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## Sunset Reservoir Wells Investigation Tritium & Helium 3 Data

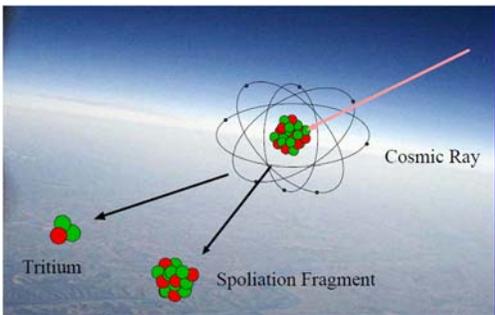
Presented by  
David Kimbrough, Ph.D., Water Quality Manager  
Presented to  
United States Environmental Protection Agency  
Jet Propulsion Laboratories, Pasadena  
April 30, 2013



 **Isotope Analysis of Hydrogen and Helium**

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${}^1\text{H} = 1$   
 ${}^2\text{H} = \text{D} = 2$   
 ${}^3\text{H} = \text{T} = 3$   
 ${}^3\text{He} = 3$   
 ${}^4\text{He} = 4$



The diagram illustrates the process of spallation. A cosmic ray (represented by a red line) strikes an atom (represented by a central nucleus of red and green spheres with orbiting electrons). This interaction results in the formation of a tritium atom (a nucleus with two red spheres and one green sphere) and a spallation fragment (a nucleus with two red spheres and two green spheres).

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## Tritium Data

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*"... investigators have attempted to generalize the age of water based on relative levels of tritium, where  $<0.8$  TU [tritium units] represents water recharged prior to 1952, and where tritium levels between 2 and 8 TU represent modern recharge."*

- Technical Memorandum (TM) Additional Investigation Results National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, California pg. 21

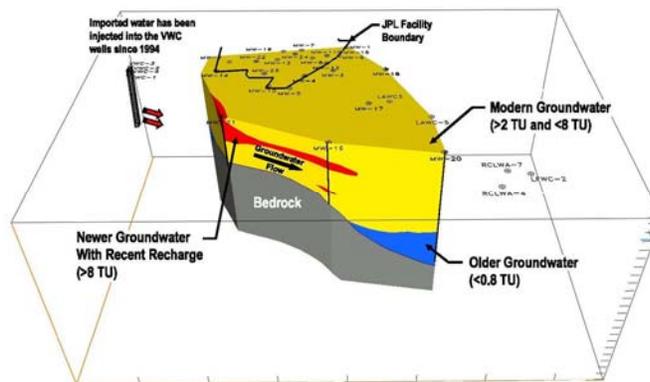
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## Figure 12 from TM on Tritium Distribution in the Raymond Basin

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Figure 1  
Tritium Concentrations and Distribution in the Raymond Basin



2005 TM Data  
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## Tritium Data

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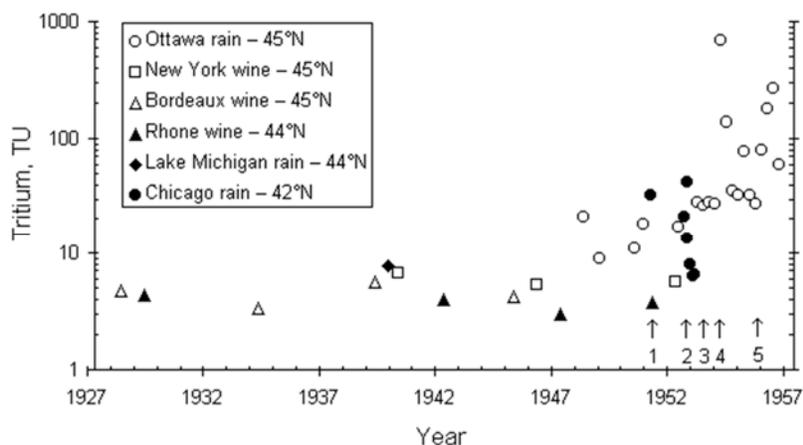
1. This is somewhat mistaken, the tritium levels in rain water *in 1952* would have contained between 2 and 8 TU.
2. Once rainwater with tritium enters the ground, its concentration begins to decline through radioactive decay.
3. In 2005, rainwater that entered the ground in 1952 would have contained 0.12 to 0.5 TU.
4. Only one sample collected in 2005, MW-20-5, contained less than 0.12 TU. All of the other water was “young” post-1952 water.

