# Isotope Isolation

## Using Stable Isotope Analysis to Quantify Non-Stormwater Flow Sources


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San Diego State University,
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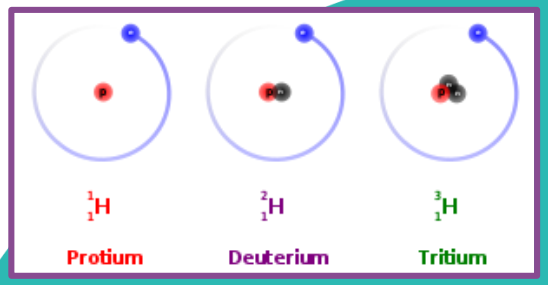
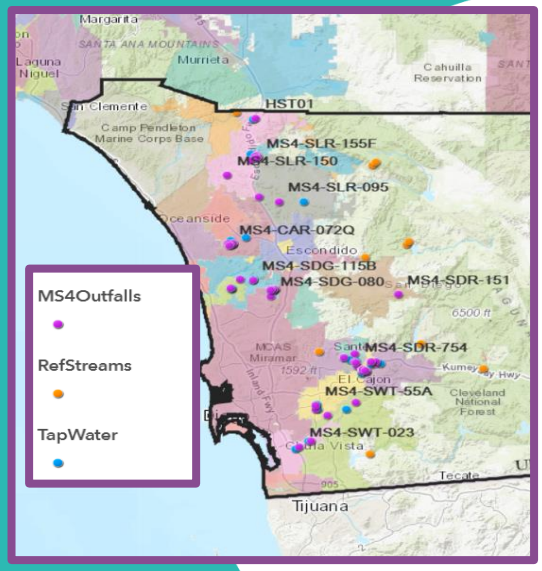
woodplc.com

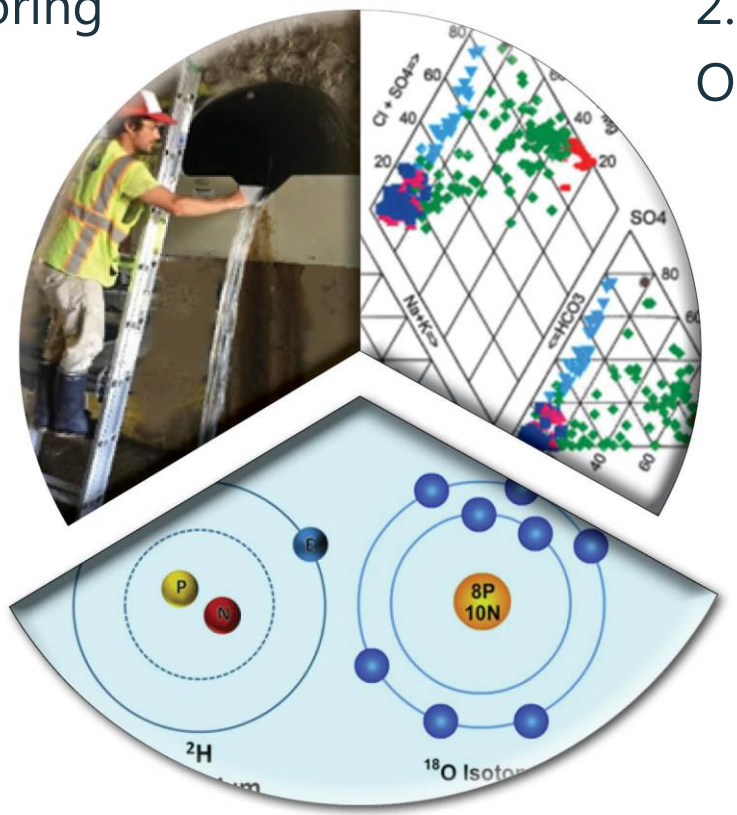


# Overview of Dry-Weather Flow Reduction Program

1. Flow monitoring

2. “Data to Doorsteps” Outreach & Education




3. Quantify flows using Isotopes

# Purpose of Study

- **<u>Why conduct this study?</u>**
  - San Diego Regional MS4 Permit requirements
  - Dry weather flow reduction goals:
    - "reduce controllable flows"

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  - San Diego Regional MS4 Permit requirements
  - Dry weather flow reduction goals

<u>Potential flow sources:</u>

- Over-irrigation (local, tap, recycled)
  - Residential
  - Agricultural
  - Commercial (golf course)
- Groundwater infiltration
- Wastewater/Sewage (RV dumpage)
- Pool draining
- Water utility operations (flushing, dewatering)

# Purpose of Study

- **Why conduct this study?**
  - San Diego Regional MS4 Permit requirements
  - Dry weather flow reduction goals

- **General questions for this study**
  - Is MS4 flow from local rain/groundwater or municipal tap water?
  - Can isotopic methods help ***quantify*** these sources?

# Scientific Background

**Isotopes** are variants of an element with **same number of protons**
but **varying number of neutrons**

*Ex.: Oxygen has 8 protons, and 8,9,10 neutrons*
*= 16O, 17O, 18O*

*Greek: "iso"= same, "topos"= place*
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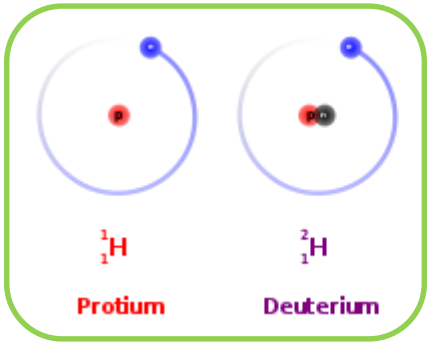


Stable
Isotopes

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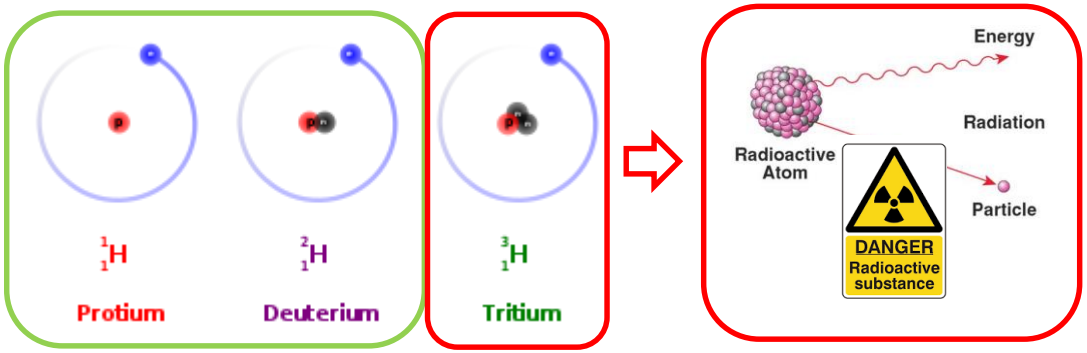


Stable Isotopes

Radioactive Isotopes

# Scientific Background (cont)

**More neutrons = More mass**

**physical property** leads to spatial patterns of isotopic composition of rainfall

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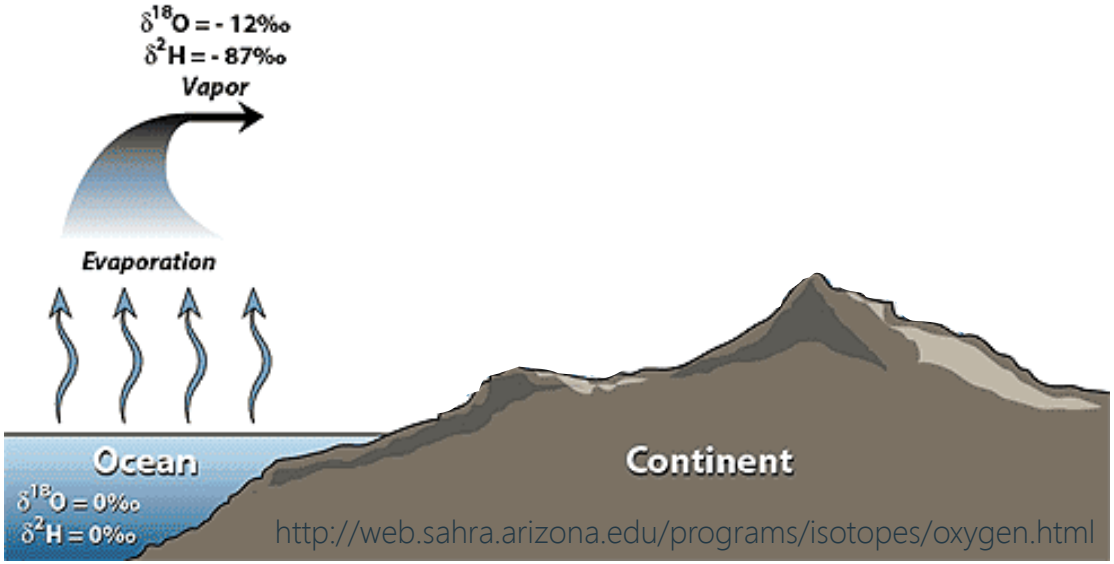
"Heavy"

More 18O




http://web.sahra.arizona.edu/programs/isotopes/oxygen.html

# Scientific Background (cont)

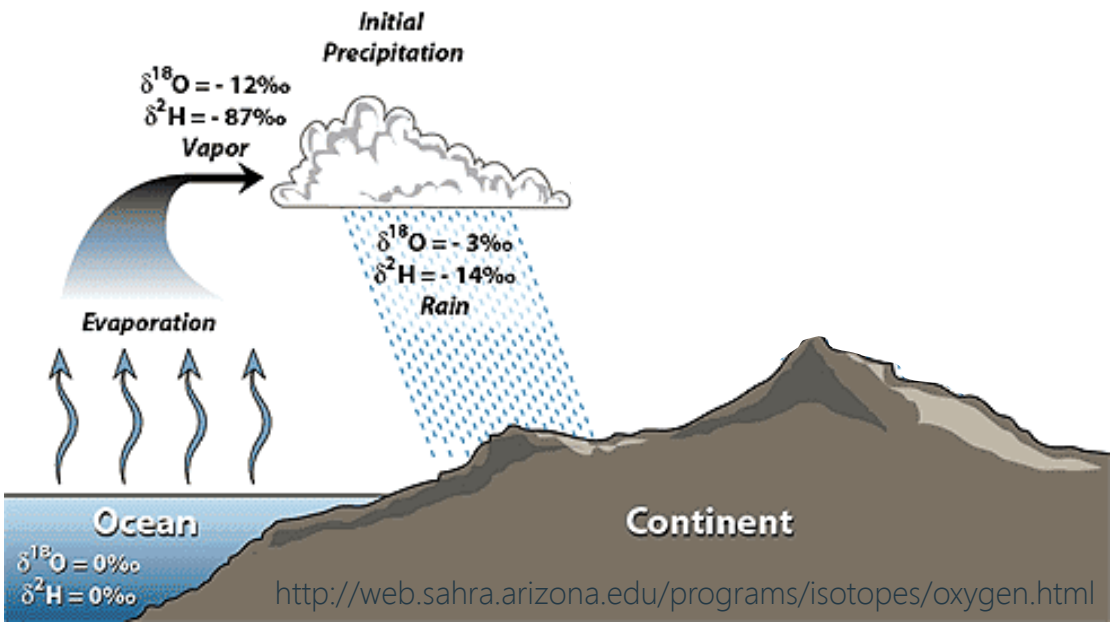
**More neutrons = More mass**

**physical property** leads to spatial patterns of isotopic composition of rainfall

1. Ocean to Continent

"Heavy" → "Light"

