



# Evaluation of Simi Valley Supply Wells Sycamore Well #3 and Niles Well #1

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# Problem Statement

Stakeholders are concerned that the presence of **perchlorate** and **radioactivity** in groundwater from two wells in Simi Valley is tied to contamination from the Santa Susana Field Laboratory (SSFL)

# Summary of Findings: 4 Lines of Evidence

**Perchlorate** and **radioactivity** in groundwater from two wells in Simi Valley does not stem from SSFL.

1. The isotopic signature of perchlorate shows it is a mix of indigenous perchlorate and that stemming from Atacama Desert-derived salt deposits and not synthetic perchlorate.
2. Perchlorate concentrations in these wells are below the maximum contaminant level (MCL) and within the range measured in other wells in Ventura County.
3. Radioactivity is below the MCL and within the range measured in other wells in Ventura County.
4. Contaminated groundwater from SSFL is not in communication with Simi Valley groundwater wells.

# Potential Sources of Perchlorate

**Indigenous** – perchlorate (presumed to be from atmospheric deposition) is common in desert soils of the southwest (SW) US, including Southern California



**Atacama Desert** – perchlorate is a minor component of the nitrate-rich salt deposits in the Atacama Desert (Chile), which have been refined and used worldwide as fertilizer, including on citrus crops in Southern California, since the late 1800s.

**Synthetic** – perchlorate is a component of solid rocket fuels and explosives, fireworks, flares, chlorate herbicides, and bleach products.

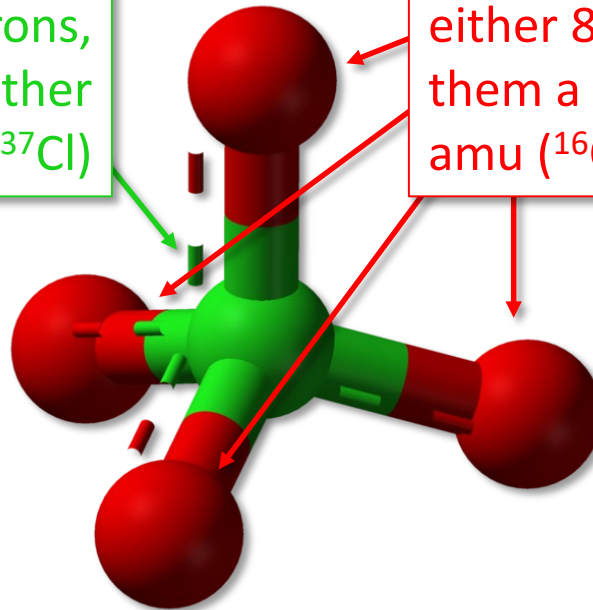


# Line of Evidence 1 – Perchlorate Forensics

Perchlorate = 1 chlorine atom + 4 oxygen atoms

Most chlorine atoms contain either 18 or 20 neutrons, giving them a mass of either 35 or 37 amu ( $^{35}\text{Cl}$  and  $^{37}\text{Cl}$ )

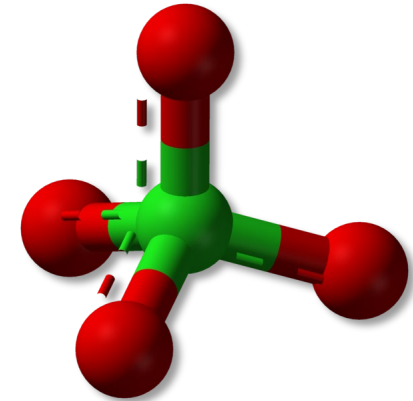
Most oxygen atoms contain either 8 or 10 neutrons, giving them a mass of either 16 or 18 amu ( $^{16}\text{O}$  and  $^{18}\text{O}$ )



*Even though all perchlorate molecules have the same chemical characteristics, some are heavier and some are lighter based on the specific the **chlorine** and **oxygen** isotopes that make up each molecule.*

# Perchlorate Isotopic Signature

We quantify the relative abundance of **chlorine** and **oxygen** isotopes in the bulk perchlorate signature to measure the **perchlorate isotopic signature**

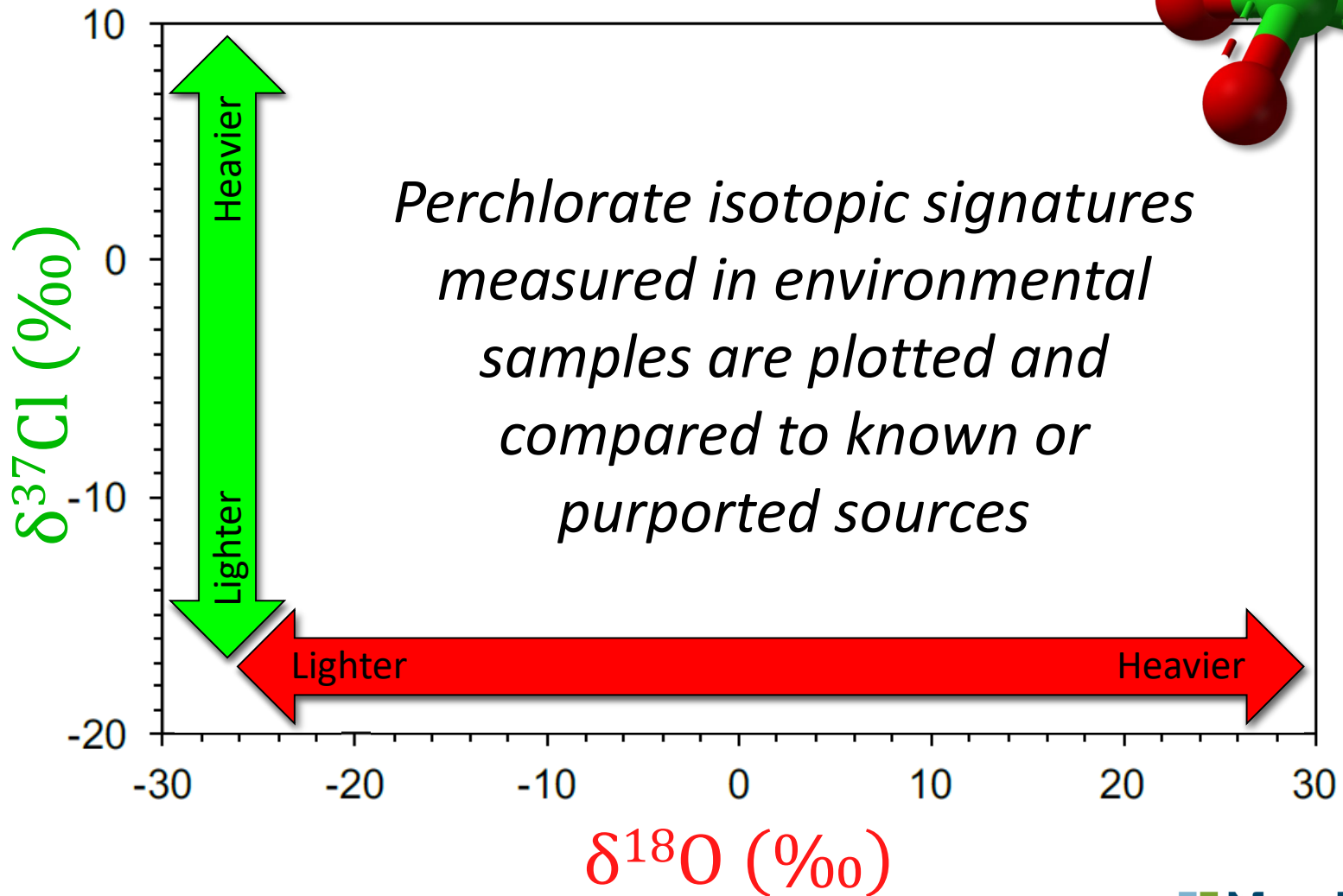
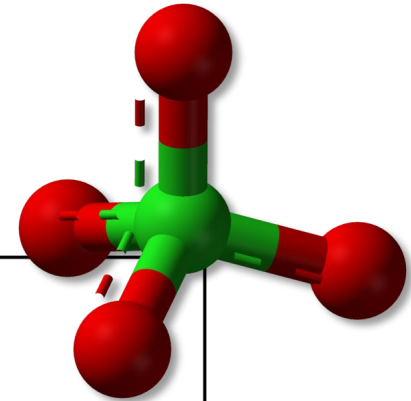


$$\delta^{37}\text{Cl} (\text{‰}) = \left[ \frac{\left(\frac{^{37}\text{Cl}}{^{35}\text{Cl}}\right)_{\text{sample}} - \left(\frac{^{37}\text{Cl}}{^{35}\text{Cl}}\right)_{\text{standard}}}{\left(\frac{^{37}\text{Cl}}{^{35}\text{Cl}}\right)_{\text{standard}}} \right] \times 1000$$

