April 2020

Phase 4 Algal Flow-Way Pilot Testing Program at Dundalk Marine Terminal

Prepared for: U.S. Department of Transportation Maritime Administration
Maryland Department of Transportation Maryland Port Administration
Maryland Environmental Service

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ABBREVIATIONS

µg/L	microgram per liter
µm	micron
AD	anaerobic digestion
ASTM	ASTM International
CH_4	methane
D1	Digester 1
D2	Digester 2
D3	Digester 3
DMT	Dundalk Marine Terminal
DO	dissolved oxygen
dry-g/m^2-day	grams dry per square meter per day
DW	dry weight
EPA	U.S. Environmental Protection Agency
Fe	iron
ft	feet
gpm	gallons per minute
gpm/lf	gpm per linear foot
H_2S	hydrogen sulfide
HDPE	high-density polyethylene
HydroMentia	HydroMentia Technologies, LLC
kg	kilogram
L	liter
LHFR	linear hydraulic flow rate
LHLR	linear hydraulic loading rate
m	meter
m^2	square meter
MARAD	U.S. Department of Transportation Maritime Administration
MDOT MPA	Maryland Department of Transportation Maryland Port Administration
MES	Maryland Environmental Service
mg	milligram
mg N/L	milligrams nitrogen per liter
mg/L	milligram per liter
Microbac	Microbac Laboratories, Inc.
mm	millimeter
N_2	nitrogen gas
NH_4	ammonium

NMP	NMP Engineering Consultants, Inc.
NTU	nephelometric turbidity unit
ppm	parts per million
ppt	parts per thousand
S	sulfur
SD	standard deviation
SM	Standard Method
TKN	total Kjeldahl nitrogen
TN	total nitrogen
TP	total phosphorus
TS	total solids
TSS	total suspended solids
UMD	University of Maryland
VS	volatile solids

1 Introduction

The U.S. Department of Transportation Maritime Administration (MARAD) and Maryland Department of Transportation Maryland Port Administration (MDOT MPA), through a cooperative agreement, provided funding for an Integrated Algal Flow-Way, Digester, and Fuel Cell Demonstration Project at Dundalk Marine Terminal (DMT) in Baltimore, Maryland. The project began in 2016 and 2017 as an innovative two-phase demonstration project designed, built, and operated to close the energy loop by producing on-site electricity (Anchor QEA 2018). Phases 1 and 2 successfully established the feasibility of integrating an algal flow-way,[1] anaerobic algal digesters, a biogas collection and conditioning unit, and a fuel cell to convert algae to energy.

In 2018, Phase 3 was added in order to test methods for improving biomass handling, separation, and recovery of the harvested algae and optimizing digester operations; the biogas conditioning unit and fuel cell were not used during this and the next phase (Anchor QEA 2019). In 2019, Phase 4 was added for supplemental testing of the algal flow-way and digesters. Phase 4 is the final phase of the project; results for this phase are summarized herein.

The MARAD Phase 4 project is a collaboration between MARAD and MDOT MPA, with support from Maryland Environmental Service (MES); Anchor QEA; HydroMentia Technologies, LLC (HydroMentia); NMP Engineering Consultants, Inc. (NMP); and the University of Maryland (UMD). Operation of the algal flow-way and experiments to enhance the biomass handling procedures were conducted by MES, Anchor QEA, HydroMentia, and NMP. The algal digester and biogas production component of the project was implemented by UMD with support from MES staff on-site at DMT (Section 4 and Appendix A).

Constructed at the DMT adjacent to the Patapsco River (Figure 1-1), the MDOT MPA algal flow-way is a linear raceway that uses water from the Patapsco River to grow algae on a surface specifically designed to enhance algal growth. The algae biomass grown on the flow-way removes nitrogen and phosphorus from surface water, improving overall water quality. Algae grown on the flow-way were used as feedstock for an algal digester system that produced biogas via anaerobic digestion (AD).

The MARAD Phase 4 testing program built on work conducted previously, with a focus on refining flow-way operation and biomass handling approaches and increasing energy production from digestion using the algal flow-way feedstock.

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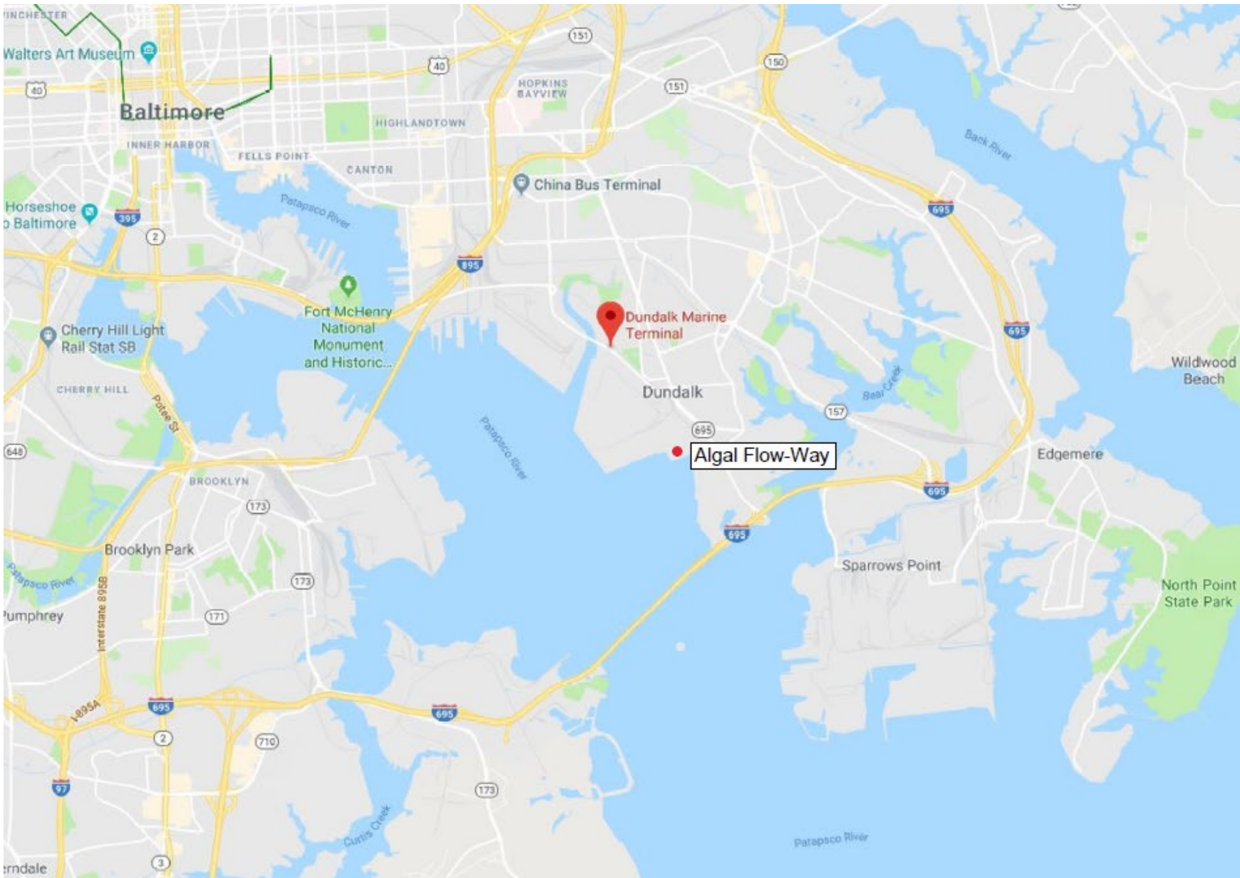
[1] Algal flow-ways are inclined (typically 1 to 2 degrees) systems designed to improve water quality by using natural algal assemblages that colonize on screens and assimilate nutrients from the overlying water into the algal biomass (Bott et al. 2015). The algae are then harvested, typically once every 7 to 14 days.

Figure 1-1
Location of Algal Flow-Way at DMT



Basemap Source: Google Maps

This report documents the testing conducted during Phase 4. Results from UMD's data analyses and operations of the digesters in the field and laboratory studies of biogas production from algal digestion are briefly summarized within this report in Section 4. Field data tables and analytical data tables for the algal flow-way testing are presented in Appendices B and C, respectively. Appendix D contains data tables used for analysis of results. Appendix E contains comparisons of water quality, biomass nutrient concentration, and algal productivity over the years at the DMT flow-way and compared to other nearby surface water stations. A description and analysis of UMD's project setup, testing procedures, results, and data analysis are included as Appendix A.

1.1 Project Objectives

The overall objective of Phase 4 was to address the following three challenges encountered during Phase 3 that affected the operating efficiency of the algal digesters: 1) increasing the total amount of algae (i.e., productivity) available for testing; 2) increasing the percent solids of the harvested algae through biomass handling; and 3) increasing energy production from AD of the harvested algal biomass. To achieve the overall project objective, Phase 4 focused on the following four investigations that were implemented concurrently throughout the project:

- **Investigation 1: Surge Versus Continuous Flow.** Testing whether the method by which water is introduced onto the flow-way—pulses of water or continuous flow—results in a quantifiable change in algal productivity. Based on algal flow-way studies in the laboratory and other algal flow-way systems, pulsed inflow stimulates algal growth (higher productivity) and community diversity (increased periphyton species). However, the impact of a pulsed inflow system on productivity has not been compared to a continuous flow system at the DMT pilot location. The investigation is beneficial because a continuous flow system would be less expensive to construct and operate.
- **Investigation 2: Flow-Way Surface Material.** Testing whether flow-way surface material has a quantifiable effect on algal productivity. Other pilot and utility-scale algal flow-way systems have employed both geomembrane liner with nylon screen and roughened concrete surfaces. In the utility-scale algal flow-way systems operated to date, harvests are conducted mechanically by employing a tractor fitted with a plow blade with a neoprene or Teflon scraper edge to sever the algae from the flow-way surface and transport the material to the solids collection area. A geomembrane liner with nylon screen requires the tractor to be operated at a slower rate and with more care to avoid damaging the surface material. Concrete surfaces with nylon screen (no geomembrane liner) also require the operator to be careful when operating the harvest equipment. A roughened concrete surface without nylon screen or geomembrane would allow large-scale flow-ways to be harvested more quickly and efficiently, but the concrete surface would be subject to potential cracking with temperature changes and soil heaving. Data from Investigation 2 will inform future value engineering efforts.
- **Investigation 3: Harvest and Dewatering Channel.** Testing the effectiveness of using a harvest and dewatering channel for increasing the efficiency of recovering solids without losing or bypassing substantial biomass while increasing percent solids of the harvested algae. Using a harvest and dewatering channel as part of the biomass handling procedure would allow time for water to separate from the biomass and drain away via gravity and evaporation, and to enhance collection of fine solids associated with the diatom-dominated system. This will increase the percent solids of the biomass, which benefits the digester system. Biomass with less moisture content would be easier to collect and handle, but there is concern that substantial biomass could be lost with the drain water in a harvest and dewatering channel, bypassing the primary biomass collection process.

- **Investigation 4: Energy Production from Harvested Algal Biomass Using AD.** Algae harvested from the algal flow-way were used as a feedstock for biogas production via AD. This provides a value-added product to offset the flow-way installation and operational costs, as well as a potential source of energy for powering a combined algal flow-way and AD system.

Investigations 1 and 2 supported the first project objective; Investigation 3 supported the second project objective, and Investigation 4 supported the third project objective. The goal of these investigations was to refine flow-way design and operation to improve the operating efficiency of the algal digester system.

Details on the procedures of these investigations are provided in Section 2.2. To perform the testing, physical modifications to the flow-way were required. The modifications included constructing two adjacent parallel (and separated) flow-ways for side-by-side comparison testing, constructing subplot areas of different surface materials, and constructing a separate harvest and dewatering channel. Modifications to the flow-way are described in Section 1.3.

