

ATC Makena Hotel, LLC  
c/o Makena Golf & Beach Club

December 17, 2021

Mr. Myron Honda  
State of Hawaii, Department of Health  
Clean Water Branch  
2827 Waimano Home Road #225  
Pearl City, HI 96782



RE: State Land Use District Boundary Amendment Docket A9-721 Condition No. 9,  
County of Maui Zoning Ordinance No. 3613 Condition No. 19, Marine Water Quality  
Monitoring.

Dear Mr. Honda,

ATC Makena Holdings, LLC, in compliance with the above referenced conditions, respectfully submits the enclosed Marine Water Quality Quarterly Monitoring Report prepared by AECOS Inc. dated November 5, 2021, for the quarterly tests performed in August of 2021.

Should you have any questions, require a hardcopy, or require additional information, please do not hesitate to contact me at (808) 640-6023, or by email at [kjudd@makenagbc.com](mailto:kjudd@makenagbc.com).

Sincerely,

Makena Golf & Beach Club,  
For ATC Makena Hotel, LLC

DocuSigned by:

2C2B511CEAD548D...  
Kaimi Judd

Vice President of Development

Enclosures (1):

- a. PDF Copy of the August 2021 Quarterly Water Quality Sampling Report

Cc:

Joshua Woodburn, Makena Golf & Beach Club  
Mark Roy, Munekiyo Hiraga  
Bryan Esmeralda, Munekiyo Hiraga

**ENCLOSURES**

**a.**

August 2021 Quarterly Water Quality Monitoring Report

---

# Mākena Golf & Beach Club quarterly water quality monitoring report

## August 2021

---

November 5, 2021

*Final*

AECOS No. 1535N

Allen Cattell, Ph.D.  
AECOS, Inc.  
45-939 Kamehameha Highway, Suite 104  
Kāneʻohe, Hawaiʻi 96744  
Phone: (808) 234-7770 Email: Cattell@aecos.com

---

## Introduction

The State Land Use Commission requires that Mākena Golf and Beach Club (MG&BC; called “Project” herein) submit water quality monitoring reports to the Hawaiʻi Department of Health (HDOH) in compliance with Condition No. 10 in the “Declaration of Conditions”, a document that pertains to the Amendment of the MG&BC District Boundary, dated April 17, 1998. The monitoring report must also ensure compliance with Condition 19 of the County of Maui, Zoning Ordinance 3613. The goals of the monitoring program established to comply with Condition No. 10 and Ordinance 3613 are: (1) assess degree to which fertilizers, as well as other nutrient sources used on land to enhance golf course turf growth and resort landscaping, leach to groundwater and subsequently reach nearshore waters; (2) establish evidence of delivery of these nutrients into the nearshore environment; and (3) determine if subsequent water quality has any measurable impacts on biological community structure in the nearshore marine environment (see annual water quality reports: *AECOS*, 2019a, b, 2021).

Water quality parameters of particular interest for the purposes of our monitoring program are termed nutrients<sup>1</sup>. Nutrient enrichment can enhance nuisance algae production in aquatic environments (HDLNR, 2014). Nutrient enrichment can also negatively impact corals and other biological components

---

<sup>1</sup> “Nutrients” are nitrogen and phosphorus compounds that promote plant growth, including algal growth in the marine environment. These chemicals are the main ingredients in applied fertilizers.

in Hawai'i coastal waters (Laws et al., 2004; MRC, 2011; *AECOS*, 2016). A separate program monitors nearshore biological assemblages off the MG&BC resort to determine if marine water quality is impacting the biota extant there (see *AECOS*, 2020).

Tables and figures throughout this quarterly report compare the most recent (August 13, 2021) water quality monitoring results with means calculated from 13 previous monitoring events undertaken quarterly between June 2018 and April 2021.

## Background

Waters south from Nahuna Point—including Mākena Bay and Maluaka Bay (Figure 1)—to Pu'u Ola'i are designated as "Class A, open coastal waters" in State of Hawai'i water quality standards (HDOH, 2014). These waters are included on the HDOH 2020 list of impaired waters in Hawai'i prepared under Clean Water Act §303(d) as impaired for nitrate+nitrite, ammonium, total nitrogen, turbidity, and chlorophyll  $\alpha$  (HDOH, 2020). These waters are listed as "Category 2" (meaning that some designated uses are attained), "Category 3" (meaning that insufficient data and/or information exist to make use-support determinations), and "Category 5" (meaning that available data and/or information indicate that at least one designated use is not supported or is threatened). These results indicate that a Total Maximum Daily Load<sup>2</sup> study may be needed.

