Assessing Nitrate Contamination and Ground-Water Age Using Isotopic and other Chemical Tracers, Woodville Karst Plain

B.G. Katz[1]. A.R. Chelette[2], and T.R. Pratt[2]

[1]U.S. Geological Survey

[2]Northwest Florida Water Management District

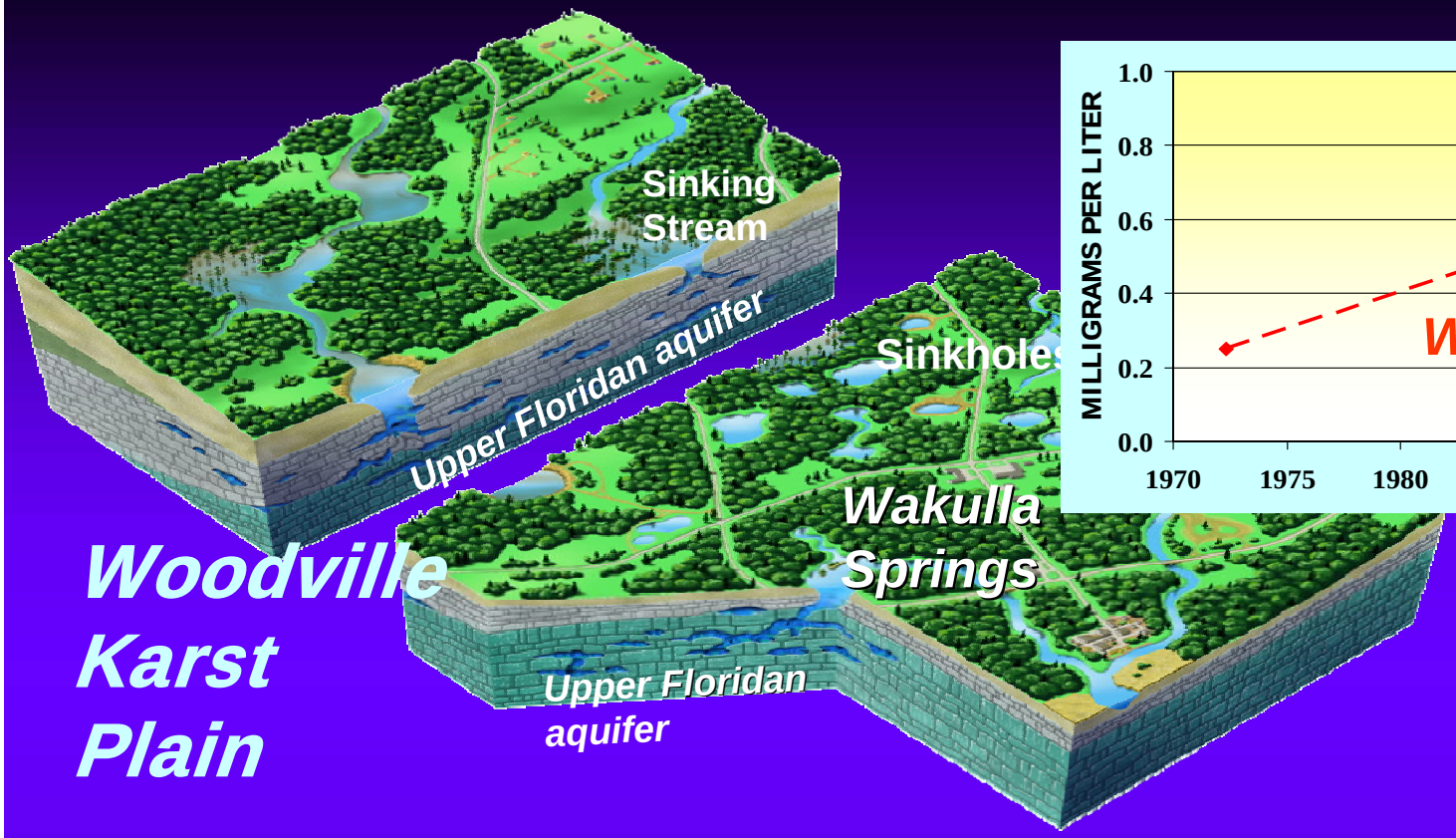
Wakulla Springs Scientific Symposium

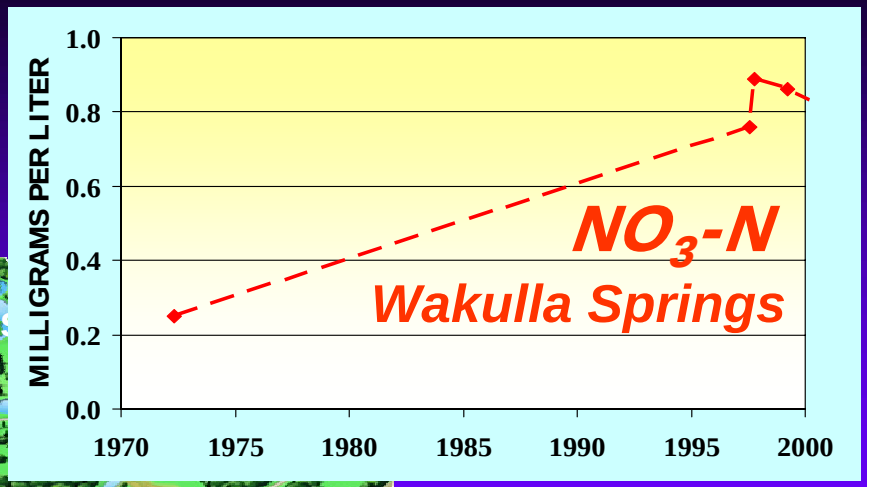
May 13, 2004

USGS

Northwest Florida Water Management District

N·W·F·W·M·D





Woodville Karst Plain

Multi-tracer approach--

-- Isotopic tracers to assess N sources,

-- $^3H/^3He$ and lumped parameter models to better understand ground-water transit times, and flow patterns in the karst plain.

USGS

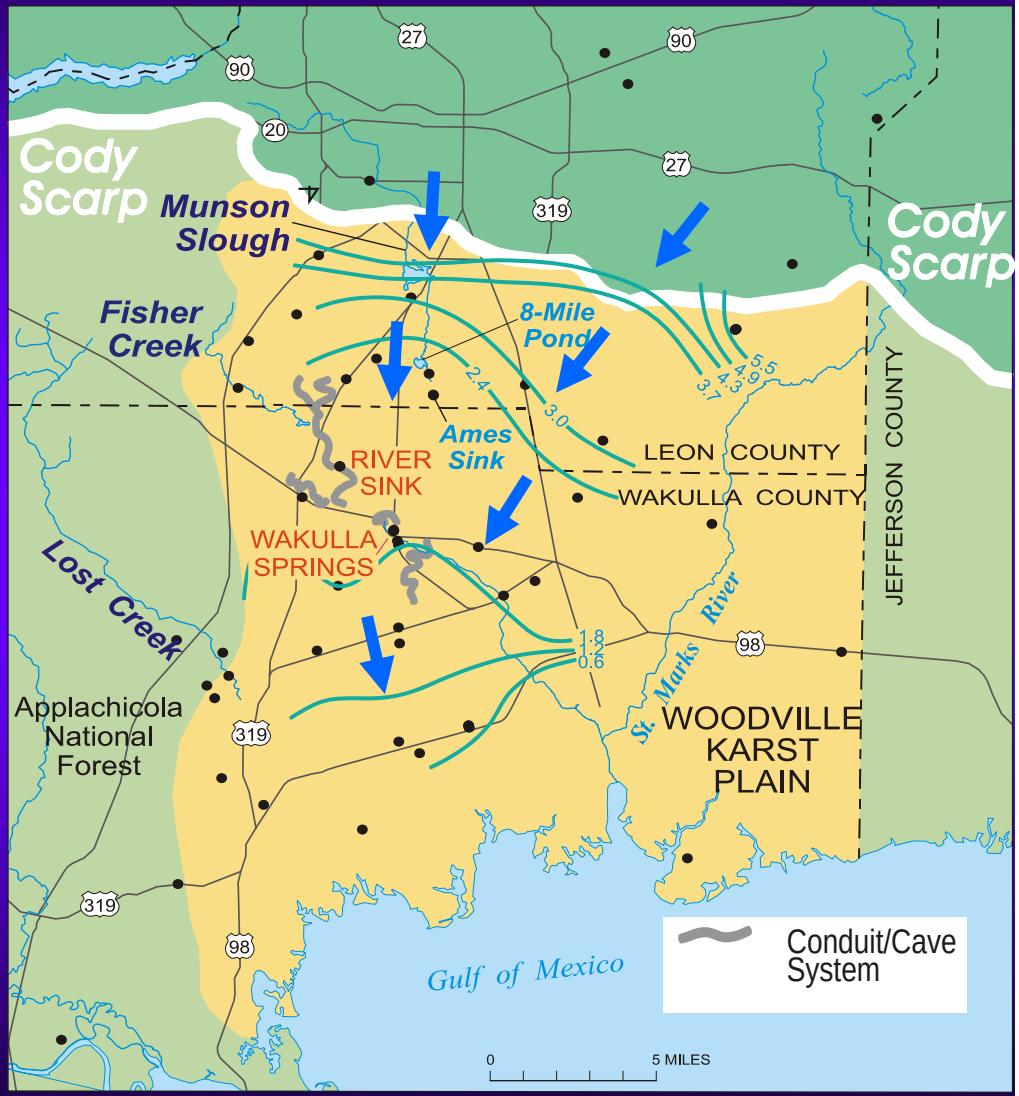
Samples collected (1997-2001)

