CAR.Committee

From: travis liggett <travis@reefpowermaui.com>
Sent: Friday, August 14, 2020 4:22 PM
To: CAR.Committee
Subject: Reef Power LLC CAR Committee Presentation v2
Attachments: REEF POWER Maui CC CAR Committee Aug-17-2020 v2.pdf

Aloha all,

Attached please find a .pdf version v2 of my presentation slides for the Monday, August 17, 2020 Climate Action and Resilience Committee to be held on BlueJeans.

My presentation tells a story about an alternative to wastewater injection that harnesses Hawaiian stream limu in a turf scrubber to remove nutrients from reuse wastewater, then irrigates a food-focused agroforest instead of injection.

The attached version v2 replaces the original version emailed earlier today.

Please do not hesitate to contact me if you have any questions.

Mahalo,
Travis Liggett
President, Reef Power LLC

REEF POWER

Reef Power LLC

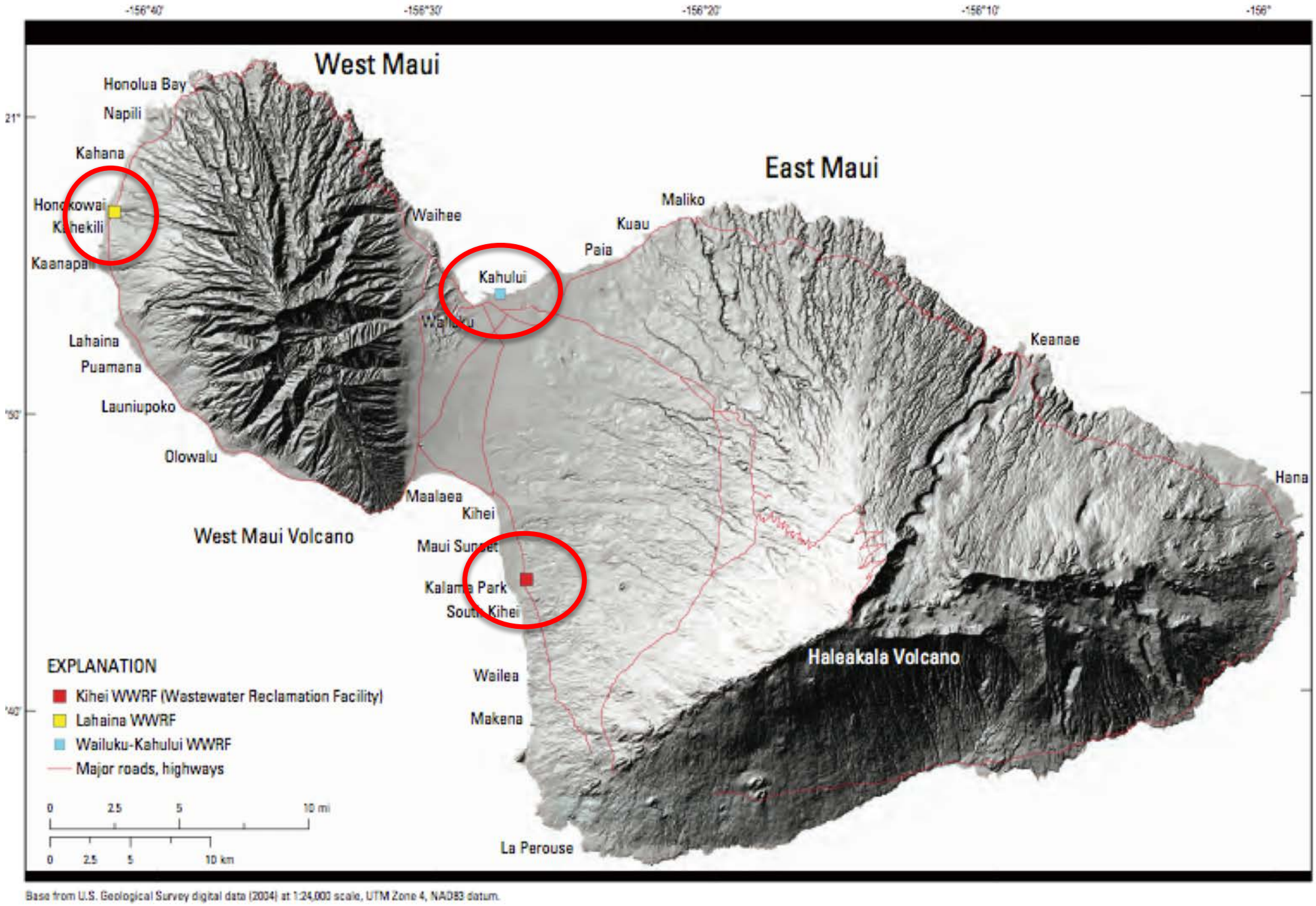
a Maui small business, presents:

"Using Hawaiian stream limu and trees to reduce municipal injection well wastewater discharges"

Maui County Council
Climate Action and Resilience Committee
August 17, 2020

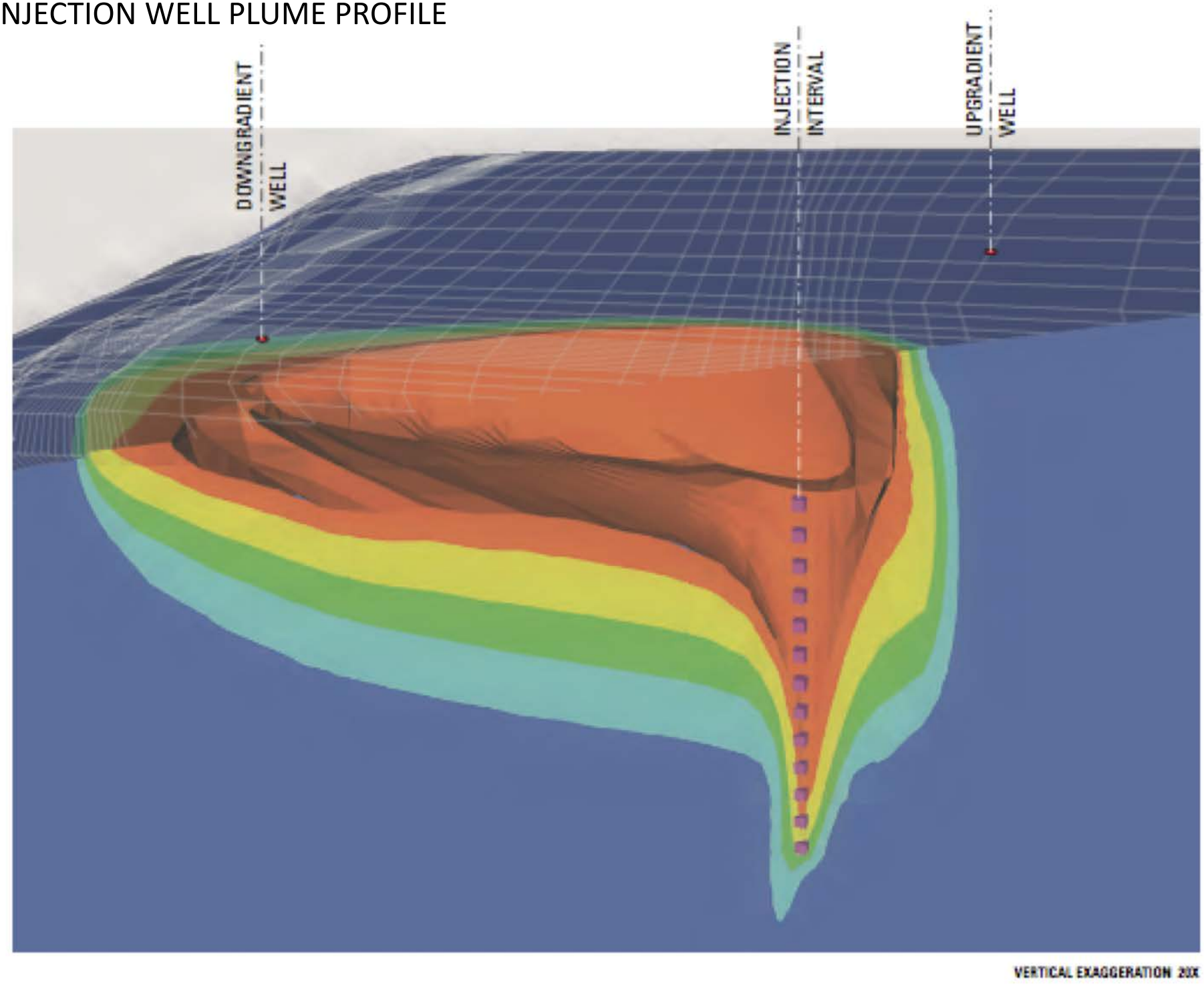

Maui's reefs are in trouble!
I'm going to tell you about an alternative
to wastewater injection that uses
Hawaiian stream limu and trees
to eliminate injection well discharges.

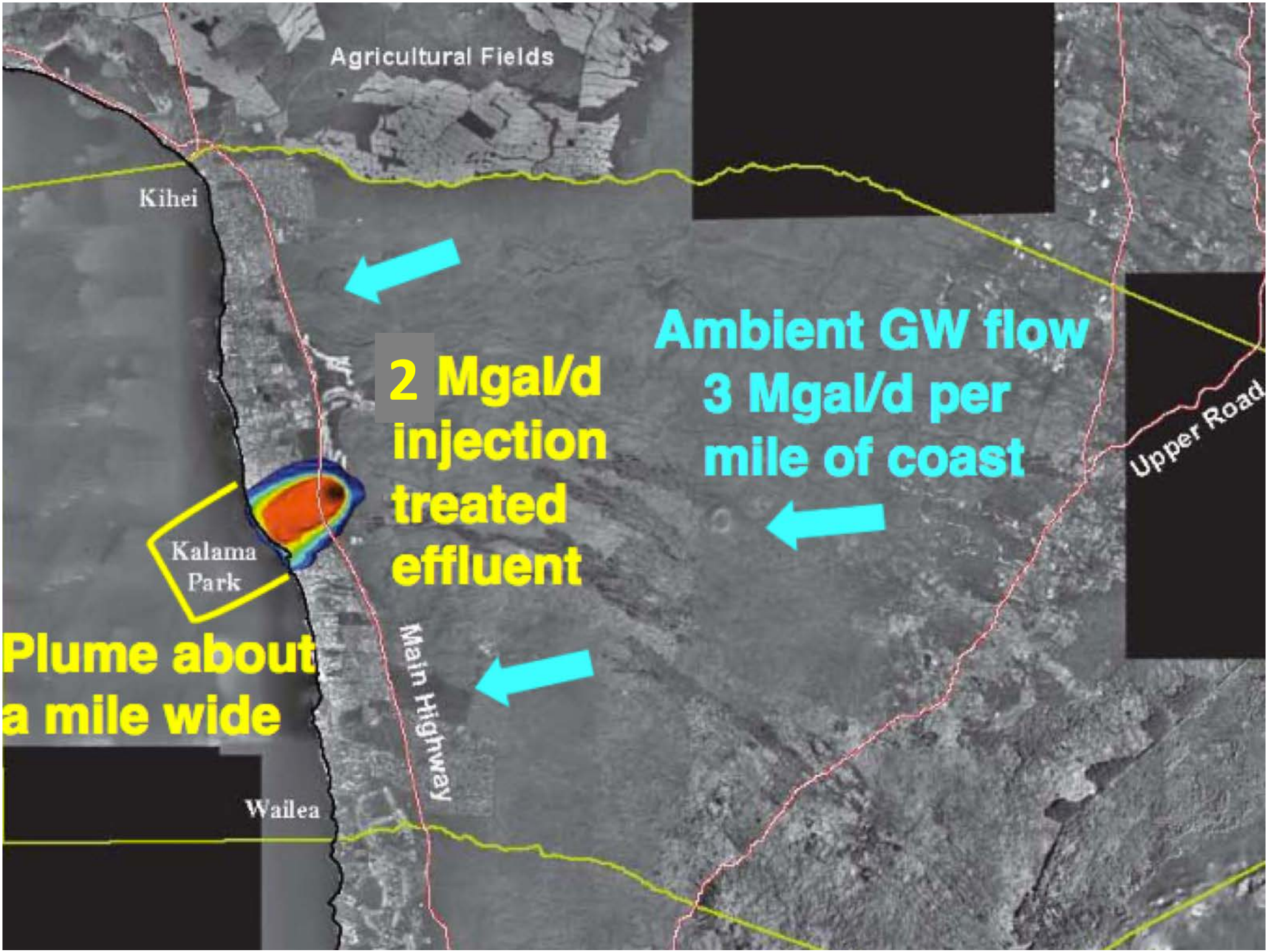
Three municipal wastewater reclamation facilities in Maui inject 10+ millions of gallons per day.



