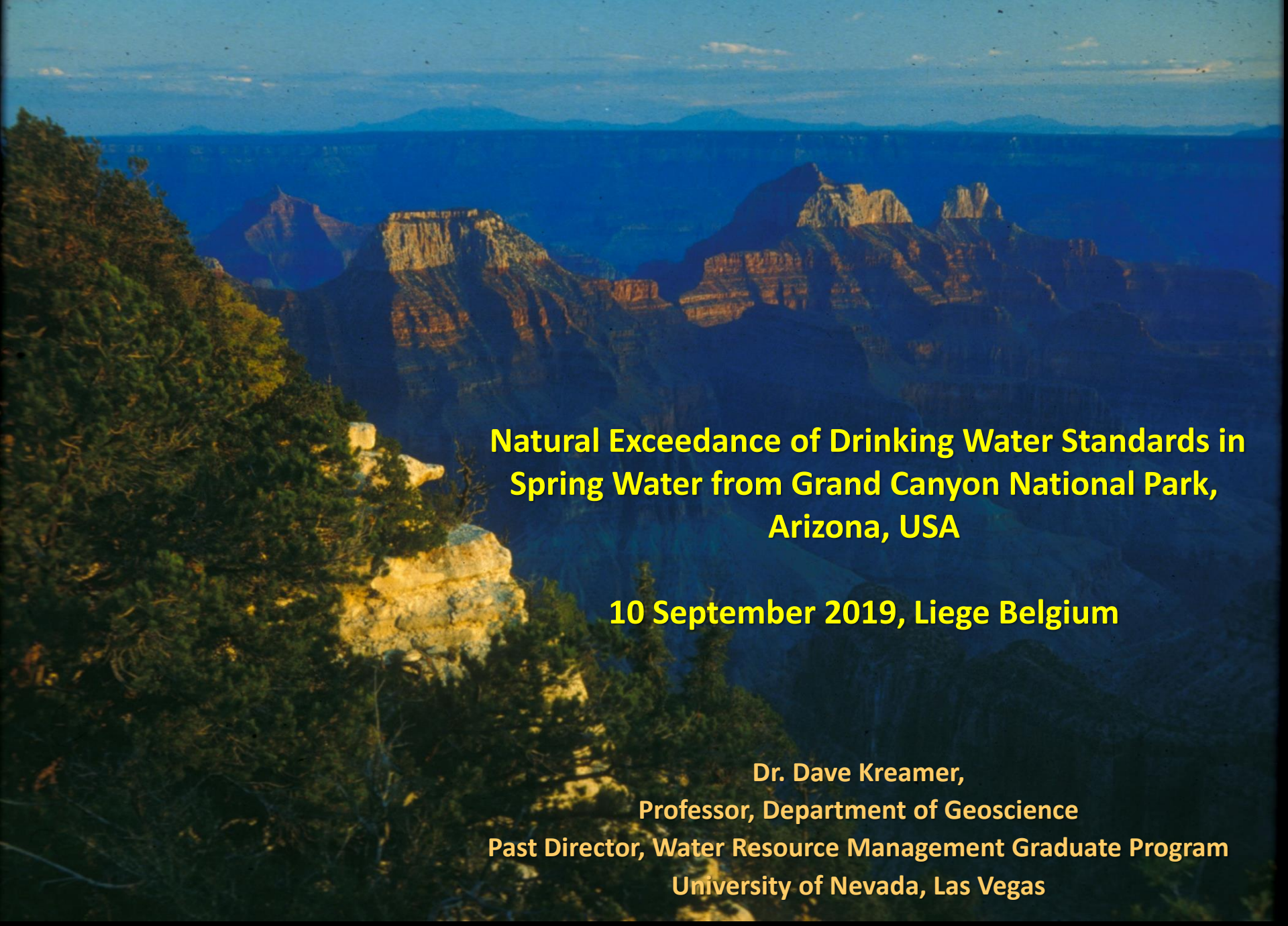

Natural Exceedance of Drinking Water Standards in Spring Water from Grand Canyon National Park, Arizona, USA

10 September 2019, Liege Belgium

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Talk Outline

- Importance of Water Quality In the Grand Canyon
- Exceedences of Maximum Contaminant levels (MCLs)
- Implications
- Future of Monitoring

Why are Spring Studies in Arid Lands Important?

