2020 TKPOA West Channel Control Projects

End of Season Report

Tahoe Keys Property Owners Association

South Lake Tahoe, California

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Signature: _____

TAHOE KEYS INTEGRATED MANAGEMENT PLAN

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1.0 BACKGROUND

The Tahoe Keys Property Owners Association (TKPOA) has been working with leading experts on aquatic invasive species (AIS) from around the country to create an adaptive, integrated plan to significantly reduce the bio volume of the infestation in the Tahoe Keys. The TKPOA has been using every tool in the toolbox, measuring success, and adapting to new methods and changing results. In addition, the TKPOA is trying to get every property owner and visitor to do their part.

Vast numbers of the public still do not know that plant fragments, whether chopped up by propellers, pulled up by boat keels, or snagged on paddles, can take root and start new infestations elsewhere. Around Lake Tahoe, efforts have been made to educate all types of boaters about the AIS problem and how easily it is to transport these fragments. The Tahoe Keepers program is specifically geared towards non-motorized vessels such as kayaks and paddle boards, while the Boat Inspection program is geared more towards motorized vessels and sail boats. However, even with these programs in place, an abundance of fragments are transported out of waterways on propellers and keels.

During the 2016 boating season, the TKPOA introduced the Boat Back-Up Station in the West Channel to help combat the number of fragments that are transported into Lake Tahoe. The primary goals of the Boat Back-Up Station project are to educate homeowners and vacationers about AIS in the Tahoe Keys, including the potential impacts of transporting fragments out into the lake, and to reduce the number of fragments that come out of the Tahoe Keys Main Lagoon. During the 2018 boating season, TKPOA installed a Bubble Curtain in the West Channel to help reduce the number of fragments spreading out into Lake Tahoe. In 2019, TKPOA installed the first of two Seabins in the West Channel to further reduce the number of fragments spreading out into Lake Tahoe by halting the plants at the Bubble Curtain and collecting into the Seabin. In 2020, the TKPOA replaced the four faulty compressors that were in the original design of the bubble curtain. It was decided to implement a more reliable compressor that could support multiple projects. With this larger compressor, the TKPOA was able to implement a Laminar Flow Aeration (LFA) system along with the bubble curtain. These efforts have been supported and partially funded by the League to Save Lake Tahoe.

2.0 TKPOA WASTE DISCHARGE REQUIREMENTS (WDR)

2.1 Section 15: Non-Chemical Control of Aquatic Invasive Plant Species

Hand-pulling of invasive aquatic weeds is encouraged. If continued use of mechanical aquatic weed harvesting is proposed, then TKPOA must develop and implement Best Management Practice control measures to limit the spread of viable plant fragments. This Order requires submission and implementation of an Integrated Management Plan (IMP) to address aquatic invasive plant species management.

2.2 Section 18: Integrated Management Plan for Aquatic Invasive Weeds (IMP) Objectives

a. Eliminate the spreading of aquatic invasive species from the Tahoe Keys to greater Lake Tahoe.
b. Enhance overall water quality of the Keys Lagoons and Keys Marina, thereby improving Lake Tahoe water quality and associated clarity.
c. Reduce habitat for non-native fish and enhance habitat for native fish in the Keys Lagoons and Keys Marina.

d. Restore and maintain established beneficial recreational uses, including water contact safety, in the Keys Lagoons and commercial uses in the Keys Marina.
e. Implement a combination of cost-effective control measures that are feasible for long-term management of aquatic invasive plants.

2.3 The WDR states that the TKPOA is to inform and engage the homeowners through education and outreach by:

a. Developing educational brochures and press releases about the IMP.
b. Promoting best management practices for homeowners on reducing nutrient loading, preventing re-introduction of aquatic invasive weeds.
c. Informing the homeowners about TRPA's required best management practices for all properties
d. Promoting the boat inspection program.

3.0 PROJECT OBJECTIVES

The objective of the Bubble Curtain, Laminar Flow Aeration, bottom barrier and Seabin Project is to:

a. Create a barrier in the West Channel which would reduce the amount of plant fragments and debris from entering Lake Tahoe
b. Collect the diverted plant fragments and debris
c. Reduce available nutrients for plants in the channel
d. Prevent growth of plants around the bubble curtain line and in the West Channel
e. Integrate these methods. These technologies have only been used independently of each other in past projects.

As part of the TKPOA's efforts to meet Section 15, Objective i and Section 18, Objective i-v, the combination of these two technologies were deployed and monitored to assess effectiveness in reducing or preventing the spread of aquatic plant fragments to Lake Tahoe through the West Channel.

4.0 GENERAL CONCEPT OF THE BOAT BACK-UP STATION, BUBBLE CURTAIN, SEABIN PROJECT AND WC LAMINAR FLOW AERATION

4.1 Boat Back-Up Station

a. The general concept: As a watercraft moves into a designated area, they stop the vessel, reverse their propeller (this is to untangle and release any weeds caught in the propeller, keel or rudder) and then back up ten feet to dislodge any weed fragments. Once this is complete, the boater continues out to Lake Tahoe proper.
b. Design: When viewing the Back-Up Station from within the Tahoe Keys West Channel, it offers a resemblance to a roadway system for boaters to follow. The entire area has the same positioning as the buoys that are out on Lake Tahoe with the addition of the informational sign, the Boat Back-Up station Stop sign, the waterway rules, and a mooring buoy. The lanes are designated with green buoys on the east, red buoys on the west and white buoys in the middle that inform boaters of the 5-mph speed limit (refer to Figure 2). Beginning the Back-Up Station is a sign informing boaters to prepare to stop (Figure 3), this sign was installed in 2020 hoping to inform boaters why the BUS helps stop invasive weeds from entering Lake Tahoe. The new sign reads "TKPOA Boat Back-Up Station, Stop the Spread of Invasive Weeds, Prepare to Stop". Next, about halfway through the

channel, there is a red stop sign with the Back-Up Station Procedures visible (Figure 4). In addition, a sign was placed on the back for incoming boaters to read “Idle Speed Only”. After the Boat Back-Up stop sign, there is a double-sided TKPOA Waterway Rules sign (Figure 5) which covers all of the TKPOA Waterway Rules that are intended to keep everyone safe. These signs in the center of the lane create the division between the incoming and outgoing boat traffic. This provides adequate space for boaters to safely follow all requirements that the Boat Back-Up Station has in place.

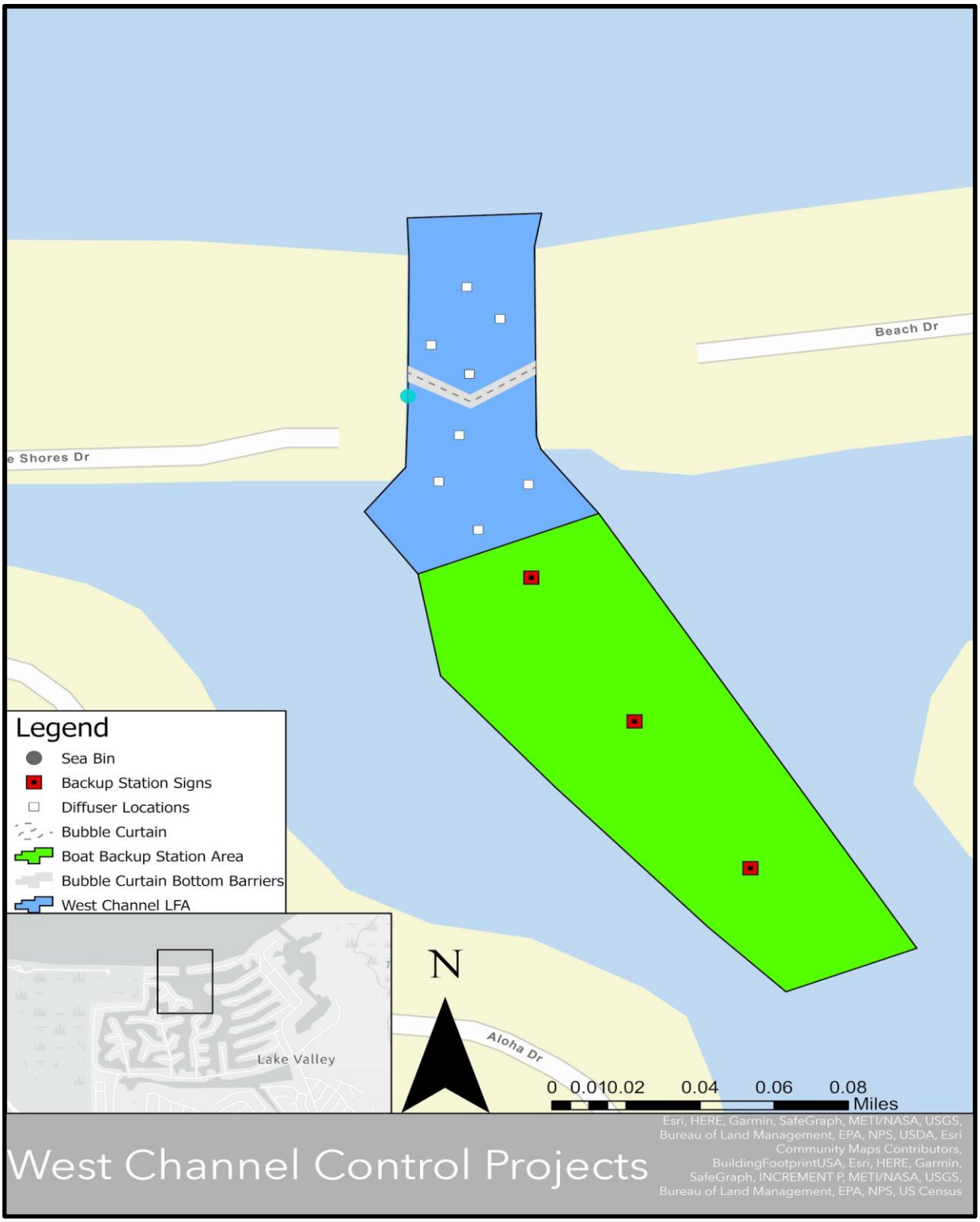

Figure 1: West Channel Control Projects Map

Figure 2: Overview of the Boat Back-Up Station oriented south facing north.