Marine waters from Pu'u Ola'i south are designated as Class AA "open coastal waters" in State of Hawai'i water quality standards (HDOH, 2014) and included on the HDOH 2020 list of impaired waters in Hawai'i for nitrate+nitrite, ammonium, and turbidity (HDOH, 2020). These waters are also listed under Categories 2, 3, and 5.

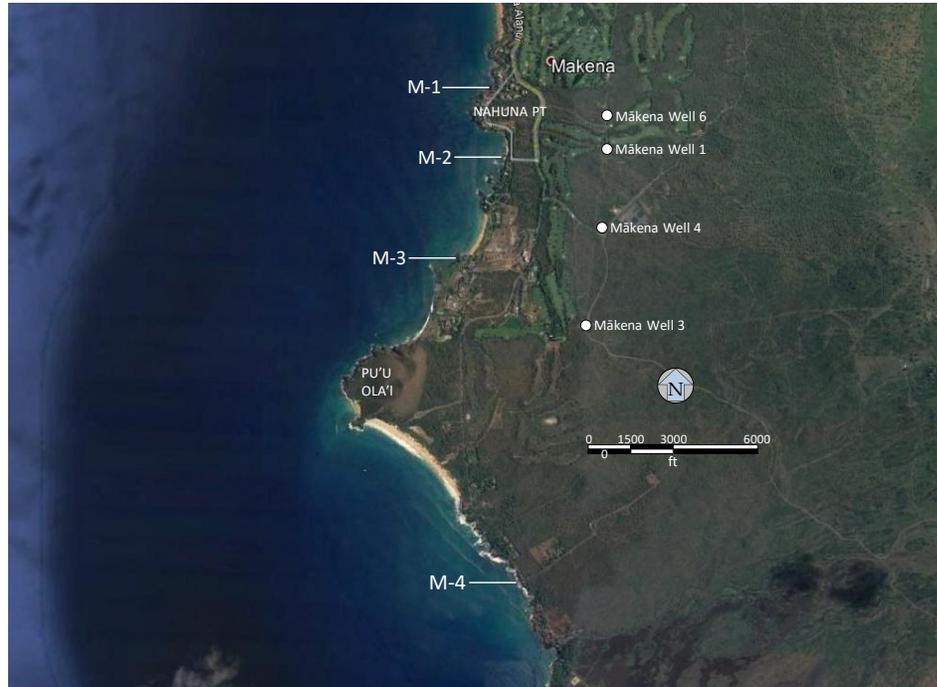
## Methods

The August 13, 2021 quarterly monitoring event was conducted along three monitoring transects in nearshore waters adjacent to MG&BC (Transects M-1, M-2, and M-3) and at a control site located well south of Pu'u Ola'i (Transect M-4). Sampling stations were set at 2-m, 10-m, 50-m, and 100-m distance from

---

<sup>2</sup> Total Maximum Daily Load (TMDL) studies are done to establish limits on point-source discharges of substances causing impairments to water quality in aquatic environments. The term "needed" in the HDOH document actually means "has not been done". A TMDL for any particular location is undertaken by HDOH and is unrelated to this monitoring effort as no point-source discharge is existing or contemplated at Mākena.

shore along each transect and water samples were collected from near the surface at each station. Water quality samples were also obtained from three source water wells: Mākena Well 1, Mākena Well 6, and Mākena Well 4 (see Fig. 1).



**Figure 1. Location of water quality monitoring transects M-1, M-2, M-3, and M-4) and irrigation water supply wells at MG&BC**

Temperature, salinity, pH, and dissolved oxygen (DO) were measured *in situ* at each station. Collected water samples were immediately chilled and returned to the AECOS laboratory (AECOS Log No. 43260) for laboratory analyses. The following parameters were measured from these samples: salinity, turbidity, ammonium, nitrate+nitrite, total nitrogen (total N), ortho-phosphate, total phosphorus (total P), and chlorophyll *a*. Table 1 lists the instruments and analytical methods used for these field measurements and laboratory analyses.

The predicted tide on the August 13, 2021 event was high at 0710 hours (+1.21 ft), falling to a low of +0.46 ft at 1224 hours (Station 1615202, Mākena; NOAA, 2021). Winds were mild (0 to 1 kts) from the north and nearshore surf was mostly calm (0 to 1 ft). Water quality samples were collected at all stations along each of the four transects between 0830 and 0930 hours, followed by sampling at the MG&BC wells.

