

Inventive Resources, Inc. (IRI)

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January 24, 2023

Tahoe Regional Planning Agency
Attn: Emily Frey, Aquatic Invasive Species Projects Coordinator
128 Market Street
Stateline, NV 89410

UVC Light Aquatic Invasive Plant Control Pilot Project-Summary of Treatment Field Activities Material

Dear Emily:

Inventive Resources Inc. (IRI) is pleased to submit the following document summarizing a few project related questions regarding the 2022 treatment season. This document is for your review and records. The questions that are being addressed are as follows.

1. A summary schedule showing the two UV boats actual treatment schedules by site for all of 2022.
2. The durations of treatment and frequency of retreatment for exposures at each of the treatment sites.
3. Problems or challenges that may have prevented full treatments at the sites.
4. Changes in treatment procedures or duration that may be more effective for Year 2 UV treatment.
5. General UV Vessel information (dimensions, key design features, light array configuration and intensities (per sq cm or other unit), light wave range for each boat, and other specs/features).

Most segments and parts of the UVC treatment vessel were mobilized and assembled by May 24th, 2022. Operational testing began right before the May Memorial Day holiday. UVC treatment began for the 2022 season in early June. There were some scheduling issues that had to be changed while in the field due to herbicide residuals that did not allow for curtains to be removed and thus delayed the UVC treatment vessel to start as planned. This caused for additional vessel movements and some increased labor usage.

Schedule

Scheduling of both the UV treatment vessels at each of the treatment sites is summarized in Table 1 below. For additional information on treatment boundaries, calendar with dates of when areas were treated, and maps are included in Attachment A.

Table 1
UVC Light Aquatic Invasive Plant Control Pilot Project
Treatment Dates and Sampling Comments

Site Location	1st UV Treatment	2nd UV Treatment	Spot Treatment	Comments
Site 10	9/26 - 9/29/22			Areas treated are noted in treatment map.
Site 11	10/5 – 10/8/22			Areas treated are noted in treatment map.
Site 15	9/12/22 – 9/16/22			Areas treated are noted in treatment map.
Site 22	6/21/22 – 6/24/22 6/27/22 – 6/29/22	8/18/22 – 8/19/22 8/22/22 – 8/26/22	10/19/22 – 10/21/22	Areas treated are noted in treatment map.
Site 23	6/7/22 – 6/10/22 6/13/22 – 6/15/22	8/31/22 9/1/22 – 9/2/22 9/6/22 – 9/9/22	10/24/22 -10/26/22	Areas treated are noted in treatment map. .
Site 24	5/31/22 6/1/22 – 6/3/22 6/6/22 – 6/7/22	7/27/22-7/29/22 8/1/22 -8/2/22 8/5/22 8/8/22	10/10/22 -10/12/22 10/27/22 – 10/28/22	Areas treated are noted in treatment map.

A typical treatment UVC vessel path in a combination site looks like Figure 1 below. The 16ft x 40ft UVC light chamber follows this path to keep a clear passage for boat travel through each site, herbicides were used along the nearshore areas.



Figure 1: Typical treatment path at a combination site.

Figure 2 illustrates the treatment path movements were side shift right, forward, side shift left, this would allow for sufficient overlap.

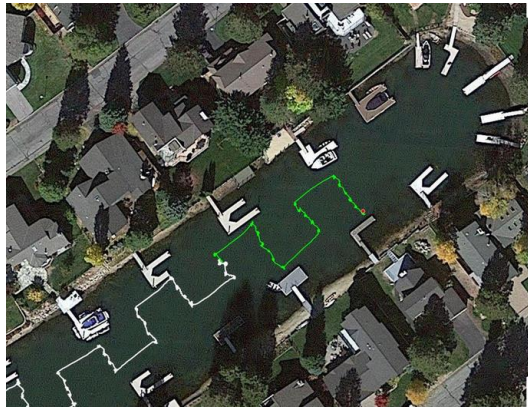


Figure 2- UVC Treatment vessel path in the UV only site using the large 16ftx40ft UV light chamber. The vessel targeted center area from dock to dock.

In Figure 3 below, the UVC cantilever treatment vessel has a light chamber with dimensions 8ft x 40 ft making it ideal for the areas under the dock and boats. Unfortunately, due to low water levels, not all areas were accessible (with water). Typical movements from this type of treatment vessel were to enter the site and sideshift until proper overlap was achieved.

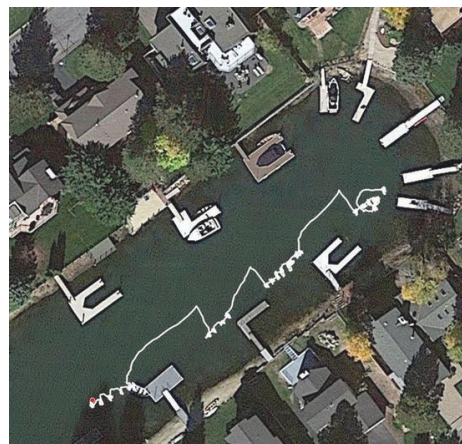


Figure 3 - UVC Cantilever treatment vessel

Duration and Frequency of Retreatment at each of the treatment sites

Treatment times varied within a site. On average an IRI treatment operator moved the treatment vessel every 15-20 minutes. The UV vessel can move in the (X, Y) direction. With overlap, treatment times are 15 minutes or more. This treatment time is consistent with what has been done over the past few testing years. The University of Nevada, Reno also determined that this treatment time was sufficient in their laboratory using Tahoe Keys water conditions. Using sonar, operators can speed up or slow down treatment times, however we were directed to limit treatment time variance and keep treatment times homogeneous for this test year.

Problems or challenges that may have prevented full treatment at the sites

As with all treatment control strategies, nothing is perfect. We have listed a few issues and challenges we faced during the 2022 treatment. They are summarized below.

- Parked boats in low water areas proved challenging as IRI had the inability to treat under with very little clearance underneath.
- Poor water quality in the combination sites. UV transmittance dropped to zero in some of these sites due to the algae and stagnant water.
- Docking stations should be closer to treatment sites. This would reduce the wasted travel time to and from sites, in some cases it took an hour to drive over to the treatment site. Adding multiple docking area locations can shorten that wasted time and focus on treatment.

- Obstacles in treatment areas. All unnecessary buoys and signs should be out of the UV treatment site during the days IRI is conducting treatment in order to have more complete treatment coverage. Often, operators had to stay at least 10ft to 20ft away from buoys and obstacles, for safety.
- Some sites received UV treatment late in the season. Early first treatment is imperative. All sites should have a first treatment by mid-July when the plants are still young and before the turions mature. UV light is more effective in treating early forming turions.
- Site 23 had significant fragment accumulation that would float into the area. (See Image Control Site Treatment Photos- Site 23 UV only. Image was taken after first treatment.)
- Add more powerful motors and/or add an outboard motor for long distance travel.
- Site 15 in particular had dense vegetation. When there is dense vegetation, it is likely that shadowing would prevent UV light to reach all the undergrowth. In addition, this area had a late treatment start and only one treatment.

Changes in UV treatment operations/durations that may be more effective for Year 2

A few improvements or modifications to UV treatment IRI can improve on for a more effective UV treatment can be as simply prioritizing sites. For example, IRI has created a 2023 preferred treatment map. Based on prior years of treatment, IRI planned for shorter treatment time durations but with increased overlap to ensure as much coverage as equipment allows. Currently we are trying to modify the light chambers structural configuration to minimize UV light gaps in treatment. Other changes that can improve treatment results are listed below.

- When shallow water conditions exist, it may be best to treat from dock to dock and/or open areas between.
- First UV treatment should occur May-July and not later. UV light is more effective when plants are tender and turions are in the early stages of development.
- Second UV treatment should occur by August-October and any spot treatments thereafter.
- UV boats need to work at different sites. This will speed up treatment and minimize unnecessary overlap. The request was made to work at different sites at the same time, but that would have made monitoring more difficult, so IRI finished one site at a time.
- Add better sonar and have access to the TKPOA Biobase data (raw data) created monthly to better strategize the treatment approach in areas based on real-time infestation density.
- Have access to the plant height data during the working season.

General UV Vessel information

IRI had two UV treatment vessels in operation during the season. The vessels have a light chamber attached and equipped with multiple skids of UV light that operate in the germicidal range (254nm - 275nm). The chamber can provide a lethal dose of radiation to damage the DNA of plant cells, thus preventing replication. Vessel III has a 16ft by 40ft light chamber and is powered by a 99kW generator. Vessel IV has an 8ft by 40ft light chamber and is powered by a 65kW generator. A power barge provides electrical power to a grid of UV-C lamps in the light chamber that is lowered over the plants.

Some features on the UV vessel include:

- Each UV treatment vessel has a slow-moving power barge with a floatation system to support the UV-C light chamber with adjustable winch cables. The winch cables assist in moving the light chamber up or down.
- A marine diesel-powered electric generator supplies all the electric power requirements for the vessel and UV-C light chamber.