Figure 3: New "Prepare to Stop" pontoon buoy; no back text

Figure 4: "Reverse Prop" buoy and "Idle Speed Only" Back Text

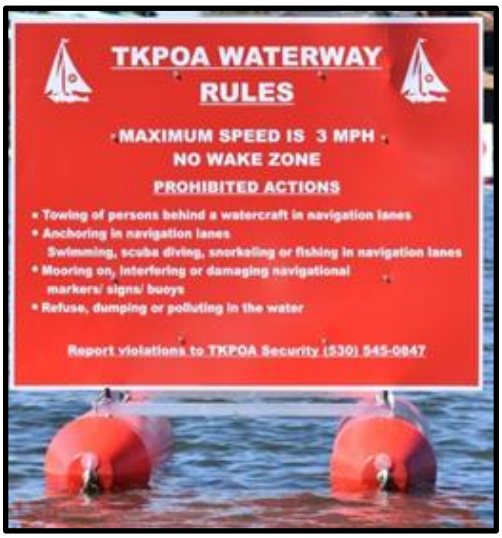

Figure 5: TKPOA Waterway Rules sign, center lane of the Back-Up Station.

4.2 Bubble Curtain

a. General Concept: In addition to the efforts of having a Boat Back-Up Station to release any weeds tangled or attached, during the 2018 season, a Bubble Curtain was installed at the West Channel. This device is to support the efforts of stopping the spread of aquatic invasive species (AIS) out into the lake. The Bubble Curtain, in combination with the Boat Back-Up Station, allows for the best chances to prevent AIS from escaping out into Lake Tahoe.
b. System Overview: The Bubble Curtain has two main components that create the air bubble barrier in the Tahoe Keys West Channel: the compressor and the tubing. The four compressors that were previously supplying air for the bubble curtain stopped working at the end of 2019. There is now one large compressor that supplies air for the bubble curtain

and the LFA diffusers. TKPOA purchased a 12.7 horsepower, 3 phase compressor with an output of 79 cubic feet per minute (cfm). This compressor pushes air through 170 feet of self-sinking airline tubes. As the bubbles push through the water, it creates a "curtain"that extends from the sediment layer to the surface (Canadian Pond) (refer to Figure 6 and 7)

Figure 6: An underwater view of the Bubble Curtain.

Figure 7: A surface view of the Bubble Curtain.

c. Design: The Bubble Curtain is set up in a "V"-shape formation that acts as a wall to stop fragments of aquatic invasive species from entering Lake Tahoe (refer to figure 9). The purpose for this design was to create three collection points for plant fragments and garbage to collect. The positioning of these collection points were based on the hydrology of Lake Tahoe and the Tahoe Keys along the prevailing winds on the Lake Tahoe Watershed. These collection points are at either side of the channel next to the bulkhead and in the direct center of the "V". As snowmelt run-off increases the level of Lake Tahoe, water levels rise inside of the Tahoe Keys as well. As the water flows into the Tahoe Keys, the collection point is in the center of the "V" on the lake proper side. When the water level is moving out of the Tahoe Keys or when the prevailing wind is from the south, the collection points are on either side of the channel. All three of these collection points were created to avoid hindering the flow of recreational boating. In 2020 three bottom barriers were placed beneath the Bubble Curtain to help disrupt the growth of aquatic plants around the tubing (refer to figure 8).

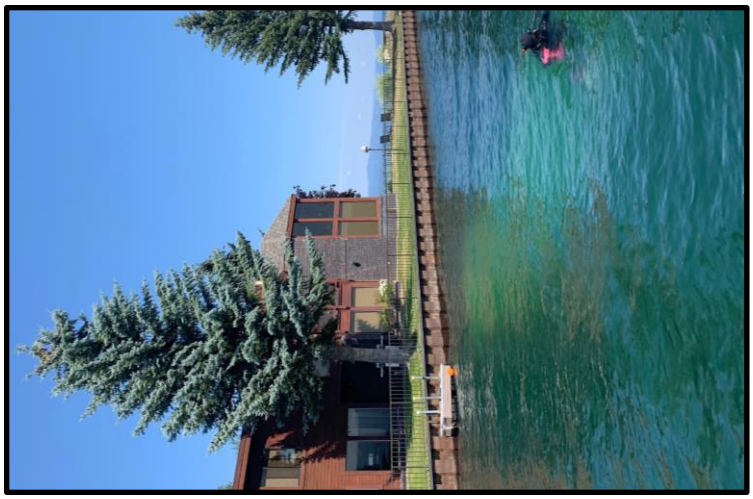

Figure 8: Installation of Bottom Barrier under the Bubble Curtain with new Seabin dock

Figure 9: An aerial view of the Bubble Curtain.

4.3 Seabin

a. General Concept: Seabins are a "trash skimmer" designed to be installed in the waters of marinas, yacht clubs, ports and any water body with a calm environment and suitable services available. The unit acts as a floating garbage bin, skimming the water surface by pumping water into the device and intercepting floating debris (refer to Figure 10).
b. System Overview*:* The seabin requires 110v, 2.5 amps, and 500 watts of power with a maximum flow of 25,000 Liters Per Hour.
c. Design: The Seabin was placed on a new dock in 2020 that is attached to the West Channel. It was strategically placed at this location to work in companion with the Bubble Curtain's design and placement. The Seabin was placed approximately ten feet from the edge of the Bubble Curtain line where plant fragments and debris frequently accumulate (refer to Figure 11). Both the Seabin and the Bubble Curtain run for 24 hours a day and seven days a week.

Figure 10: Seabin.

Figure 11: New Seabin Dock.

4.4 West Channel Laminar Flow Aeration

a. General Concept: The Laminar Flow Aeration (LFA) is a technology used for improving water quality where there is consistently low dissolved oxygen and a buildup of fine organic sediment. LFA uses microporous ceramic disks, called diffusers, that are placed throughout the area needing oxygen. These disks are connected by self-sinking hoses connected to an air compressor. Air is pumped through the system, creating an abundance of bubbles that rise and create laminar flow, and provide oxygenation to the bottom of the water column where dissolved oxygen is typically the lowest. Increasing dissolved oxygen in the sediment layer triggers a reaction that turns ammonia into nitrite and then nitrate. This process is believed to be in part responsible for the reduction in the organic matter seen in other LFA studies.
b. System Overview: The Laminar Flow Aeration system placed in the West Channel has 8 diffusers (4 of these are placed North of the bubble curtain towards Lake Tahoe and 4 are South of the bubble curtain in the main lagoon) (See Figure 12). Refer compressor specs to section 4.2 b.
c. Design: On August 12, 2020 the WC LFA was installed in the channel connecting the Tahoe Keys to Lake Tahoe in accordance with Clean- Flo International. This was conducted using a GPS of the LFA locations and then lowering the ceramic disks into the water with a rope. It was decided to place the LFA in a diamond formation, this allowed it to cover a larger surface area within the confines of the West Channel. (Refer to Figures 1, 12 and 14)

Figure 12: West Channel LFA layout with Bubble Curtain

5.0 2019 RECOMMENDATIONS IMPLEMENTED DURING 2020 SEASON

In an effort to further improve the Boat Back-Up Station the TKPOA proposed the following actions:

a. Seabin Dock

In 2019 it was suggested that the way the Seabin was mounted should be changed. The old design was mounted onto the bulkhead. Due to the fixed positioning of the mounting point, when the Tahoe Keys experienced a low water year the Seabin was above the waterline, rendering it useless. In 2020 the TKPOA attempted to install 2 docks that were designed to protect the Sea Bin from waves coming from the Lake. A diver spent several hours attempting to move the large rocks on the East and West side of the channel to install the seabins. Due to the size and positioning of the rocks, the diver was only successful in creating space for the dock pylons on the West side of the channel. Therefore, in 2020, the dock was only installed on the West side.

b. Bottom Barriers for Bubble Curtain

In the 2019 report it was also suggested that bottom barriers be placed under the air hose again to reduce the amount of interference for the bubble curtain. During the 2020 season, divers were hired to place three 10x25 bottom barriers beneath the bubble curtain. These bottom barriers are superior to the ones previously used due to the higher quality. They require less maintenance and stay in position much better. It was also recommended that mid-season underwater maintenance is conducted to reduce the amount of regrowth along the air hose. While the diver was installing the bottom barrier, they also cleaned off the air hose. WIth the use of a scrubbing brush, the diver went along the length of the hose and cleaned off all the growth that had accumulated. This allowed the bubble curtain to produce a stronger flow which stopped more weed fragments from escaping into Lake Tahoe.

c. Outreach within the Lake Tahoe Basin

It has been recommended in the past few years to improve public outreach to inform homeowners and the public with the ongoings at TKPOA. This year we have made numerous changes to ensure this is implemented. In 2020, articles, emails, pamphlets, flyers and social media were utilized to increase public outreach. Information regarding our projects and program plans were sent to homeowners in the Keys Breeze Article as well as email blasts. Flyers were sent out monthly to inform the homeowners about the tasks and projects completed as well as monthly results. In 2020, the Water Quality AIS

team also created an Instagram account. This is a modern way to give the homeowners live updates and information regarding the program.

d. Bubble Curtain Compressor

In 2019, it was recommended to replace the compressor used for the bubble curtain. This year a new compressor was installed for the West Channel bubble curtain and LFA diffusers. Previously, four smaller compressors were used for the Bubble Curtain. These did not have enough power to keep the Bubble Curtain and the LFA Diffusers working to their full potential. At times, the compressors overheated which shut the system down for a period of time. Also, the lake's wave action created by wind events, and wakes caused by high boating activity, hindered the effectiveness of the system. This past summer, a new larger compressor was installed. This compressor has more horsepower to push more air through the system, making it more effective and efficient.

e. New Back-Up Station Sign

In 2020, a new sign was placed in the Back-Up Station to provide more information to boaters. Previously, there was no sign explaining why boaters needed to back up their propeller before entering Lake Tahoe. Many people have asked the Water Quality staff the purpose behind the procedure. Believing it would provide more clarity, as well improve the back-up rate, the Water Quality staff implemented a new sign. This sign was placed in the front of the Back-Up Station and read "Stop The Spread of Invasive Weeds, Prepare to Stop" (pictured above). This sign helped boaters understand the importance of backing up their propeller.