1.2 Algal Flow-Way History at Port of Baltimore

The first algal flow-way was constructed at DMT in 2013 to assess the potential for improving water quality by removing nutrients and sediment from the Patapsco River (Smith et al. 2013). An algal flow-way has operated each year from 2013 to 2018 at DMT, and each year improvements to the system design, method of operation, and biomass handling techniques were implemented (Smith et al. 2013, Smith et al. 2016, Selby et al. 2016, Selby et al. 2018, Anchor QEA 2019). Previous versions of the flow-way experimented with various lengths of flow-way surface, different pump rates at which Patapsco River water was delivered to the flow-way, changes to flow-way slope from 0.46% for years 2013 through 2017 to 0.90% for 2018 and 2019, using tipping buckets to deliver Patapsco River water to the flow-way in a pulsed manner, operating for varying lengths of time and seasons, various manual harvest methods, transporting via vacuum truck, and air drying by evaporation in an open area. From 2013 to 2016, dried algal biomass was periodically collected, weighed, and disposed of in a local landfill. From 2017 to 2019, harvested algal biomass was used as feedstock to the algal digesters for Phases 2 through 4 of the MARAD project.

1.3 Flow-Way Modifications for 2019 (MARAD Phase 4)

The flow-way area consisted of an asphalt surface covered with a geomembrane liner that was overlain by a flexible low-profile nylon screen. The flow-way area was 206 feet (ft) long and 9.5 to 10.5 ft wide with a slope of approximately 1%. The low-profile nylon screen was used to enhance algal growth by providing a suitable surface for the algae to attach. Water was pumped directly from the Patapsco River to the top of the flow-way area.

This subsection describes the modifications to the flow-way system in 2019, as they relate to the investigations supported. Modifications to the flow-way were completed in March and April, and the algal flow-way began operation on April 26, 2019.

1.3.1 Investigation 1: Surge Versus Continuous Flow

Investigation 1 tested the impacts on algal productivity of inflow being introduced onto the flow-way as pulses of water (surge) or as continuous flow. The flow-way area was divided into two adjacent parallel (and separated) flow-ways, each approximately 206 ft long and 3 ft wide. The two parallel flow-ways were operated side-by-side for the duration of the 2019 monitoring period to allow for direct comparison of algal productivity throughout different water quality and weather conditions.

One flow-way had a surge box (Figure 1-2) as used in Phase 3. The surge or pulsed flow-way is oriented around a self-siphoning surger. It relies upon an automatic siphoning device to deliver flows to the algal flow-way in surges or pulses, similar to waves often associated with highly productive, natural periphytic algal communities. The energy associated with such pulses can enhance productivity by augmenting the transfer of nutrients, gases, and metabolites through diffusion and physical transport, and by increasing exposure to light energy critical for photosynthesis.

The second flow-way had continuous water flow from a pipe (Figure 1-3). The inflow system was replumbed to split water from the Patapsco River between the two adjacent flow-ways (Figure 1-4), and flow meters were installed on each side. The target flow rate was 45 gallons per minute (gpm) per flow-way, or a 15-gpm per linear foot (gpm/lf) linear hydraulic flow rate (LHFR). LHFR is discussed Section 2.4.1.

Figure 1-2
Surge Flow-Way with Surge Box

Figure 1-3
Continuous Flow-Way

Figure 1-4
Inflow System Splitting Flow Between Two Adjacent Flow-Ways

1.3.2 *Investigation 2: Flow-Way Surface Material*

To test the impacts of flow-way surface material on algal productivity (Investigation 2), test sections (i.e., subplots) of different flow-way surface materials were installed in 2019.[2] The following three surface materials were evaluated on both adjacent flow-ways (Figure 1-5):

1. Roughened concrete (i.e., Concrete Only)
2. Concrete with a low-profile 3-D[3] loop multifilament nylon grid (i.e., Concrete + Grid)

[2] In 2018, similar testing of flow-way surface material was conducted during Phase 3, but on a smaller scale. Additional study was recommended because of the limited data, and there was concern that the Concrete Only subplot had a smoother finish than would be representative of typical roughened (broom-finished) concrete at other flow-way facilities.

[3] Prior to August 2017, the DMT flow-way surface material was polyliner with a 2-D extruded HDPE grid. In August 2017, the grid was changed to a 3-D screen to increase the growth of algae after small-scale testing indicated improved growth compared to the 2-D grid.

3. Polyliner with low-profile 3-D loop multifilament grid as used in Phase 3 (i.e., Liner + Grid)

Larger sections of the Concrete Only and Concrete + Grid surface materials were installed within 100 ft of the inflow because higher algal growth rates were typically observed closer to the water source during previous flow-way operations. The Liner + Grid subplot area was also established by field demarcation because that surface material was used for the majority of the flow-way surfaces. Specific locations of the three surface material subplots from the upstream end of the flow-ways were as follows:

- Liner + Grid: Location: 25 to 29.5 ft
- Concrete + Grid: Location: 38 to 42.5 ft
- Concrete Only: Location: 45 to 49.5 ft

Each subplot was approximately 4.5 ft long and spanned the width of each flow-way.

Figure 1-5
Surface Material Subplots

1.3.3 *Investigation 3: Harvest and Dewatering Channel*

To test the impacts of using a harvest and dewatering channel on the effective recovery and dewatering of harvested algal solids (Investigation 3), a channel was constructed along the northern side of the surge flow-way. A separate 1-ft-wide and 3-inch-deep harvest and dewatering channel was cut into the adjacent asphalt surface, beginning halfway down the surge flow-way and ending at the bottom of the surge flow-way for a length of approximately 108 ft (Figure 1-6). Algal material was pushed into this channel during harvest and allowed to dewater via gravity draining and evaporation over a period of 7 days. At the bottom of the harvest and dewatering channel, a small concrete containment area was constructed to capture liquid draining down the channel to assess solids lost through the gravity draining process (Figure 1-7).

Figure 1-6
Harvest and Dewatering Channel

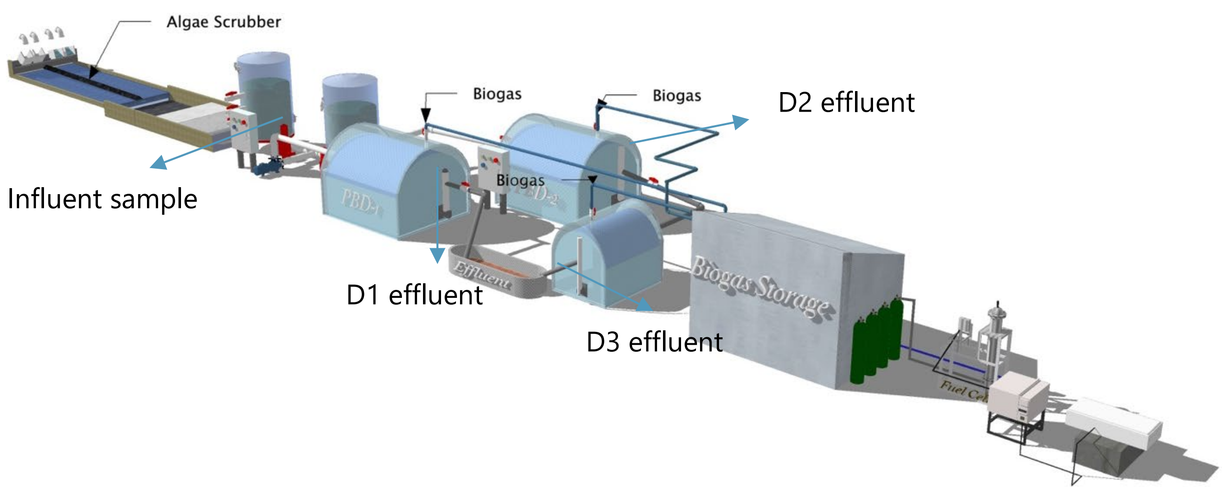
Note:
The harvest and dewatering channel is to the right of the two flow-ways.

Figure 1-7
Harvest and Dewatering Channel Containment Area with Adjacent Main Flow-Way Sump Area

1.3.4 Investigation 4: Energy Production from Harvested Algal Biomass Using Anaerobic Digestion

The digesters were operated during Phase 4 in a similar manner to Phase 3, with two parallel systems. Digester 1 (D1) was operated independently and Digester 2 (D2) and Digester 3 (D3) were connected in series. The system was modified for Phase 4 by incorporating a recirculation and heating system that was installed and tested during the final months of Phase 3 digester operation. D1 and D2 were also modified to increase their effective digestion capacity from 1,700 to 2,000 liters (L) each, to provide sufficient volume for smooth recirculation and heating (Figure 1-8).

Figure 1-8
Algal Digestion System at the Port of Baltimore, with Sampling Points Noted with Blue Arrows



2 Algal Flow-Way Operations

2.1 Harvest Schedule

Algal biomass was harvested from the flow-ways weekly for the operating schedule (May 16, 2019 to October 24, 2019; Table 2-1). A testing schedule and sampling plan were developed at the beginning of Phase 4, establishing the weeks when each harvest procedure (Section 2.2) would be implemented and the samples that would be collected. The three different harvest procedures were implemented throughout the duration of the project in a 3-week repeating cycle. Some data and samples were collected every week, while other data and samples were collected only for certain harvest procedures. A field data form was also developed at the beginning of Phase 4 to collect data for harvest procedures in a similar format (Appendix B).

Table 2-1
Flow-Way Harvest Schedule and Investigation Type

Operating Week	Harvest Date	Harvest Number	Type
Week 0	April 26, 2019	none	Start-Up
Week 1	May 2, 2019	none	Start-Up
Week 2	May 9, 2019	none	Start-Up
Week 3	May 16, 2019	1	Investigation 1 - Surge vs. Continuous Flow[1]
Week 4	May 23, 2019	2	Investigation 1 - Surge vs. Continuous Flow
Week 5	May 30, 2019	3	Investigation 1 - Surge vs. Continuous Flow
Week 6	None – pump down[2]		
Week 7	June 12, 2019	5	Investigation 1 - Surge vs. Continuous Flow
Week 8	June 20, 2019	6	Investigation 2 – Flow-Way Surface Material
Week 9	June 27, 2019	7	Investigation 3 – Harvest and Dewatering Channel[3]
Week 10	July 3, 2019	8	Investigation 1 - Surge vs. Continuous Flow
Week 11	July 11, 2019	9	Investigation 2 – Flow-Way Surface Material
Week 12	July 18, 2019	10	Investigation 3 – Harvest and Dewatering Channel
Week 13	July 25, 2019	11	Investigation 1 - Surge vs. Continuous Flow
Week 14	August 1, 2019	12	Investigation 2 – Flow-Way Surface Material
Week 15	August 8, 2019	13	Investigation 3 – Harvest and Dewatering Channel
Week 16	August 15, 2019	14	Investigation 1 - Surge vs. Continuous Flow
Week 17	August 22, 2019	15	Investigation 2 – Flow-Way Surface Material
Week 18	August 29, 2019	16	Investigation 3 – Harvest and Dewatering Channel
Week 19	September 5, 2019	17	Investigation 1 - Surge vs. Continuous Flow

Operating Week	Harvest Date	Harvest Number	Type
Week 20	September 12, 2019	18	Investigation 2 – Flow-Way Surface Material
Week 21	September 19, 2019	19	Investigation 3 – Harvest and Dewatering Channel
Week 22	September 26, 2019	20	Investigation 1 - Surge vs. Continuous Flow
Week 23	October 3, 2019	21	Investigation 2 – Flow-Way Surface Material[4]
Week 24	October 10, 2019	22	Only to support algal digester testing[5]
Week 25	October 17, 2019	23	Only to support algal digester testing[5]
Week 26	October 24, 2019	24	Only to support algal digester testing[5]

Notes:

1. Inflow pump failure and partial dry-out of the flow-ways occurred prior to harvest. A backup pump was temporarily installed until a new pump was installed on May 31, 2019.
2. New inflow pump failure and partial dry-out of the flow-ways occurred prior to harvest. Pump operation was restored. No harvest occurred due to dry-out.
3. Data for Harvest 7 (Investigation 3 - Harvest and Dewatering Channel) was corrupted by damage to the flow-ways that occurred in the days following harvest.
4. Surge box stopped functioning after previous harvest. Surge flow-way receiving continuous flow.
5. Surge box not functioning. Surge flow-way receiving continuous flow. Flow rate to surge flow-way was increased after Harvest 21 for observation.