- A programable controls system with timers automates repetitious operations and remote cameras allow operator to make more visual observations on plant conditions underneath the chamber.
- Current models have a 99 kW and 65 kW generators. Several smaller vessels have propane generators, and some include gasoline conversion.
- Considerations on solar power with propane backup is currently being used on several small experimental vessels to allow for unmanned operation. This could dramatically reduce treatment cost.
- UV-C lamps and LED-UVC products are becoming more mainstream because of increased use and demand due to COVID. These products, including UV-C lamps are rapidly undergoing changes to make them more effective. We are conducting on-going in-house testing on many improved types available.
- As manufacturers improve UV-C light output the exposure time and distance between lamp and thus plants can be improved greatly.

Attachment 2 has some general UV treatment vessel specifications and illustrates a schematic of each. Other UV-C pilot tools that can result in faster and more effective treatment, especially in hard to access and shallow areas are being worked on. Other tools that allow for remote and unmanned operation, faster travel and other features that result in less treatment cost are also being pursued.

Attachment 3 has a treatment comparison of Site 24, before UV treatment versus after UV treatment area. The images presented are of Curlyleaf pondweed and Eurasian watermilfoil. An image taken on 6/16/22 illustrate healthy and thriving plants with dense plant growth before UV treatment. That same area was treated after the image was taken, 14 days later approximately 6/30/22, plants have collapsed, and decomposition has started. Additional images taken at 29 days post UVC treatment, illustrate a sediment cloud forming when the underwater cameras were lowered to investigate. At the 29 day mark most plants had decomposed and very little was left standing. Depending on water temperature it can take up to 4 weeks for treated plants to completely breakdown.

Attachment 4 has project images of both treatment vessels in operation around the Tahoe Keys area.

All project and video images from the UVC project are available upon request. If you need more information, images, or have any questions or concerns, please do not hesitate to call me at 209-545-1663 or by email at john@IRIproducts.com.

Sincerely,

Inventive Resources Inc.



John J. Paoluccio
President, Inventive Resources Inc.



Evangelina Paoluccio P.E.
Project Engineer, Inventive Resources Inc.

Attachment A
UVC Light Aquatic Invasive Plant Control Pilot Project 2022
Treatment Boundary Maps and Dates

MAY						
Sun	Mon	Tues	Weds	Thur	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
	Turbidity	Curtain	Installation			
15	16	17	18	19	20	21
	Turbidity	Curtain	n			
	Baseline	Water	Quality	&	Macrophyte	
22	23	24	25	26	27	28
29	30 Memorial Day	31 Site 24, 1				

AUGUST						
Sun	Mon	Tues	Weds	Thur	Fri	Sat
	1 Site 24, 2	2 Site 24, 2	3	4	5 Site 24, 2	6
7	8 Site 24, 2	9 Site 24, 2	10	11	12	13
14	15	16	17	18 Site 22, 2	19 Site 22, 2	20
21	22 Site 22, 2	23 Site 22, 2	24 Site 22, 2	25 Site 22, 2	26 Site 22, 2	27
28	29	30	31 Site 23, 2			

JUNE						
Sun	Mon	Tues	Weds	Thur	Fri	Sat
			1 Site 24, 1	2 Site 24, 1	3 Site 24, 1	4
5	6 Site 24, 1	7 Site 24, 1	8 Site 23, 1	9 Site 23, 1	10 Site 23, 1	11
12	13 Site 23, 1	14 Site 23, 1	15 Site 23, 1	16	17	18
19	20	21 Site 22, 1	22 Site 22, 1	23 Site 22, 1	24 Site 22, 1	25
26	27 Site 22, 1	28 Site 22, 1	29 Site 22, 1	30		

SEPTEMBER						
Sun	Mon	Tues	Weds	Thur	Fri	Sat
				1 Site 23, 2	2 Curtains Removed	3
4	5 Labor Day	6 Site 23, 2	7 Site 23, 2	8 Site 23, 2	9 Site 23, 2	10
11	12 Site 15, 1	13 Site 15, 1	14 Site 15, 1	15 Site 15, 1	16 Site 15, 1	17
18	19	20	21	22 Curtains Removed	23	24
25	26 Site 10, 1	27 Site 10, 1	28 Site 10, 1	29 Site 10, 1	30	

JULY						
Sun	Mon	Tues	Weds	Thur	Fri	Sat
					1	2
3	4 4th of July	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27 Site 24, 2	28 Site 24, 2	29 Site 24, 2	30

OCTOBER						
Sun	Mon	Tues	Weds	Thur	Fri	Sat
2	3 Site 10, 1	4	5 Site 11, 1	6 Site 11, 1	7 Site 11, 1	8 Site 11, 1
9	10 Site 24, 3	11 Site 24, 3	12 Site 24, 3	13 Site 24, 3	14 Site 24, 3	15
16	17	18	19 Site 22, 3	20 Site 22, 3	21 Site 22, 3	22
23	24 Site 23, 3	25 Site 23, 3	26 Site 23, 3	27 Site 24, 3	28 Site 24, 3	29
30	31 Halloween					

Key Legend

Number after the site location is the treatment number.

1 = first treatment.

2 = second treatment.

3 = spot treatment.

EXHIBIT	REVIEWED BY JAP	CHECKED BY EP	DRAWN BY DS	SCALE NTS	DATE 01-24-23	Inventive Resources, Inc. 5038 Salida Blvd / PO Box 1316 Salida, California 95368 General Information: 209.545.1663
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UVC Light Aquatic Invasive Plant Control Pilot Project 2022
Tahoe Keys
Schedule

Schedule

First Treatment: September 26-29

Key



Area treated by 16'x40' boat



Area treated by 8'x40' boat



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UVC Light Aquatic Invasive Plant Control Pilot Project 2022

Tahoe Keys

Site 10 Combination UV / Endothal

Schedule

First Treatment: October 5-8

Key



Area treated by 16'x40' boat



Area treated by 8'x40' boat



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UVC Light Aquatic Invasive Plant Control Pilot Project 2022

Tahoe Keys

Site 11 Combination UV / Endothal



Schedule

First Treatment: September 12-16

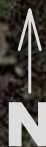
Key



Area treated by 16'x40' boat



Area treated by 8'x40' boat



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UVC Light Aquatic Invasive Plant Control Pilot Project 2022
Tahoe Keys
Site 15 Combination UV / Endothal