6.0 2020 WEST CHANNEL LFA WATER QUALITY AND SEDIMENT DATA COLLECTION

The West Channel LFA Project was implemented in August of 2020 as a way to reduce the organic matter buildup. This project aligns with the TKPOA WDR and the second and third objectives of the IMP which states "Enhance overall water quality of the Keys Lagoons and Keys Marina, thereby improving Lake Tahoe water quality and associated clarity". And to "Reduce habitat for non-native fish and enhance habitat for native fish in the Keys Lagoons and Keys Marina.". The TKPOA WQ Staff conducted sediment and nutrient sampling twice during the 2020 season at dedicated sites (Figure 13) for the West Channel LFA system. One sampling was conducted prior to activating the system (8/10/2020) and another was conducted at the end of the sampling season (11/11/2020).

6.1 Sampling Overview

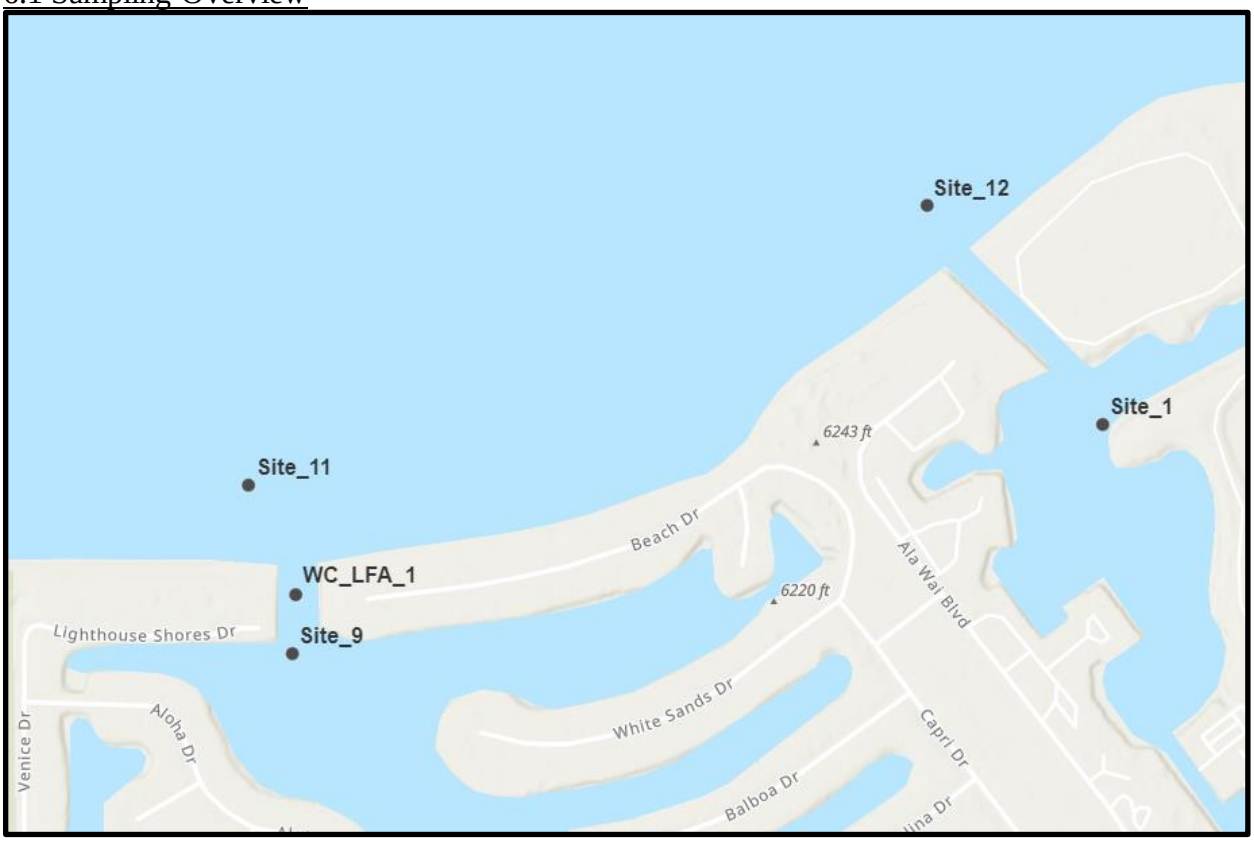

Figure 13: West Channel LFA Sampling Sites

The TKPOA selected these sites based on their proximity to the project area. Sites 1 and 12 were selected as control sites. Site 12 has similar conditions to site 11, as they are both in Lake Tahoe and site 1 has similar conditions to site 9 since they are both just inside the East and West Channels. The site WC_LFA_1 was created because it is in the middle of the project area.

6.2 Methods

Water samples were collected by TKPOA Water Quality staff. Sampling is further discussed in the following sections. Sediment level reduction is monitored and evaluated by TKPOA Water Quality staff. Evaluations are conducted using Lowrance hydroacoustic scanners in companion with the BioBase analysis software. The scanners use sonar technology to measure underwater topography. Sediment organic matter reduction is monitored twice a year by sediment sampling at the 5 sampling sites.

6.2.1 System Layout

Clean-Flo International was granted the contract to design the West Channel LFA system for the Tahoe Keys, strategically placing eight diffusers in the locations shown below in Figure 14. The same company designed and implemented the original LFA system near Emerald Dr.

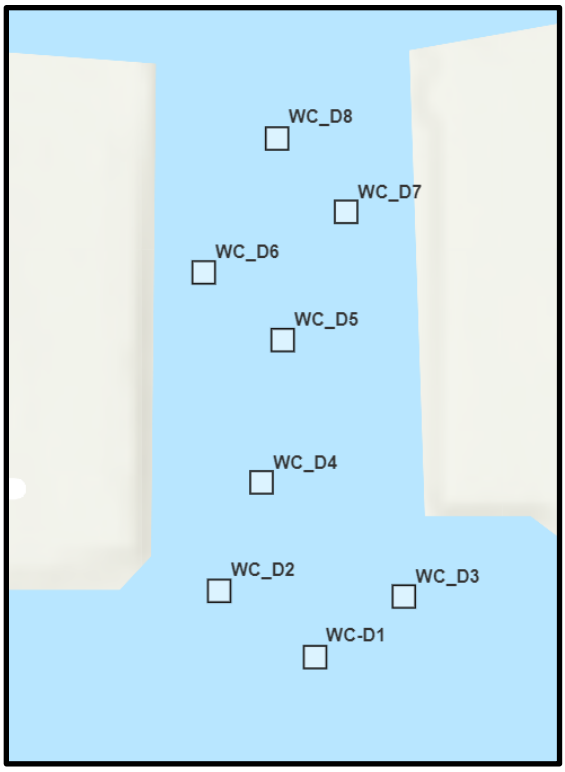

Figure 14: West Channel Diffuser map with diffuser numbers

This system was specifically designed for the project area's size and water depth. It consists of a 12.7 horsepower compressor, variable frequency drive, eight microporous ceramic diffusers (refer to Figure 14), stainless manifold with equal number of ports and control valves, and approximately 170 feet of self-sinking airline.

Figure 15: Diffuser.

6.2.2 Monitoring

Bimonthly monitoring for the project for water quality was conducted from August 10th to November 11th, 2020 according to the monitoring schedule.

a. Equipment

Water Quality data was collected using the YSI ProDSS, a multiparameter water quality instrument. The TKPOA also uses an HDS 7 Lowrance system with sonar transducer for hydroacoustic scans. Initial muck levels were assessed by using a telescoping pole with a plate mounted to the end. The pole has marks every decimeter to indicate depth. Sediment samples were taken with a Van Veen grab sampler.

b. Calibration

The TKPOA Water Quality staff calibrated the ProDSS and Pro1020 monthly and no later than one day prior to each scheduled sampling event. Both meters were calibrated according to the manufacturer's instructions. On the day of sampling, DO was calibrated for more accurate readings, a method suggested by the manufacturer. The Pro1020 and ProDSS calibration information was logged on a calibration worksheet and then archived with the sampling data sheets for that event.

c. Parameters

The monitored parameters for this project consisted of atmospheric and physical attributes such as:

i. Time Start / End
ii. Air Temp Start / End
iii. Cloud Cover Start / End
iv.Last Precipitation
v. Wind Speed Start / End
vi. Wind Direction Start / End
vii. General Comments

d. Water Quality

Parameters measured at each of the designated sites for water quality are shown in the following table:

Parameter	Method of Measurement	Description
Time of Day	Watch	Time of sampling at each site
Depth	YSI ProDSS or Water Sounder	Depth in meters of water at each site. Used to determine the 5 sampling points in the water column.
Temperature	YSI ProDSS and YSI Pro1020	Measure of acidity or alkalinity of water, with pH 7 being neutral. Surface, mid-point, and bottom were collected during the season to monitor effects of plant biomass on overall pH.
Specific Conductance	YSI ProDSS	Measure in micro Siemens per centimeter (µS/cm) of dissolved ionic particles in the water. Acts as a good indicator of Total Dissolved Solids.
Dissolved Oxygen	YSI ProDSS and YSI Pro1020	Amount (in parts per million) of oxygen present in water. An important parameter in water quality assessment due to its influence on aquatic organisms. (Fondriest Environmental Inc. 2016).
pH	YSI ProDSS	Measure of acidity or alkalinity of water, with pH 7 being

		neutral. Surface, mid-point, and bottom were collected during the season to monitor effects of plant biomass on overall pH.
Phycocyanin (PC)	YSI ProDSS	A measure of Phycocyanin in the water column. Phytocyanin is a blue-copper containing pigment found in harmful algae.
Chlorophyll (Chl-a)	YSI ProDSS	Chlorophyll content in the water column.
Oxidation Reduction Potential	YSI ProDSS and YSI Pro1020	Oxidation Reduction Potential (ORP) recorded in millivolts. This is a key component in water quality to determine the health of an ecosystem.
Turbidity (FNU)	YSI ProDSS	Measurement of water clarity using Formazin Nephelometric Units

Table 1: Water Quality parameters.

e. Hydroacoustic Scans

Muck levels were monitored bi-monthly using Lowrance hydroacoustic scanners in companion with the BioBase analysis software. Once completed, scans were immediately uploaded to the BioBase system and then reviewed by BioBase analysts. TKPOA Water Quality staff analyzed scan results next to lake level data for more accurate measurements. Lake level data was retrieved from the USGS database.

