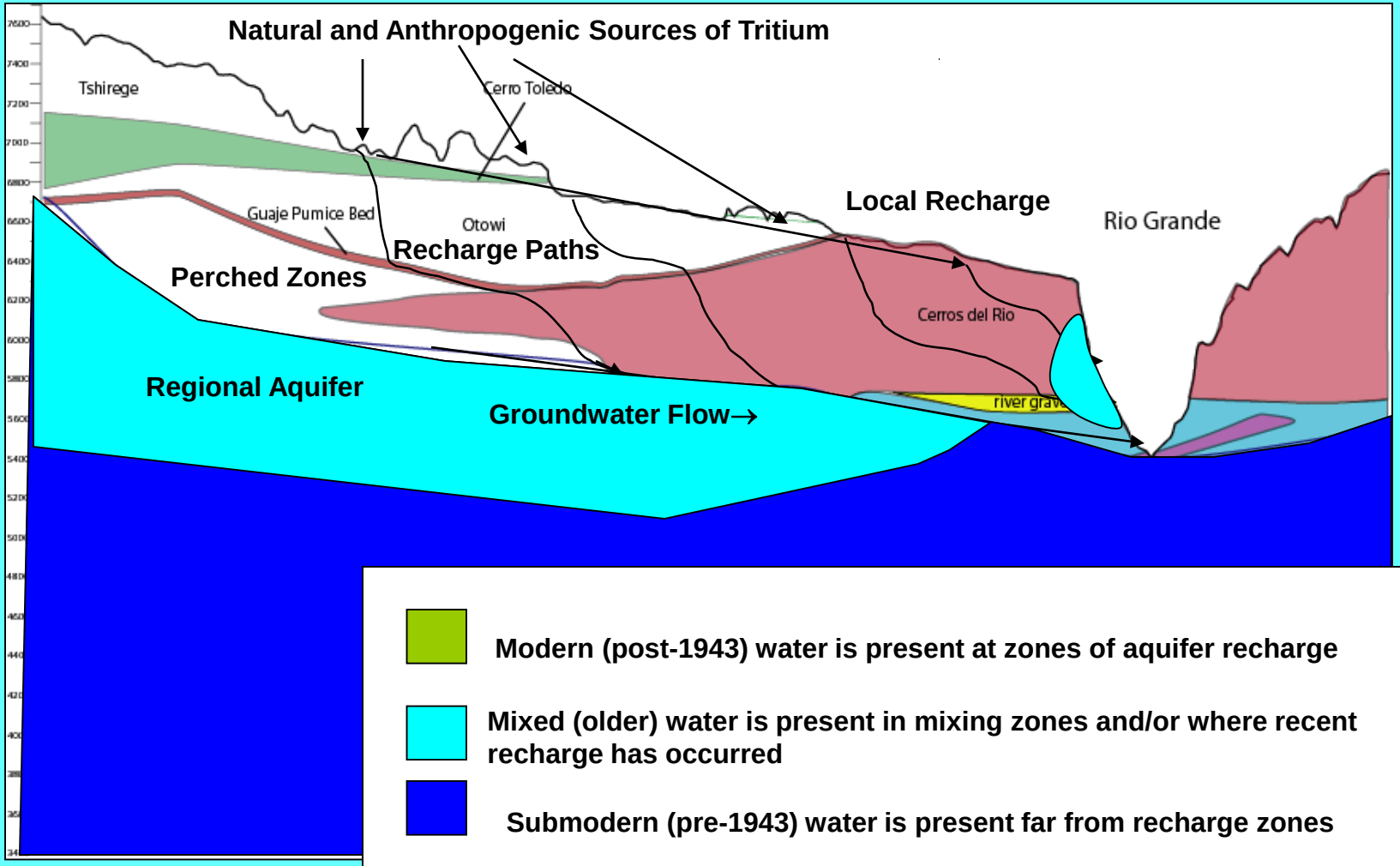
Analytical Methods

- **Tritium**, helium ingrowth and electrolytic enrichment
- **Carbon-14**, accelerator mass spectrometry
- **Stable isotopes**, isotope ratio mass spectrometry
- **Anions**, ion chromatography
- **Metals**, inductively couple (argon) plasma-optical emission spectroscopy (ICP-OES) and inductively couple (argon) plasma-mass spectrometry (ICP-MS)
- **Total carbonate alkalinity**, titration