Schedule

First Treatment: June 21-24, 27-29

Second Treatment: August 18, 19, 22-26

Spot Treatment: October 19-21

Key



Area treated by 16'x40' boat



Area treated by 8'x40' boat

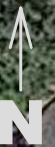


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	JAP		

UVC Light Aquatic Invasive Plant Control Pilot Project 2022

Tahoe Keys

Site 22 UV Only

Schedule

First Treatment: June 7-10, 13-15

Second Treatment: August 31, September 1-2, 6-9

Spot Treatment: October 24-26

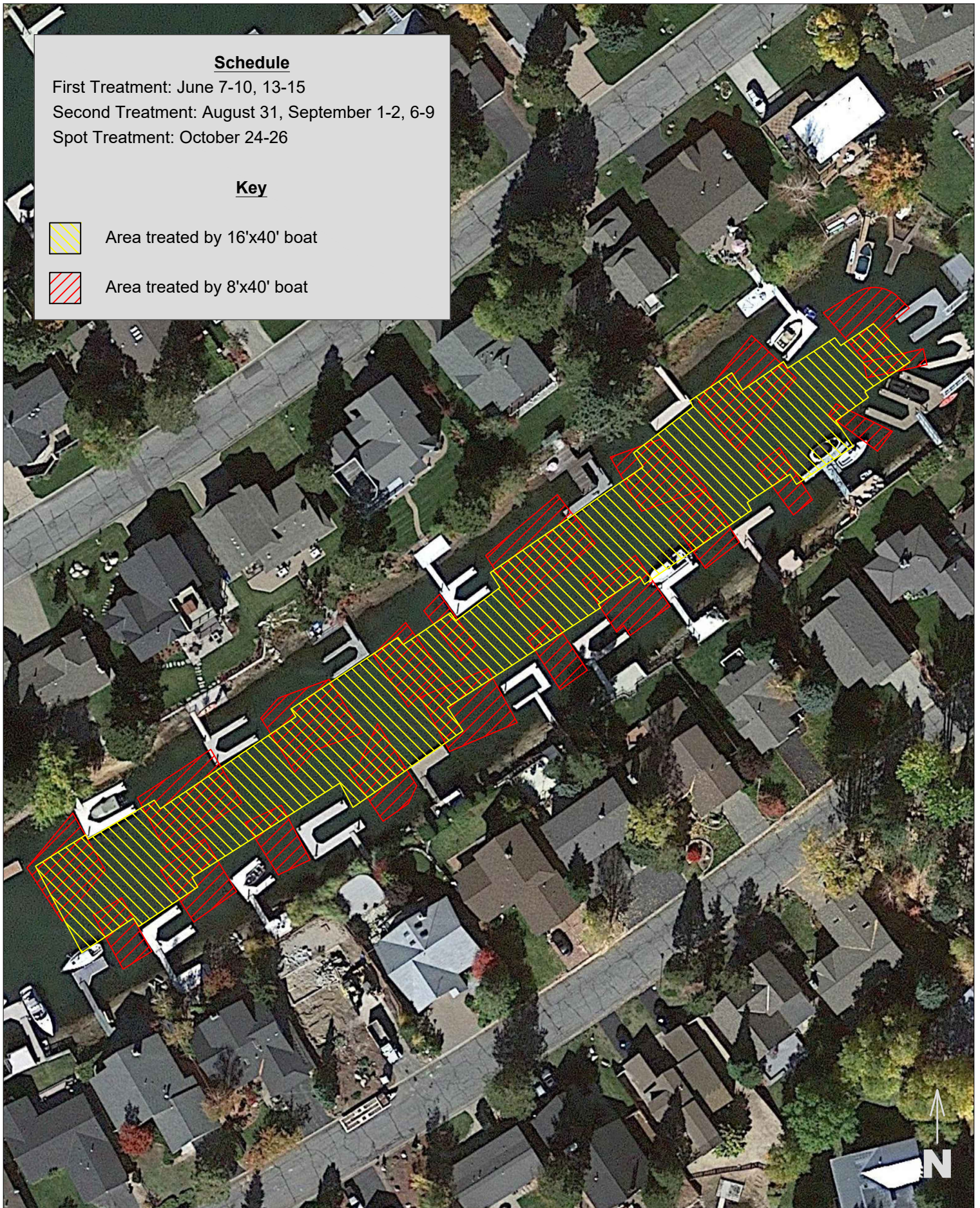
Key



Area treated by 16'x40' boat



Area treated by 8'x40' boat



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UVC Light Aquatic Invasive Plant Control Pilot Project 2022

Tahoe Keys

Site 23 UV Only

Schedule

First Treatment: May 31, June 1-3, 6-7

Second Treatment: July 27-29, August 1-2,5,8

Spot Treatment: October 10-12, 27-28

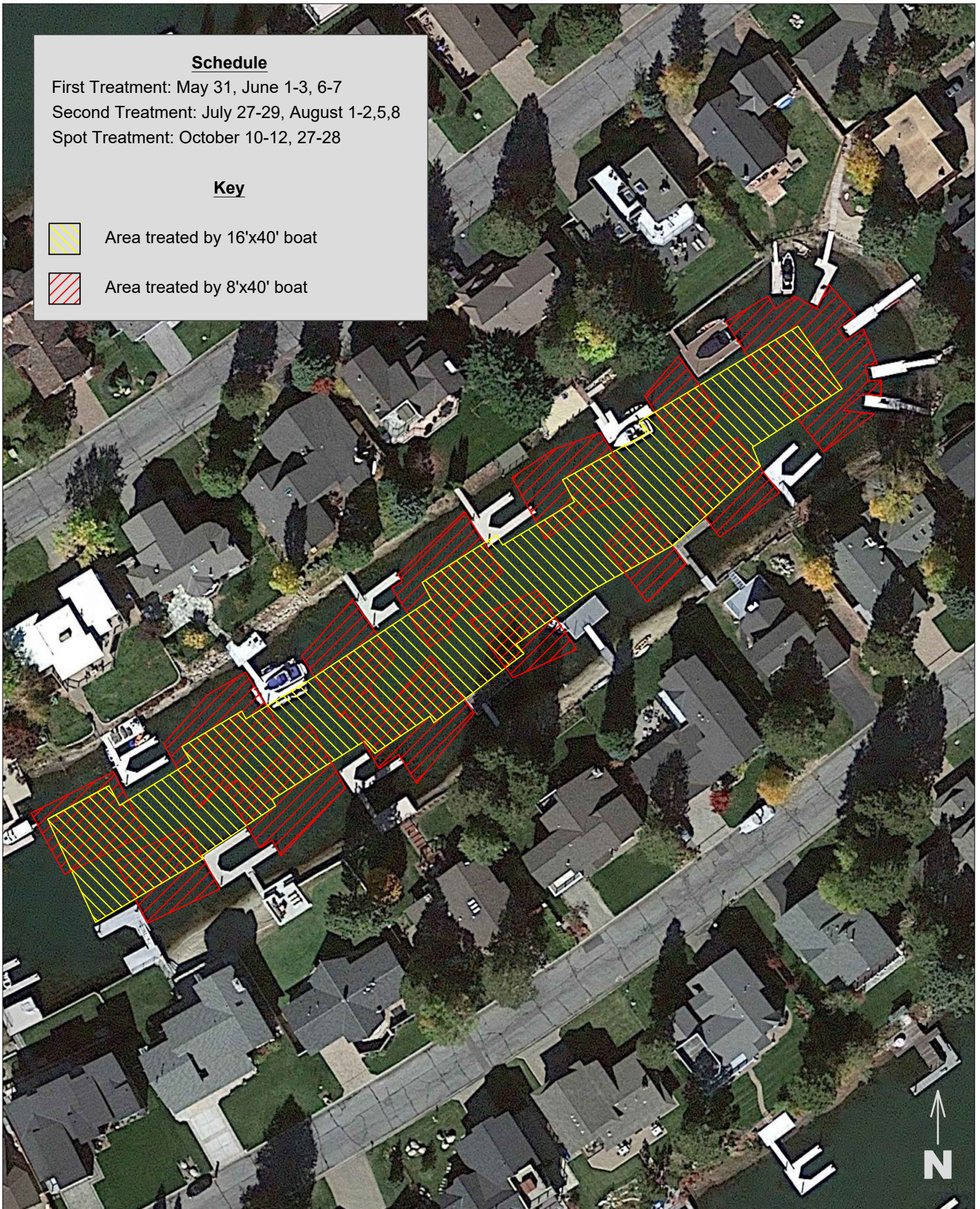
Key



Area treated by 16'x40' boat



Area treated by 8'x40' boat



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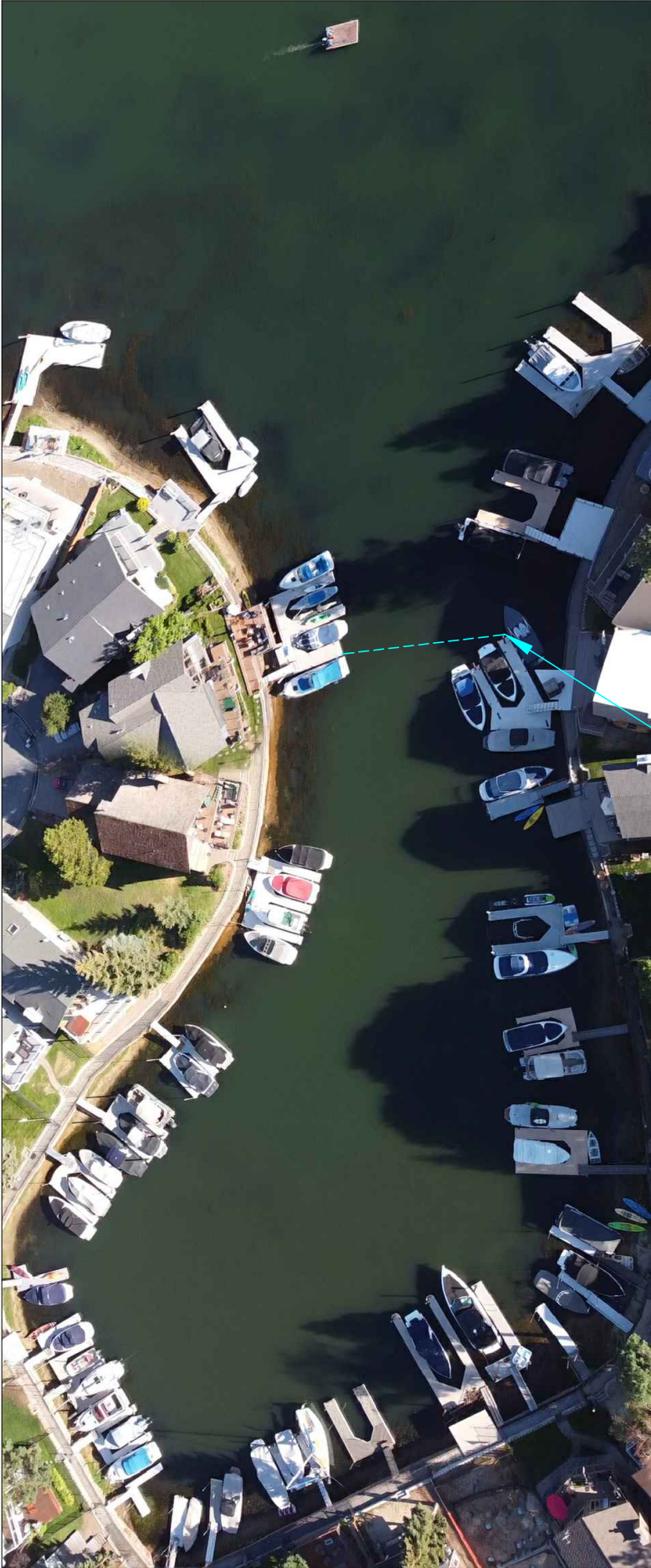
DATE
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UVC Light Aquatic Invasive Plant Control Pilot Project 2022