6.2.3 Sampling Procedures

During the 2020 season, staff collected samples for sediment, nutrients to comply with the project permits.

a. Sampling Checklist
   i. Check the weather forecast for sampling day to determine if conditions are appropriate for sampling to occur.
   ii. Verify sampling materials delivery.
   iii. Verify, if applicable, that the selected analytical lab is scheduled to pick up samples the day after they are to be collected, as hold times on parameters (such as nutrients) require quick processing.
   iv. Calibration of the YSI ProDSS and YSI Pro1020 should occur monthly and take place no later than a day prior to the scheduled sampling event. Sampling should not occur if calibration is not completed. Calibrate according to the manufacturer's instructions.

b. Water Quality Sampling Procedure
   i. Review the Sampling Checklist.
   ii. Verify that all required sampling equipment is gathered.
   iii. Once on the boat with all necessary materials, the Sample Collector will begin to complete the data sheet, indicating Date, Sample Collector, Boat Driver, Start time, Air Temperature, Cloud Coverage, Last Precipitation, Wind Speed, and Wind Direction.

After i-iii were documented the following were collected at five separate depths with the YSI ProDSS:

iv. Depth (m), Water Temperature (℃), pH, Dissolved Oxygen, Oxidation-Reduction Potential (ORP), Algae Content, Ammonium.
v. Turbidity (FNU) and Electric Conductivity (uS/cm) are collected at each site midpoint.
vi. Observations (i.e. the presence of algae, odor, fish, insects, or amphibians in a sample site etc.) are recorded at each site, if applicable.
vii. Check that the blue calibration cup is not covering the YSI sensors. If so, remove the calibration cup. Do not pour out the water in the calibration cup.
viii. Lower the instrument to the desired depth in the water column, according to the data sheet (Bottom, Q1, Mid, Q3, Surface).
ix. Allow adequate time to ensure the YSI data balances before recording information onto the data sheet.
x. Complete for each column of each category on the data sheet.
xi. Verify that all required data has been collected before moving on to the next site

c. Sample Grabs: The following information shall be recorded on each sample bottle at the time of sampling:
   i. Sample ID Number (for contract laboratories)
   ii. Sampling Date and Time
   iii. Site Name/ Station Code
   iv. Preservative (optional depending on sampling)
   v. Collector's Initials

d. Surface Grabs: The Sample Collector should be wearing arm-length, disposable, powder-free gloves when handling the sample containers to prevent contamination of the sample.
   i. Holding the correct sample bottle, lower into the water column until the water reaches two inches below the top of the Collector's elbow-length glove.
   ii. Triple rinse the collection bottles before collecting the actual sample, filling roughly three-quarters of the bottle.
   iii. Secure sample bottle cap and place in iced cooler for preservation.

e. Sediment Samples
   i. Triple rinse sample bucket, VanVeen sediment sampler and sample jar.
   ii. Set the Van Veen sampler and lower it to the bottom
   iii. Lift the sampler and empty content into sample bucket
   iv. Scoop contents into sample jar with gloved hand.
   v. Place the sample jar into an iced cooler for preservation.

6.2.4 Laboratory Analysis

Laboratory analysis for the water quality and sediment samples were collected to assess ambient water quality conditions in the Tahoe Keys lagoons. The following laboratory analysis results include:

a. Nutrients
   i. Orthophosphorus – Dissolved inorganic phosphorus that is readily available for aquatic plants and algae.

ii. Total Phosphorus – Amount of all forms, dissolved and particulate, of phosphorus present in the sample.
iii. Nitrate-Nitrogen – Amount of nitrogen bound to a nitrate ion present in the sample.
iv. Nitrite-Nitrogen –Amount of nitrogen bound to a nitrite ion present in the sample.
v. Total Kjeldahl Nitrogen – Measure of ammonia and organic forms of nitrogen.
vi. Total Nitrogen – Sum of all forms of nitrogen, including Nitrate-Nitrogen, Nitrite-Nitrogen, and TKN.

b. Sediments
i. Aluminum - Amount of aluminum in the sediment sample.
ii. Phosphorus - Amount of all forms, dissolved and particulate, of phosphorus present in the sample.
iii. Orthophosphorus - Dissolved inorganic phosphorus that is readily available for aquatic plants and algae.
iv. Organic Matter - Total organic material present in the sample.
v. Ammonia - Measure of Nitrogen in the form of NH4
vi. Total Solids - Measures percent of total solids in the sample
vii. Nitrate Nitrogen – Amount of nitrogen bound to a nitrate ion present in the sample.
viii. Nitrite Nitrogen –Amount of nitrogen bound to a nitrite ion present in the sample.

The separate laboratory coolers were prepared once sampling was completed. Nutrient and sediment samples were picked up by WetLab Environmental Testing Laboratory in Sparks, Nevada.

6.3 Water Quality Sampling Results

The figures below display the data that was collected to monitor the West Channel LFA project. This data was collected to comply with WDR permit and ensure water quality remained within the parameters stated in the Lake Tahoe Basin Plan (Basin Plan, 2020).

a. Turbidity

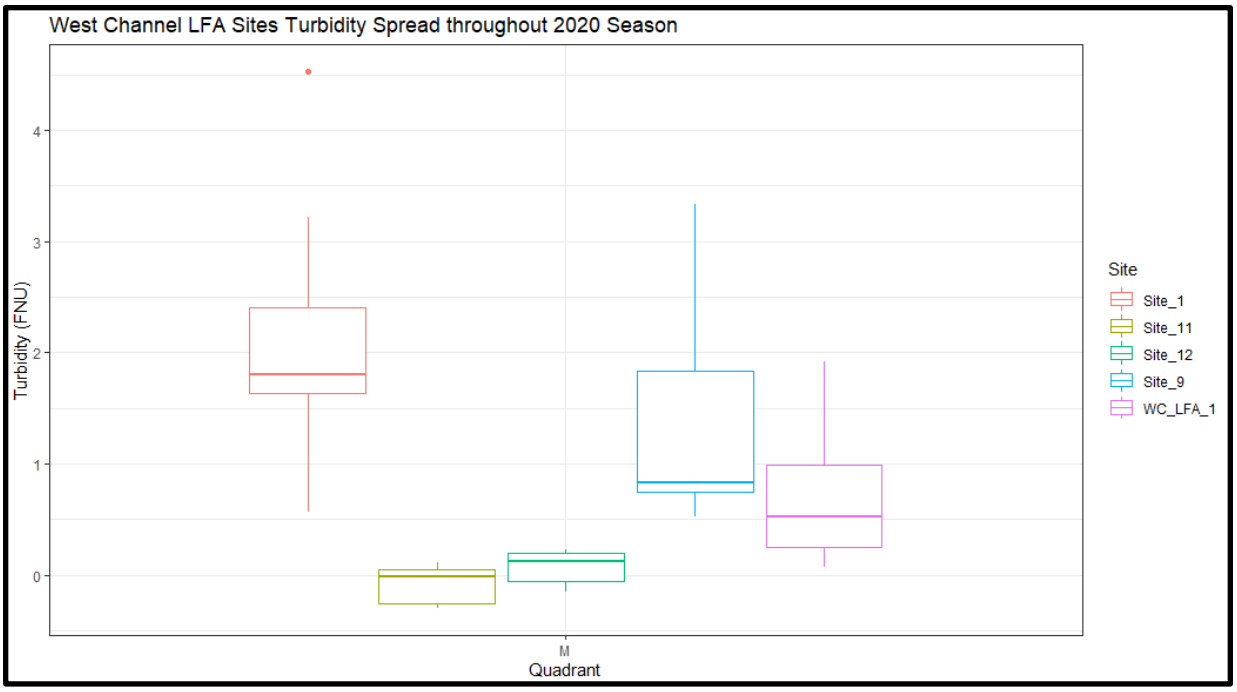

Figure 16: Turbidity Boxplot for West Channel LFA Sites

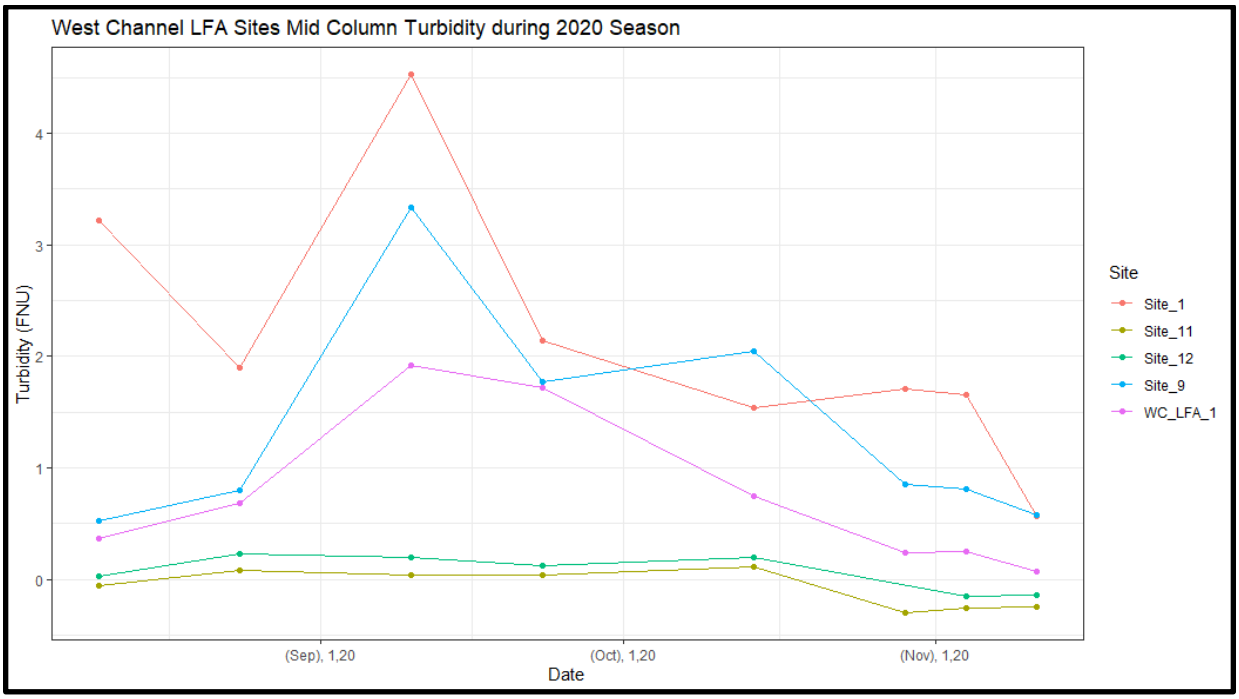

Figure 17: Turbidity readings from 8/10/2020 to 11/11/2020

Figures 16 and 17 show Turbidity readings in FNU from the YSI ProDSS Turbidity sensor. Turbidity at the Lake Tahoe sites (sites 11 and 12) was lower than the sites within the east and west channels. Figure 17 shows a spike in PC during the beginning of September at the control Site 1, WC_LFA_1 and Site 9.

