

The Measurement of the Microbial Safety of our Recreation Waters is a S.W.A.G.



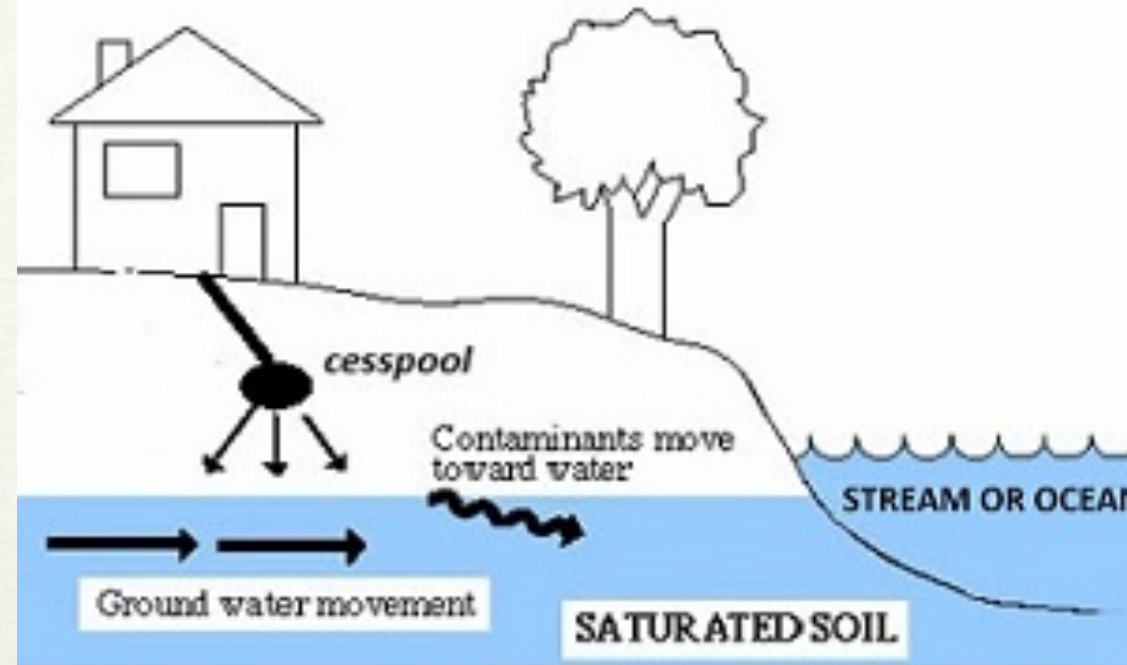
ahhh, I dunno,
Methanobrevibacterium smithii ?

And we are going to be ok !

R. H. Bennett Ph.D., President
Applied Life Sciences LLC

**KONA COAST
WATERKEEPER®**

Cesspools contaminate our
ground water, streams and oceans



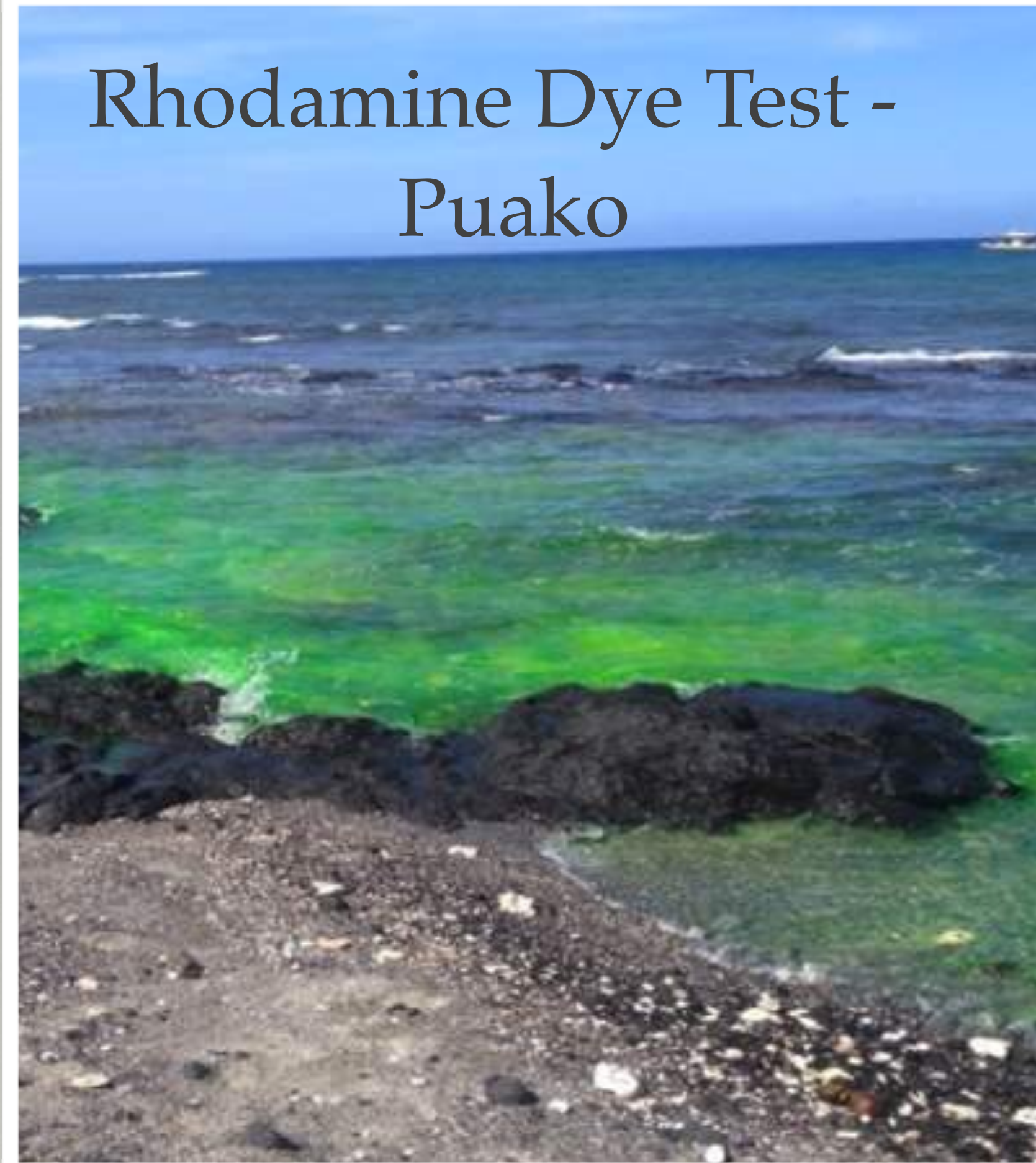
Cesspools and Septic Sys.

- ❖ 50,000 cesspits Hawaii Island *
- ❖ 30 MGD sewage discharged *
- ❖ Microbial attenuation
unknown (McCray 2010)
- ➔ ❖ 410,000 Lbs nitrogen per yr.**
- ❖ Septic Systems no better

*<http://health.hawaii.gov/wastewater/cesspools/>

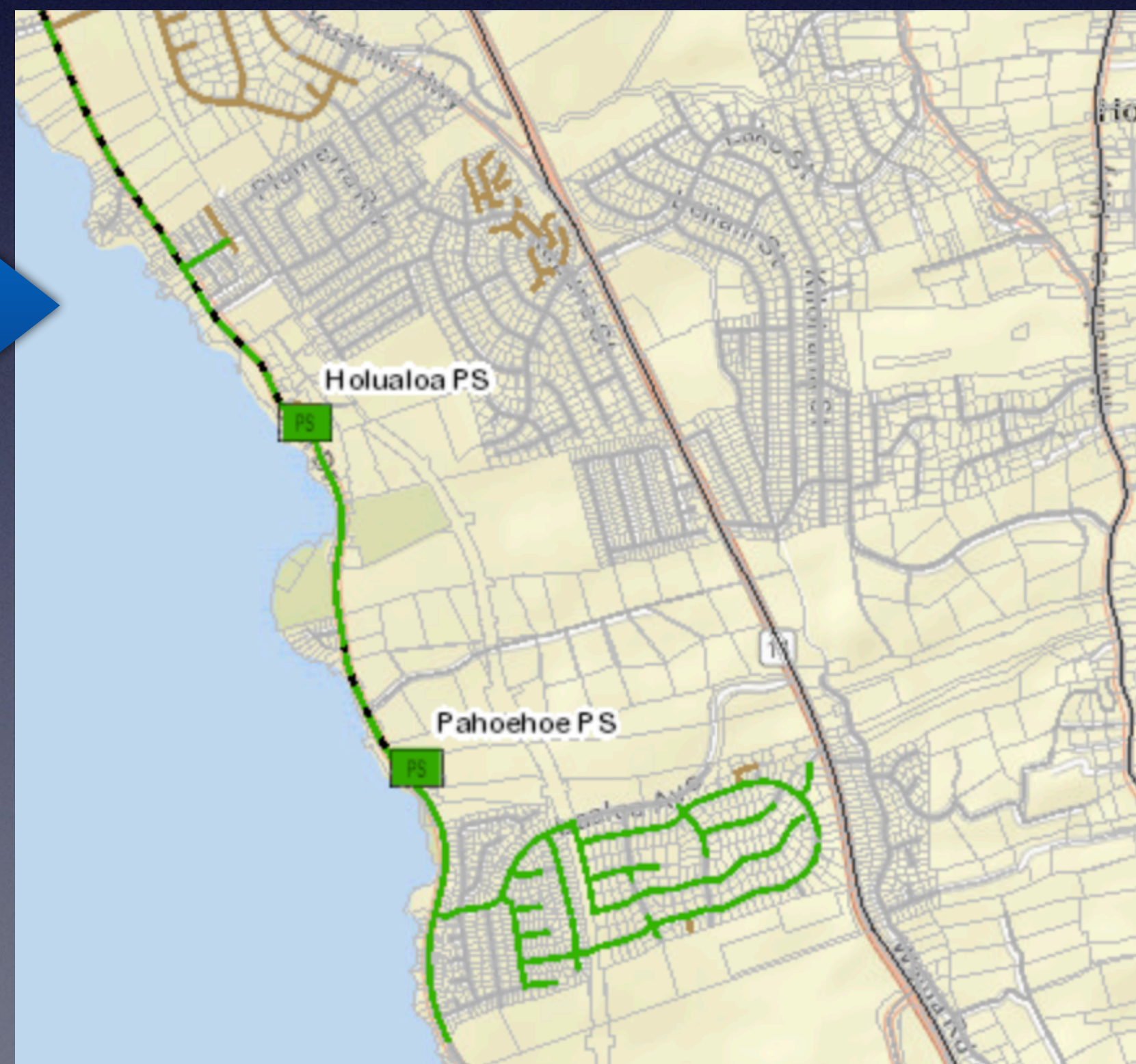
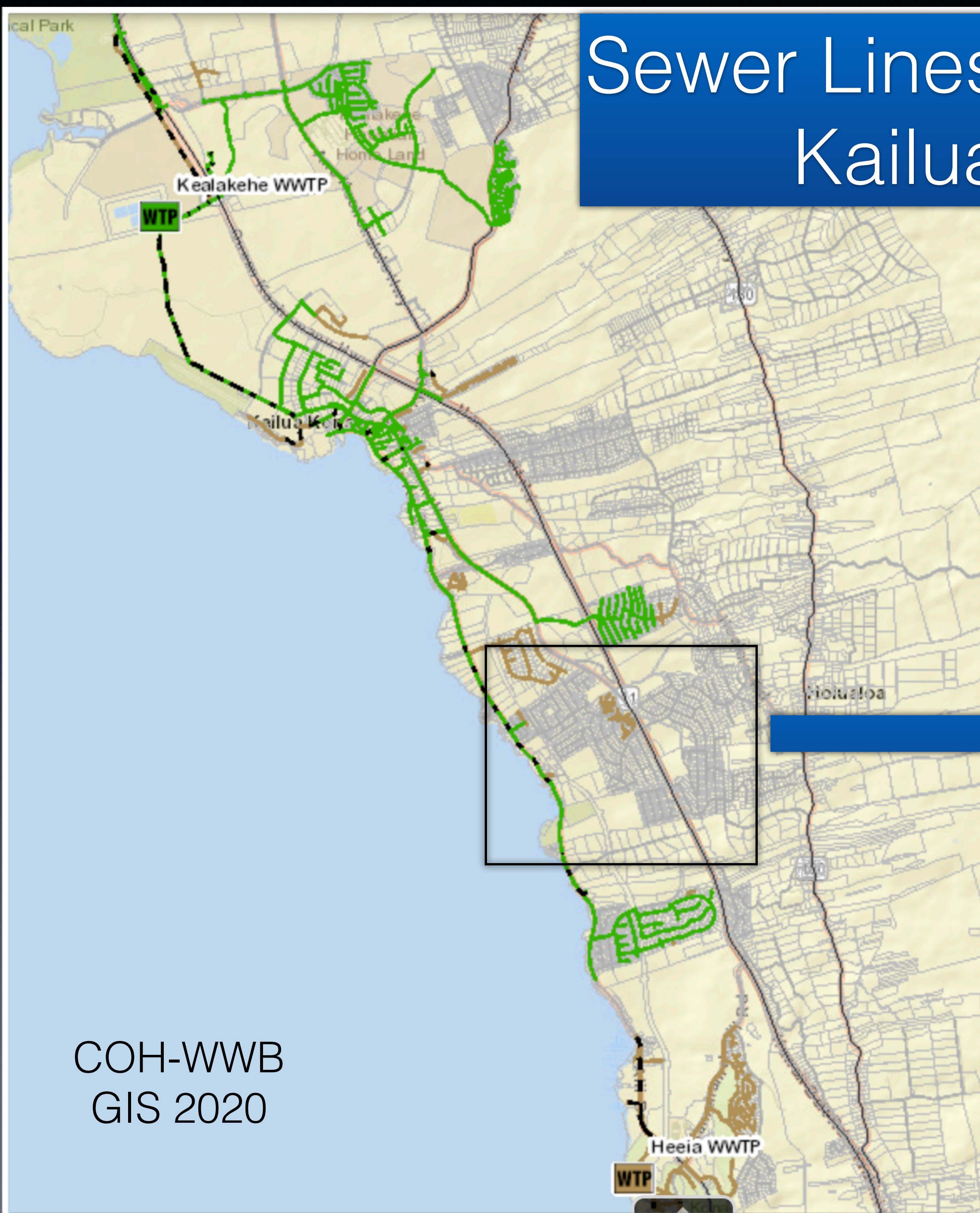
** Reray 2004 adapted, Watershed Septic System Model