Tahoe Keys

Site 24 UV Only

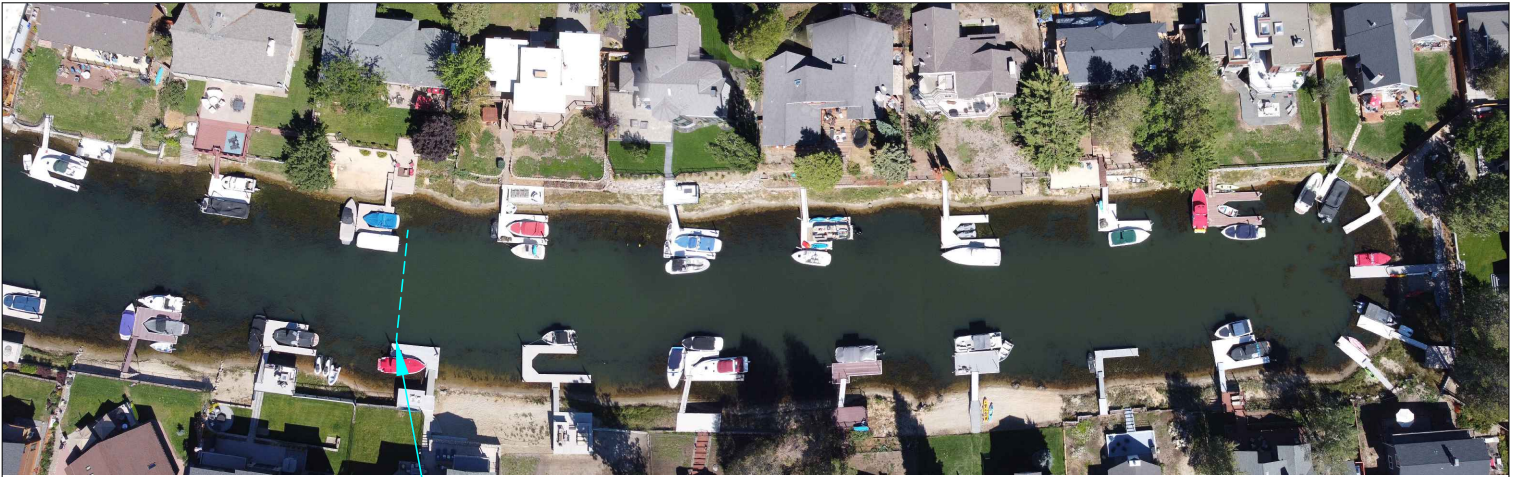


Site 22
Photo taken August 24th.

Treatment area boundary
Harvested above / UV below

Schedule
First Treatment: June 21-24, 27-29
Second Treatment: August 18, 19, 22-26
Spot Treatment: October 19-21

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JAP		



Site 24 UV Only

Photo taken August 24th.

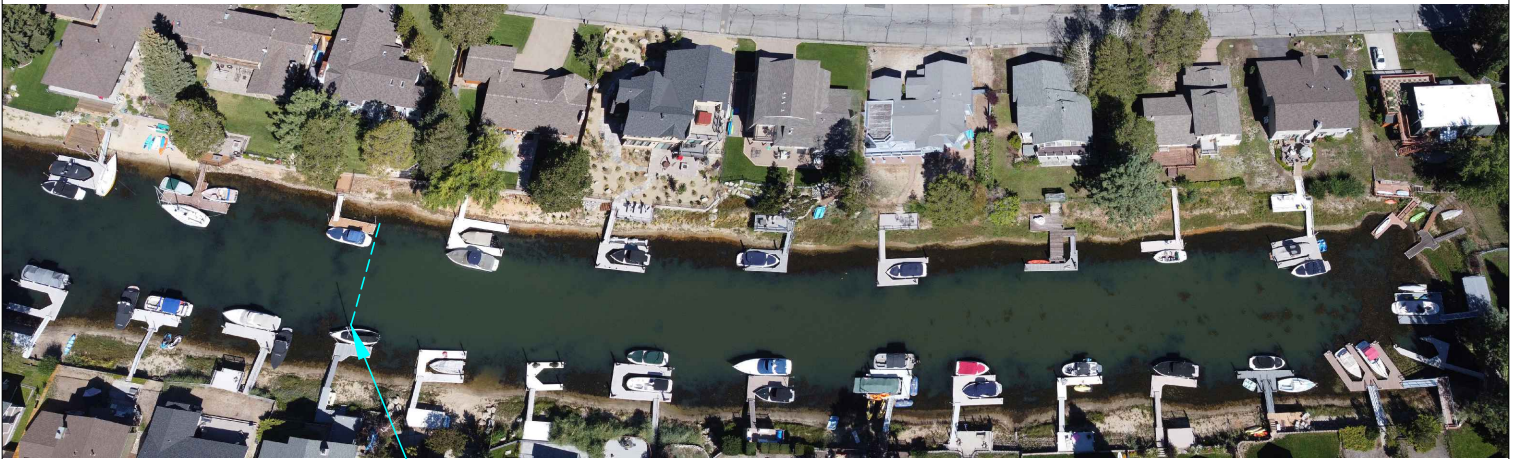
Treatment area boundary
Harvested left / UV right

Schedule

First Treatment: May 31, June 1-3, 6-7

Second Treatment: July 27-29, August 1-2,5,8

Spot Treatment: October 10-12, 27-28



Site 23 UV Only

Photo taken August 24th.

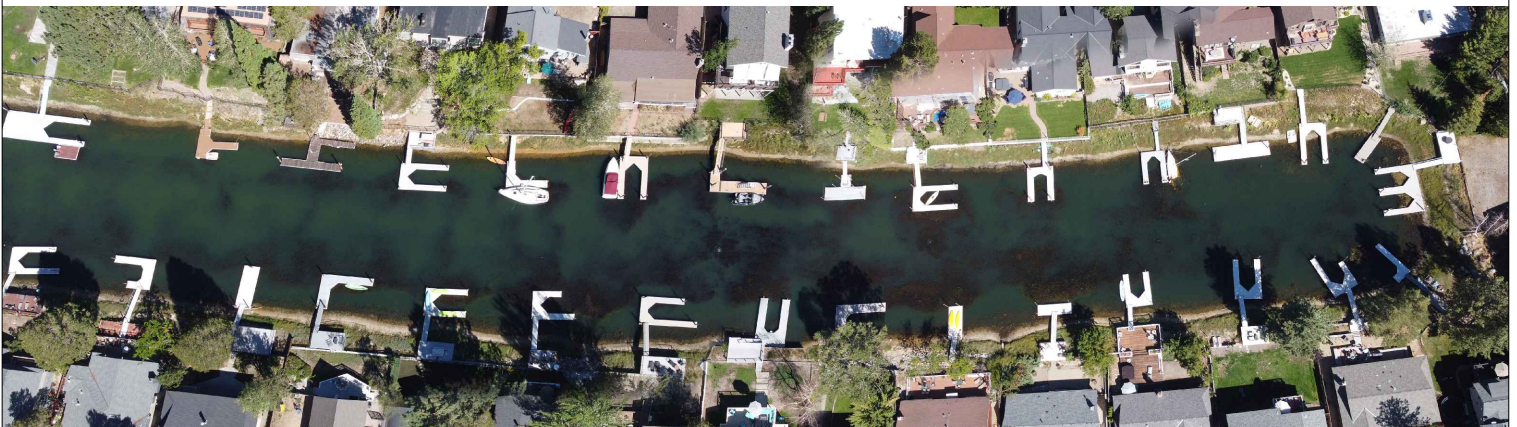
Treatment area boundary
Harvested left / UV right

Schedule

First Treatment: June 7-10, 13-15

Second Treatment: August 31, September 1-2, 6-9

Spot Treatment: October 24-26



Control Site 18 No Treatment

Photo taken August 24th.