**Table 1. Analytical methods and instruments used for water quality analyses reported herein.**

Analysis	Method	Reference	Instrument
Temperature	SM 2550B	SM (2017)	YSI Model 550 DO meter thermistor
Salinity	SM 120.1	SM (2017)	Accument AB200
pH	SM 4500H+	SM (2017)	pH pHep HANNA meter
Dissolved Oxygen	SM 4500-O G	SM (2017)	YSI Model 550 DO meter
Turbidity	EPA 180.1	USEPA (1993b)	Hach 2100Q Turbidimeter
Ammonium	EPA 349	USEPA (1997a)	Lachat Quickchem 8500
Nitrate + Nitrite	EPA 353.2	USEPA (1993a)	Lachat Quickchem 8500
Total Nitrogen	EPA 353.4	USEPA (1993a)	Shimadzu TNM-1
Ortho-Phosphate	EPA 365.5	USEPA (1997b)	Lachat Quickchem 8500
Total Phosphorus	EPA 365.5	USEPA (1997b)	Lachat Quickchem 8500
Chlorophyll $\alpha$	SM-10200H(M)	SM (1998)	Turner Fluorometer

## Results

Water quality results, displayed in Tables 2 and 3, are compared with long-term mean values. On August 13, 2021, salinities were elevated compared to long-term means, especially for Transect M-1 through M-3. Temperatures, on the other hand, were very close to long-term means along all four transects. Temperature values also changed little with distance from shore or between transects. pH means for Transect M-1 through M-3 were very slightly elevated compared to long-term means. pH means also decreased slightly from north to south. DO saturation means also decreased north to south and generally with distance from shore. Turbidity means were lower than long-term means at Transects M-2 through M-4 and decreased with distance from shore along all four transects. Chlorophyll  $\alpha$  values showed trends in keeping with turbidity (not unusual as turbidity is a measure of particulates and chlorophyll  $\alpha$  measures particulate algae (phytoplankton) concentration in the water).

Nitrate+nitrite concentrations on August 13, 2021 (Table 3) were low at all stations compared with long-term means: especially along Transect M-1 through Transect M-3, and to a lesser degree at Transect M-4. There was no particular horizontal distribution in nitrate+nitrite concentrations with distance

**Table 2. Physical/chemical water quality and chlorophyll  $\alpha$  means for June 2018 through April 2021 ( $n = 13$ ) compared to August 2021 results.**