Rhodamine Dye Test - Puako



Sewer Lines & Cesspits Kailua-Kona

Sewers for all, not likely.
Trenching alone \$3-4M per mile



COH-WWB
GIS 2020

Sewer Spill

7.12.2020



Sewers Leak

Infiltration and Exfiltration

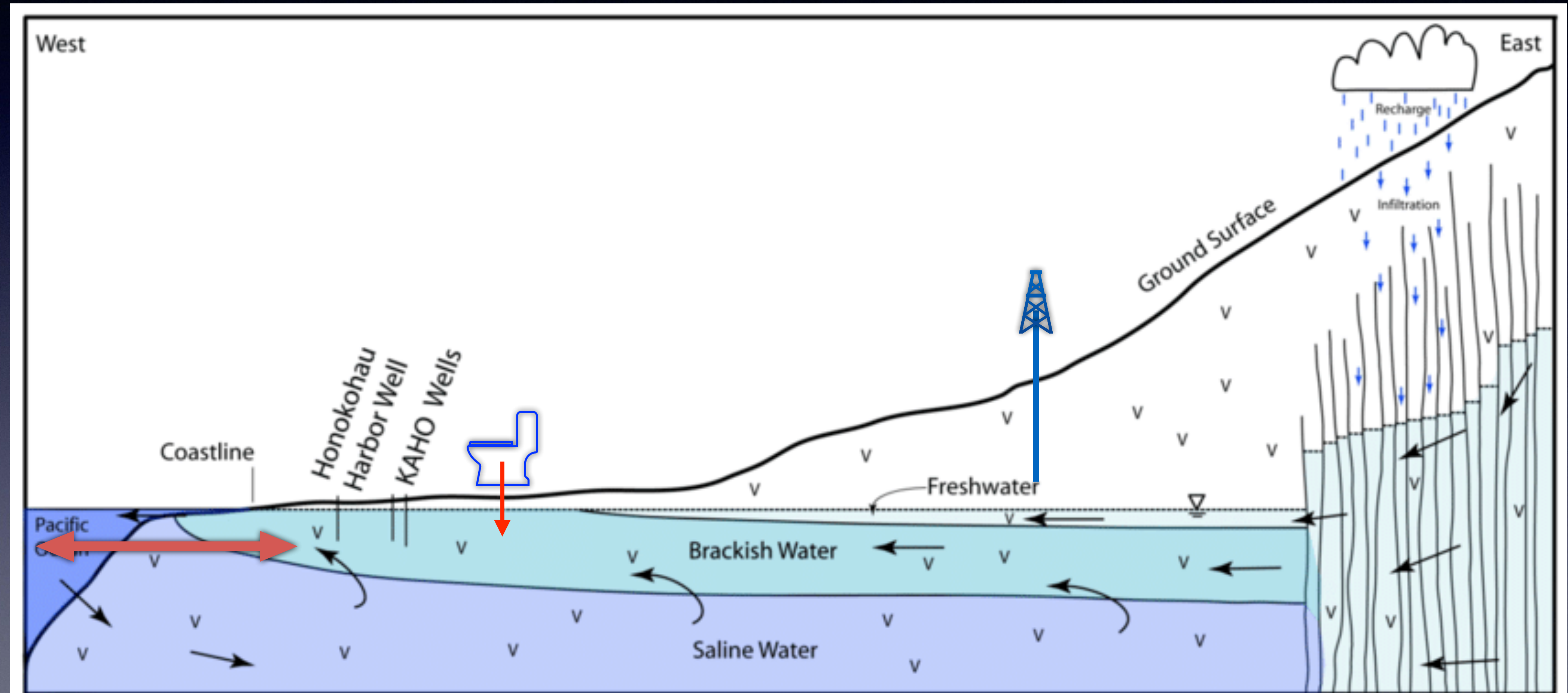
Chlorides 600-2000 mg/l

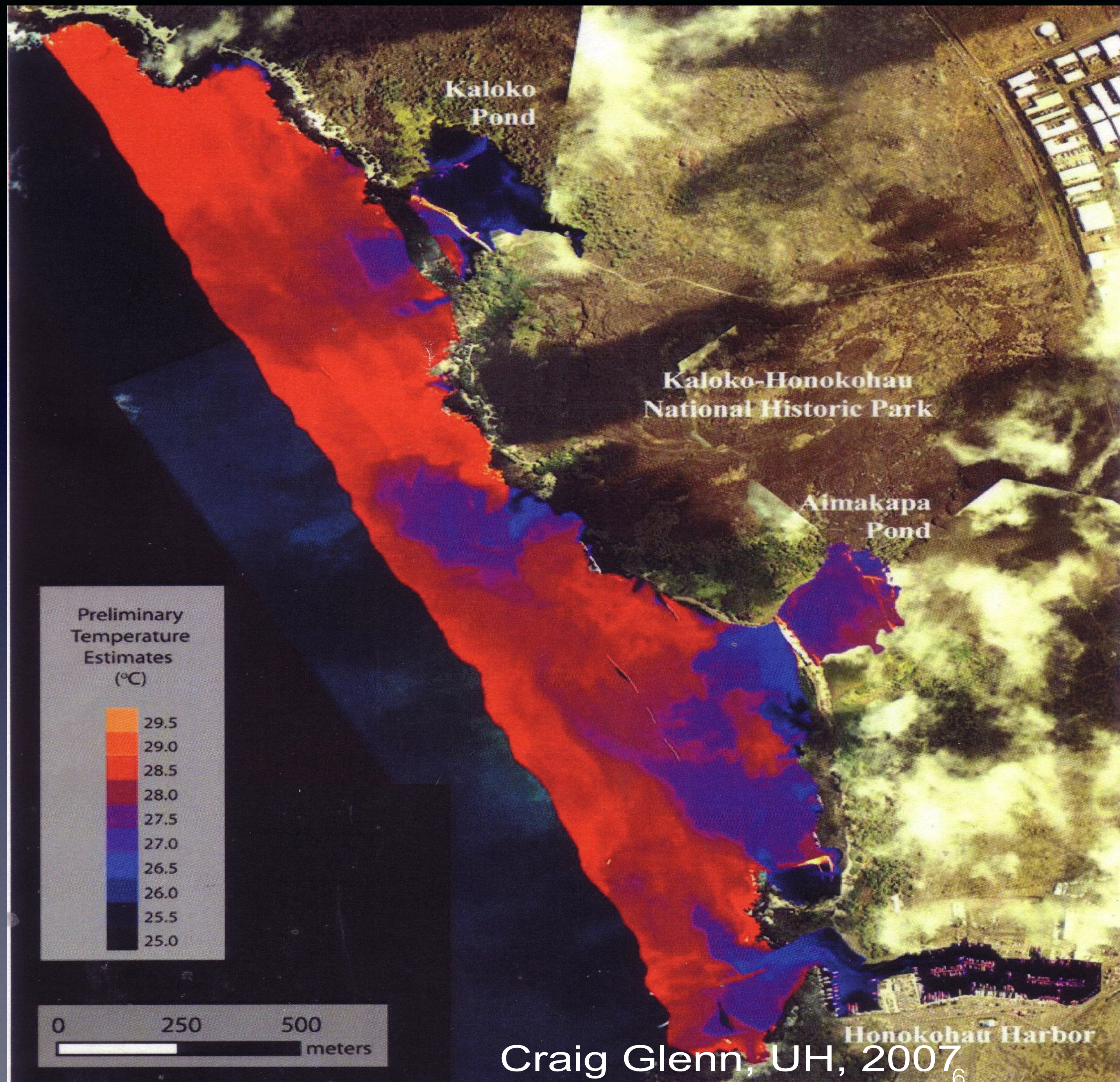
Drinking Water 100-400 mg/L

- ✱ Sewer pipes in this section of Ali'i Drive are 50+ years old
- ✱ Other iron pipes in system fully rusted through
- ✱ Replacement process finally underway by COH



Kona's Subterranean Estuary System





Huge volumes of nutrient rich ground water move into the ocean every day

Honokohou



Cesspits, Septic Systems, Sewers, and Storm Water Create Risk.

Water Drains to the Sea

**Our monitoring tools are.....
Antiquated
Misinterpreted.**

**The monitoring program
underfunded and poorly
staffed.**

Risk misrepresented



The Enterococci Water Test

US Beaches Act 2000
\$1M/yr for Hawai'i

Requires Testing and Postings



History of the Fecal Indicator Bacteria (FIB) Tests /Recreation Water

- ❖ Coliforms 1890's
- ❖ Fecal Coliforms 1966
- ❖ Enterococci Marine Water
- ❖ Formerly Fecal Strep.
 - ❖ 1970 EPA method / Risk
 - Risk assessments conducted in regions with known waste water discharges

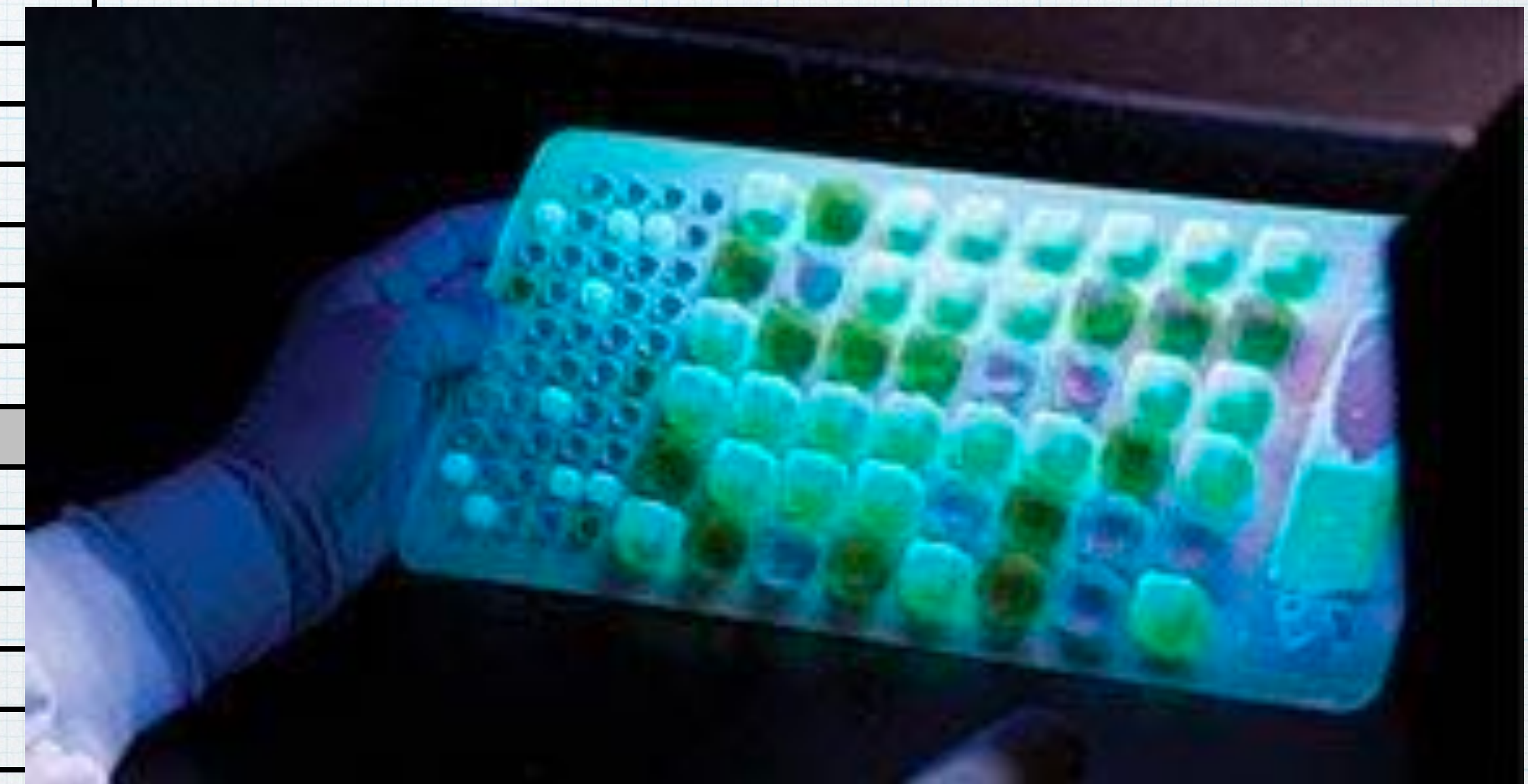
Deficiencies

- 50 species of Enterococci.
 - Only 2 low level pathogens
- Grow in clusters and chains.
 - Hard to count accurately
- Persists and grows in fresh and marine environments.

IDEXX 51-Well Quanti-Tray® MPN Table

Enterolert MPN System

No. of wells giving positive reaction	MPN per 100 ml sample	95% Confidence Limits	
		<u>Lower</u>	<u>Upper</u>
0	<1.0	0.0	3.7
1	1.0	0.3	5.6
2	2.0	0.6	7.3
3	3.1	1.1	9.0
4	4.2	1.7	10.7
5	5.3	2.3	12.3
6	6.4	3.0	13.9
7	7.5	3.7	15.5
8	8.7	4.5	17.1
9	9.9	5.3	18.8
10	11.1	6.1	20.5
11	12.4	7.0	22.1
12	13.7	7.9	23.9
13	15.0	8.8	25.7
14	16.4	9.8	27.5
15	17.8	10.8	29.4
16	19.2	11.9	31.3
17	20.7	13.0	33.3
18	22.2	14.1	35.2
19	23.8	15.3	37.3
20	25.4	16.5	39.4



Sea water 1:10 Fresh water

US Beaches Act 2000

PUBLIC LAW 106-284—OCT. 10, 2000

Funds and requires states to monitor and post violations of standards and beach closures

Criteria elements	Estimated illness rate (NEEAR GI): 36 NGI per 1,000 recreators		OR	Estimated illness rate (NEEAR GI): 32 NGI per 1,000 recreators	
	Magnitude			Magnitude	
Indicator	GM (CFU/100 mL)*	STV (CFU/100 mL)*		GM (CFU/100 mL)*	STV (CFU/100 mL)*
Enterococci – marine and fresh water	35	130		30	110
OR					
<i>E. coli</i> – fresh water	126	410		100	320

Duration: The water body GM and STV should be evaluated over a 30-day interval. **Frequency:** The selected GM magnitude should not be exceeded in any 30-day interval, nor should there be greater than a 10 percent excursion frequency of the selected STV magnitude in the same 30-day interval.



Risk estimates made for human recreation in waters near

sewer and wastewater discharge point sources.

There are no such estimates for non point sources of pollution ie. The Kona Coast



Relative Risk of GI Illness
as a function of Enterococci
Concentration in Marine
Waters:
Poor Correlation $r=0.37$ and
Weak Statistical Significance
 $p=0.051$
The risk is viral gastroenteritis

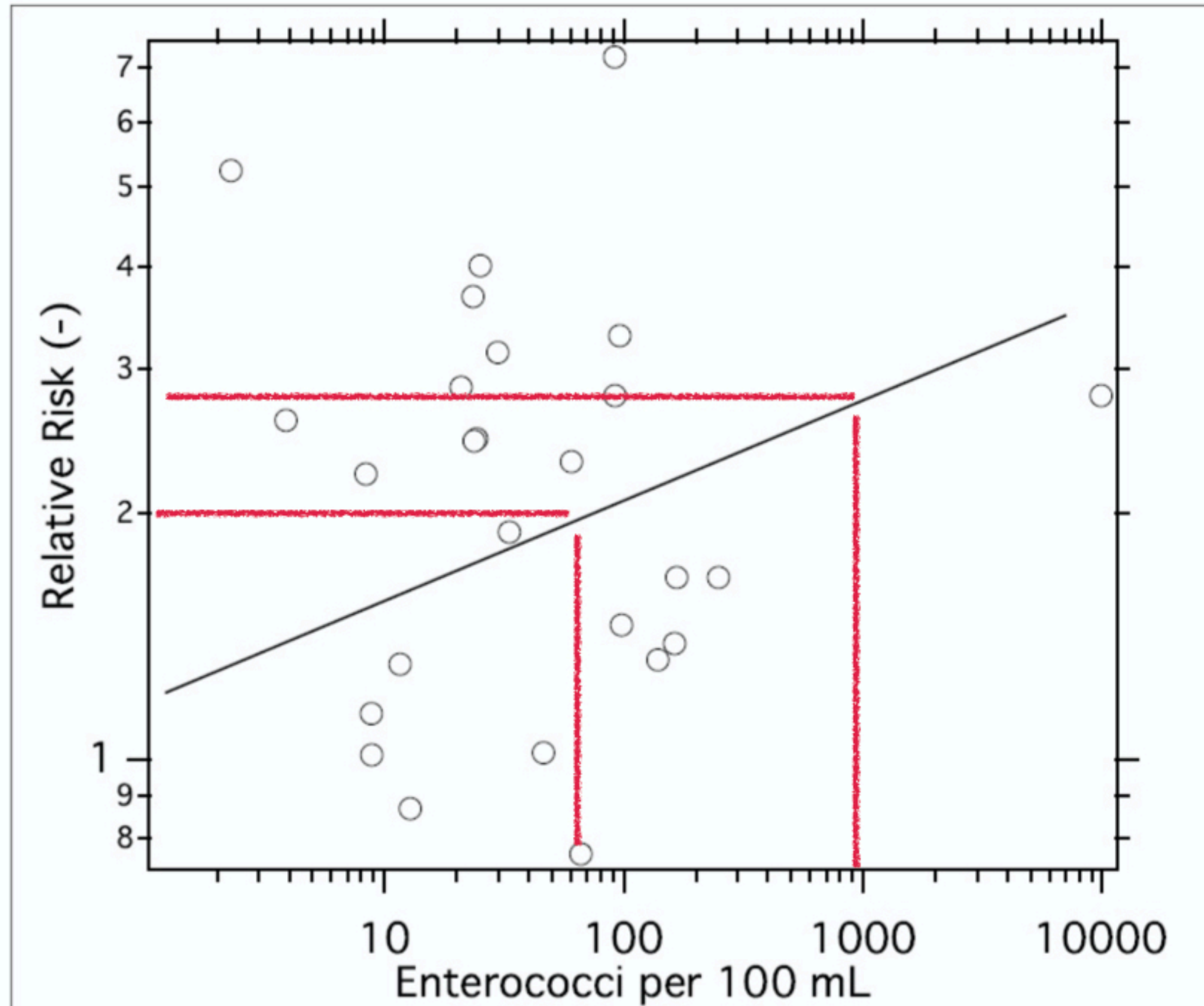
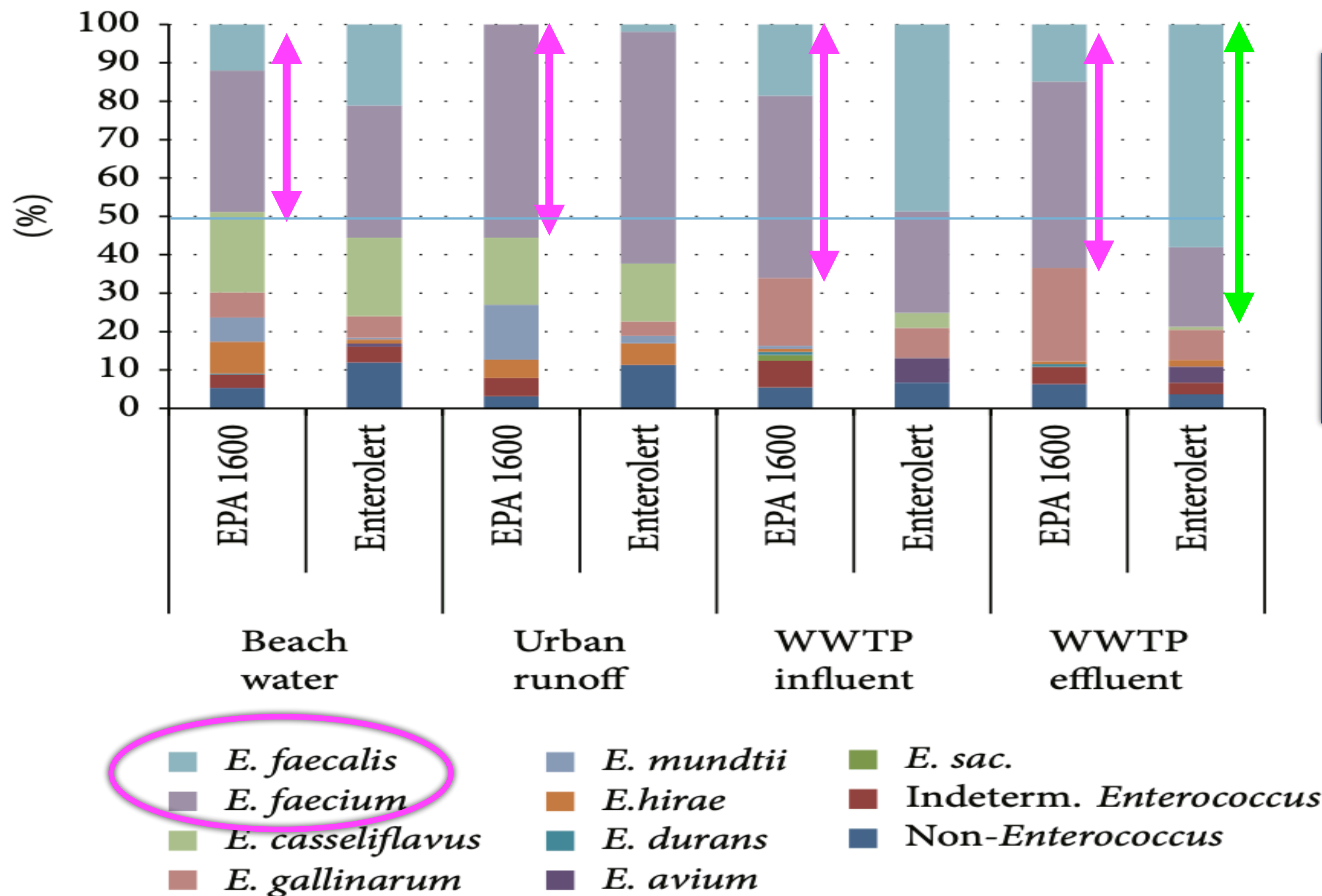