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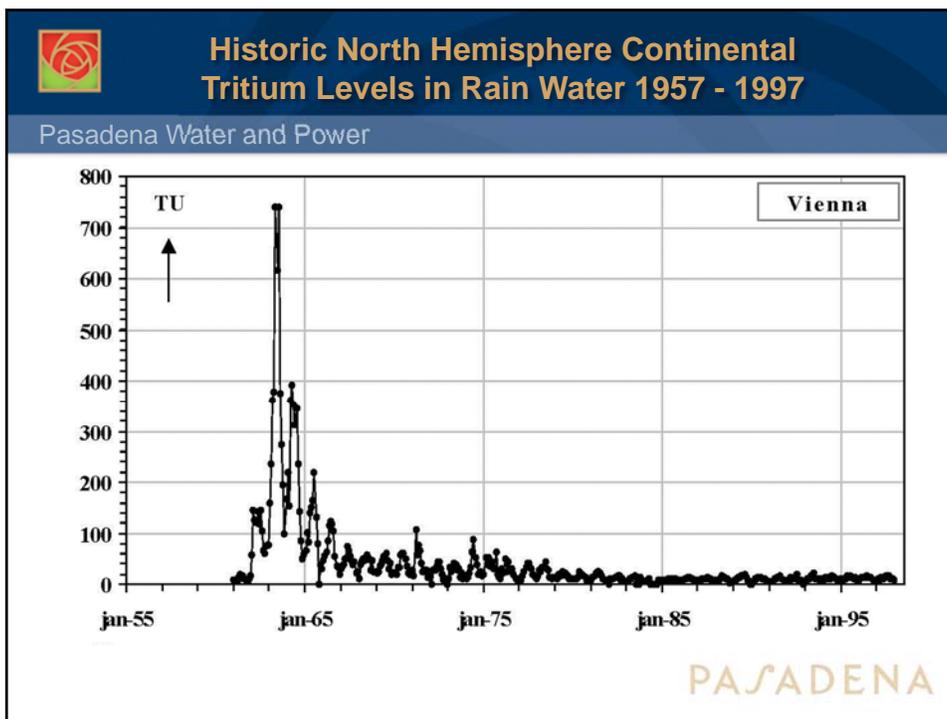


## Historic Northern Hemisphere Continental Tritium Levels in Wine and Rain 1927 - 1957

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**Historic Tritium Levels in Rain Water 1987**

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344 G. Uchirin et al.

**TABLE 1. Ranges of Environmental Tritium (1987)**

Source	Reservoir	Northern hemisphere (TU)	Southern hemisphere (TU)
Precipitation	Continental	30-80	5-20
	Coastal	2-20	0.5-2
	Surface water	10-80	5-20
	Sub-surface water	3-300	0-50
Oceans	Mixed layer	0.5-2	0.1-0.5
Glaciers		0-200	0-50
Atmosphere	HTO (troposphere)	1-100	
	HT	ca. 10 <sup>6</sup>	
	CH <sub>3</sub> T	ca. 2×10 <sup>4</sup>	

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## Tritium Data

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1. The half-life of  $^3\text{H}$  is 12.3 yr.
2. Most of the samples collected in 2005 had tritium concentrations between 0.8 and 8.0 TU, which corresponds to water that had between 2 and 20 TU when it first entered the aquifer and lost contact with the atmosphere.
3. This corresponds to water that was last exposed to air in 1987, or about 20 years old.
4. The helium-3 data gives a similar value for the Sunset Reservoir Wells.

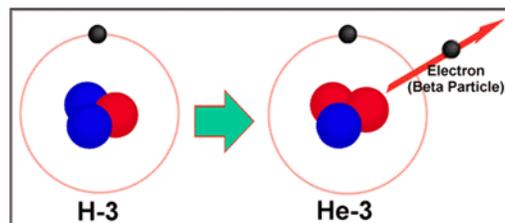
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## Helium-3 Data

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1.  $^3\text{H}$  decays to  $^3\text{He}$  by beta particle emission.
2. The ratio of  $^3\text{H}$  to  $^3\text{He}$  can be used to determine the age of the groundwater
3. Groundwater Age (in years) =  $-17.8 \ln (1 + ^3\text{He}/^3\text{H})$ .



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Figure 2. Particle tracking simulations using the independently-developed RBMB Model indicate that capture zones of the Sunset Reservoir Wells are south of the JPL Facility.



## Results

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**Both Tritium and Helium-3 Results Show that the Water in the Sunset Reservoir Wells is between 20 – 30 years old.**



## Conclusions

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Based Upon the Tritium and Helium-3 Results, the Water is too Young to have been Influenced by Agricultural Activities, including Chilean Nitrate Fertilizers.