More 18O

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Less 18O

# Scientific Background (cont)

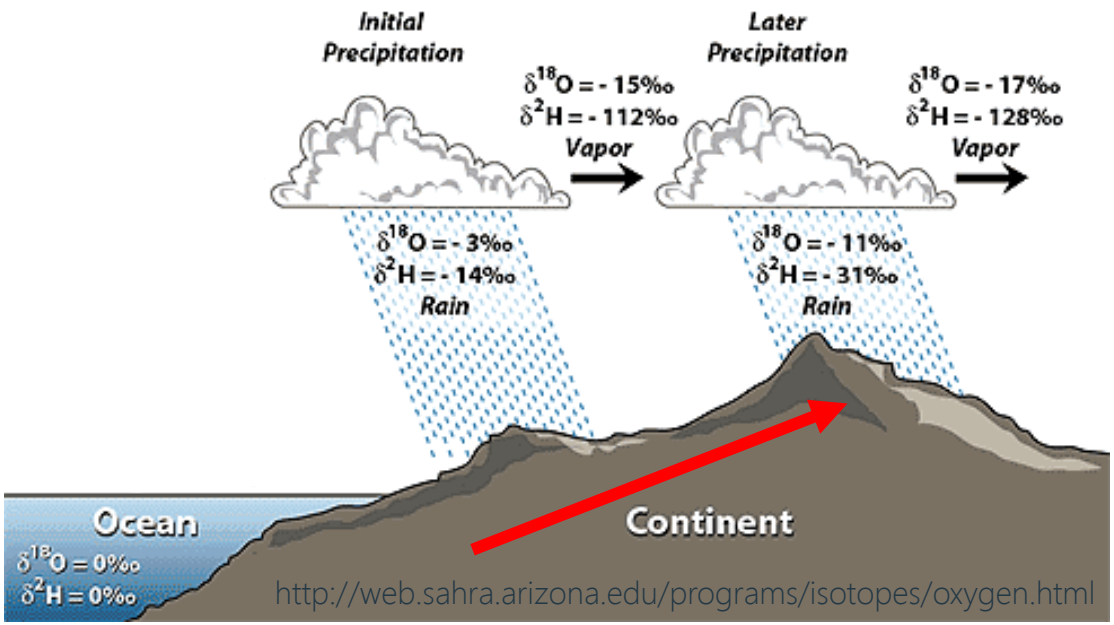
**More neutrons = More mass**

**physical property** leads to spatial patterns of isotopic composition of rainfall

1. Ocean to Continent
2. Elevation

"Heavy" → "Light"

More 18O

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Less 18O

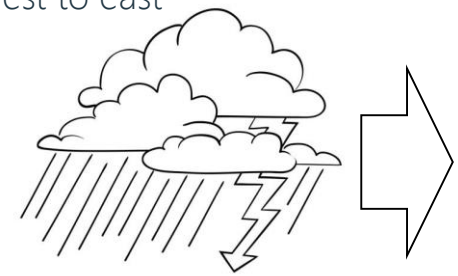
# Scientific Background (cont)

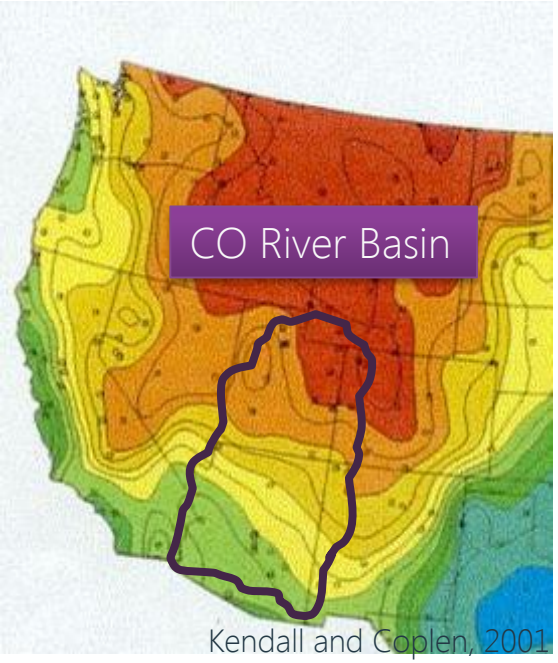
**More neutrons = More mass**

**physical property** leads to spatial patterns of isotopic composition of rainfall

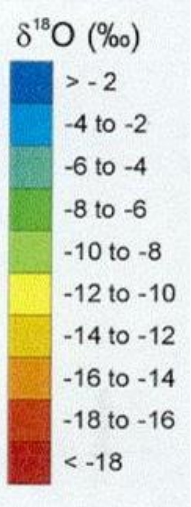
"Heavy" → "Light"

Storms mostly move from west to east






Kendall and Coplen, 2001




More 18O

Less 18O

# Scientific Background (cont)

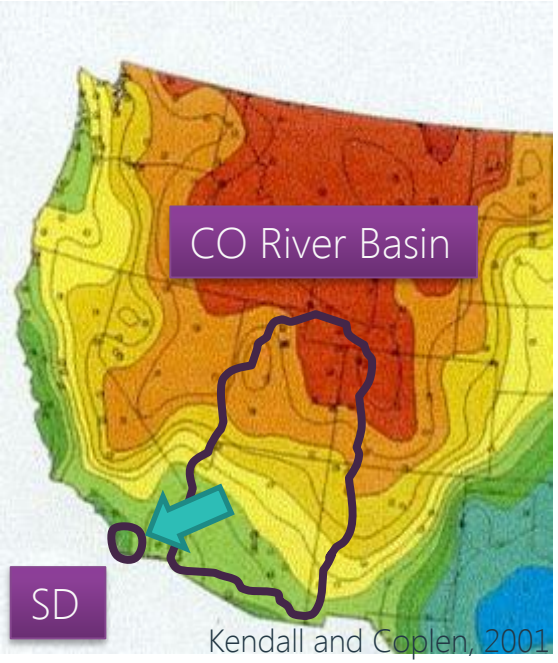
**More neutrons = More mass**

**physical property** leads to spatial patterns of isotopic composition of rainfall

**San Diego imports water from Colorado River**

**CO River water is depleted in O18**

"Heavy" → "Light"

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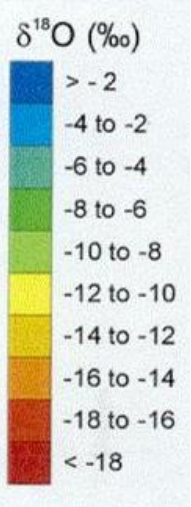


More 18O

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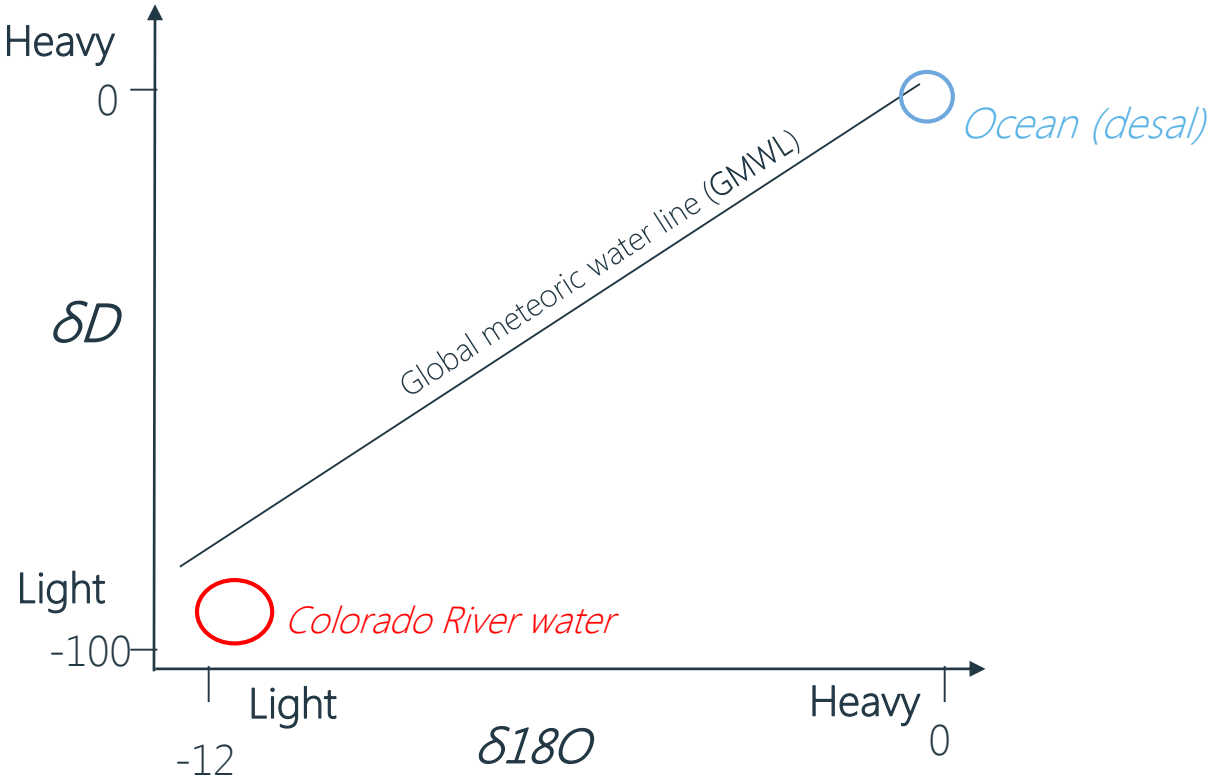
# Analytical Approach

## **I**sotopic **E**nd-**M**ember **M**ixture **A**nalysis **(IEMMA)**



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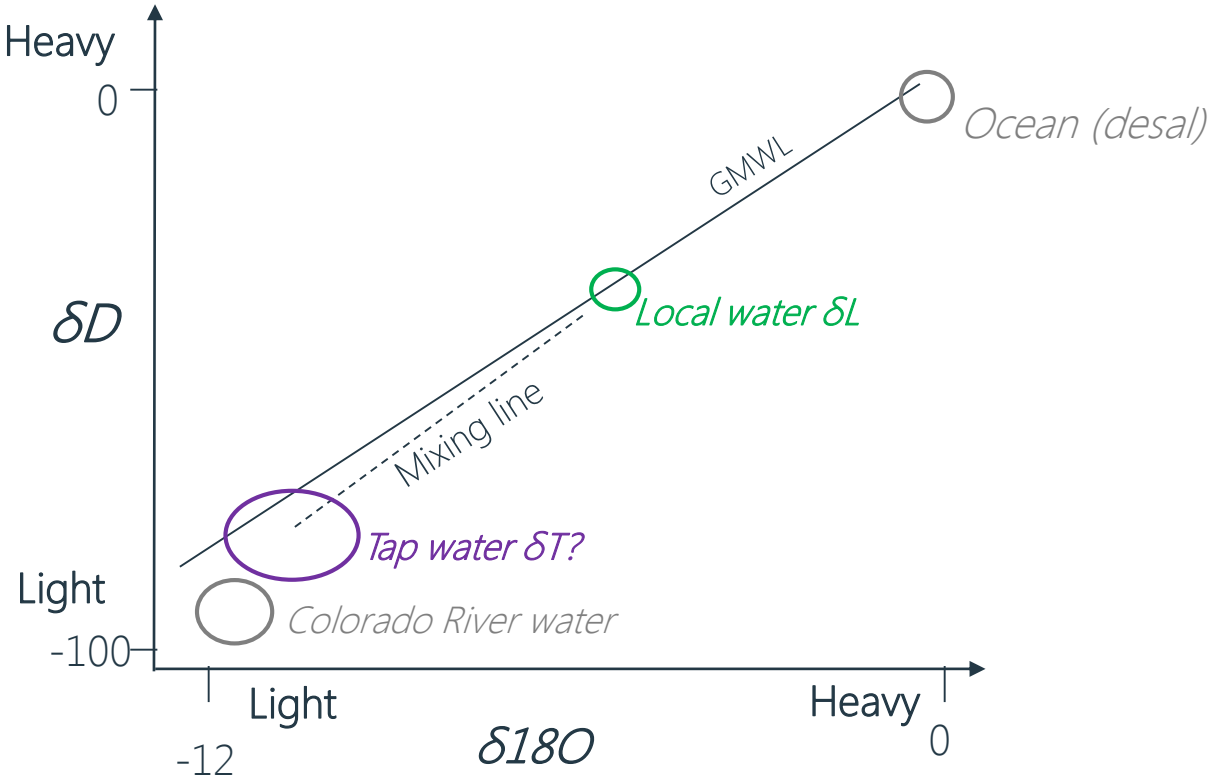