Figure 4



Wade TJ, Pai N, Eisenberg JN, Colford JM Jr. Do U.S. Environmental Protection Agency water quality guidelines for recreational waters prevent gastrointestinal illness? A systematic review and meta-analysis. *Environ Health Perspect.* 2003;111(8):1102-1109. doi:10.1289/ehp.6241



The Official Enterococci Tests are NOT species specific

FIGURE 2: Distribution of predominant *Enterococcus* species found among beach water, urban runoff, and wastewater treatment plant (WWTP) influent (untreated) and effluent (treated) samples.

Tsikrikonis, Giorgos, et al. "Differences in biofilm formation and virulence factors between clinical and fecal enterococcal isolates of human and animal origin." *Microbial pathogenesis* 52.6 (2012): 336-343.

Public Policy , Regulations and Regulators Greatly Overstate the Contemporary Disease Risk from Human Feces

HDOH-Wastewater Branch
2014

“Untreated wastewater contains pathogens such as bacteria, protozoa and viruses that can cause gastroenteritis, Hepatitis A, conjunctivitis, leptospirosis, salmonellosis and cholera”.



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Hawai'i Public Health Policy is shaped by:

- History
- Bureaucratic Risk Aversion
- Inattention to the scientific data

The Yuk Factor

Molecular Microbiology

No longer dependent on culture and grow methods

What does nothing grew mean?



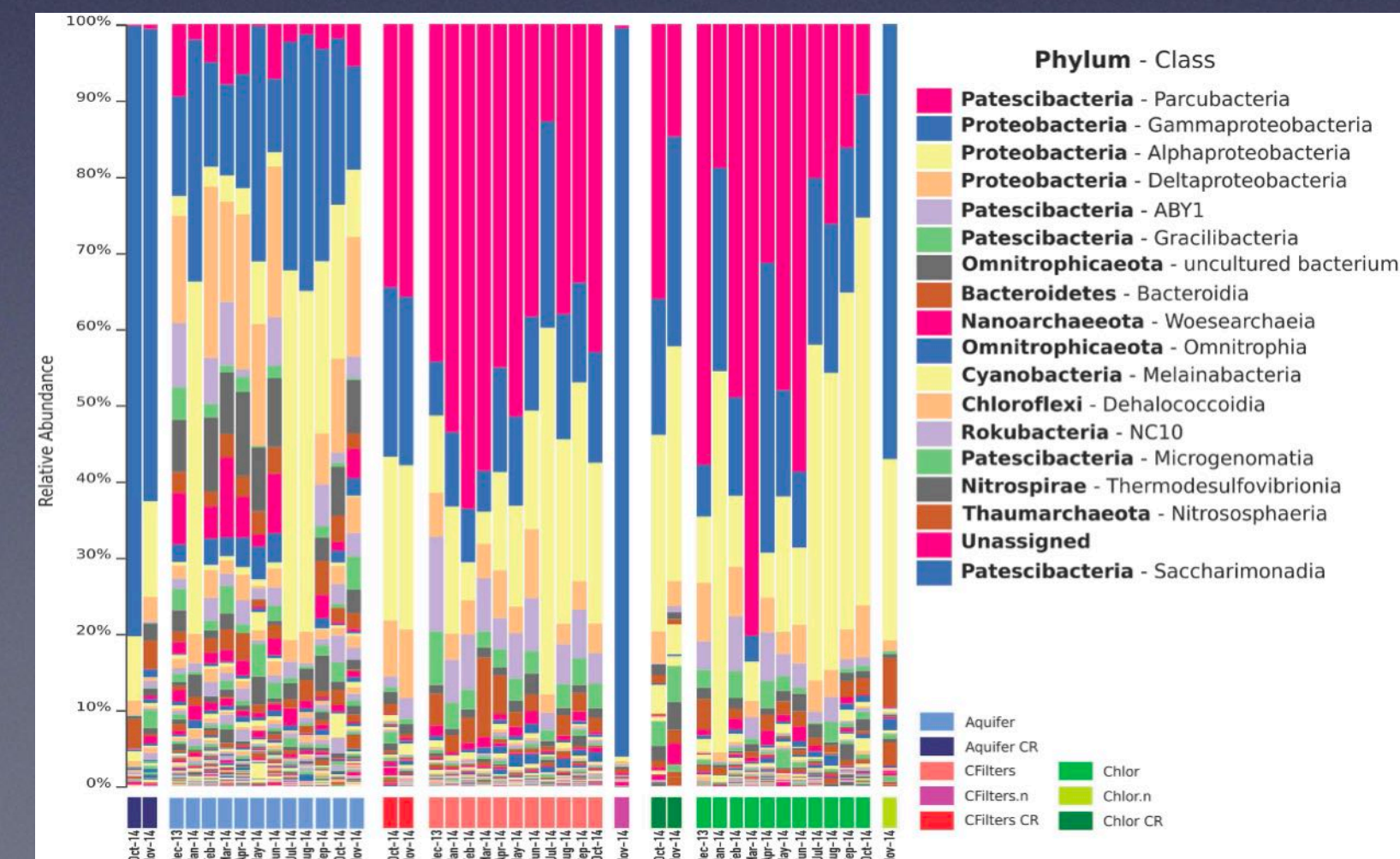
Detect and Quantitate Unique DNA/RNA Segments

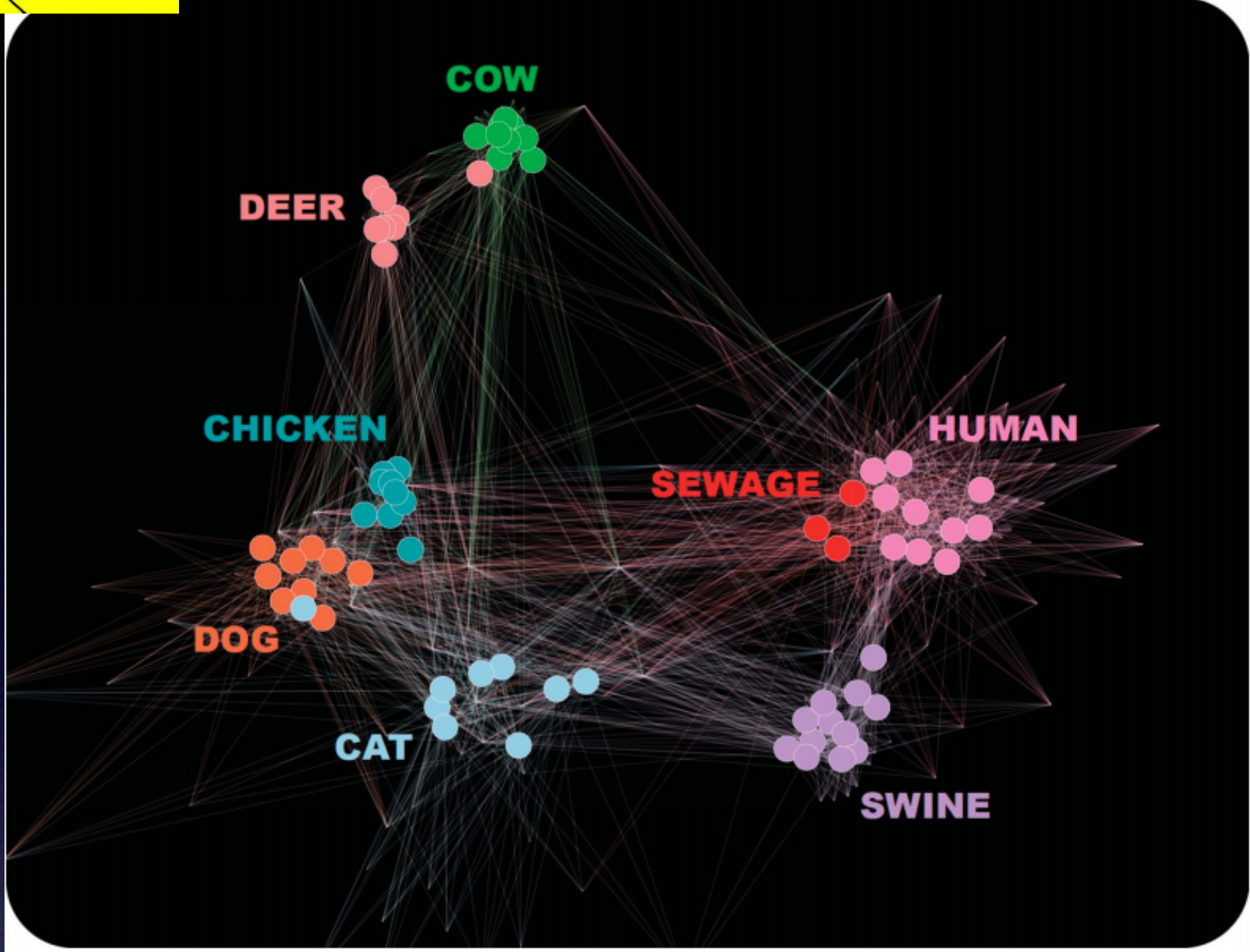
PCR

for any microbe
ie. COVID



NEXTGEN Sequencing





The sewage microbiome is not the same as the Intestinal microbiome

We have been looking in all the wrong places.



Available online at www.sciencedirect.com

ScienceDirect

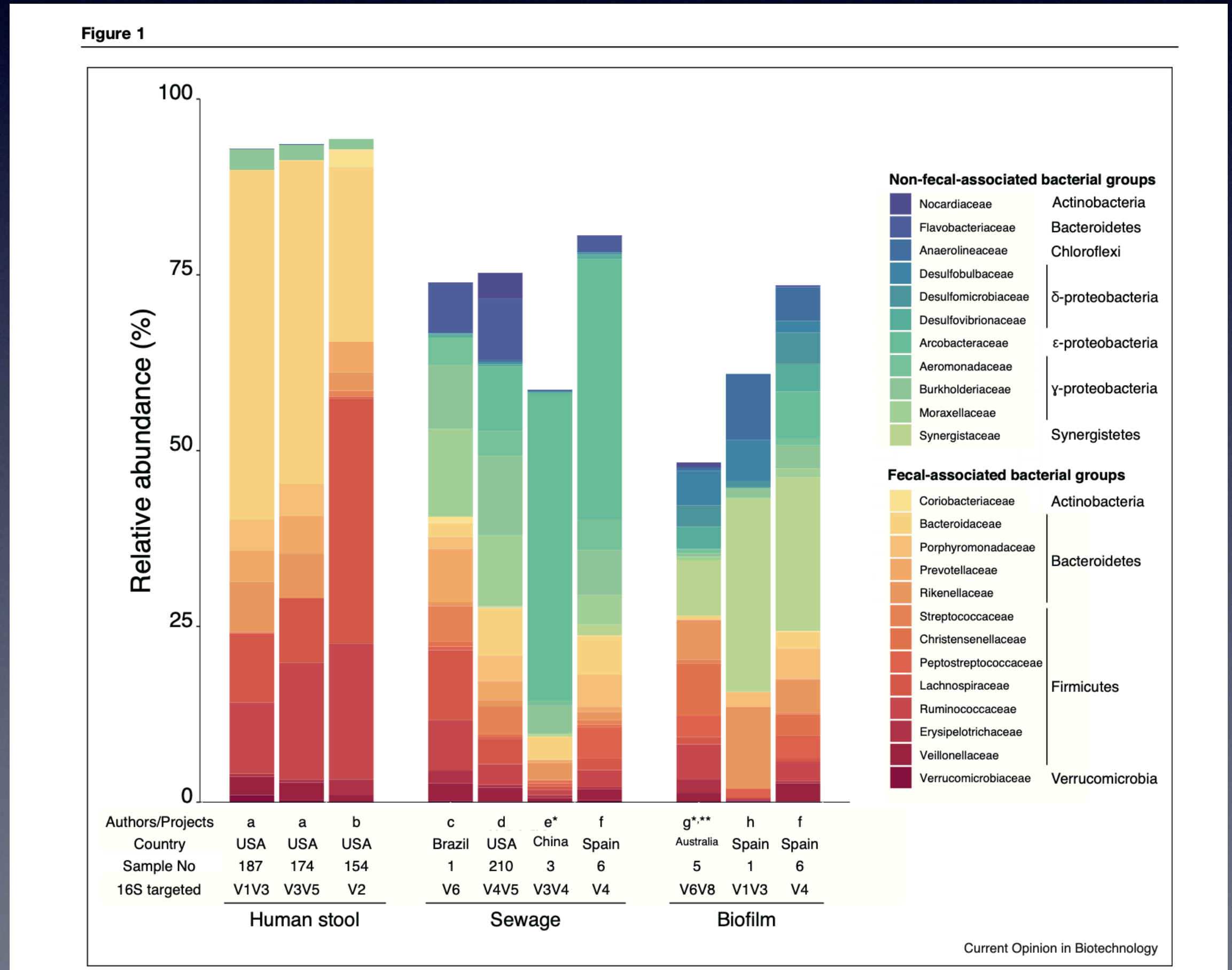
Current Opinion in Biotechnology

The unexpected habitat in sewer pipes for the propagation of microbial communities and their imprint on urban waters

Sandra L McLellan and Adélaïde Roguet



Curr. Opin. Biotech. 2019, 57:34-41



Ocean users are the “canary in the coal mine”

170 ml of water ingested per day
and 77 days surfing per year.
(Oregon)

Slight Increase GI illness
(Stone 2008)

Skin infection, another story....