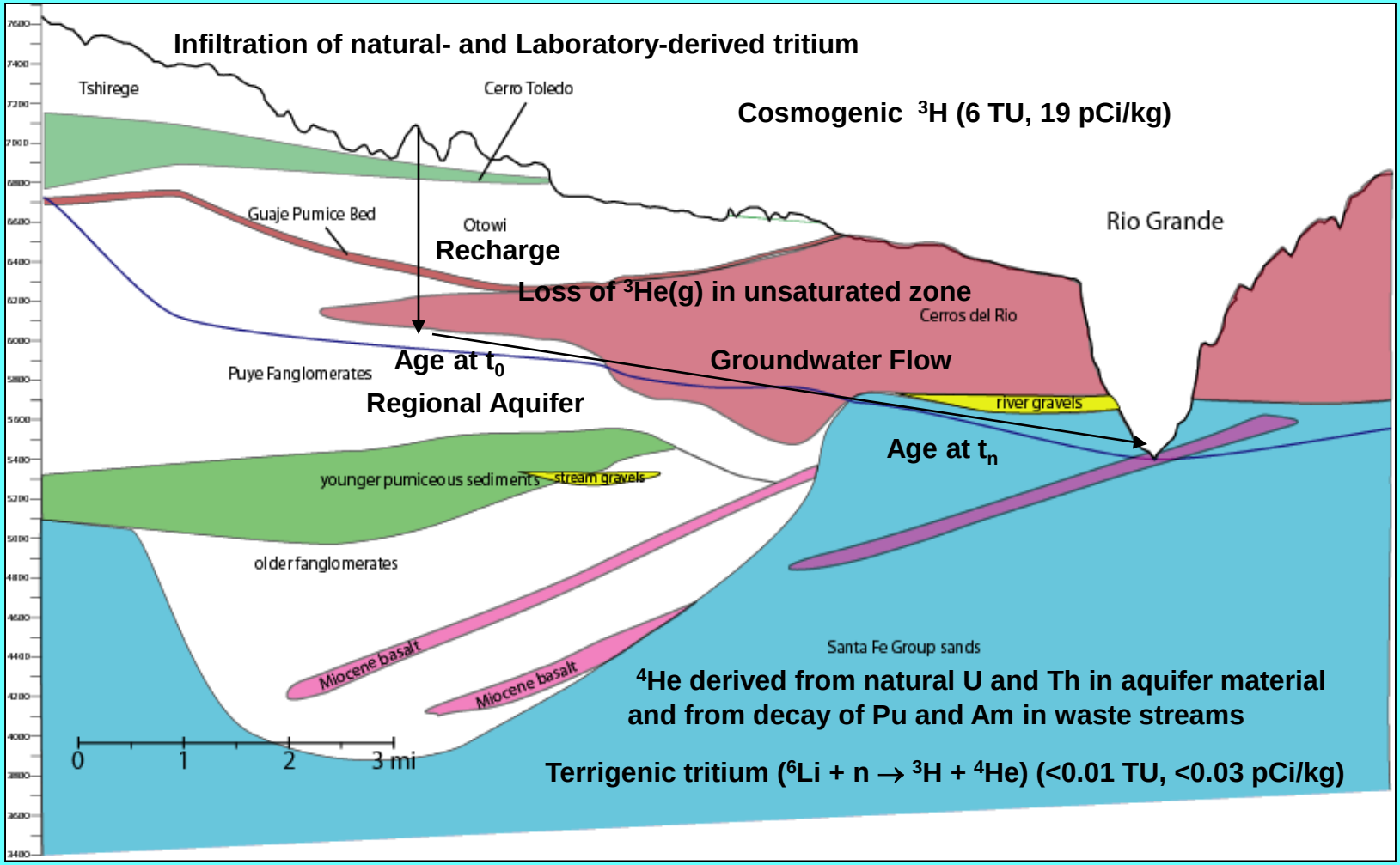

Campsite Springs
Pajarito Ski Well #2
Young Spring
PC Spring
LAO-B
LAOI(A)-1.1
Homestead Spring
Bulldog Spring
PA-10.6
CDV-5.6
CDV-5.0 Spring
R-18
MCOBT-4.4
Barbara Spring
Water Canyon Gallery Spring
AL-10.6 Spring
Starmer Spring
Martin Spring
Burning Ground Spring
TA-18 Spring
R-15
MCOI-6
R-23i
R-1
R-2
TW-2
R-6
R-6(i)
R-4
TW-3
R-9
POI-4
TW-1A
TW-1
TW-8
R-11
R-13
R-28
R-23
O-1
Spring 2B
Spring 3A
Spring 3
Spring 4
Spring 4C
Spring 3C
Spring 4AA
Spring 4A
Spring 4B
Spring 5
Spring 9A
Spring 6
SAMPLING STATIONS
N
Kilometers
0
2
4
Surface Water
Alluvial Ground Water
Perched/Intermediate Ground Water
Regional Ground Water
State of New Mexico Environment Department
DOE Oversight Bureau
Surface Water
Well
Spring
Paved Road
Drainage
LANL
SPATIAL DATA SOURCES:
RRES Remediation Project,
Los Alamos National Laboratory
NMED DOE Oversight Bureau
PROJECTION:
New Mexico State Plane Coordinate System
Central Zone
North American Datum, 1983
Map Produced by K. Granzow, June, 2006
Rev. January, 2007
NMED DOE Oversight Bureau
134 State Road 4, Suite A
White Rock, NM 87544