Transect	DFS <sup>†</sup> (m)	Salinity (ppt)		Temperature (°C)		pH		DO (% Sat.)		Turbidity <sup>‡</sup> (NTU)		Chl. $\alpha$ <sup>‡</sup> ( $\mu\text{g/L}$ )	
		Means	August 2021	Means	August 2021	Means	August 2021	Means	August 2021	Means	August 2021	Means	August 2021
M-1	2	33.68	35.05	26.7	26.6	8.13	8.30	103	105	1.53	1.33	0.78	0.50
	10	33.84	35.04	26.4	26.7	8.18	8.26	106	105	0.83	1.10	0.50	0.51
	50	34.03	35.12	26.4	26.6	8.19	8.26	102	98	0.71	0.89	0.41	0.33
	100	34.31	35.18	26.4	26.6	8.16	8.26	99	92	0.47	0.27	0.26	0.31
	<b>Means</b>	<b>33.97</b>	<b>35.10</b>	<b>26.5</b>	<b>26.6</b>	<b>8.17</b>	<b>8.27</b>	<b>103</b>	<b>100</b>	<b>0.89</b>	<b>0.90</b>	<b>0.49</b>	<b>0.41</b>
M-2	2	33.94	35.19	26.7	26.5	8.14	8.27	99	95	2.05	1.40	0.43	0.31
	10	33.97	35.10	26.6	26.6	8.16	8.26	95	93	1.47	1.17	0.36	0.25
	50	34.05	35.18	26.5	26.6	8.17	8.25	96	94	0.88	0.31	0.28	0.19
	100	34.26	35.14	26.5	26.5	8.15	8.23	98	92	0.98	0.20	0.30	0.19
	<b>Means</b>	<b>34.06</b>	<b>35.15</b>	<b>26.6</b>	<b>26.6</b>	<b>8.16</b>	<b>8.25</b>	<b>97</b>	<b>94</b>	<b>1.35</b>	<b>0.77</b>	<b>0.34</b>	<b>0.24</b>
M-3	2	33.66	35.06	26.6	26.5	8.16	8.22	108	98	0.73	0.90	0.59	0.39
	10	34.10	35.19	26.5	26.5	8.16	8.24	104	96	0.56	0.44	0.41	0.19
	50	34.33	35.22	26.5	26.5	8.16	8.22	101	91	0.43	0.20	0.27	0.19
	100	34.42	35.17	26.5	26.5	8.15	8.22	98	87	0.41	0.20	0.22	0.18
	<b>Means</b>	<b>34.13</b>	<b>35.16</b>	<b>26.5</b>	<b>26.5</b>	<b>8.16</b>	<b>8.23</b>	<b>103</b>	<b>93</b>	<b>0.53</b>	<b>0.44</b>	<b>0.37</b>	<b>0.24</b>
M-4	2	34.10	34.86	26.2	26.3	8.11	8.14	101	97	1.30	0.88	0.60	0.51
	10	34.12	35.02	26.1	26.4	8.12	8.13	101	94	0.99	0.78	0.47	0.46
	50	34.46	34.88	26.2	26.5	8.13	8.12	99	87	0.63	0.38	0.31	0.26
	100	34.58	34.82	26.2	26.6	8.12	8.07	97	85	0.45	0.30	0.22	0.23
	<b>Means</b>	<b>34.32</b>	<b>34.90</b>	<b>26.2</b>	<b>26.5</b>	<b>8.12</b>	<b>8.12</b>	<b>100</b>	<b>91</b>	<b>0.84</b>	<b>0.59</b>	<b>0.40</b>	<b>0.37</b>
<b>Hawai'i Dry Criteria</b>		<b>+/- 10%</b>		<b>+/- 1C°</b>		<b>7.6-8.6</b>		<b>≥75%</b>		<b>≤0.20 NTU</b>		<b>≤0.15 <math>\mu\text{g/L}</math></b>	
† distance from shore		‡ geometric mean		Red exceeds standard									

**Table 3. Nutrient water quality geometric means for June 2018 through April 2021 ( $n = 13$ ) compared to August 2021 results.**

Transect	DFS <sup>†</sup> (m)	NO <sub>3</sub> +NO <sub>2</sub> (µgN/L)		NH <sub>4</sub> (µgN/L)		TN (µgN/L)		PO <sub>4</sub> (µgP/L)		TP (µgP/L)	
		Means	August 2021	Means	August 2021	Means	August 2021	Means	August 2021	Means	August 2021
M-1	2	58	20	18	22	201	116	2	5	10	11
	10	48	12	21	22	171	107	2	5	7	13
	50	37	13	18	4	162	84	2	6	10	13
	100	26	15	22	53	145	121	1	8	8	10
	<b>Means</b>	<b>42</b>	<b>15</b>	<b>20</b>	<b>25</b>	<b>170</b>	<b>107</b>	<b>2</b>	<b>6</b>	<b>9</b>	<b>12</b>
M-2	2	31	5	11	14	127	111	3	5	29	7
	10	31	4	14	16	132	85	3	4	11	10
	50	28	4	14	18	126	91	3	3	9	5
	100	18	3	14	77	112	139	2	6	10	10
	<b>Means</b>	<b>27</b>	<b>4</b>	<b>13</b>	<b>31</b>	<b>124</b>	<b>107</b>	<b>3</b>	<b>5</b>	<b>15</b>	<b>8</b>
M-3	2	52	8	15	114	189	114	3	6	8	6
	10	39	14	12	81	149	81	3	4	7	4
	50	25	18	22	94	128	94	2	2	9	4
	100	17	1	15	89	117	89	2	3	8	3
	<b>Means</b>	<b>33</b>	<b>10</b>	<b>16</b>	<b>95</b>	<b>146</b>	<b>95</b>	<b>3</b>	<b>4</b>	<b>8</b>	<b>4</b>
M-4	2	14	5	13	118	103	118	2	4	9	4
	10	14	7	17	100	101	100	2	5	9	8
	50	9	8	18	94	97	94	2	2	9	4
	100	6	8	16	125	89	125	2	4	5	4
	<b>Means</b>	<b>11</b>	<b>7</b>	<b>16</b>	<b>109</b>	<b>98</b>	<b>109</b>	<b>2</b>	<b>4</b>	<b>8</b>	<b>5</b>
<b>Dry Criteria</b>		≥3.5 µgN/L		≥2µgN/L		≥110 µgN/L		ns		≥16µgP/L	
† distance from shore		Red exceeds standard				ns - no standard					

from shore. Ammonium concentrations, on the other hand, were elevated along all four transects compared with long-term means. Ammonium means increased progressively from north to south and did not show any trends relative to distance from shore. Total nitrogen concentrations were low compared to long-term means except at Transect M-4 where concentrations were slightly elevated compared with the long-term mean. Ortho-phosphate

means were very slightly elevated compared with all four long-term transect means.