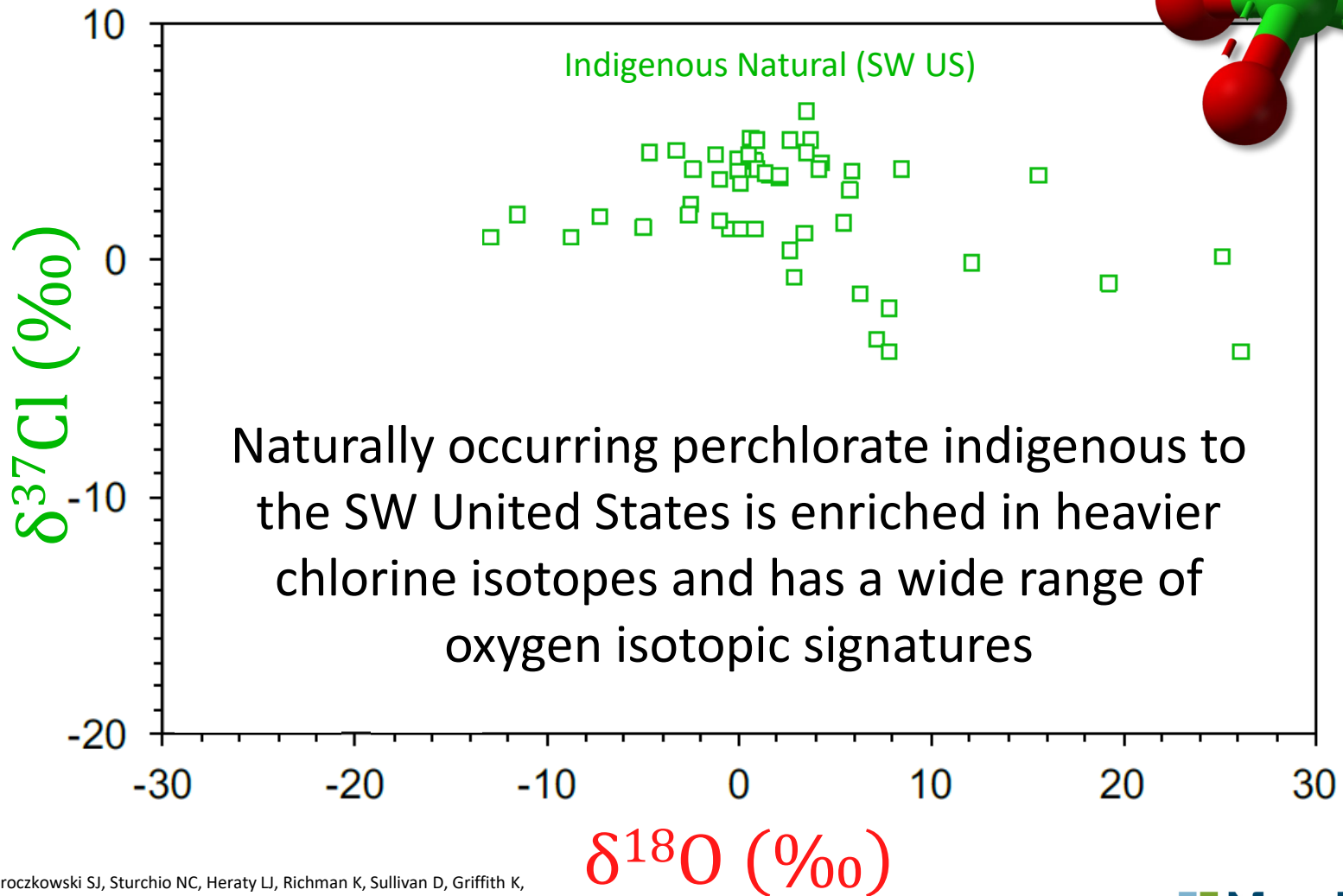
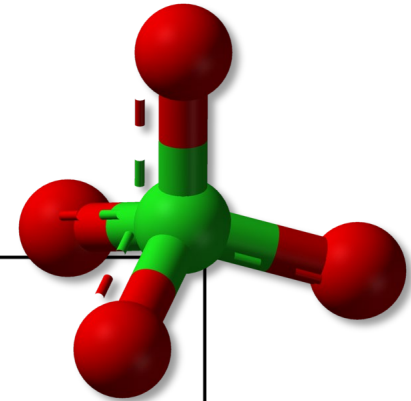
$$\delta^{18}\text{O} (\text{‰}) = \left[ \frac{\left(\frac{^{18}\text{O}}{^{16}\text{O}}\right)_{\text{sample}} - \left(\frac{^{18}\text{O}}{^{16}\text{O}}\right)_{\text{standard}}}{\left(\frac{^{18}\text{O}}{^{16}\text{O}}\right)_{\text{standard}}} \right] \times 1000$$

*The isotopic signature of the bulk perchlorate reflects the extent to which it is enriched in heavier or lighter **chlorine** and **oxygen** isotopes as compared to standards*

# Perchlorate Isotopic Signature

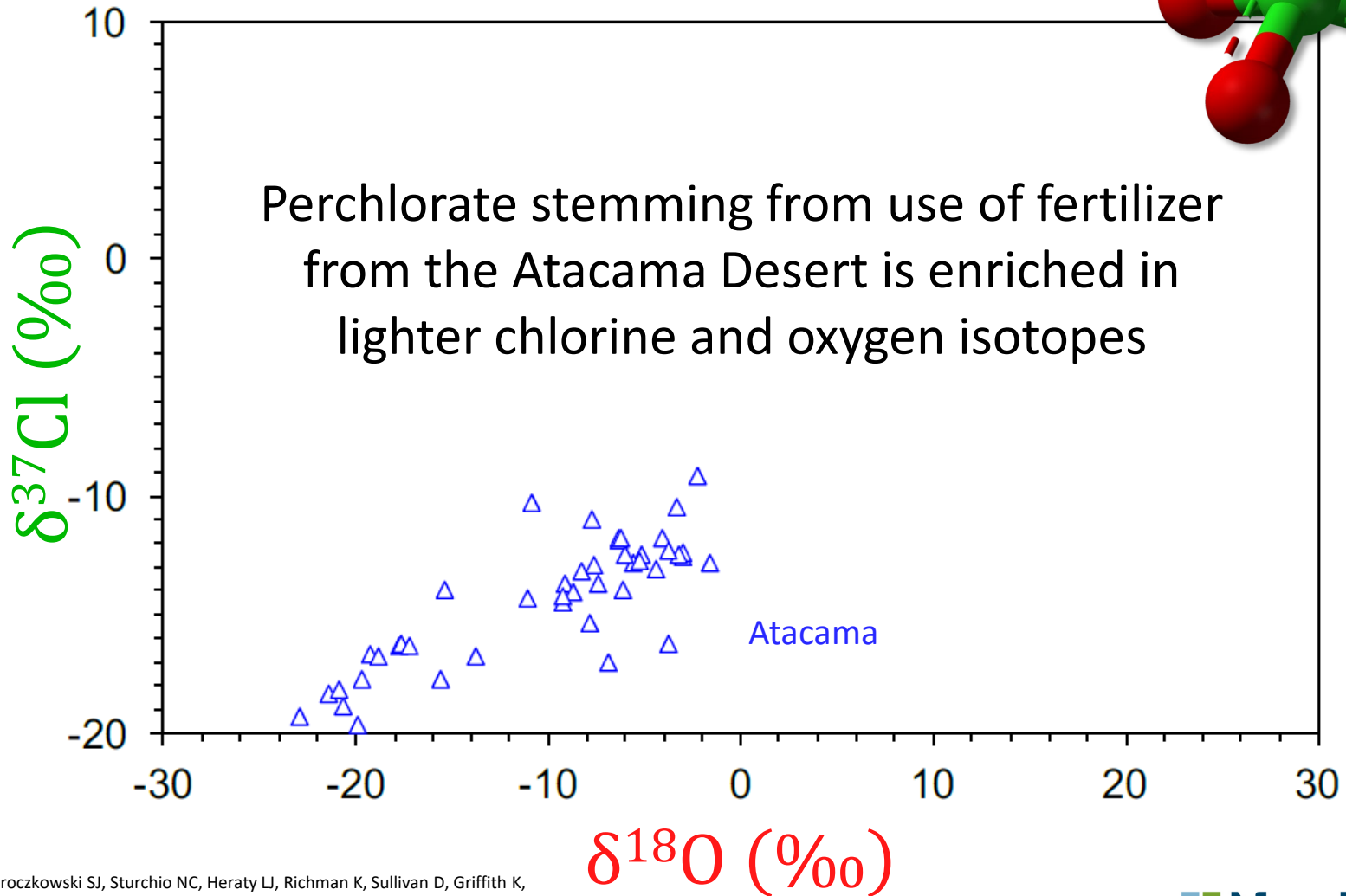
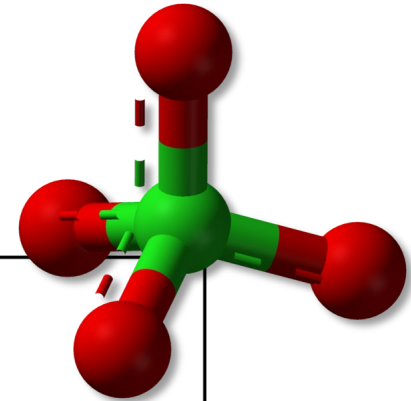