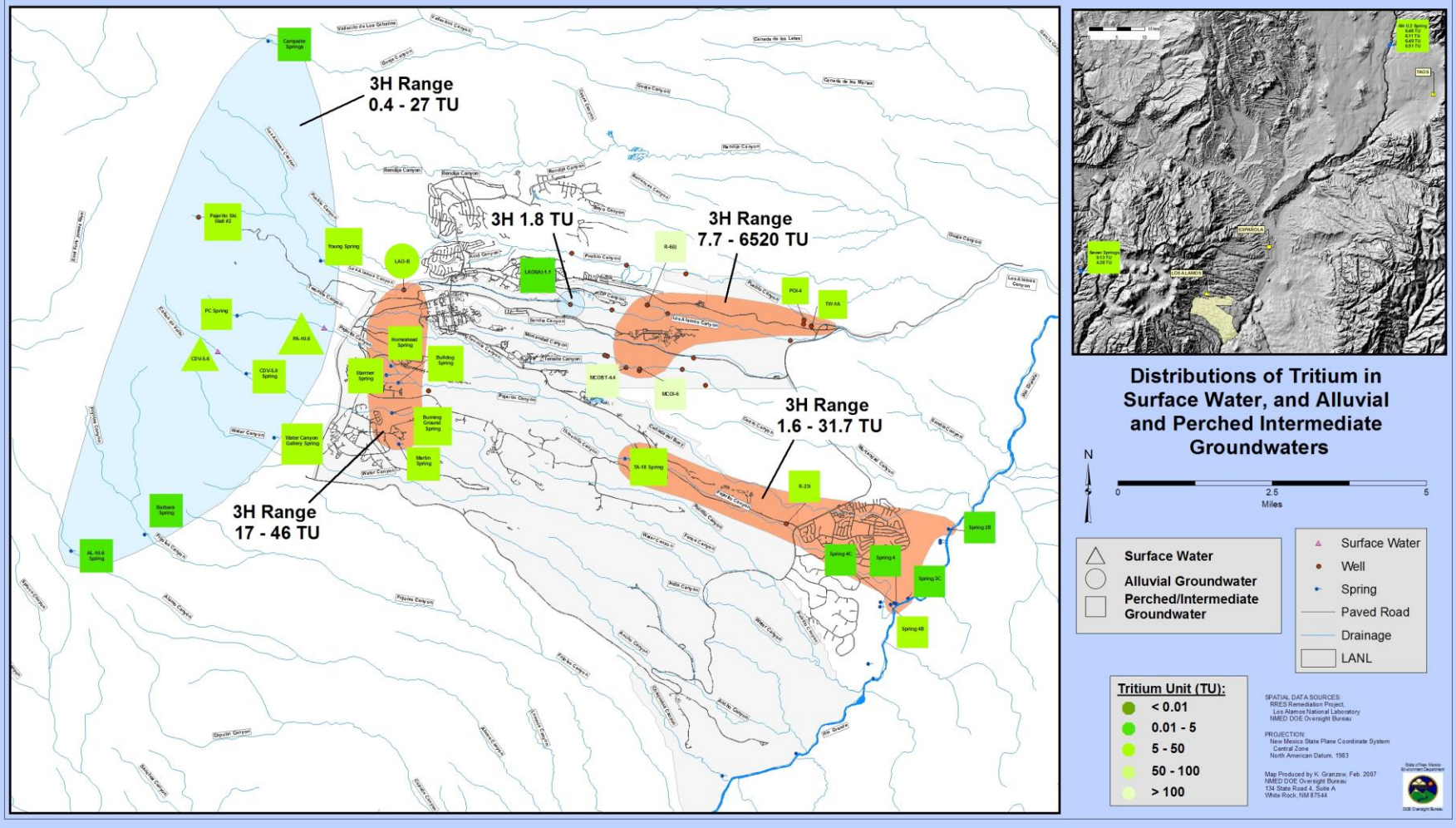

Campsite Springs
Pajarito Ski Well #2
Young Spring
PC Spring
LADII(A)-1.1
LAD-B
Homestead Spring
Bulldog Spring
R-1
R-2
TW-2
R-8
R-8(i)
POI-4
TW-1A
R-4
TW-3
R-9
TW-1
TW-8
R-11
O-1
Spring 2B
R-13
Spring 3A
Spring 3
R-18
MCOBT-4.4
R-28
R-23
Spring 4
R-15
MCOI-8
TA-18 Spring
Spring 4C
Spring 3C
R-25I
Spring 4AA
Spring 4A
Spring 4B
Spring 5
Spring 6
Spring 5A
RA-10.6
CDV-6.6
CDV-6.0 Spring
AL-10.6 Spring
Barbara Spring
Water Canyon Gallery Spring
Starmer Spring
Martin Spring
Burning Ground Spring
SAMPLING STATIONS
Surface Water
Alluvial Ground Water
Perched/Intermediate Ground Water
Regional Ground Water
Surface Water
Well
Spring
Paved Road
Drainage
LANL

Generalized Expected Trends in Groundwater Age for Conceptual Model of Groundwater Flow



Conceptual Model for Tritium and Helium




3H Range
0.4 - 27 TU
3H 1.8 TU
3H Range
7.7 - 6520 TU
3H Range
1.6 - 31.7 TU
3H Range
17 - 46 TU
Distributions of Tritium in Surface Water, and Alluvial and Perched Intermediate Groundwaters
N
0
2.5
5
Miles
Surface Water
Alluvial Groundwater
Perched/Intermediate Groundwater
Surface Water
Well
Spring
Paved Road
Drainage
LANL
Tritium Unit (TU):
< 0.01
0.01 - 5
5 - 50
50 - 100
> 100
SPATIAL DATA SOURCES:
RRES Remediation Project,
Los Alamos National Laboratory
NMED DOE Oversight Bureau
PROJECTION:
New Mexico State Plane Coordinate System
Central Zone
North American Datum, 1983
Map Produced by K. Granzow, Feb. 2007
NMED DOE Oversight Bureau
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White Rock, NM 87544
DOE Oversight Bureau