45 wells, 4 springs, 3 sinking streams

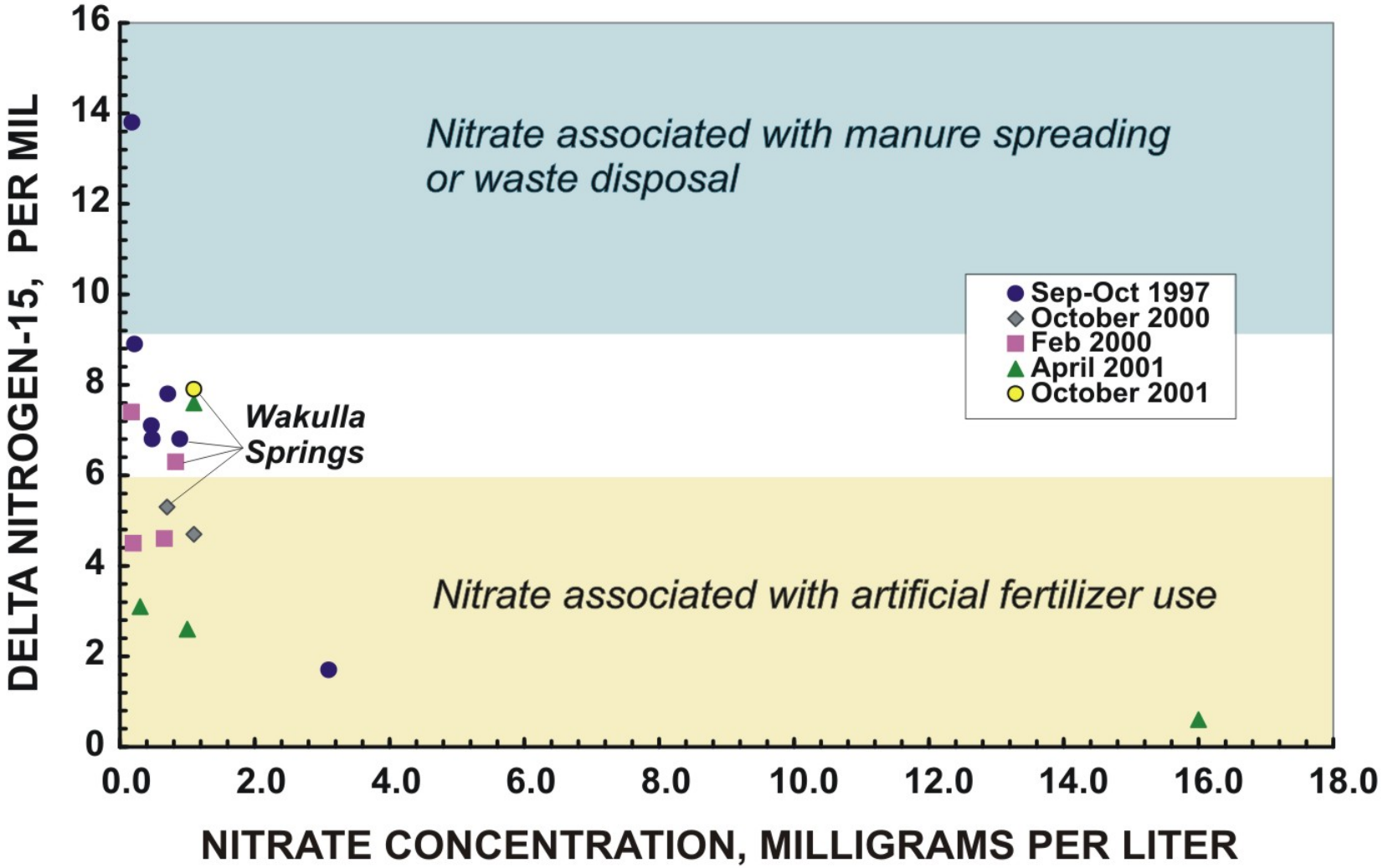
62 samples analyzed for major ions, nutrients, dissolved gases, DOC

Subset

32 stable isotope analyses
18 $^{3}H/^{3}He$ analyses

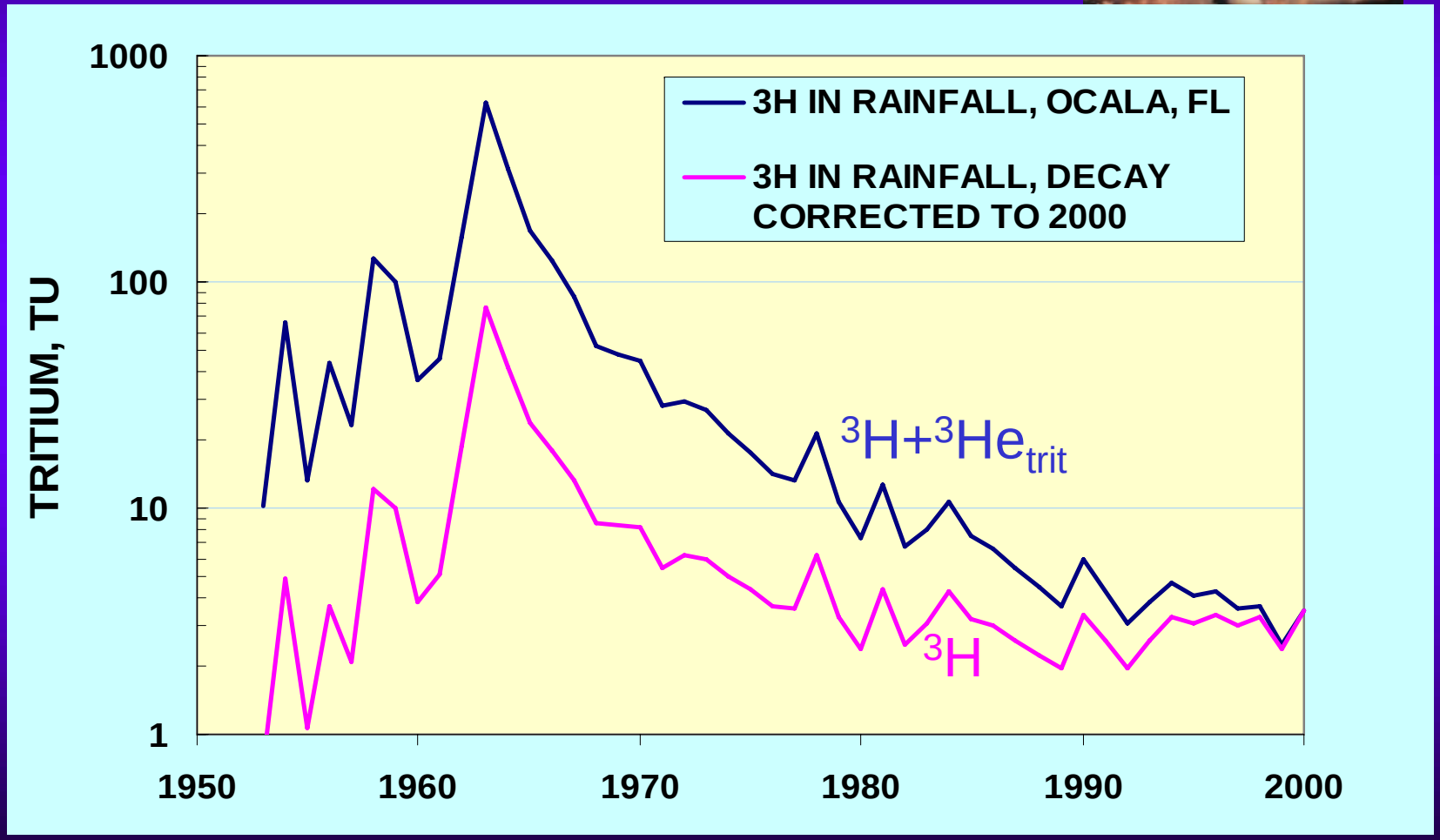


Sources of nitrate in ground water and springs, Woodville Karst Plain



USGS

Tritium in Rainfall, Ocala, FL (IAEA site)