# Indigenous Natural Perchlorate

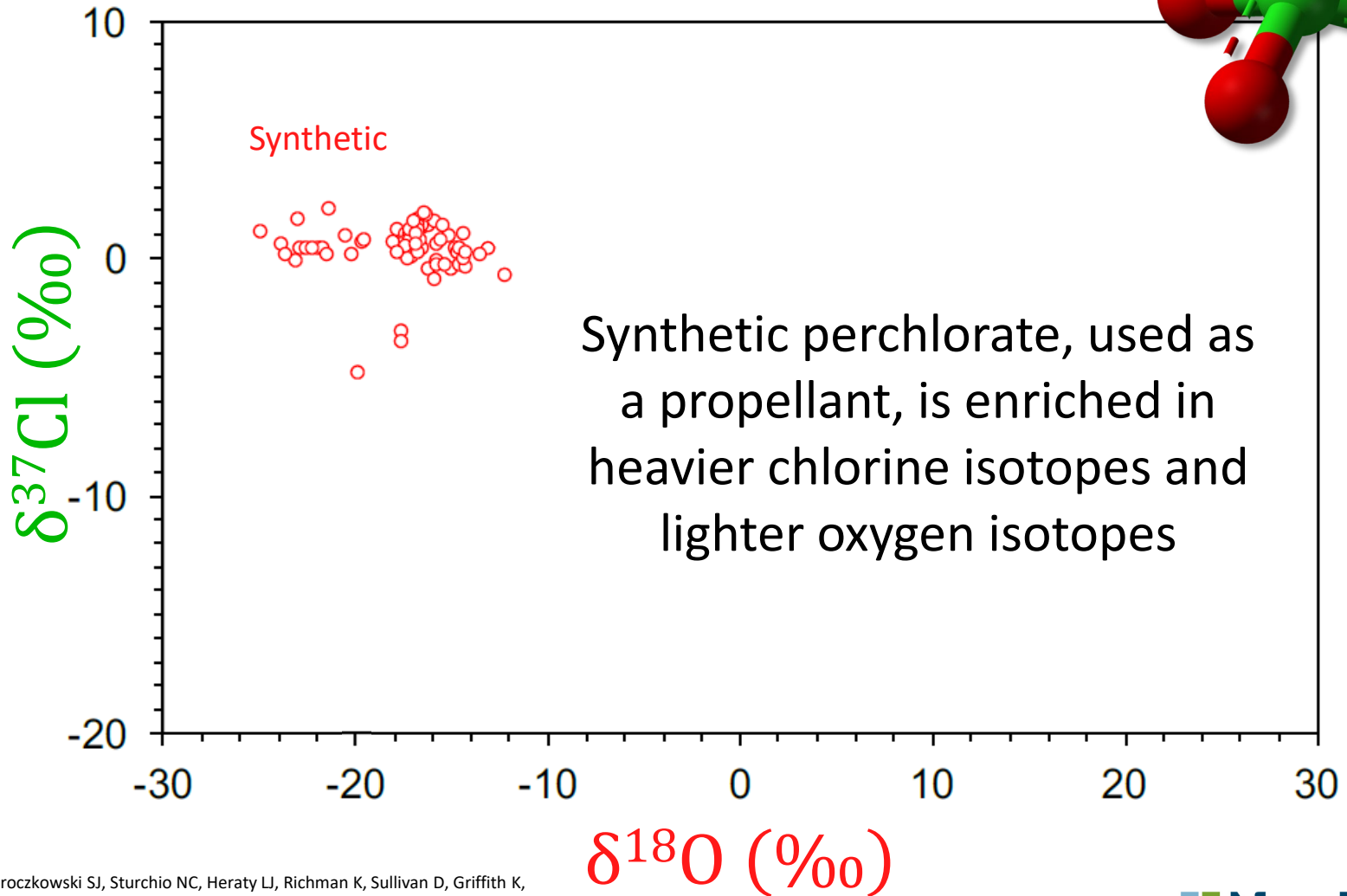
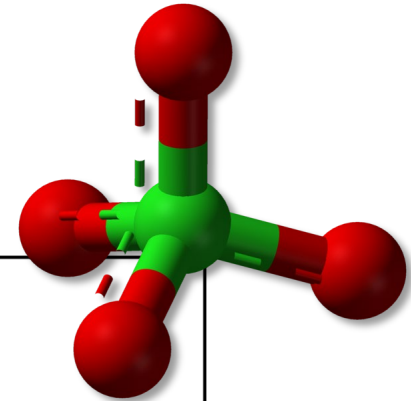




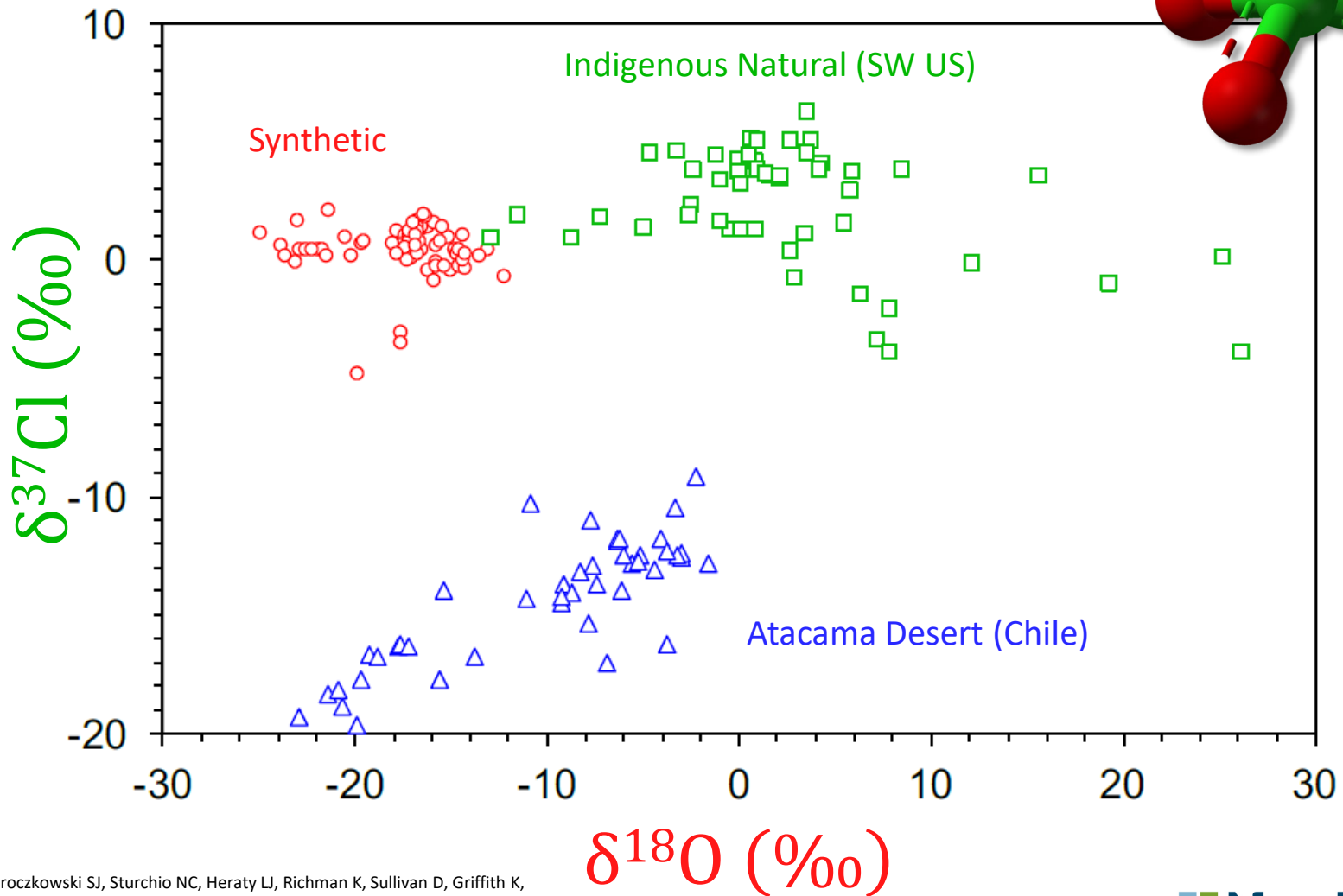
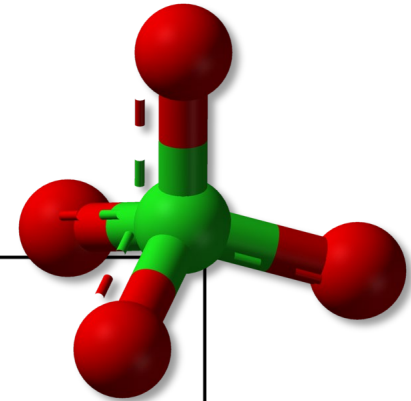
# Atacama Desert Perchlorate