The following events occurred in 2019 that disrupted flow-way operations and harvesting:

- May 11 to May 13, 2019: Inflow pump failure occurred, resulting in partial dry-out of the flow-ways.
- June 1 to June 4, 2019: Inflow pump failure occurred, resulting in partial dry-out of the flow-ways.
- July 1, 2019: Bottom of the flow-ways were found to be damaged, likely due to a storm event in the preceding days, which caused flooding in the harvest and dewatering channel and some material to be washed away.
- September 26, 2019: Surge box stopped functioning after harvest and was not repaired. Surge flow-way received continuous flow for the 4 remaining operating weeks.

2.2 Harvest Procedures

While some portions of the harvest procedures were identical among the three investigations, others were not. This subsection summarizes the general procedures relevant to all harvests and the three investigation-specific procedures.

Each week, the 2019 general harvest procedures included the following:

- Water quality data for the inflow water and the discharge water were collected at the top and bottom of the flow-ways as follows (Appendix C). The inflow and discharge water were measured for water temperature, pH, salinity, conductivity, dissolved oxygen (DO), DO saturation, and turbidity. The inflow water was also sampled for laboratory analysis of nitrate/nitrite as N, total Kjeldahl nitrogen (TKN), ammonia as N, total phosphorous (TP), chlorophyll-a, and total suspended solids (TSS). The outflow water was sampled for laboratory analysis of TSS (Appendix C, Table C-6).

- All harvests were conducted as "zero-flow harvests." The inflow pump was turned off, and the flow-way was allowed to drain for approximately 1 hour prior to harvest to allow the majority of residual water to gravity drain.
- Once the flow-way water was shut off and draining had begun, photographs were taken to document conditions.
- After approximately 1 hour of draining and prior to harvest, the outfall pipes from the sump area at the end of the flow-way were blocked using expanding plugs. Algae was then manually harvested by walking along the flow-way and severing the algae from the flow-way by pushing a squeegee attached to a broom handle from the top (near the inflow) to the bottom (near the sump) of the flow-way. Harvested algal biomass was collected in the sump area. Each side of the flow-way was harvested and quantified separately.
- Samples were collected from the harvested biomass for analytical testing and for use in biomass handling and dewatering experiments (Section 3.1).
- Algal solids were vacuumed from the sump area at the bottom of the flow-way into a Vermeer vacuum truck, which was then driven to a truck scale and weighed. The wet weight of the harvest was calculated by subtracting the truck tare weight from the total weight.
- Algae and water were then pumped from the Vermeer vacuum truck to decant tanks to feed the algal digester experiments (Appendix A).

2.2.1 Investigation 1: Surge Versus Continuous Flow

For Investigation 1, no harvest procedural changes were made. This was considered a normal harvest for comparison of surge and continuous flow productivity. Each flow-way (surge and continuous) was harvested separately, quantifying the harvest weight for each and obtaining samples for percent solids, total nitrogen (TN), and TP laboratory analysis.

2.2.2 Investigation 2: Flow-Way Surface Material

For Investigation 2, algal material was harvested from a subplot area of each of the three different surface materials on each flow-way (three different surface subplots on the surge flow-way and three different surface subplots on the continuous flow-way). Harvest weight for each subplot was quantified and samples obtained for percent solids. After the algal biomass from the subplot areas was collected, each flow-way (surge and continuous) was then harvested separately as described previously for Investigation 1, quantifying the harvest weight for each and obtaining samples for percent solids. The following two procedural changes were made:

- After the 1 hour of draining, algal material from subplot areas on each side of the flow-way was collected prior to harvesting the entire length of each flow-way.

- The weights of the material collected from the subplot areas for each flow-way were added to the total weight for that flow-way.

2.2.3 Investigation 3: Harvest and Dewatering Channel

For Investigation 3, the harvest procedure was designed to test the solids recovery and dewatering channel performance for recovery of solids and dewatering the biomass to improve biomass handling. Algal material on the continuous flow-way was harvested the typical way, quantifying the harvest weight for each and obtaining samples for percent solids. Algal material on the surge flow-way, however, was pushed into the harvest and dewatering channel and allowed to drain. This material was left in place and observed for 7 days before it was collected and weighed, quantifying the harvest weight and obtaining samples for percent solids. The water draining from the harvest and dewatering channel was collected in a sump area, weighed, and a sample obtained for percent solids and TSS. It was then put into the sand filter (constructed as part of Phase 3) for secondary recovery of fine solids and to meet discharge turbidity standards. A sample of the sand filter discharge water was obtained for TSS testing. These testing procedures are further described in Section 3, along with a summary of the results. The following two procedural changes were made:

- After the 1 hour of draining, the solids on the surge flow-way were squeegeed into the solids recovery and dewatering channel adjacent to the flow-way instead of to the sump area at the bottom of the flow-way and allowed to dry over a 7-day period.
- After the 7-day drying period, samples were collected from the harvest and dewatering channel for analytical testing and the algal solids were removed from the channel, weighed, and put into the decant tanks to feed the algal digester experiments

2.3 Sample Collection and Laboratory Analysis

Water quality data for the inflow and discharge water were collected in the field at the top and bottom of the flow-ways with handheld meters. Data collected included water temperature, pH, salinity, conductivity, DO, DO saturation, and turbidity. A laboratory testing program was established with two laboratories for Phase 4. Algal biomass samples were analyzed by Eurofins TestAmerica in Pittsburgh, Pennsylvania. Water samples were analyzed by Microbac Laboratories, Inc. (Microbac) in Baltimore, Maryland. For the biogas production, UMD conducted laboratory testing in-house (Appendix A).

Inflow and outflow water samples for the algal flow-ways at DMT, as well as ambient water samples from MDOT MPA's Hawkins Point site, were sent to Microbac. Inflow water samples were collected weekly from water entering the flow-way surge box. Outflow water samples were collected weekly from the sump area at the bottom of the flow-ways.

Water samples were also collected biweekly from the Patapsco River at MDOT MPA's Hawkins Point site, for comparison and to verify if conditions are similar (Appendix C, Table C-7). Hawkins Point is a potential location for a scaled-up algal flow-way system. These samples were collected by kayaking from the shore to the approximate discharge/inflow location of the scaled-up system. The coordinates were 39.21305° N, 76.54741° W and were navigated to using a Garmin Instinct GPS watch. Once at the approximate location, a small anchor was dropped to limit drift. A water column sampler was dropped until bottom was reached. From this benthic measurement, a middle mark was found on the removed sampler. The unit was then lowered to the middle of the water column and sealed. Sample bottles were filled from the sampler while on the kayak, and placed on ice once returned to shore (approximately 10 minutes).

Analytical testing of inflow and Hawkins Point water samples included the following:

- Nitrate/nitrite as N (U.S. Environmental Protection Agency [EPA] 353.2)
- TKN (Standard Method [SM] 4500-N Org B+NH3 G-11)
- Ammonia as N (SM 4500-NH3 B+G-11)
- TP (SM 4500)
- Chlorophyll-a (SM 10200 H 1 plus 2)
- TSS (SM 2540 D-11)

Analytical testing of outflow water samples included the following:

- TSS (SM 2540 D-11)

Algal biomass samples were collected each week from the various harvest procedures. Analytical testing of biomass samples included the following:

- Total solids (TS) (SM 2540B)
- Percent solids (SM 2540G)

In addition, during the harvest procedure for comparison of surge and continuous flow productivity (typically once every 3 weeks), analytical testing of biomass samples included the following:

- TKN (SM 4500 NorgC-2011)
- Nitrate/nitrite as N (EPA 353.2)
- TP (SM 4500 P E)

Lastly, when the on-site sand filter was utilized during solids recovery and harvest and dewatering channel testing, analytical testing of inflow and discharge water samples included the following:

- TSS (SM 2540 D-11)

2.4 Algal Flow-Way Operating Conditions

2.4.1 Analysis of Flows

Flow to the algal flow-ways was initiated on April 26, 2019. On May 11, 2019, flow stopped due to pump failure and was restored on May 13, 2019. After allowing for algal growth, the initial harvest occurred on May 16, 2019. Another pump failure occurred on June 1, 2019, for a period of approximately 3 days, resulting in dry-out of the flow-ways. Pump operations were resumed on June 4, 2019, and continued without disruption through October 24, 2019, for a total monitoring period of 168 days.

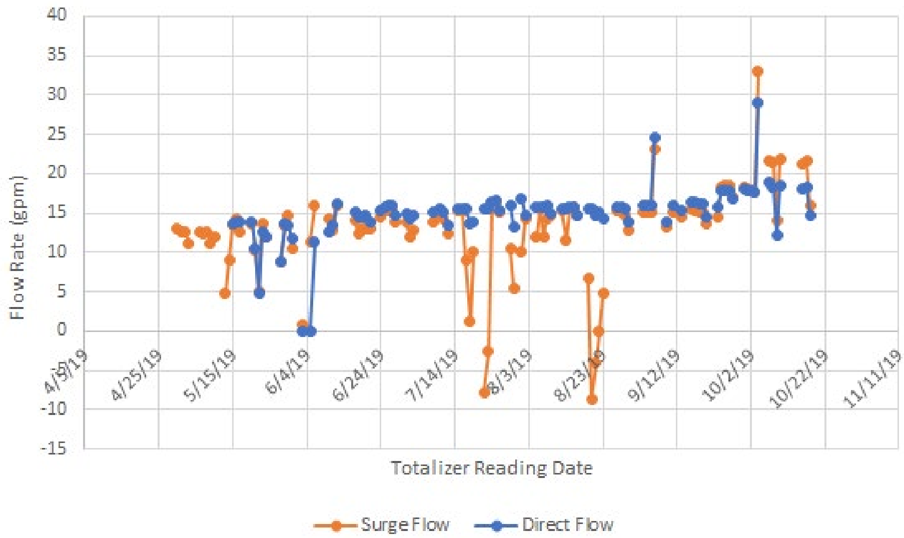
Flow to the system was measured using Master Meter Octave Ultrasonic flow meters. Interruptions in flow meter operations on the surge flow-way occurred for a 3-week period from mid-July through early August, and then for a 1-week period in late August. The temporary low and negative flow meter readings were likely due to the ultrasonic transducer being blocked by debris that was cleared away by additional flow.

Excluding the 4 weeks where the flow meter readings were in error, the mean daily flow rates for the June 6 through October 24, 2019 monitoring period were 48.7 and 48.6 gpm for the surge and continuous flow-ways, respectively.

Because flow energy and disturbance impact periphyton productivity, an important component of algal flow-way design is the linear hydraulic loading rate (LHLR). LHLR refers the rate of flow per linear width of flow-way. The target LHLR for the 2019 monitoring period was 15 gpm/lf. For the referenced period, the mean LHLR for both the surge and continuous flow-ways was 16.2 gpm/lf.

Figure 2-1 illustrates daily LHLR rates for the monitoring period. Inaccurate readings from the surge flow-way meter as noted previously are associated with flow rates significantly below average.