Generally, groundwater seepage into nearshore coastal waters will result in a lowering of salinity and an increase in nitrate+nitrite concentrations. These conditions were not evident from the present sampling event as nitrate+nitrite concentrations were relatively low and salinity values were relatively high at all four nearshore (2-m) stations, possibly because samples were collected not long after a high tide.



**Figure 2. Approximated current flow off Mākena coast during morning hours (0200 to 1100 hours) of August 13, 2021 (PacIOOS, 2021).**

Water quality further offshore reflects water moving into the Mākena vicinity from, most typically, north or south along the coast and is therefore not much influenced by local groundwater influx. Using the PacIOOS Regional Ocean Modeling System (ROMS), we can display approximated water current movements off the southwestern coast of East Maui that occurred just prior to and during our August 13, 2021 sampling event (PacIOOS, 2021). The surface

flow on this date was from slightly west of north in the early morning hours and then offshore to the southwest (Figure 2, above) in late morning hours.

## Discussion

Salinities along all four nearshore stations (2-m) during the present sampling event were high and nitrate+nitrite concentrations were generally low except at Sta. 2-m on Transect M-1. These results indicate no evidence of high nitrate+nitrite concentrations associated with low salinity groundwater intrusion. Ammonium concentrations were high along all transects, especially along Transect M-4. Ammonium concentrations nearshore are not typically related to salinity levels, but are generated within these waters from natural biological processes.

## Nutrient Subsidies

Tables 4 and 5 present estimates of groundwater nitrate+nitrite and ortho-phosphate subsidies in nearshore marine waters calculated for the August 13, 2021 sampling event. Measured nearshore nitrate+nitrite concentrations (based on salinity values) were high only at Sta. 2-m on Transect M-1. No nitrate+nitrite subsidies were estimated for Sta. 2-m on any of the four transects.

**Table 4. Estimated nitrate+nitrite subsidies at nearshore (2-m) stations on August 13, 2021.**

Location	Measured		Estimated NO <sub>3</sub> +NO <sub>2</sub> (µgN/L)	Subsidy NO <sub>3</sub> +NO <sub>2</sub> (µgN/L)
	NO <sub>3</sub> +NO <sub>2</sub> (µgN/L)	Salinity (PSU)		
	Seibu Wells	1640	1.39	---
M-1	20	35.05	64	0
M-2	5	35.19	64	0
M-3	8	35.06	64	0
M-4	5	35.02	64	0

Ortho-phosphate concentrations were slightly elevated at all stations on all four transects compared with long-term means (Table 3). Concentrations decreased slightly from Transect M-1 through M-4, suggesting that if a source of elevated

ortho-phosphate existed, it was located north of the Mākena area. Thus, the small ortho-phosphate subsidies given in Table 5 can be presumed to be from an unknown source—not from Mākena groundwater seepage.

**Table 5. Estimated ortho-phosphate subsidies at nearshore (2-m) stations on August 13, 2021.**

Location	Measured		Estimated	Subsidy
	PO <sub>4</sub>	Salinity	PO <sub>4</sub>	PO <sub>4</sub>
	(µgP/L)	(PSU)	(µgP/L)	(µgP/L)
<b>Seibu Wells</b>	68	1.39	---	---
<b>M-1</b>	5	35.05	2	3
<b>M-2</b>	5	35.19	2	3
<b>M-3</b>	6	35.06	2	4
<b>M-4</b>	5	35.02	2	3