To Ensure Sustained Water Supply and Recreational Uses

Indicator of Longterm Spring Health and Ecosystem Impact

Native American religious and cultural traditions, and historical importance

General Information on this study

- 4164 Sampling Events Analyzed

- Over 75% Springs
- About 21-23% surface water
- Approximately 1-2 % well water or other

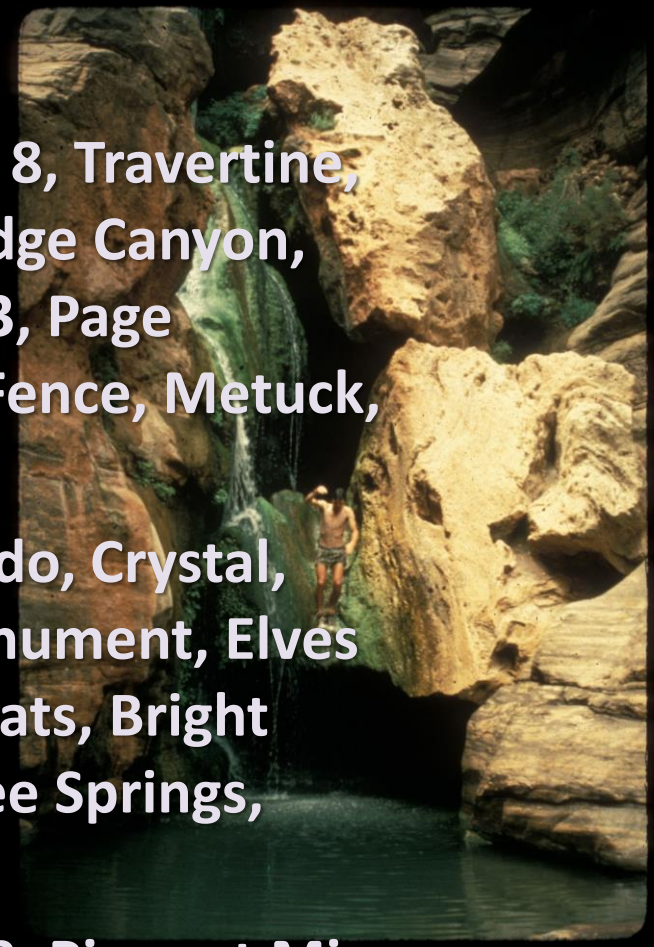
- Evaluated U.S. Environmental Protection Agency's Maximum Contaminant Levels (MCLs)

- Most Analyses before 2000

Arsenic (As)

- 87 % of time not analyzed
- Non detect (11.6% of total analyzed)
- Some detection of As (88.4% of total analyzed)
- 53.8 % above MCL when analyzed
- 78 Springs above MCL of 0.01 mg/L

Arsenic above MCL 0.01mg/L



- Springs include: Pumpkin, Marble Canyon 8, Travertine, South Canyon, Mesquite, Hance rapid, Bridge Canyon, Vasey's, Santa Maria, Tilted, River mile 213, Page (Miner's), Marble Canyon 2, Red Canyon, Fence, Metuck, JT, Warm, Lower Milkweed
- Creeks include: Kanab, Paria, Little Colorado, Crystal, Nankoweep, Travertine, Matakamiba, Monument, Elves Chasm, Stone, Havasu, Clear, Hermit, Tapeats, Bright Angel, Indian Garden, Shinumo, Deer, Three Springs, Diamond
- Wells include: 23077, 23032, 43536, 23029, Pinenut Mine Monitoring well, Red Spring well, Hermit Mine Monitoring well, 222 s13 E71 28 Ccc1, Diamond Creek near mouth
- Others: Hermit Mine Sump, GCCA505R Sump, GCCA506R sump, GCDE501R

Beryllium

- 93.2 % of time not analyzed
- Non detect or below detection limit (74.6% of total analyzed)
- Some detection of Be (25.4% of total analyzed)
- 8.8 % Above MCL when analyzed
- 17 Springs above MCL of 0.004 mg/L

Photo David Loope

Beryllium over MCL 0.004 mg/L

Springs over MCL include: Monument, Santa Maria, Hawaii, Dripping, Page (Miner's), Indian, Hermit

Wells: Tusayan

Other: Clearwell overflow (treated sewage outfall for South Rim)

Cadmium

91.9 % of time not analyzed

Non detect (60.8 % of total analyzed)

Detection of Cd (39.2 % of total analyzed)