Figure 2-1
Daily Linear Hydraulic Loading Rates



Notes:
Inaccurate surge flow readings occurred for a 3-week period from mid-July through early August, and for a 1-week period in late August due to flow meter equipment malfunction. The vendor was contacted regarding a possible cause, but none could be determined.

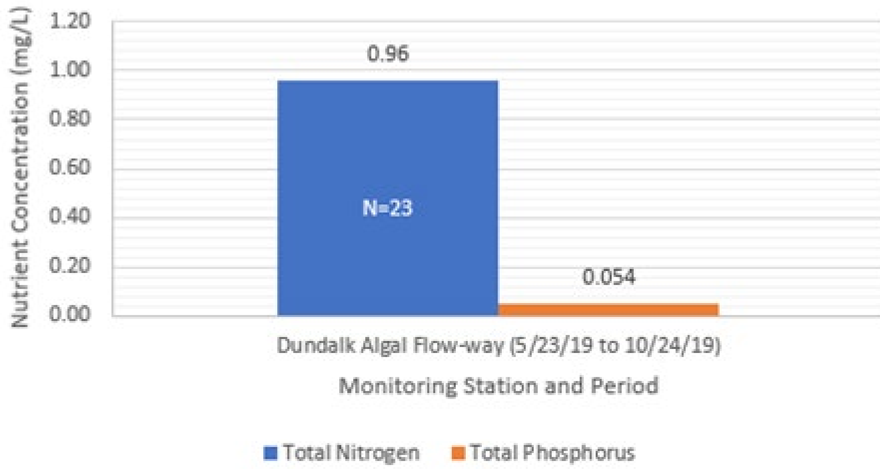
2.4.2 *Total Nitrogen and Total Phosphorus*

Primary environmental conditions affecting algal growth rate include inflow nutrient concentrations (phosphorus, nitrogen, carbon, and micronutrients), water temperature, and pH. In carbon-limited source waters, pH can significantly impact available carbon.

For the 2019 monitoring period, water quality testing was performed, as specified in Section 2.3, to quantify inflow nitrogen and phosphorus concentrations relative to algal productivity and nutrient concentration in the algal biomass at the DMT flow-ways. For prior (2013 through 2018) pilot operating periods, inflow nitrogen and phosphorus concentrations were not monitored. However, in Appendix E, water quality data from nearby water monitoring stations are discussed as a potential proxy.

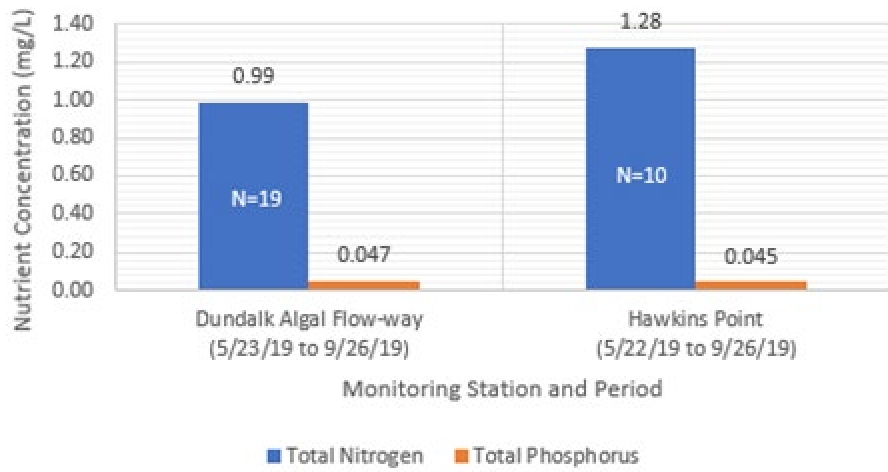
As shown in Figure 2-2 and Appendix C, mean TN and TP concentrations for inflows to the DMT flow-ways from May 23, 2019, through October 24, 2019, monitoring period were 0.96 and 0.054 milligram per liter (mg/L), respectively.

Figure 2-2
Mean Total Nitrogen and Phosphorus in Inflow to the DMT Algal Flow-Ways During 2019



As stated in Section 2.3, water samples were also collected biweekly from the Patapsco River at the Hawkins Point site, which is a potential site for a utility-scale algal flow-way. Figure 2-3 illustrates DMT and Hawkins Point mean TN and TP concentrations for the May 22, 2019 through September 26, 2019 period. The Hawkins Point TN concentration of 1.28 mg/L (N=10) was 29% higher than the 0.99 mg/L concentration (N=19) at the DMT flow-ways. There was a negligible (3%) difference between TP levels of 0.0465 and 0.0451 mg/L at the DMT and Hawkins Point sites, respectively.

Figure 2-3
Total Nitrogen and Phosphorus at DMT Algal Flow-Ways and Hawkins Point from Mid-May to September 2019



Weekly TN and TP concentrations from grab samples collected at the DMT flow-way inflow and at Hawkins Point for the May 23, 2019 through October 24, 2019 monitoring period are shown in Figures 2-4 and 2-5.

Figure 2-4
Total Nitrogen in DMT Algal Flow-Ways Inflow and at Hawkins Point

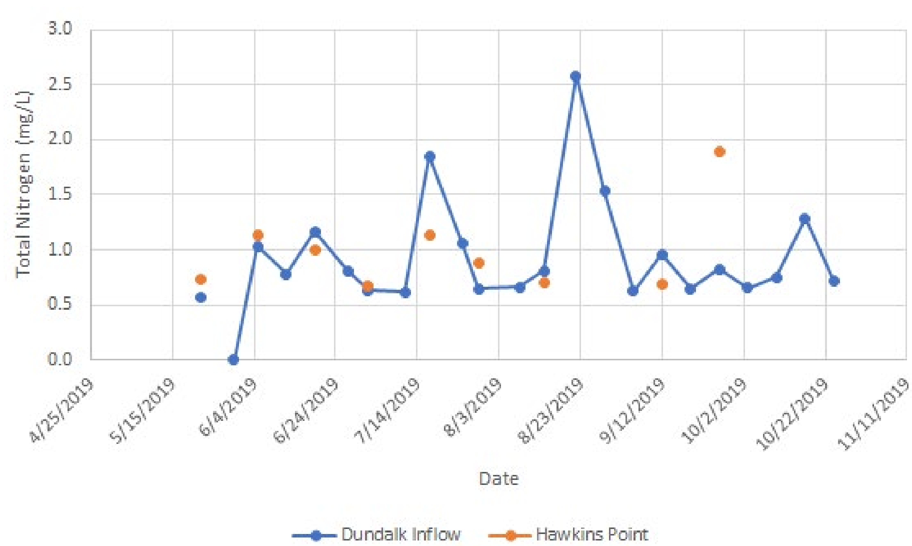
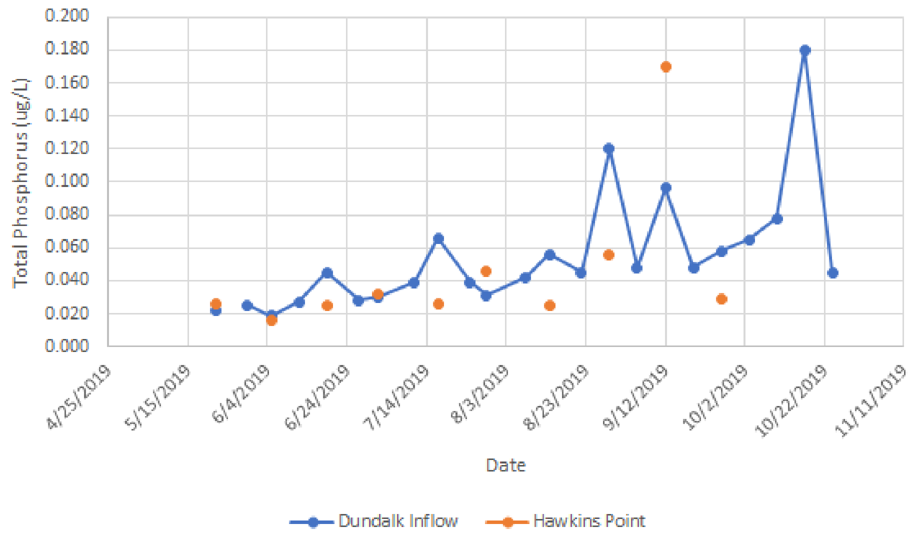


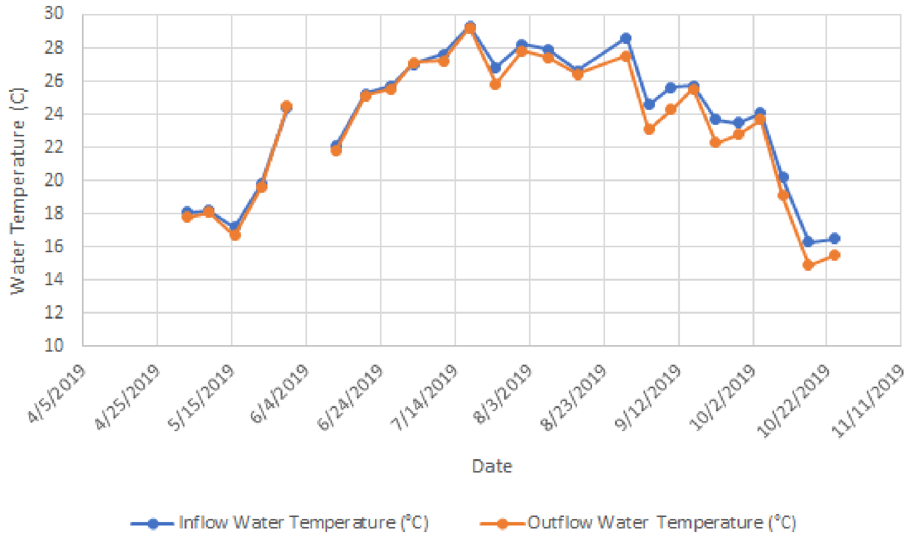
Figure 2-5
Total Phosphorus in DMT Algal Flow-Ways Inflow and at Hawkins Point



2.4.3 *Water Temperature and Dissolved Oxygen*

As discussed in Appendix E, water temperature is correlated with algal productivity and therefore TN and TP removal. Illustrated in Figure 2-6 are weekly inflow and outflow water temperatures at DMT. Mean water temperature for the 2019 monitoring period was 24.2°C. Inflow temperatures ranged from 16.5°C to 29.3°C, while outflow temperatures ranged from 14.9°C to 29.2°C.

Figure 2-6
Weekly Inflow and Outflow Water Temperatures



Algal flow-way treatment systems increase oxygen levels, which positively impacts the ecological community of the receiving water. Weekly inflow and outflow DO concentrations and percent saturation are shown in Figures 2-7 and 2-8. Mean weekly inflow DO increased from 6.4 to 8.0 mg/L over the monitoring period, while percent DO saturation increased from 78.9% to 97.4%.