b. <u>Dissolved Oxygen</u>

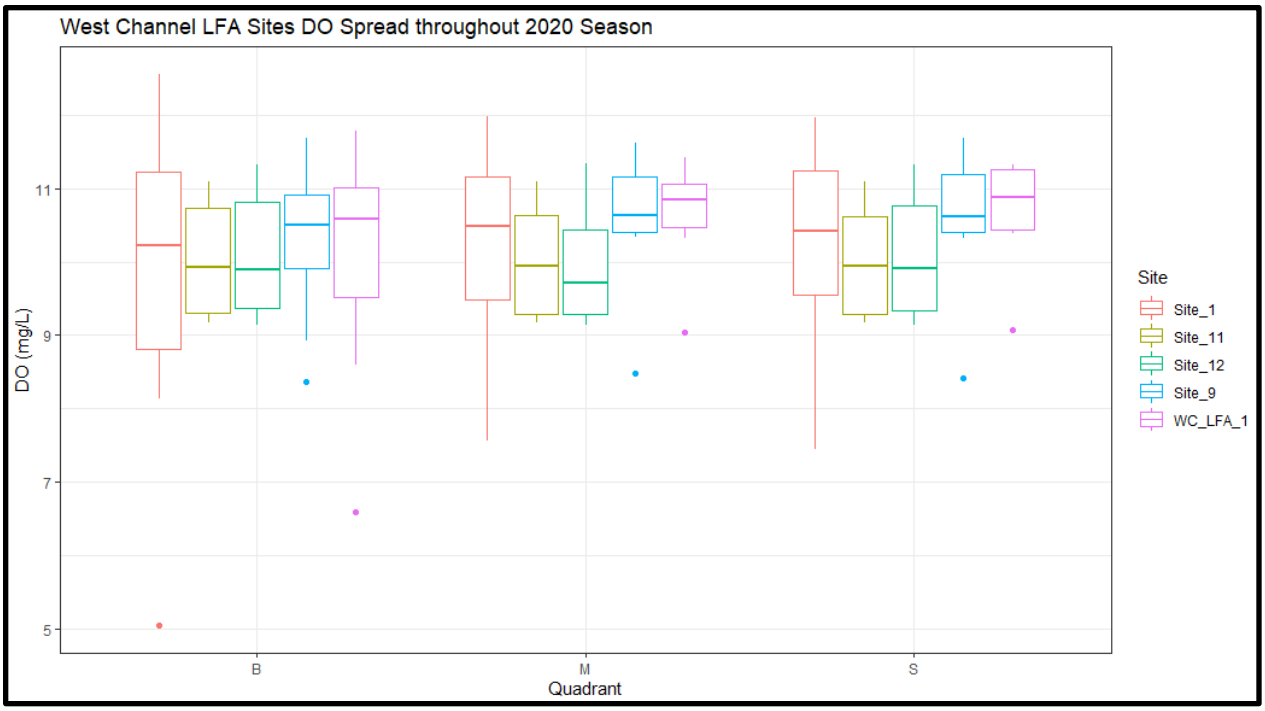

Figure 18: West Channel Sites DO Boxplot for data 8/10/2020-11/11/2020

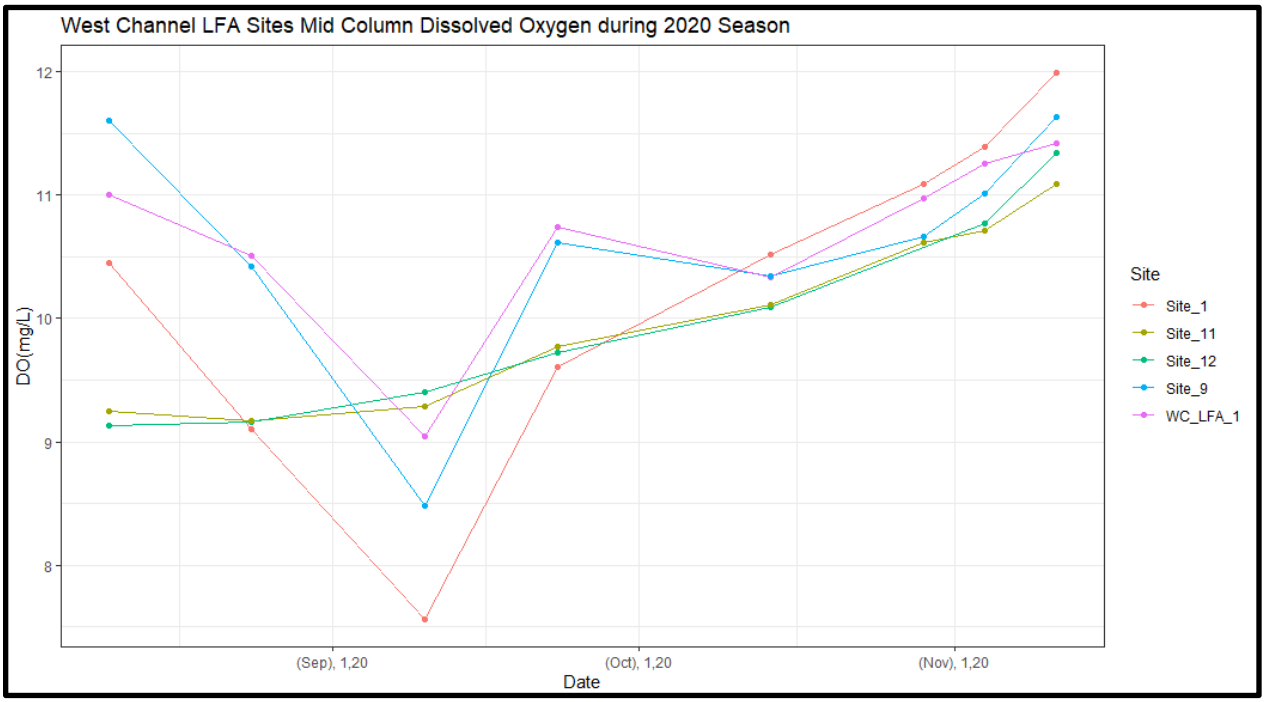

Figure 19: Mid Column Dissolved Oxygen 8/10/2020-11/11/2020

Figures 18 and 19 show the DO readings from the YSI ProDSS Dissolved Oxygen Sensor. Figure 19 shows how DO was constant in Lake Tahoe. DO rose at all sites as the water temperature decreased later in the season.