5.91 times more likely to report a skin
illness (95% CI 2.76–12.63; $P < 0.0001$)

relative to non-users (Florida)
(Fleischer 2010)

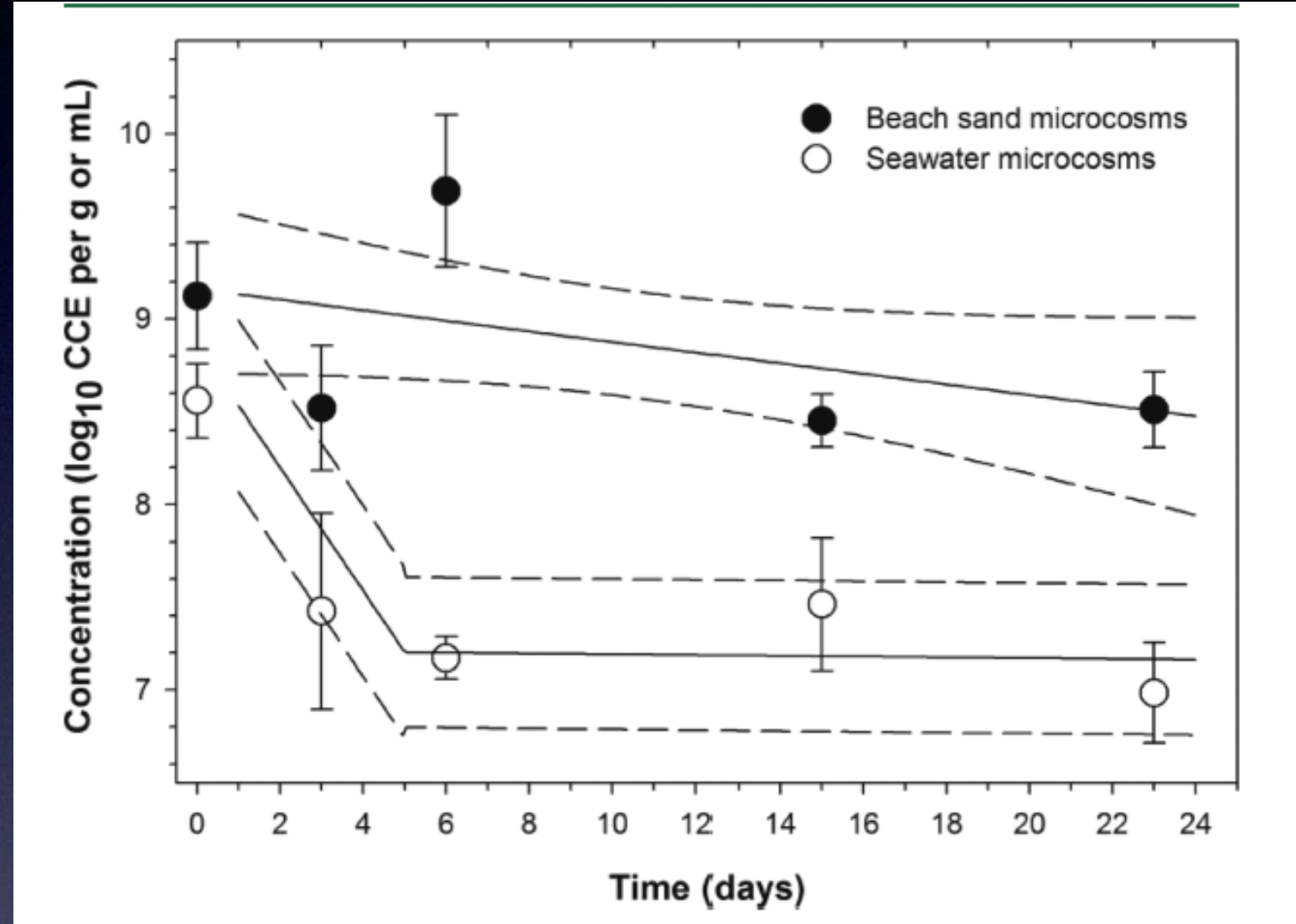


The Sand Microcosm !!

Calif. Beaches

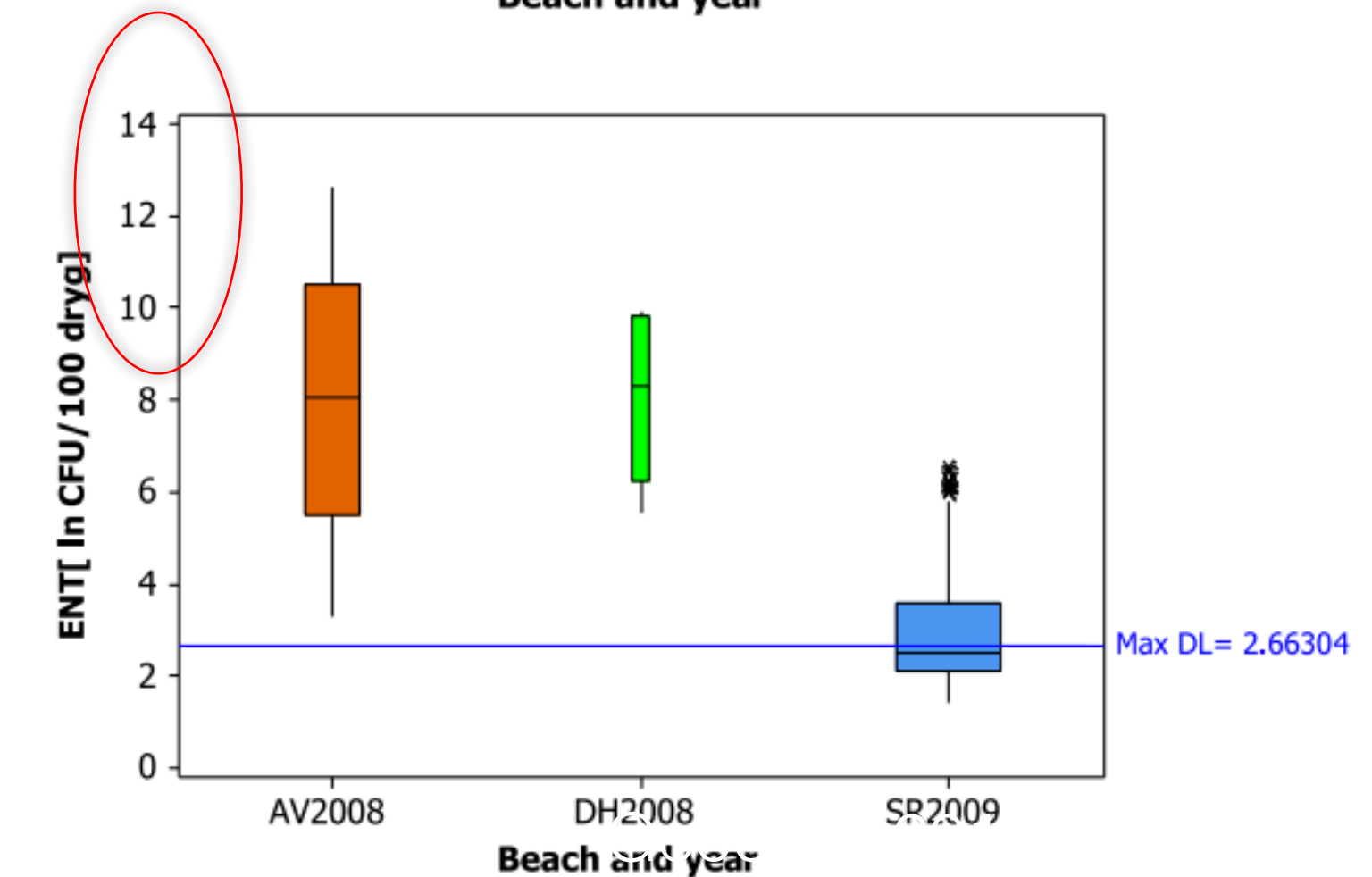
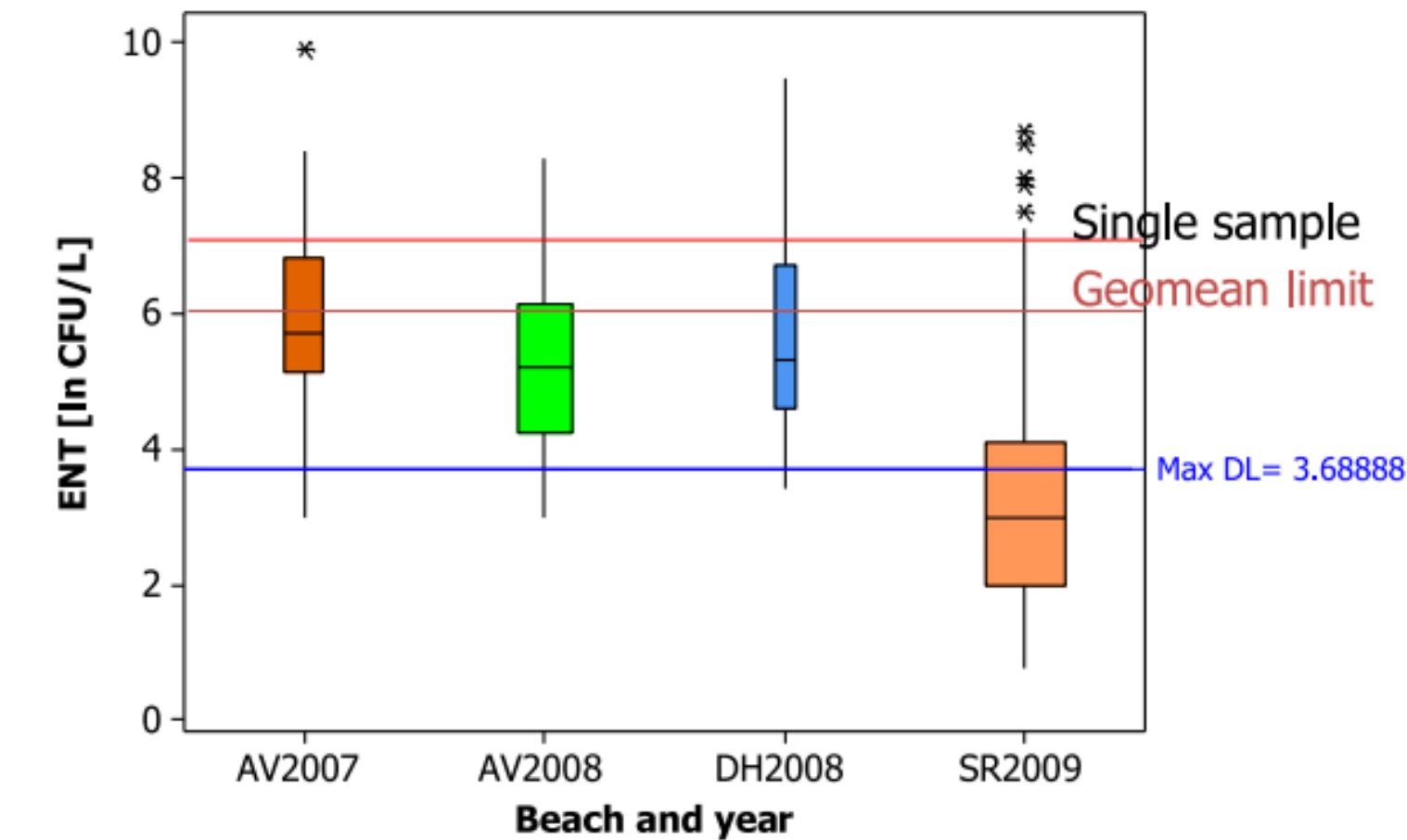
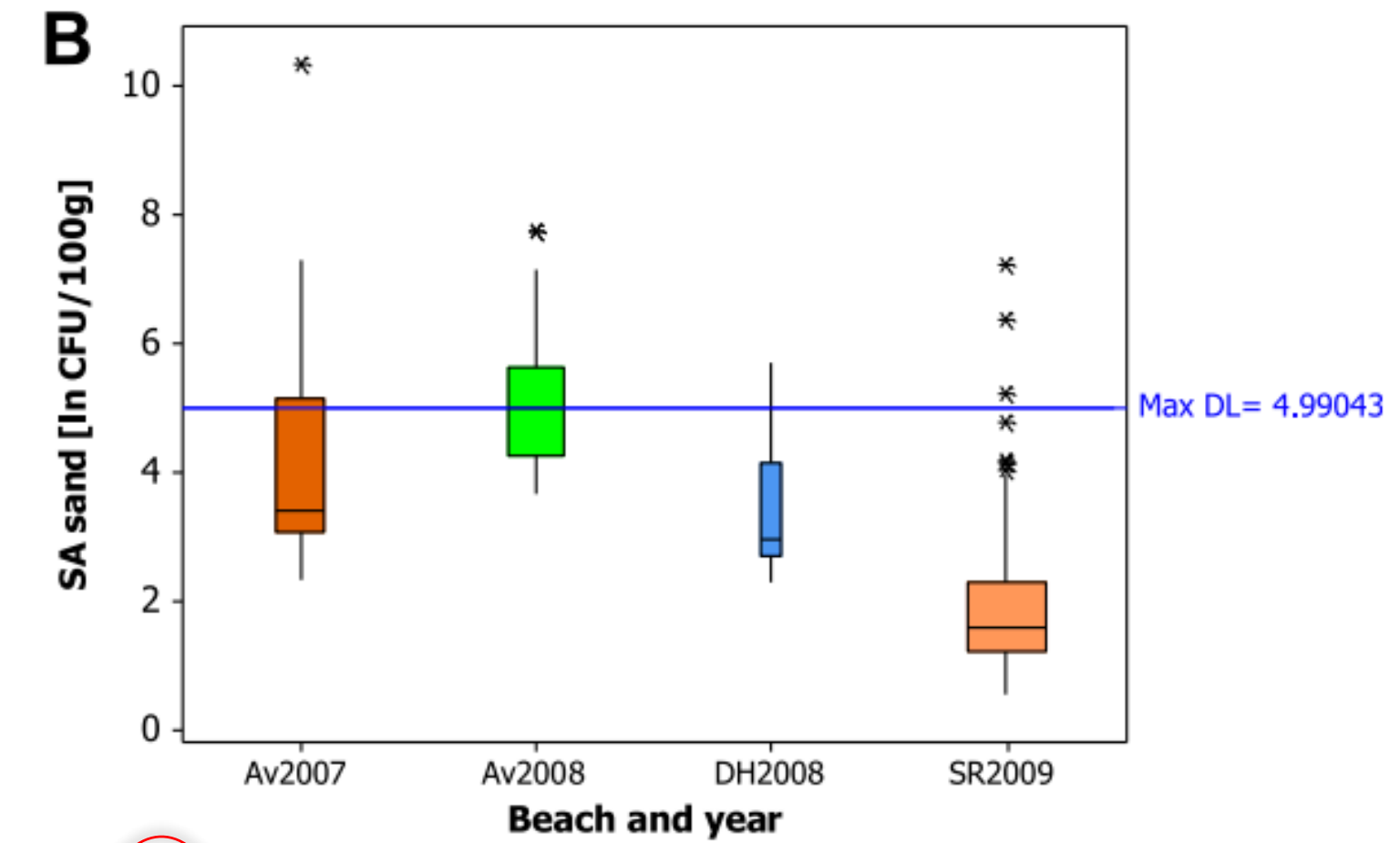
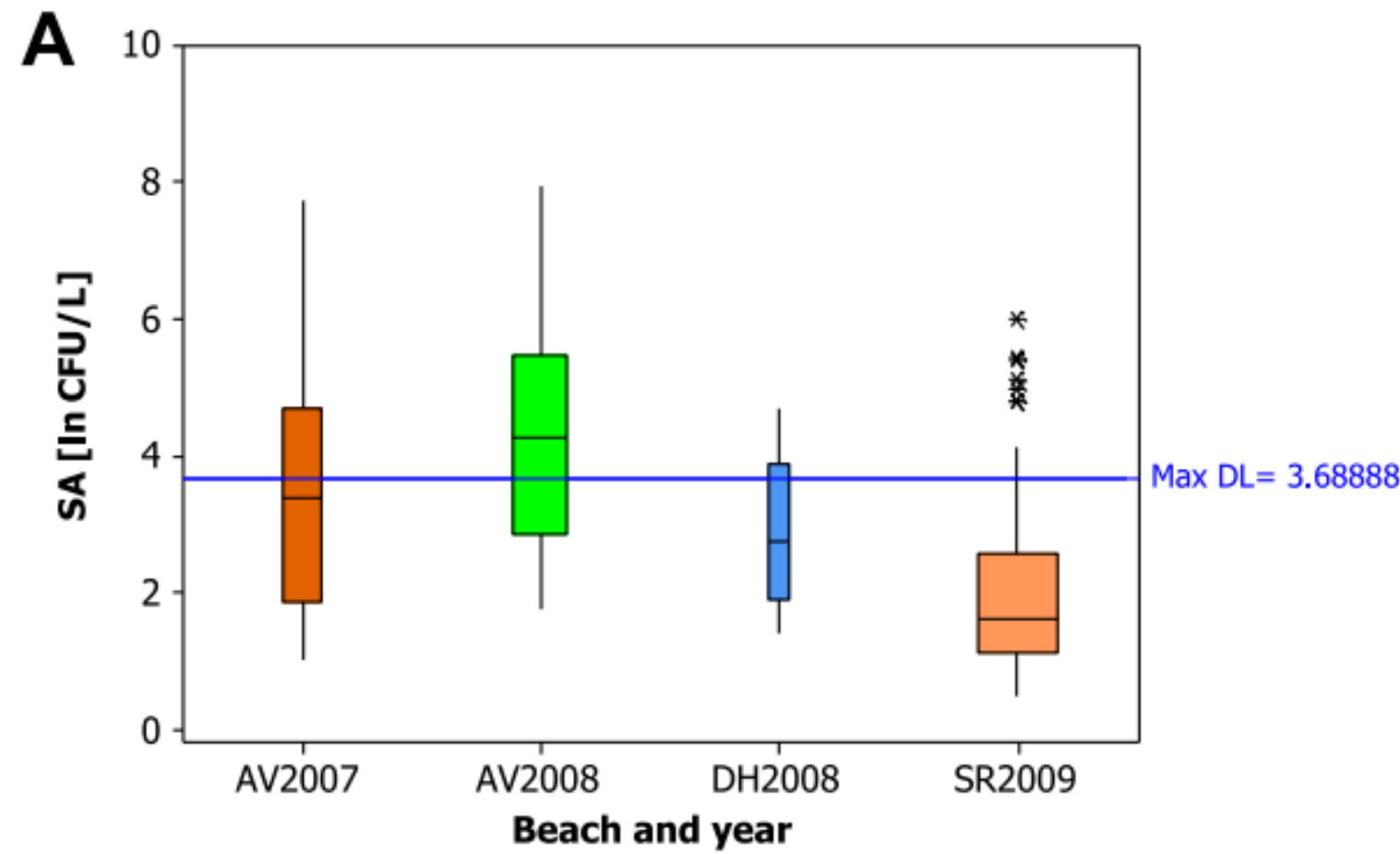
Water