Base from U.S. Geological Survey digital data (2004) at 1:24,000 scale, UTM Zone 4, NAD83 datum.

INJECTION WELL PLUME PROFILE




Agricultural Fields
Kihei
2 Mgal/d injection treated effluent
Ambient GW flow 3 Mgal/d per mile of coast
Upper Road
Kalama Park
Plume about a mile wide
Main Highway
Wailea

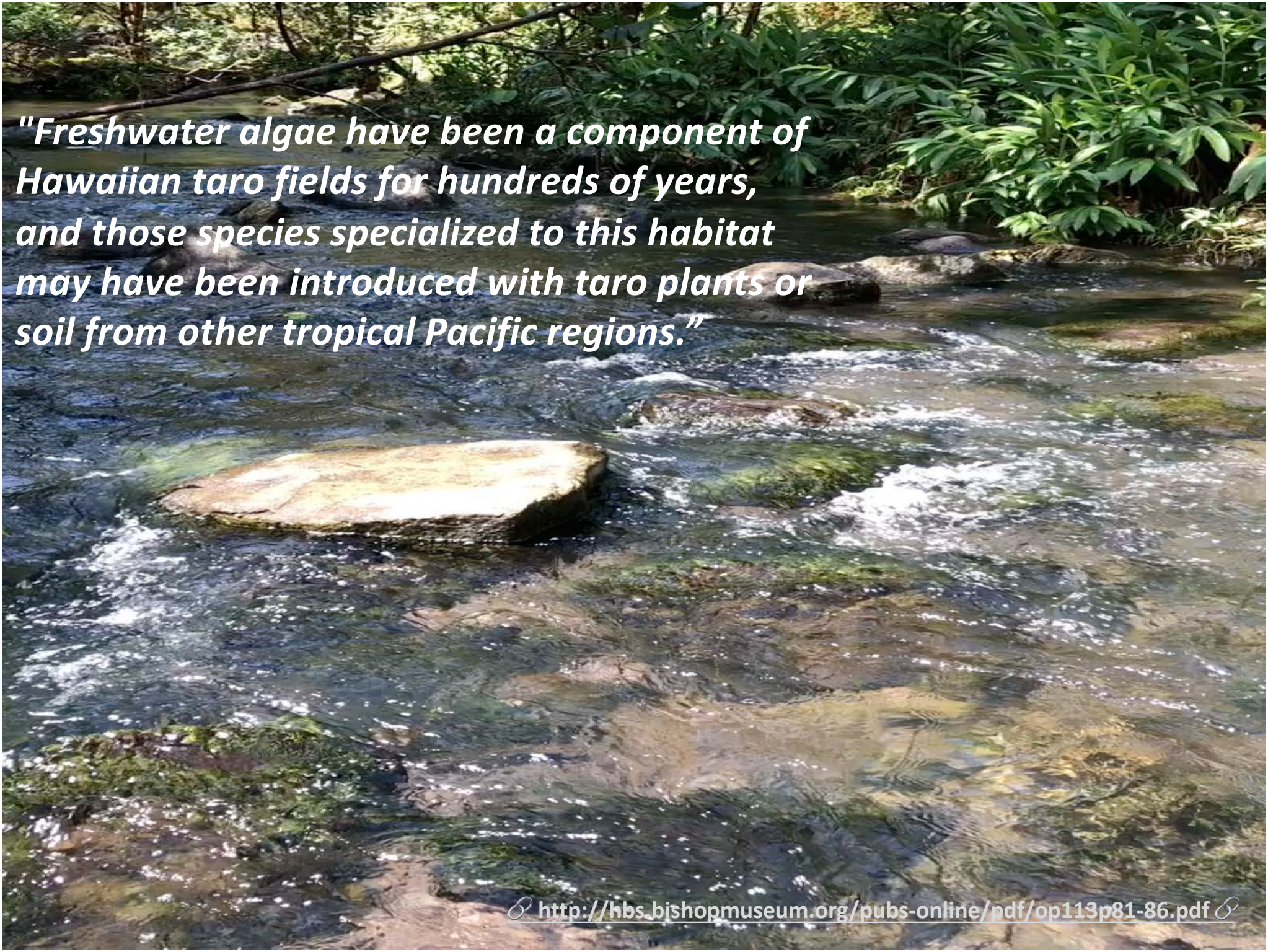
Maui municipal injection wells release 356,000 lbs. dissolved nutrients (N + P) into groundwater yearly

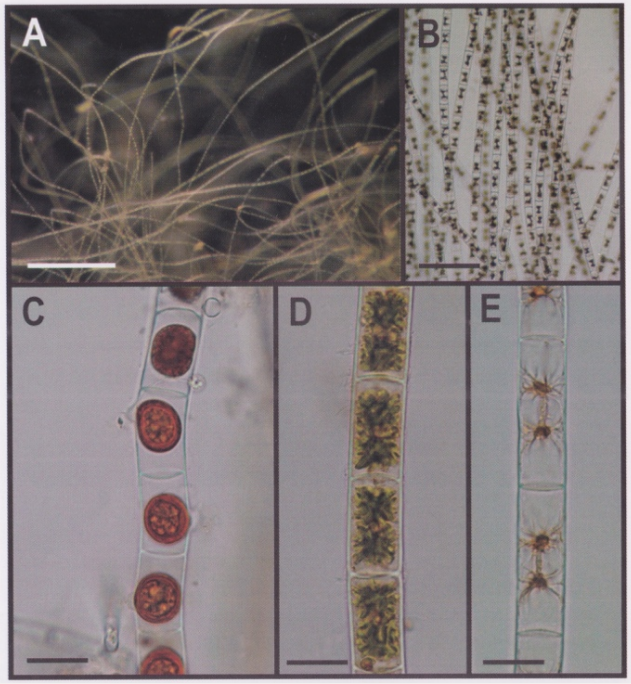
	TOTAL (MGD)	REUSE (MGD)	INJECTED (MGD)	nutrient concentration (mg/L)		INJECTED NUTIRENTS lbs/day	tons/year
Kahului-Wailuku	5.5	0.4	5.1	12.4	N	527.4	96.3
			5.1	2.4	P	102.1	18.6
Lahaina	4.0	1.5	2.5	5.6	N	116.8	21.3
			2.5	0.5	P	10.4	1.9
Kihei-Wailea	3.7	1.6	2.1	9.99	N	175.0	31.9
			2.1	2.44	P	42.7	7.8
						974.4	177.8
					lbs/yr	355651	

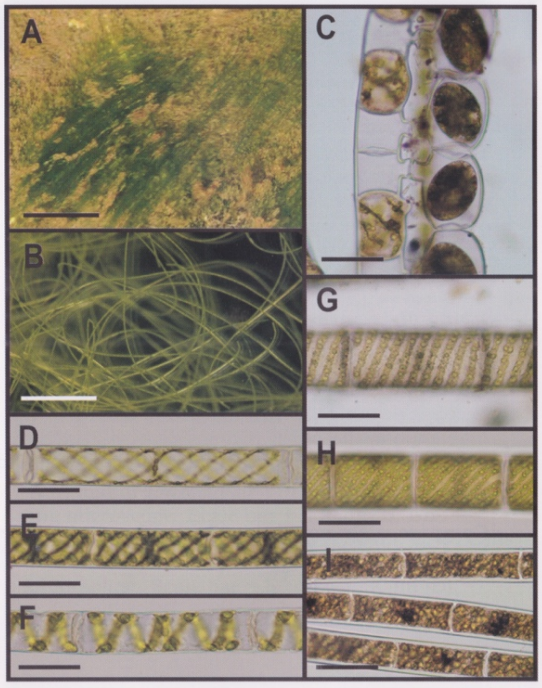
= data from Aecos water quality testing results 8/13/2020

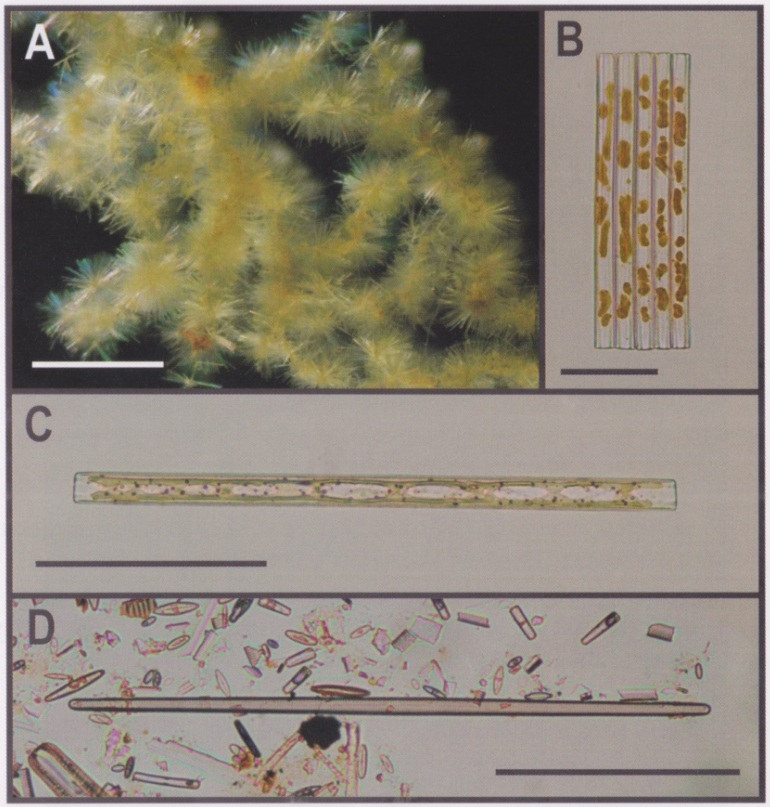
= data from County of Maui describing 2017 flows

Kahului / Kihei / Lahaina average
4 lbs. of dissolved nutrients discharged into groundwater for each resident every year

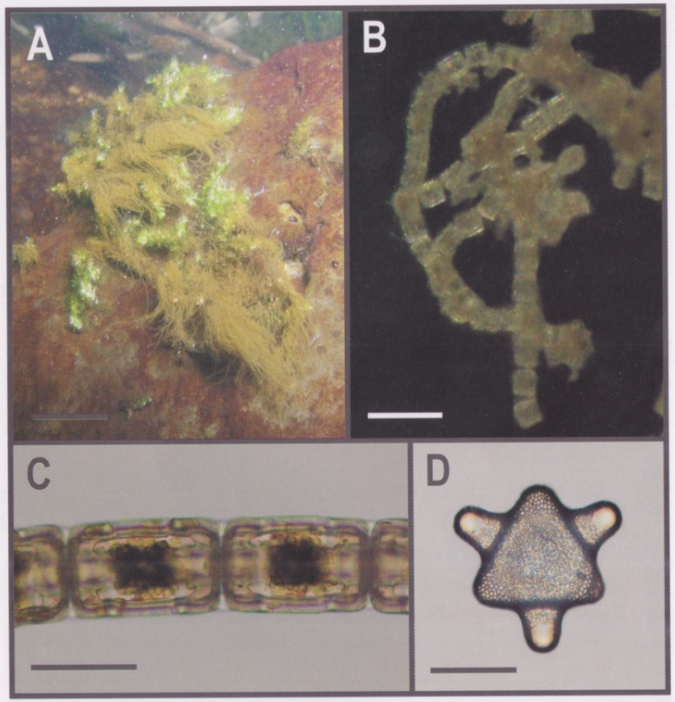

"Freshwater algae have been a component of
Hawaiian taro fields for hundreds of years,
and those species specialized to this habitat
may have been introduced with taro plants or
soil from other tropical Pacific regions."
http://hbs.bishopmuseum.org/pubs-online/pdf/op113p81-86.pdf