5.0 % Above MCL when analyzed

13 Springs above MCL of 0.005 mg/L

Cadmium over MCL 0.005 mg/L

Springs over MCL include: Monument, Santa Maria, Hawaii, Dripping, Horn, Indian, Hermit

Creeks: Kanab

Wells: Tusayan

Other: almost - Clearwell overflow (treated sewage outfall for South Rim)

Lead

- 90.7 % of time not analyzed
- Non detect (51.3 % of total analyzed)
- Some detection of Pb (48.7 % of time analyzed)
- 3.9 % Above MCL when analyzed
- 5 Springs above MCL of 0.015 mg/L

Lead over MCL 0.015 mg/L

Springs over MCL include: Big, Fern Glen, Diamond

Creeks: Kanab, Little Colorado, Paria, Nankoweep, Elves Chasm, Havasu, Pipe

Mercury

93.7 % of time not analyzed

Non detect (75.4 % of total analyzed)

Some detection of Hg (24.6 % of time analyzed)

3.4 % Above MCL when analyzed

2 Springs above MCL of 0.002 mg/L

Mercury over MCL 0.002 mg/L

Springs over MCL include: Milkweed, Monument

Creeks: Monument, Paria, Crystal, Burnt Canyon well, Havasu

Wells: Hotel Spring

Selenium

- 92.8 % of time not analyzed
- Non detect (32.7 % of time analyzed)
- Some detection of Se (67.3 % of total analyzed)
- 8.3 % Above MCL when analyzed
- 7 Springs above MCL of 0.05 mg/L