Figure 2-7
Weekly Inflow and Outflow Dissolved Oxygen

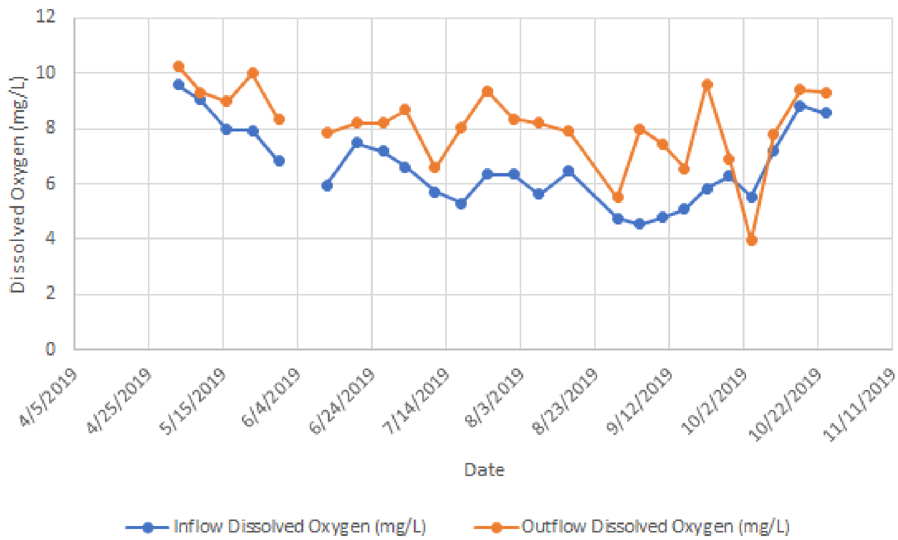
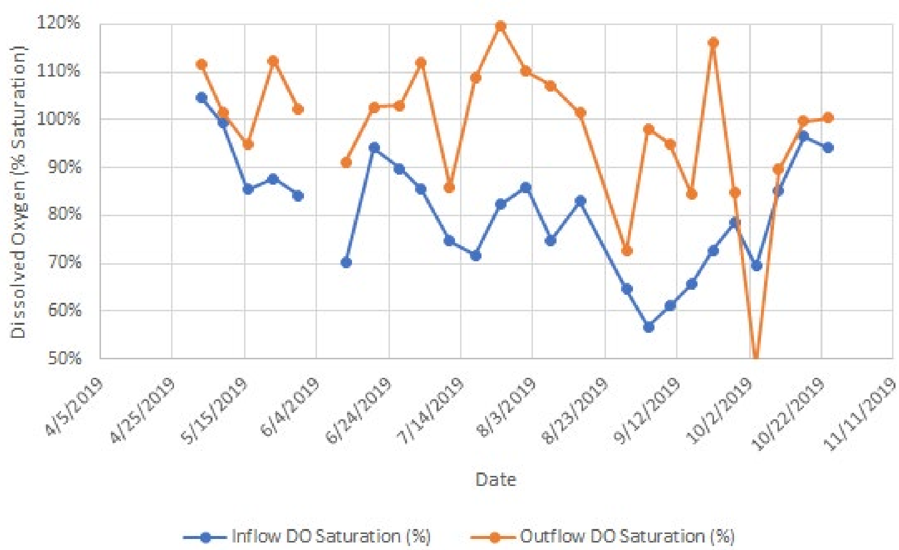


Figure 2-8
Weekly Dissolved Oxygen Percent Saturation



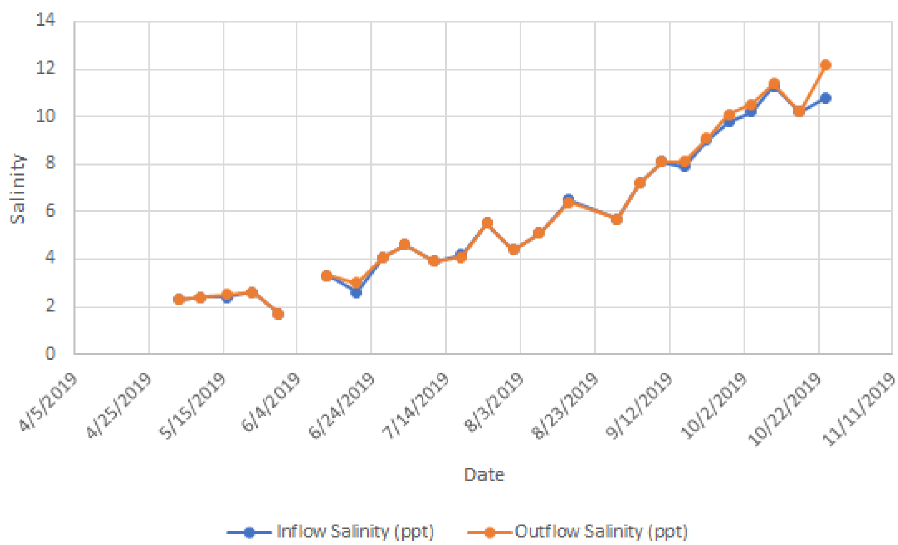
2.4.4 *Salinity and pH*

Inflow salinity concentrations, changes in salinity over time, and the relative rate of change impact the algal flow-way biological community including species diversity and dominance. Algal species diversity and dominance correspondingly affect productivity as well as tissue nutrient concentrations, as discussed in Section 3.4.2.

Salinity during the 2019 DMT monitoring period ranged from 1.7 to 11.3 parts per thousand, with a relatively continuous increase over the monitoring period (Figure 2-9).

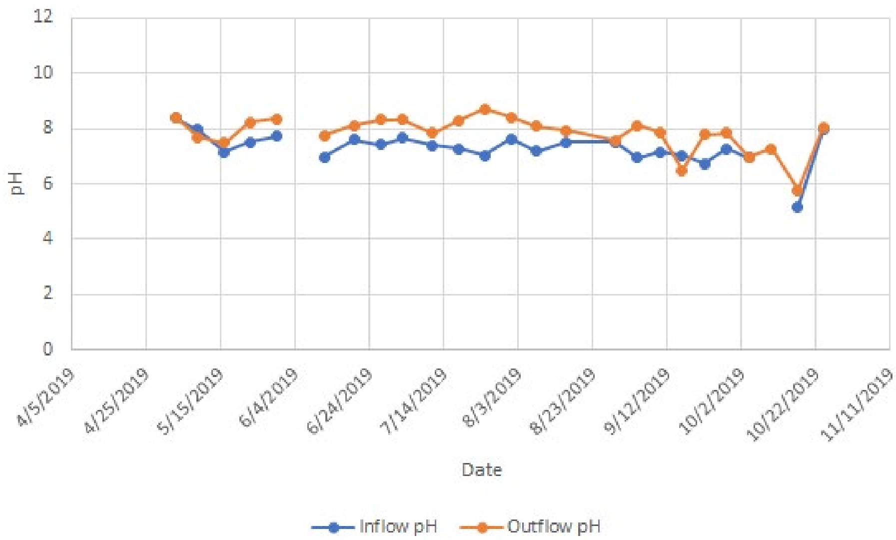
Appendix E discusses salinity values over the 2013 through 2019 DMT monitoring periods, illustrating the variable salinity conditions based on proxy water quality monitoring. It is expected that these variations in salinity have impacted algal species diversity and dominance at DMT.

Figure 2-9
Inflow and Outflow Salinity



The pH of inflow water impacts carbon availability. Outflow pH from algal flow-way systems will vary based on inflow pH, water chemistry, algal productivity, flow-way design, hydraulic detention time, and on a diurnal basis. As illustrated in Figure 2-10, inflow and outflow pH were relatively consistent over the monitoring period, with mean inflow and outflow pH of 7.2 and 7.8, respectively.

Figure 2-10
Inflow and Outflow pH



3 Algal Flow-Way Testing and Results

As described in Section 1.1, three investigations (surge versus continuous flow, flow-way surface material, and harvest and dewatering channel testing) were conducted to evaluate methods to increase the total amount of algae produced by the algal flow-ways and to increase the percent solids of the harvested algae through biomass handling. Two additional one-time investigations were also completed, stemming from questions that arose throughout the course of the study. These included the potential variability of algal biomass in different field samples of the same harvest material, and the potential differences in the nutrient content of filamentous green algae biomass versus diatom biomass.

A summary of the testing and results is provided in this section. Full laboratory analytical results for weekly harvests, the three investigations performed, and surface water samples are summarized in Appendix C. Appendix D contains tables used to support data evaluations.

3.1 Investigation 1: Surge Versus Continuous Flow

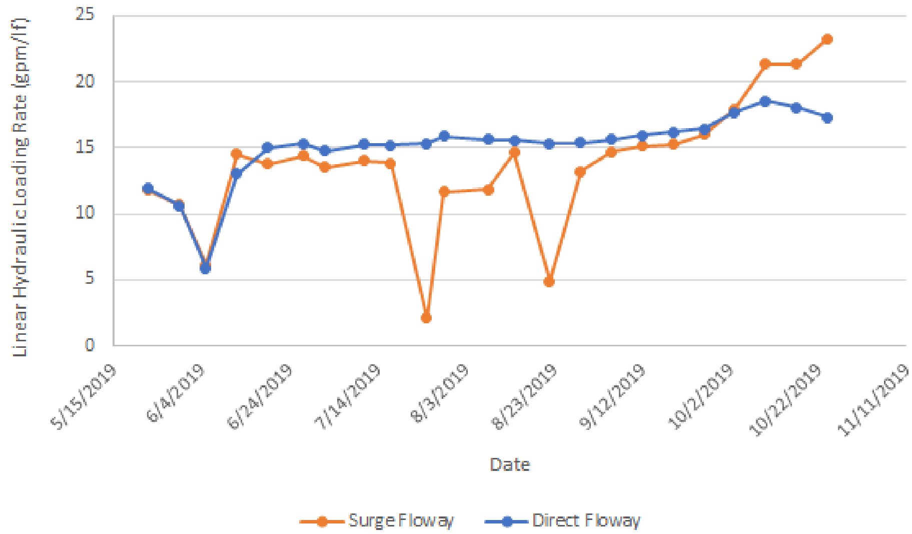
The goal of this investigation was to observe whether the method by which water is introduced onto the flow-way results in a quantifiable change in algal productivity with the Patapsco River as a source of water. As described in Section 1.3, the flow-way system was divided into two parallel and separated flow-ways. Inflow was introduced onto one flow-way as pulses of water through a surge box (self-siphoning surge system) similar to the one used in Phase 3. Inflow was introduced onto the other flow-way as continuous flow through a pipe. Inflow from the pump was split between the two adjacent flow-ways, and a flow meter was installed on each side to monitor flow rates. The adjacent flow-ways were operated side-by-side for the duration of the project to allow for direct comparison of algal productivity over the course of the project and throughout different water quality and weather conditions that both flow-ways would experience.

3.1.1 Flow Rate

As noted in Section 2.4.1, the DMT pilot was operated consistently at a 16.2 gpm/lf LHLR for both the surge and continuous flow-ways. The LHLR was consistent near the 15 gpm/lf objective for 2019 and well within the 20 gpm/lf LHLR typical of algal flow-ways dominated by filamentous green algae. By maintaining similar flow rates with a common water source, the primary difference between the surge and continuous flow-ways was the dynamics of how flow was introduced onto the flow-way.

Figure 3-1 illustrates weekly LHLR rates for the monitoring period. Flow rates significantly below average in Figure 3-1 are likely the result of temporary blinding of the ultrasonic flow meter transducer.