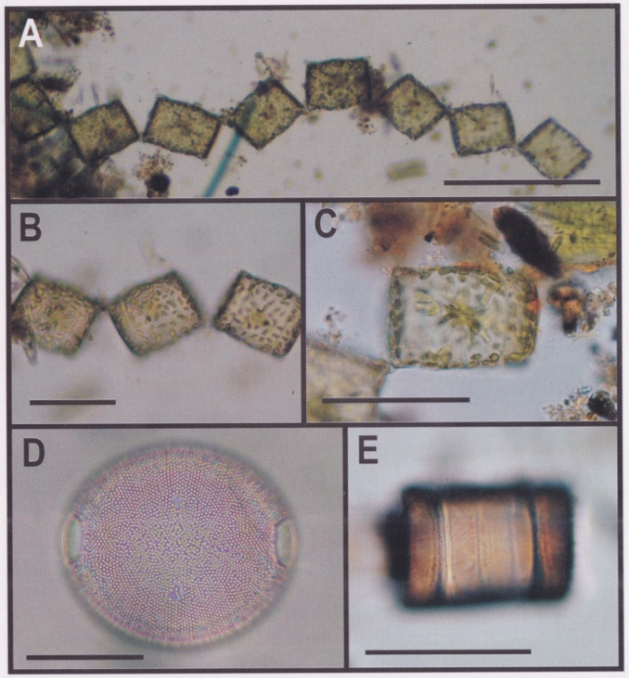




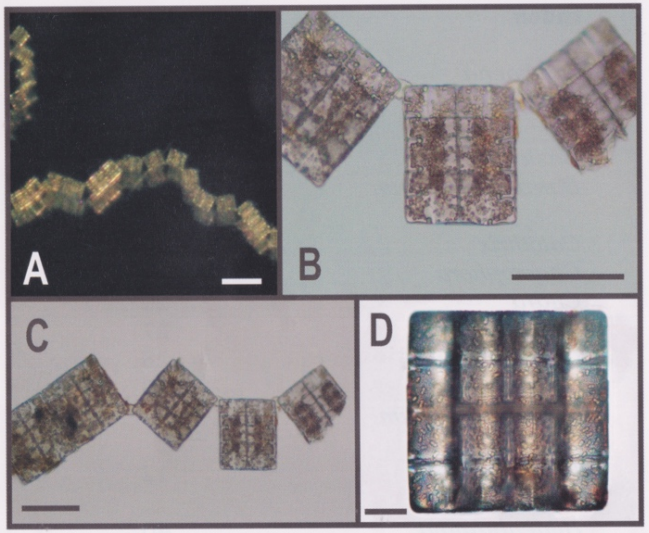


Hawaii DLNR DAR Technical Report 04-02 by Alison R. Sherwood "Stream macroalgae of Hawai'i: An identification guide to the common genera"



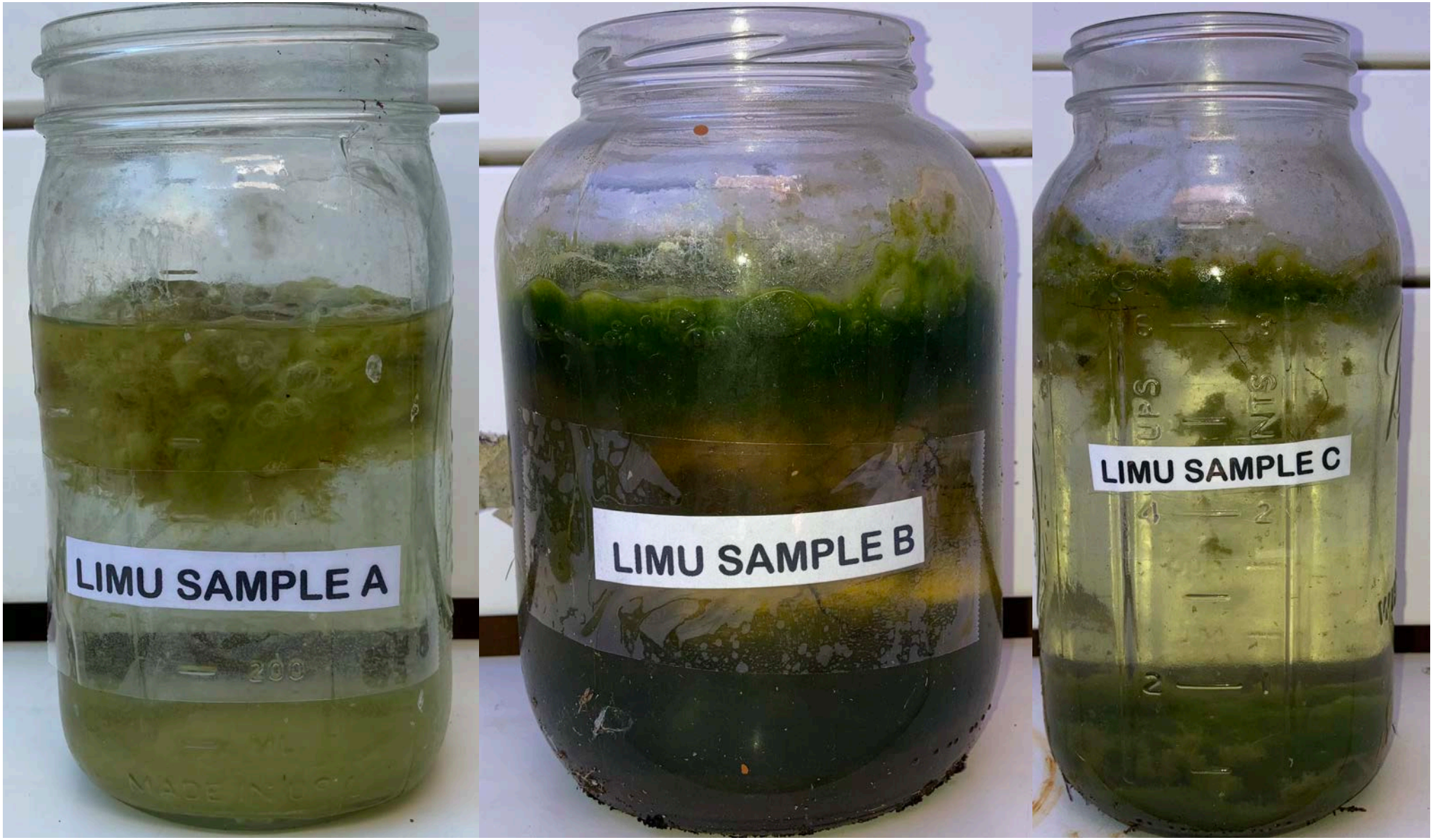


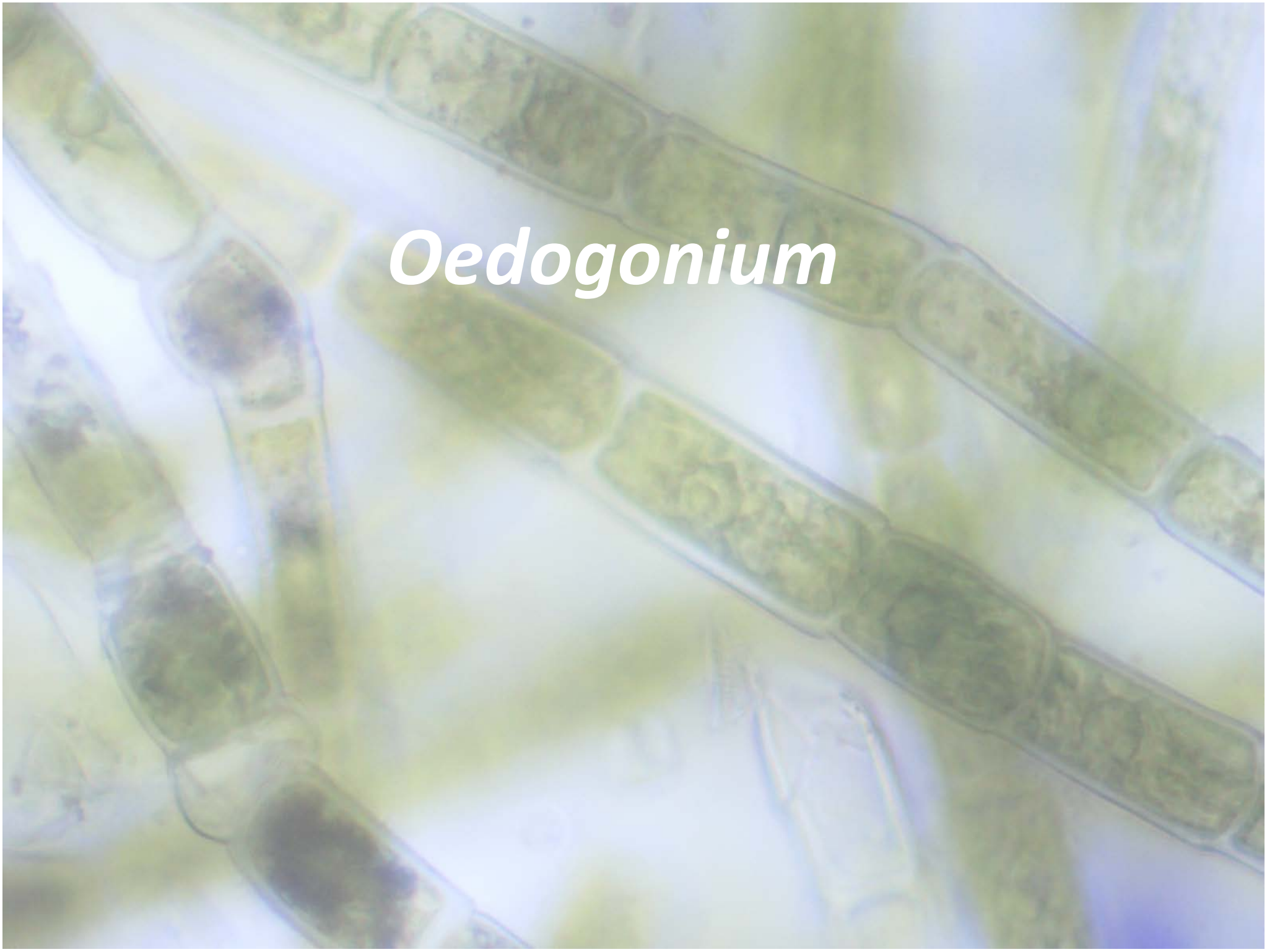
Clockwise from upper left: Stigleoclonium, Spirogyra, Synedra, Terpsinoe, Pleurosia, Hydrosera



We used three samples of Hawaiian stream limu (freshwater macroalgae) to conduct a simple growth test to see if they “like” R1 sterilized reuse wastewater from the Kihei WWRF.

(Sample A has testified to the Maui County Council several times.)