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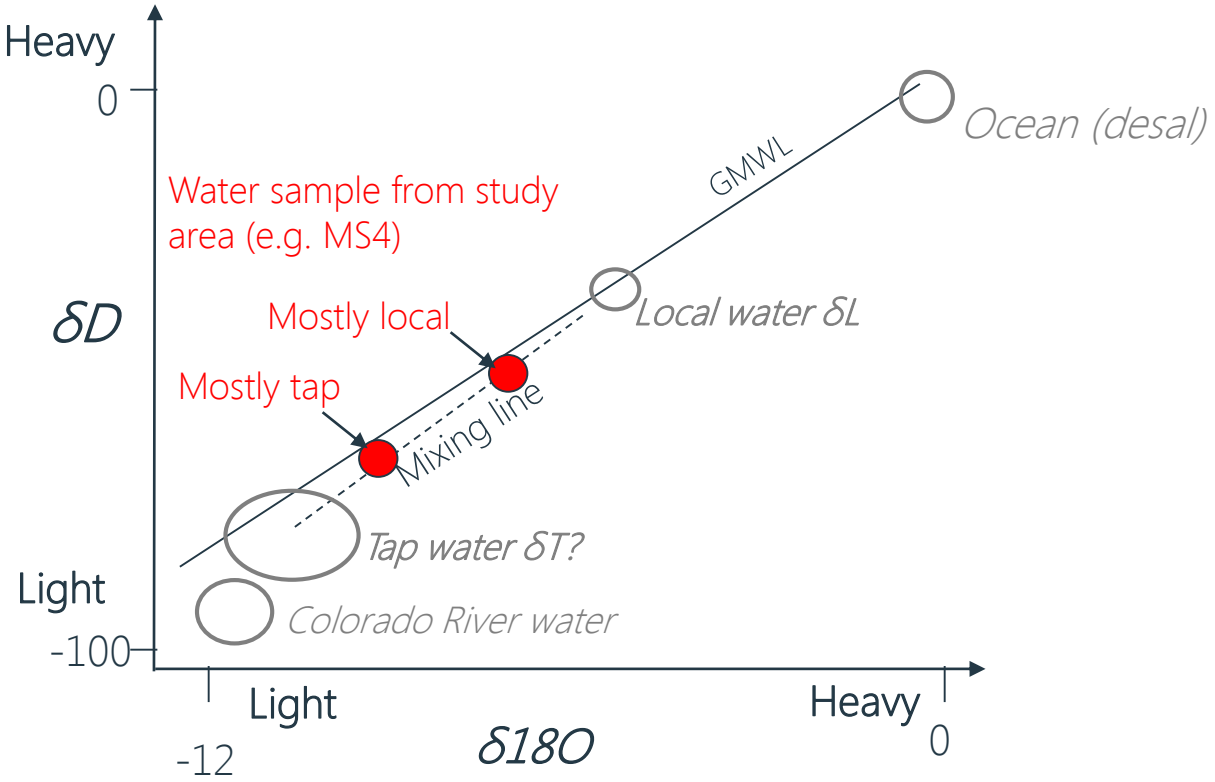

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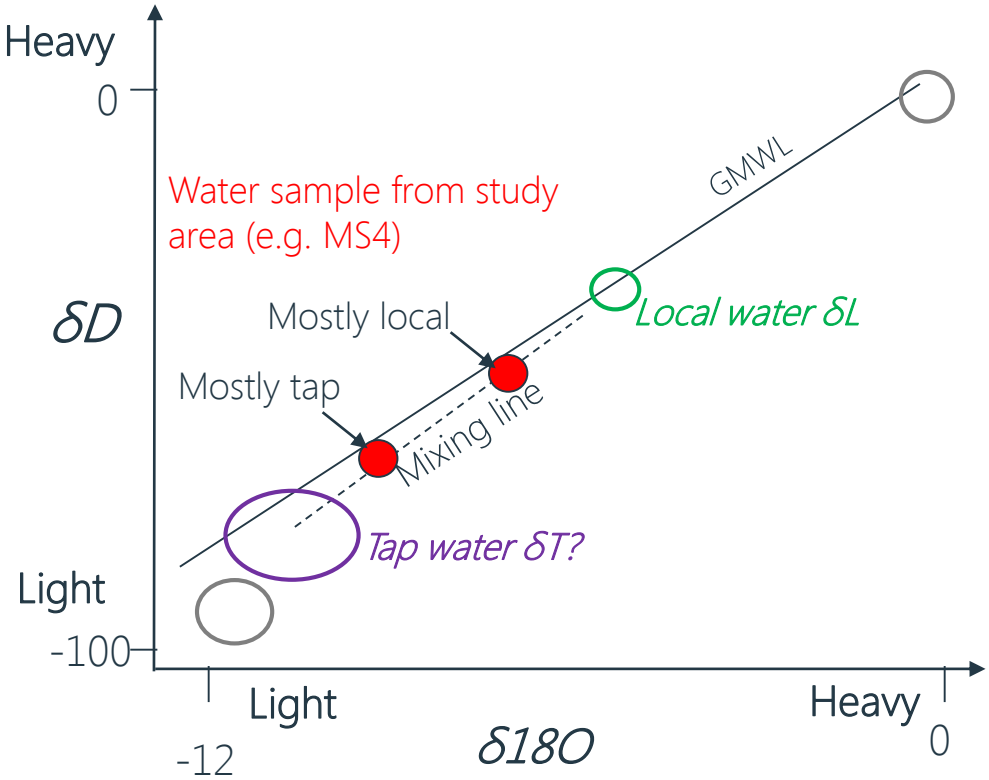