Sand

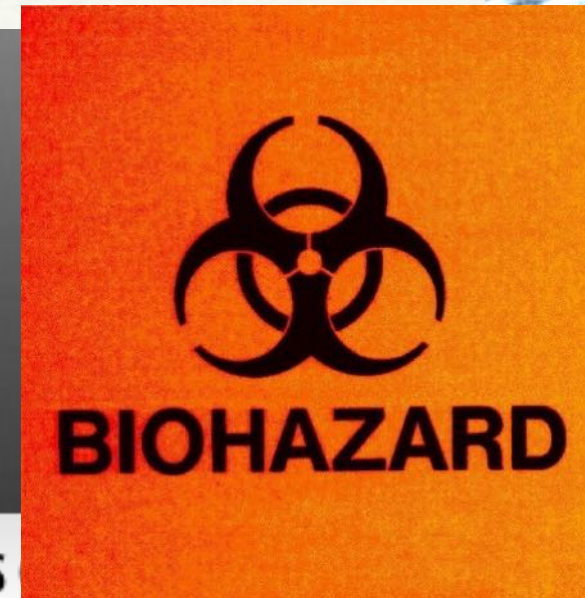
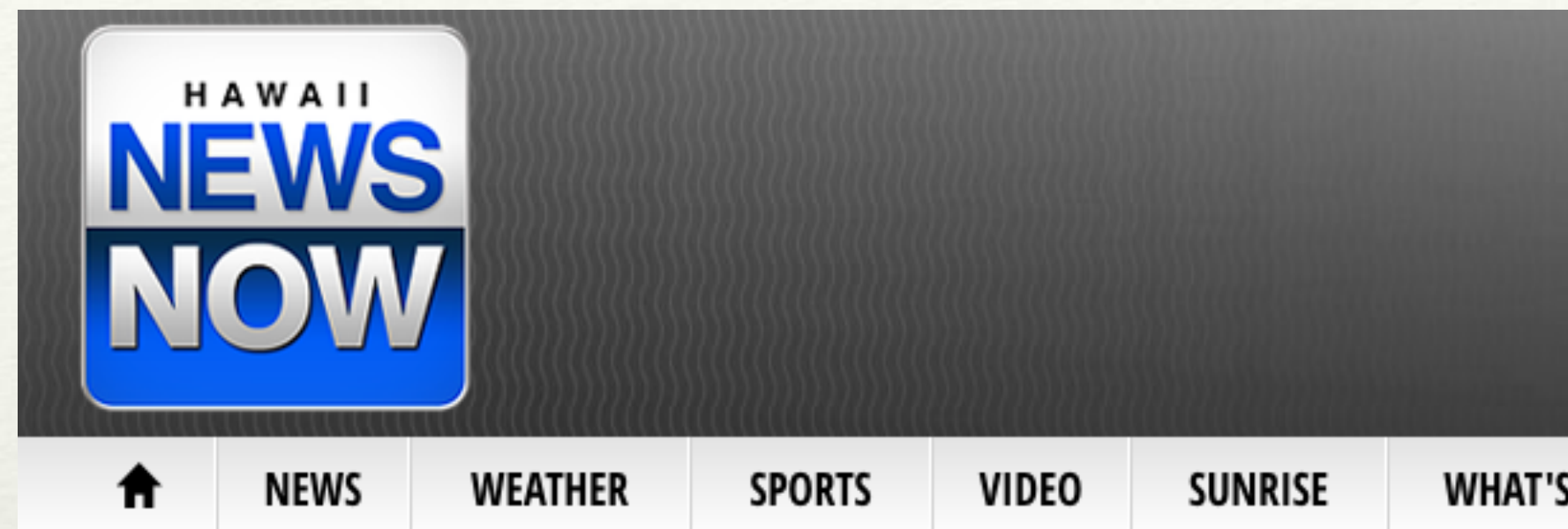


Total Bacteria, No light exposure
(Zhang 2015)

Ent. and Staph bacteria;
far more numerous and
far more persistent in sand



Staphylococcus aureus in wastewater and beach sand.



Hawaii Leads Nation in Deadly Staph Infections



Dr. Alan Tice

By [Leland Kim](#)

HONOLULU (KHNL) -- There are reports from across the nation of students being diagnosed with antibiotic-resistant staph infections. In Nebraska, four basketball players got sick with staph infections.

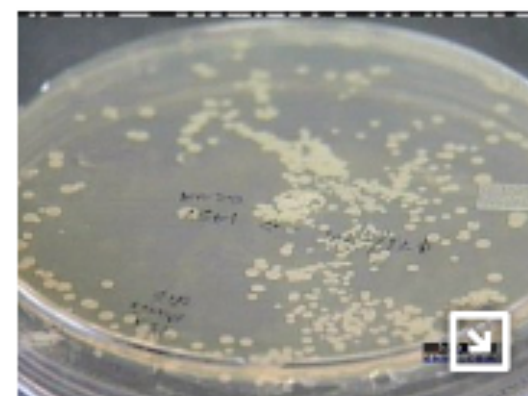
A high school football player in Virginia and a middle school girl in Mississippi recently died from a strain of staph called MRSA.

So, the question is do we need to be concerned in Hawaii about the superbug known as MRSA? The answer is yes.

Hawaii is home to beautiful beaches, but our tropical paradise is also home to bacteria that causes staph infections.

And the deadliest strain is called Methicillin-Resistant Staphylococcus Aureus, more commonly known as MRSA.

"This is an organism that once it gets into the body, can go to the heart, or the lungs and people can die," said Dr. Alan Tice, an infectious diseases specialist with the University of Hawaii's John A. Burns School of Medicine.



S.aureus 40/cm² causing infection in 20% of subjects.

(Singh 1971)

Low correlation(.64) with Enterococci in sand (Goodwin 2012)

Staphylococcus aureus (many different strains)

33% Nasal and Fecal Carriers

Most strains low pathogenicity

Common in beach sand, low prevalence MRSA



In Hawai'i Staph infections not "Reportable" as required for TB, HIV etc.

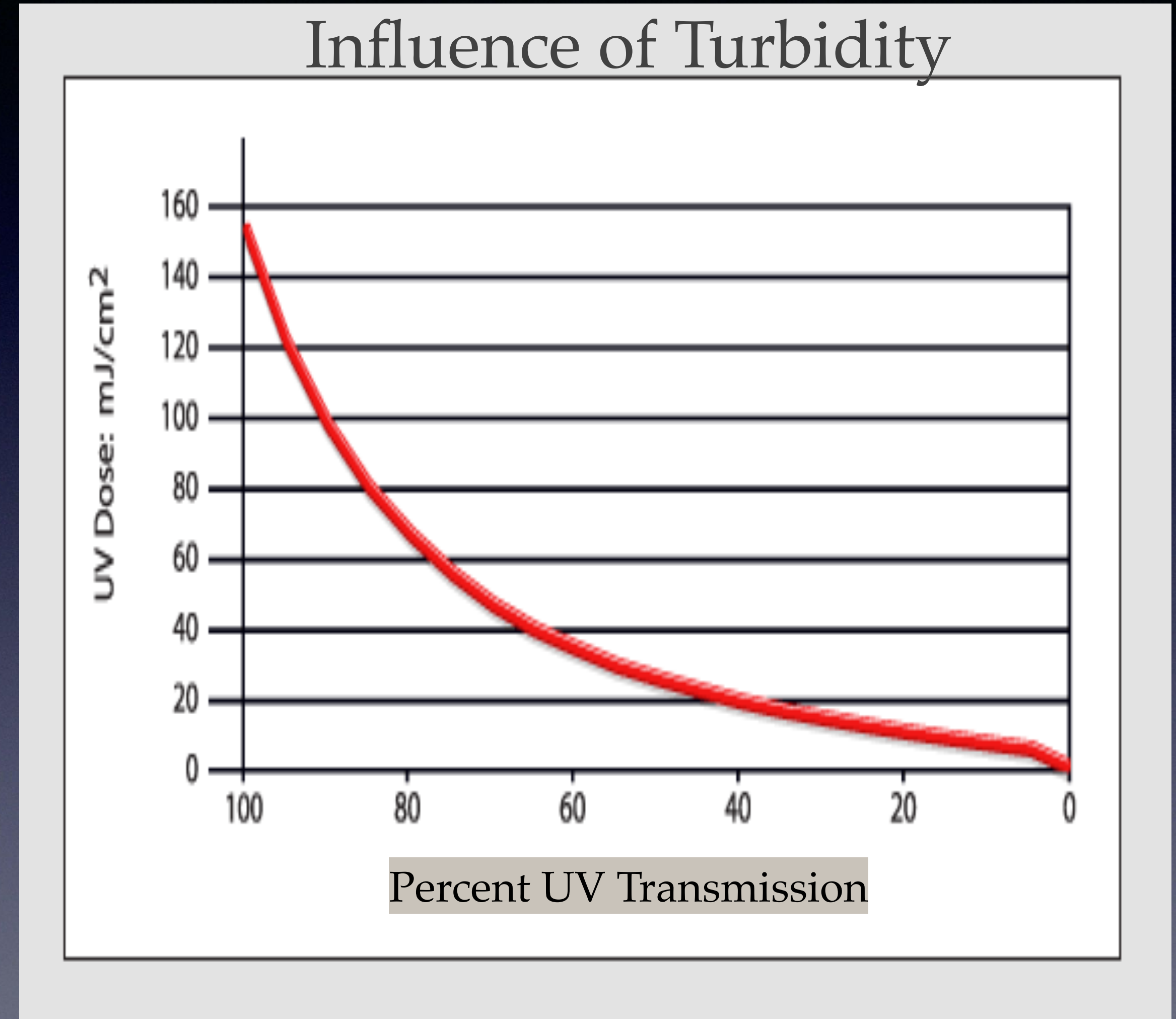
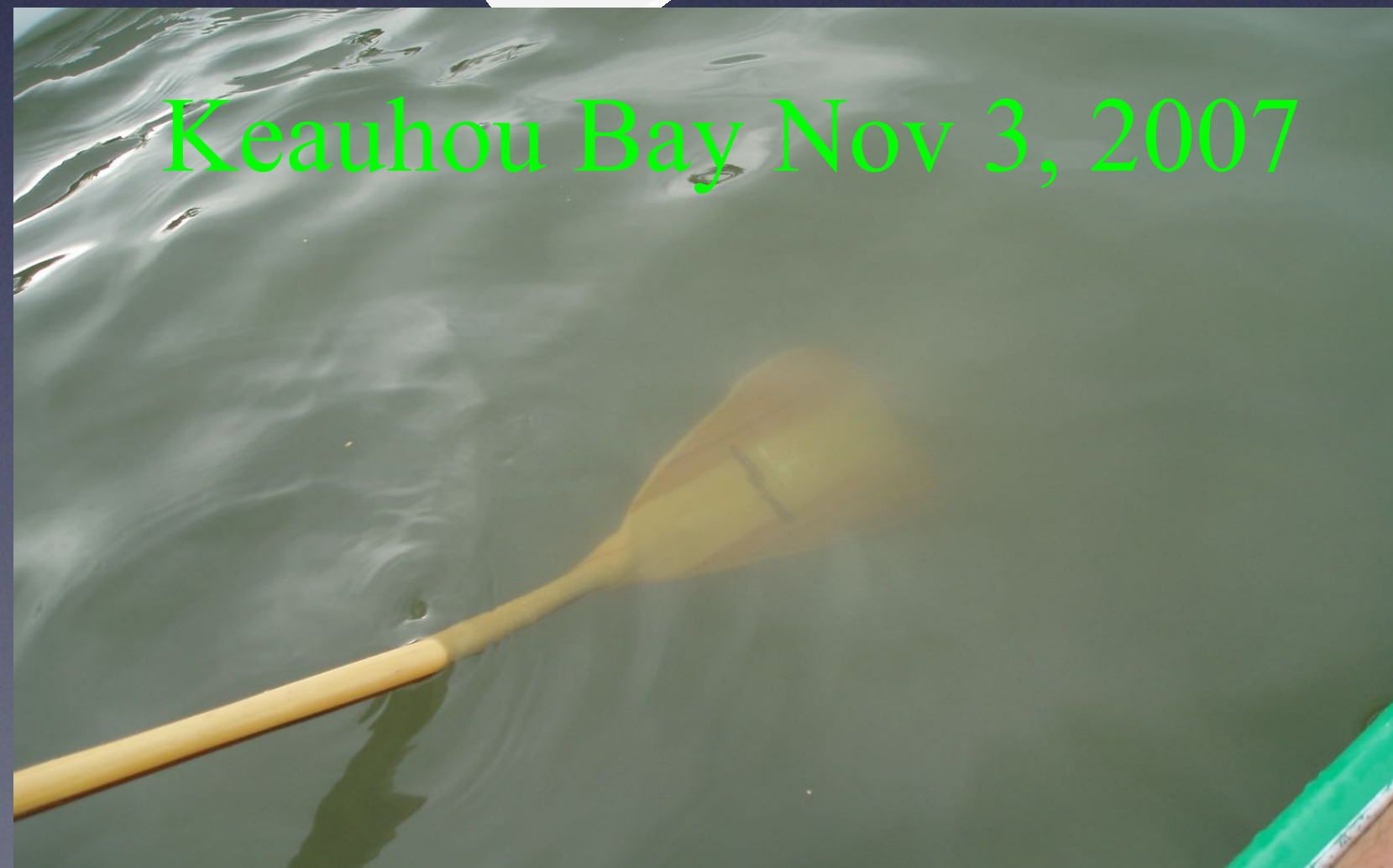
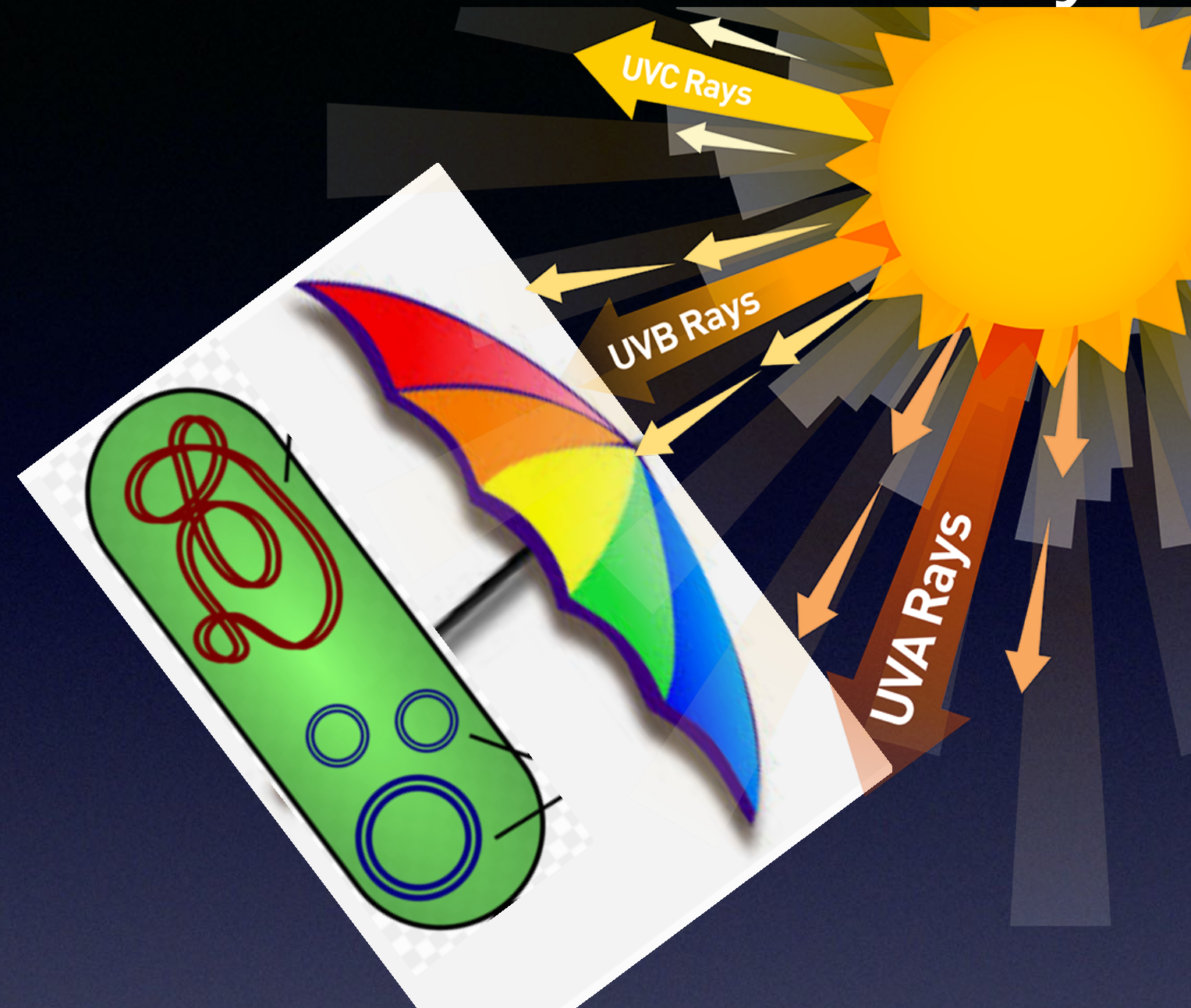
**NUTRIENTS > ALGAE =
PATHOGEN SUNSCREEN**

Rotten Iron Sewer Pipes
Found Recently
Aug 2020

May 28, 2020
Phytoplankton (algae) Bloom



Turbidity is UV “shade” for bacteria



Sunlight UV Effects Marine Bacteria and Virus

UV dose/time inactivates bacteria and virus.