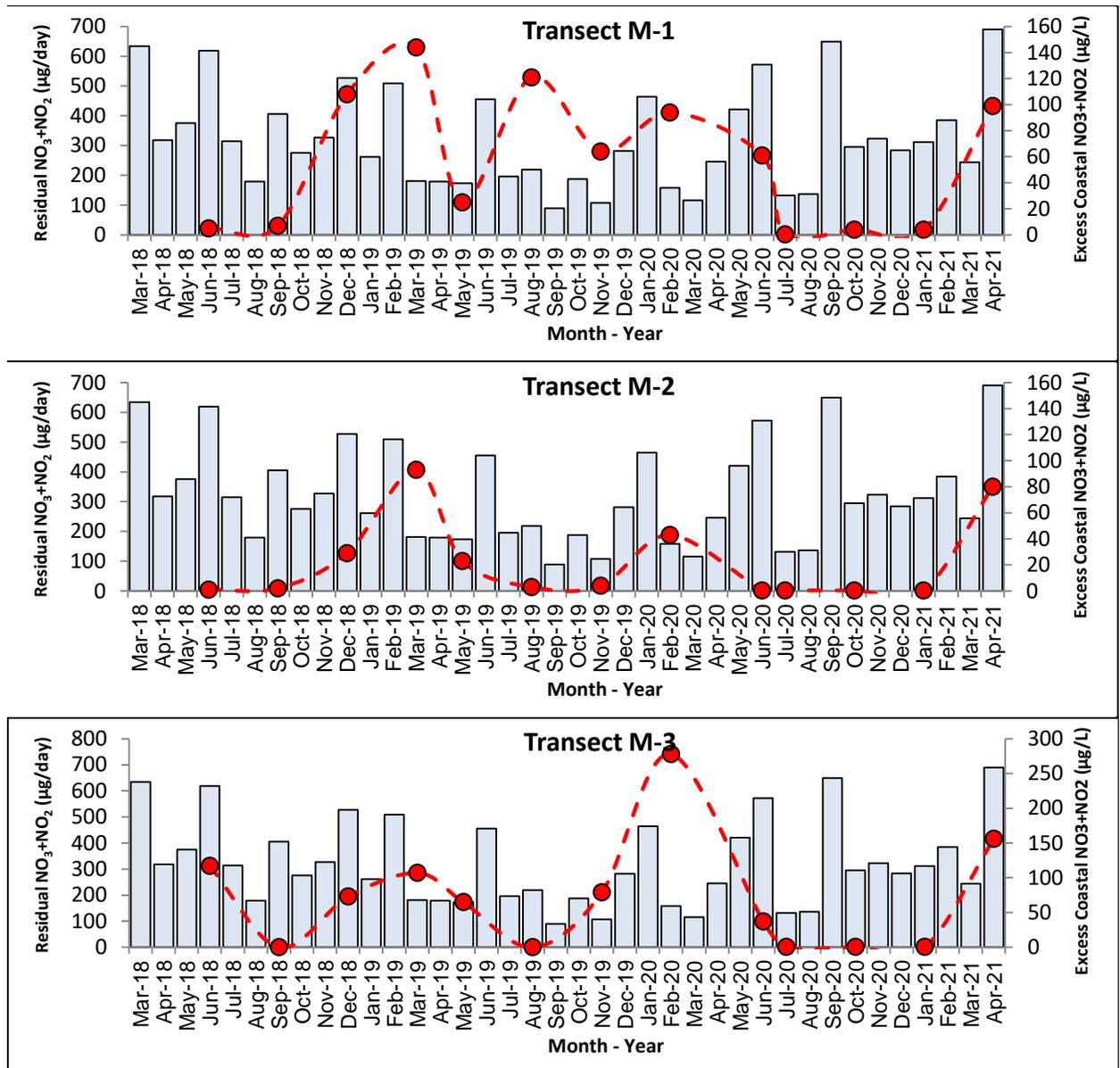
## Irrigation and Fertilizer Tracking

We track turf and landscape fertilization/irrigation data provided by Jonathan Galicinao (MG&BC) on a monthly basis. Nutrient concentrations are measured in irrigation supply wells during each quarterly sampling event. Figure 3 presents our comparison of estimated fertilizer “residual” (blue bars) with actual sampling event nitrate+nitrite concentrations (red circles) at the 2-m stations on Transects M-1, M-2, and M-3. By residual is meant the 20% of nitrogen fertilizer concentration that was not taken up by plants or by absorption to soil/organic particles. The 80% loss of applied fertilizer nitrogen is an average for Maui golf courses detailed in a U. S. Geologic Survey report (USGS, 2018).

## Nutrient Limitation

Inorganic nitrogen and phosphorus compounds are typically identified as potentially “limiting” nutrients in Hawaiian marine waters. Increases in a limiting nutrient concentration can result in enhanced growth of phytoplankton and macroalgae. Excessive algal growth has happened in the coastal waters off Kīhei due to discharge of both nitrogen and phosphorus compounds from the Kīhei Wastewater Treatment Plant (Laws et al., 2004; Dailer et al., 2010).