USGS
science for a changing world

$^3H/^3He$ Dating Method

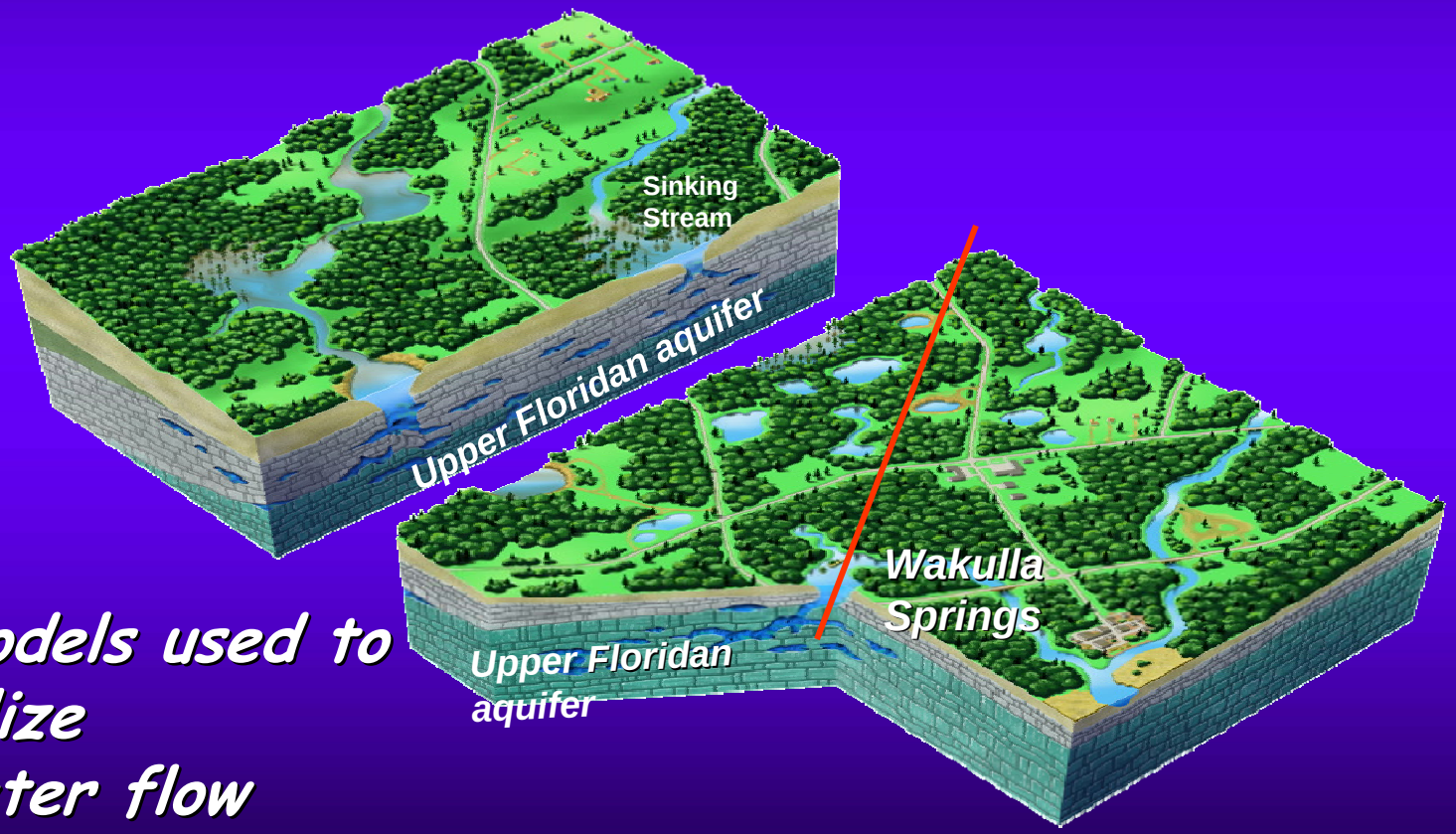
Schlosser et al. (1988, 1989)

- $T(age) = (t_{1/2}/\ln 2) \ln[1 + {}^3He_{trit}/{}^3H]$
- $^3He_{tot} = {}^3He_{trit} + {}^3He_{eq} + {}^3He_{exc} + {}^3He_{nuc}$
  - *Ne and ^4He used to calculate $^3He_{eq}$, $^3He_{exc}$, $^3He_{nuc}$*
  - *Crustal terrigenic $^3He/^4He$ ratio: $2 X10^{-8}$*

USGS
science for a changing world

GROUND-WATER AGE OR TRANSIT TIME—

Tracer concentrations measured in ground water and springs are dependent on how water moves through system.