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## Tritium Data in NASA's 2007 TM

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- ***“Tritium concentration (activity) is a useful parameter for assessing the age of water for periods of up to 60 years, due to its relatively short half-life of 12.4 years.”***

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# Stable Isotope Analysis of Nitrate

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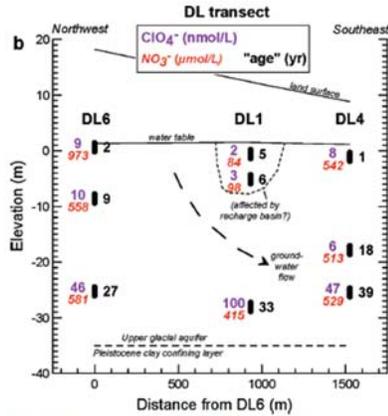


FIGURE 1. (a) Map of Long Island, New York, showing locations of samples. (b) Vertical profile of the DL groundwater transect in 2007 showing well screens (vertical bars),  $\text{ClO}_4^-$  and  $\text{NO}_3^-$  concentrations, and composite mean apparent groundwater ages.

*“Atacama Perchlorate as an Agricultural Contaminant in Groundwater: Isotopic and Chronologic Evidence from Long Island, New York”, Bölke, Hattinger, Sturchio, Gu, Abbene, Mroczkowski, Environ.Sci.Technol. 2009,43,5619–5626*

***“At the DL transect, apparent groundwater ages ranged from 1 to 39 years and increased with depth (Figure1b), consistent with distributed recharge.”***

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# Stable Isotope Analysis of Nitrate

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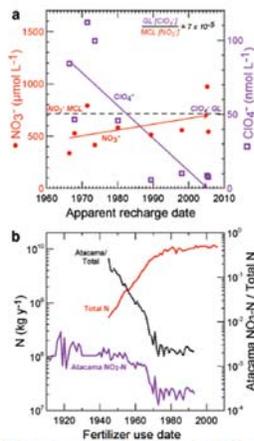


FIGURE 4. Trends related to changing agricultural inputs. (a)  $\text{ClO}_4^-$  and  $\text{NO}_3^-$  concentrations in dated groundwaters, compared to EPA  $\text{NO}_3^-$  maximum contaminant level (MCL) and New York  $\text{ClO}_4^-$  guidance level (GL). Data are from Northport (NP wells) and North Fork (DL transect, minus DL1s and DL1m). (b) Records of national (USA) Atacama  $\text{NO}_3^-$  and total N fertilizer use (2, 45, 46).

*“Atacama Perchlorate as an Agricultural Contaminant in Groundwater: Isotopic and Chronologic Evidence from Long Island, New York”, Bölke, Hattinger, Sturchio, Gu, Abbene, Mroczkowski, Environ.Sci.Technol. 2009,43,5619–5626*

***“Dated Long Island groundwaters provide a record of decreasing  $\text{ClO}_4^-$  and relatively constant or slightly increasing  $\text{NO}_3^-$  in recharge between about 1966 and 2006 (Figure4). An upward decrease in  $\text{ClO}_4^-$  concentrations in DL groundwater could indicate either (1) decreasing proportion of Atacama  $\text{NO}_3^-$  with constant  $\text{ClO}_4^-$  concentration in applied N fertilizer mixtures, or (2) constant application rates of both Atacama  $\text{NO}_3^-$  and other N fertilizers during a period when  $\text{ClO}_4^-$  concentrations in Atacama  $\text{NO}_3^-$  fertilizer decreased.”***

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## Tritium Data in NASA's 2012 TM

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- ***“Fogg et al. (1999) show that nitrate and other contamination from agricultural land use in the Salinas Valley area has a likely impact on groundwater for centuries following the time of fertilizer application because of the inherent time lag involved in contaminant transport.”***
- **The Salinas Valley is 145 km long and 30 km wide**
- **The Raymond Basin is 14 km long and 12 km wide**
- **What may be true for the Salinas Valley is not true for the Raymond Basin.**

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## Age of Water

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- *“Weissman et al. (2002) performed extensive numerical simulations of groundwater age dispersion in an alluvial fan aquifer system near Fresno, CA and concluded **simulated arithmetic mean groundwater ages** do not correspond to mean ages estimated from simulated CFC concentrations. Results emphasize the potential ambiguity of **“mean”** groundwater ages estimated from environmental tracer concentrations in typically heterogeneous geologic systems. The significant dispersion of groundwater ages also implies that ultimate, maximum effects of nonpoint source, anthropogenic contamination of groundwater may not be reached until after many decades or centuries of gradual decline in groundwater quality.”*
- **Weissman et al. is talking about simulated average ages derived from several sample locations. That is not the situation here.**

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