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DATE 01-24-23

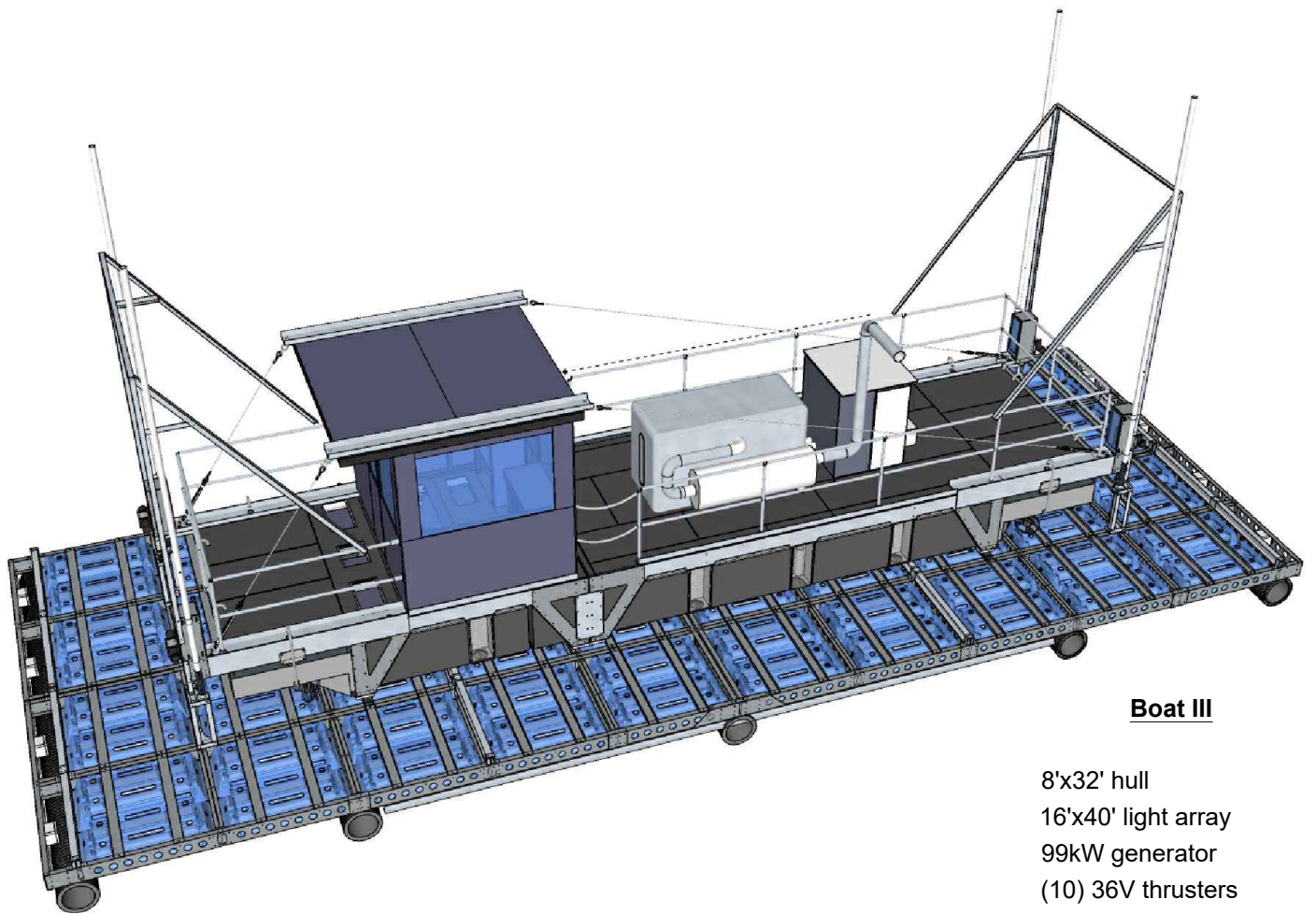
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UVC Light Aquatic Invasive Plant Control Pilot Project 2022

Tahoe Keys

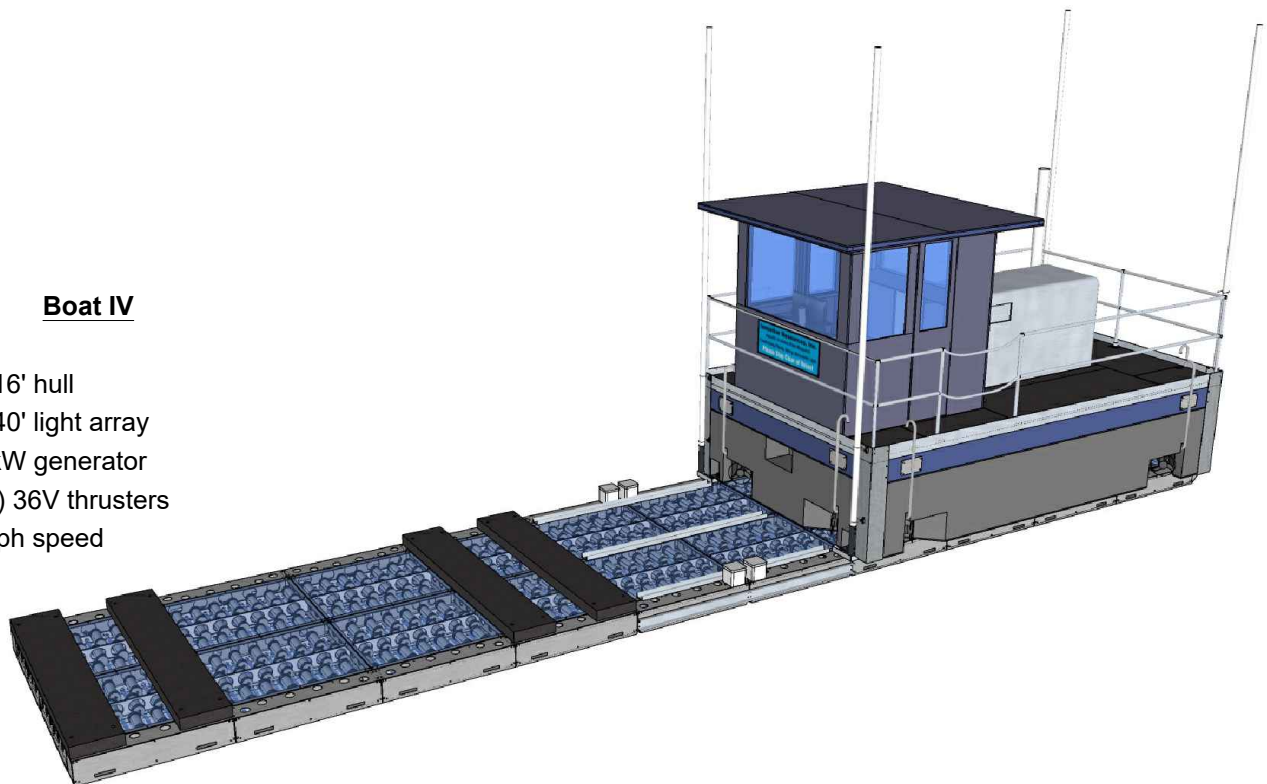
24, 23, Control Site Treatment Photos

Attachment B
UVC Light Aquatic Invasive Plant Control Pilot Project 2022
UV Treatment Vessel General Information



Boat III

8'x32' hull
 16'x40' light array
 99kW generator
 (10) 36V thrusters
 0.8mph speed