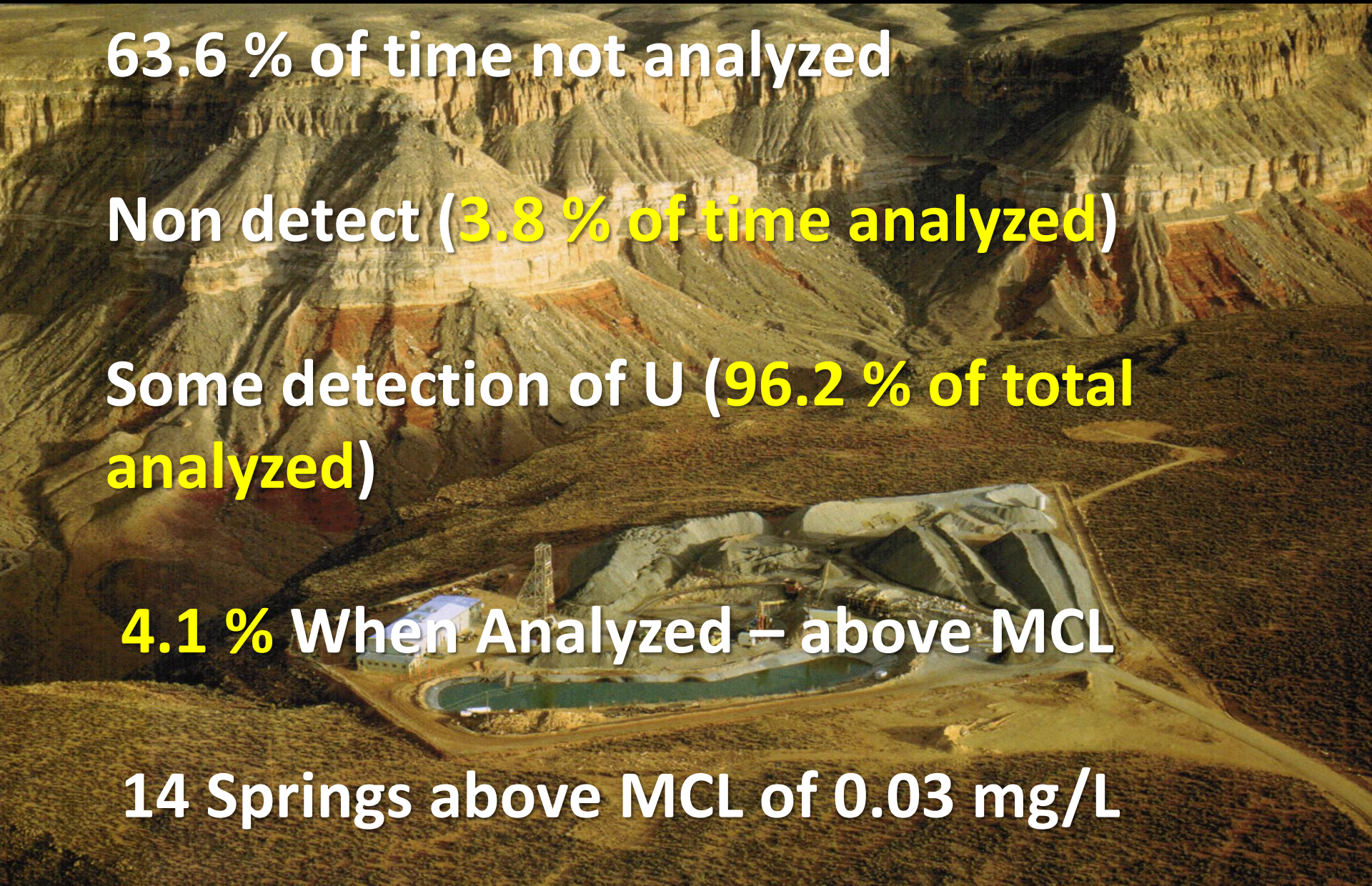
Selenium over MCL 0.05 mg/L

Springs over MCL include: Monument, Santa Maria, Dripping, Hawaii

Creeks: Kanab, Paria, Little Colorado, Matakamiba, Monument, Havasu, Nankoweep, Elves Chasm, Stone

Wells: Tusayan

Uranium



63.6 % of time not analyzed

Non detect (3.8 % of time analyzed)

Some detection of U (96.2 % of total analyzed)

4.1 % When Analyzed – above MCL

14 Springs above MCL of 0.03 mg/L

Uranium over MCL 0.03 mg/L

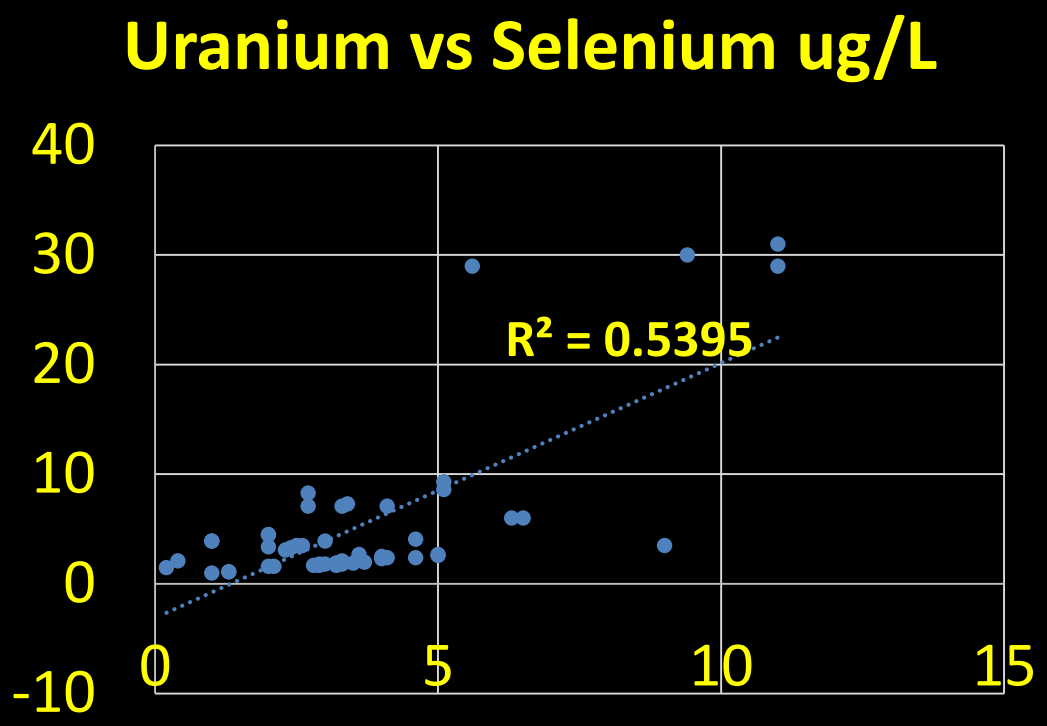
Springs over MCL include: Horn up, Horn West, Horn, Salt, (GCAE517R, 15140, 15139, GCAG501R, GCAA503R, GCBE501R)