**%TAP=100 x (δS - δL) (δT-δL)**

%TAP = percent tap water

δL = δ18O of local water

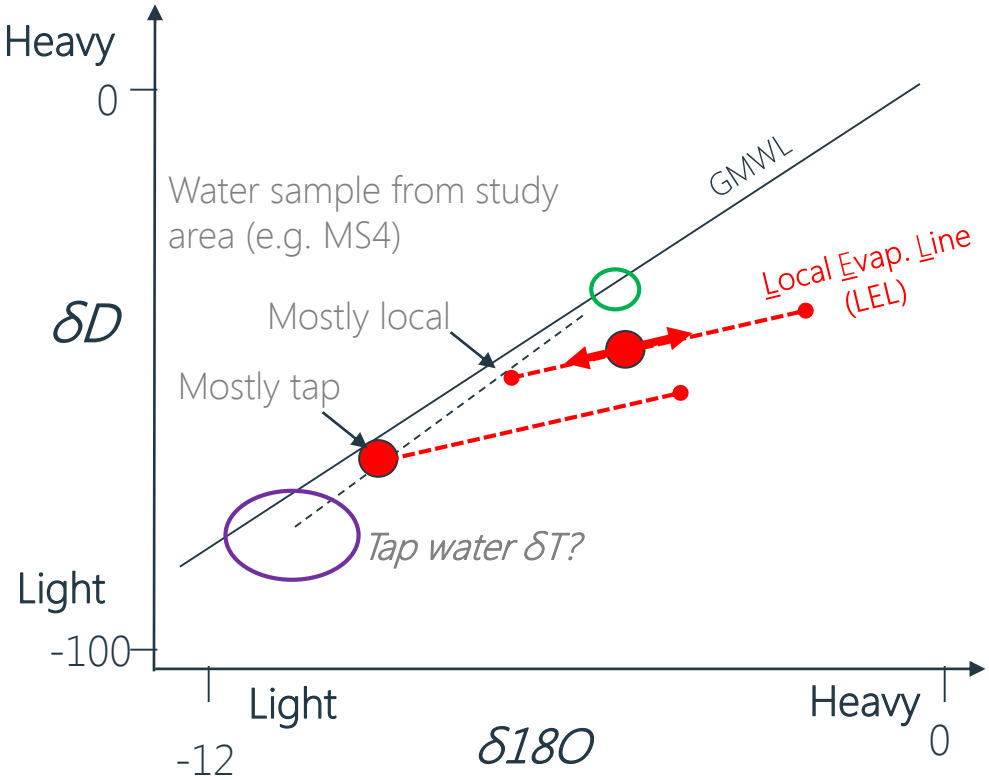
δS = δ18O of sample

δT = δ18O of tap water

# Analytical Approach (cont)

## Isotopic End-Member Mixture Analysis (IEMMA)

## ....with Evaporation




Local Evaporation Line from literature, Temp/Humidity

**%TAP=100 x (δS - δL) (δT-δL)**

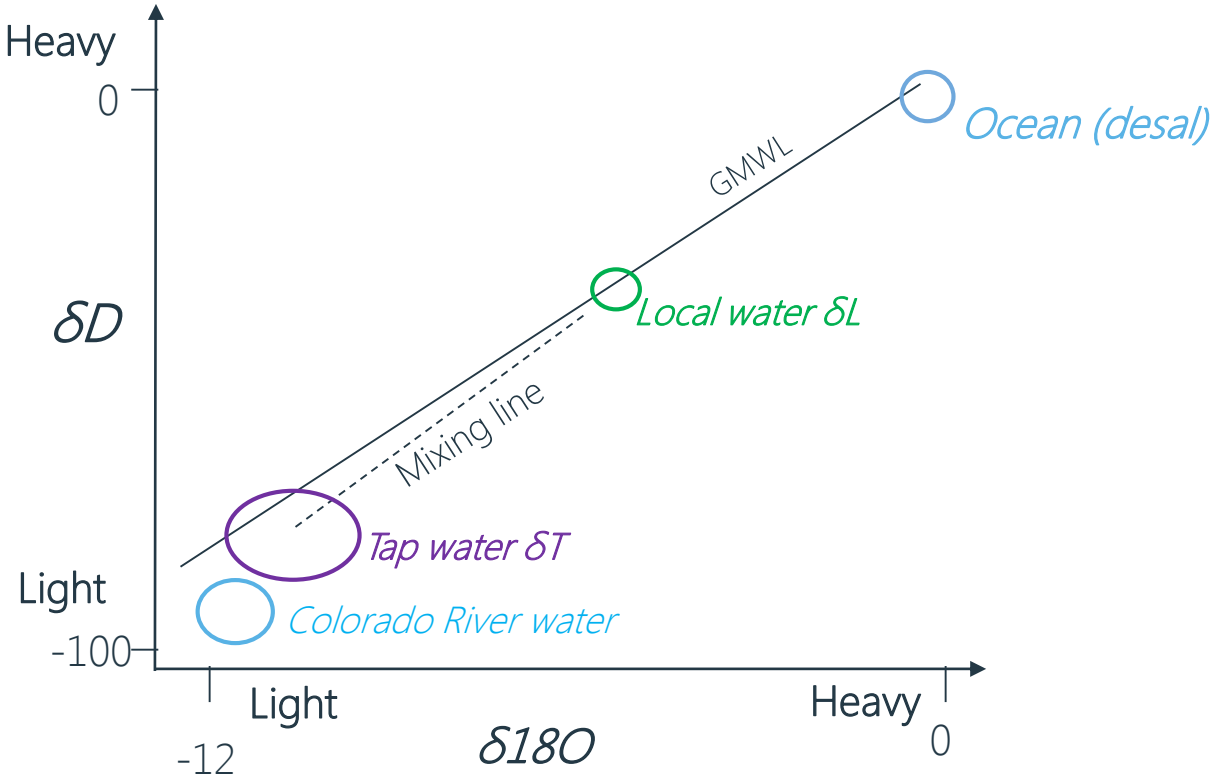
%TAP = percent tap water

δL = δ18O of local water

δS = δ18O LEL/MixLine

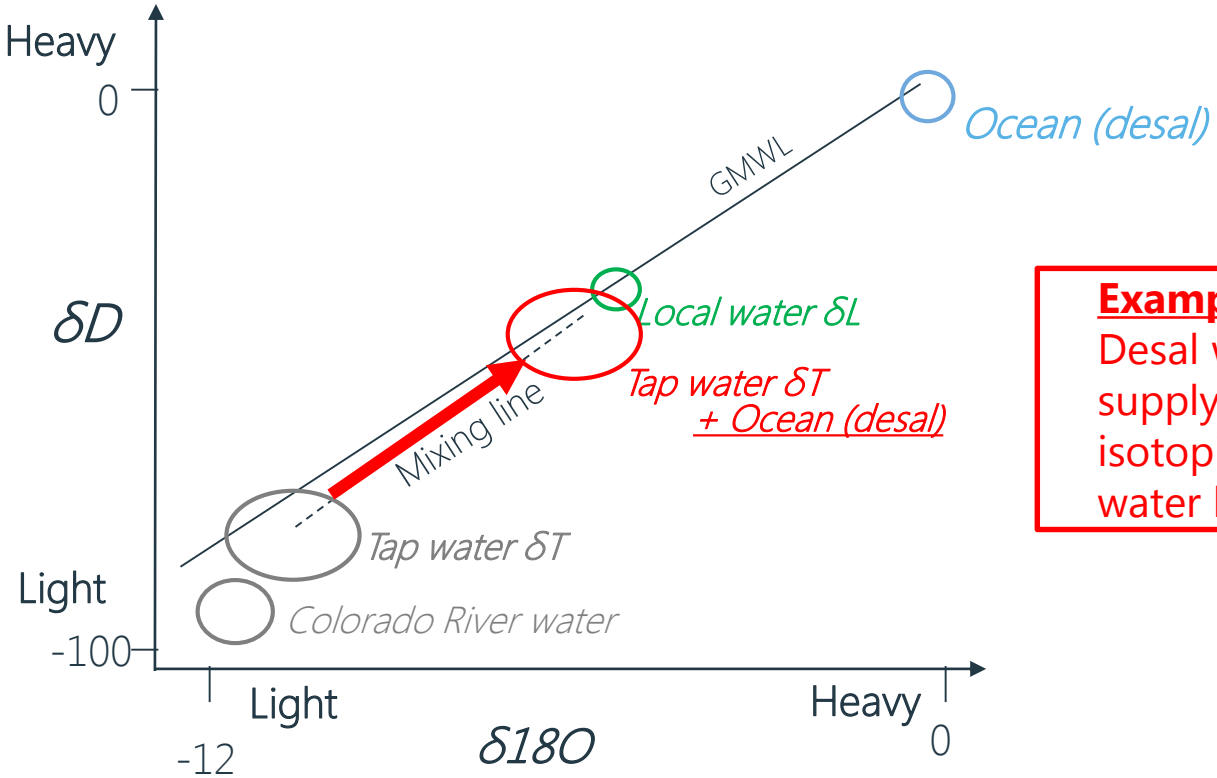
δT = δ18O of tap water

# Where might IEMMA *not* work?



# Where might IEMMA *not* work?

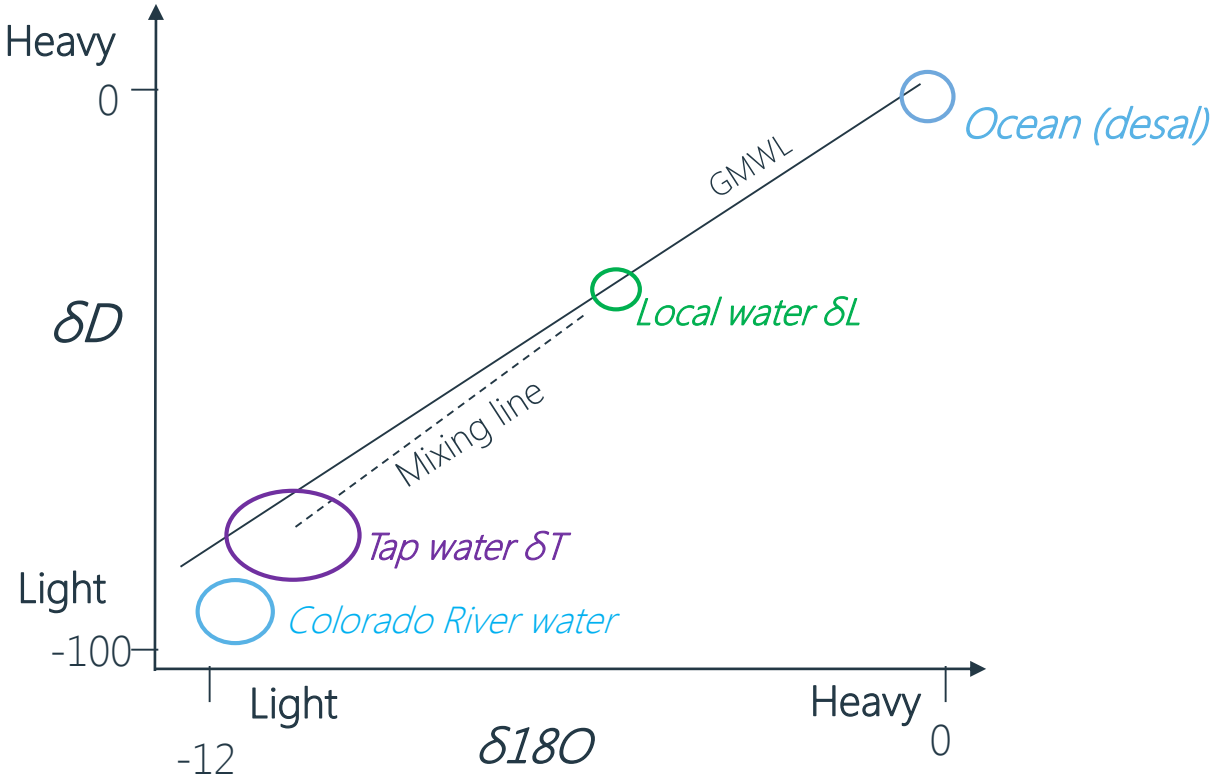
•Isotopic composition of **Tap (δT) too similar to Local (δL)**




**Example**
Desal water added to water supply will shift Tap water to isotopically resemble Local water by enriching 18O and D

# Where might IEMMA *not* work?

- Isotopic composition of Tap (δT) too similar to Local (δL)
- **Spatial or Temporal variability** in Water District



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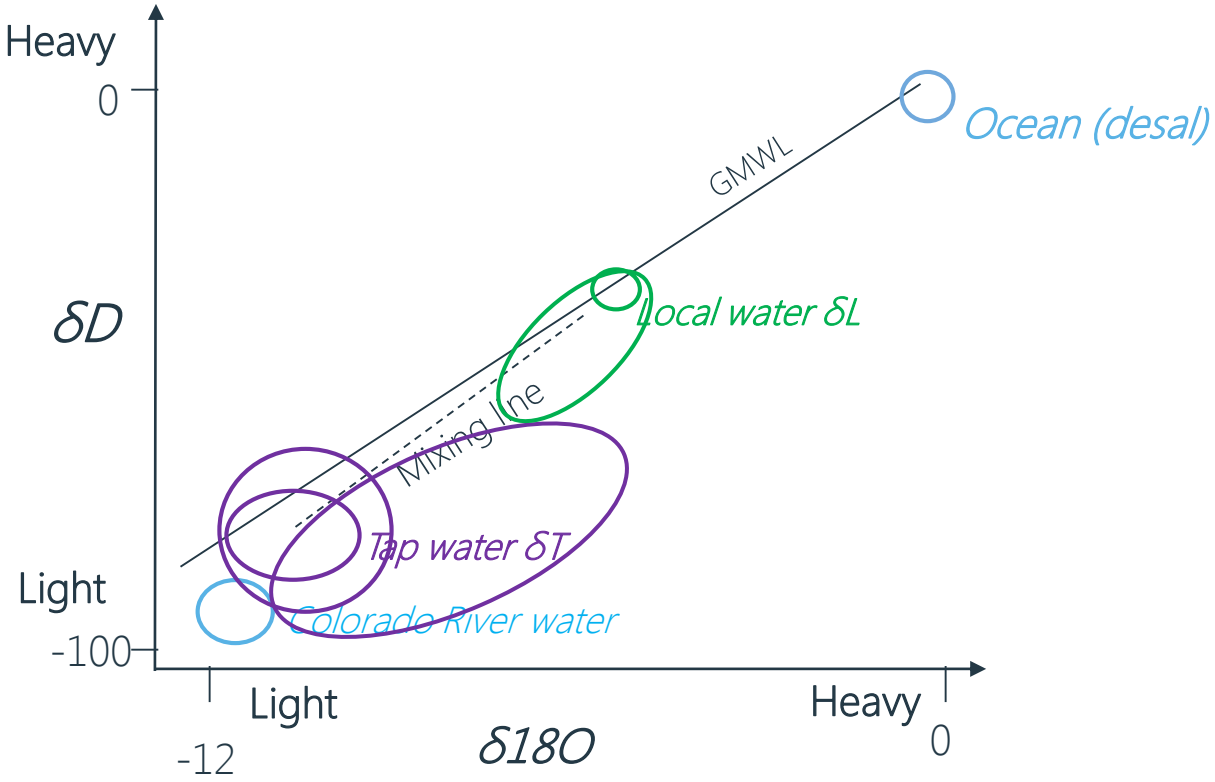
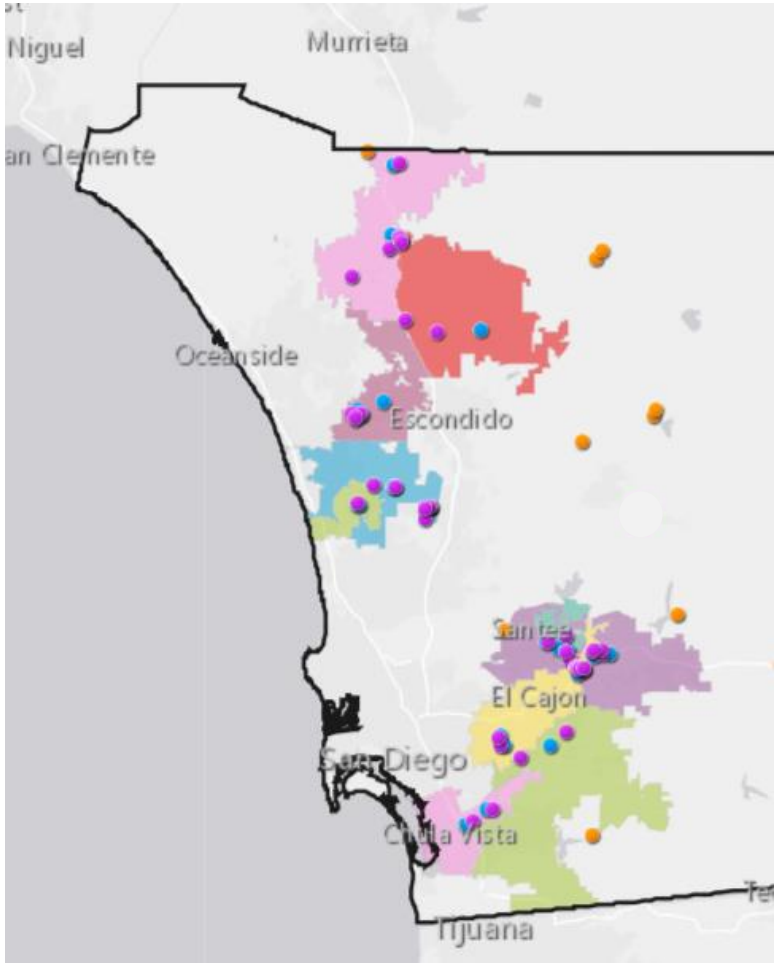


# Research Questions

1. **Do Local and Tap end-members vary in space and time?**

2. **Are Local and Tap end-members isotopically different enough for IEMMA?**

3. **What fraction MS4 discharge is Local water vs Tap water?**

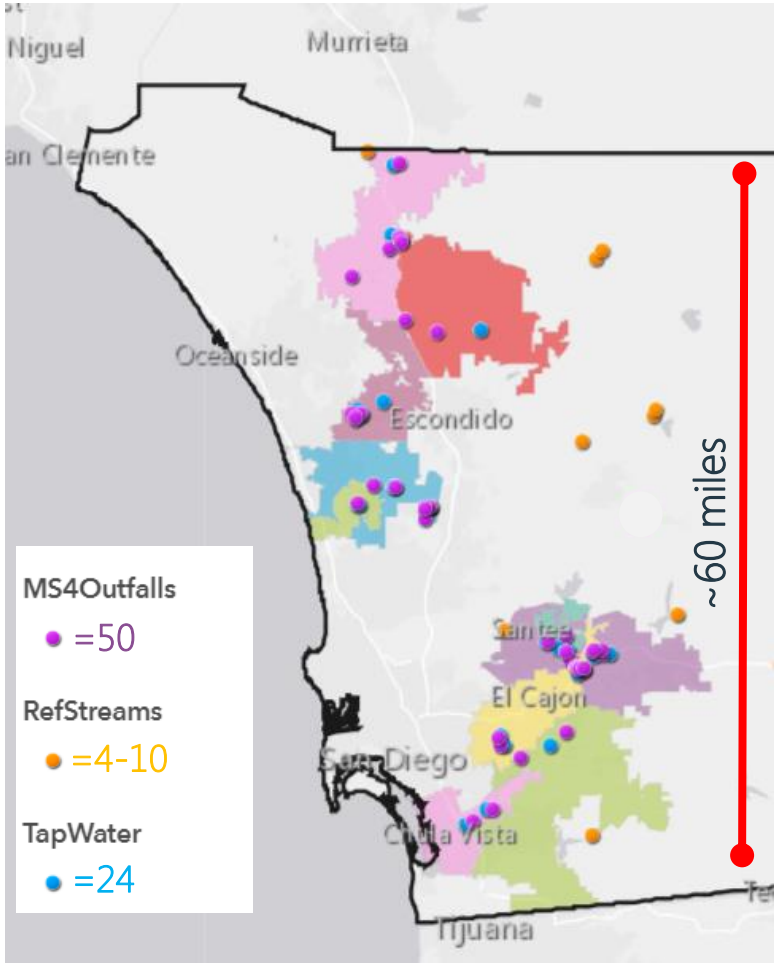


# Sampling Design

- **Sampling May 1-Oct 1, 2018**
- **50 MS4 outfalls sampled in May, Aug, Oct (n=3)**
- **20 Priority MS4 sampled bi-weekly (n=10)**
- **4-10 streams sampled bi-weekly (n=10)**
- **24 tap water sampled bi-weekly (n=10)**