Figure 3-1
Weekly Linear Hydraulic Loading Rate



3.1.2 Productivity

Each flow-way (surge flow and continuous flow) was harvested separately, with harvest weight quantified for each and harvest samples obtained for percent solids, TN, and TP laboratory analysis. Table 3-1 shows the mean productivity from the surge and continuous flow-ways for four different monitoring scenarios as follows:

1. Weeks when only Investigation 1 was performed (surge versus continuous testing)
2. Weeks when Investigation 2 was performed (material removed from flow-way surface material subplots) prior to harvest
3. Weeks when Investigation 3 was performed (harvest and dewatering channel testing, surge flow-way algae was harvested into the harvest and dewatering channel and material collected later)
4. Mean of all weeks

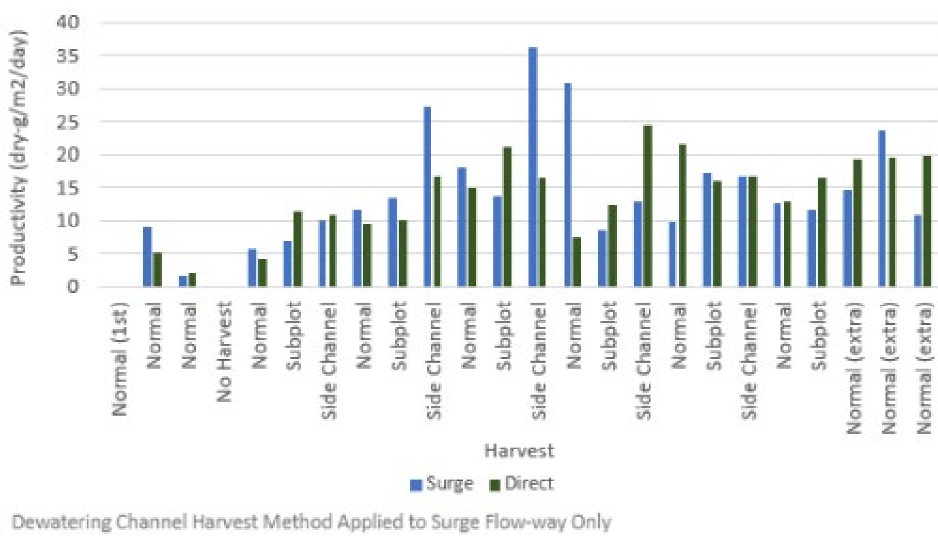
Table 3-1
Mean Flow-Way Productivity per Investigation and Flow-Way Inflow Type

Flow-Way Inflow Type	Mean Productivity (dry-g/m^2-day)			
	Investigation 1 Harvest Weeks (Surge vs. Continuous Flow)	Investigation 2 Harvest Weeks (Flow-Way Surface Material Subplots)	Investigation 3 Harvest Weeks (Harvest and Dewatering Channel)	All Harvest Weeks
Surge	12.4	11.9	20.6	14.7
Continuous	12.4	14.6	17.1	14.1

Weekly productivity rates are illustrated in Figure 3-2. Productivity during the first 4 weeks of harvests (3 weeks of surge versus continuous flow testing and 1 week of flow-way surface material testing) were impacted by both start-up and two pump failures that resulted in partial dry-out of the flow-ways (Sections 2.1 and 2.4.1).

For the 2019 monitoring period, there was no significant correlation between surge or continuous flow and an increase in algal productivity. However, the results of this testing may vary under different water quality conditions such as higher nutrients or salinity.

Figure 3-2
Weekly Flow-Way Productivity, May 16 to October 24, 2019, Sorted Chronologically

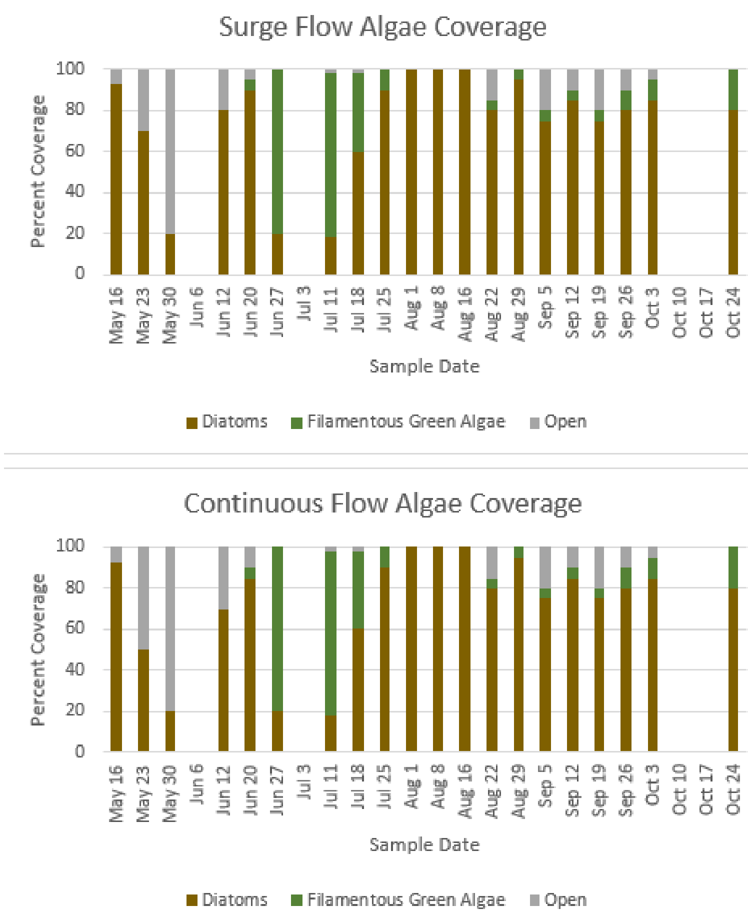


3.1.3 *Algal Species Dominance*

Throughout the course of the project, no major differences in algal community type were observed on the surge versus continuous flow-way based on field observations of percent coverage (Figure 3-3).

Similar to algal productivity, the algal community may also vary with changes in nutrient concentrations or salinity. Changes in nutrient concentrations and salinity are known to impact species diversity and dominance. Based on the limited monitoring period of Phase 4, no clear relationship was observed on how surge versus continuous flow alone affected algal species on the flow-ways.

Figure 3-3
Percent Coverage of Diatoms, Filamentous Green Algae, and Open Space



3.2 Investigation 2: Flow-Way Surface Material

The goal of this investigation was to observe the quantifiable effect of flow-way surface material on algal productivity. From 2013 through 2018, the DMT flow-ways were constructed of an asphalt surface covered with an ethylene propylene diene terpolymer geomembrane liner that was overlain with a 2-D high-density polyethylene (HDPE) attachment screen. In 2018, the attachment screen was replaced with a low-profile 3-D loop multifilament nylon screen. See Section 1.3.2 for details on the three surface materials tested.

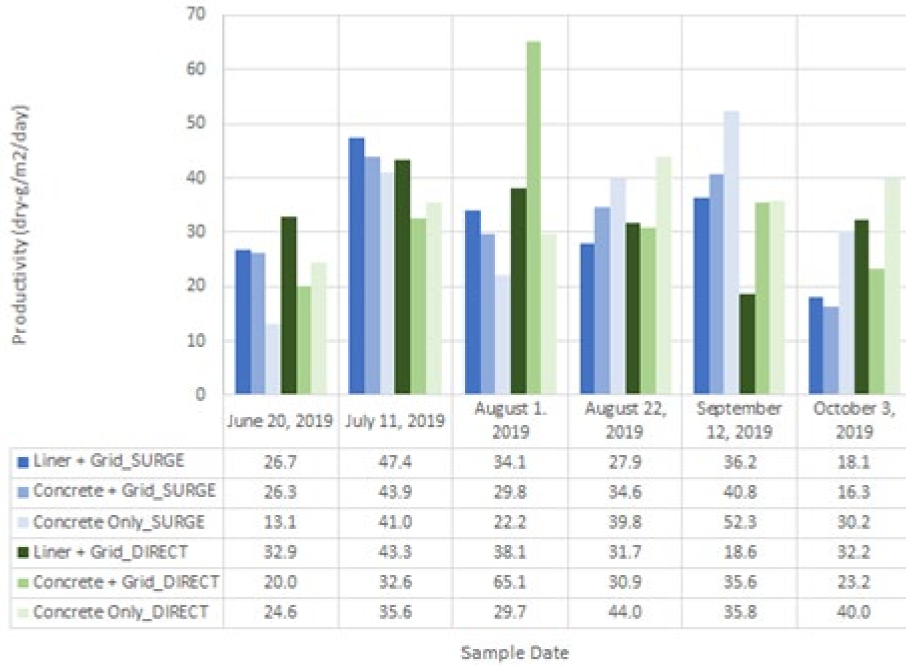
Algal biomass was collected from the subplot areas prior to the full harvest approximately once every 3 weeks during the project (Table 3-2). The algal material from each subplot was collected with a shop-vac, weighed, and then filtered through a 75-micron (μm) polyester mesh bag to separate biomass from water and increase the percent solids for the laboratory sample for improved solids measurement accuracy. The retained material was weighed, and a sample obtained for percent solids laboratory analysis. By filtering and consolidating solids, sample weighing and drying error impacts were significantly reduced. This analysis is discussed in greater detail in conjunction with Figure 3-7.

Table 3-2
Flow-Way Surface Material Testing Dates

Harvest	Date
6	June 20, 2019
9	July 11, 2019
12	August 1, 2019
15	August 22, 2019
18	September 12, 2019
21	October 3, 2019

Figure 3-4 shows the calculated productivity for each 1-square-meter surface material subplot over the six testing dates. A defined and consistent relationship between flow-way surface material and productivity was not observed from week to week.

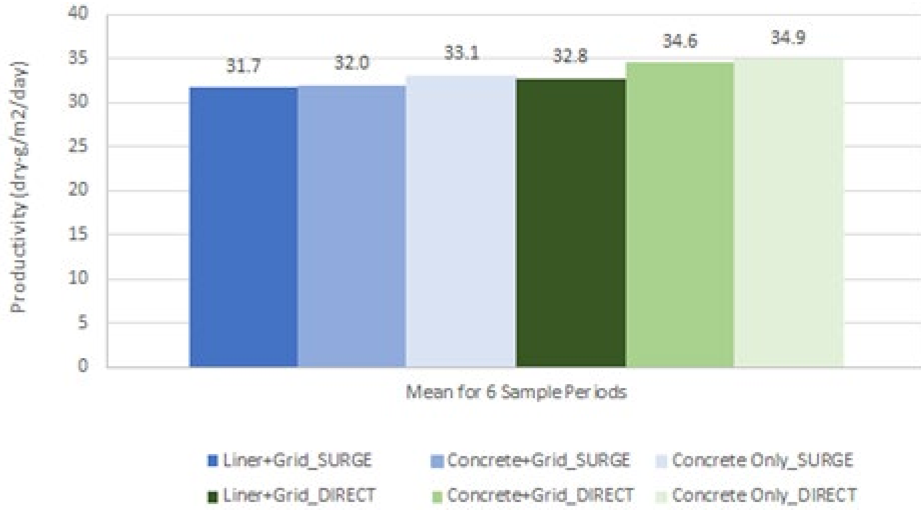
Figure 3-4
Subplot Data: Flow-Way Surface Productivity per Sample Period



	June 20, 2019	July 11, 2019	August 1, 2019	August 22, 2019	September 12, 2019	October 3, 2019
Liner + Grid_SURGE	26.7	47.4	34.1	27.9	36.2	18.1
Concrete + Grid_SURGE	26.3	43.9	29.8	34.6	40.8	16.3
Concrete Only_SURGE	13.1	41.0	22.2	39.8	52.3	30.2
Liner + Grid_DIRECT	32.9	43.3	38.1	31.7	18.6	32.2
Concrete + Grid_DIRECT	20.0	32.6	65.1	30.9	35.6	23.2
Concrete Only_DIRECT	24.6	35.6	29.7	44.0	35.8	40.0

Figure 3-5 shows the mean productivity for each subplot area over the entire testing period. Slightly higher productivities were observed for all of the subplots on the continuous flow-way compared to the surge flow-way. In addition, for both flow-ways (surge and continuous), mean productivity increased from Liner+Grid to Concrete+Grid to Concrete Only. However, the highest productivity for the six subplots (34.9 dry-g/m^2/day for Concrete Only subplot on the continuous flow-way) was only about 10% higher than the lowest productivity (31.7 dry-g/m^2/day for Liner+Grid subplot on the surge flow-way).