c. Phycocyanin

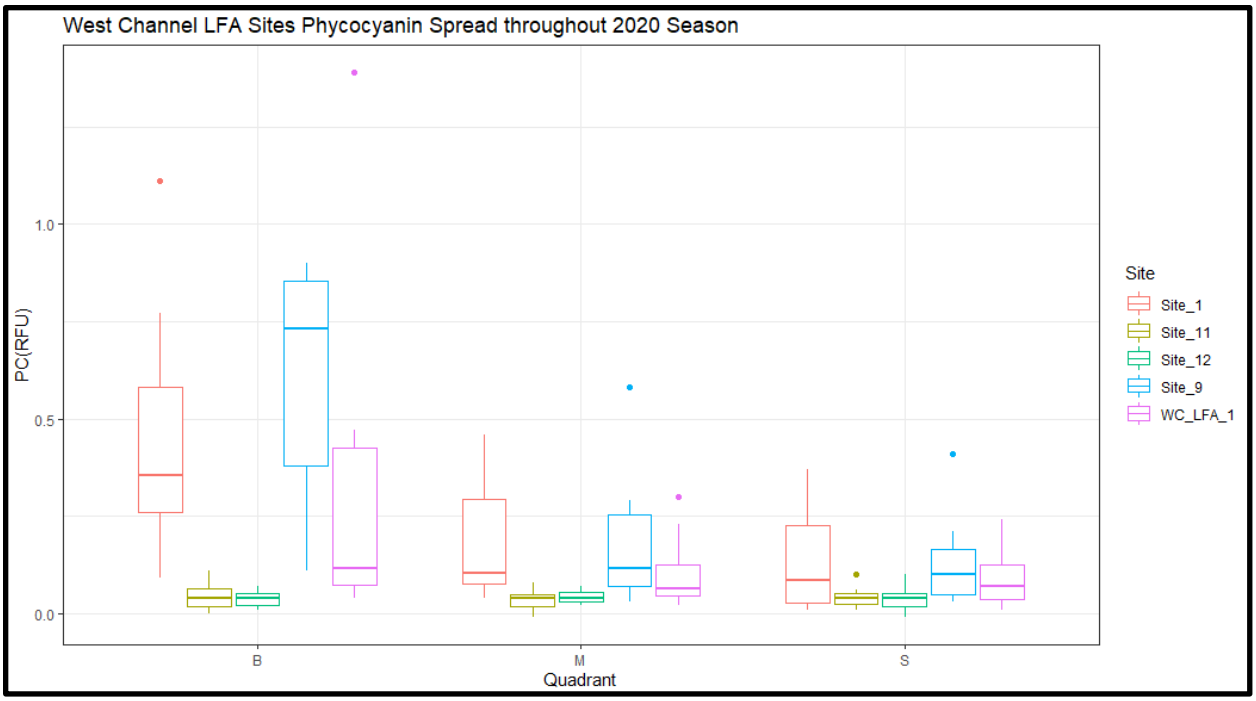

Figure 20: Phycocyanin Boxplot 8/10/2020-11/11/2020

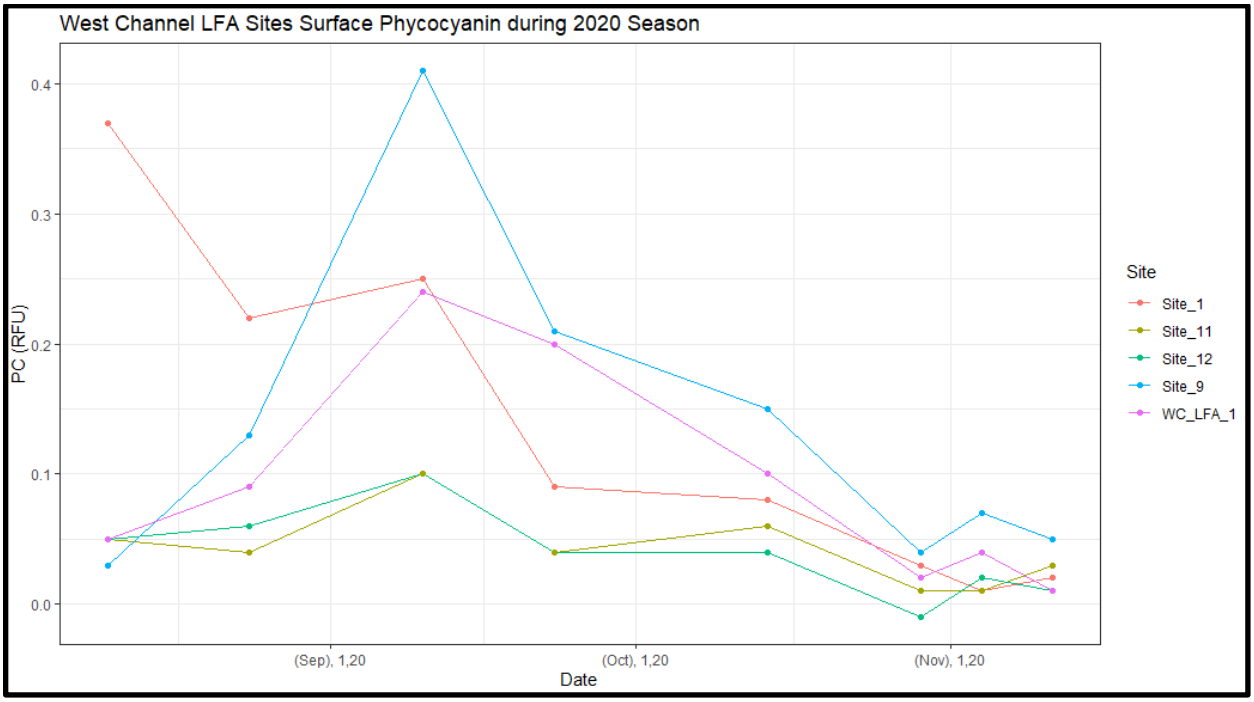

Figure 21: Surface Phycocyanin Readings 8/10/2020-11/11/2020

Figures 20 and 21 show phycocyanin (PC) readings from the YSI ProDSS chlorophyll/PC sensor. Figure 20 shows low to no PC at the sites within Lake Tahoe, slightly higher PC at WC_LFA_1 and the highest at the site 1 and site 9 just within the east and west channels.

6.4 Nutrient and Sediment Sampling Results

6.4.1 Nutrient Sampling Results

Date	Quadrant	Site #	Orthophosphate (mg/L)	Ammonia (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Nitrate Nitgroen (mg/L)	te Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)
8/10/2020	M	Site_1	ND	ND	0.36	ND	ND	ND	0.35
8/10/2020	M	Site_12	ND	ND	ND	ND	ND	ND	ND
8/10/2020	M	Site_9	ND	ND	ND	ND	ND	ND	ND
8/10/2020	M	Site_11	ND	ND	ND	ND	ND	ND	ND
8/10/2020	M	LFA_1	ND	ND	ND	ND	ND	ND	ND
11/11/2020	M	Site_1	ND	ND	0.27	ND	ND	ND	0.26
11/11/2020	M	Site_12	ND	ND	ND	ND	ND	ND	ND
11/11/2020	M	Site_9	ND	ND	0.29	0.024	ND	ND	0.29
11/11/2020	M	Site_11	ND	ND	ND	ND	ND	ND	ND
11/11/2020	M	LFA_1	ND	ND	ND	ND	ND	ND	ND

Table 2: Nutrient Sampling Results

Table 2 shows the results from the two nutrient sampling events. Site 9 showed a slight increase in Total Phosphorus while phosphorus was not detected at any other sites at either sampling.

6.4.2 Sediment Sampling Results

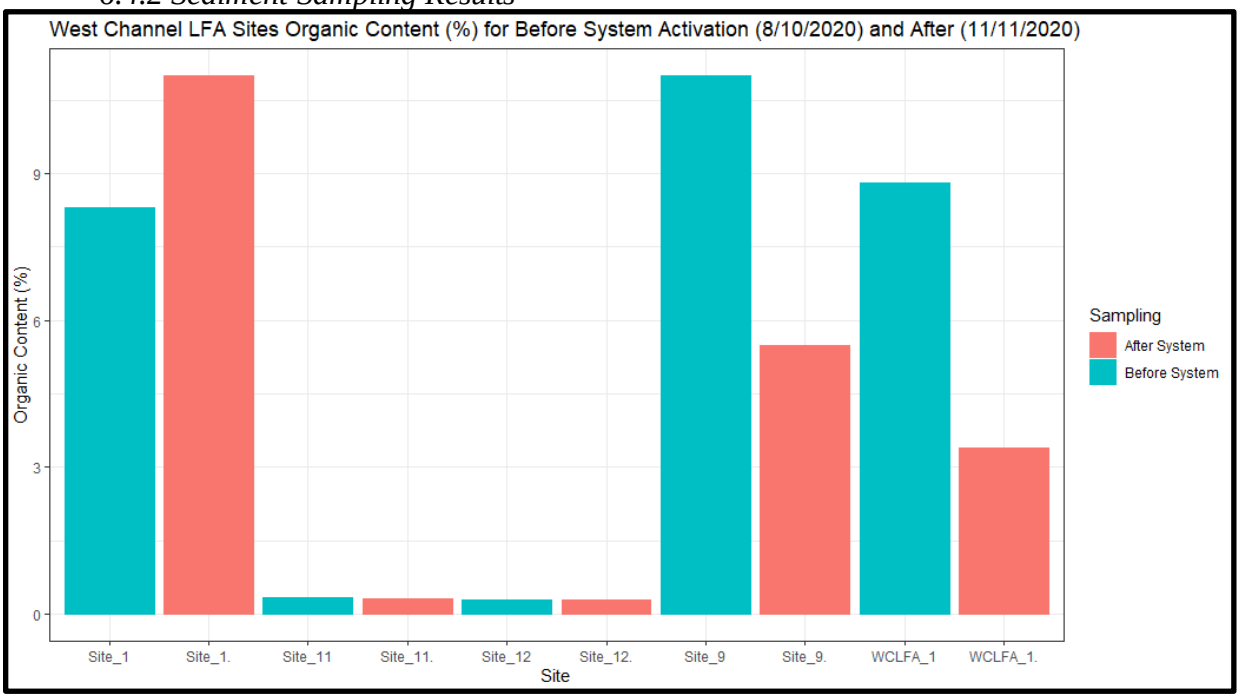

Figure 22: Organic Content % results from Sediment Sampling Before and After System Activation

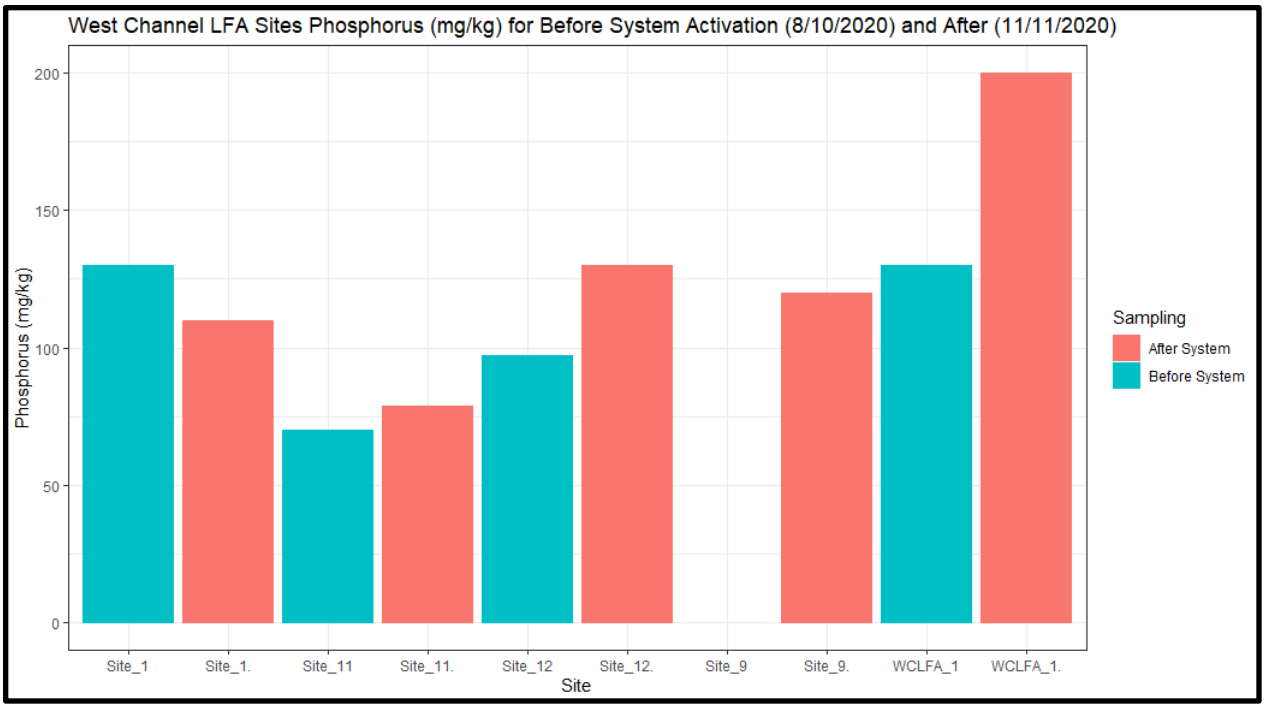

Figure 23: Phosphorus Results from Sediment Sampling Before and After System Activation