## Study Sites

10 water districts sampled



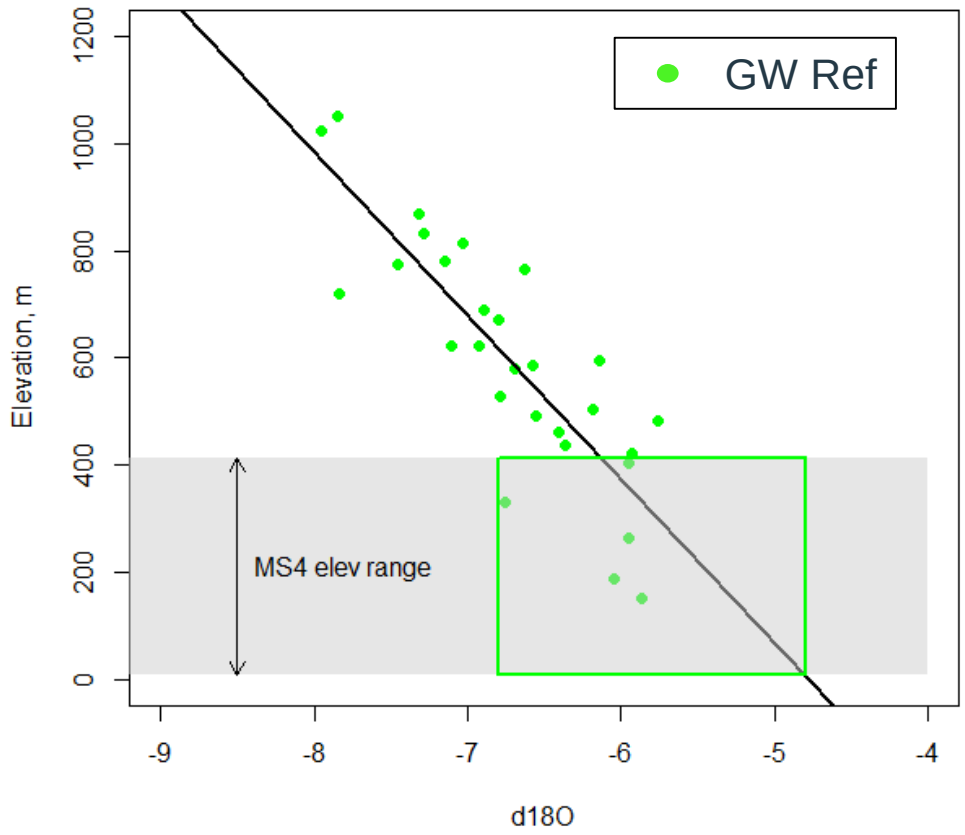
# Q1: Do Local and Tap end-members differ isotopically in SPACE and time?

## Local endmember values vary with elevation (space)…

Local water at high elevations can be similar to Tap water…

…not as good for reference….

… but hard to find good reference sites at lower elevations



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→ Need to calculate "Elevation-specific" local reference (*δL)* based on regression and/or mean or range of low-elevation sites

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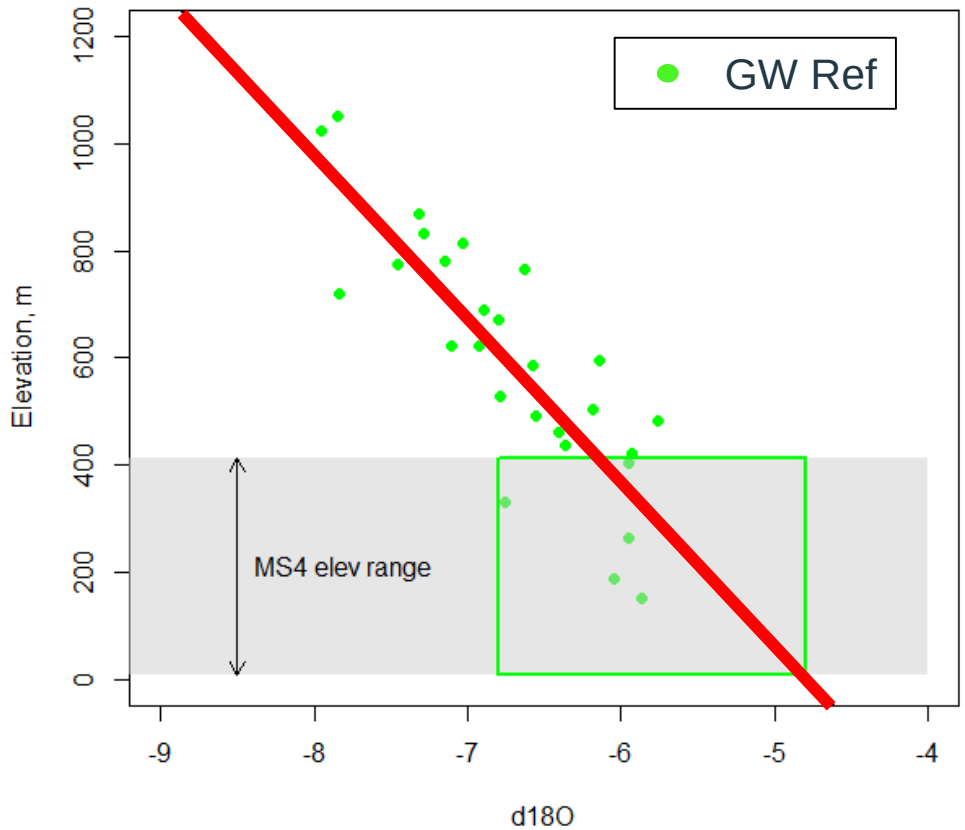

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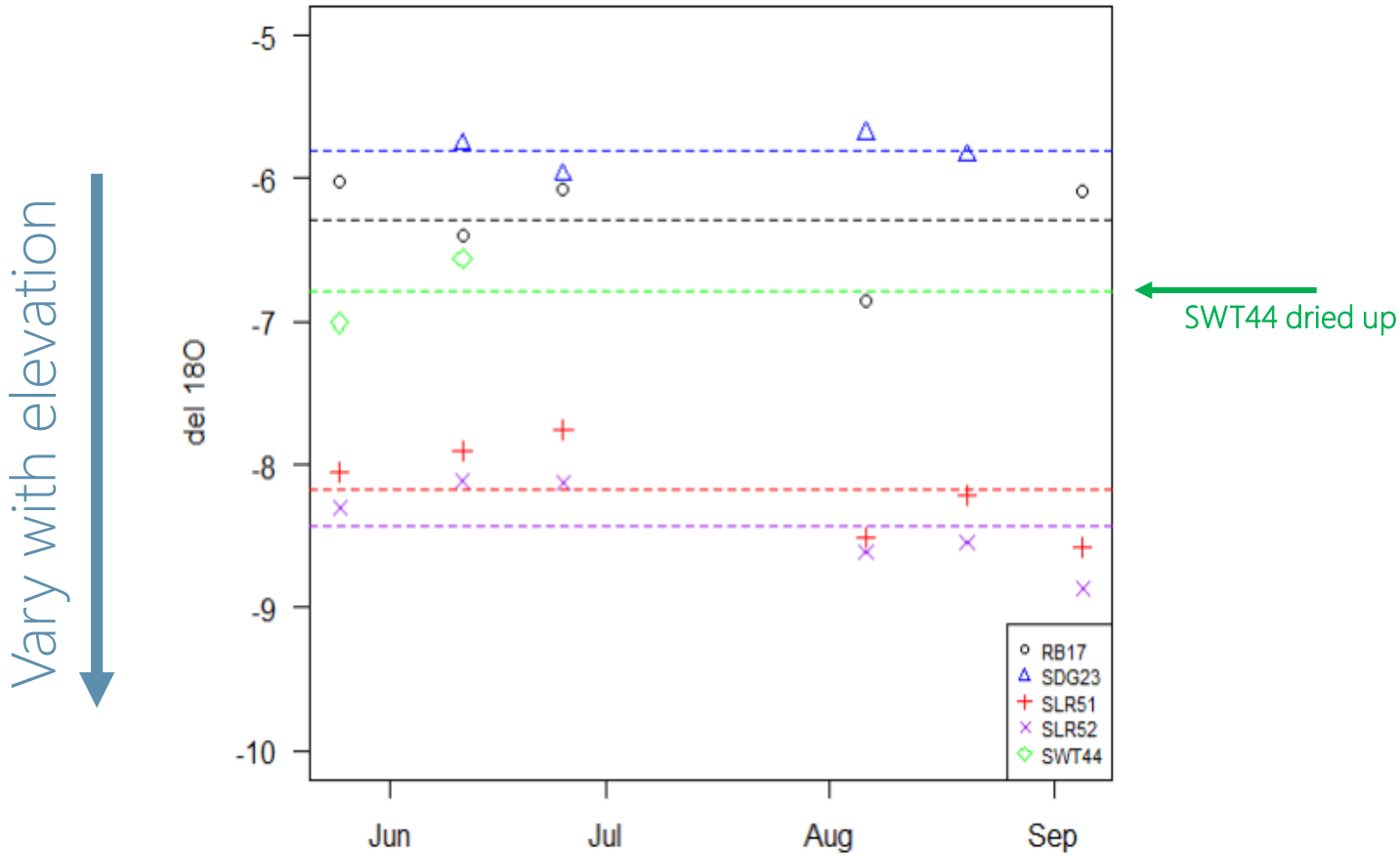
## ...but Local water endmembers are mostly stable over time



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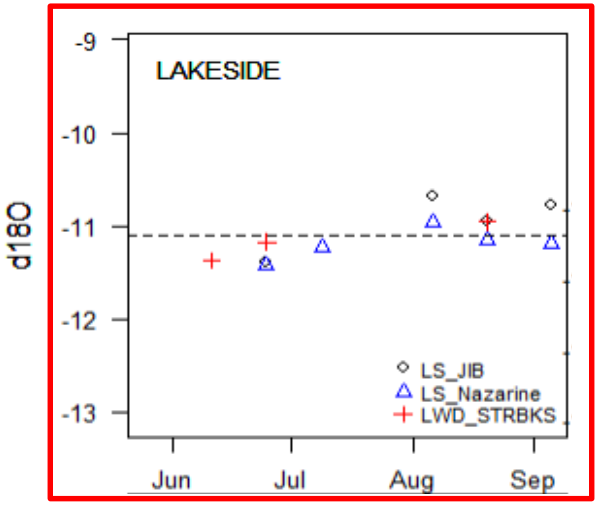

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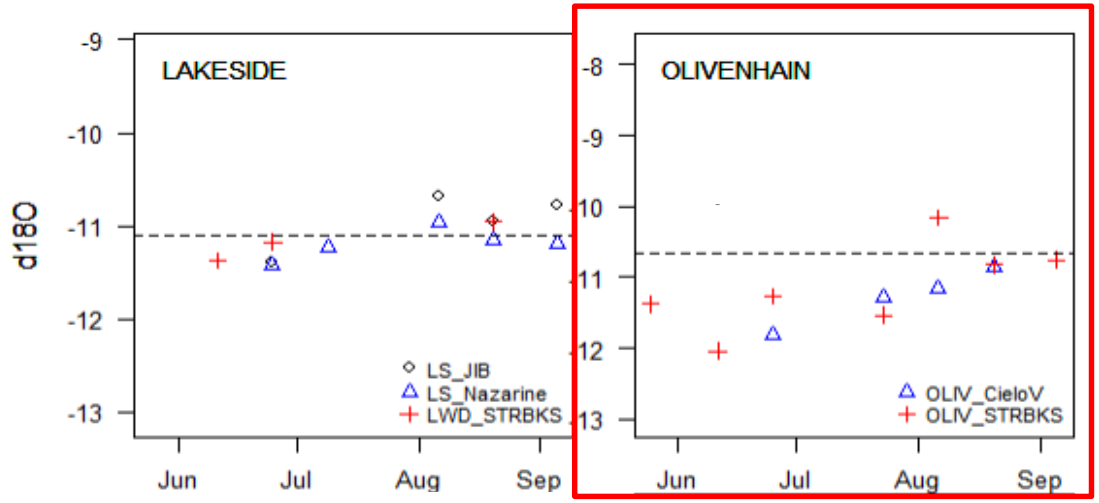