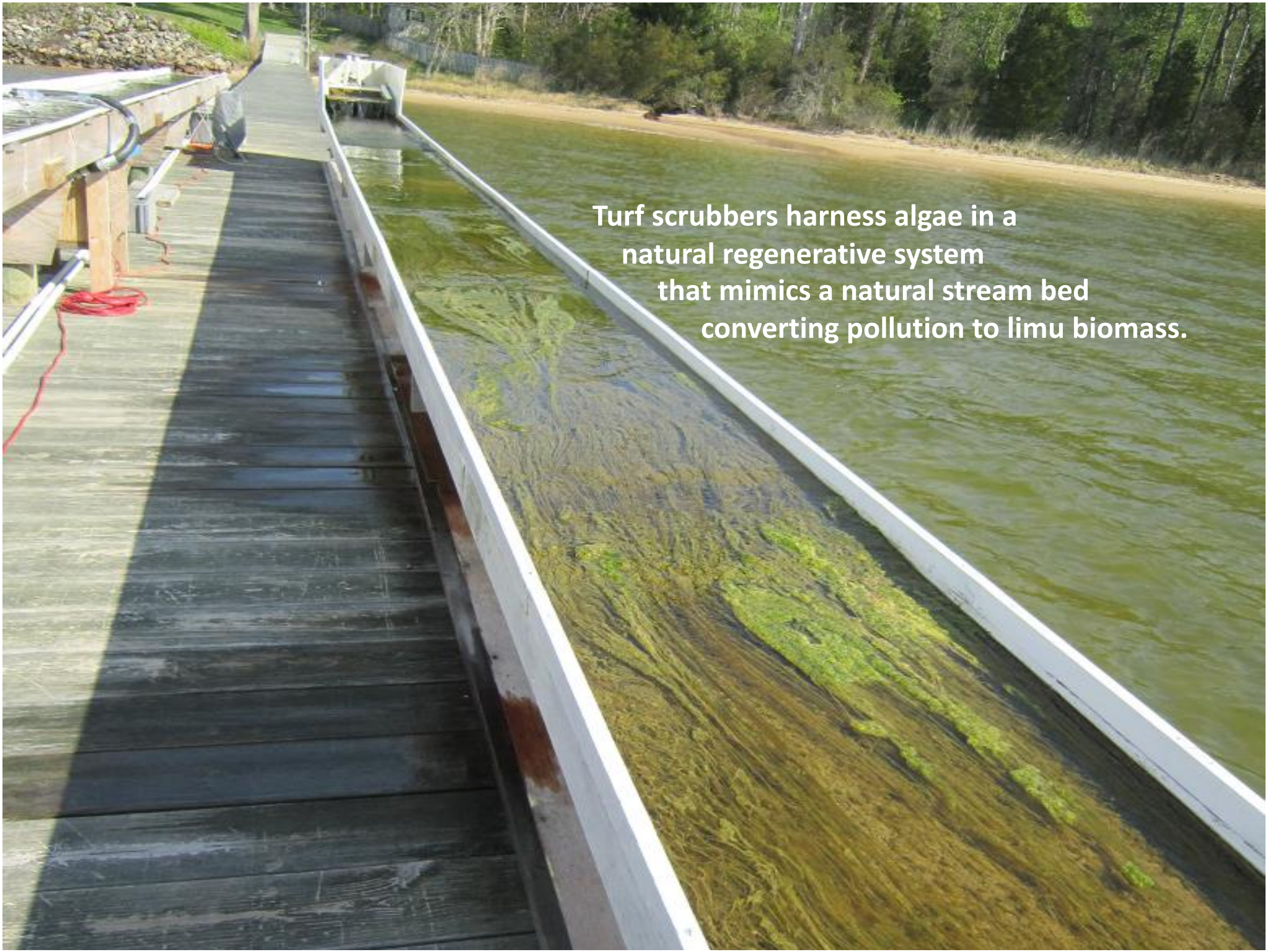



Oedogonium


100% Tap Water
2/3 Tap + 1/3 R1
1/3 Tap + 2/3 R1
100% R1
LIMU SAMPLE A
00 oz R1 / 24 oz TAP
LIMU SAMPLE A
08 oz R1 / 16 oz TAP
LIMU SAMPLE A
16 oz R1 / 08 oz TAP
LIMU SAMPLE A
24 oz R1 / 00 oz TAP

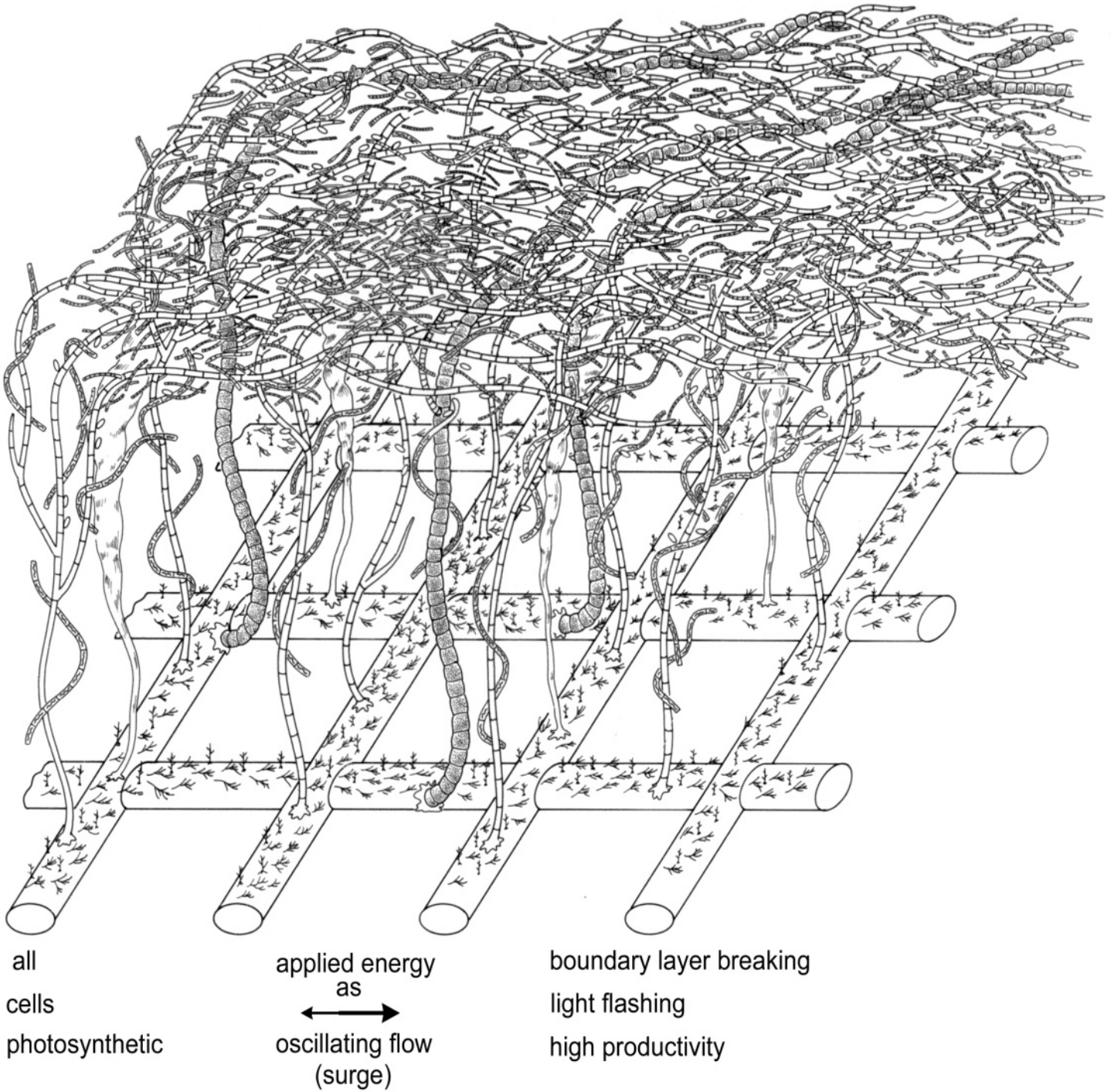

100% Tap Water
2/3 Tap + 1/3 R1
1/3 Tap + 2/3 R1
100% R1
LIMU SAMPLE B
00 oz R1 / 24 oz TAP
LIMU SAMPLE B
08 oz R1 / 16 oz TAP
LIMU SAMPLE B
16 oz R1 / 08 oz TAP
LIMU SAMPLE B
24 oz R1 / 00 oz TAP


100% Tap Water
2/3 Tap + 1/3 R1
1/3 Tap + 2/3 R1
100% R1
LIMU SAMPLE C
00 oz R1 / 24 oz TAP
LIMU SAMPLE C
08 oz R1 / 16 oz TAP
LIMU SAMPLE C
16 oz R1 / 08 oz TAP
LIMU SAMPLE C
24 oz R1 / 00 oz TAP


Turf scrubbers harness algae in a
natural regenerative system
that mimics a natural stream bed
converting pollution to limu biomass.


A pilot turf scrubber consists of:
1. A floway
2. A mesh attachment matrix
3. A headworks to create water surges

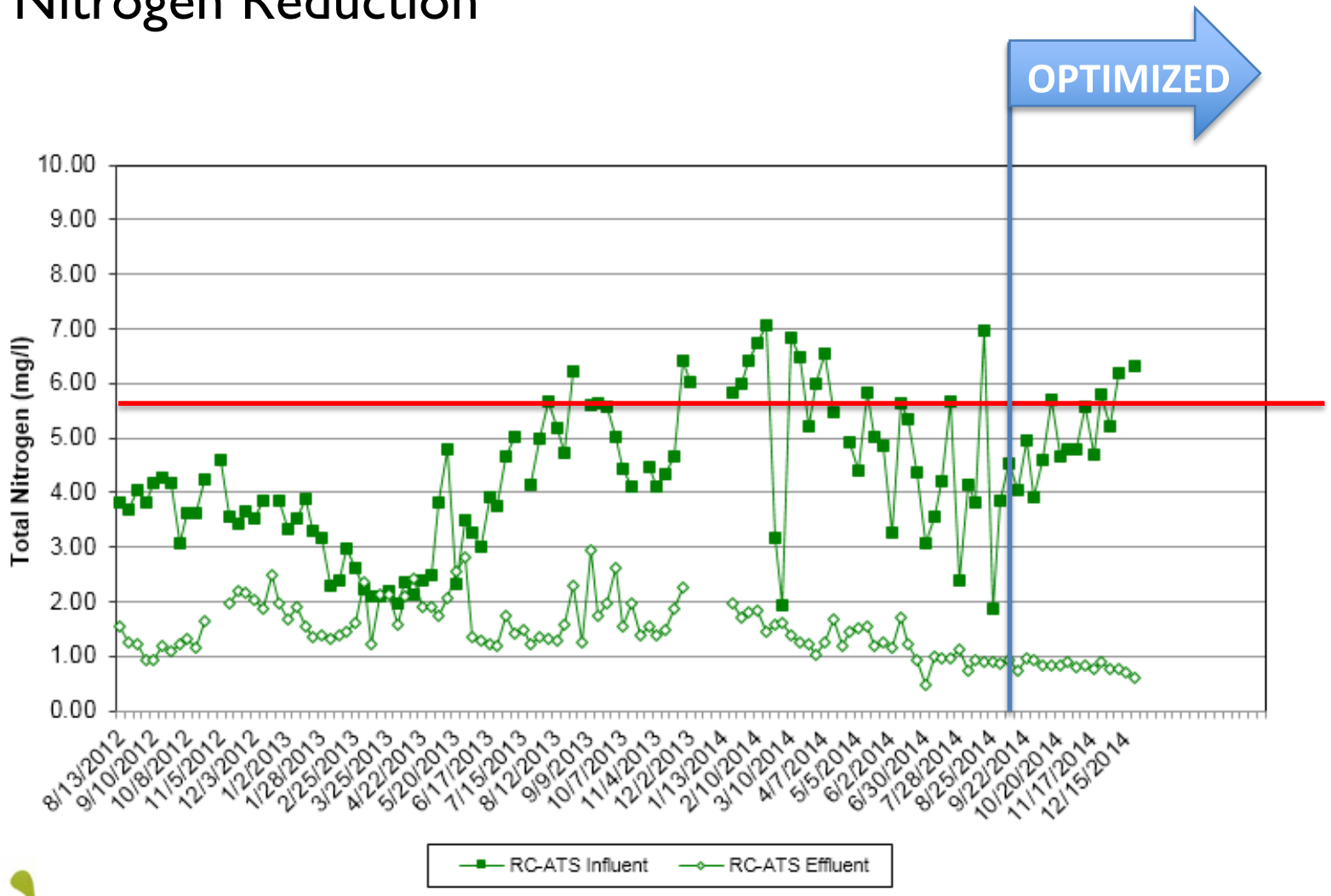
Turf scrubber algal mesh attachment matrix closeup:




Algal turfs present as vibrant living systems of green biomass

Turf scrubbers have been demonstrated up to several acres in scale.