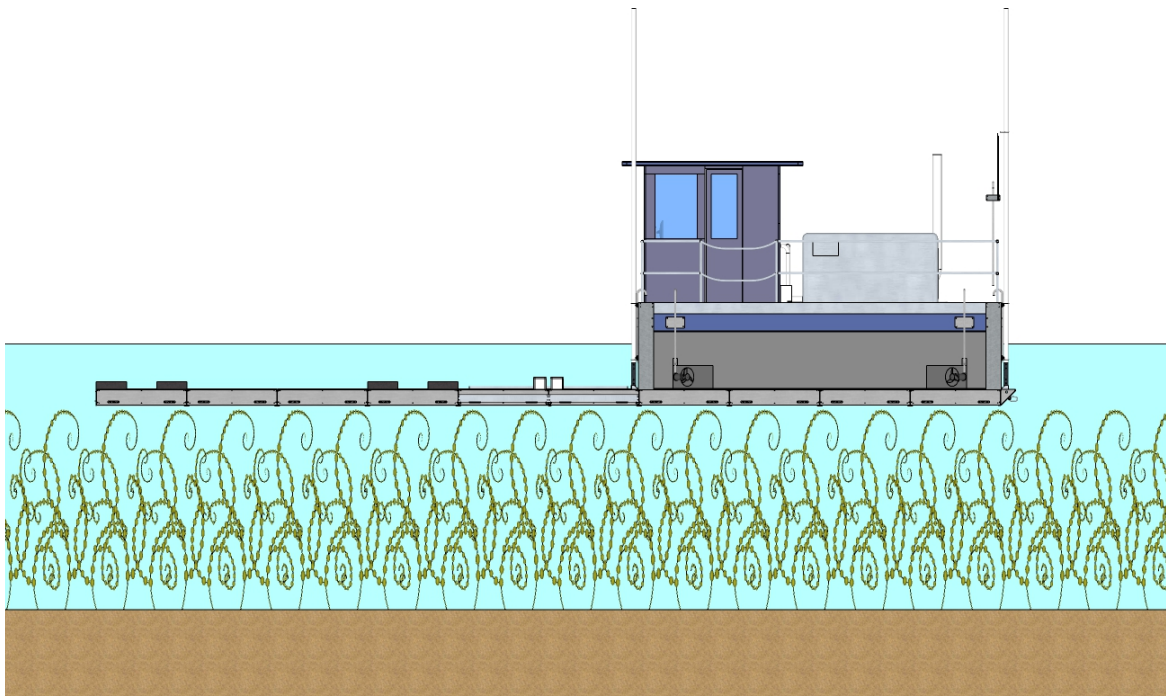


Boat IV

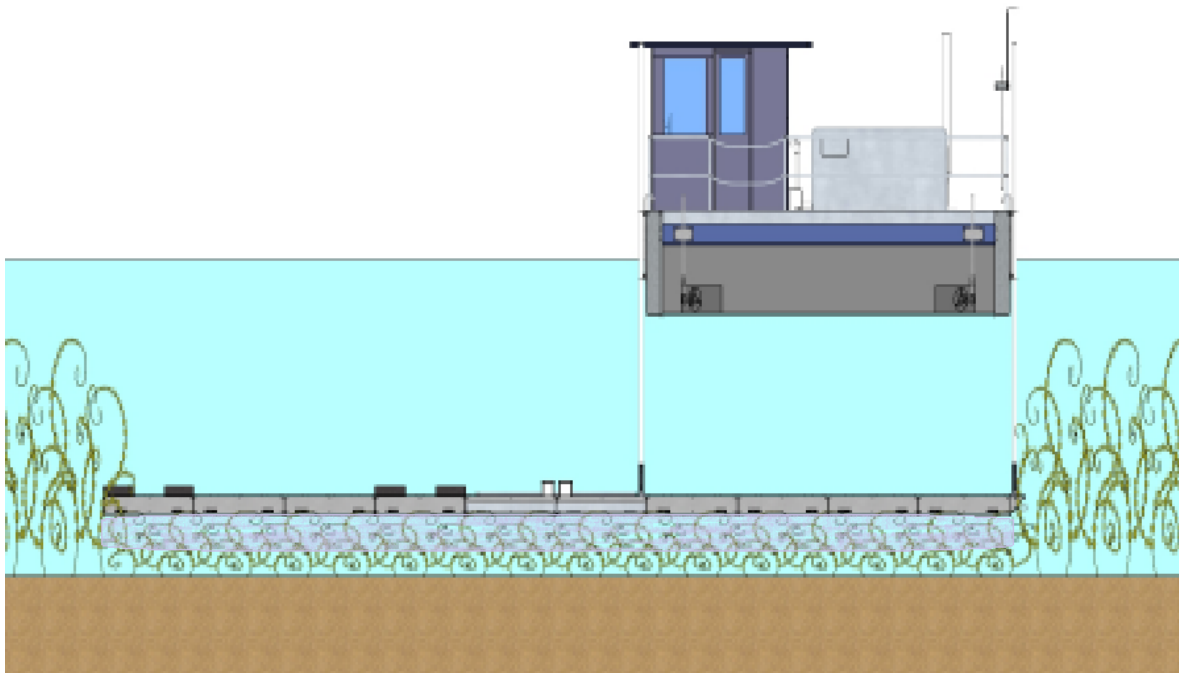
9'x16' hull
 8'x40' light array
 65kW generator
 (12) 36V thrusters
 2mph speed

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UVC Light Aquatic Invasive Plant Control Pilot Project 2022
 Tahoe Keys
 Boat Specifications



UVC Treatment vessel in the locked traveling position.



UVC Treatment vessel in the treatment position. The chamber can be lowered up to 15 feet, consolidating the aquatic plants.