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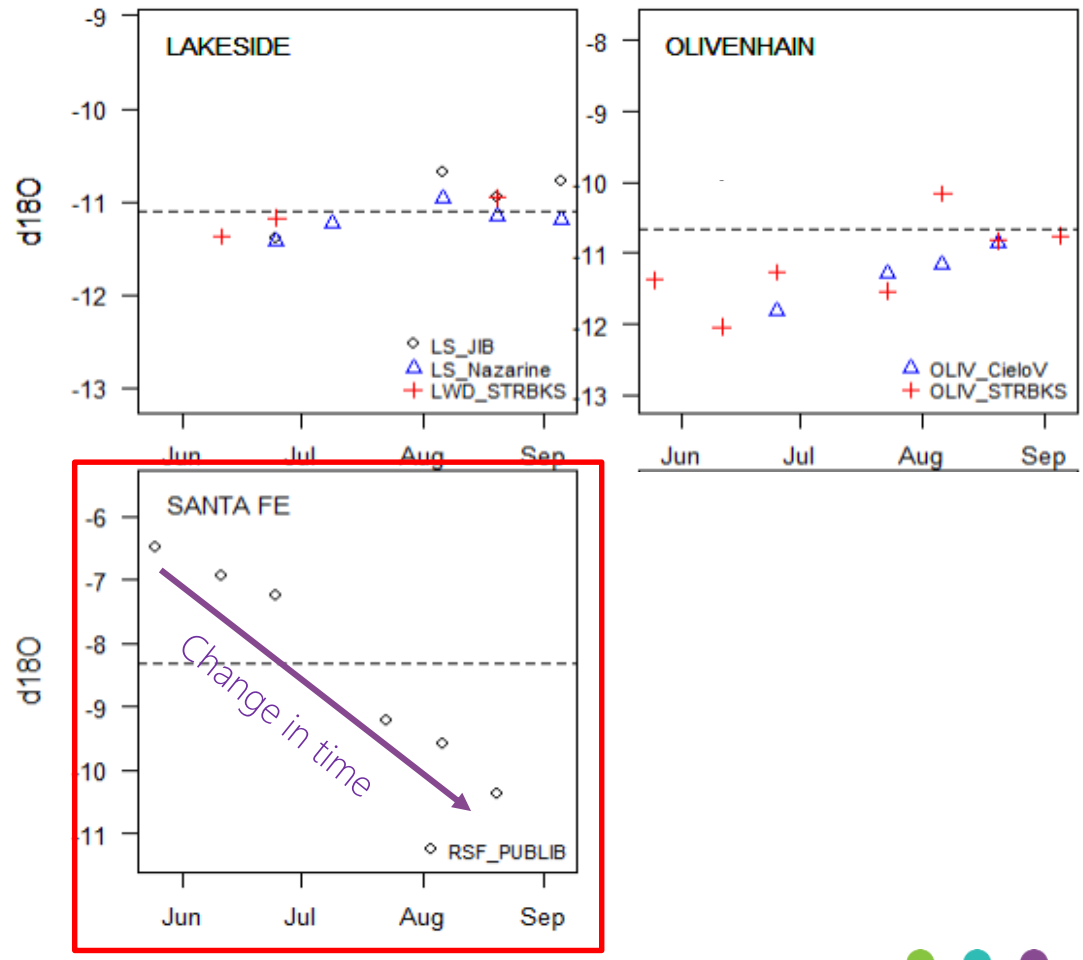

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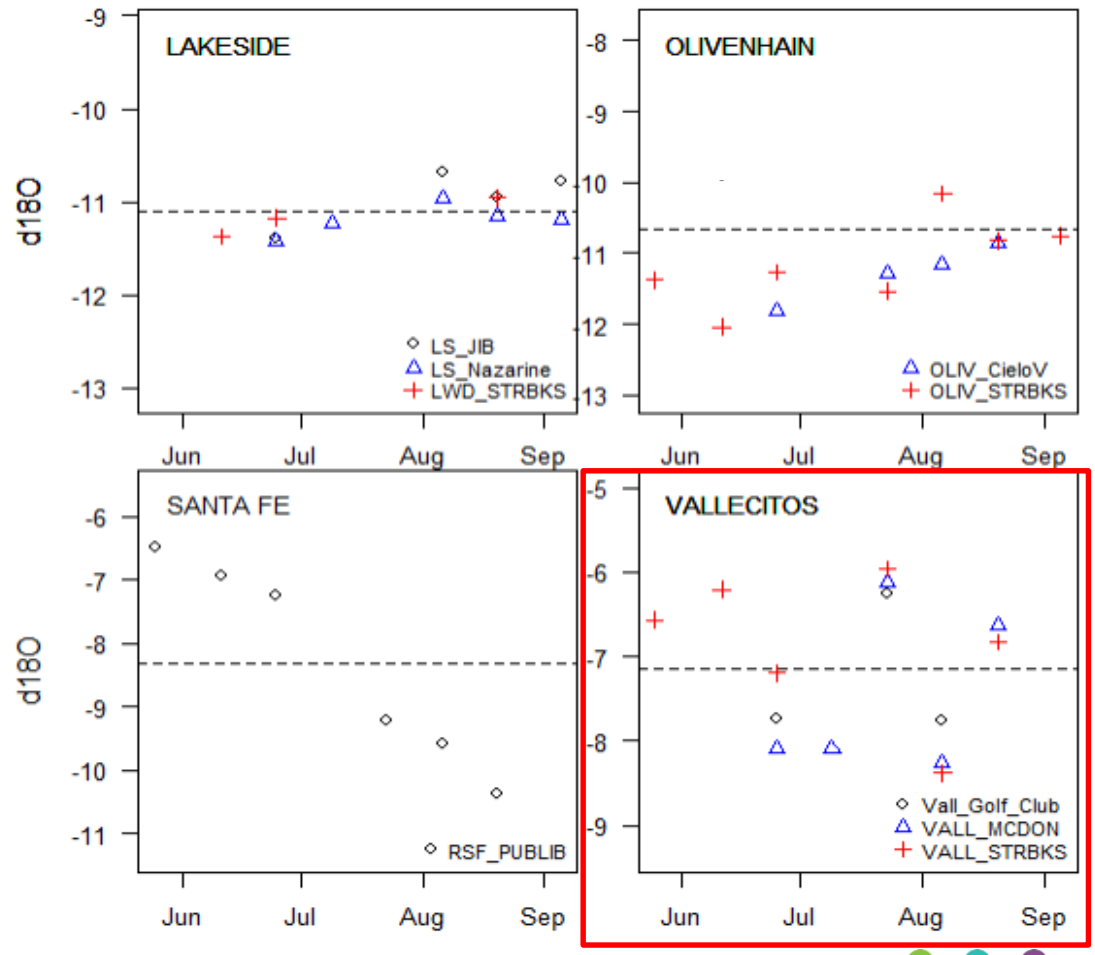

# Q1: Do Local and Tap end-members differ isotopically in space and time?

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→ Is the variability important for calculation of %TAP?

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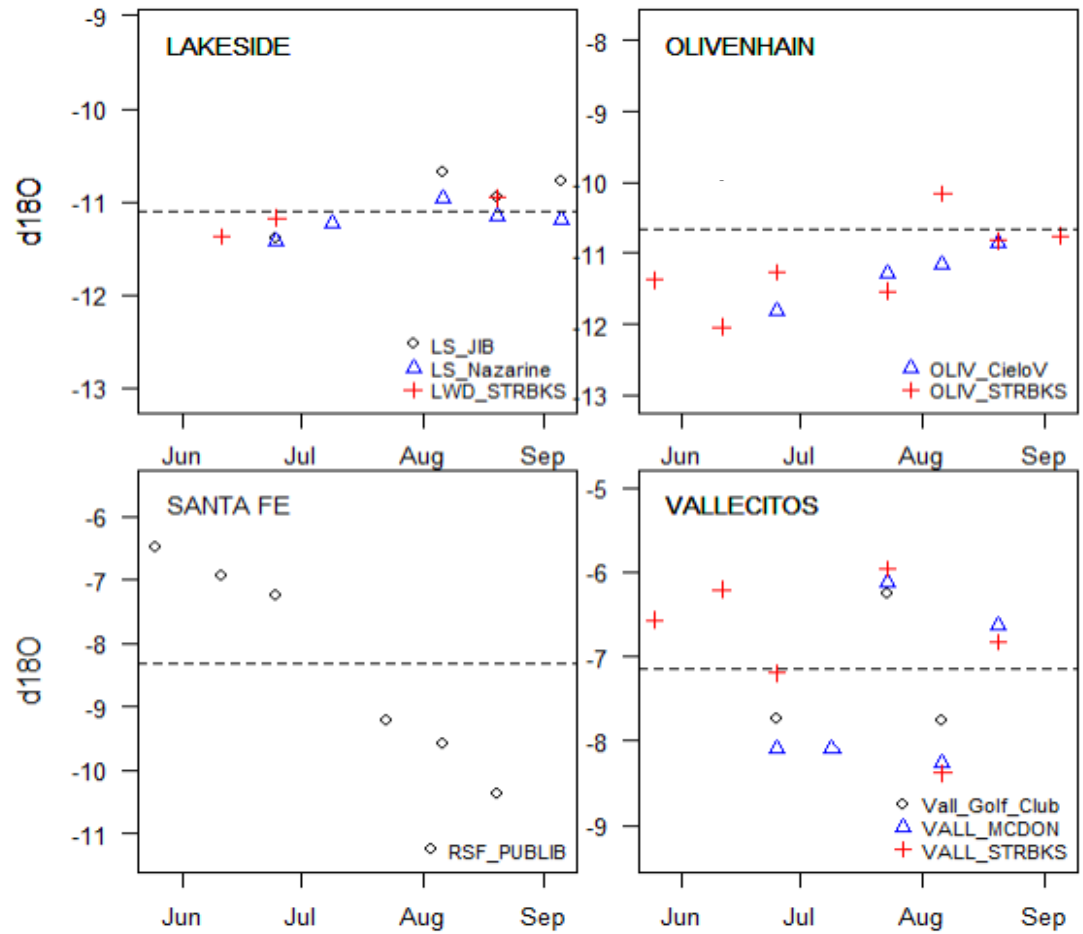
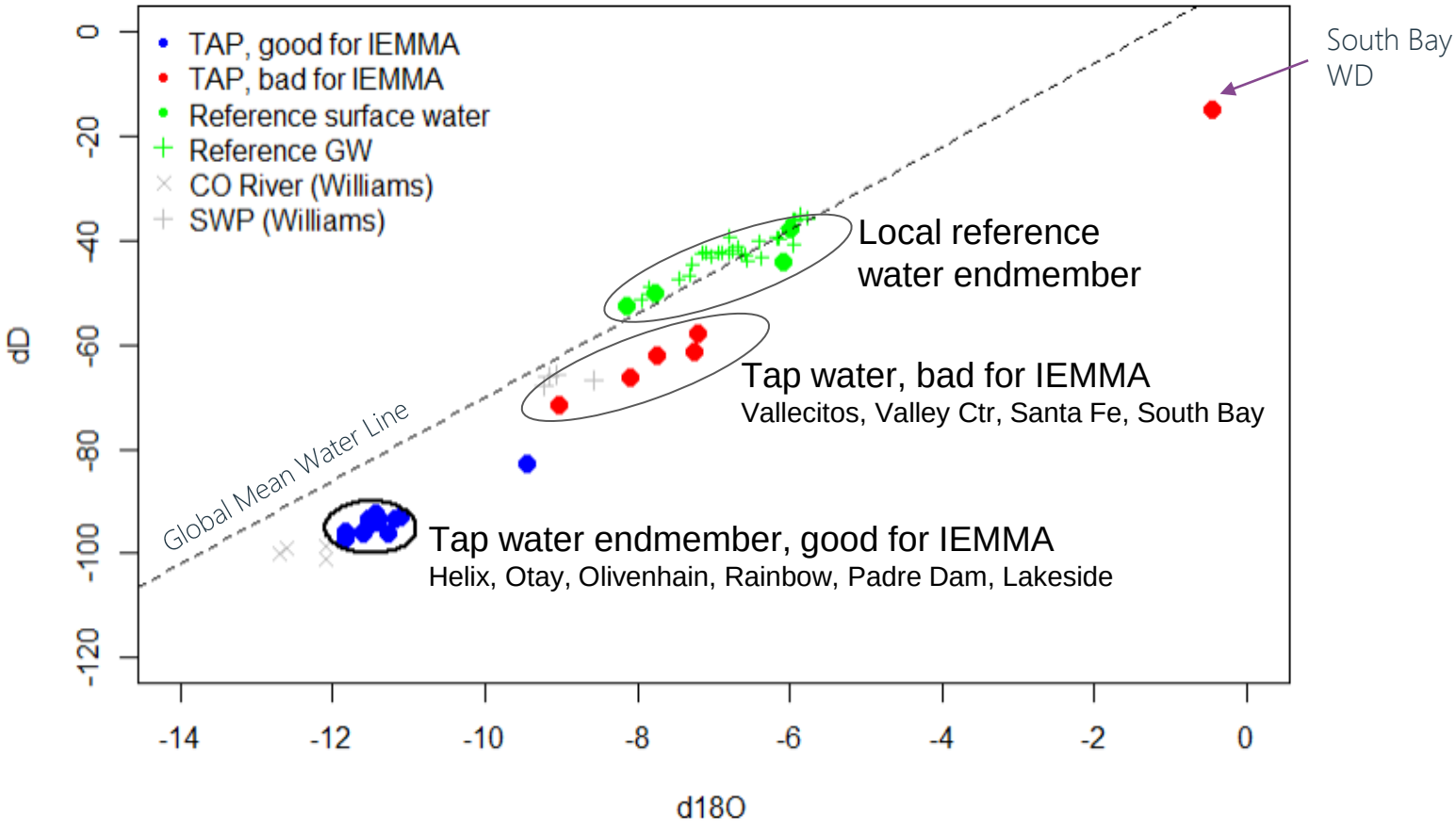