Atmospheric Tritium Input Curve and Perched Intermediate-Depth Groundwater

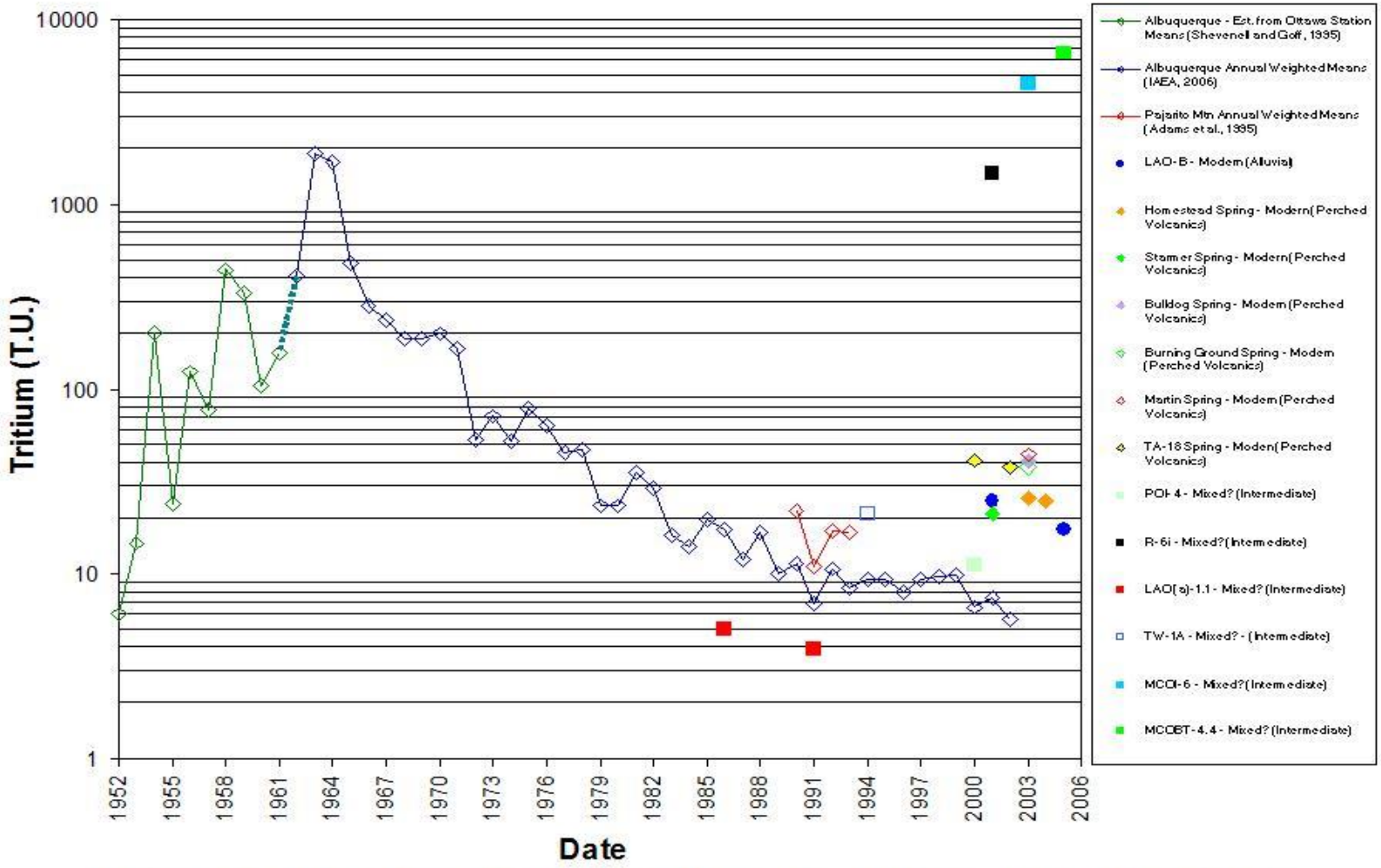
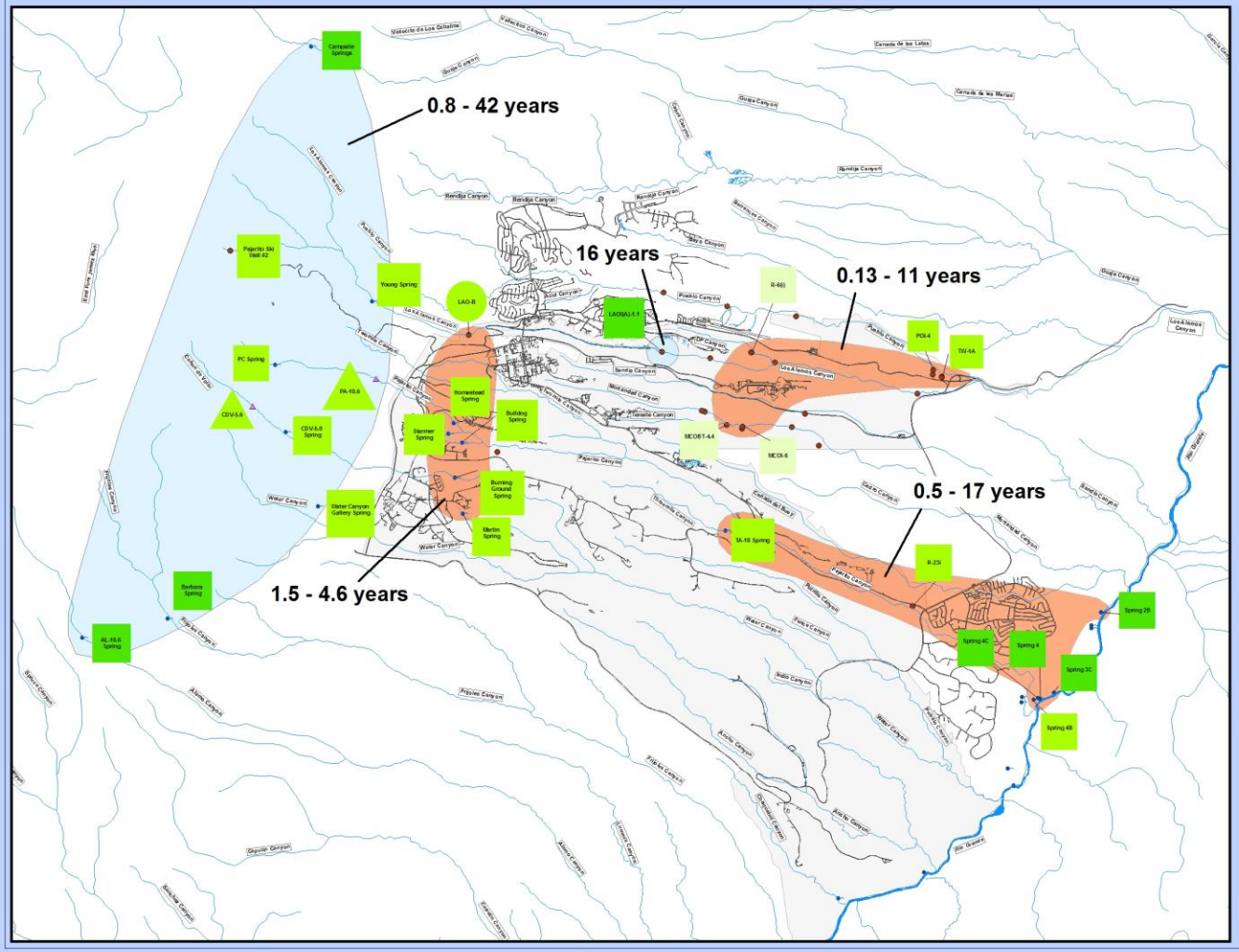
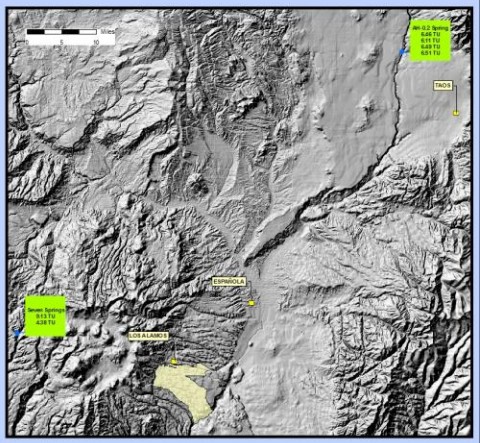