Algal Turf Scrubber® Optimization for High Level Total Nitrogen Reduction

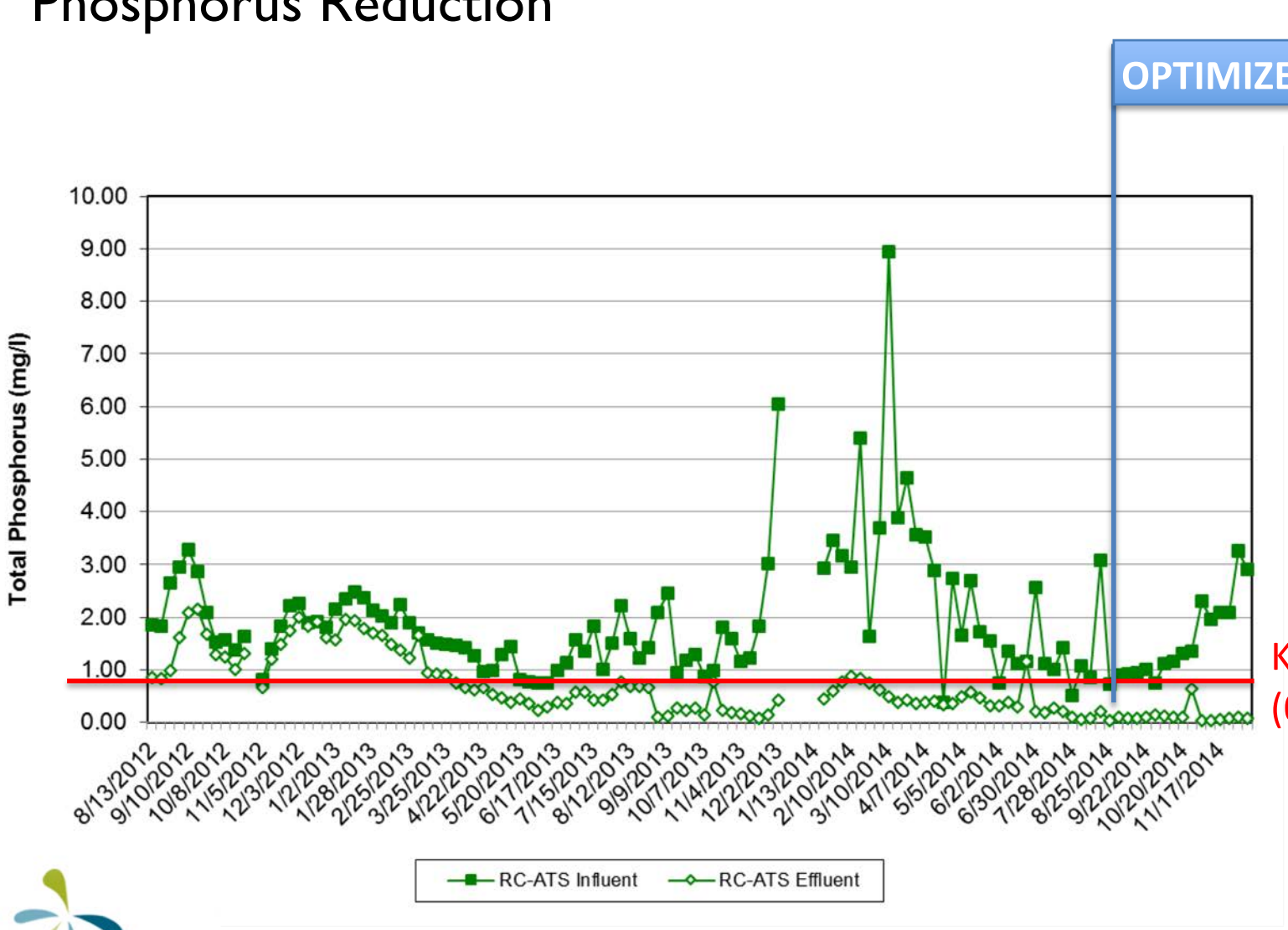


Kihei/Lahaina TN (5.6 mg/L)

HydroMentia
WATER TREATMENT TECHNOLOGIES

Data from Recycle ATS™ (RC-ATS™) System

Algal Turf Scrubber® Optimization for High Level Total Phosphorus Reduction



HydroMentia
WATER TREATMENT TECHNOLOGIES

Data from Recycle ATS™ (RC-ATS™) System

A 2-3 acre turf scrubber can produce 50-100 tons of valuable biomass per year.

Container medium / potting soil made from composted limu supports plant growth very well.

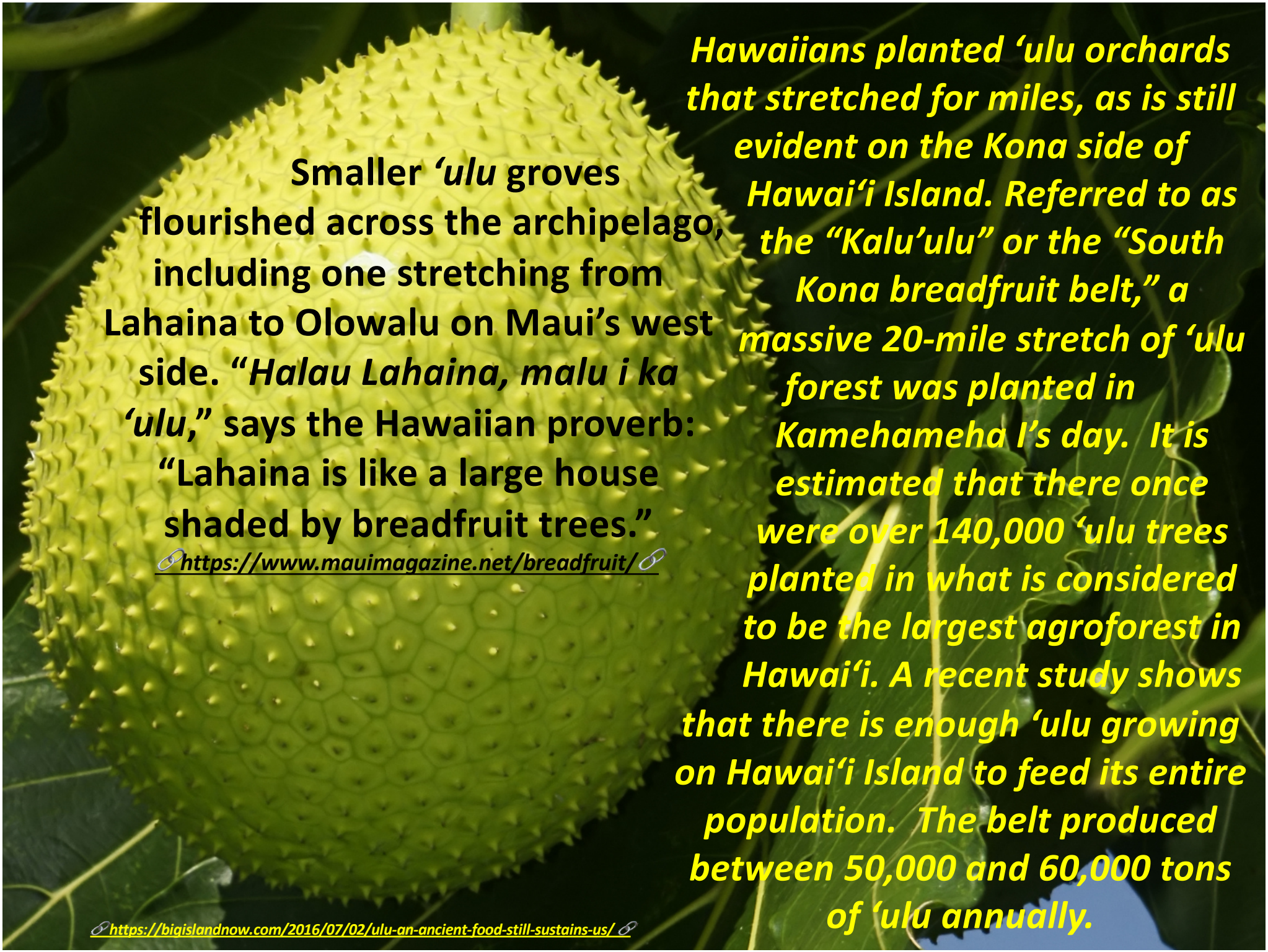
100%
Composted algae

50 / 50%

100%
Peat moss

According to an etiological Hawaiian myth, the breadfruit originated from the sacrifice of the war god Kū. After deciding to live secretly among mortals as a farmer, Kū married and had children. He and his family lived happily until a famine seized their island. When he could no longer bear to watch his children suffer, Kū told his wife that he could deliver them from starvation, but to do so he would have to leave them. Reluctantly she agreed, and at her word, Kū descended into the ground right where he had stood until only the top of his head was visible. His family waited around the spot he had last been, day and night, watering it with their tears until suddenly, a small green shoot appeared where Kū had stood. Quickly, the shoot grew into a tall and leafy tree that was laden with heavy breadfruits that Kū's family and neighbors gratefully ate, joyfully saved from starvation.

🔗**https://core.ac.uk/download/pdf/10598053.pdf**🔗
🔗**http://explore-art.pem.org/object/oceanic-art-and-culture/E12071/detail**🔗

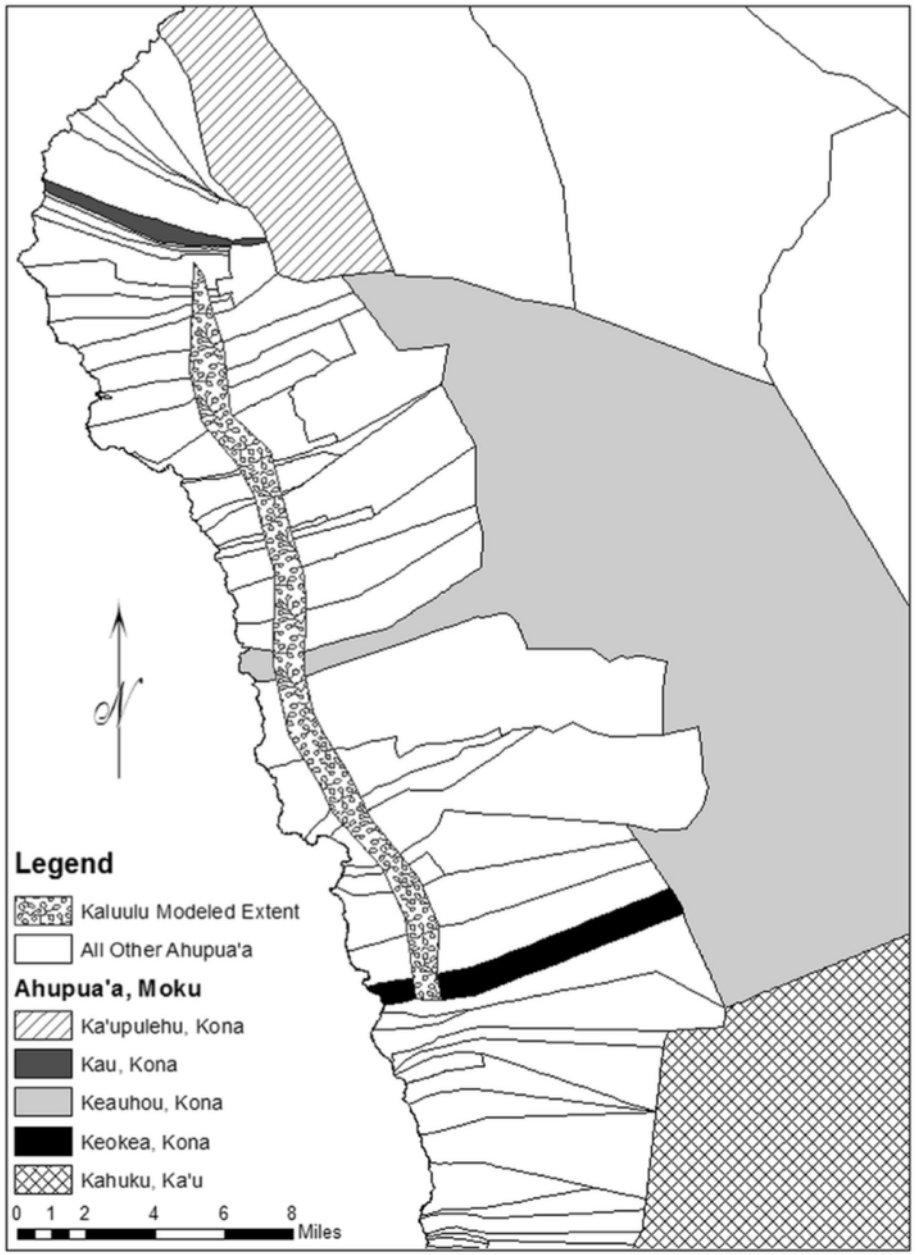


Smaller *'ulu* groves flourished across the archipelago, including one stretching from Lahaina to Olowalu on Maui's west side. "*Halau Lahaina, malu i ka 'ulu*," says the Hawaiian proverb: "Lahaina is like a large house shaded by breadfruit trees."

https://www.mauimagazine.net/breadfruit/

Hawaiians planted 'ulu orchards that stretched for miles, as is still evident on the Kona side of Hawai'i Island. Referred to as the "Kalu'ulu" or the "South Kona breadfruit belt," a massive 20-mile stretch of 'ulu forest was planted in Kamehameha I's day. It is estimated that there once were over 140,000 'ulu trees planted in what is considered to be the largest agroforest in Hawai'i. A recent study shows that there is enough 'ulu growing on Hawai'i Island to feed its entire population. The belt produced between 50,000 and 60,000 tons of 'ulu annually.