Varies by species

Low Dose UV can render microbes VBNC, leading to false negs.

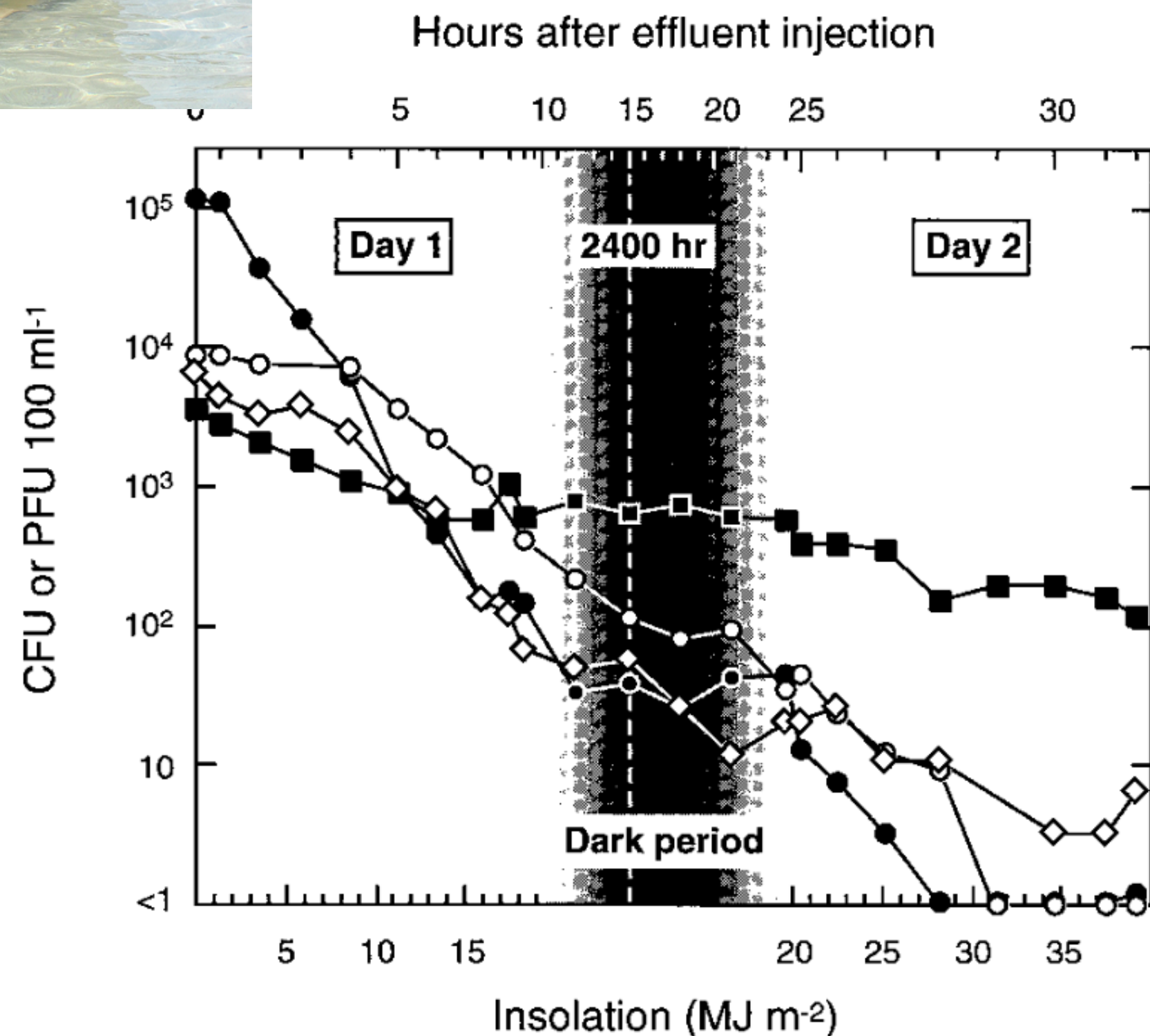
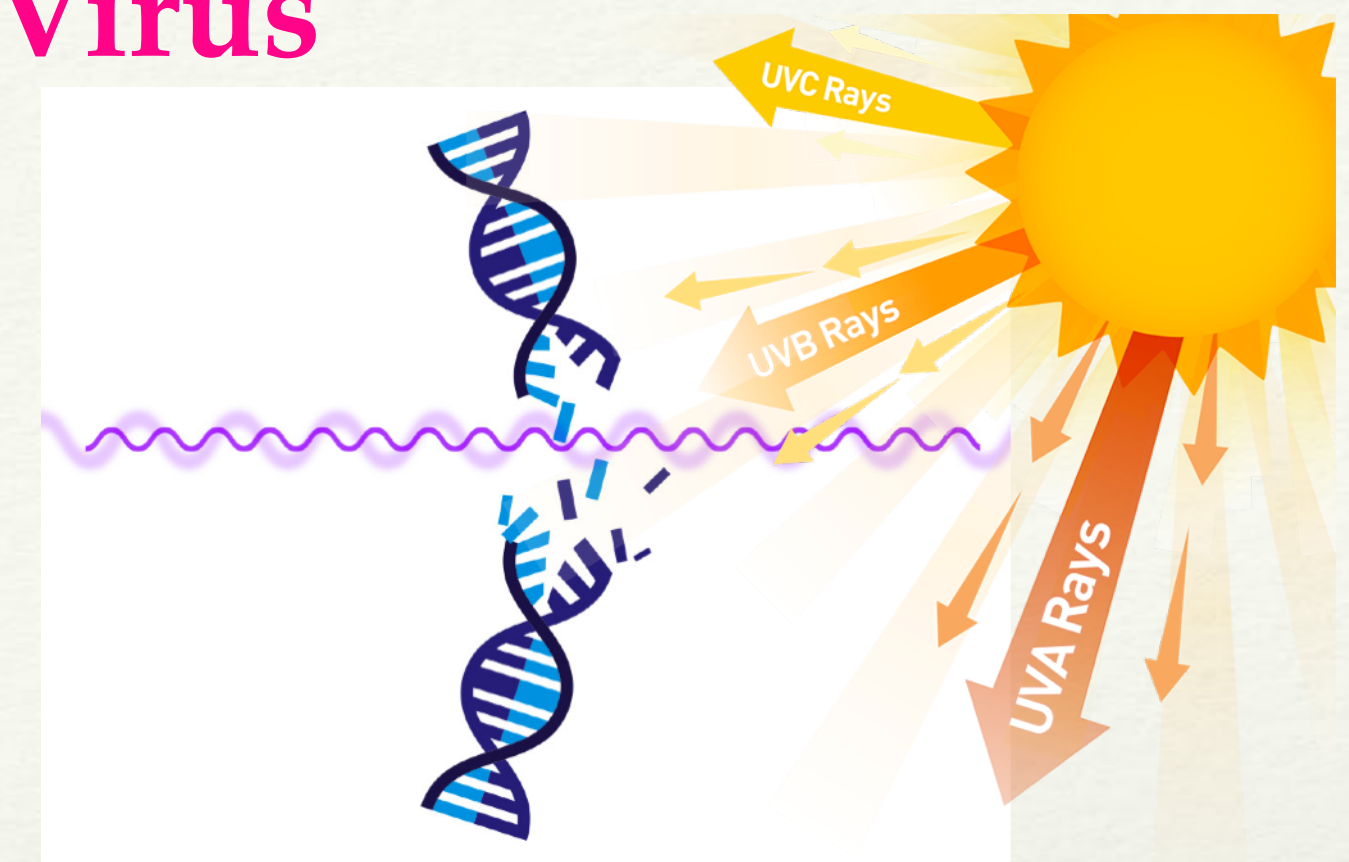
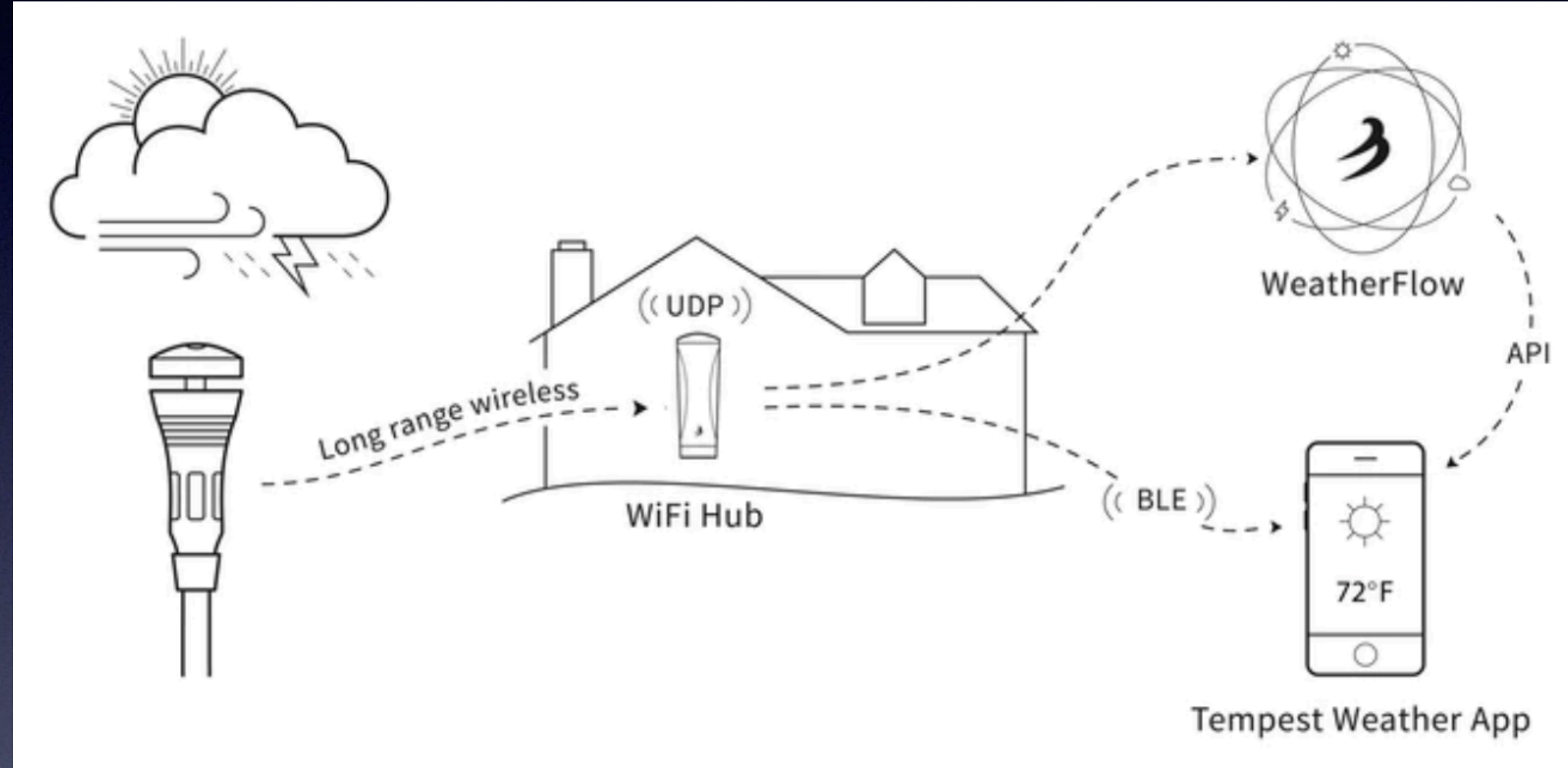


FIG. 6. Inactivation in seawater of somatic coliphages (■), F-RNA phages (◇), enterococci (○), and fecal coliform bacteria (●) from untreated sewage, as a function of insolation and time. The insolation scale is linear during daylight hours; the time scale is linear during the overnight period. Samplings in which no CFU were detected in 100 ml are presented as <math><1</math> on the (\log_{10}) y axis.



<https://shop.weatherflow.com/products/tempest>

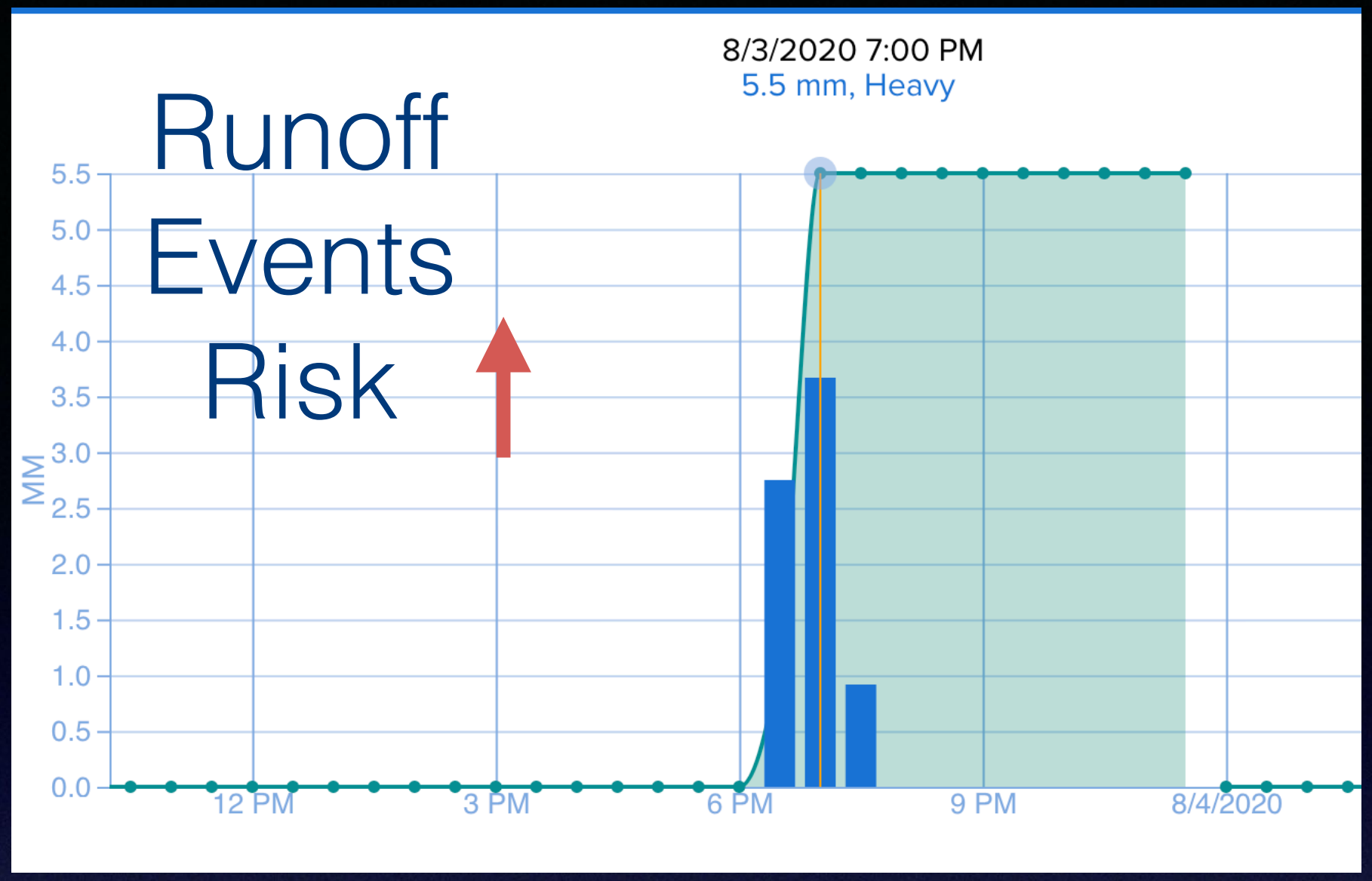
Using site specific *Tempest™* weather data to estimate relative microbial risk from ocean recreation