Figure 6-9. Atmospheric Tritium Curve and Initial Tritium Activities for Samples Collected Beneath the Pajarito Plateau - Perched Alluvial and Volcanics, and Intermediate Aquifers





Ranges of Apparent Ages in Surface Water, and Alluvial and Perched Intermediate Groundwaters

N

0 2.5 5
Miles

Surface Water
Alluvial Groundwater
Perched/Intermediate Groundwater

Surface Water
Well
Spring
Paved Road
Drainage
LANL

Tritium Unit (TU):
- < 0.01
- 0.01 - 5
- 5 - 50
- 50 - 100
- > 100

SPATIAL DATA SOURCES:
RRES Remediation Project,
Los Alamos National Laboratory
NMED DOE Oversight Bureau

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

Map Produced by K. Granzow, Feb. 2007
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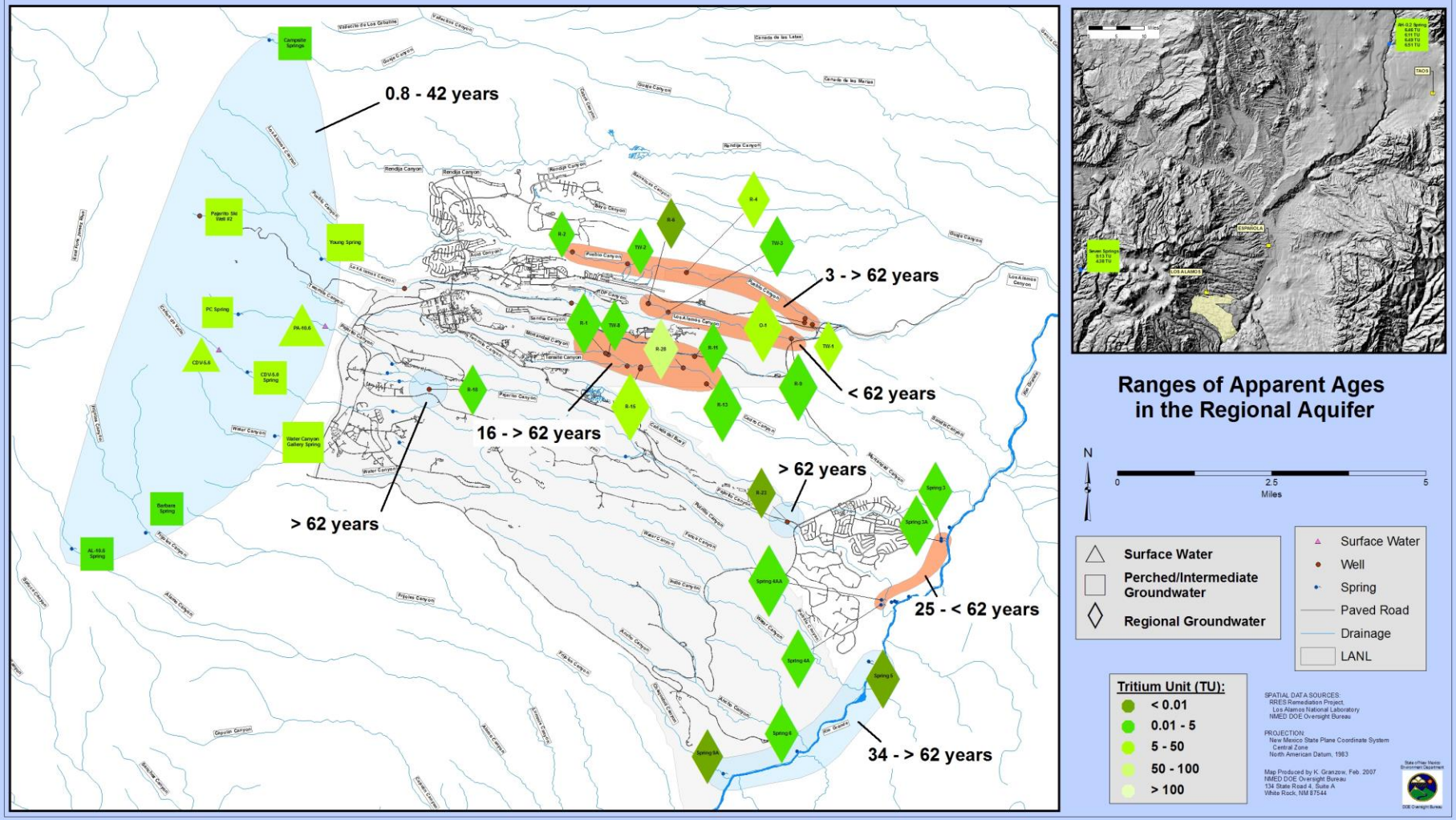
State of New Mexico Environment Department
DOE Oversight Bureau


0.8 - 42 years
3 - > 62 years
< 62 years
16 - > 62 years
> 62 years
> 62 years
25 - < 62 years
34 - > 62 years
Ranges of Apparent Ages in the Regional Aquifer
N
0
2.5
5
Miles
Surface Water
Perched/Intermediate Groundwater
Regional Groundwater
Surface Water
Well
Spring
Paved Road
Drainage
LANL
Tritium Unit (TU):
< 0.01
0.01 - 5
5 - 50
50 - 100
> 100
SPATIAL DATA SOURCES:
RRES Remediation Project,
Los Alamos National Laboratory
NMED DOE Oversight Bureau
PROJECTION
New Mexico State Plane Coordinate System
Central Zone
North American Datum, 1983
Map Produced by K. Granzow, Feb. 2007
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Tritium and Chloride Concentrations, Apparent Age, and Mixing Ratios

Well/ Spring	Tritium (TU, pCi/kg)	Age (yrs)	Chloride (ppm)	Mixing Ratio Modern : Submodern (%)
R-15	8.57, 27.60	16	5	8 : 92
R-28	45.10, 145	NC	25.7	20 : 80
Spring 4A	0.19, 0.61	54	5.3	6 : 94

Average concentrations of tritium and chloride are provided in this table.