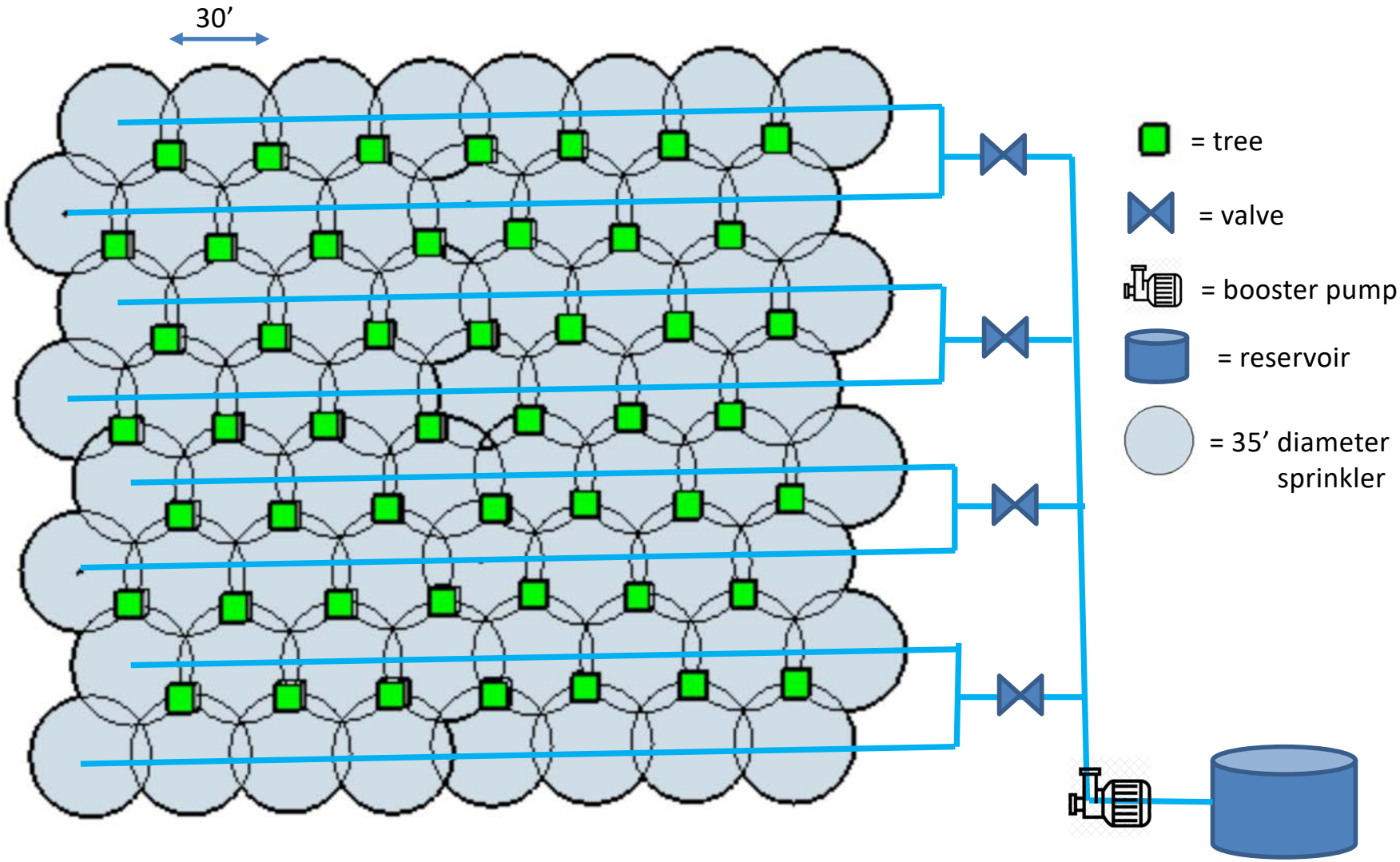
https://bigislandnow.com/2016/07/02/ulu-an-ancient-food-still-sustains-us/



"The establishment of the kaluulu agricultural zone in Kona can be viewed as a result of a series of cultural decisions within environmental constraints."

🔗 ***https://tinyurl.com/Lincoln-2014*** 🔗

Preliminary scaled ‘ulu irrigation design
30’ tree spacing gives 49 trees per acre



Proposed irrigation rate + annual rain rate in Kihei ≅ precipitation in lower Hana

	proposed irrigation rate	+	Kihei rain rate	=	proposed max H20 loading		Hana town rain rate	ulu low water	ulu high water	hemp low 3x crop	hemp high 3x crop	N. Kihei sugar evapotranspiration	N. shore sugar evapotranspiration	
(in/yr)	**63.9**		**12.6**		**76.5**	**(in/yr)**	**79.23**	**60**	**120**	**60**	**90**	**59.1**	**90.6**	**(in/yr)**
(in/day)	0.18		0.03		0.21	(in/day)	0.22	0.16	0.33	0.16	0.25	0.16	0.25	(in/day)
(mm/day)	4.45		0.88		5.32	(mm/day)	5.51	4.18	8.35	4.18	6.26	4.11	6.30	(mm/day)

= REEF POWER pilot test forest watering rate (in/yr) = (1320 gallons/day)*(231 in3/gallon)*(365 days/yr)/[(110 ft * 110 ft)*(12 in/1 ft)^2]

https://www.idcide.com/weather/hi/kihei.htm

actual total H2O loading rate will be significantly lower than this value because irrigation stops on rainy days

https://www.usclimatedata.com/climate/hana/hawaii/united-states/ushi0014

http://www.fao.org/3/a-i3085e.pdf

https://www.hempbasics.com/hhusb/hh2cul.htm

https://industrialhempfarms.com/hemp-farming-guide/

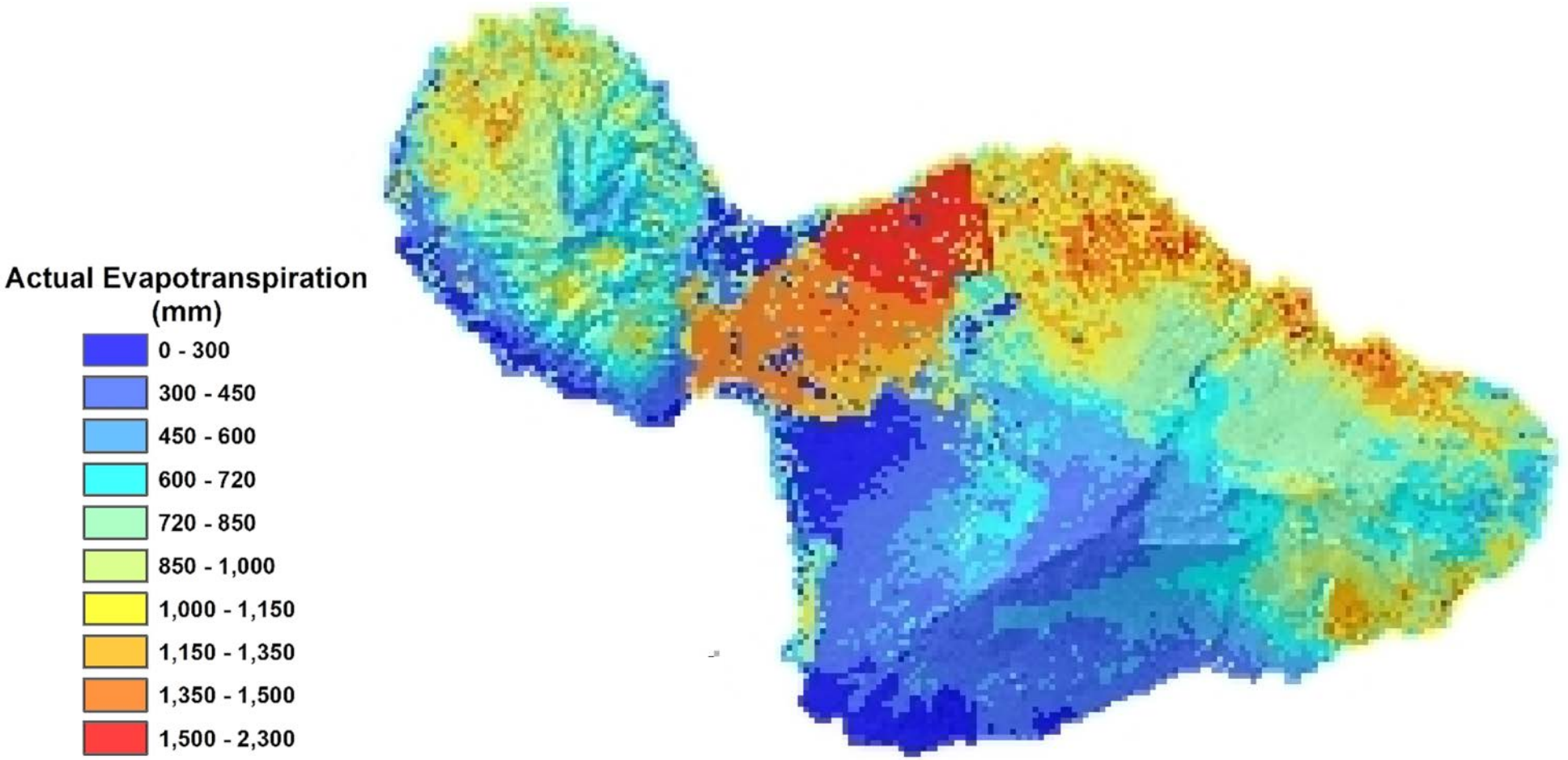
see evapotranspiration map below http://evapotranspiration.geography.hawaii.edu/