Maintaining low limiting nutrient concentrations is essential to maintaining a more pristine and diverse biological community in marine waters.



**Figure 3. Mean estimated nitrate+nitrite residuals to golf course turf and landscaping (blue columns; g/day) and measured nitrate+nitrite (red circles µg/L) levels at 2-m stations of Transect M-1, M-2, and M-3.**

We can estimate the limiting nutrient (nitrogen or phosphorus) by comparing molar ratios (N:P ratios) of dissolved inorganic nitrogen (DIN: nitrate, nitrite, and ammonium) to dissolved inorganic phosphate (DIP: ortho-phosphate). N:P ratios for 20 Hawaiian algal species range from 15:1 to 44.1 with an average of

about 29:1 (Atkinson and Smith, 1983). High N:P ratios (>29.1) are potentially related to DIP limitation, whereas low N:P ratios (<29.1) are likely related to DIN limitation.

**Table 6. A summary of average DIN and DIP values for thirteen monitoring events (June, 2018 – April, 2021) and April, 2021.**

Transect	DFS <sup>†</sup> (m)	DIP (μM/L)		DIN (μM/L)		DIN:DIP ratio		N/P Limited potential	
		Means	August 2021	Means	August 2021	Means	August 2021	Means	August 2021
<b>M-1</b>	2	0.06	0.16	5	3	84	19	P	N
	10	0.06	0.16	5	2	76	15	P	N
	50	0.06	0.19	4	1	61	6	P	N
	100	0.03	0.26	3	5	106	19	P	N
<b>M-2</b>	2	0.10	0.16	3	1	31	8	P	N
	10	0.10	0.13	3	1	33	11	P	N
	50	0.10	0.10	3	2	31	16	P	N
	100	0.06	0.19	2	6	35	30	P	P
<b>M-3</b>	2	0.10	0.19	5	9	49	45	P	P
	10	0.09	0.13	4	7	39	53	P	P
	50	0.07	0.06	3	8	47	124	P	P
	100	0.06	0.10	2	6	37	66	P	P
<b>M-4</b>	2	0.06	0.13	2	9	29	68	P	P
	10	0.06	0.16	2	8	34	47	P	P
	50	0.06	0.06	2	7	30	113	P	P
	100	0.06	0.13	2	10	24	74	N	P

Analyses using accumulating data averages can be useful to decipher trends. Because we're still gathering data, sufficient nutrient and chlorophyll  $\alpha$  data are not presently available to make statistical inferences regarding actual limiting nutrient determinations in Mākena waters. Data presented herein are based on our 13 sample sets and N vs. P limitation will vary from place to place along the coast and over time as additional monitoring results are added to the data set

(see Table 6, above). For example, during the present sampling event, N:P values for monitoring stations along Transects M-1 and M-2 were potentially DIN limited, due to the fact that DIP concentrations were relatively high along these transects compared with DIN concentrations, except at Sta. 100 on Transect M-2. DIP concentrations, on the other hand, were potentially limiting along Transects M-3 and M-4. N to P limitation can also vary between stations along individual transects, as shown in Transect M-2 for the present sampling event.

Since different algal species present a wide range of N:P requirements (Atkinson & Smith, 1983), constantly changing nutrients in these waters tend to prevent excessive algal growth by preventing extensive growth of just one or a few species.

## Conclusions

The August 13, 2021 monitoring event provided a somewhat different picture of water quality off MG&BC compared with most past monitoring events. This difference was due to the somewhat rare occurrence of elevated ortho-phosphate concentrations at all stations along each of the four transects. As a result, DIN appeared to be the limiting nutrient along transects M-1 and M-2, except at Sta. 100 on Transect M-2. DIP appeared to be the limiting nutrient at all stations along transects M-3 and M-4. Elevated ortho-phosphate concentrations along all four transects occurred at typical oceanic salinity concentrations showing no influence from Mākena area groundwater input.

## References

- AECOS*, Inc. (*AECOS*). 2016. Marine biological surveys for the proposed Mākena Resort M-5/M-6/S-7/B-2 project, Mākena, Maui. ATC Mākena Holdings, LLC. *AECOS* No. 1470A: 56 pp.
- \_\_\_\_\_. 2018. Mākena Golf & Beach Club quarterly water quality sampling event. July 2018. Prep. for Mākena Golf & Beach Club. *AECOS* No. 1535A: 15 pp.
- \_\_\_\_\_. 2019a. Mākena Golf & Beach Club, 2018 annual water quality monitoring report. Prep. for Mākena Golf & Beach Club. *AECOS* No. 1535C: 30 pp.