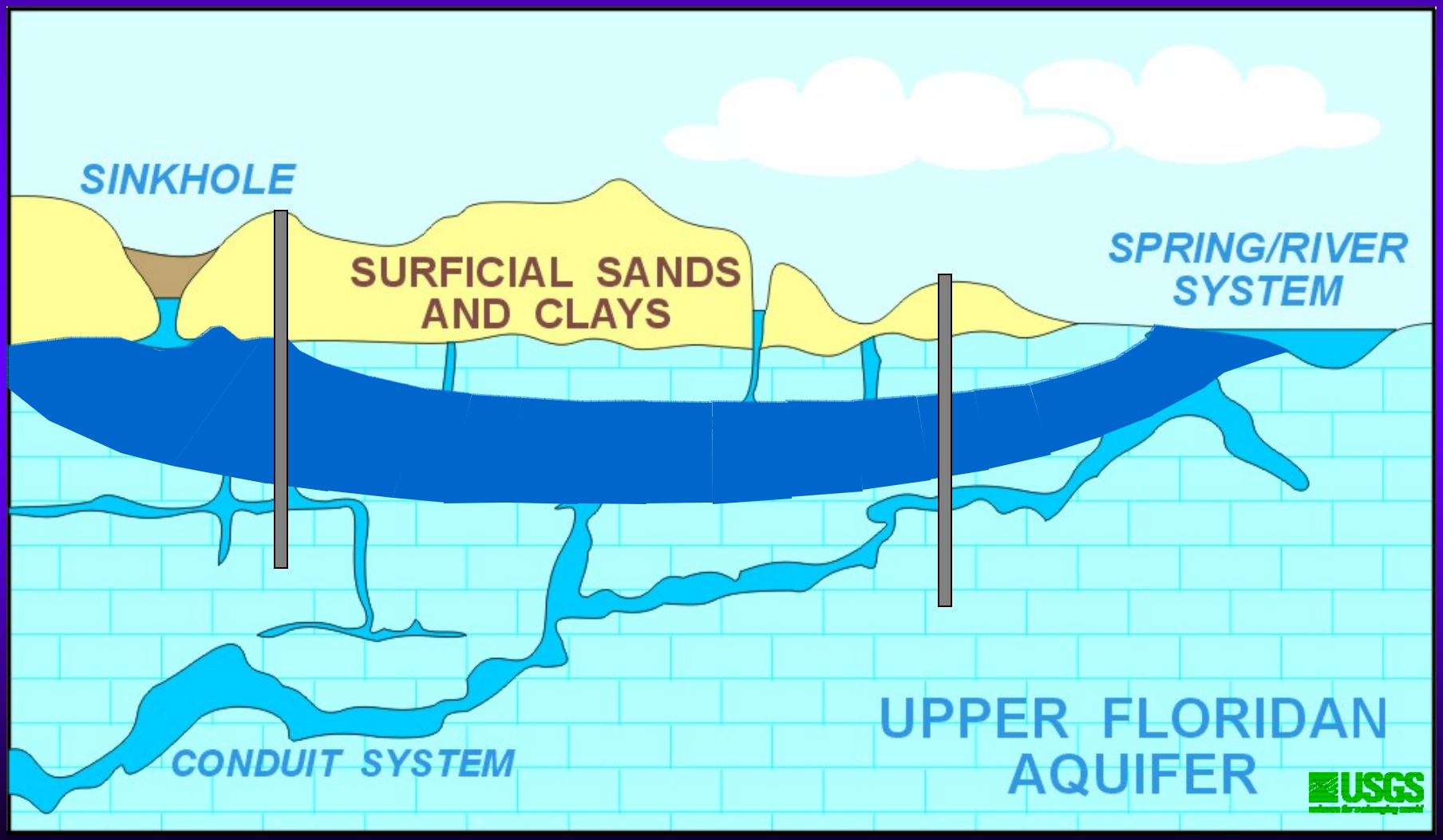


Various models used to conceptualize ground-water flow

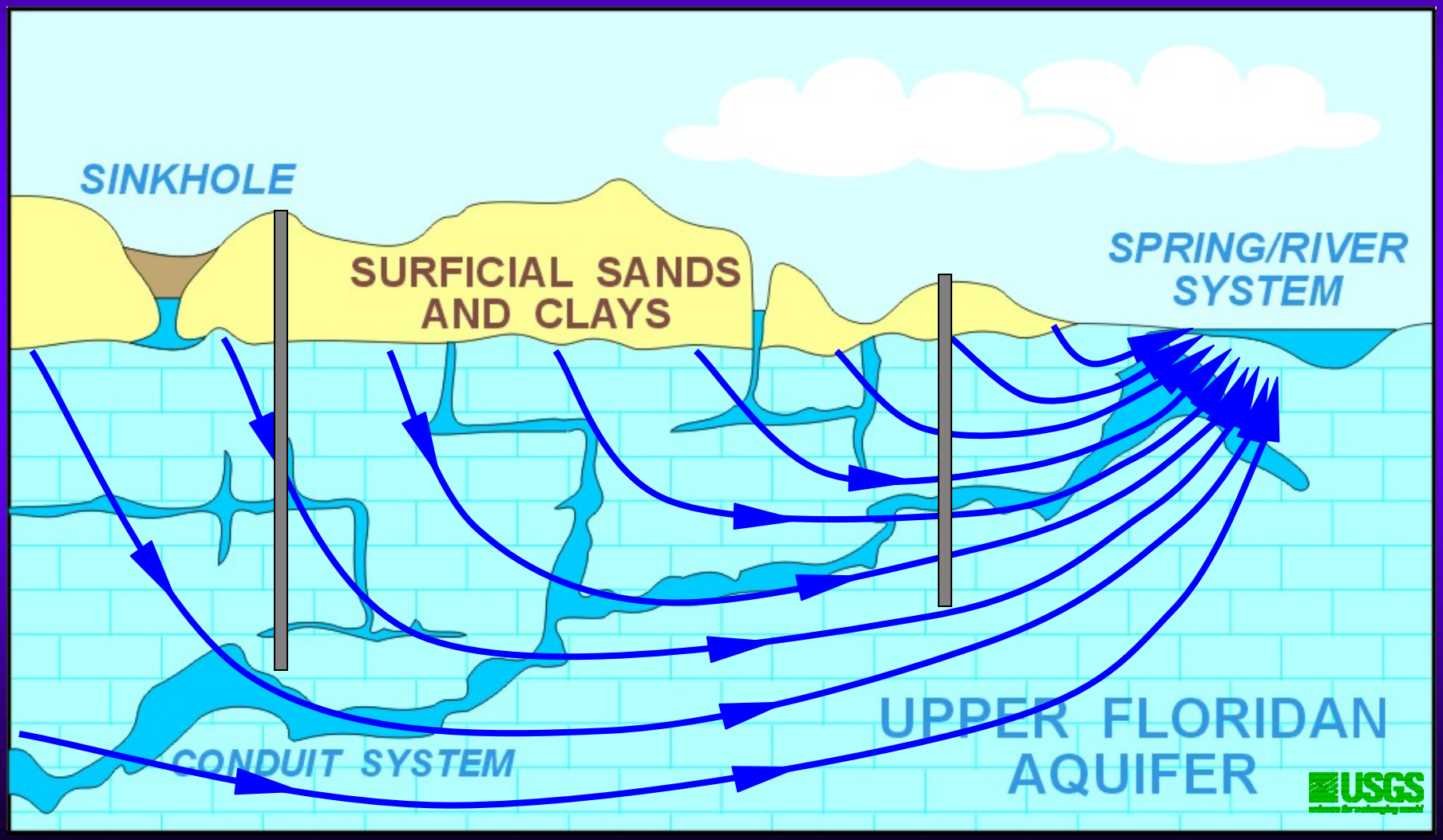
USGS

Piston Flow Model

$$C_t = C_o e^{-\lambda t}$$

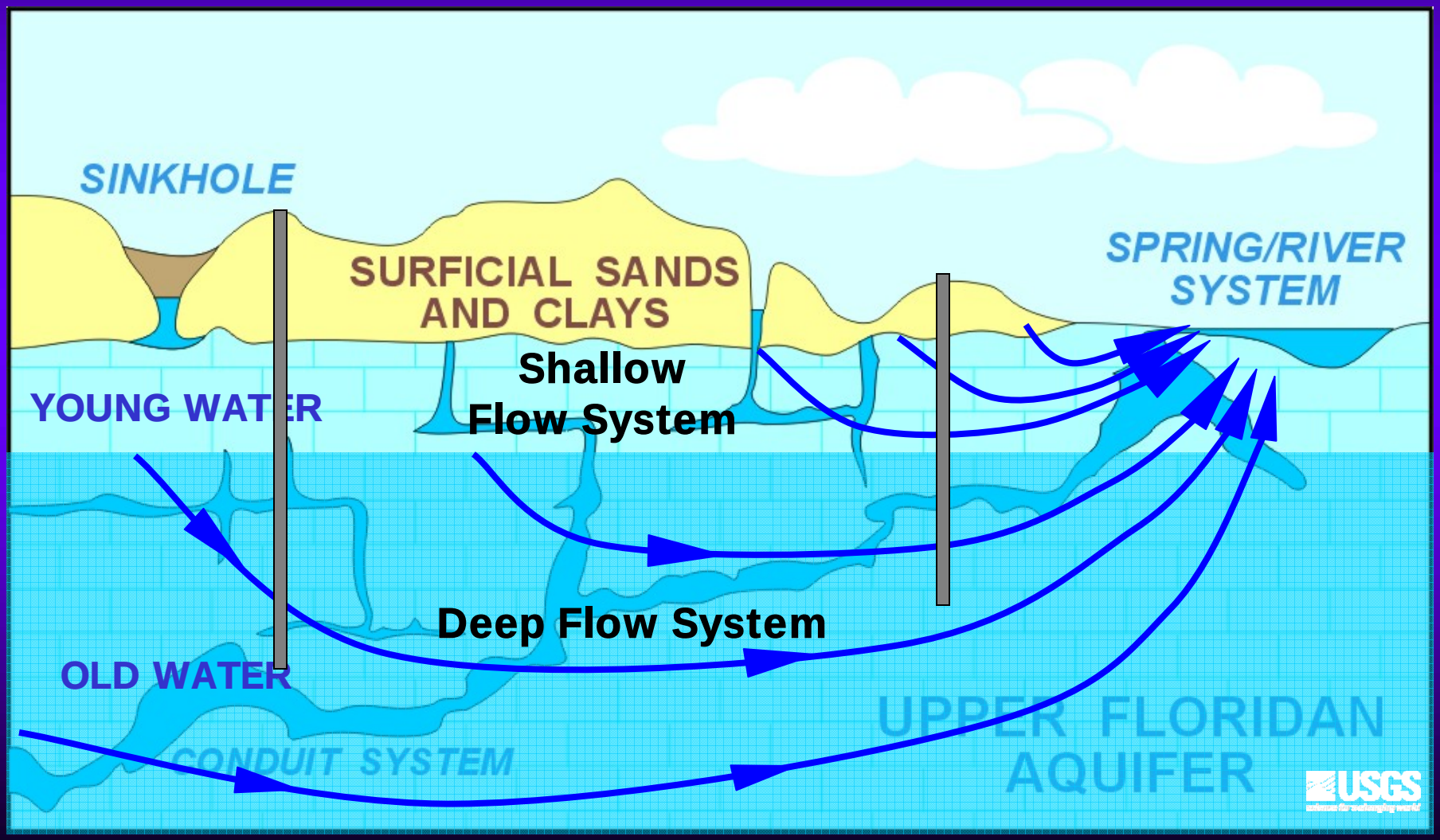