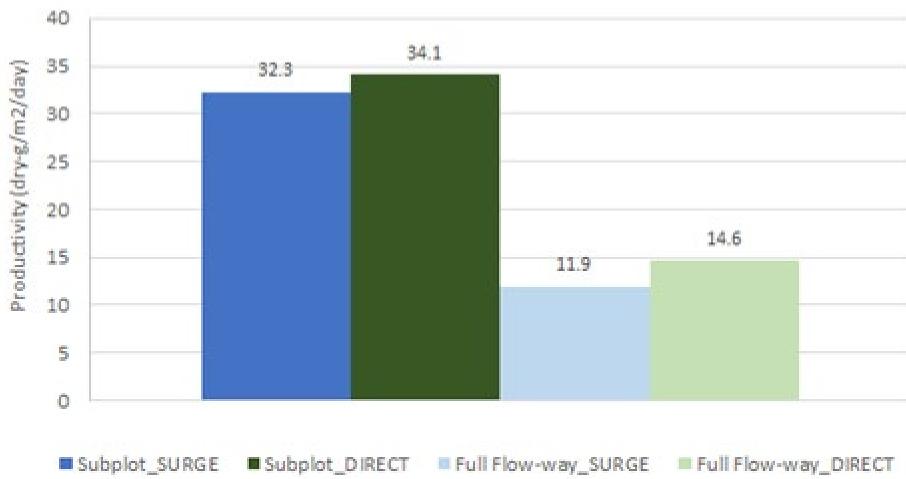
Figure 3-5
Subplot Data: Mean Flow-Way Surface Productivity for Six Sample Periods



During the Phase 3 MARAD project in 2018, algal productivity was lower for the Concrete Only subplot area than the other subplot areas with nylon screen. At that time, additional study was recommended because of the limited data, and there was concern that the Concrete Only subplot had a smoother finish than would be representative of typical roughened (broom-finished) concrete at other flow-way facilities. During the Phase 4 project, no significant difference was found in terms of algal productivity on the Concrete Only subplot.

The calculated mean productivity for each square-meter subplot area was significantly higher than the corresponding weekly productivity calculated for each entire flow-way (Figure 3-6). Similar results have been observed in other flow-way studies, with inconsistent productivity values between subplots and whole flow-way harvest.

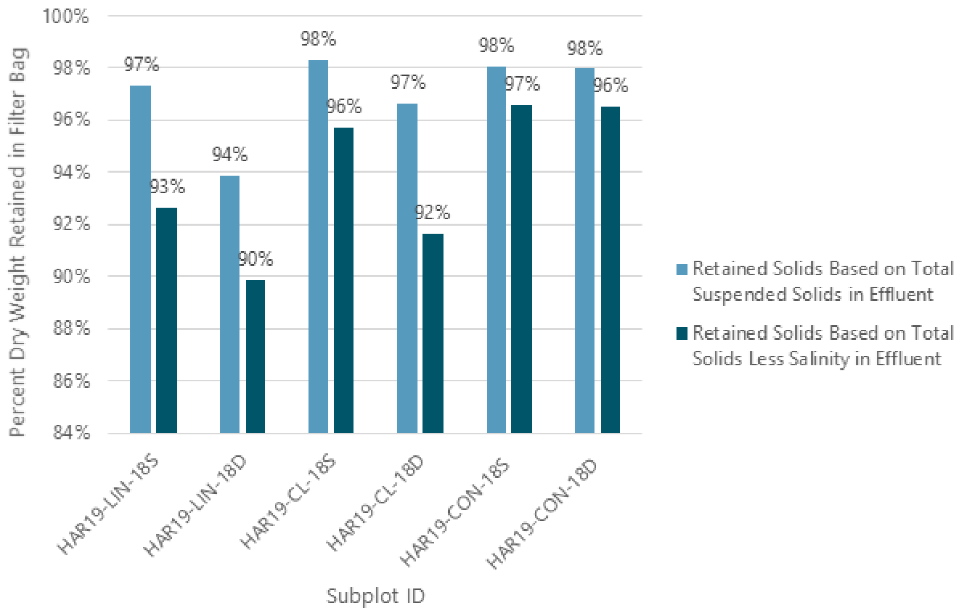
Figure 3-6
Subplot (1 m^2) Versus Full Flow-Way (57 m^2) Productivity Data for Six Sample Periods



During Harvest 18, the effluent draining from the 75-µm polyester mesh filter bag was collected and samples sent to the laboratory for TS and TSS analysis. The expectation was that the filter bag would retain approximately 90% of the TS and the remaining 10% would pass through the filter bag in the effluent. This assumption was based on the filter bag testing completed during Phase 3.

As shown in Figure 3-7, this assumption was confirmed. For all subplot areas, the 75-µm filter bags retained on average 97% of the solids based on TSS of the effluent, or 94% of the solids based on TS of the effluent adjusted for salinity-related dissolved solids. Accordingly, the reported subplot productivity rates for Phase 4 underestimate actual productivity by 3% to 6% because fine solids passing the 75-µm screen in the effluent were not accounted for in the subplot productivity values.

Figure 3-7
Subplot Mesh Bag Effluent Test



Note:
In Subplot IDs, LIN = liner + grid, CL = concrete + grid, and CON = concrete only

3.3 Investigation 3: Harvest and Dewatering Channel

The goal of this investigation was to observe the effectiveness of harvesting the algal biomass from a harvest and dewatering channel, instead of directly into a biomass collection area, in terms of increasing the efficiency of recovering solids and increasing percent solids of the harvested algae. During harvest, algal material on the surge flow-way was pushed into the harvest and dewatering channel instead of into the general biomass collection area. Instead of being collected immediately to determine weight and TS of the biomass from the surge flow-way, the material in the harvest and dewatering channel was left in place and allowed to drain via gravity and evaporate over a period of 7 days. Observations were made throughout the 7-day cycle, noting weather conditions, precipitation events, and relative dryness of the algal biomass (data sheets provided in Appendix B). After 7 days the material was collected and weighed to quantify the harvest weight, and samples were taken for laboratory analysis of percent solids. Additionally, samples were collected for laboratory analysis of percent solids 1 hour and 4 hours after material entered the harvest and dewatering channel to observe water loss during the first 4 hours post-harvest.

Water draining from the harvest and dewatering channel was collected in the small containment area. After about 1 hour, this drain water was collected and weighed, and a sample was collected for percent solids and TSS laboratory analysis. The drain water was then put into the sand filter (constructed as part of Phase 3) for secondary recovery of fine solids and to meet turbidity standards for discharge water. A sample of the sand filter discharge water was obtained for laboratory analysis to observe if the removal efficiency of the sand filter was similar to Phase 3. It is possible additional solids may have been lost down the harvest and dewatering channel after the initial 1 hour of draining or throughout the 7-day cycle due to mobilization during rain events, but field observations did not indicate this to be significant because there was no major transport of algal material into the dewatering channel sump area after precipitation events.

Harvest and dewatering channel testing occurred approximately once every 3 weeks during the project (Table 3-3). An initial testing date of June 27, 2019 (Harvest 7) was excluded from the evaluation because the flow-ways were damaged by a storm and the harvest and dewatering channel was flooded during the 7-day testing period, corrupting the data for that week.

Table 3-3
Harvest and Dewatering Channel Testing Dates

Harvest	Date
10	July 18, 2019
13	August 8, 2019
16	August 29, 2019
19	September 19, 2019

Challenges were encountered with the harvest and dewatering channel testing. The channel was constructed by saw-cutting and jack-hammering out the existing asphalt because a milling machine could not be used. This led to minor irregularities in the channel bottom slope, which caused some areas not to drain completely. Further, this area of the marine terminal experiences land heaving due to the underlying soils. Throughout Phase 4, the harvest and dewatering channel slope was impacted by the heaving, progressively causing more areas not to drain fully, which further affected consistent draining in the dewatering channel. After the 7-day cycle, biomass in some areas of the harvest and dewatering channel (mostly toward the top) was dry and could be picked up with no drippage. Other areas were holding water and the biomass was wet and mucky.

During the first two testing dates, a composite sample was made of all the material in the harvest and dewatering channel (dry and wet) by collecting equal portions of material about every 10 feet along the channel. During the last two testing dates, the material in the harvest and dewatering channel was separated into mostly dry areas and mostly wet areas, and a composite sample was made for each area. The mostly dry areas had more consistent slope and positive drainage. The wetter areas had irregular slope, inconsistent drainage, and more standing water. Generally, precipitation during the 7-day cycle did not rehydrate the algal biomass or cause it to wash downstream. It mostly ran off the surface or around the biomass in the harvest and dewatering channel.

Water draining from the harvest and dewatering channel ranged from 0.6% to 1.5% TS over the four testing dates, averaging 1.0% TS. The total dry weight (DW) of algal biomass that was lost with the drain water ranged from about 2% to 17% of the total DW of biomass over the four testing dates. The weight of the drain water ranged from about 200 to 340 pounds per harvest, which was about half of the typical harvest weight for the surge flow-way. These results were similar to the 2018 Phase 3 study, in which an improvised dewatering channel was created by temporarily blocking off a portion of the main flow-way along one side and allowing the material to dewater for about an hour. In the Phase 3 study, water draining from the improvised dewatering channel ranged from 0.7% to 1.0% TS, the total DW of algal biomass lost with the drain water ranged from 6% to 16% of the total DW of biomass, and the weight of the drain water was about one-third of the typical full harvest weight. Therefore, the Phase 4 values were consistent with the work completed in Phase 3.

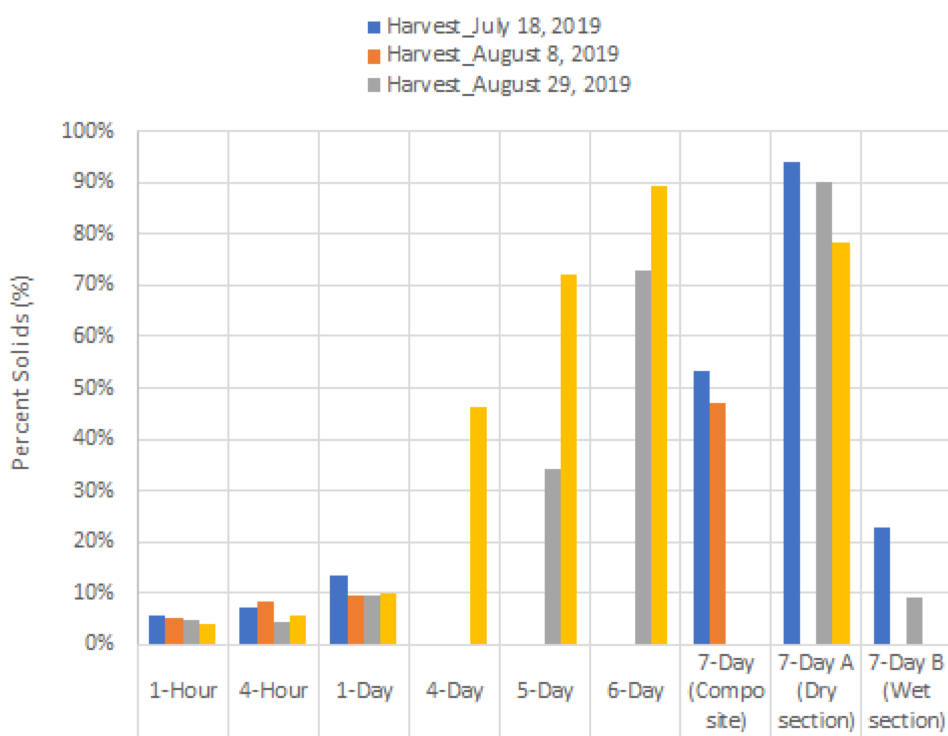
For the first two tests, when material in the harvest and dewatering channel was composited (dry and wet together), the percent solids of the material after the 7-day cycle was about 78%, compared to a mean of 3.8% when collected immediately after harvesting. For the last two tests, when material in the harvest and dewatering channel was separated into mostly dry and mostly wet, the percent solids of the material after the 7-day cycle was between 80% and 94% for the mostly dry and 9% to 11% for the mostly wet.