# Synthetic Perchlorate

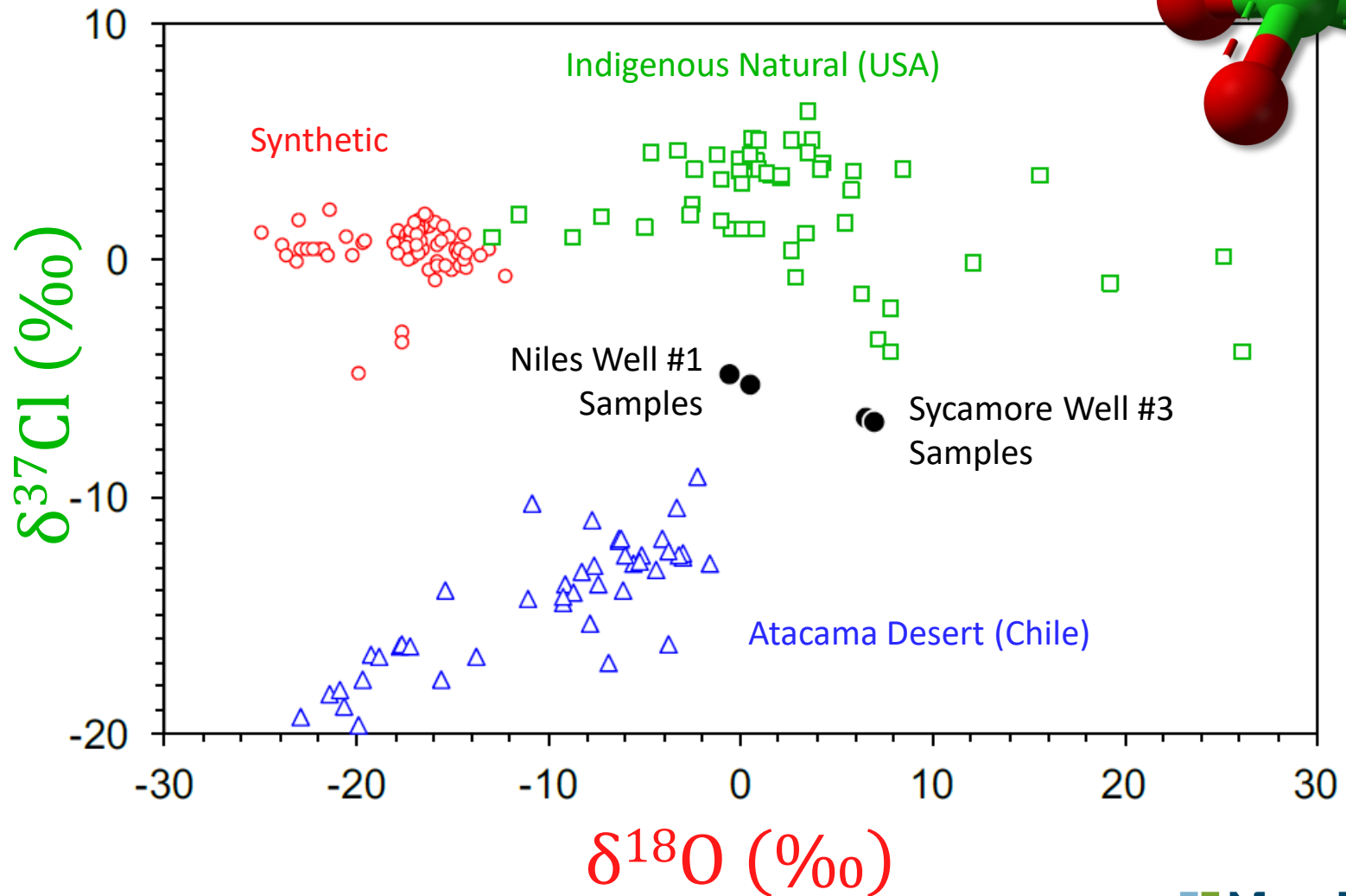
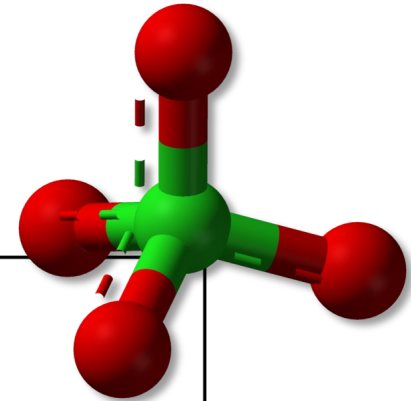


# Perchlorate Signatures are Distinct



Böhlke JK, Mroczkowski SJ, Sturchio NC, Heraty LJ, Richman K, Sullivan D, Griffith K, Hatzinger PB, 2017, Stable isotope analysis of oxygen ( $^{18}\text{O}$ : $^{17}\text{O}$ : $^{16}\text{O}$ ) and chlorine ( $^{37}\text{Cl}$ : $^{35}\text{Cl}$ ) in perchlorate: Reference materials, calibrations, and interferences. Rapid Communications in Mass Spectrometry 31, 85-110.

# Niles and Sycamore Well Samples



# Line of Evidence 1 – Perchlorate Forensics

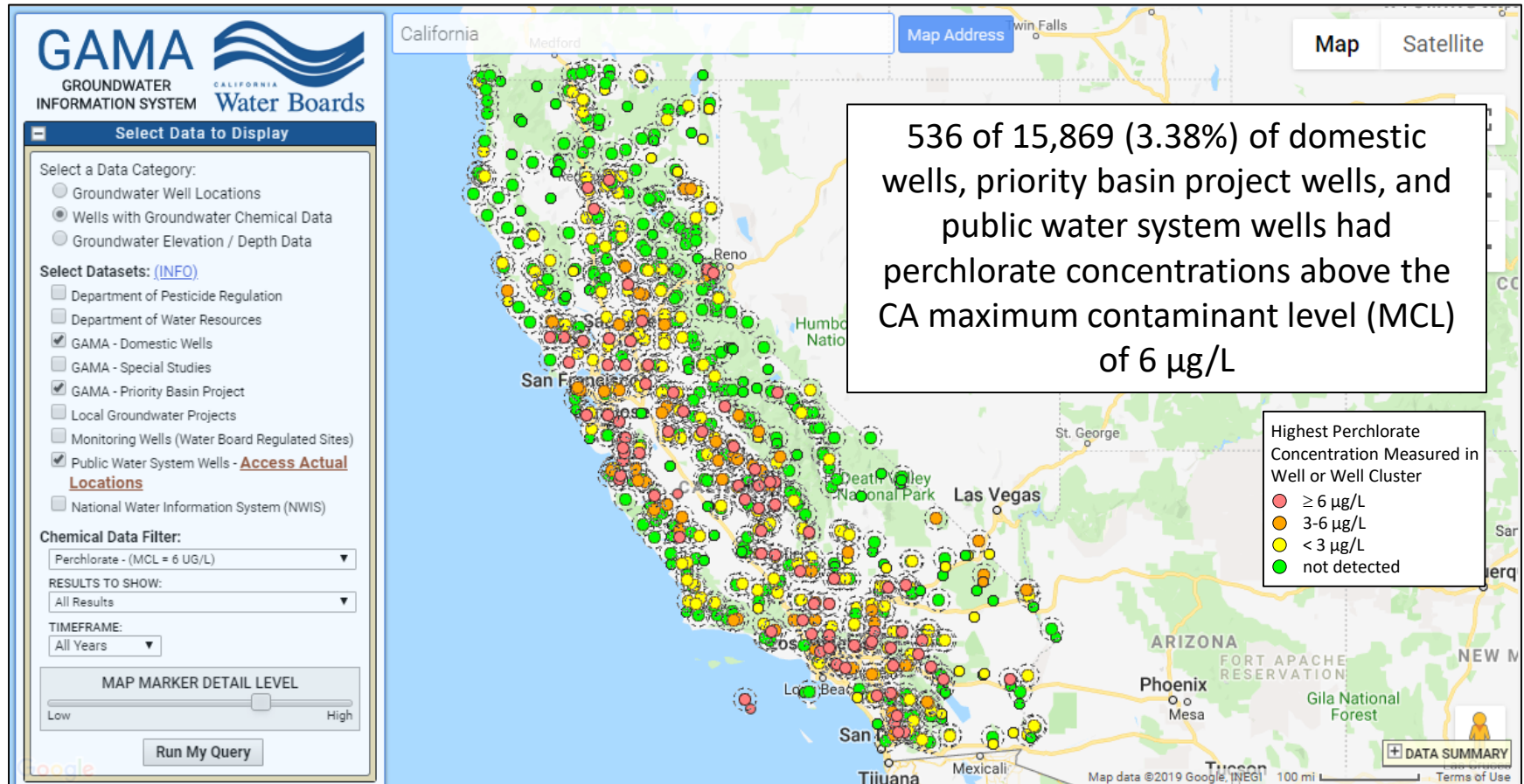
- The perchlorate in Niles Well #1 and Sycamore Well #3 **is a mixture of indigenous and Atacama Desert perchlorate.**
- The perchlorate in Niles Well #1 and Sycamore Well #3 **is not synthetic perchlorate.**
- *Regardless of source, the amount of perchlorate in water from these wells is reduced in water delivered to consumers*
  - *The concentration of perchlorate in water delivered to consumers is far below the standard set by the State of California (MCL = 6 µg/L)*

## Line of Evidence 2 – Perchlorate Concentrations

How do perchlorate concentrations in Sycamore Well #3 and Niles Well #1 compare to those in other groundwater wells throughout California and/or Ventura County?