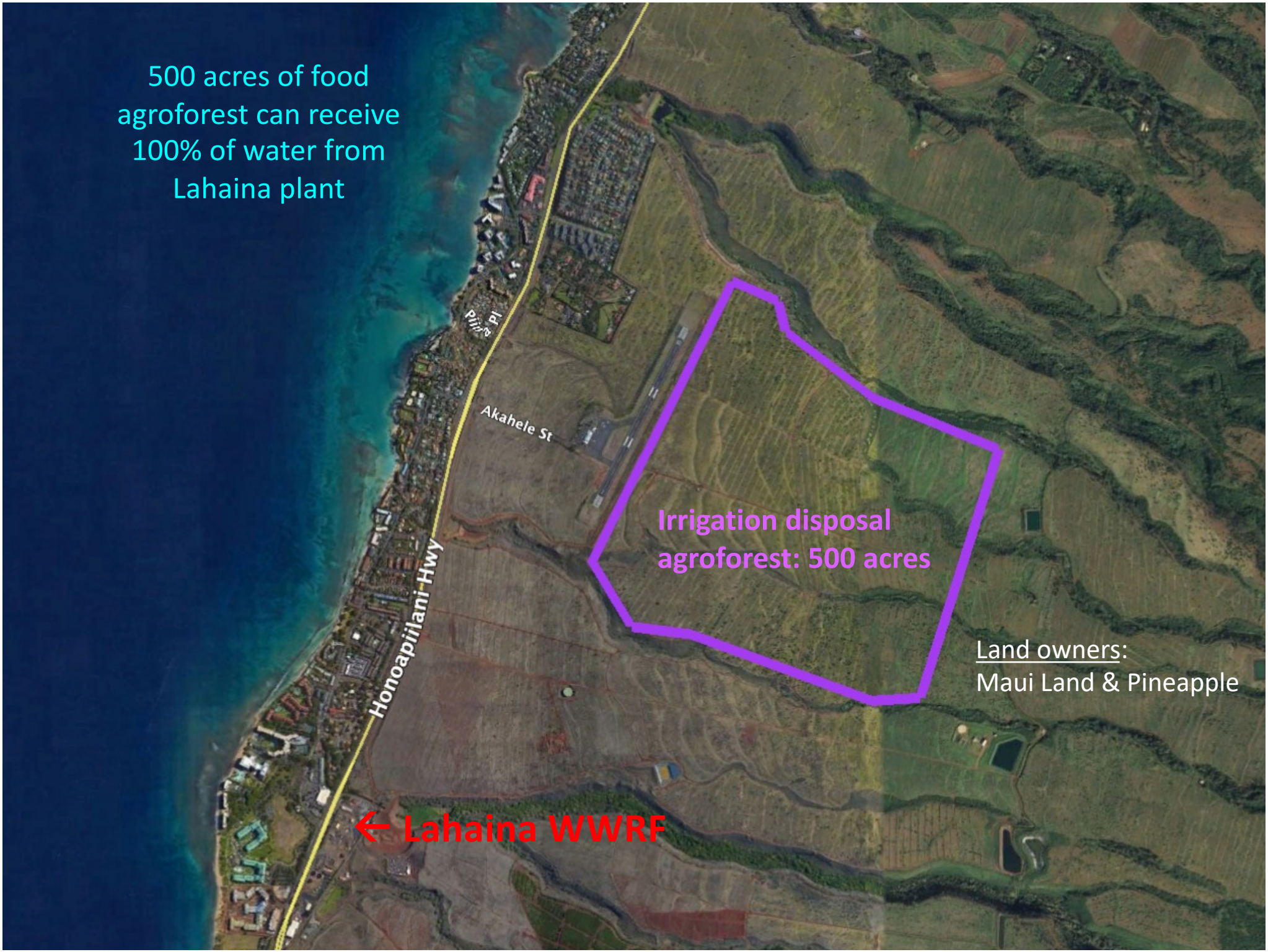
e·vap·o·tran·spi·ra·tion

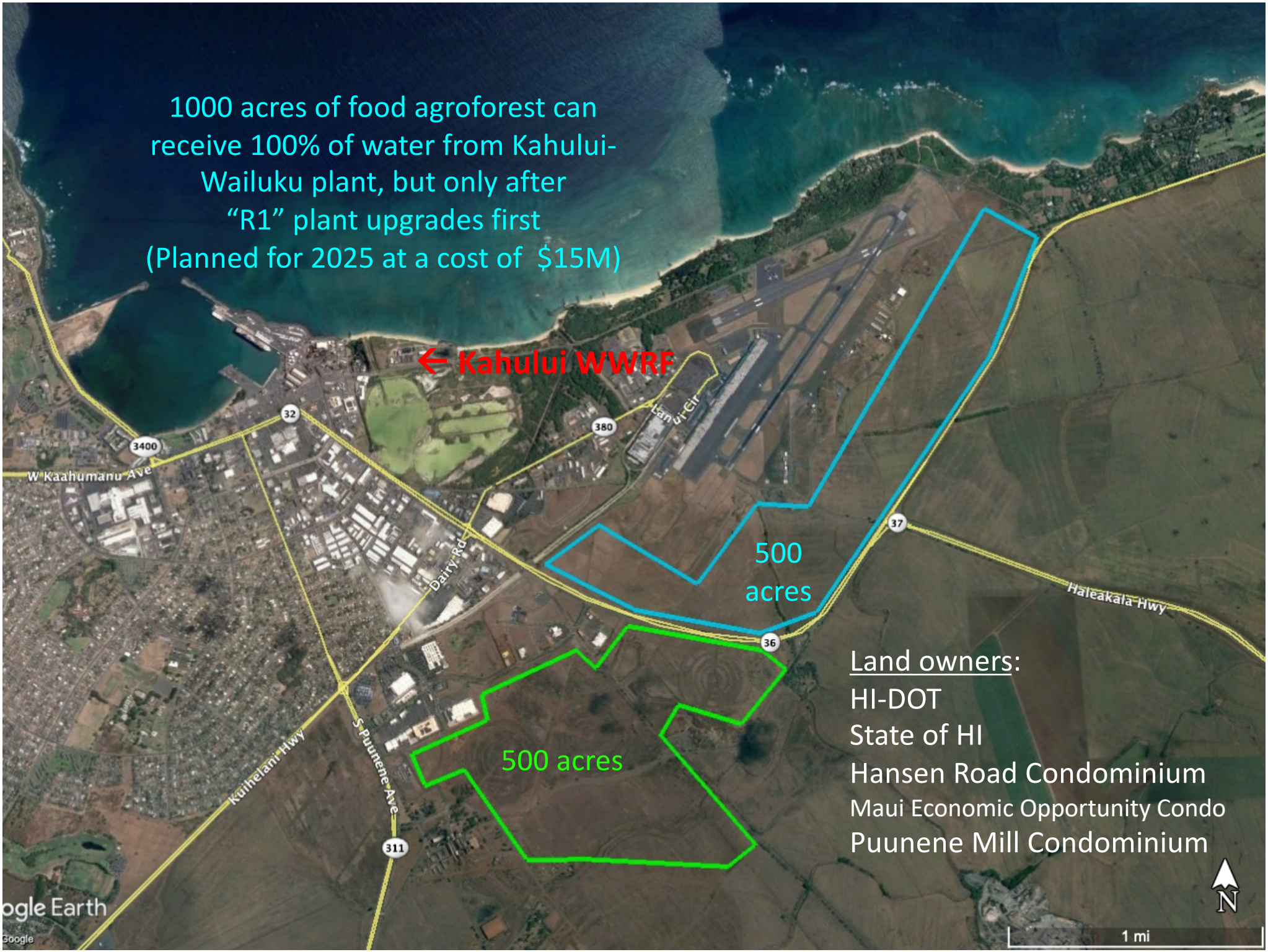
/iˌvapōˌtranspəˈrāSHən/

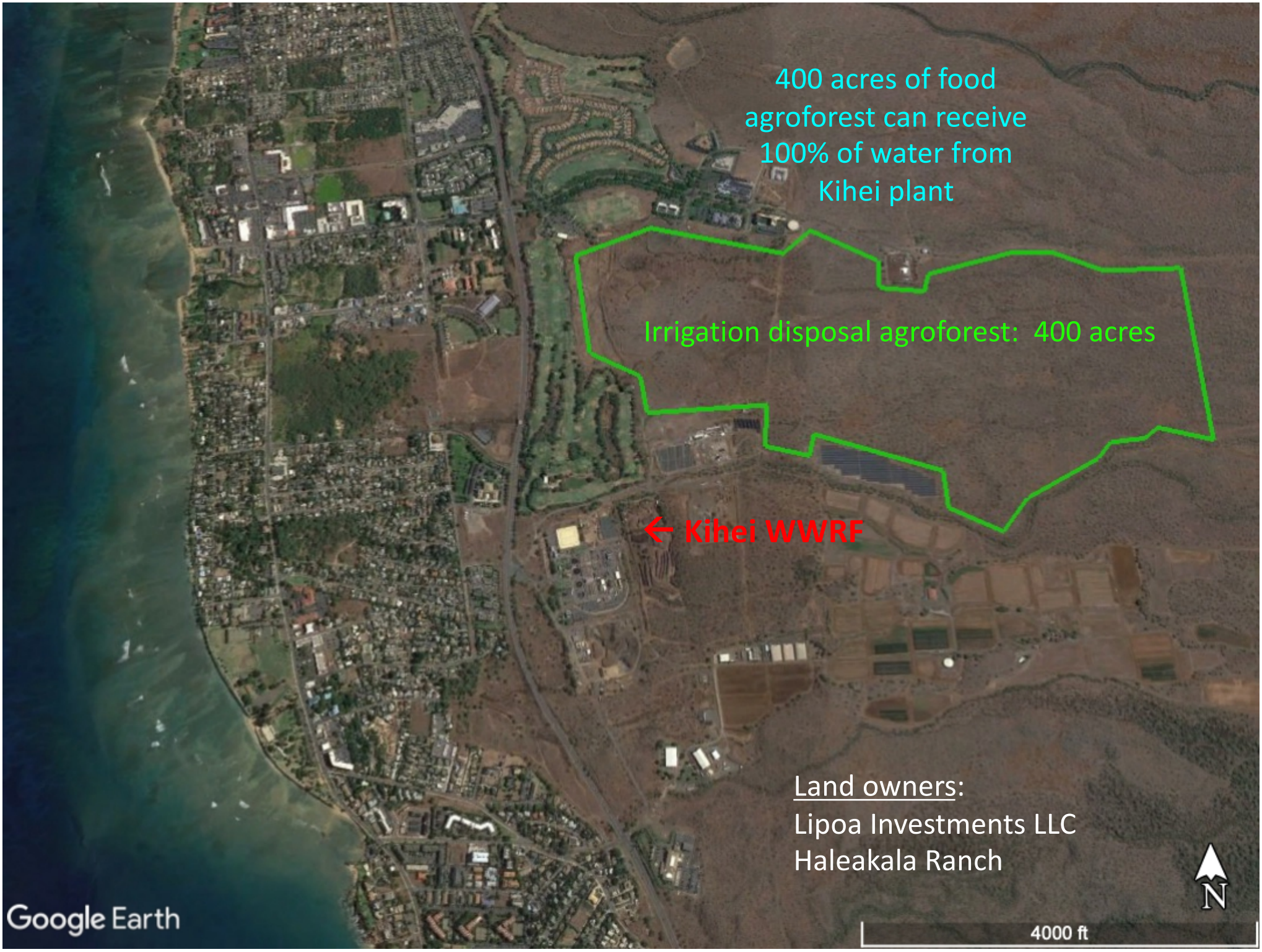
noun

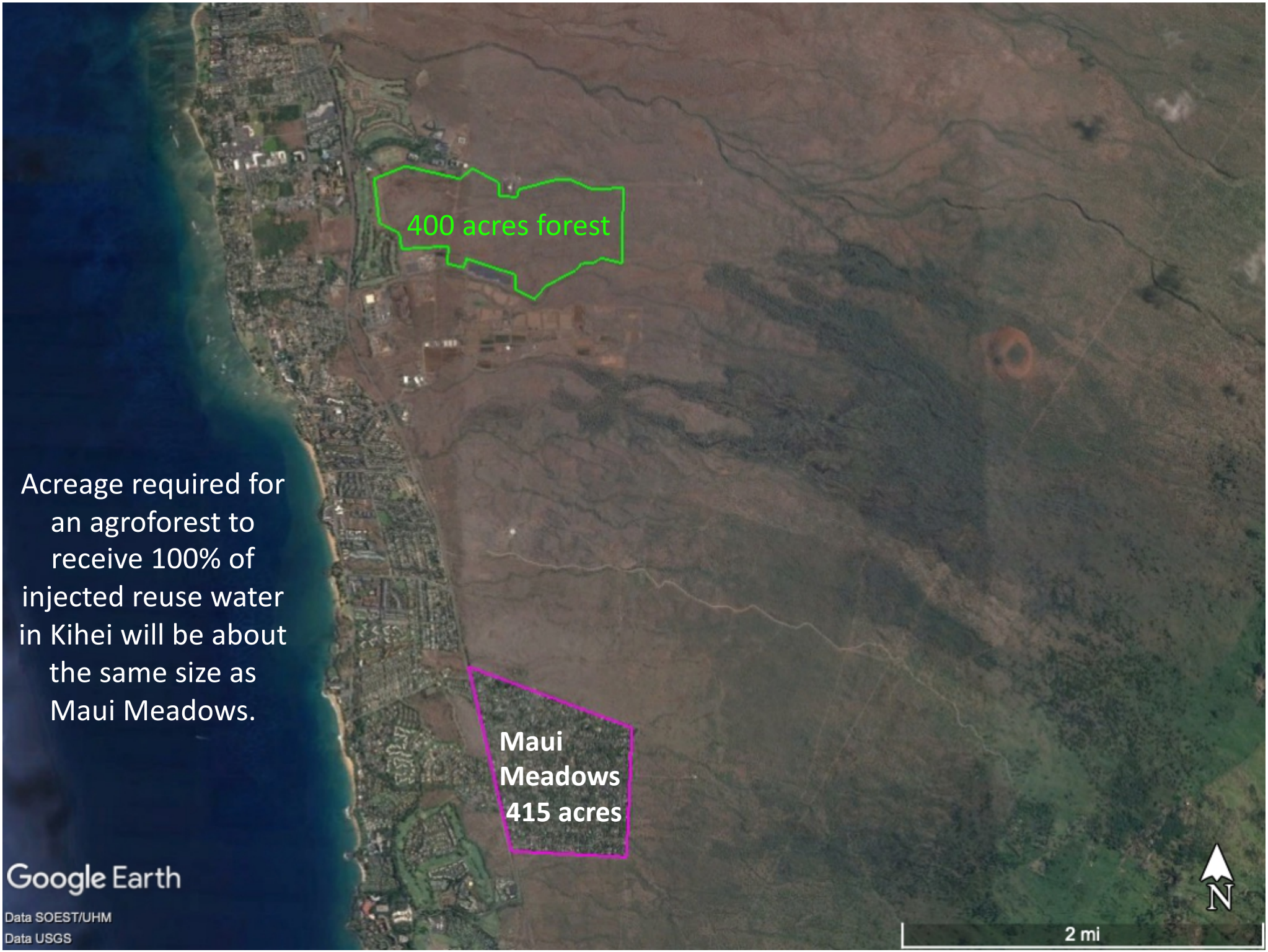
the process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.