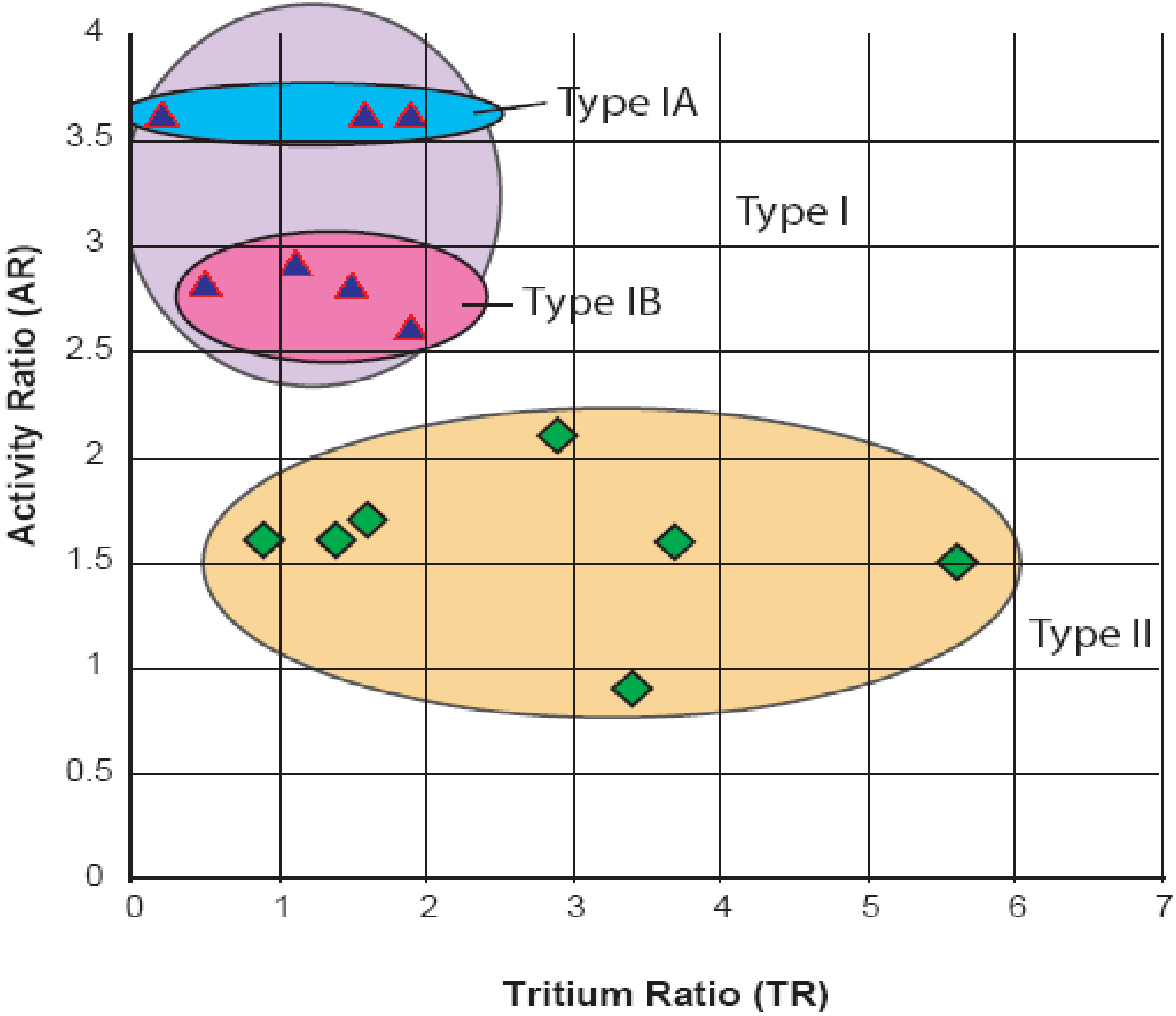
Creeks: Horn down, (GCBB004R, GCBB006R, GCBB014R, KAN003W)

Wells: Canyon Mine Well, (23032, GCBD501R, GCBD511R, GCBE501R)