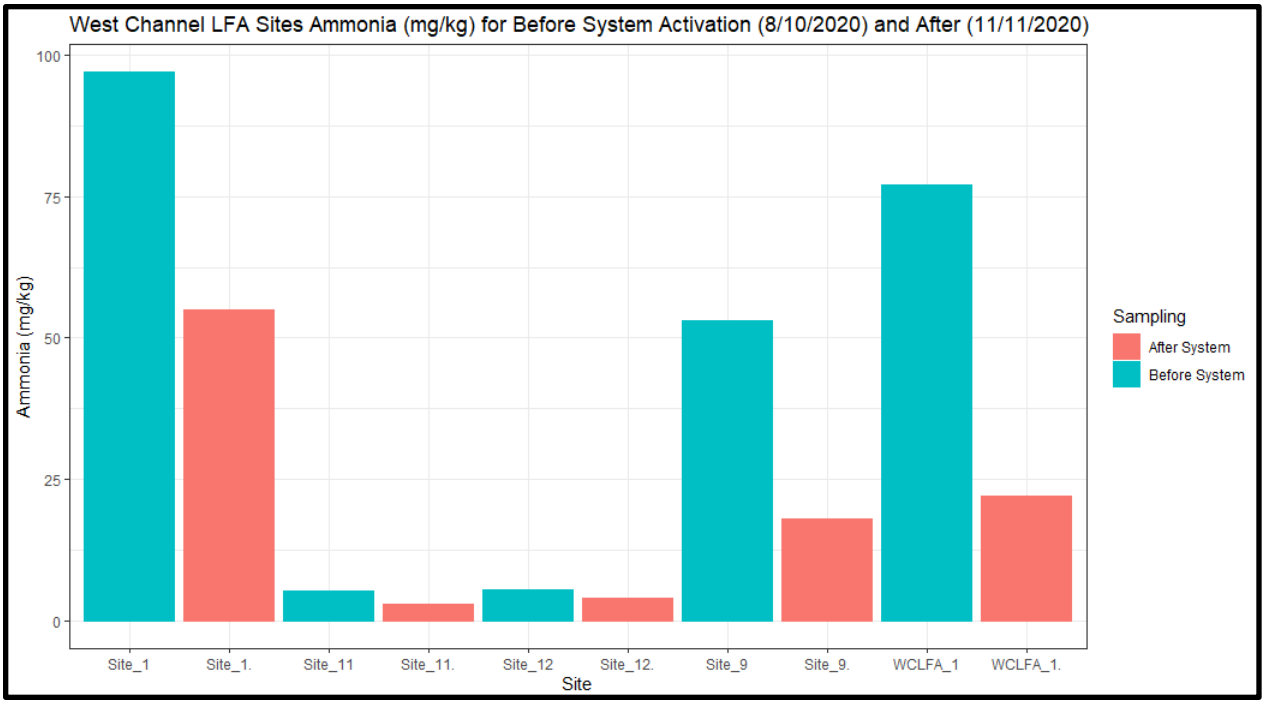

Figure 24: Ammonia Results from Sediment Sampling Before and After System Activation

Figures 22-24 show the results from the two sediment sampling events. Figure 22 shows an increase of organic content at control site 1, a reduction at the sites within the West Channel and no change at the sites within Lake Tahoe. Figure 23 shows an increase in phosphorus at sites within the West Channel and a small reduction at the control Site 1. Figure 24 shows a reduction of ammonia content at all sites including the control sites.

6.5 Sampling Results Discussion

The WDR permit issued by LRWQCB states "Tahoe Keys Lagoons are physically connected to Lake Tahoe and have no site-specific water quality objectives (WQOs) of their own, so Lake Tahoe WQOs apply." Meaning, that even though the environment of the Tahoe Keys Lagoons is drastically different from Lake Tahoe Proper, they still need to meet the same objectives. As displayed in the figures above the chemistry inside the lagoons is much different than in Lake Tahoe proper.

Year	Total Nitrogen (TN), mg/L	Total Phosphorus (TP), mg/L	Total Dissolved Solids (TDS) (mg/L)	pH	Turbidity (NTU)
2007	0.28	0.030	74	9.16	0.75
2008	0.15	0.033	84	7.67	1.46
2009	0.33	0.043	87	9.15	7.97
2010	0.20	0.019	101	8.87	1.20
2011	0.18	0.023	71	8.31	1.72
2012	4.57	0.019	No data	8.88	No data
2013	0.24	0.026	81	7.97	1.88
2016	0.397	0.025	25.8	9.12	1.56
2017	0.647	0.033	31.39	7.84	2.27
2020	0.53	0.035	No Data	8.3	3.12
WQO	**0.15**	**0.008**	**60**	**7.0-8.4**	**3.00**

Table 3: Water Quality Objectives and past years results (TKPOA 2016)

6.5.1 Turbidity, Dissolved Oxygen and Phycocyanin Discussion

Turbidity in the Tahoe Keys Lagoons is significantly higher than in Lake Tahoe proper. Figure 16 shows turbidity range for all the sites sampled for the West Channel LFA project. It can be seen that sites 11 and 12 (located in Lake Tahoe just outside of West and East Channels respectively) have a much lower average than the sites located just within the channel. Site 9 and Site 1 have similar turbidity levels while WC_LFA_1 has slightly lower average than those two sites. This demonstrates how turbidity decreases as the lagoon water mixes with the lake water. Figure 17 shows how Lake Tahoe turbidity remains relatively constant while the lagoon turbidity varies. This is likely due to proliferation of algae, increased suspended solids and increased organic matter within the lagoon water.

Figure 17 shows a spike in turbidity after September, this spike in turbidity was accompanied by lower dissolved oxygen (figure 19) and higher PC levels (figure 21). This spike was also detected at control site 1 within the east channel. Therefore, it may not be directly connected to the operation of the LFA system. Monitoring during 2021 could help determine if the LFA system is effective

at improving water quality to meet WQOs stated in the Lahontan Basin Plan and decreasing habitat for aquatic macrophytes as required by the WDR.

6.5.2 Sediment Sampling Results Discussion

Sediment sampling results show that there was a decrease in percent organic matter at the sites within the West Channel compared to the control sites in the East Channel. However, this decrease is not likely due to the LFA system as the sediment sampling results from the other LFA project area did not show a decrease when compared to the control site. The reduction was likely due to the Tahoe Resource Conservation District (TRCD) funded a diver assisted hand pulling project conducted by Marine Taxonomic Services (MTS). This is promising as a combination of these two methods may be effective at reducing nutrients that fuel aquatic macrophyte growth which would decrease available habitat and help the TKPOA comply with WDR requirements.

The nutrient sampling results suggest that the LFA System is not releasing nutrients from the sediment into the water column due to the non detect results for most of the analytes. Figure 24 shows a decrease in ammonia at all sites that were sampled. Figure 23 shows an increase of phosphorus at WC_LFA_1.

7.0 SUMMARY OF FINDINGS FOR BACK-UP STATION AND BUBBLE CURTAINS

7.1 Boat Back-Up Station

The Boat Back-Up Station was implemented in the Spring of 2016 as to reduce the amount of plant fragments that enter Lake Tahoe through TKPOA waterways. This project aligns with the TKPOA WDR and the first objective of the IMP which states " Eliminate the spreading of aquatic invasive species from the Tahoe Keys to greater Lake Tahoe." This project has reduced the amount of aquatic invasive species from entering Lake Tahoe but not eliminated them (see results section below).

7.1.1 Back-Up Station Observations

Throughout the 2020 season, the TKPOA Staff monitored the Boat Back-Up Station for compliance of boaters. It has been determined that:

a. Homeowners were more prone to stop and conduct the procedures than renters.
b. Homeowners that were not educated via our outreach were more understanding and easily complied with what was being requested.
c. Most renters did not understand the concept of what was trying to be achieved.
d. For a majority of renters, it was a nuisance for them to be educated on the water by TKPOA Staff about the intent and expectations of the Boat Back-Up Station.
e. More boaters this season knew what the Boat Back-Up Station was, and its purpose, and many completed it without being instructed to do so.

7.1.2 Boat Back-Up Station Results

a. During the 2020 season, there were 188 boats that were observed during 13 monitoring events. There was a 93.6% compliance rate for boats that utilized the station. Of the 93.6%, 137 boats backed up on their own and 39 boats were instructed, then complied. Twelve (12) boats failed to comply.
b. The following dates and times were when observation was conducted and data was collected:

Date	Time	Boats observed	Boats that backed up on their own	Boats that were instructed on the Boat Backup Station	Boats that failed to yield for instruction or compliance
6/12/2020	1445-1600	2	1	0	1
6/19/2020	1400-1530	37	23	13	1
6/26/2020	1345-1515	34	28	4	2
7/17/2019	1400-1445	16	8	5	3
7/31/2020	1300-1500	20	16	2	2
8/4/2020	1030-1300	13	11	0	2
8/14/2020	1315-1515	43	27	15	1
8/20/2020	0945-1045	6	6	0	0
10/2/2020	1400-1530	17	17	0	0
		188	137	39	12
Percents			72.87%	20.74%	6.38%
Percent Totals			93.62%		6.38%

Table 4: 2020 Boat Back-Up Station data collected.

c. This is the fifth year implementing The Boat Back-Up Station. Exposure and communication of what the concept is continues to show improved compliance. The table below shows the total boats observed and their back-up rates since the project's implementation (refer to Table 3).

Year	Total Boats Observed	Backed Up Without Instruction	Backed Up with Instruction	Failed to Comply
2016	119	17.60%	0.00%	82.40%
2017	115	29.00%	37.00%	34.00%
2018	267	70.79%	20.97%	8.61%
2019	294	74.49%	18.71%	6.80%
2020	**188**	**72.87%**	**20.74%**	**6.38%**

Table 5: Boat Back-Up Station totals from the 2016-2020 boating seasons.

7.2 Bubble Curtain and Seabin

The Bubble Curtain and Seabin technologies were implemented in the spring of 2019 as to reduce the amount of plant fragments that enter Lake Tahoe through TKPOA waterways. This project aligns with the TKPOA WDR and the first objective of the IMP which states " Eliminate the spreading of aquatic invasive species from the Tahoe Keys to greater Lake Tahoe." This project has reduced the amount of aquatic invasive species from entering Lake Tahoe but not eliminated them (see results section below).