Exponential Mixing Model

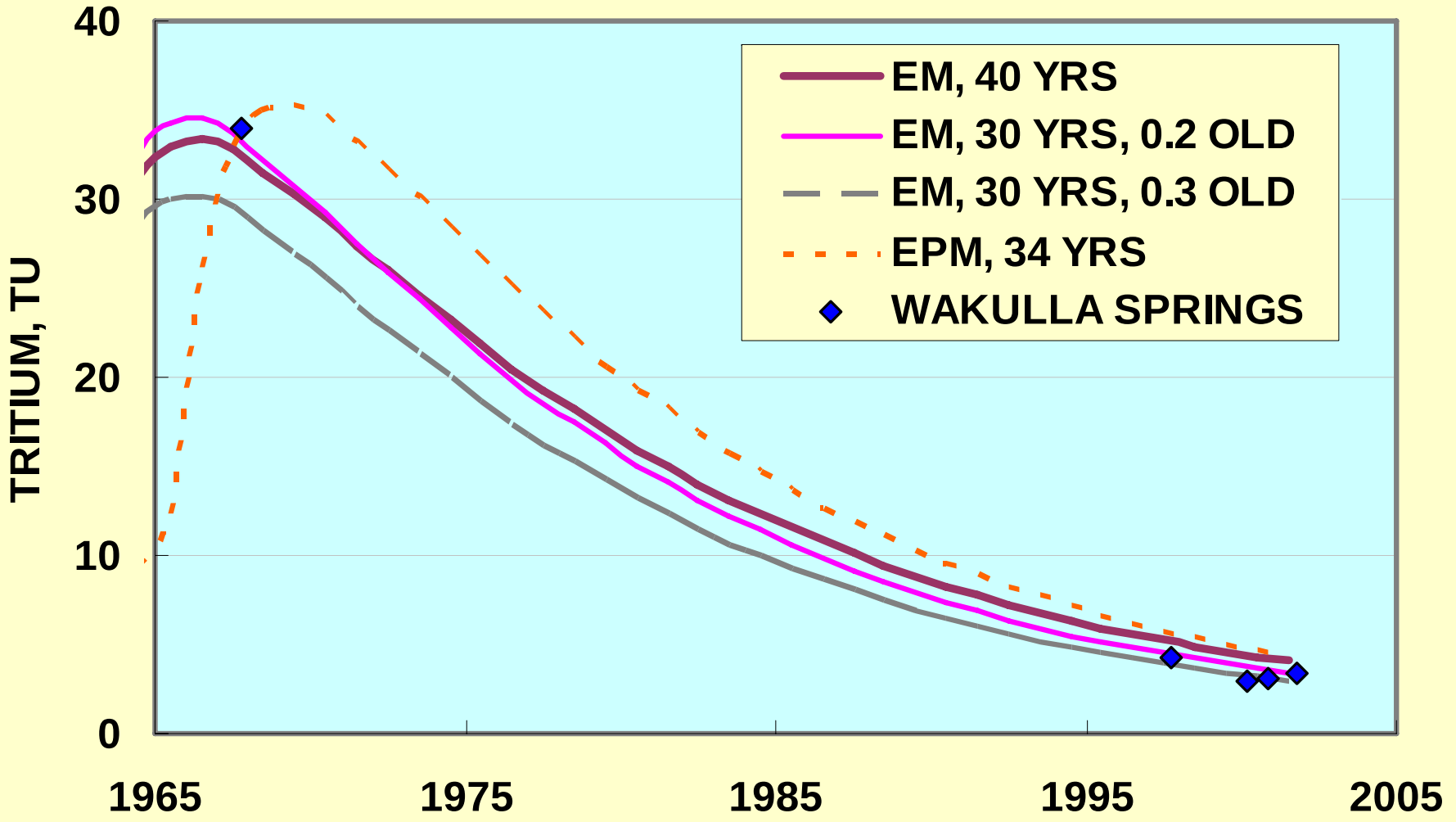


Binary-Mixing Model

$$f_{yw} = \frac{C_m - C_{ow}}{C_{yw} - C_{ow}}$$

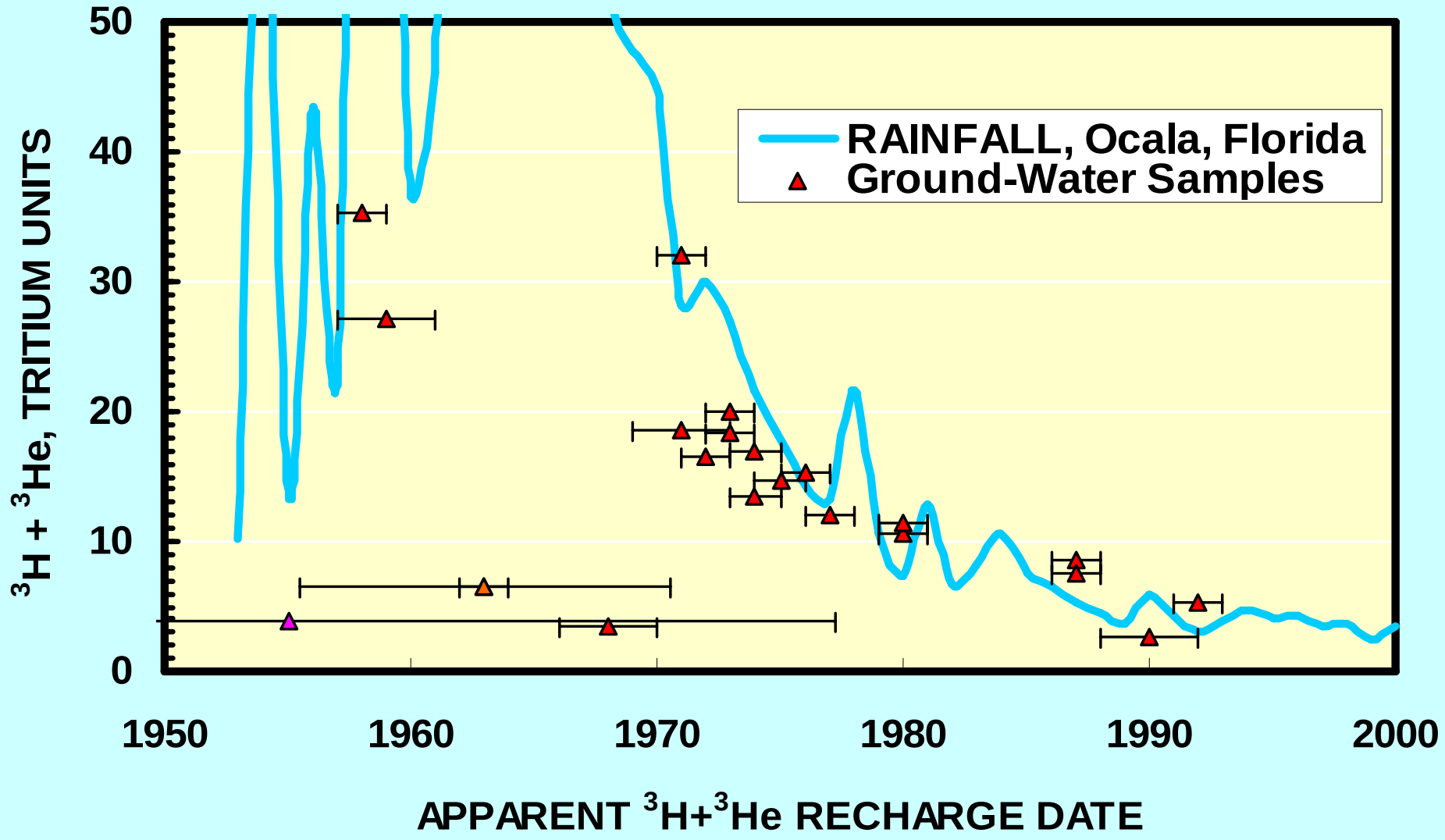


Mean transit time models:



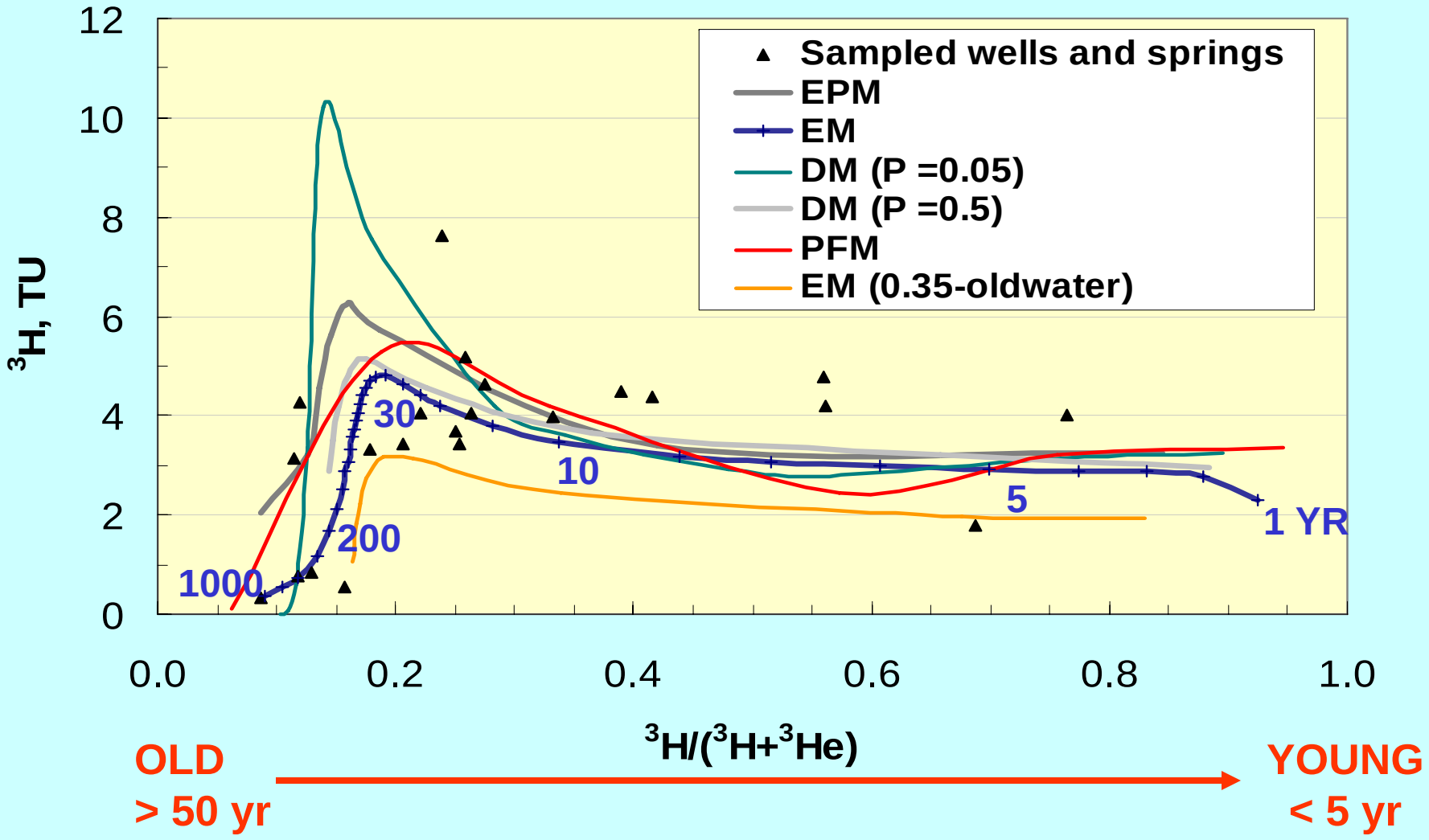
USGS

$^3H + ^3He$ in Rainfall and Ground Water

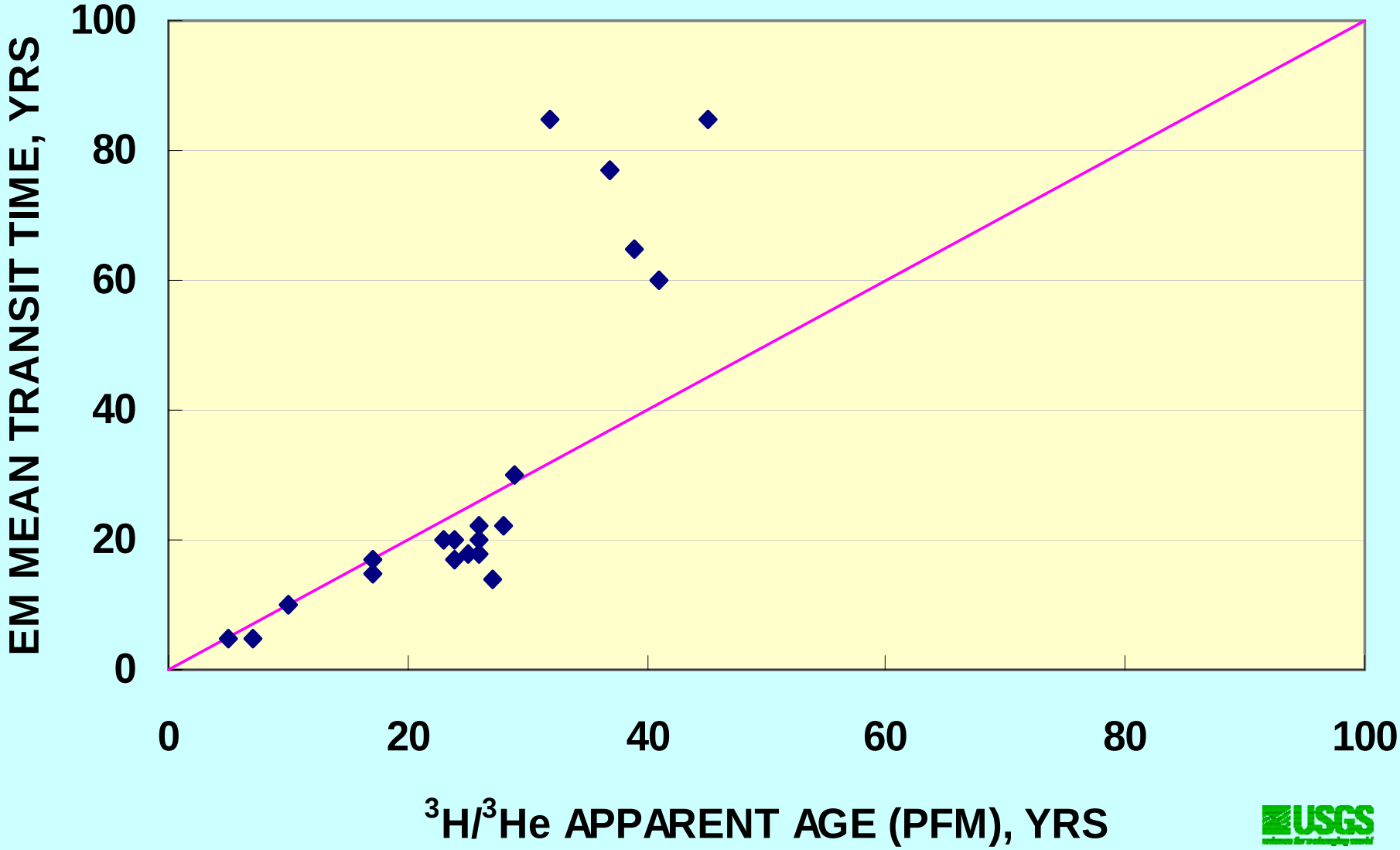


USGS

Comparison of model-generated curves with ^3H and ^3He data for sampled wells and springs



Piston Flow Model (PFM) ages vs. Exponential Mixing Model (EM) mean transit times



Chemistry and Age of Ground Water

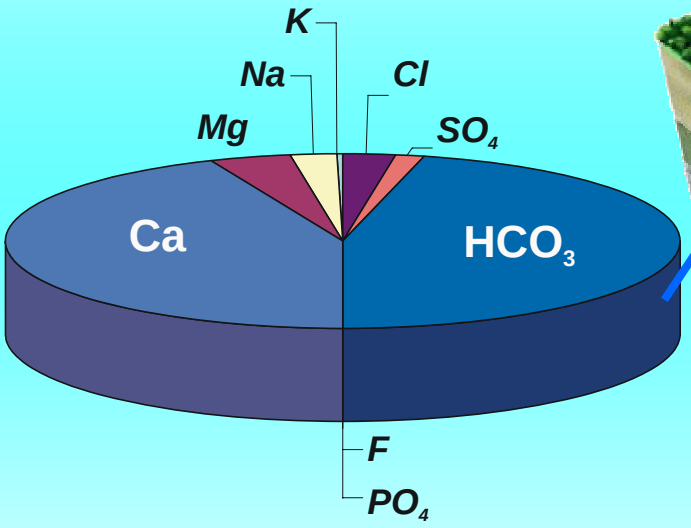
Mean residence times (τ) tested for correlation (Spearman's Rho)

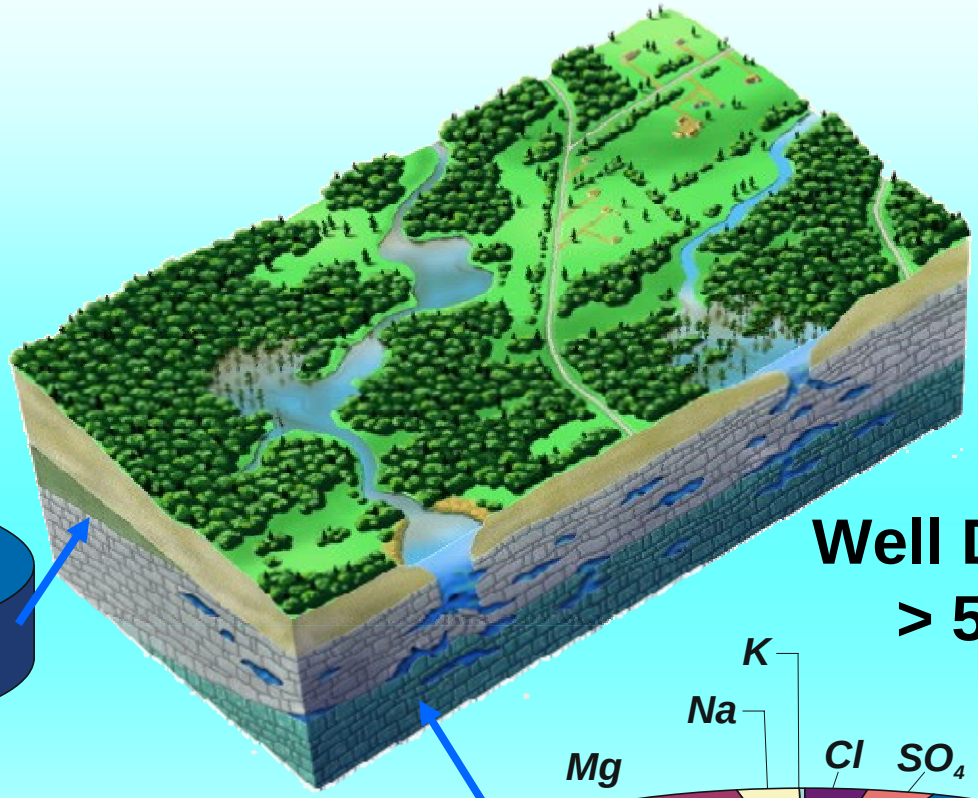
- *-- No correlation between τ and depth*
- *-- Inverse correlation between τ and dissolved O_2 ($p<0.05$)*
- *-- Positive correlation between τ and calcite SI ($p<0.05$)*
- *-- Positive trends between τ and $\delta^{13}C$, Mg, dissolved solids, dolomite SI*