Other: Hermit Mine Sump (Up to 36.6), Pigeon Mine Main Sump, Hermit Mine Shaft

Site Name	Site Code	Site Type (spring or creek)	Date	Se (µg/L)	Uranium (µg/L)
Cottonwood Creek #1		creek	5/25/2000	0.2	1.5
Grapevine East Spring		spring	5/25/2000	0.4	2.1
Indian Gardens Spring		Creek below pump house	12/19/1981	1	1
Fern Spring			8/24/1994	1	3.9
	3.61524E+14		8/24/1994	1	3.9
Grapevine Main Spring		spring	4/10/2001	1.3	1.1
Grapevine Main Spring		spring	4/30/2001	1.3	1.1
Cottonwood Creek #2		creek	11/29/2000	2	1.6
Havasu Well			8/23/1994	2	3.4
Havasu Spring			8/23/1994	2	4.5
	3.61303E+14		8/23/1994	2	4.5
Cottonwood Creek #2		creek	4/9/2001	2.1	1.6
Miners Spring		spring	5/24/2000	2.3	3.1
Miners Spring		spring	4/7/2001	2.4	3.3
Miners Spring		spring	11/28/2000	2.5	3.5
JT Spring		spring	4/8/2001	2.6	3.5
Grapevine East Spring		spring	4/9/2001	2.7	7.1
Grapevine East Spring		spring	11/29/2000	2.7	8.3
Boucher East Spring			5/26/2000	2.8	1.7
Pumphouse Spring			5/22/2000	2.9	1.7
Pumphouse Wash Gage			12/7/2000	2.9	1.8
Pumphouse Spring			4/7/2001	3	1.8
	3.60059E+14		11/20/1981	3	3.9
Red Canyon Spring		spring	9/26/2001	3.2	1.7
Pumphouse Spring			12/7/2000	3.2	1.9
Boucher East Spring			4/12/2001	3.2	1.9
Boucher East Spring			12/4/2000	3.3	1.8
Hawaii Spring			5/25/2000	3.3	1.9
Hermit Spring			12/4/2000	3.3	2
Hermit Spring			4/11/2001	3.3	2.1
Monument Spring			12/5/2000	3.3	7.1
Monument Spring			4/9/2001	3.4	7.3
Hawaii Spring			12/4/2000	3.5	1.9
Pipe Creek			5/22/2000	3.6	2.7
Hawaii Spring			4/11/2001	3.7	2
Pipe Creek			4/8/2001	4	2.3
Burro Spring			5/22/2000	4	2.5
Pipe Creek			12/7/2000	4.1	2.4
Monument Creek Spring No.1			5/24/2000	4.1	7.1
Burro Spring			4/8/2001	4.6	2.4
JT Spring		spring	5/11/2001	4.6	4.1
	3.60437E+14		9/1/1981	5	2.6
Burro Spring			12/7/2000	5	2.7
Horn Creek			5/22/2000	5.1	8.6
Horn Creek			12/6/2000	5.1	9.3
Horn Creek			4/7/2001	5.6	29
Lonetree Spring		spring	4/11/2001	6.3	6
Lonetree Spring		spring	5/1/2001	6.5	6
	3.61143E+14		11/19/1981	9	3.5
Salt Creek Spring			5/23/2000	9.4	30
Salt Creek Spring			4/10/2001	11	29
Salt Creek Spring			12/6/2000	11	31




Type IA
Type I
Type IB
Type II
Activity Ratio (AR)
Tritium Ratio (TR)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
1
2
3
4
5
6
7

Element	Exceedances	MCL	Site	Conc.	Year	Source
Arsenic	78	0.01	Pumpkin Spring	0.350	1985	Wenrich et al. 1994
Beryllium	17	0.004	Monument Spring	0.128	1992	Zukosky 1994
Cadmium	13	0.005	Monument Spring	0.019	1992	Zukosky 1994
Lead	5	0.015	Big Spring	0.032	1985	Wenrich et al. 1994
Mercury	2	0.002	Milkweed Spring	0.0038	1993	Alpine 2010
Selenium	7	0.05	Monument Spring	0.112	1992	Zukosky 1994
Uranium	14	0.03	Horn Spring	0.4	2002	Liebe 2003

Records of EPA Maximum Contaminant Level (MCL) exceedances at GRCA Springs for select elements, including the number of exceedances (Exceedances), MCL (mg/L), site of maximum exceedance (Site) concentration of maximum exceedance in mg/L (Conc), year of highest exceedence (Year), and original report of exceedance (Source).

Implications and Monitoring

1. Many Exceedences of drinking water standards (MCLs)

2. Most Monitoring 15-20 Years Old for MCL Exceedences

3. Exact locations of sampling points inconsistent, as were meterological and hydrological conditions

4. Large Data Gaps – trend and correlation analysis difficult

5. Maximum Contaminant Level Goals (MCLGs) for drinking water quality associated with no or minimal risk were regularly exceeded

Conclusion

Many unknowns in Grand Canyon Water Quality

More information will give better understanding

Thank you!