Attachment C

**UVC Light Aquatic Invasive Plant Control Pilot Project 2022 Site 24 -Before UVC
Treatment versus After UVC Treatment**

Site 24

Non-Treated vs. Treated

Not treated with UV Light: 6-16-22

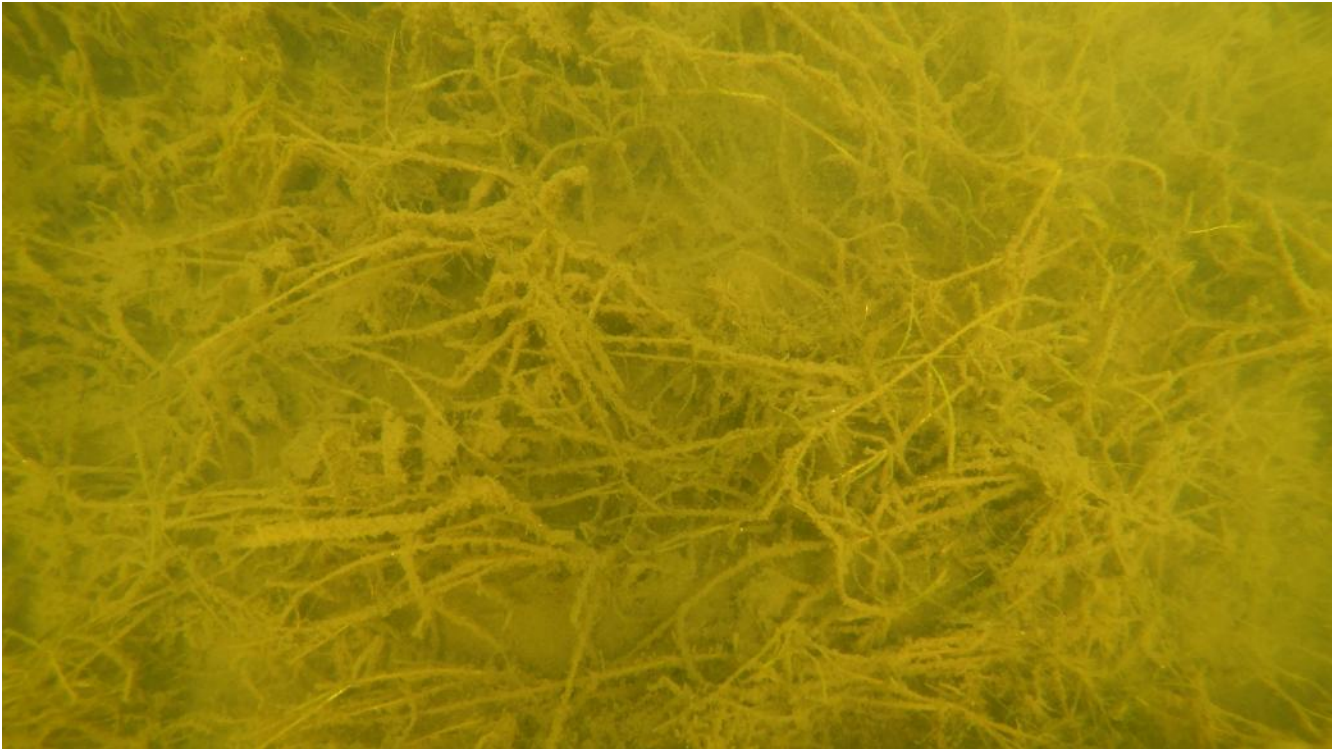


Green and healthy



Thick dense plant growth

Treated with UV Light - 14 Days After Treatment

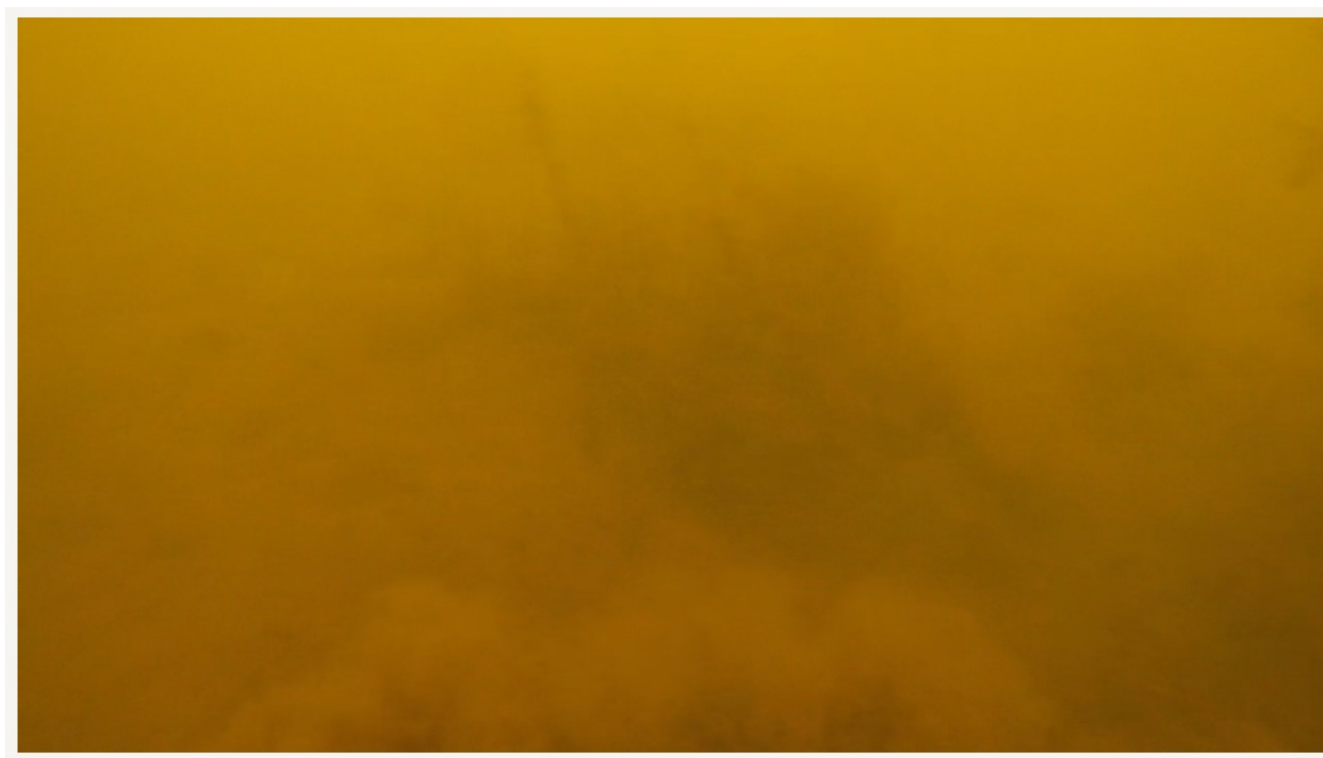


Plants have fallen and the decomposition has started



14 days after being treated with UV Light. Allow 2-4 weeks for plants to completely to dissolve

29 days after treatment



In the image above you can see a sediment cloud forming when the underwater camera was lowered. Most plants have decomposed. All images and videos are available upon request.

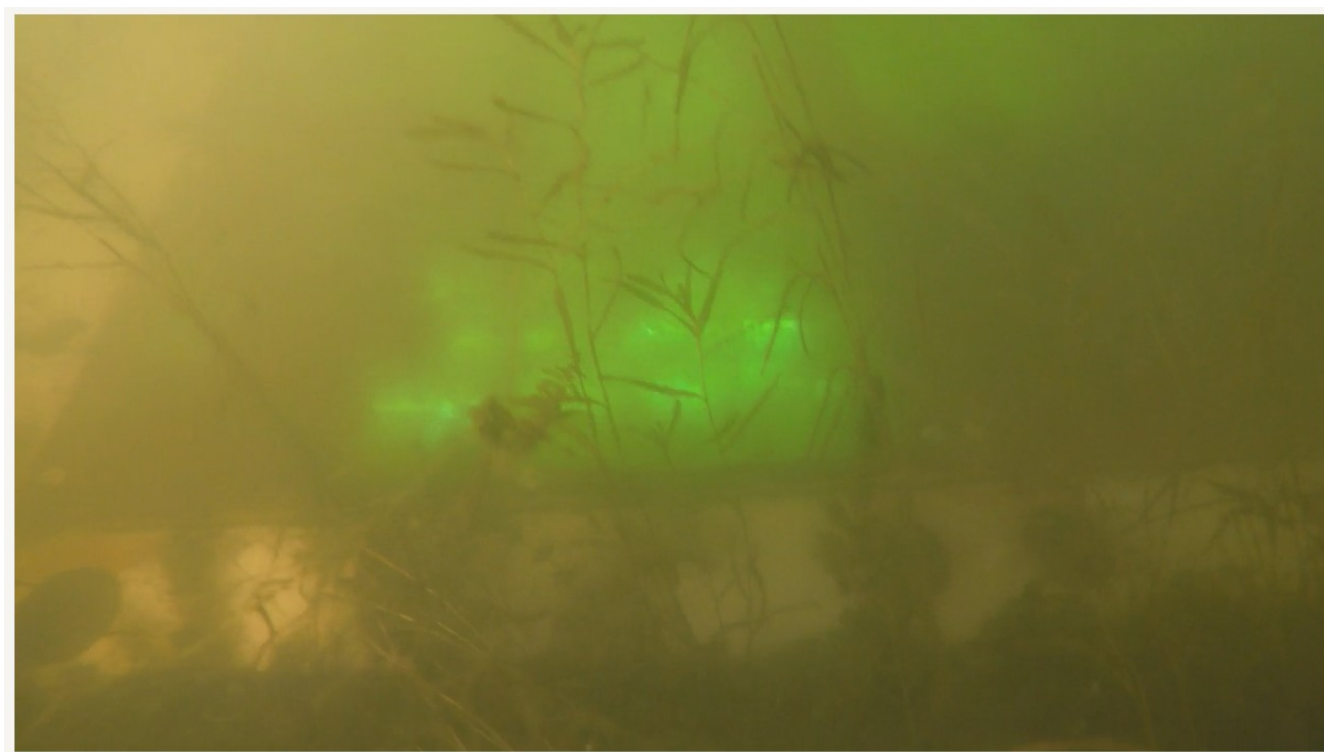


Image above is of the array treating plants.

Attachment D
UVC Light Aquatic Invasive Plant Control Pilot Project 2022
Various UV treatment vessel in operation

**UV Tahoe Treatment Project Photos
Tahoe Keys Areas
2022**

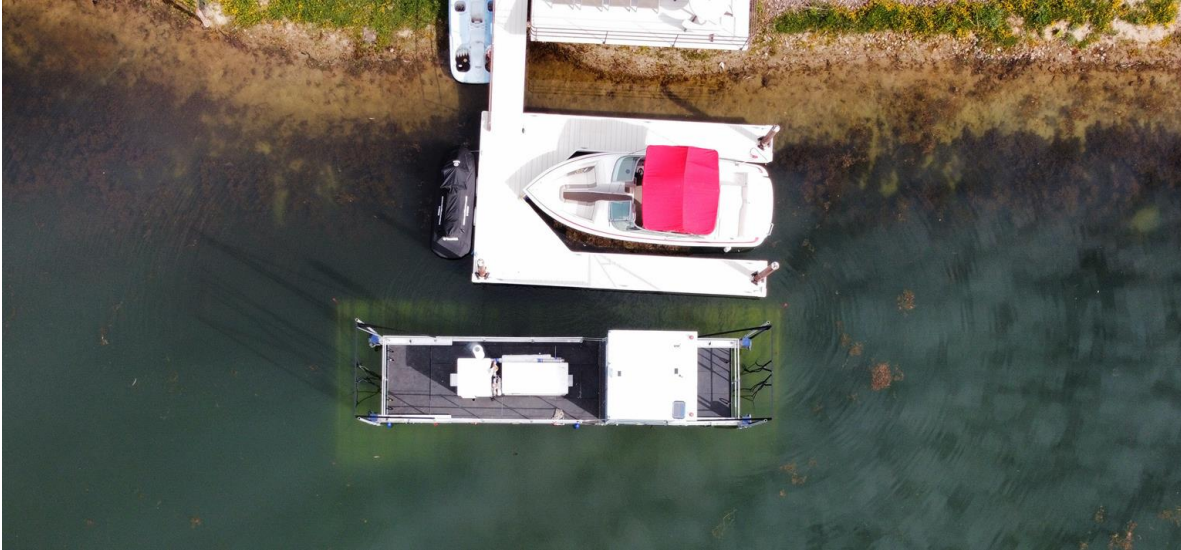


Image A – 16ft x 40ft treatment vessel treating from dock to dock.



Image B - 16ft x 40ft treatment vessel treating from dock to dock at Tahoe Keys.



Image C- Cantilever 8ft x 40ft treatment vessel treating nearshore.



Image D - Cantilever 8ft x 40ft treatment vessel treating nearshore.



Image E - UV treatment vessel during operational testing (UV lights on).