USGS

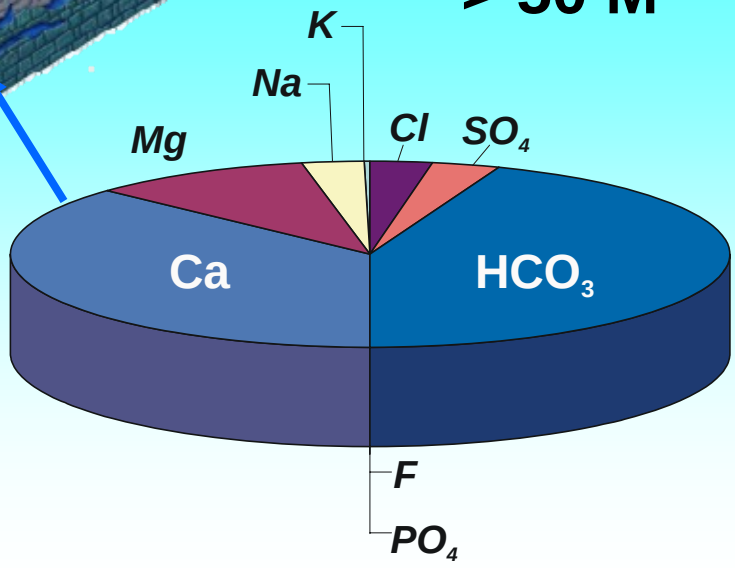
MEDIAN COMPOSITION OF MAJOR IONS

Well Depths
< 50 M



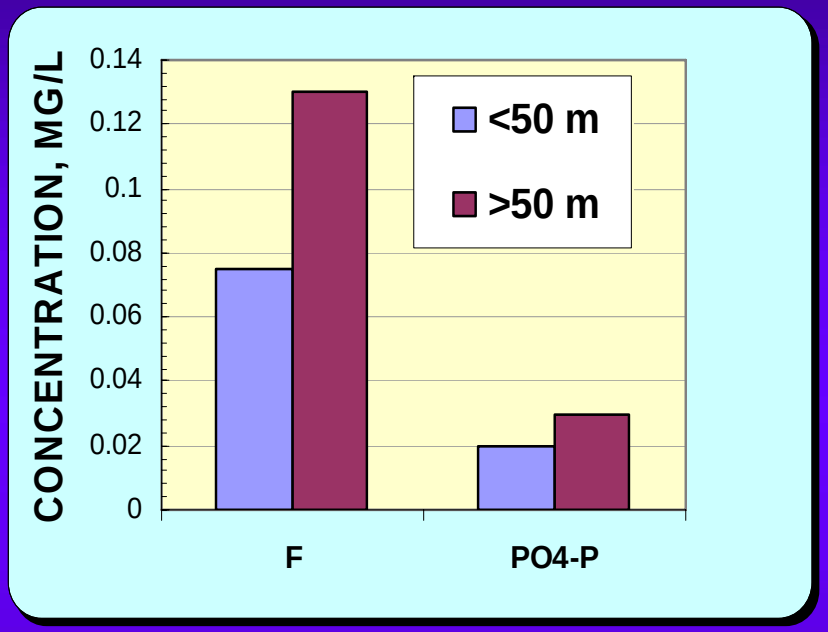


Well Depths
> 50 M



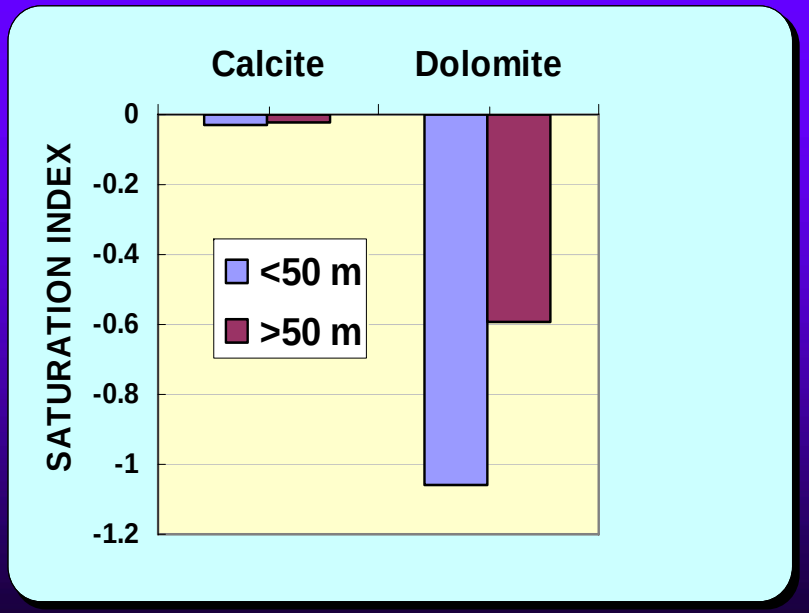
USGS

Changes in water chemistry with depth in UFA



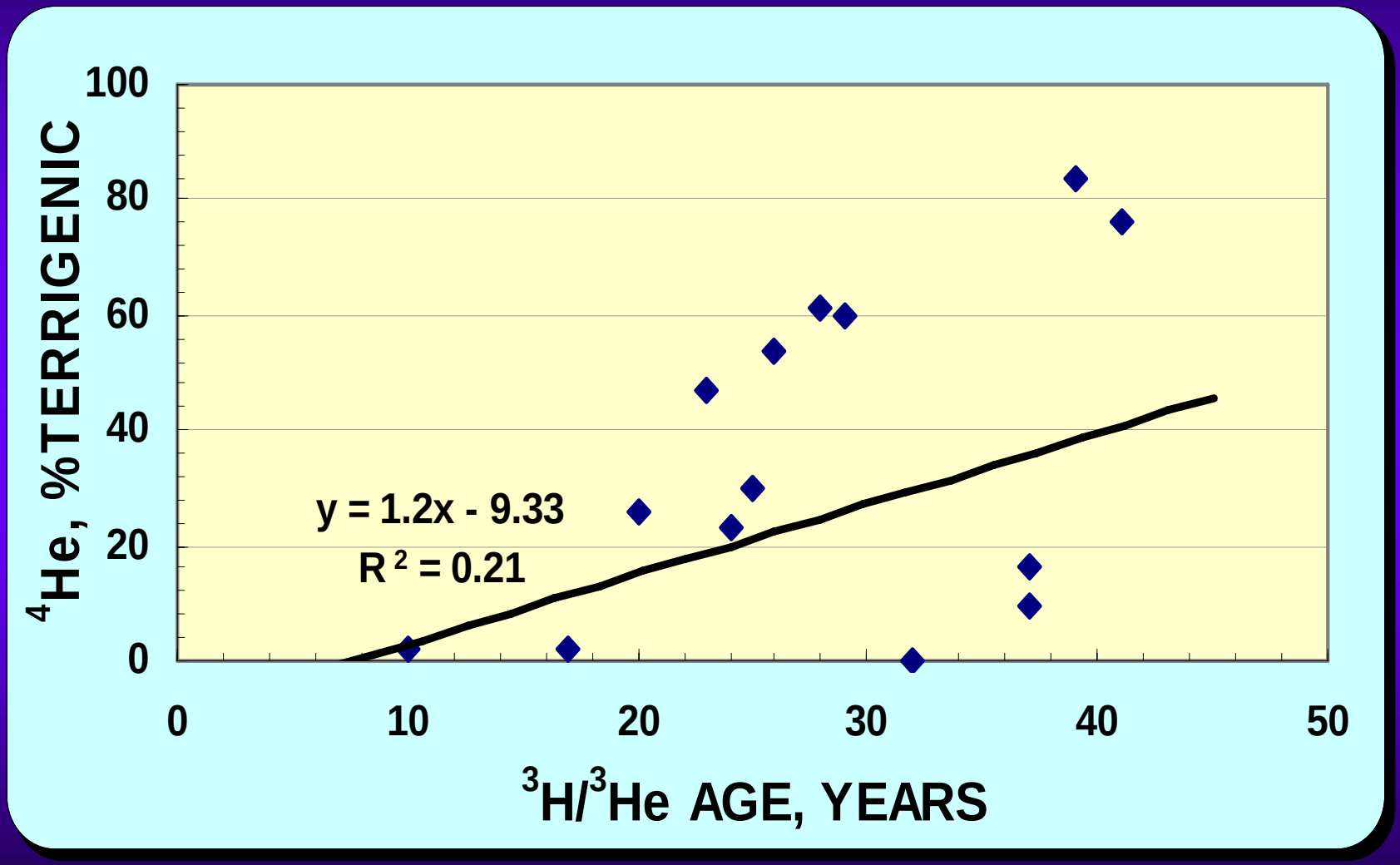
Increase in median F and PO_4 concentrations