Reported age is apparent age, based on tritium/helium-3 dating method.

Modern water refers to alluvial groundwater and submodern refers to regional aquifer.

TU means tritium unit (One TU = 3.222 pCi/kg tritium).

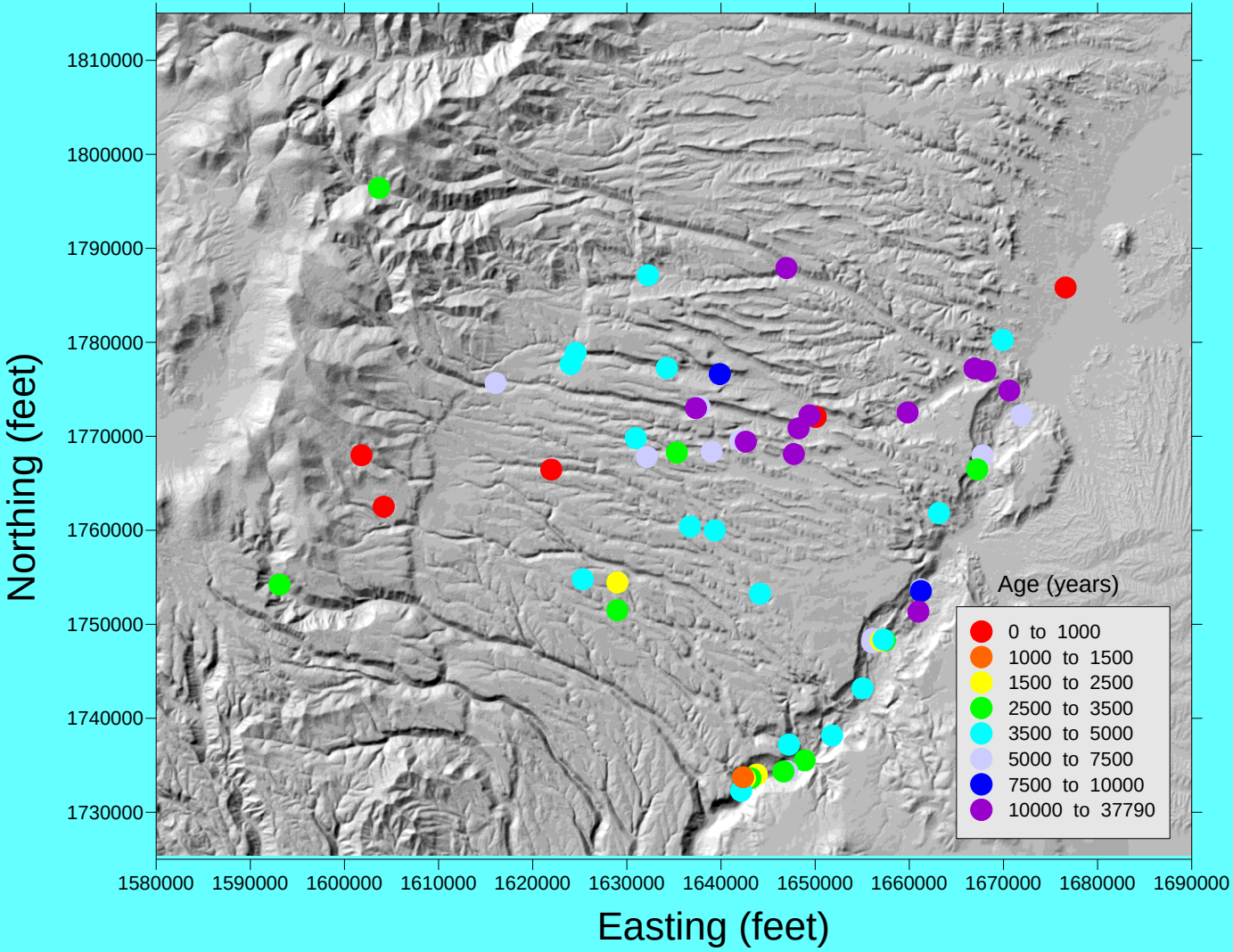
Mixing equation: $Cl_{sample} = (X)\ (Cl_{regional\ aquifer}) + (1\text{-}X)\ (Cl_{alluvial\ groundwater})$.

Background concentration of chloride is 2.0 mg/L, or ppm, within the regional aquifer.

Average concentrations of chloride in alluvial groundwater are 32 and 37 mg/L (ppm), within Mortandad and Pajarito canyons, respectively.

NC means not calculated.

Map of Uncorrected Average Groundwater Ages (^{14}C) for the Pajarito Plateau and Surrounding Area



Summary and Conclusions

- Groundwater can have a mixed age, containing modern and submodern components.
- Recharge to the regional water table, containing tritium and other non-adsorbing chemicals, occurs beneath the central portion of the Pajarito Plateau.
- Travel time of surface water to the regional water table is as fast as 25 years within Mortandad Canyon (well R-15).

Summary and Conclusions

- Mixed groundwater at R-15 contains an average of 8 percent modern water (alluvial groundwater) and 92 percent submodern water (regional aquifer), based on chloride concentrations.