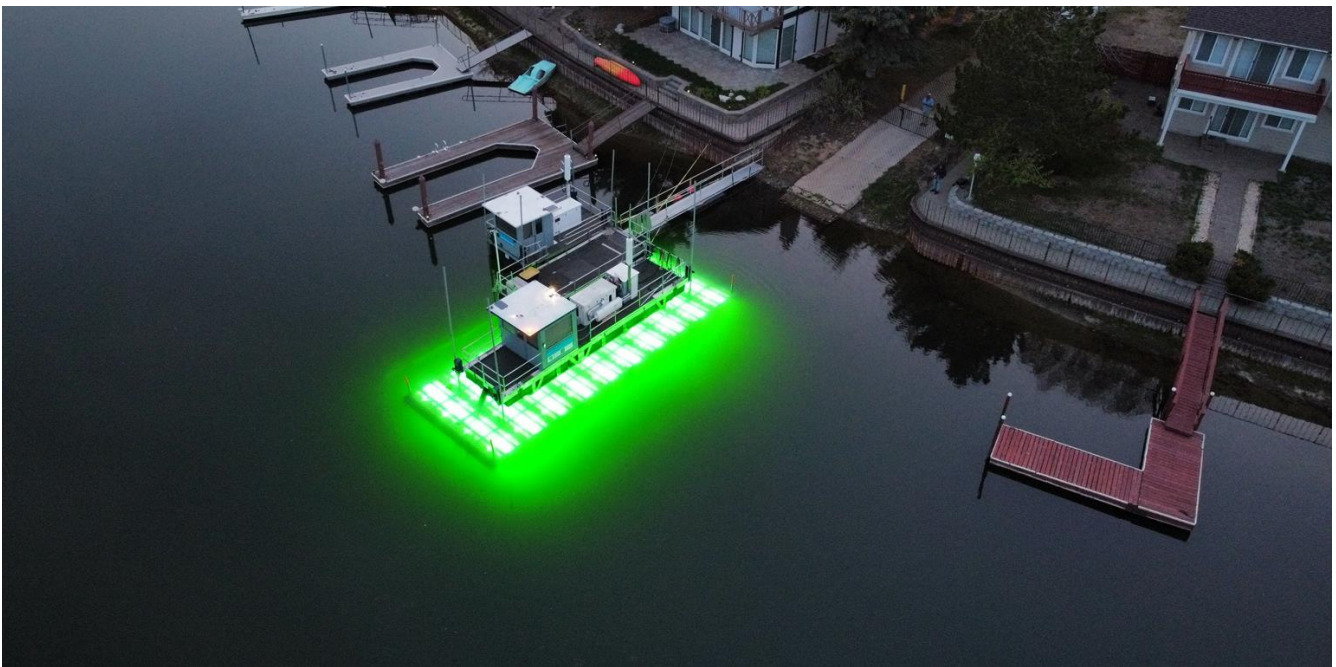


Image F- UV treatment vessel during operational testing (UV lights on).

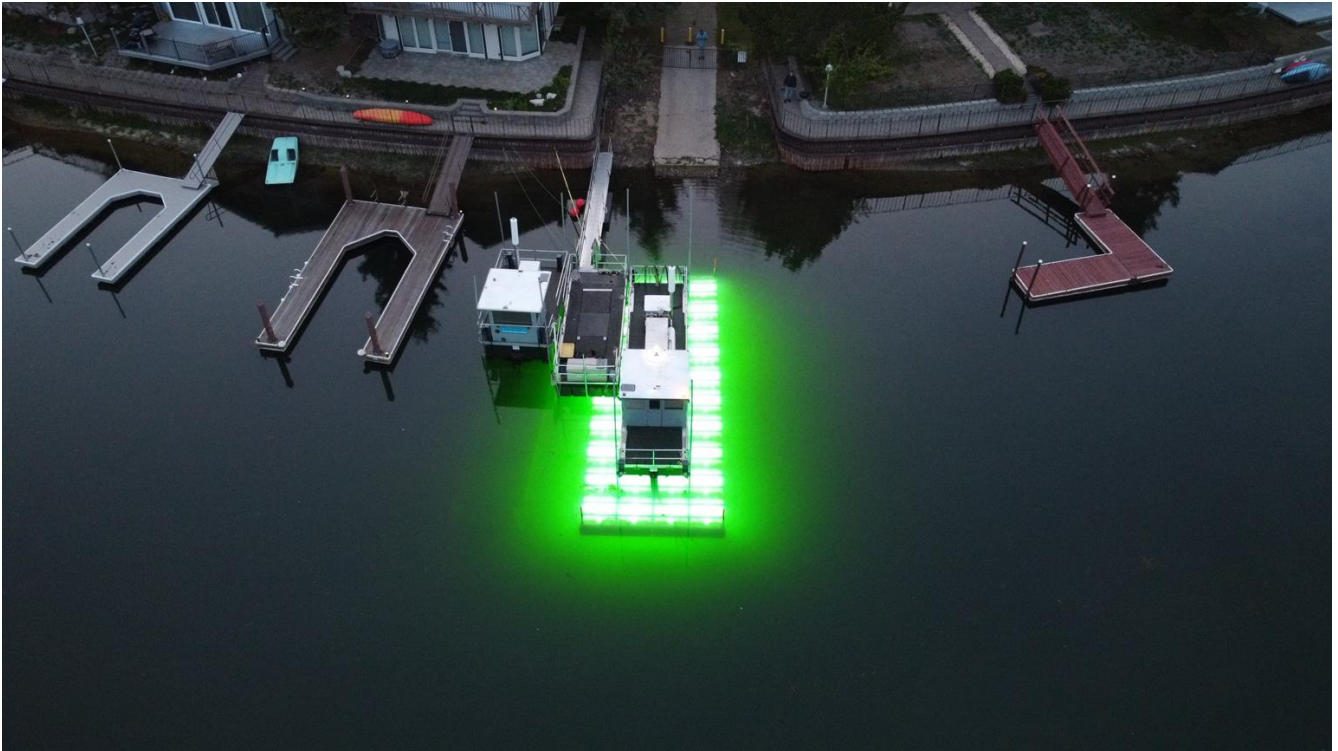


Image H- UV treatment vessel during operational testing (UV lights on).

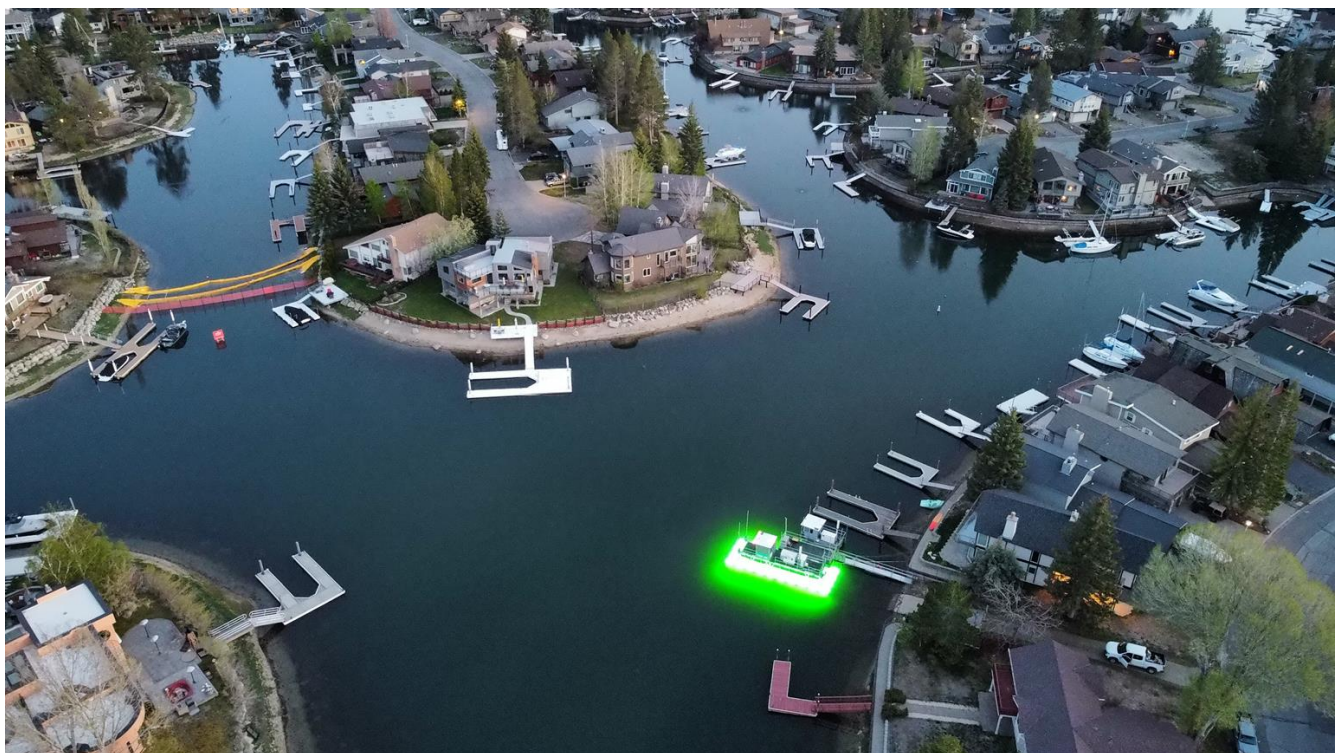


Image G - UV treatment vessel during operational testing (UV lights on).