Increase in saturation index with respect to dolomite and calcite



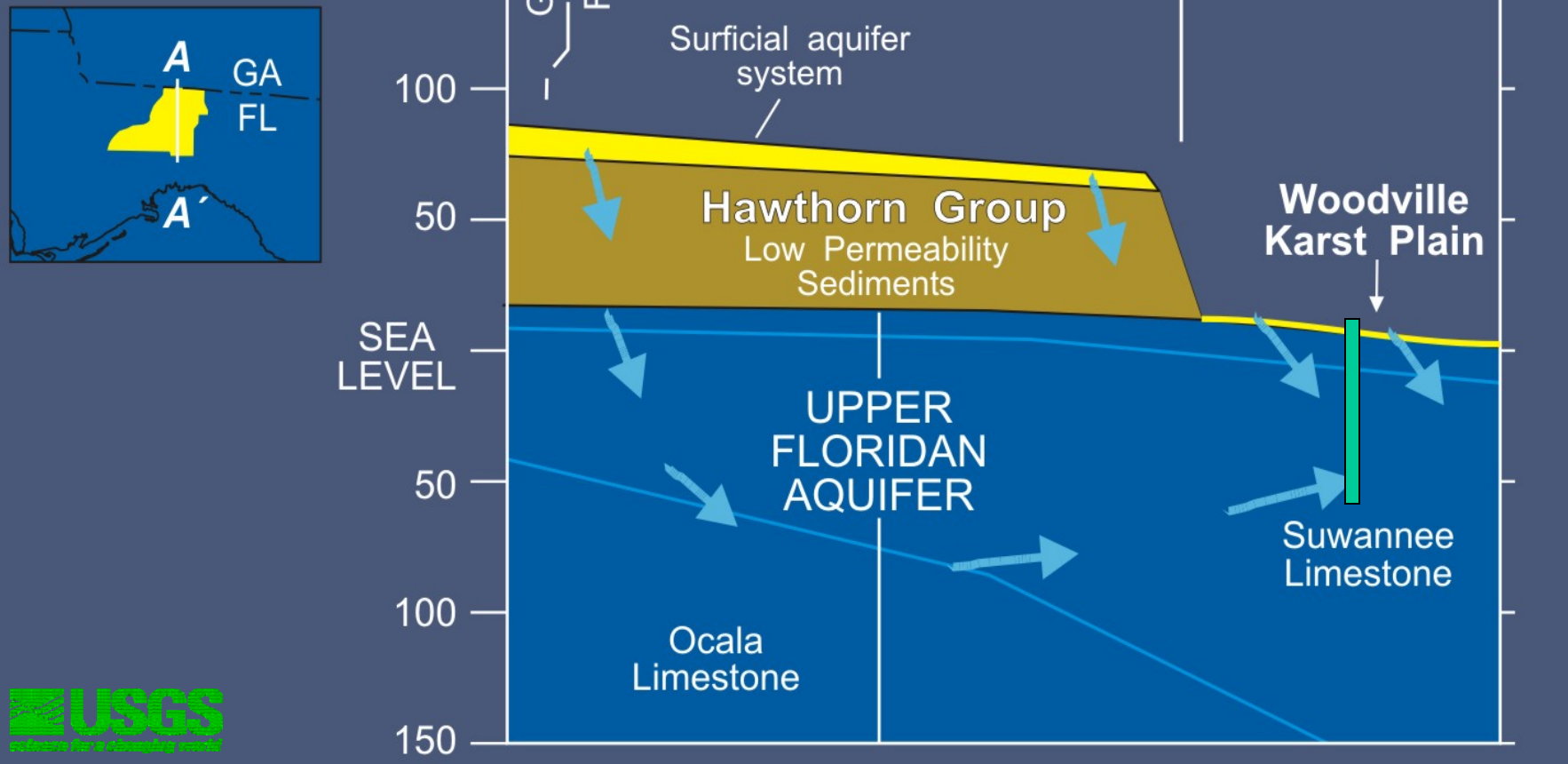
USGS

Increase in terrigenic ^{4}He in older waters:



USGS

GENERALIZED HYDROGEOLOGIC SECTION
LEON COUNTY, FLORIDA



CONCLUSIONS

- Short ground-water transit times (med. 17 yrs) coupled with localized nitrogen sources at surface result in elevated nitrate concentrations in the UFA

- Short transit times indicate connections with conduit/sinkhole systems; whereas transit times > 50 yrs indicate solute flow dominated by very slow moving water in micropores of matrix.

USGS
science for a changing world

USGS—City of Tallahassee Cooperative Study

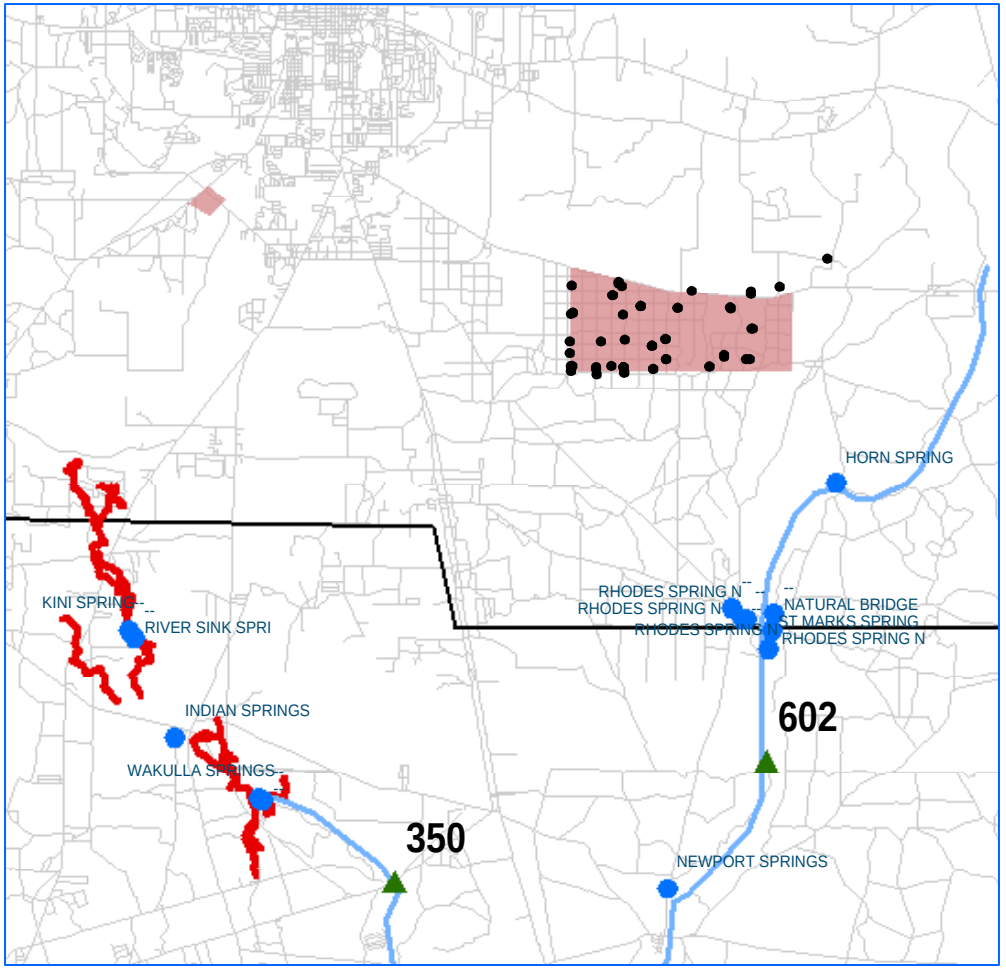
Track the possible movement of water and contaminants from the SE sprayfield in Tallahassee

3-Pronged Approach:

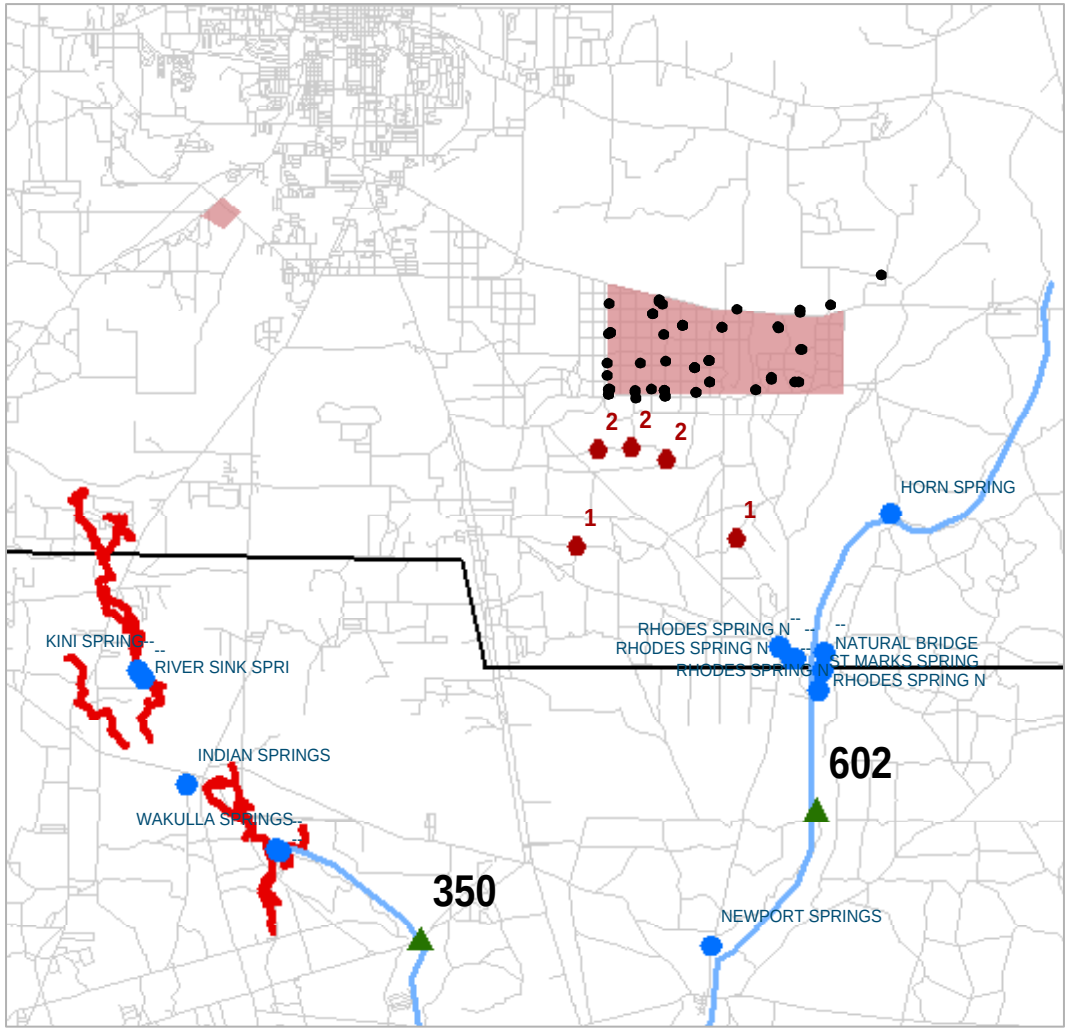
GW Flow Modeling

Geochemical Tracers

Microbiological Tracers



Installation of new wells



Water from wells to be sampled for more than 100 organic compounds commonly associated with wastewaters:
pharmaceuticals, non-ionic surfactants, food additives, fragrances, antioxidants, flame retardants, plasticizers, industrial solvents, disinfectants, fecal sterols, PAHs, domestic pesticides.

Also, samples will be screened for human viruses