# Q2: Are Local and Tap end-members isotopically different enough for IEMMA?

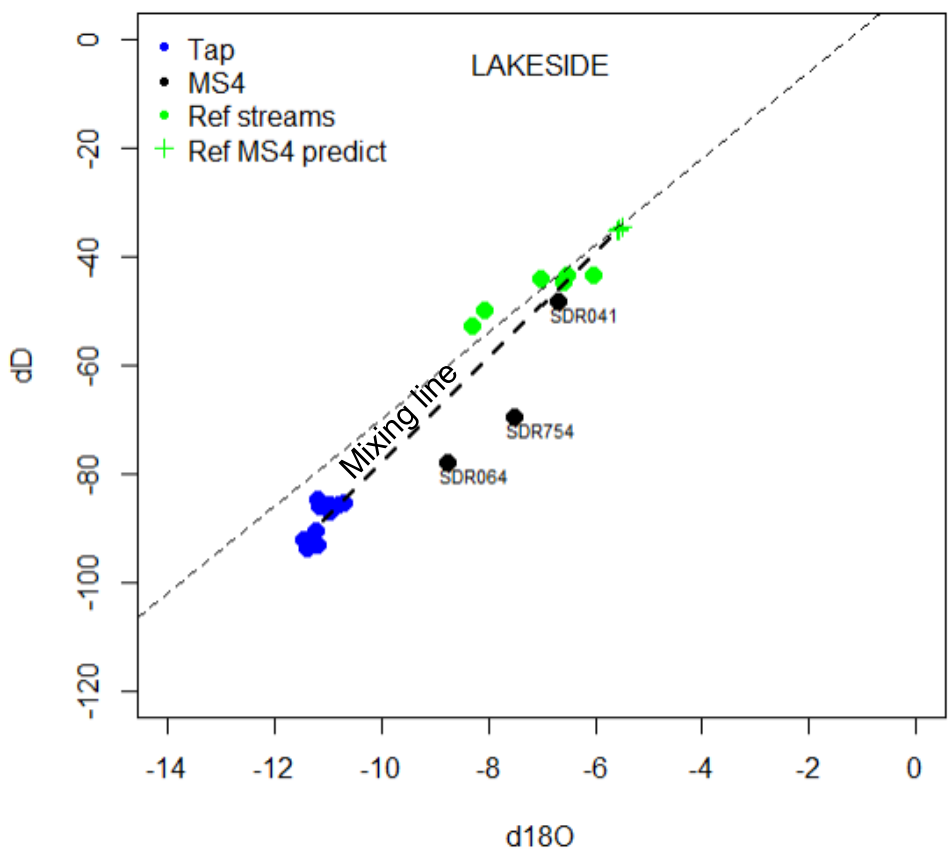
## Answer: Yes *and* No

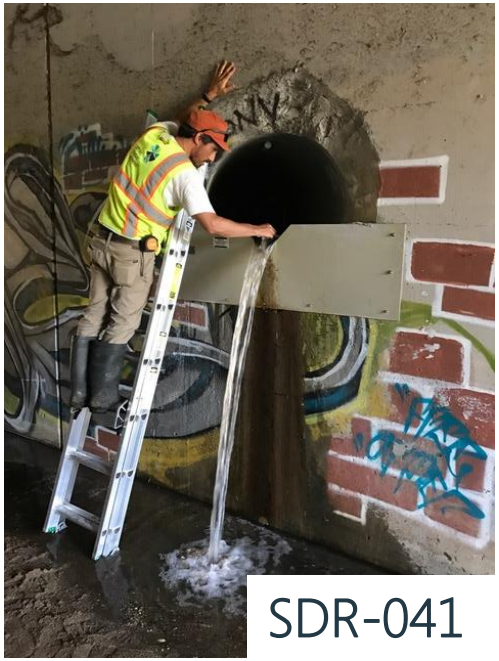
6 water districts good (blue), 4 districts moderate/bad for IEMMA (red)



# Q3: What fraction MS4 discharge is local water vs tap water?

## Tap water % (no evaporation)



SDR-041

SDR-064

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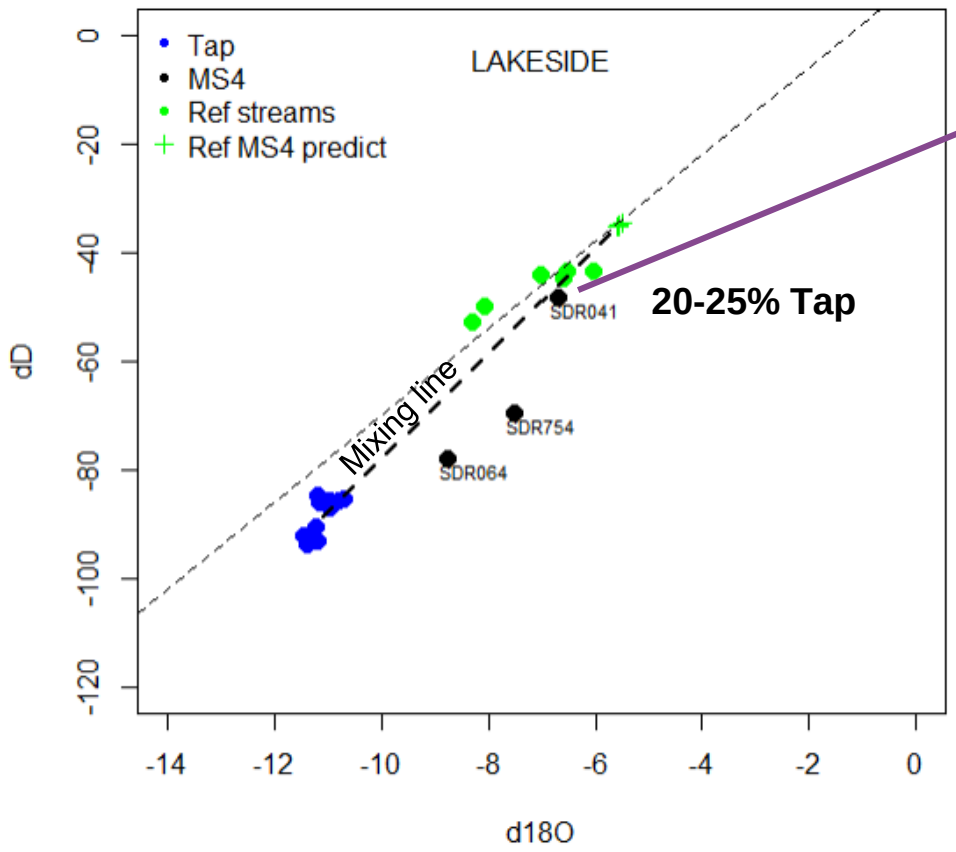


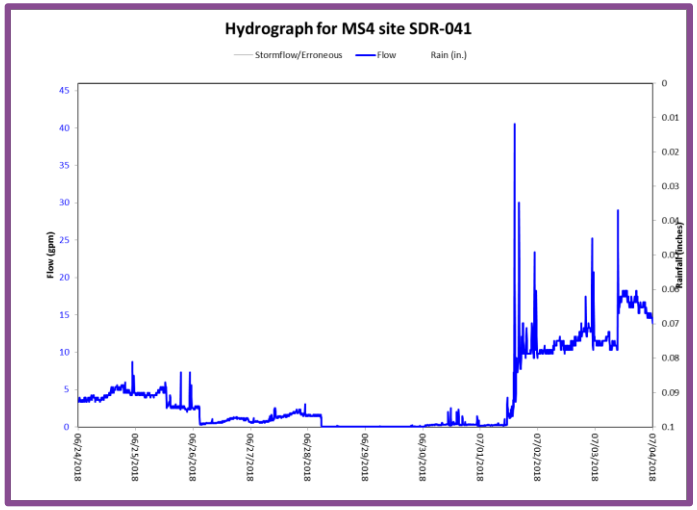


Some sharp peaks,
also some Low-Moderate baseflow

Indicates local water intrusion

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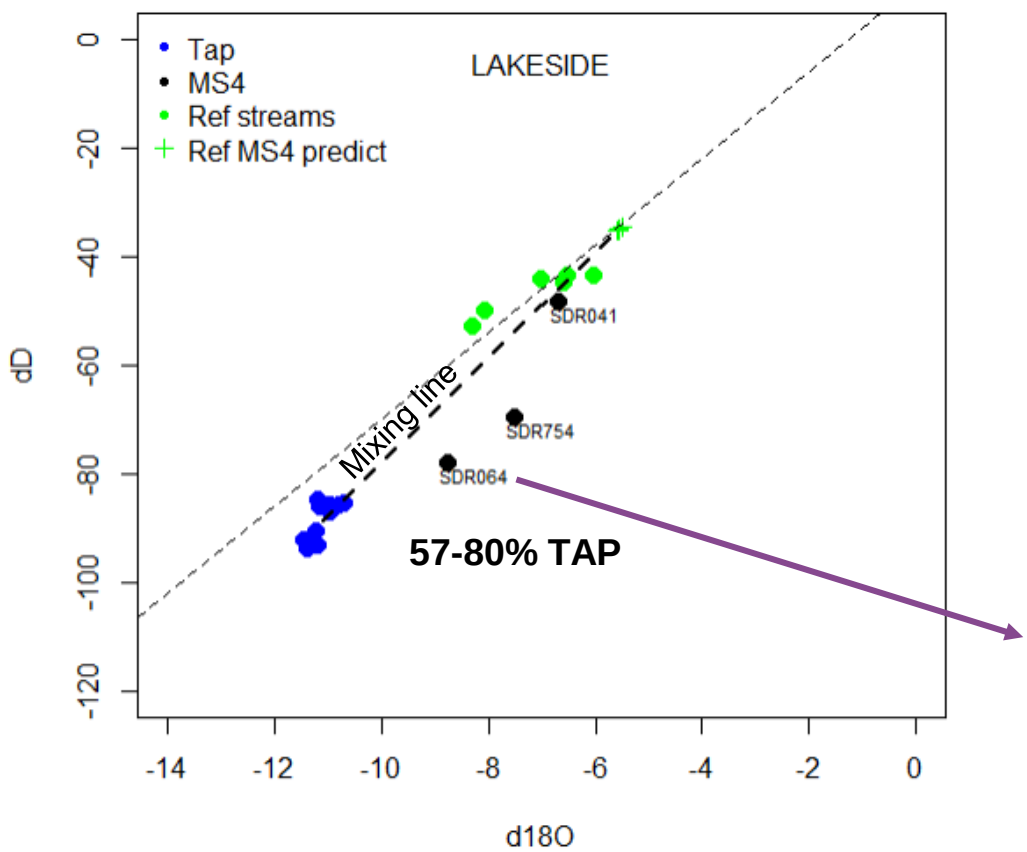