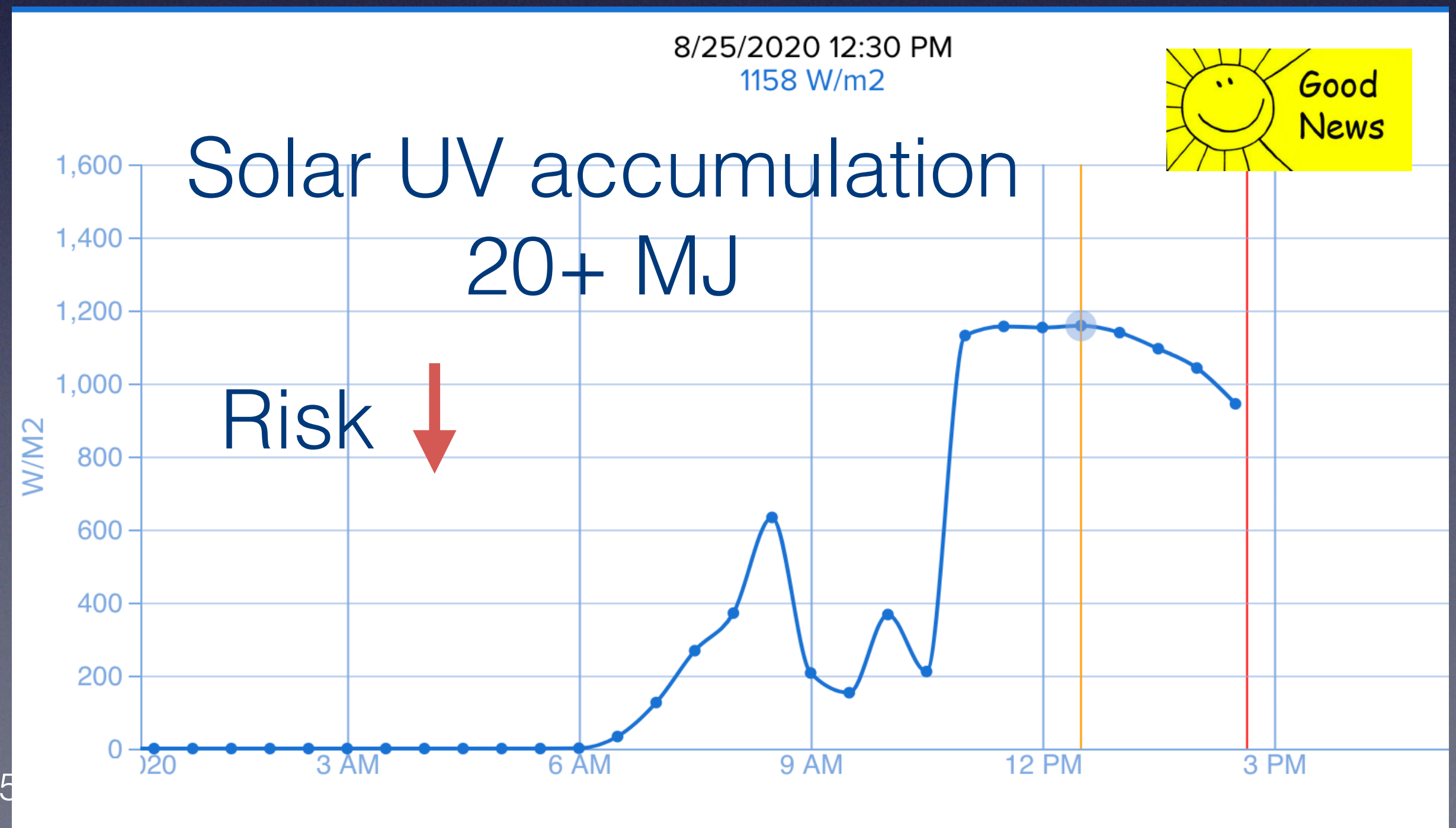
<https://shop.weatherflow.com/products/tempest>

Beach Cooperator???

808rhb@gmail.com



San Diego "Alerts" at 0.2 in. rain



Sucralose

A viable wastewater indicator

Extremely stable

No degradation in WW treatment

UV stable

No microbial breakdown

No natural analog

Not metabolized

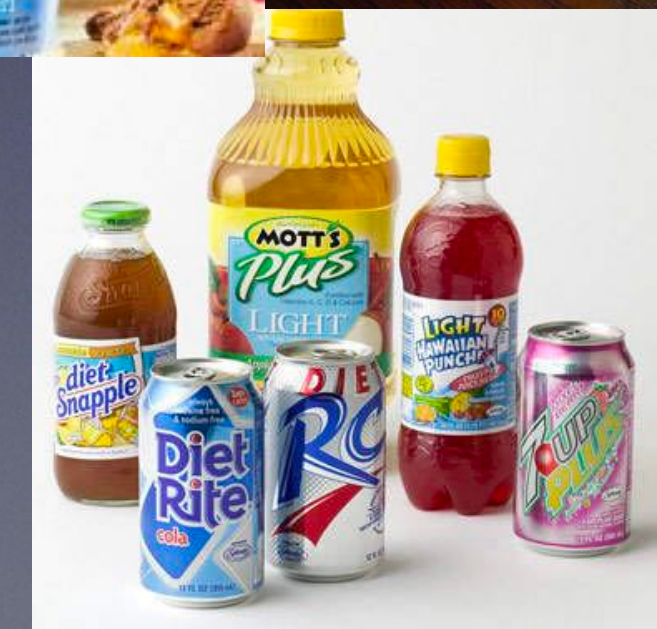
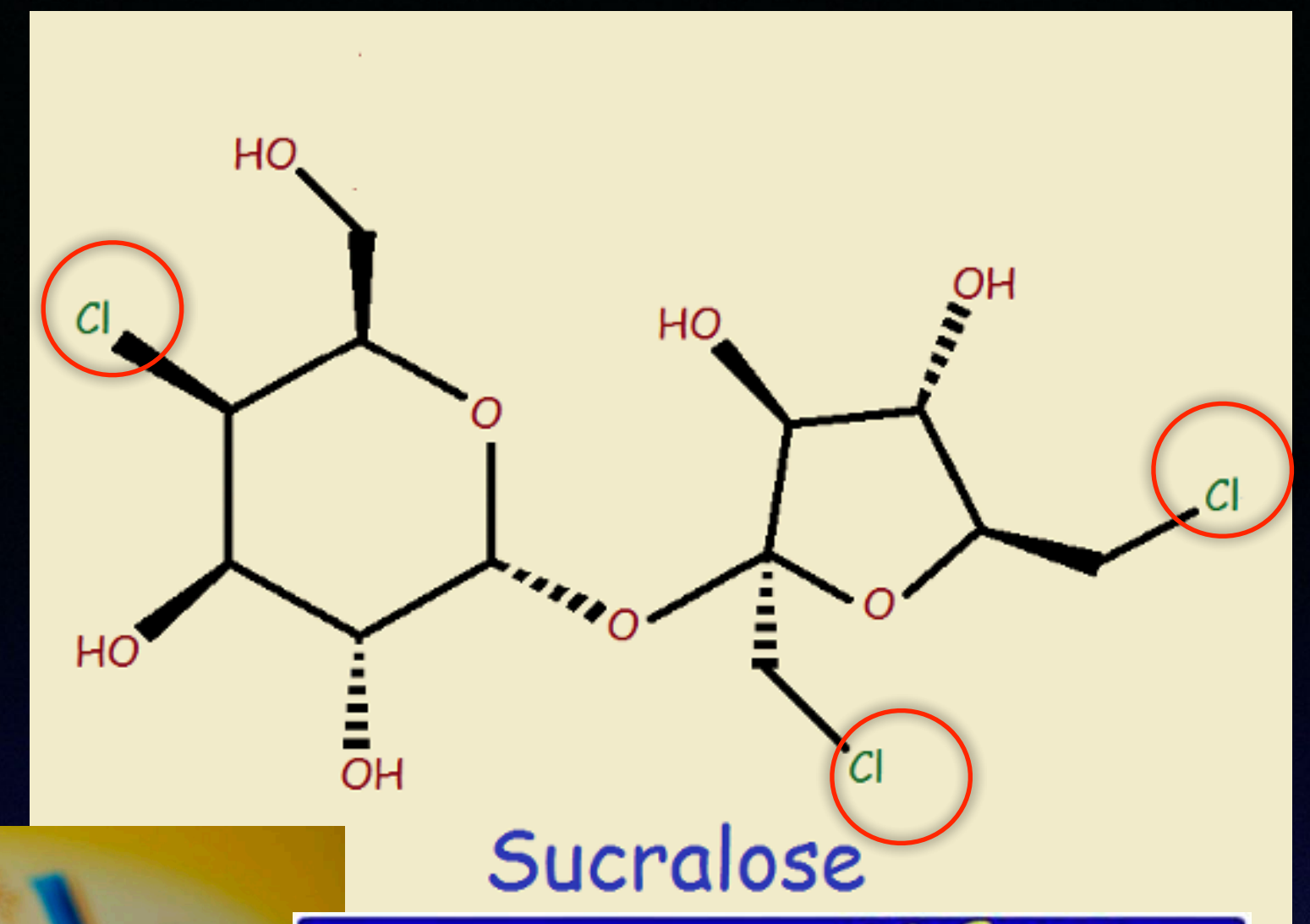
Mostly excreted with feces /24h

Measurement by SPE Orbitrap Mass Spec.

MDL 12 ng/L

Very precise and accurate

400+ Products



Sucralose in Wastewater and the Near Shore

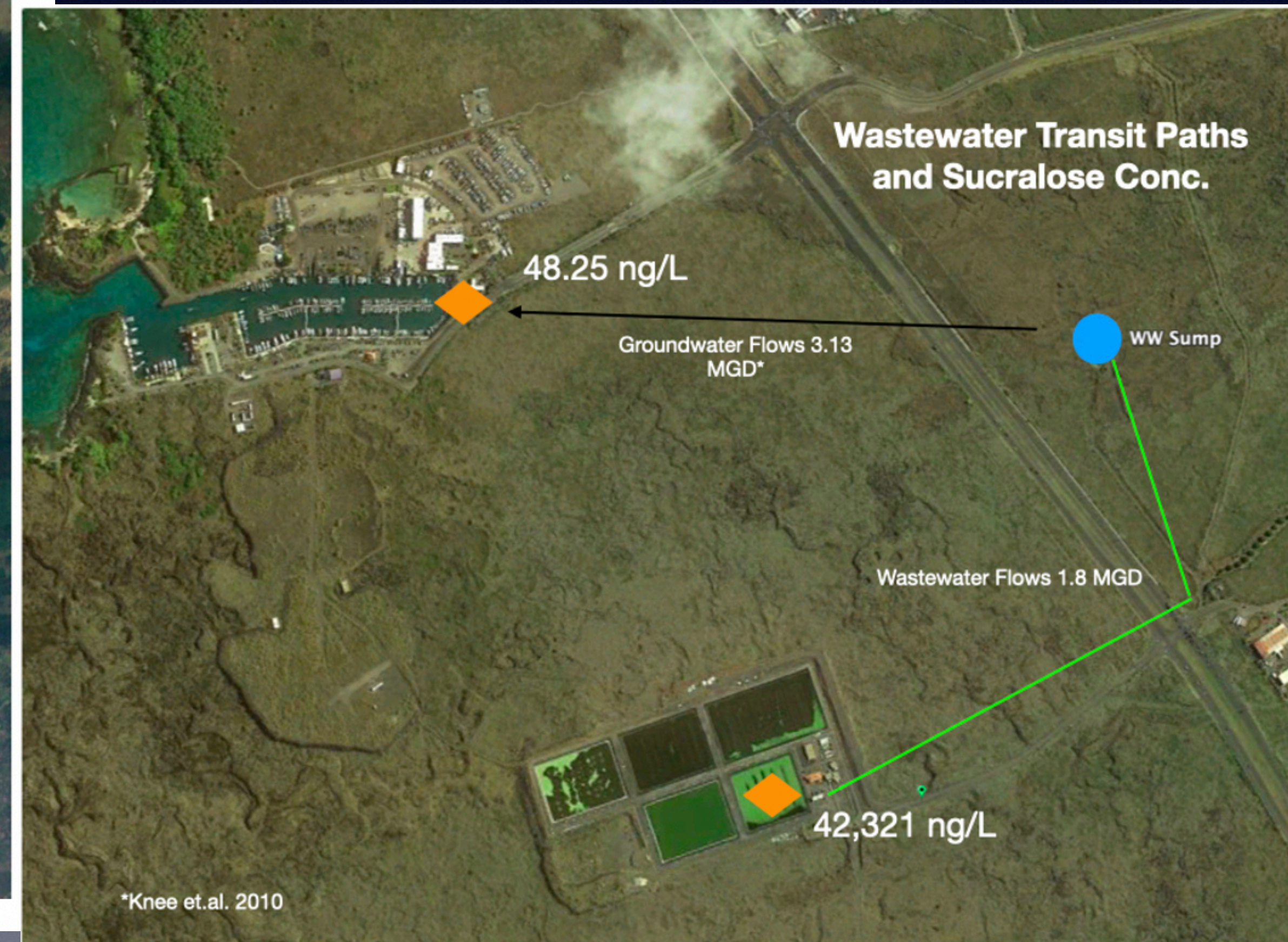
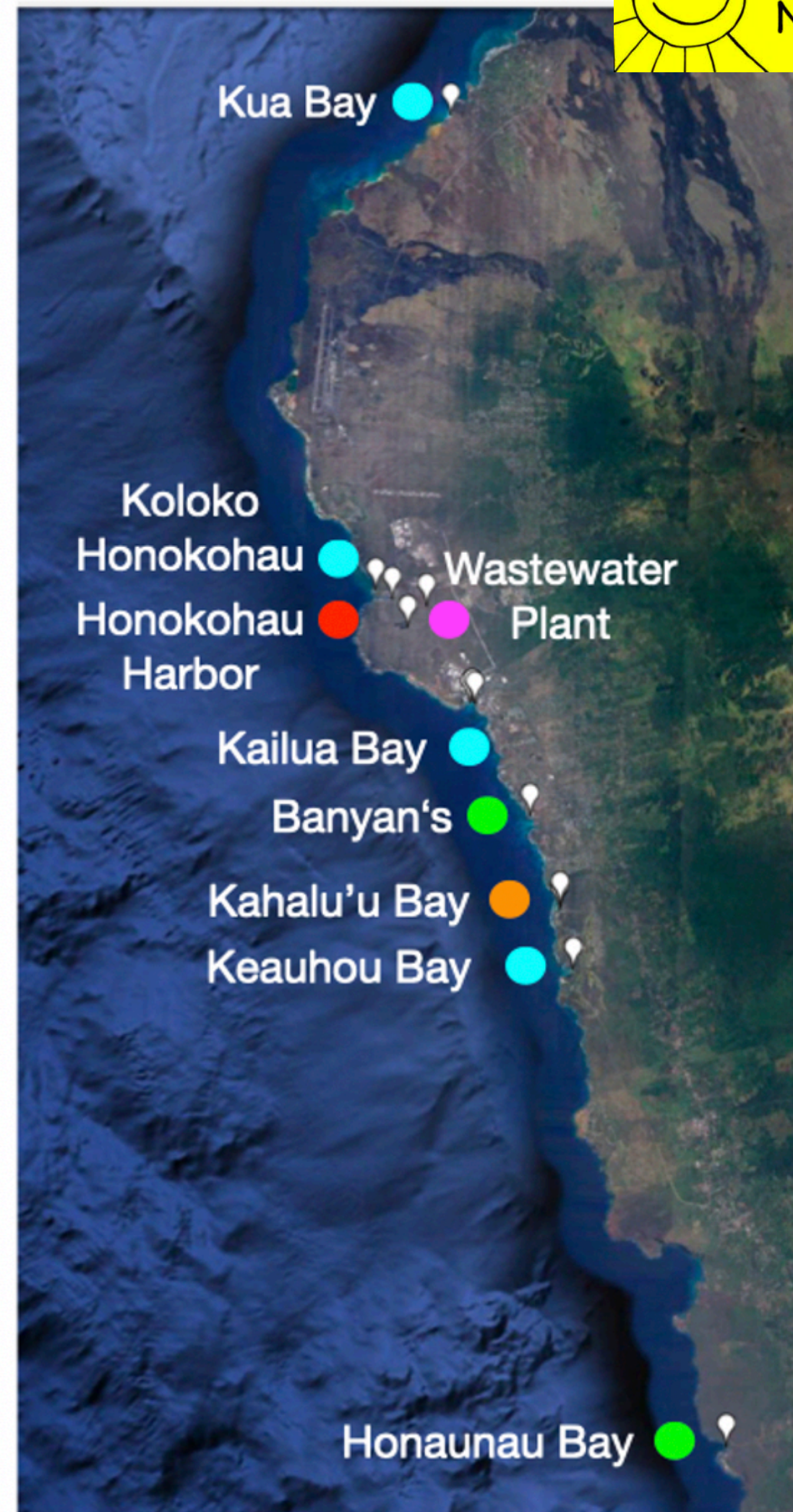
Figure 1. Kona Coast Map of Sampled Sites and the Ratio to the MDL

Sucralose* in Municipal Wastewater and the Near Shore Waters of the Kona Coast, Hawai'i

Ratio of the site concentration to the Method Detection Limit of 12.10 ng/L

- >1000
- >3.0
- 2.1 - 3.0
- 1.0 -2.0
- < 1.0

* Sucralose is the artificial sweetener Splenda™



*Knee et.al. 2010

Figure 2. Three sites in Kahalu'u Bay with widely different Sucrose to MDL ratios.