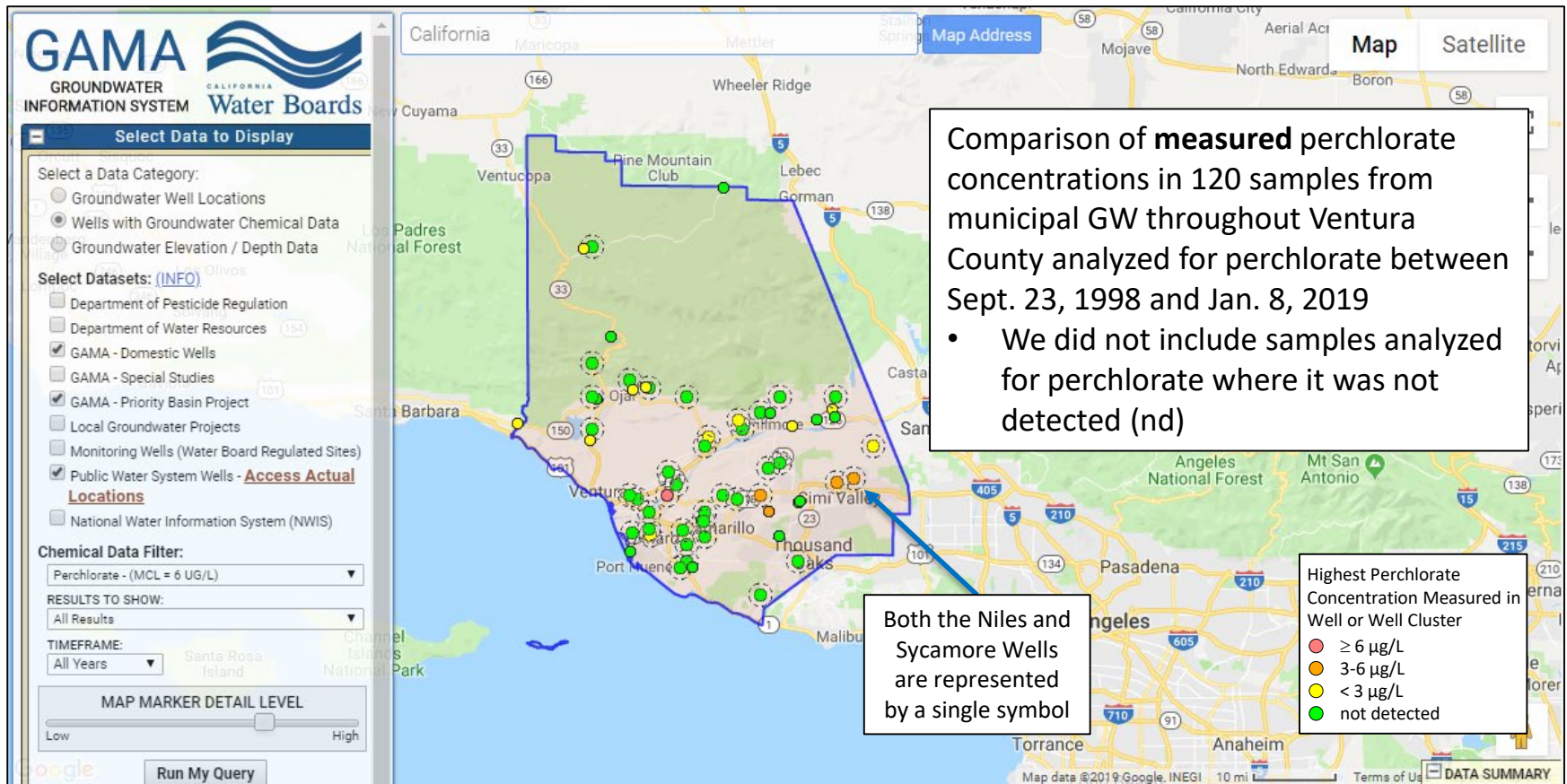
*Caveat: The water in these wells is blended with imported surface water before it is delivered to the consumer, which reduces perchlorate concentrations. Therefore, the perchlorate concentrations discussed herein are far greater than those in water delivered to consumers.*

# Perchlorate is Detected Throughout CA GW



Data accessed May 7, 2019

# Perchlorate in Ventura County Municipal GW Wells



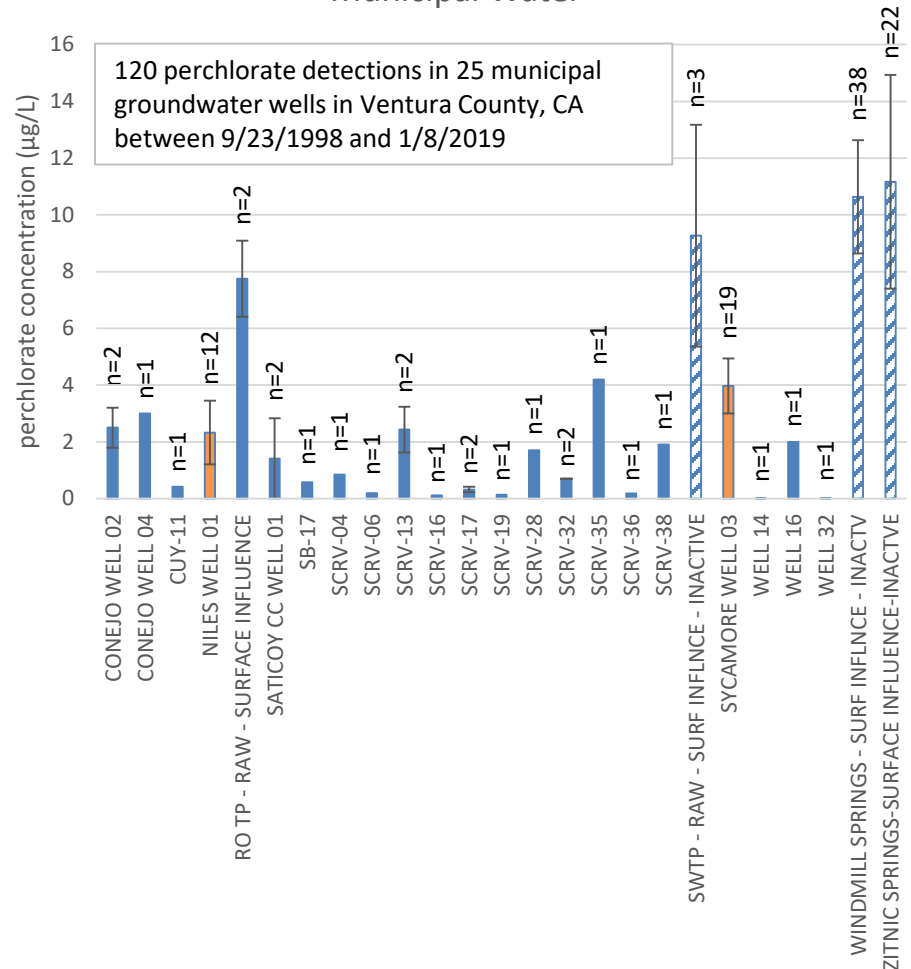
Data accessed April 25, 2019



# Perchlorate Conc. in Context: Ventura Co.

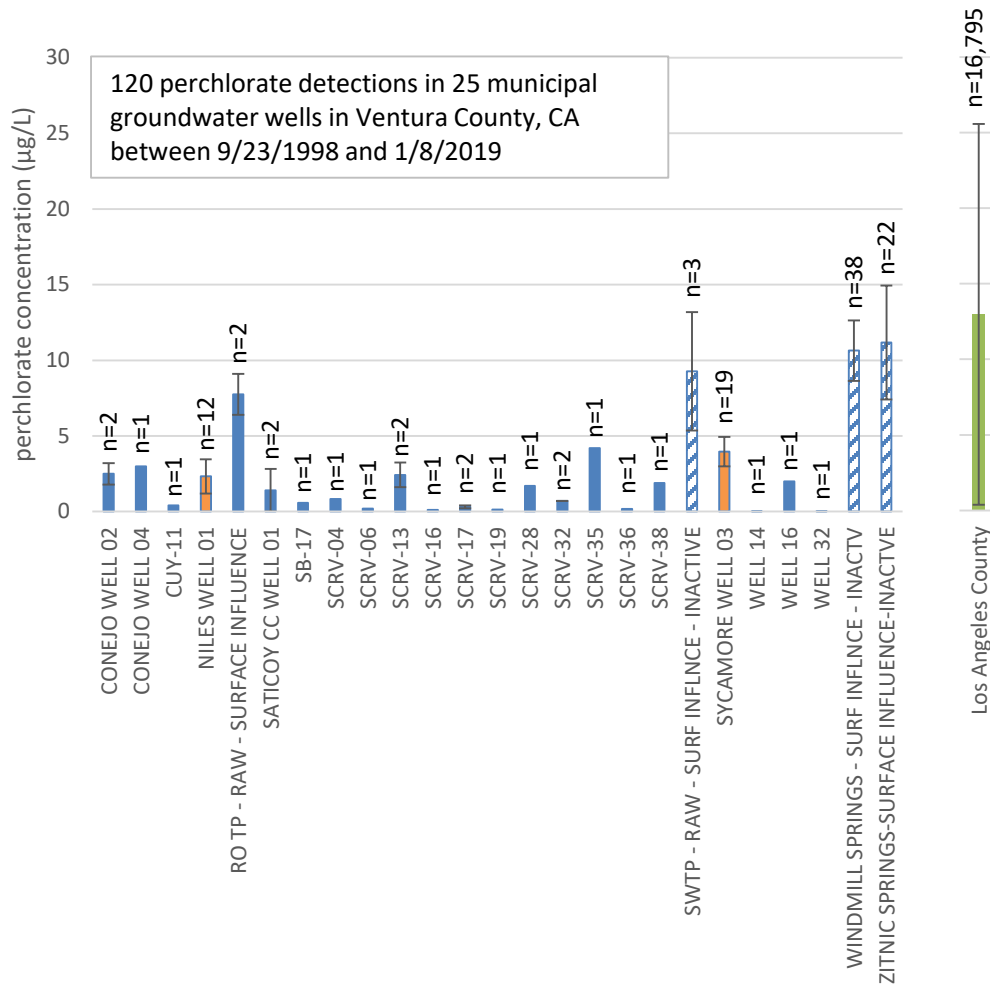
Perchlorate concentrations in Niles Well #1 and Sycamore Well #3 (orange) are not materially greater than wells throughout Ventura County