AECOS, Inc. (AECOS). 2019b. Mākena Golf & Beach Club, 2019 annual water quality monitoring report. Prep. for Mākena Golf & Beach Club. AECOS No. 1535G: 21 pp.

\_\_\_\_\_. 2020. Marine biological surveys for the proposed Mākena Future Lands Project, Mākena, Maui. Prep, for AREG AC Mākena Propco LLC. AECOS No. 1602: 64 pp.

\_\_\_\_\_. 2021. Mākena Golf & Beach Club, 2020 annual water quality monitoring report. Prep. for Mākena Golf & Beach Club. AECOS No. 1535K: 22 pp.

Atkinson, M. J. and S. V. Smith. 1983. C:N:P ratios of benthic marine plants. *Limnol. & Oceanogr.*, 28(3): 568-574.

Dailer, M. L., R. S. Knox, J. E. Smith, M. Napier, and C. M. Smith. 2010. Using  $\delta^{15}\text{N}$  values in algal tissue to map locations and potential sources of anthropogenic nutrient inputs on the island of Maui, Hawai'i, USA. *Mar. Poll. Bull.* 60(5): 655-671.

Hawaii Department of Health (HDOH). 2014. Hawai'i Administrative Rules, Title 11, Department of Health, Chapter 54, Water Quality Standards. November 15, 2014. 110 pp.

\_\_\_\_\_. 2020. 2020 State of Hawai'i water quality monitoring and assessment report: integrated report to the U.S. Environmental Protection Agency and the U.S. Congress pursuant to §303(3) and §305(b), Clean Water Act (P.L. 97-117). 134 pp.

Hawai'i Department of Land and Natural Resources (HDLNR). 2014. Status of Maui's Coral Reefs. URL: <http://dlnr.hawaii.gov/dar/files/2014/04/MauiReefDeclines.pdf>.

Laws, A. E., D. Brown, and C. Peace. 2004. Coastal water quality in the Kihei and Lahaina districts of the Island of Maui, Hawaiian Islands: impacts from physical habitat and groundwater seepage: implications for water quality standards. *Inter. J. Environ. Poll.*, 22(5): 531-546.

Marine Research Consultants, Inc. (MRC). 2011. An evaluation of causal factors affecting coral reef community structure in Ma'alaea Bay, Maui, Hawaii. Job No. WW09-22. Prep. for County of Maui. 84 pp.

National Oceanic and Atmospheric Administration (NOAA). 2021 Tide Predictions for gauge 1615202, Mākena, HI. Available at URL: <https://tidesandcurrents.noaa.com>. Last retrieved April 15, 2021.

Pacific Islands Ocean Observing System (PacIOOS). 2021. Available online at URL: <https://www.pacioos.hawaii.edu/currents-category/model/>. Last retrieved January 30, 2021.

Standard Methods (SM). 1998. Standard Methods for the Examination of Water and Wastewater, 20<sup>th</sup> Edition. American Public Health Association, American Water Works Association, Water Environment Federation.

\_\_\_\_\_. 2017. Standard Methods for the Examination of Water and Wastewater, 23<sup>rd</sup> Edition. American Public Health Association, American Water Works Association, Water Environment Federation.

U.S. Environmental Protection Agency (USEPA). 1993a. Method 353.2 Revision 2.0: Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry. National Exposure Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268. 15 pp.

\_\_\_\_\_. 1993b. Method 180.1: Determination of Turbidity by Nephelometry. Version 2. Exposure Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268. 11 pp.

\_\_\_\_\_. 1997a. Method 349.0: Determination of Ammonia in Estuarine and Coastal Waters by Gas Segmented Continuous Flow Colorimetric Analysis. National Exposure Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268. 16 pp.

\_\_\_\_\_. 1997b. Method 365.5: Determination of Ortho-Phosphate in Estuarine and Coastal Waters by Automated Colorimetry Analysis. National Exposure Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268. 9 pp.

U.S. Geological Survey. (USGS). 2018. Spatially Distributed Groundwater Recharge Estimated Using a Water-Budget Model for the Island of Maui, Hawai'i, 1978-2007. Scientific Investigations Report 2014-5168. U.S. Department of the Interior. U.S. Geological Survey. 64 pp.