7.2.1 Bubble Curtain and Seabin Monitoring

a. The Bubble Curtain and Seabin collection and monitoring took place from June 29, 2020 to October 30, 2020. Once a day, between the times of 8:00 AM and 10:00 AM, two

TKPOA staff took skimmer poles and a barge boat (equipped with a net secured to the front) to the Boat Back-Up Station and the Bubble Curtain area. While there they would skim all the floating fragments of weeds and then analyze the amount of each species found.

b. To determine the volume of weeds collected, staff used a clear one cubic-foot box, with holes on the bottom and sides for drainage. Vegetation was placed into the one-foot box and packed down to avoid measuring volume of air between the vegetation. Staff roughly estimated the percentage of each plant species by sorting through the collected material. Information was recorded on a data sheet and later input into the TKPOA WQ database. The estimation method is similar to the Annual TKPOA Macrophyte survey. Vegetation collected from both the West Channel and the Seabin were measured and estimated separately.

7.2.2 Bubble Curtain and Seabin Results and Recommendations

a. Over the 131 days of monitoring, approximately 95 ft^3 of weed fragments were collected, sorted and identified.

b. These plants and their approximate percentages were: Eurasian Water Milfoil (*Myriophyllum spicatum*) 41%, Coontail (*Ceratophyllum demersum*) 25%, Curly Leaf Pondweed (*Potamogeton crispus*) 18%, Elodea (*Elodea canadensis*) 10%, Richardson Pondweed (*Potamogeton richardsonii*) 2%. Leafy Pondweed (*Potamogeton foliosus*), Common Bladderwort (*Utricularia macrorhiza*) and common grass clippings were all under 1% (Refer to Figure 25).

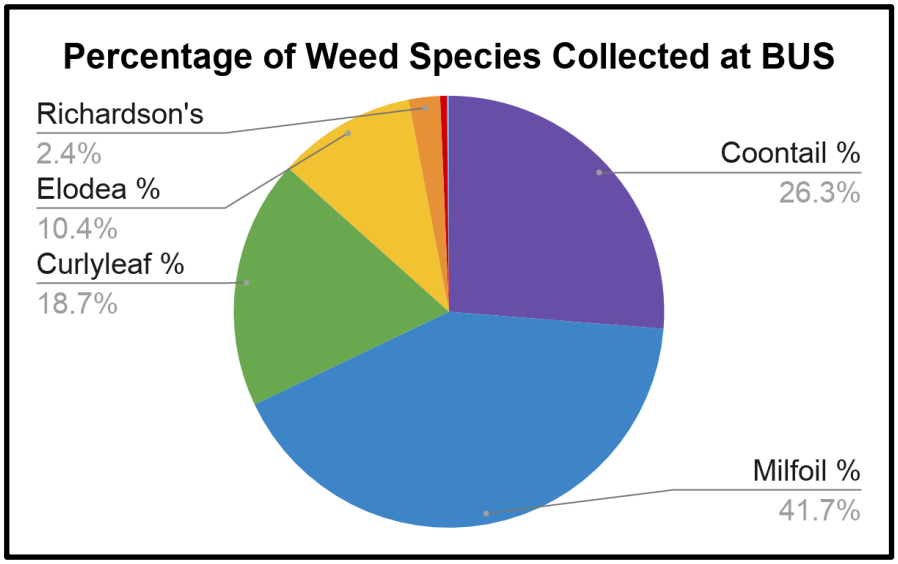

Figure 25: Graph of Estimated Plant Fragment Percentages.

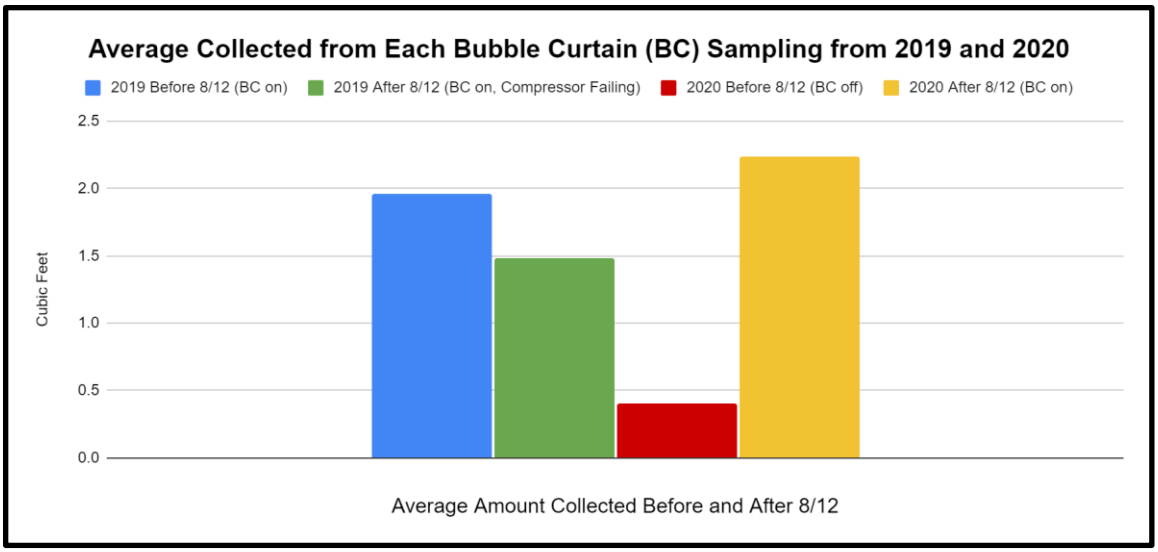

Figure 26: Comparison of the Amount of Weeds Collected at Boat Back-Up Station Before and After System was Turned On for 2019 and 2020

c. Due to the Bubble Curtain being turned on half way through the monitoring season (8/12/2020), WQ Staff analyzed the amount of weeds collected before and after to see the efficiency of the system. As shown in figure 26 above, it can be seen that when the Bubble Curtain is on, more weed fragments are collected. In 2019 after 8/12, the compressors began failing due to faulty design (as shown in the green bar). Based on the data, it can also be determined that when the Bubble Curtain is not fully functional it is not as effective. This means that when the Bubble Curtain is on and fully functional, it is more efficient at keeping weed fragments from entering into Lake Tahoe.
d. The Seabin was affected by the lake's wave action that was created by wind events and wakes caused by high boating activity. It is recommended in 2021 to install a wave attenuator on the lake side of the Seabin. A wave attenuator will protect the Seabin from wind, waves or wakes while creating an eddie for it to function per its design. This will allow the Seabin to work more effectively and therefore prevent more fragments from entering Lake Tahoe. This recommendation aligns with the IMP Objective a. in section 2.2, to eliminate the spread of aquatic invasive species from the Tahoe Keys. It also aligns with Project Objective b. in section 3.0, to collect the diverted plant fragments and debris.

8.0 2021 Implementation Plan

The Boat Back-Up Station will be in place prior to the 2021 Memorial Day holiday weekend. This will be monitored on an opportunity basis due to the fact that the project has been proven to be effective. The bubble curtain and LFA system operate continuously throughout the year. AIS staff will begin monitoring and collecting fragments after the Memorial Day holiday weekend. The sea bin will not be installed until a solution is implemented that protects it from waves and boat wakes.

9.0 Public Education and Outreach

In 2020, TKPOA improved the outreach program to enhance the way information is communicated to homeowners as well as the general public. These changes helped the TKPOA meet WDR

objectives stated in section 2.0 of this report. This season, a new TKPOA Instagram (@tahoekeyspoa_wq) was created to give homeowners a modern approach to learning about new projects, meeting the staff, and getting updates about the program. This platform also allowed the homeowners and the general public to directly communicate with the team and ask questions in a user-friendly and efficient manner. In addition to Instagram, monthly flyers were sent out to homeowners. These flyers communicated monthly results, projects completed and updates on specific projects. In the 2020 season, TKPOA WQ also hosted several boat tours to inform TKPOA's various stakeholders on the ongoing projects in the Tahoe Keys as well as a tour of the area.

In addition to the new outreach program, TKPOA WQ also continued utilizing outreach sources that have proved successful in the past. In April 2020, a *Keys Breeze* article was sent out to homeowners to kick off the season. The 2020 Harvesting and AIS Program Plan was sent to the homeowners with quarterly billing through email. The TKPOA distributed information to the general public through rack cards, posters and with boater education on the water from TKPOA staff. Articles about the Boat Back-Up Station were written and posted on both the TKPOA Keys Weeds Management Website (http://www.keysweedsmanagement.org/) and the TKPOA Website (https://www.tkpoa.com/), in addition to weekly and monthly letters and emails that were sent to the homeowners.

In the 2017 season, there was progression to help inform all TKPOA residents on the Boat Back-Up Station. TKPOA created a video with the procedures for the Boat Back-Up Station to inform the public of the AIS problem within the Tahoe Keys. The short clip covers the current AIS problem, how to enter the Boat Back-Up Station properly, complete the proper procedures, and exit in Tahoe safely. There is a great visual on how weeds can get tangled up on the propeller and how the weeds are removed with a simple switch into reverse while backing up at least ten feet. This allows boaters to continue out to the lake without transferring more plant fragments. The video can be found at http://www.keysweedsmanagement.org/. To get to the video directly, go to the "Take Action" tab and scroll down to "Boat Back-Up Station."

10.0 2019 BEST IN THE BASIN

Due to the integration of these technologies and the success that the project has had in its first year, it was awarded the 2019 Tahoe Regional Planning Agency (TRPA) Best in Basin for Environmental Improvement Projects.

11.0 ACKNOWLEDGEMENTS

The League to Save Lake Tahoe authorized a $5,000 grant for this project in December of 2018. The League also donated a $15,478 grant for the Laminar Flow Aeration project in the West Channel in 2020. TKPOA members also paid $6,000 toward this work through overwhelming homeowner approval of the Revised Second Payment of the Special Assessment.

12.0 LIST OF PREPARERS

The following individuals prepared the text presented in this report.

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Michael Bangs TKPOA	B.S. Environmental Sciences with Applied Geology Emphasis	Contributing Author Data Collection Data Analysis
Meghan Hoffmann TKPOA	B.A Biology and Secondary Education	Primary Author Data Collection
Moire Breslin TKPOA	B.S. Food Marketing with Environmental and Sustainability Studies	Contributing Author Data Collection
Ben Hopper TKPOA	A.S. Fire Science - In Progress	Data Collection
April Hillman TKPOA	B.S. Environmental Science with Conservation Biology Emphasis	Data Collection

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