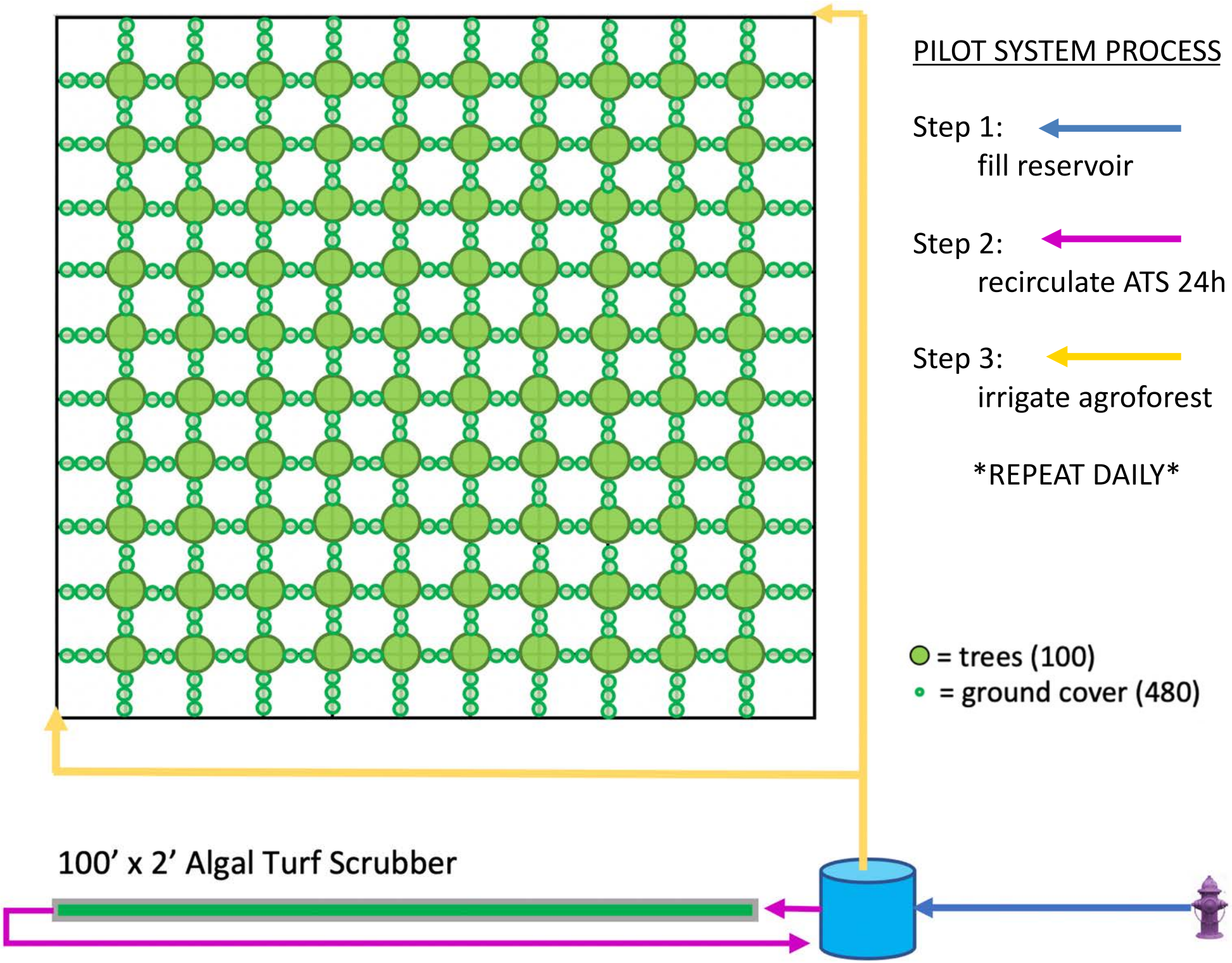

500 acres of food agroforest can receive 100% of water from Lahaina plant
Akahele St
Honoapiilani Hwy
Irrigation disposal agroforest: 500 acres
Land owners:
Maui Land & Pineapple
← Lahaina WWRF


1000 acres of food agroforest can receive 100% of water from Kahului-Wailuku plant, but only after "R1" plant upgrades first (Planned for 2025 at a cost of $15M)
← Kahului WWRF
500 acres
500 acres
Land owners:
HI-DOT
State of HI
Hansen Road Condominium
Maui Economic Opportunity Condo
Puunene Mill Condominium
W Kaahumanu Ave
Dairy Rd
Kuihelani Hwy
S Puunene Ave
Haleakala Hwy
Lanui Cir
32
380
3400
37
36
311
N
1 mi
Google Earth
Google


400 acres of food agroforest can receive 100% of water from Kihei plant
Irrigation disposal agroforest: 400 acres
← Kihei WWRF
Land owners:
Lipoa Investments LLC
Haleakala Ranch
N
4000 ft
Google Earth


400 acres forest
Acreage required for an agroforest to receive 100% of injected reuse water in Kihei will be about the same size as Maui Meadows.
Maui Meadows 415 acres
Google Earth
Data SOEST/UHM
Data USGS
N
2 mi


ATS demonstration pilot in Germany


PILOT SYSTEM PROCESS
Step 1:
fill reservoir
Step 2:
recirculate ATS 24h
Step 3:
irrigate agroforest
REPEAT DAILY
= trees (100)
= ground cover (480)
100’ x 2’ Algal Turf Scrubber


2017
2019
Just
Add
Water
Google Earth
Image © 2020 Maxar Technologies

Model 🔗 input: injected wastewater flowrates & nutrient concentrations
output: 330 pounds of breadfruit / resident / year

	TOTAL (MGD\)	REUSE (MGD)	INJECTED (MGD\)	nutrient concentration (mg/L)		INJECTED lbs/day	NUTIRENTS tons/year	ATS nutrient removal** (g/m2/day)	75% nutrient reduction	acres forest @5280 gal/acre/day***	# "modules" = ~2 acres ATS	# 'modules' = ~100 acres forest	ATS acres/facility	ATS**** $M/module	ATS $/facilty	forest***** $M/module	forest $M/facilty	upgrades $M/facility	TOTAL $M/facility	ATS operations $M/module/year	forest operations $M/module/year	TOTAL ops. $/year	ATS dry biomass metric tons/yr	ratio acres ATS/forest	ulu trees #/facility	food M lbs/facility	food lbs/resident/yr
Kahului-Wailuku	*5.5*	*0.4*	*5.1*	*10.4*	*N*	*527.4*	*96.3*	*1.11*	*39.9*																		
			5.1	*2.4*	*P*	*102.1*	*18.6*	*0.73*	*11.8*																		
Kahului-Wailuku*	5.5	0.4	5.1	5.6	N	238.2	43.5	1.11	**18.0**	966	9	10	18	3	27	2	20	26	73	0.125	0.125	2.4	933	0.02	49,000	27	173
				0.7	P	29.8	5.4	0.73	3.4																		
Lahaina	4	1.5	2.5	5.6	N	116.8	21.3	1.11	**8.8**	473	5	5	10	3	15	2	10	2	27	0.125	0.125	1.3	457	0.02	24,500	13	87
				0.5	P	10.4	1.9	0.73	1.2																		
Kihei-Wailea	3.7	1.6	2.1	9.99	N	175.0	31.9	1.11	**13.3**	398	7	4	14	3	21	3	12	2	35	0.125	0.125	1.4	685	0.03	19,600	11	69
				2.44	P	42.7	7.8	0.73	4.9																		
						612.8 *	111.8 *		**40.1**	1837	21	19	42		63		42	30	135			5.0	2075 **		93,100	51	330
																							(35 g / m2 / day)		(248.6 kg/tree/yr)		
			without Kahului R1 upgrades:			974.4	177.8																		https://tinyurl.com/Lincoln-2014		
			lbs/yr			355651																					

* after "R1" upgrades planned by County

** "*A controlled stream mesocosm for tertiary treatment of sewage*" https://www.sciencedirect.com/science/article/abs/pii/0925857495000569

*** watering rate of REEF POWER LLC pilot

**** See APPENDIX A below

***** $20K/acre for existing agricultural land in Kahului & Lahaina (based on $8500/acre irrigation hardware), $30K/acre in Kihei due to additional land preparation required

= effluent data from County of Maui describing 2017 flows

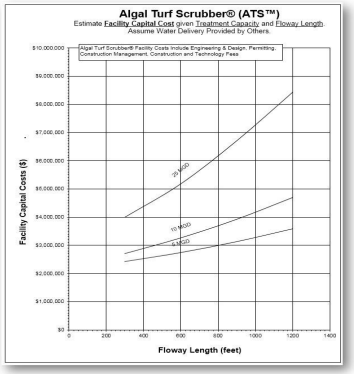
= estimated Kahului nutrient concentrations after planned $15M County of Maui "R1" upgrade by 2025

= Kahului "R1" upgrades $15M (County of Maui 2020), Kahului conveyance to parcel of interest $11M, Kihei/Lahaina conveyance $2M https://tinyurl.com/Maalaea-feasibility

= data from 8/13/2020 independent testing results

INSTALLATION COST			
$MM	Lahaina	Kahului	Kihei
upgrades	2	26	2
ATS	15	27	21
forest	10	20	12
SUBTOTALS	27	73	35
		TOTAL	135
OPS $MM/yr	1.3	2.4	1.4
		TOTAL/yr	5.0

APPENDIX A ATS cost estimate guidance from HydroMentia Technologies LLC President Mark Zivojnovich



5 MGD				10 MGD			25 MGD		
Floway Length (ft)	Floway Area (acres)	CAPEX	OPEX	Floway Area (acres)	CAPEX	OPEX	Floway Area (acres)	CAPEX	OPEX
300	1.2	$2,426,000	$ 104,000	2.4	$2,698,000	$136,000	6.0	$3,999,000	$248,000
600	2.4	$2,745,000	$ 108,000	4.8	$3,259,000	$146,000	12.0	$5,184,000	$282,000
900	3.6	$3,133,000	$ 112,000	7.2	$3,924,000	$154,000	18.0	$6,713,000	$324,000

The OPEX numbers that I presented represent values that would be associated with a stand-alone Algal Turf Scrubber® facility. Some of the cost items are also conservative in nature.

To assist you in better understanding the OPEX values that I shared, provided below is additional detail.

OPEX include the following cost assumptions for a 25 MGX x 300' floway.

- Pumping Costs - $130,000
- Harvest Equipment Fuel and Maintenance - $4,950
- Facilities Maintenance & Replacement - $35,700
- Harvest Labor - $18,150
- Site Maintenance & Visits Labor - $10,850
- Water Quality & Tissue Monitoring - $20,000
- Technology Consultation - $5,000
- Contingency – 15% or $22,395

INSTALLATION COST			
$MM	Lahaina	Kahului	Kihei
upgrades	2	26	2
ATS	15	27	21
forest	10	20	12
SUBTOTALS	27	73	35
		TOTAL	135
OPS $MM/yr	1.3	2.4	1.4
		TOTAL/yr	5.0


We can trade sick reefs for
93,000 breadfruit trees and
enhance food security in
Maui during a crisis that
stops mainland deliveries for
an extended period of time.

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Tax-deductible contributions toward our vision are welcomed through our project fiscal sponsor: Maui Nui Marine Resource Council.

🔗https://bit.ly/ReefPower2020🔗