**Sucralose Detection
Kahalu'u Bay, Hawai'i
Oct. 2019**

**Ratio to the
Method Detection
Limit.**

Ex. 3.07 is 3x the
detection limit

**Method Detection
Limit
12 ng/L**

**Likely Sewage
Contamination
2 of 3 sites**

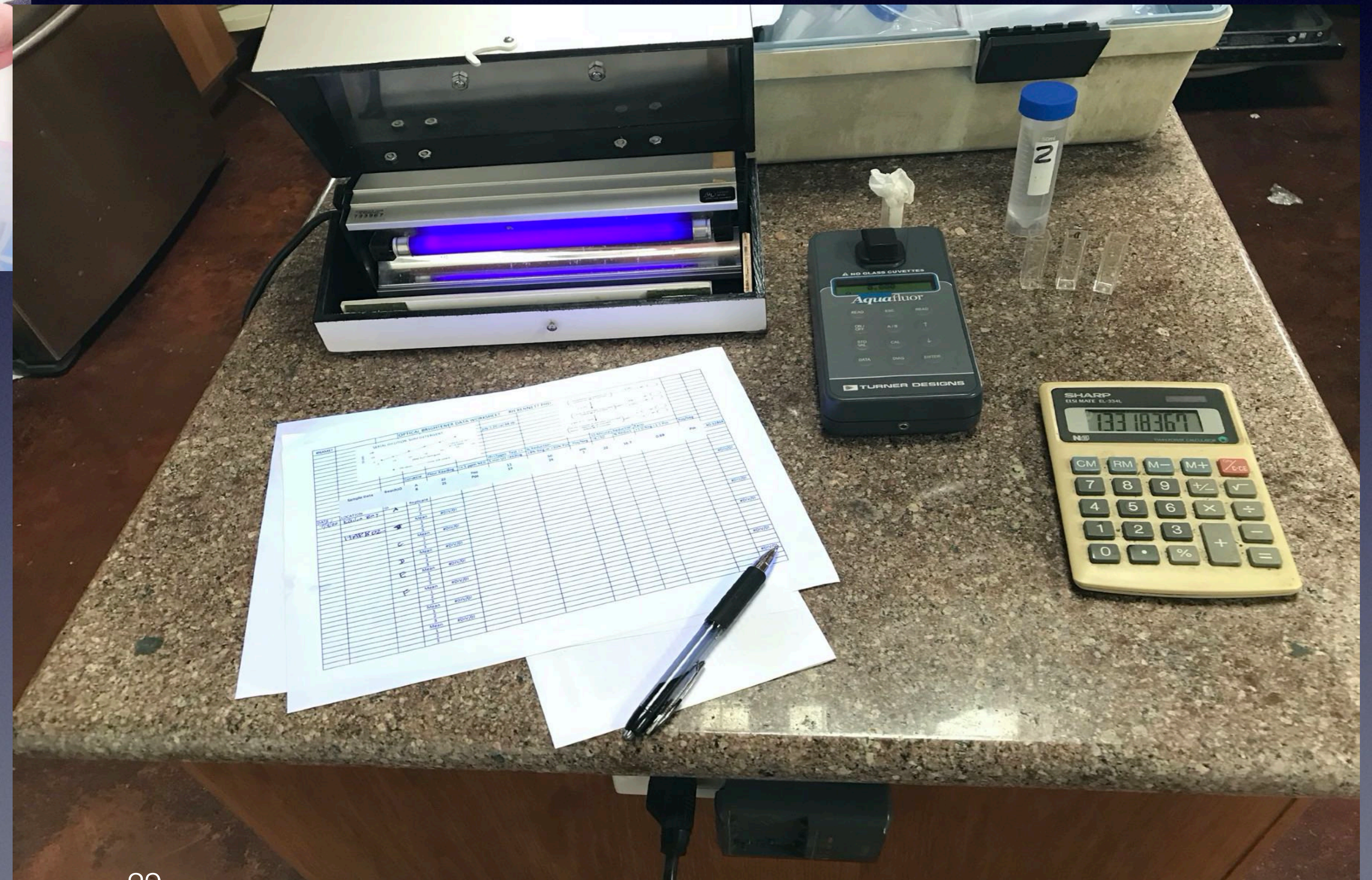
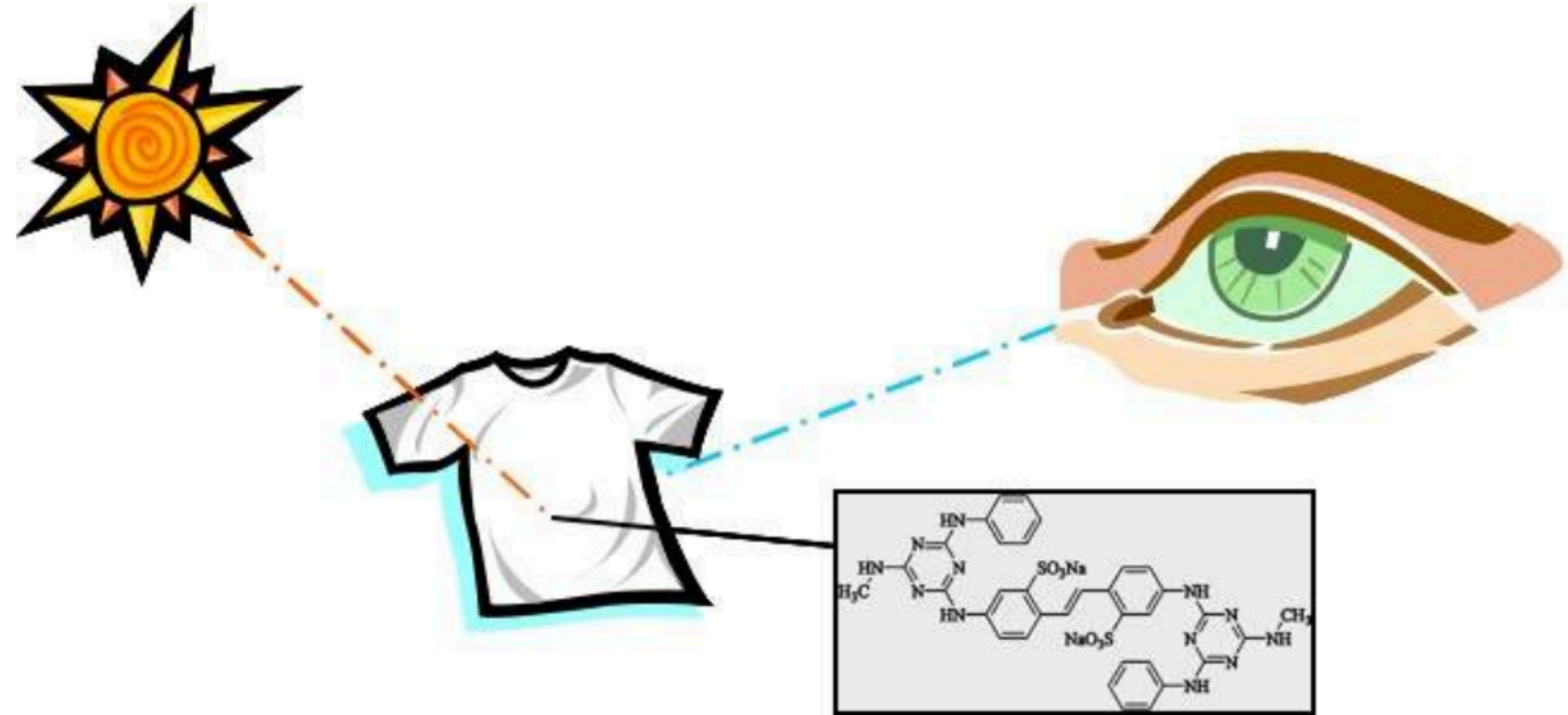


The S. section of
Ali'i Dr. is not
sewered

The data suggest
discrete
groundwater
conveyances

Evaluation of optical brightener photodecay characteristics for the detection of human fecal contamination

Yiping Cao, John F. Griffith and Stephen B. Weisberg



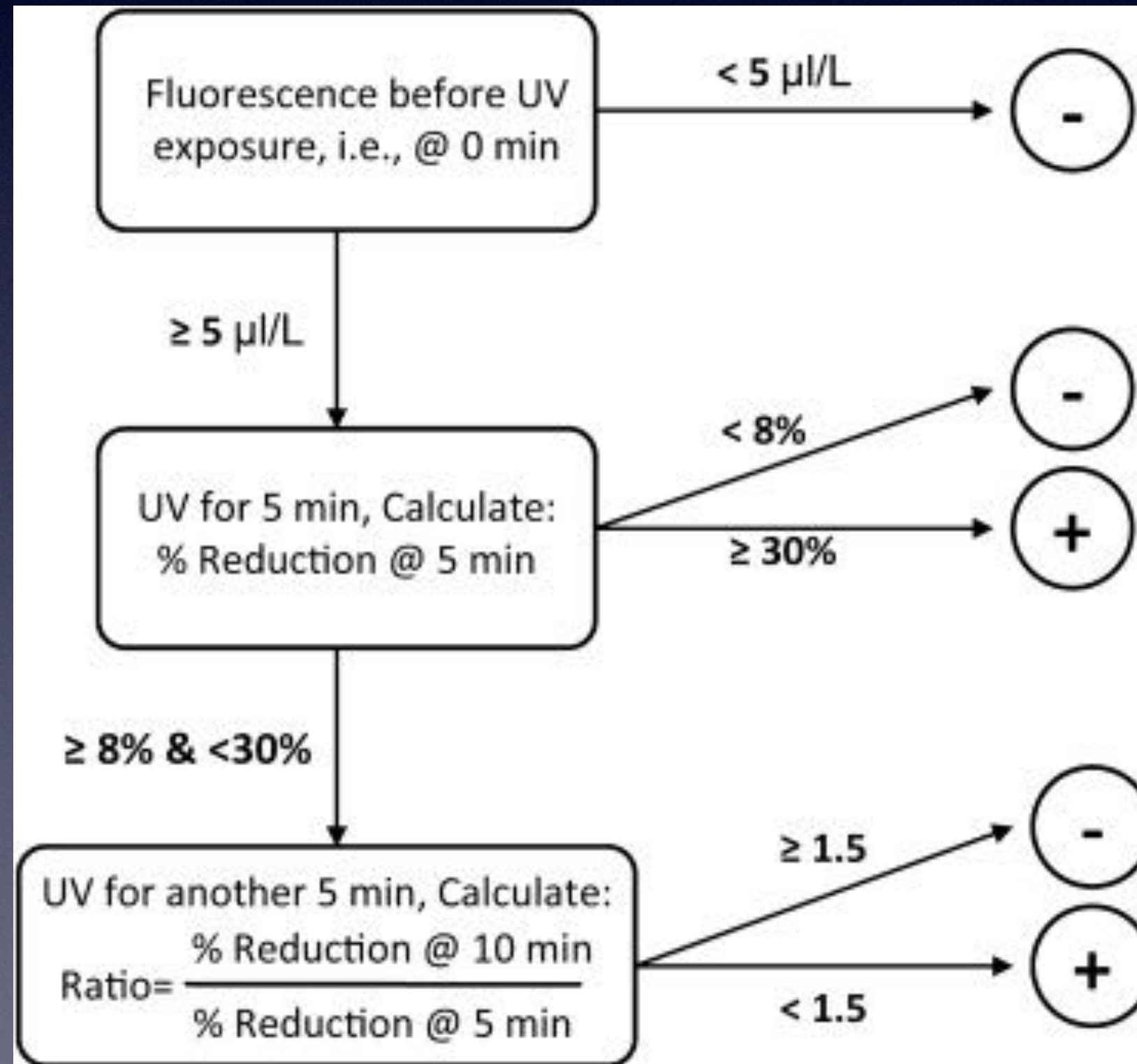
Cao, Y., Griffith, J. F., & Weisberg, S. B. (2009). Evaluation of optical brightener photodecay characteristics for detection of human fecal contamination. *Water research*, 43(8), 2273-2279.



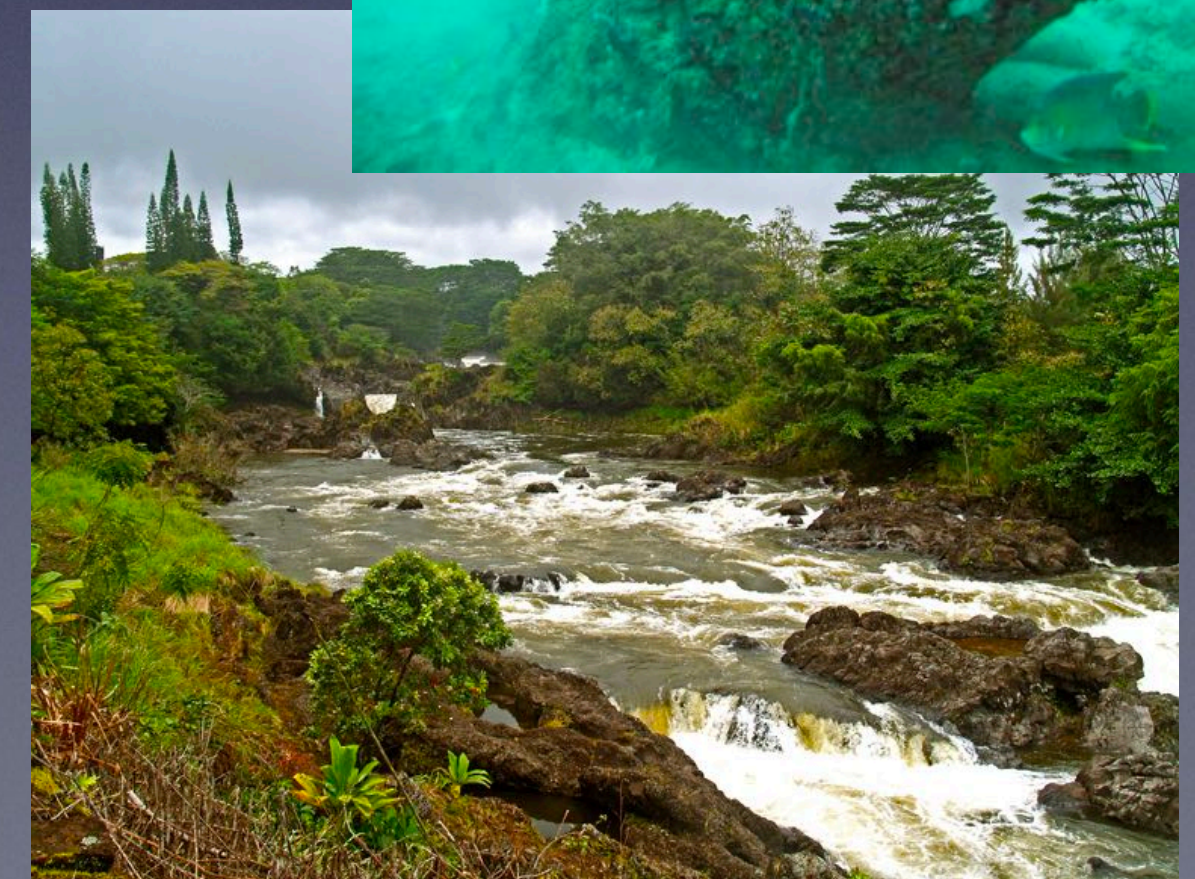
Preliminary Results Ocean "OB" Tests

Recent Discharges

UV Decays OB's



Protocol accounts for fluorescence from D.O.C's





Ocean Waters “Universal Precautions” - OWUP

We must assume they are always contaminated

1. DO NOT recreate in water with storm water runoff. Risk goes down after two days of full sun on the water.
2. Avoid floating greasy scum. It can arise from cesspits.
3. Open wounds do not heal in seawater. It harms the tissue and invites Staph infections.
4. Vigorously clean and medicate wounds created in the sea. Watch for signs of infection.
5. Don't ignore a pus-filled pimple that arises on the body. If it gets larger, seek medical attention.
6. Wash off seawater and sand. Wash sand out of swim suits. Launder and dry!
7. Gastrointestinal disease lasting more than a day or two, and those with fever, seek medical attention.
8. Any serious sign, like widespread bruising, fever, or swelling of a limb a day or so after a swim, requires immediate medical attention



The Research need has never been greater.
We need your support !

<https://waterkeepershi.org/kona-coast-waterkeeper>



LET US MAKE THEM
PROUD
MĀLAMA PONO