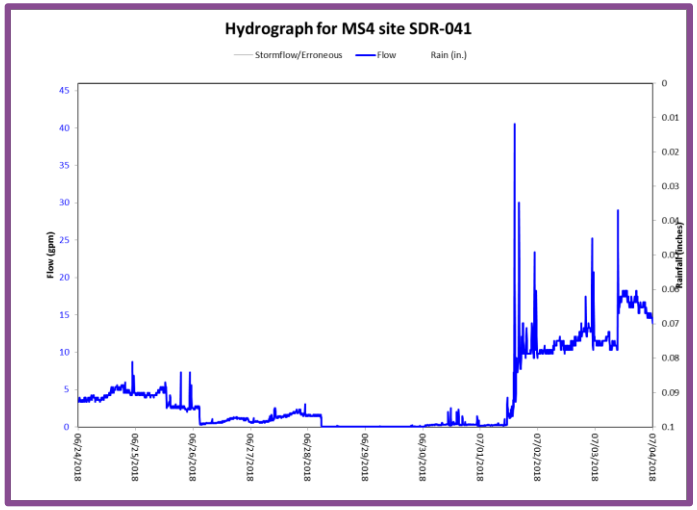


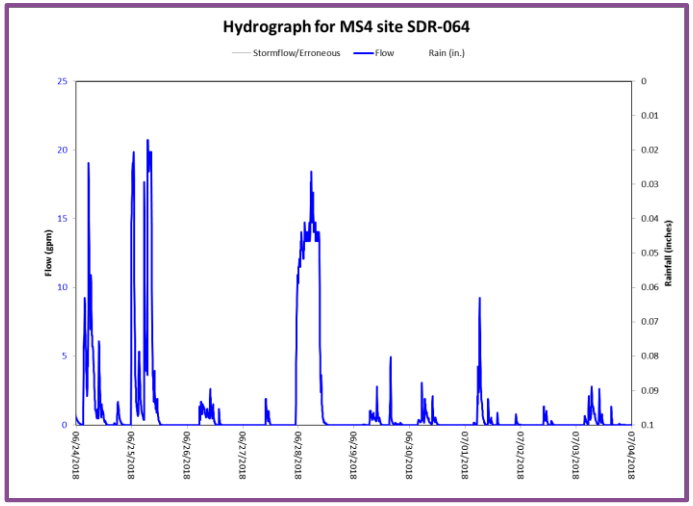

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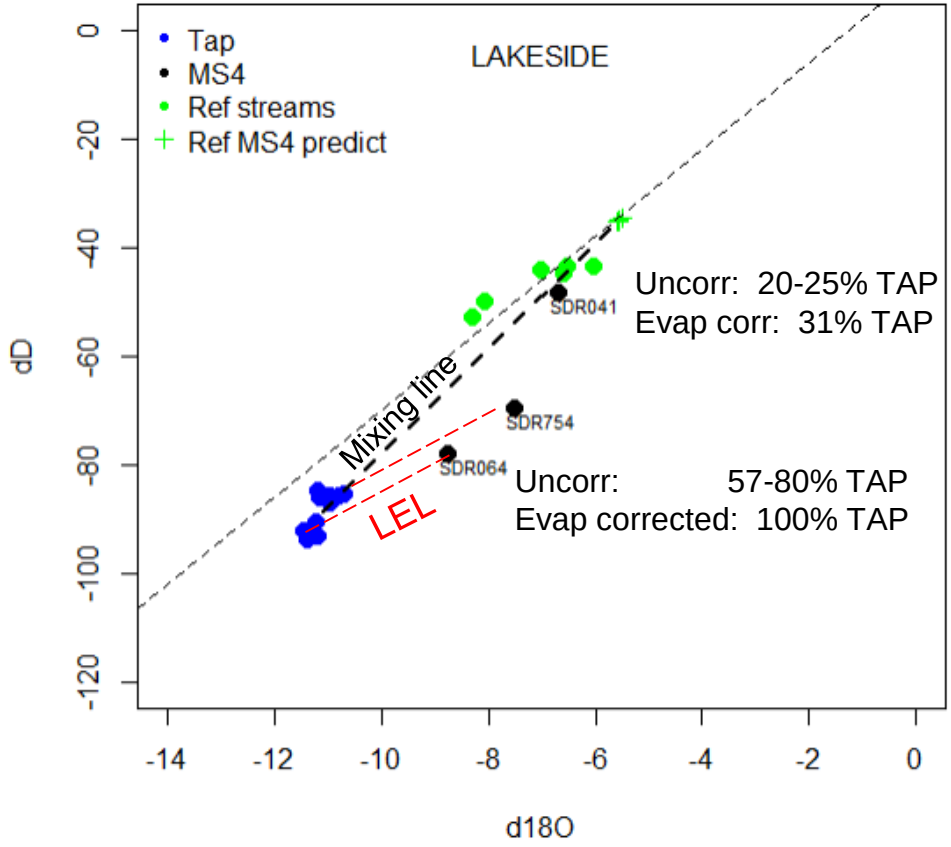


**LEL** = **L**ocal **E**vaporation **L**ine

Corrects for evaporative enrichment of 18O (lighter O16 evaporates)

Shows SDR-064 is 100% TAP

LEL correction introduces uncertainty

# Conclusions

## Research Questions

1. Do Local and Tap end-members vary in space and time?

   Local reference samples varied:

   a) Space: Yes, predictable with elevation
   b) Time: No

   → Need reference sites at same elevation as sites of interest, biweekly

# Conclusions

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   a) Space: Yes, predictable with elevation
   b) Time: No

   → Need reference sites at same elevation as sites of interest, biweekly

   Tap reference vary over:

   a) Space: among but (usually) not within water districts
   b) Time: for some districts. Reflects changing water supply?

   → 2-3 tap sites in each district ok, but need ~biweekly sampling

# Conclusions

## Research Questions

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2. Are Local and Tap end-members isotopically different enough for IEMMA?

   Local and Tap endmembers sufficiently different

   → calculate % TAP in 8/10 districts

   → 40/50 MS4 sites are in good/moderate water districts

# Conclusions

## Research Questions

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2. Are Local and Tap end-members isotopically different enough for IEMMA?

   Local and Tap endmembers sufficiently different

   → calculate % TAP in 6/10 districts

3. What fraction MS4 discharge is Local water vs Tap water?

   TAP % varies widely: 0-100%. Why?

wood.

# Thank you!

**<u>Special thanks to:</u>**
Wood field staff

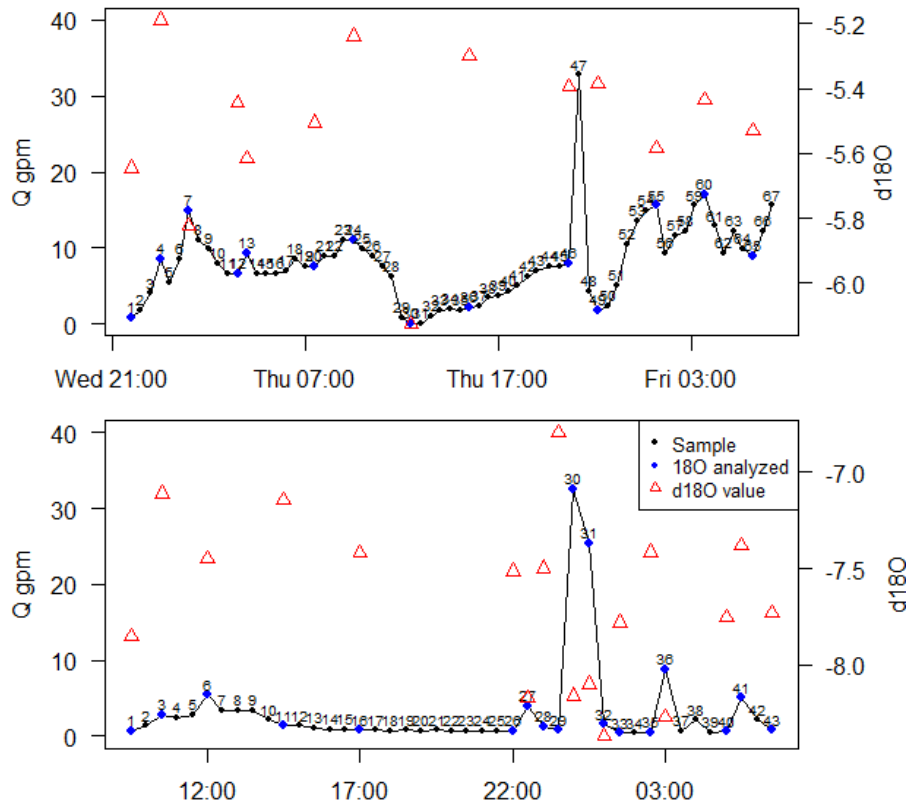
*County of San Diego:*
Joanna Wisniewska and Ryan Jensen

*San Diego State University:*
Dr. Trent Biggs, Dr. Chun-Ta Lai,
and Hannah Carney

# Some next steps

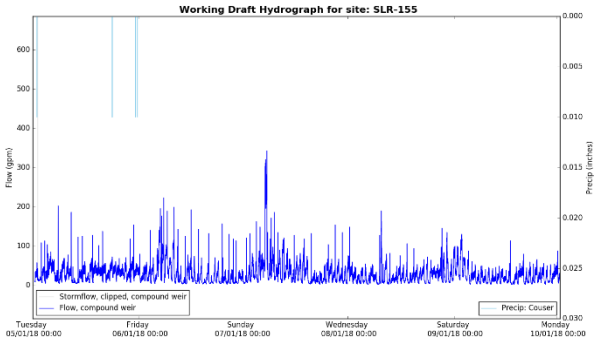
Autosampler at 2 sites

Not much correlation with flow?

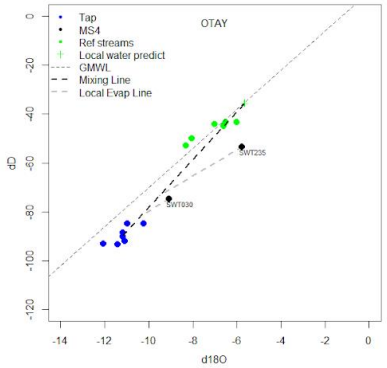


# Multiple Ordered Lines of Evidence (MOLE)

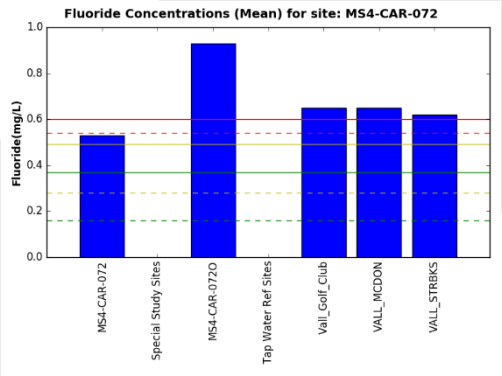
## 1. Flow Data

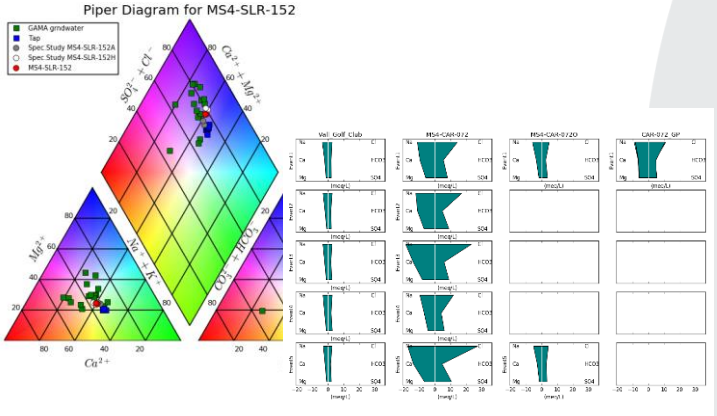



## 2. Isotopes




## 4. Indicators




**FLOW SOURCES?**

## 3. Geochemistry