Ventura County Perchlorate Detections in Municipal Water



\*<http://geotracker.waterboards.ca.gov/gama/gamamap/public/>  
 Accessed April 25, 2019

# Perchlorate Conc. in Context: LA County



Perchlorate concentrations in Niles Well #1 and Sycamore Well #3 and other Ventura Co. wells are lower than concentrations in wells in neighboring Los Angeles County.\*

<http://geotracker.waterboards.ca.gov/gama/gamamap/public/>

Ventura County data accessed April 25, 2019

Los Angeles County data accessed June 19, 2019 and treated the same as Ventura County Data, described on slide 16

## Line of Evidence 2 – Perchlorate Concentrations

- The perchlorate in Niles Well #1 and Sycamore Well #3 is consistent with other measured perchlorate concentrations in municipal groundwater wells throughout Ventura County.
- *The water in these wells is blended with imported surface water before it is delivered to consumers, which reduces perchlorate concentrations. Therefore, the perchlorate concentrations discussed herein are far greater than those in water delivered to consumers.*
  - *The concentration of perchlorate in water delivered to consumers is far below the standard set by the State of California (MCL = 6 µg/L)*

## Line of Evidence 3 – Radioactivity

- How do activities of uranium, gross beta, and plutonium compare to the US Environmental Protection Agency (EPA) and/or CA MCL, where applicable?
- How do activities of uranium, gross beta, and plutonium compare to other measurements throughout Ventura County?

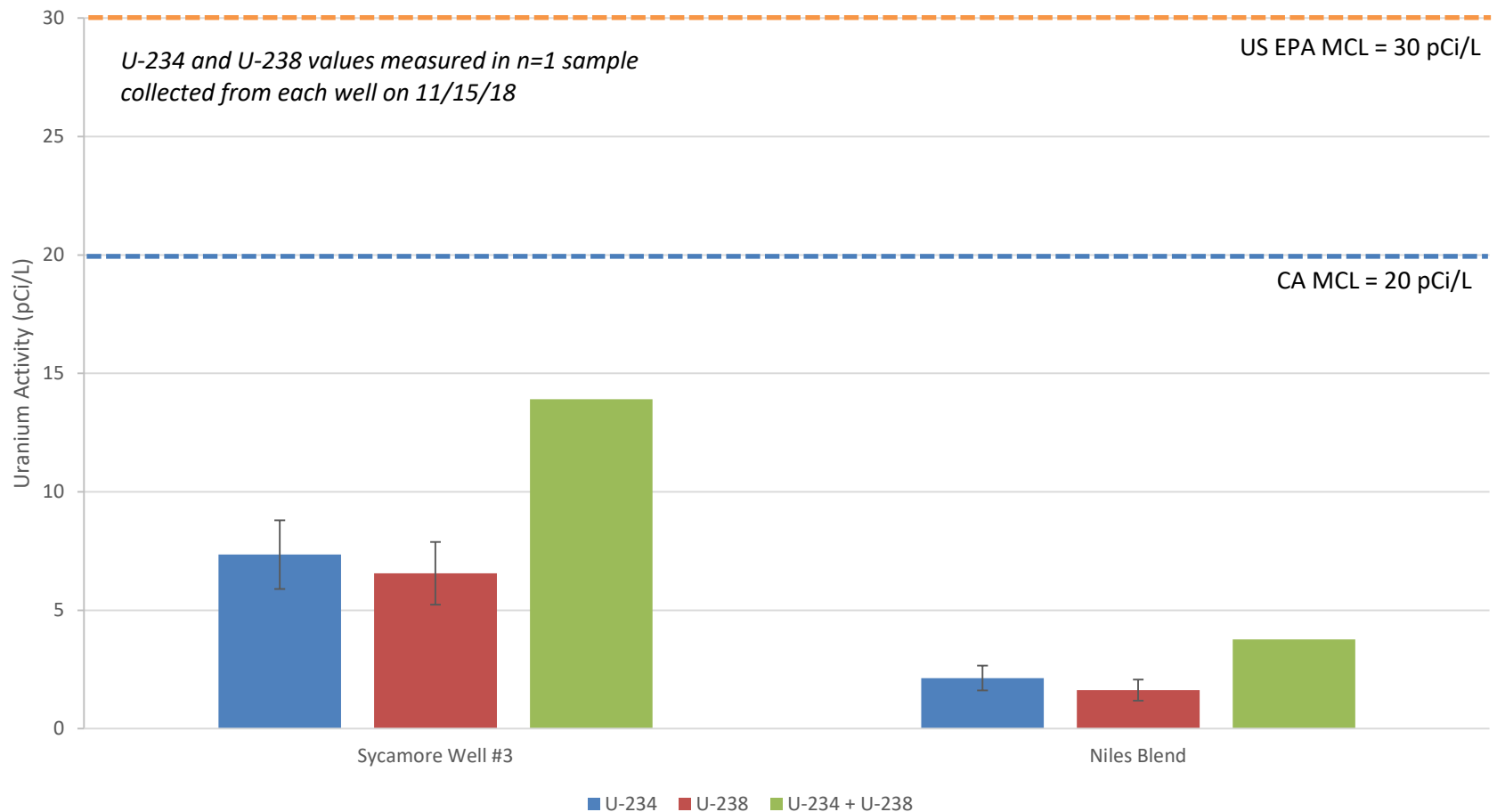
# Potential Sources of Radioactivity – Uranium

- Uranium (U) is a naturally occurring radioactive element in rocks, soil, water, plants, animals and humans.
- It is common in specific types of igneous, metamorphic, and sedimentary rocks.
- There are three main isotopes of uranium (U-234, U-235, and U-238).
- Enriched U-235 is used as fuel in nuclear reactors and in nuclear weapons.
- Depleted uranium, which is poor in U-235 but rich in U-238, is used by the military in tank armor, bullets, and missiles for its strength and density.



Pitchblende (also called uraninite) from Niederschlema-Alberoda deposit, Saxony, Germany; Image Credit: [Geomartin](#)

# Uranium Activities Are Below the US and CA MCLs



*Note: U-235 was not detected in either sample*

# Uranium Activities Are Within the Range Measured in Other Ventura County GW Samples

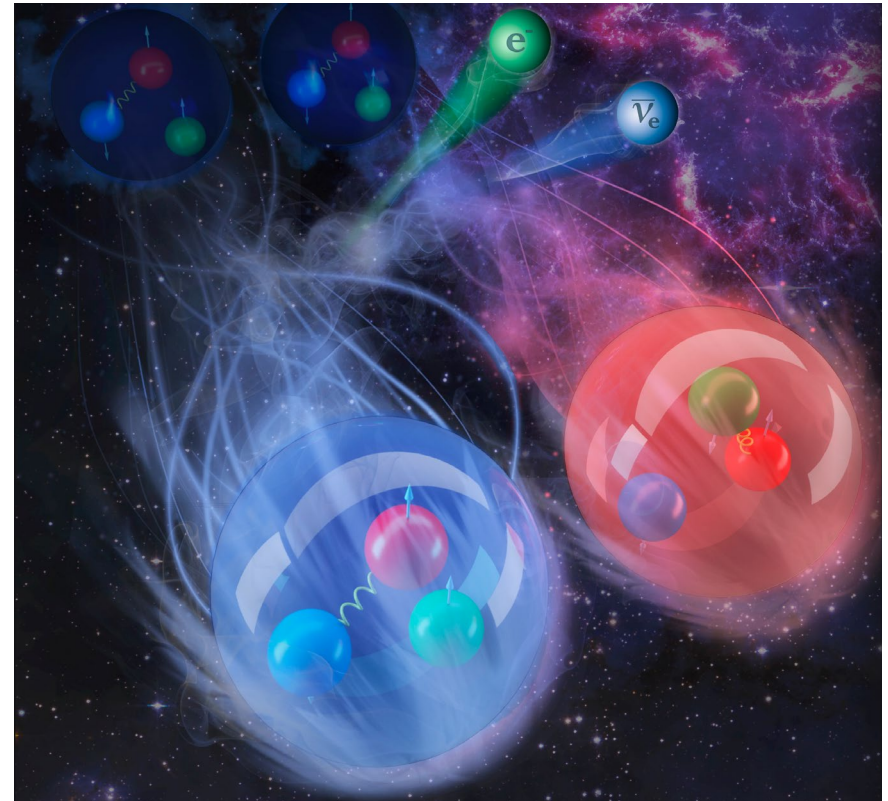
- 200 uranium measurements in samples collected from groundwater throughout in Ventura County, CA\*
- Comparing the number of samples in the database to the observed value (OV) in the Sycamore Well #3 and Niles Blend puts these values in context

	Sycamore Well 3	Niles Blend
U-234	Activity = 7.35 pCi/L # of Samples in Database > OV = 75 <b>Percentile = 63%</b>	Activity = 2.14 pCi/L # of Samples in Database > OV = 156 <b>Percentile = 22%</b>
U-238	Activity = 6.56 pCi/L # of Samples in Database > OV = 86 <b>Percentile = 57%</b>	Activity = 1.63 pCi/L # of Samples in Database > OV = 163 <b>Percentile = 19%</b>
U-234 + U-238	Sum Activity = 13.91 pCi/L # of Samples in Database > OV = 19 <b>Percentile = 96%</b>	Sum Activity = 3.77 pCi/L # of Samples in Database > OV = 135 <b>Percentile = 33%</b>

\*<http://geotracker.waterboards.ca.gov/gama/gamamap/public/>; accessed September 2018; there were actually 204 uranium observations in Ventura County though the four observations from San Nicolas Island were not included in the analysis

# Potential Sources of Radioactivity – Gross Beta

- Beta particles are a type of radiation emitted by some radionuclides.
- Gross beta is a measurement of the total beta particles emitted by a number of different beta particle sources.
- There are numerous naturally-occurring sources of beta particles in the environment, but Potassium-40 and Radon-228 are the most common sources in groundwater.\*
- Beta emitters have many uses, especially in medical diagnosis, imaging, and treatment. They can also be used as tracers in agricultural studies (Strontium-90), luminous aircraft and commercial exit signs (Tritium), drug metabolism studies (Tritium), dating organic matter (Carbon-14), and in a variety of industrial instrumentation.