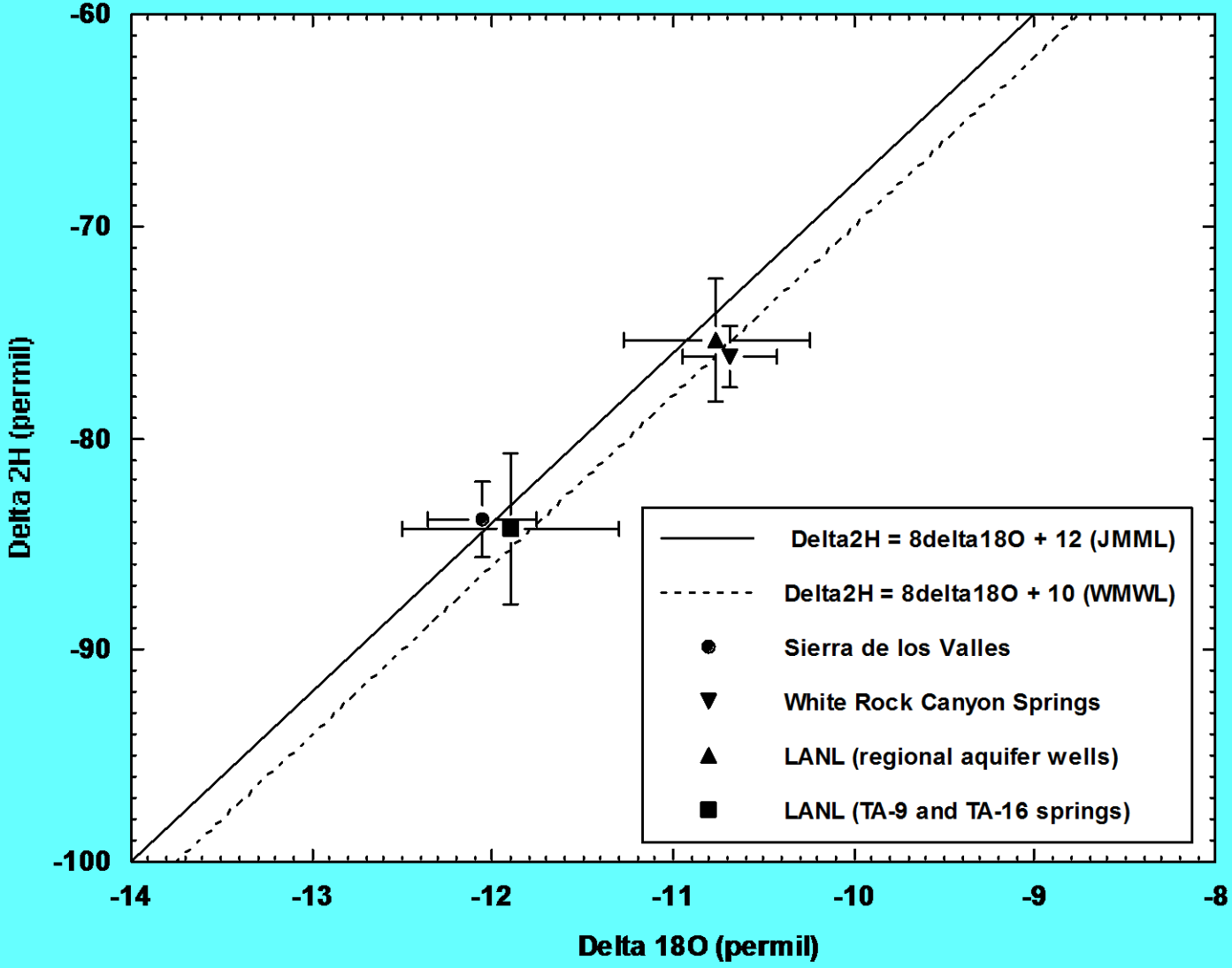
- Apparent ages (modern component) for White Rock Canyon springs range from 0.5 to 45 years. Ages depend on length of flow paths within perched intermediate-depth zones and along the regional water table.

- Submodern groundwater is common in the regional aquifer. Average ages for groundwater range from 570 to 37,800 years, based on uncorrected C-14.