Interactions between two nucleons slow down beta decays in atomic nuclei; Graphic Credit: [Lawrence Livermore National Laboratory](https://www.llnl.gov/)

\*Welch, A.H., Z. Szabo, D.L. Parkhurst, P.C. Van Metre, A.H. Millin, 1995, Gross-beta activity in ground water: natural sources and artifacts of sampling and laboratory analysis, Applied Geochemistry, 10 (5): 491-503



# Gross Beta Activities Are Low

	Sycamore Well #3		Niles Blend	
	Sample	MRL	Sample	MRL
Gross Beta	7.4 pCi/L	3 pCi/L	4.3 pCi/L	3 pCi/L

- Gross Beta activities are low and well below the MCL “trigger” of 50 pCi/L\*
  - The MCL “trigger” is Gross Beta minus Potassium-40

\*This MCL is not an official regulatory level, but is used as a trigger for EPA and CA State Water Resources Control Board Division of Drinking Water (SWRCB-DDW). If the trigger level is exceeded additional testing is required to determine the source of beta radiation and if the MCL of 4 mrem/year has been exceeded.

[https://www.waterboards.ca.gov/water\\_issues//programs/gama/docs/coc\\_radionuclides.pdf](https://www.waterboards.ca.gov/water_issues//programs/gama/docs/coc_radionuclides.pdf)

# Gross Beta Activities Are Within the Range Measured in Other Ventura County GW Samples

- 295 Gross Beta measurements in samples collected from groundwater throughout in Ventura County, CA\*
- Comparing the number of samples in the database to the observed value (OV) in the Sycamore Well #3 and Niles Blend puts these values in context

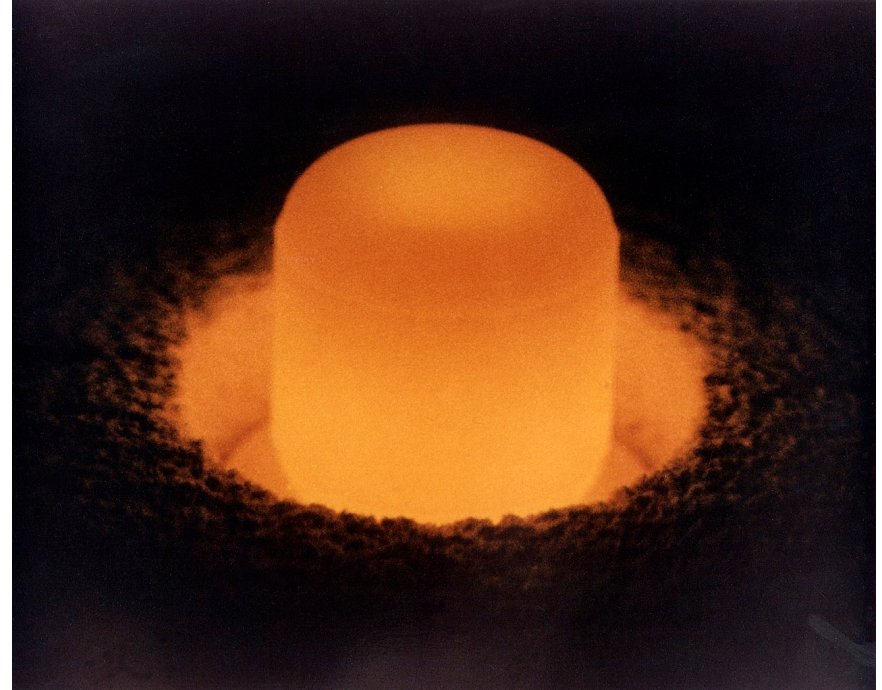
	Sycamore Well #3 Raw Water	Niles Blend
Gross Beta	Activity = 7.4 pCi/L # of Samples in Database > OV = 65 Percentile = 68%	Activity = 4.3 pCi/L # of Samples in Database > OV = 128 Percentile = 38%

<http://geotracker.waterboards.ca.gov/gama/gamamap/public/>  
accessed April 30, 2019

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# Potential Sources of Radioactivity – Plutonium

- Trace elements of plutonium are found in naturally occurring uranium ores.
- Plutonium (Pu) is a byproduct of the nuclear power industry.
- There are six main isotopes of Plutonium (Pu-238, Pu-239, Pu-240, Pu-241, Pu-242 and Pu-244).
- Pu-238 is used in radioisotope thermoelectric generators to make electricity in space probes.
- Pu-239 is used in nuclear weapons and some nuclear reactors.



A pellet of Plutonium-238 glowing from its own heat.  
Image Credit: US Department of Energy

# Plutonium Activities Are Low

	Sycamore Well #3		Niles Blend		Method Blank
	Sample	MRL	Sample	MRL	MDC
Pu-238	nd	-	0.434 pCi/L (B)	0.13 pCi/L	0.164 pCi/L
Pu-239/240	0.099 pCi/L	0.047 pCi/L	nd	0.079 pCi/L	0.094 pCi/L
Pu-241	nd	-	nd	6.5 pCi/L	7.35 pCi/L

- All plutonium activities are low
- There is no MRL specific to plutonium
- Plutonium is an alpha emitter, and plutonium activities in these samples are well below the CA and US MCL of 15 pCi/L for gross alpha

## Line of Evidence 3 – Radioactivity

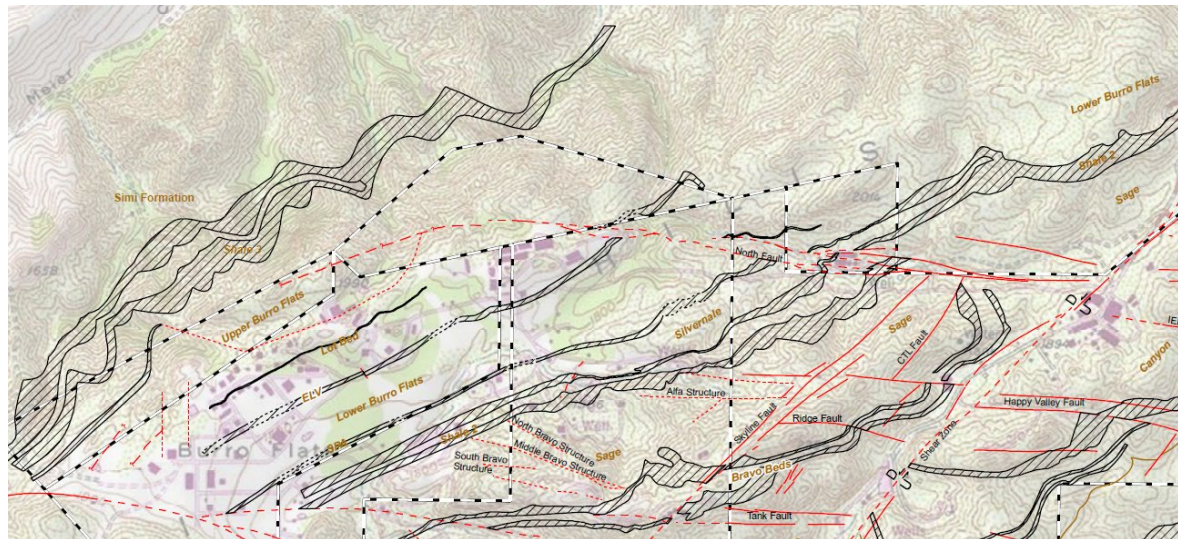
- All measurements of radioactivity in the Sycamore Well #3 raw water and the Niles Blend samples are low and below their respective MCL
- Comparing U and gross beta activities in samples to the CA Water Board database shows that levels in Sycamore Well #3 raw water and Niles Blend samples are within the range of U and gross beta activities throughout Ventura County

## Line of Evidence 4 - Hydrogeology

What does the hydrogeological information tell us about the potential for communication between SSFL contamination and Simi Valley supply wells?

# Geology is Not Conducive to Transport

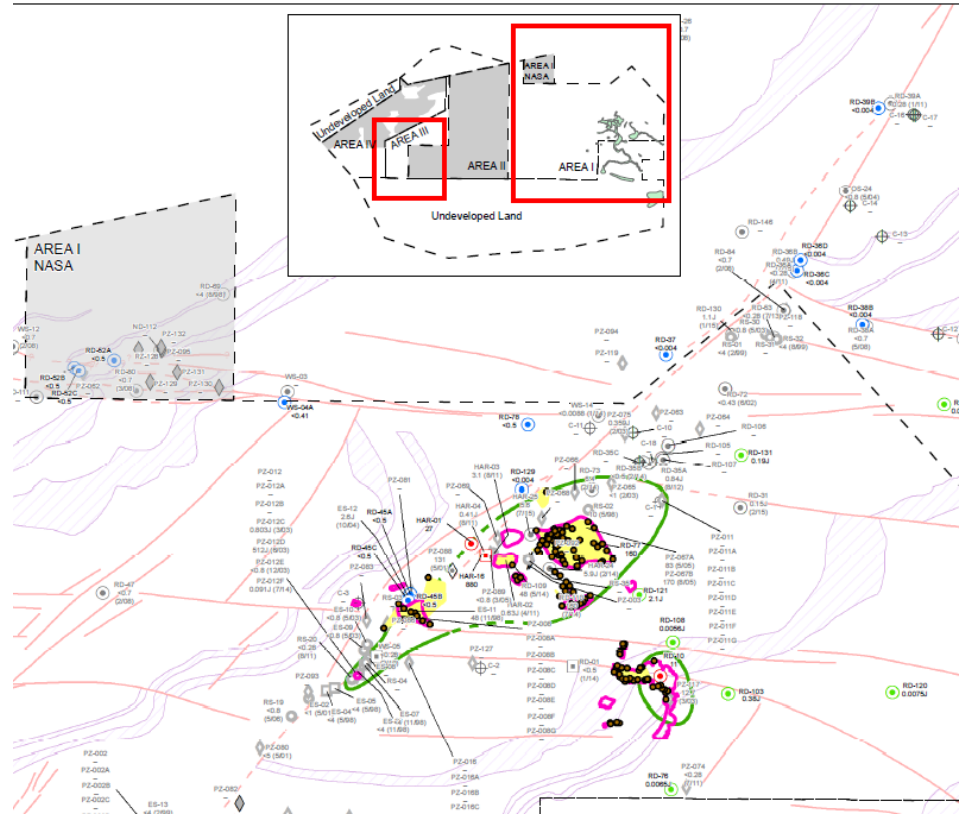
Low permeability hydrostratigraphic units and structures are present and prevent communication between SSFL and alluvial aquifer hosting Simi Valley supply wells



*The transport of any groundwater (contaminated or not) from SSFL to Simi Valley supply wells will be inhibited by subsurface geology*

# Extent and Magnitude of SSFL Contamination Is Well-Characterized

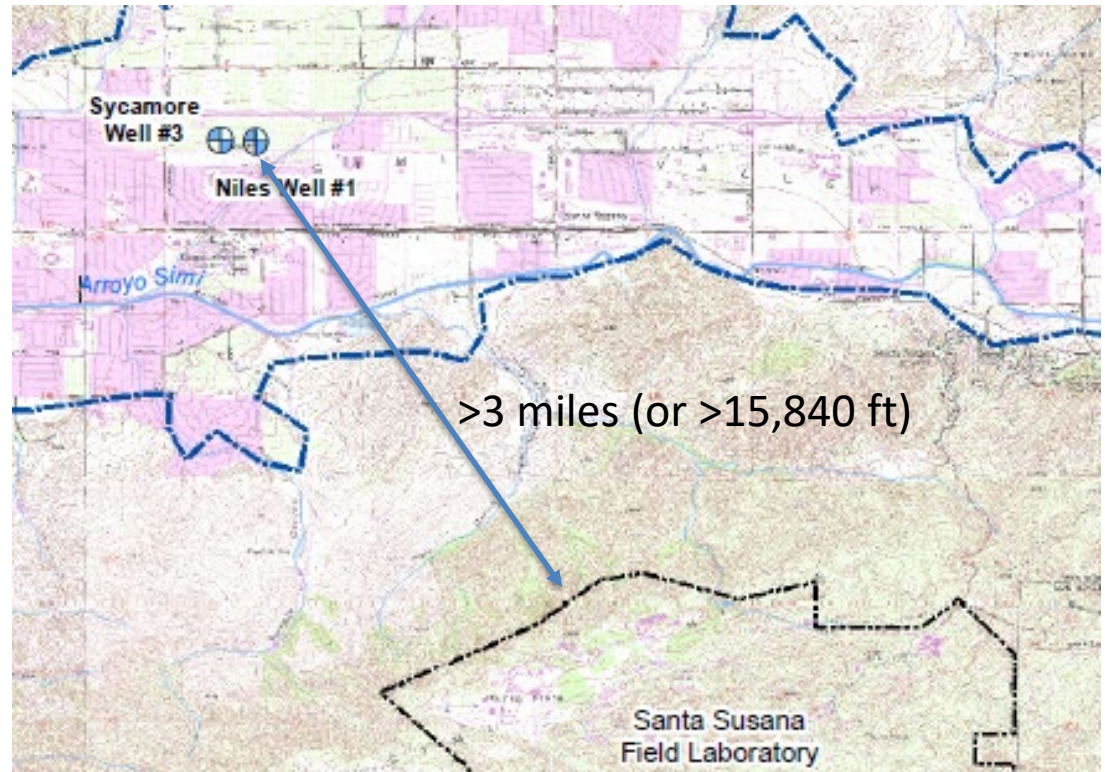
- Extent and magnitude of perchlorate and other contaminants in soil and groundwater has been well characterized.
- Plumes associated with known sources are <1,000 feet across.





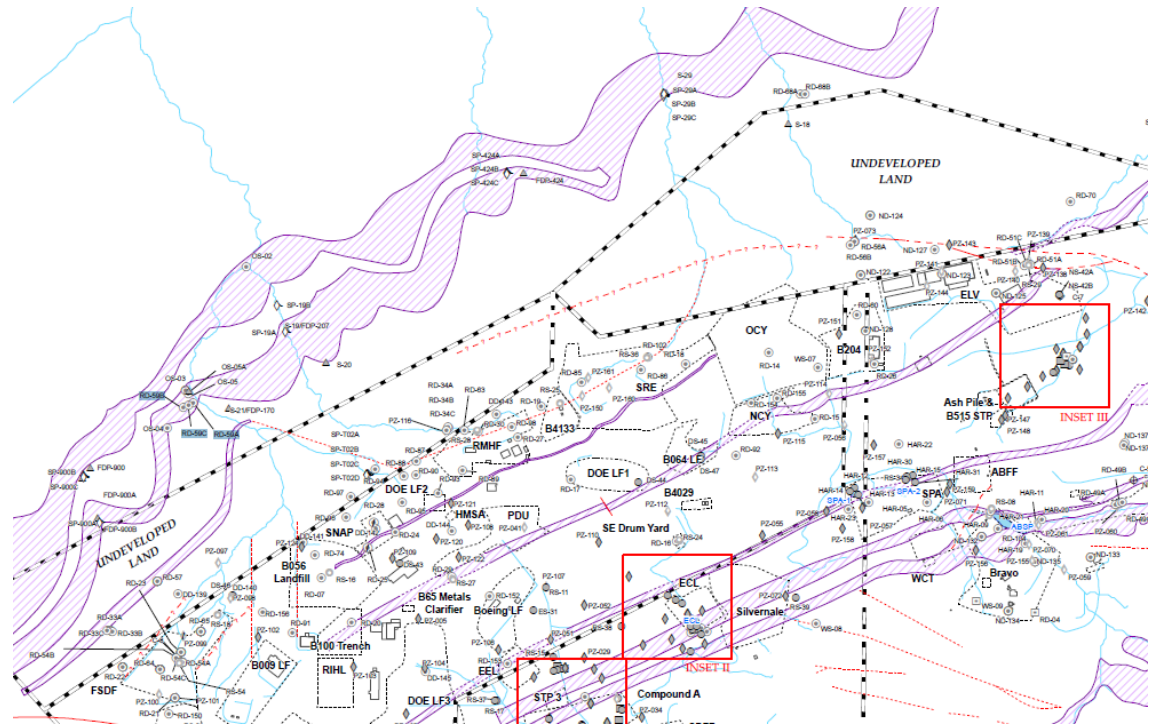
# Long Transport Distance Between SSFL and Simi Valley Wells

Closest detected groundwater contamination attributable to SSFL is >3 miles (or >15,840 ft) from Simi Valley supply wells



# Contamination Not Detected between SSFL and Simi Valley Wells

Numerous off site monitoring points downgradient of SSFL do not contain perchlorate and other contaminants of potential concern (COPCs) above screening levels



# Summary of Findings: 4 Lines of Evidence

**Perchlorate** and **radioactivity** in groundwater from two wells in Simi Valley does not stem from SSFL.

1. The isotopic signature of perchlorate shows it is a mix of indigenous perchlorate and that stemming from Atacama Desert-derived salt deposits and not synthetic perchlorate.
2. Perchlorate concentrations in these wells are below the MCL and within the range measured in other wells in Ventura County.
3. Radioactivity is below the MCL and within the range measured in other wells in Ventura County.
4. Contaminated groundwater from SSFL is not in communication with Simi Valley groundwater wells.

# List of Acronyms

amu	atomic mass unit
Cl	chlorine
COPCs	contaminants of potential concern
EPA	Environmental Protection Agency
GW	groundwater
MCL	maximum contaminant level
MDC	minimum detectable concentration
µg/L	micrograms per liter (equal to part-per-billion, ppb)
mrem	millirem
MRL	method reporting limit
nd	not detected
O	oxygen
OV	observed value
pCi/L	picocuries per liter
Pu	plutonium
SSFL	Santa Susana Field Laboratory
SW	southwest
SWRCB-DDW	State Water Resources Control Board Division of Drinking Water
U	uranium
US	United States