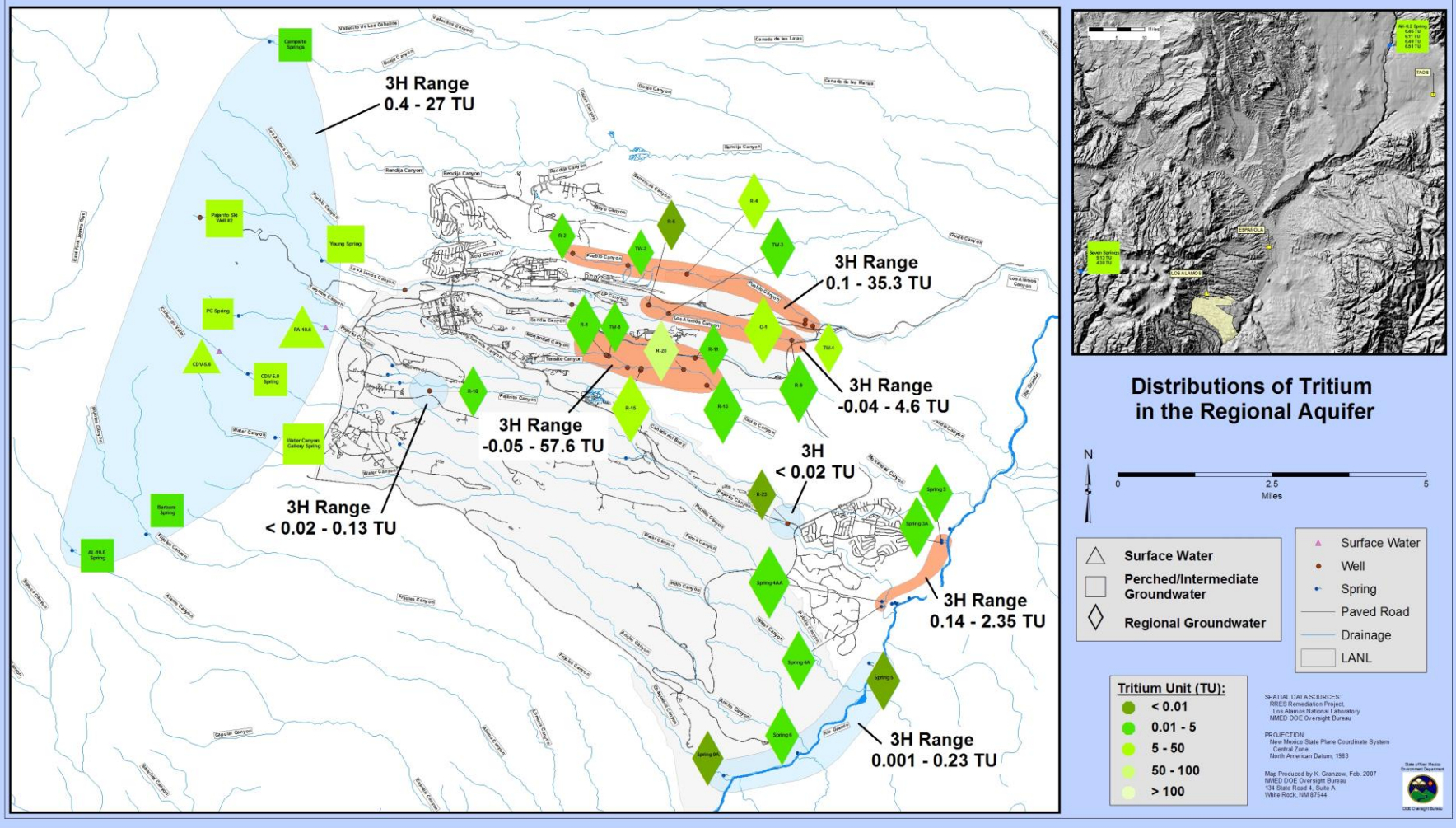
Sampling at PC Spring on March 30, 2005

(Samplers include Shannon Allen and Marcey Hess. Photograph taken by Steve Yanicak)

Supplemental Material



Stable Isotope Results for Springs and Wells wiith One Standard Deviation Shown as Error Bars.


3H Range
0.4 - 27 TU
3H Range
0.1 - 35.3 TU
3H Range
-0.04 - 4.6 TU
3H Range
-0.05 - 57.6 TU
3H
< 0.02 TU
3H Range
< 0.02 - 0.13 TU
3H Range
0.14 - 2.35 TU
3H Range
0.001 - 0.23 TU
Distributions of Tritium
in the Regional Aquifer
N
0
2.5
5
Miles
Surface Water
Perched/Intermediate
Groundwater
Regional Groundwater
Surface Water
Well
Spring
Paved Road
Drainage
LANL
Tritium Unit (TU):
< 0.01
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Atmospheric Tritium Input Curve and White Rock Canyon Springs

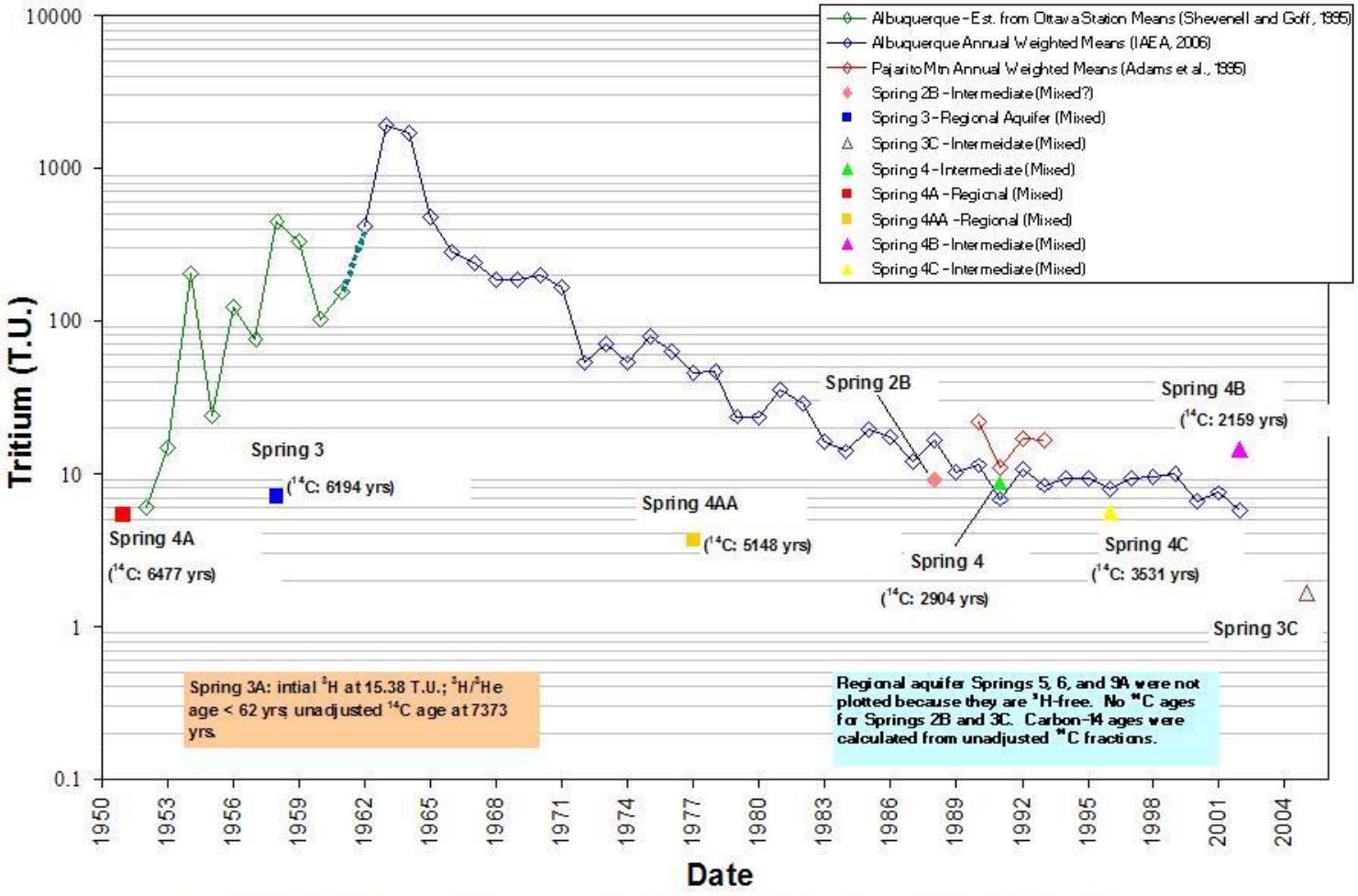

Figure 6-15. Atmospheric Tritium Curve and Initial Tritium Activities for Samples Collected at the White Rock Canyon springs