In addition to the samples collected from the harvest and dewatering channel after 7 days of drying, material samples were also collected from the harvest and dewatering channel after 1 hour and 4 hours to observe the rate at which dewatering occurred during the first 4 hours of dewatering. These samples were sent to the laboratory for TS analysis. The 1-hour samples ranged from 3.7% to 8.9% solids, averaging 6.5%. The 4-hour samples ranged from 5.2% to 9.3% solids, averaging 7.1%. These results are included in Figure 3-9.

During Investigation 3, it was proposed that instead of sending algal biomass to the laboratory for TS testing, a microwave could potentially be used to dry the material on site and obtain data the same day. A procedure was developed following ASTM International (ASTM) Standard ASTM E 1358-97, in which a 100-gram initial sample of algal biomass would be microwaved 30 seconds at a time, measuring the mass after each iteration until the mass change between successive readings was less than 4%. The percent solids would then be calculated by dividing the final weight of biomass by the initial weight. If results of this process were comparable to the laboratory results for the same sample, this would allow for more immediate results for percent solids over the 7-day cycle in the harvest and dewatering channel.

Figure 3-8 shows the percent solids for the dewatering channel material from the microwave drying procedure. Figure 3-9 shows percent solids from the microwave drying procedure and the comparable laboratory results for the 1-hour, 4-hour, and 7-day dewatering channel material samples. The percent solids values obtained by the microwave drying procedure were typically 10% to 40% lower than the laboratory results for the comparable sample when the algal biomass was less than 10% solids. The cause of this difference was not identified. For biomass that was above 75% solids, the microwave drying procedure results were less than 5% lower than the laboratory results for the comparable samples.

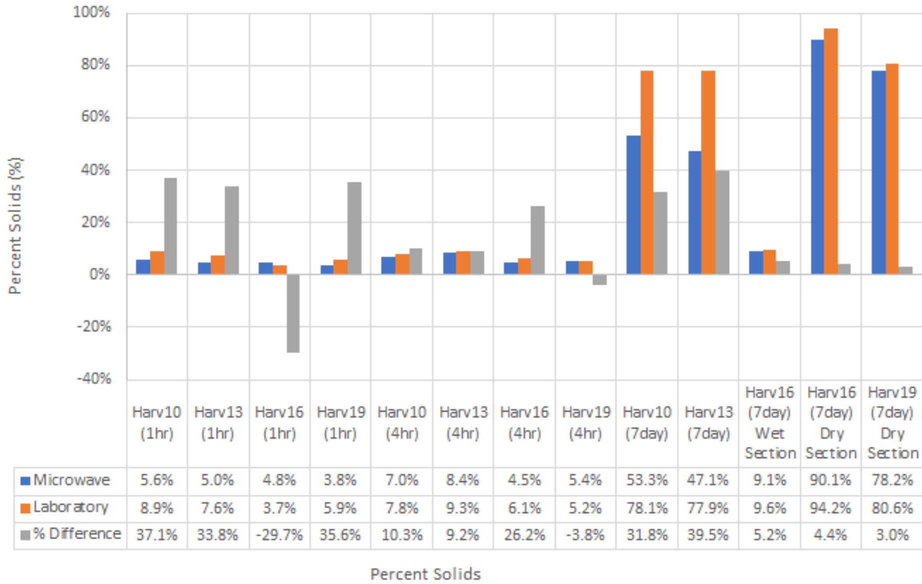
Figure 3-8
Post-Harvest Percent Solids from Harvest and Dewatering Channel – Microwave Method



	1-Hour	4-Hour	1-Day	4-Day	5-Day	6-Day	7-Day (Composite)	7-Day A (Dry section)	7-Day B (Wet section)
Harvest_July 18, 2019	5.6%	7.0%	13.5%				53.3%	94.1%	22.7%
Harvest_August 8, 2019	5.0%	8.4%	9.6%				47.1%		
Harvest_August 29, 2019	4.8%	4.5%	9.5%		34.2%	73.0%		90.1%	9.1%
Harvest_September 19, 2019	3.8%	5.4%	9.9%	46.4%	71.9%	89.1%		78.2%	

Time Post Harvest

Figure 3-9
Post-Harvest Percent Solids from Harvest and Dewatering Channel – Microwave Versus Laboratory Method



3.3.1 Sand Filter Performance

The water draining down the harvest and dewatering channel and collecting in the small containment area was collected after about 1 hour. A turbidity meter reading was taken in nephelometric turbidity units (NTUs), and then the water was put into the sand filter (constructed as part of Phase 3) for secondary recovery of fine solids and to meet turbidity standards for discharge water. A turbidity meter reading was also taken of the discharge water from the sand filter.

Turbidity of the input water to the sand filter exceeded the range (greater than 1,000 NTU) of the meter for three out of the four testing weeks. It was 442 NTU during the 1 week a reading was obtained. Output water from the sand filter ranged from 79 to 196 NTU over the 4 testing weeks.

3.4 Other Testing and Observations

3.4.1 Variation of Biomass in Different Samples

During Phase 4, a question was raised about potential variability of the biomass in different field samples collected from the same harvest material. As described in Section 2.2, typical harvest procedures included manually severing the algae from the flow-way and pushing the material from the top to the bottom of the flow-way into a sump area. Laboratory samples were then collected from the sump area for analytical testing of the representative TS for the entire flow-way harvest. The surge and continuous flow-ways were harvested and sampled separately.

During Harvest 11 on July 25, 2019, after the harvest material for each flow-way was squeegeed into the sump area, several independent grab samples of the harvest material were collected from the sump area to evaluate the general variation in laboratory results for TS for separate field samples from the same batch of harvest material.

Figures 3-10 and 3-11 show the variation of TS results from the different field samples collected of the same harvest material for the surge and continuous flow-ways, respectively. The surge flow-way TS results varied from 47,000 to 56,000 mg/L, with a mean of 52,750 mg/L. All results were within one standard deviation. Three of the four results were less than 7% from the mean value, and one was approximately 11% from the mean. The continuous flow-way TS results varied from 31,000 to 40,000 mg/L, with a mean of 37,400 mg/L. All these results were also within one standard deviation. Four of the five results were less than 7% from the mean value, and one was approximately 17% from the mean.

Figure 3-10
Harvest 11 – Surge Flow-Way Four Sample Comparison

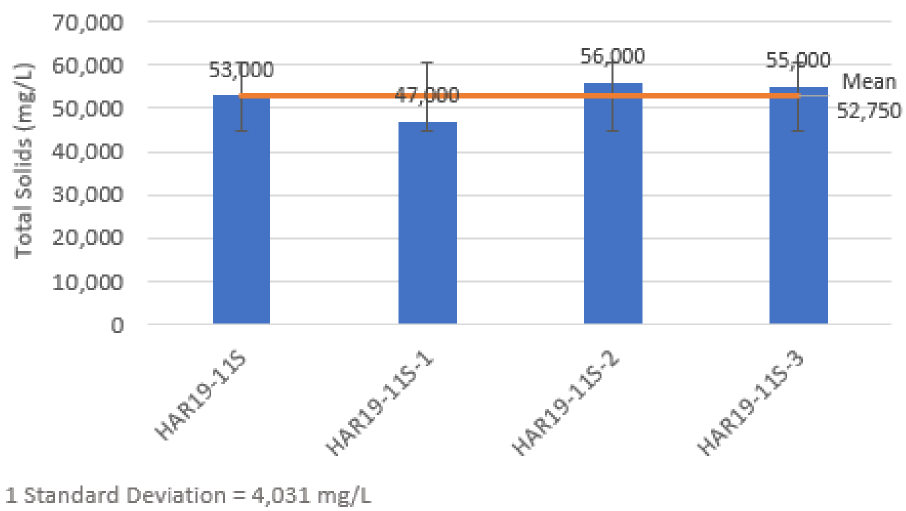


Figure 3-11
Harvest 11 – Continuous Flow-Way Five Sample Comparison

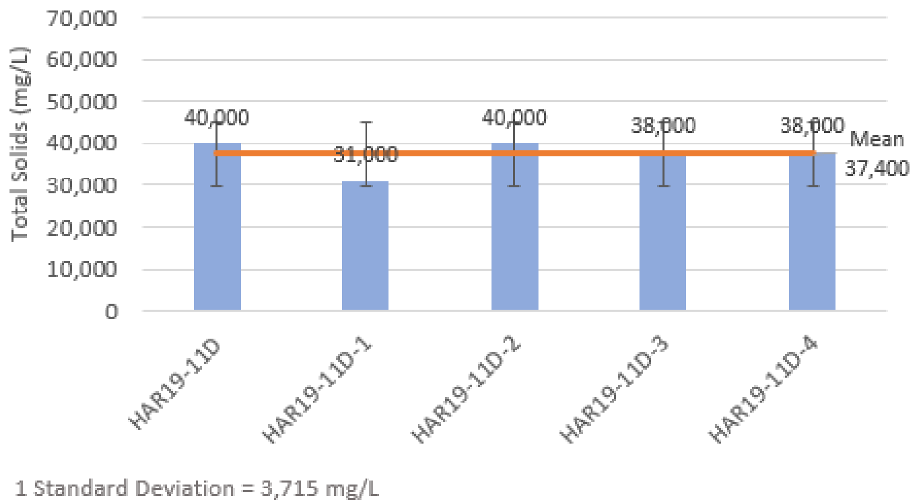
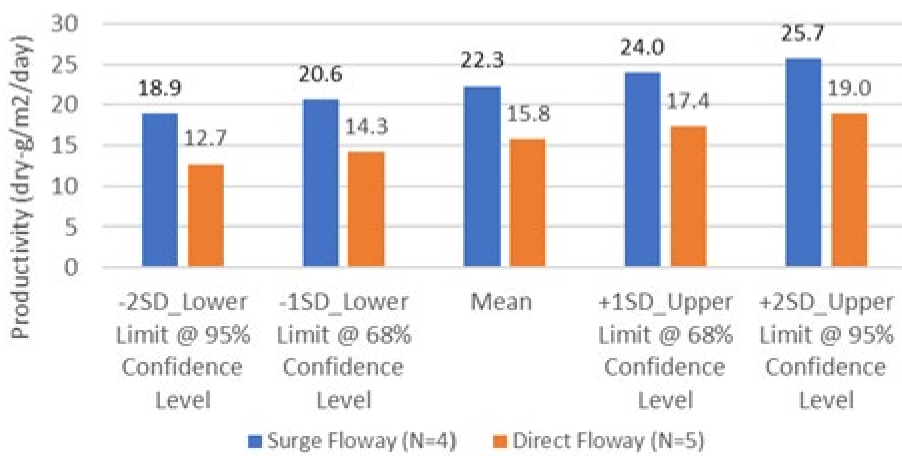


Figure 3-12 shows the resulting range of productivities based on the variation of TS results from the different field samples collected, with a 68% and 95% confidence level, calculated using an average wet weight of harvest material per flow-way of 750 pounds during Phase 4.

Figure 3-12
Surge and Continuous Flow-Way Sample Variation Analysis



3.4.2 Nutrient Content of Filamentous Green Algae Versus Diatoms

During Phase 4, another question was raised about potential differences in the nutrient content of the biomass of filamentous green algae versus diatoms. For most of the study period, diatoms dominated the flow-ways. However, there was some observed growth of filamentous green species in small patches. Furthermore, in previous years, the filamentous green algae were more prevalent. If the system were more dominated by filamentous green algae, the biomass harvesting and handling procedures would be very different and could be more similar to large-scale flow-way operations, such as those in Florida. Additionally, questions were raised about how the different algal species impact the general effectiveness of the flow-way system to remove nutrients from the inflow water.

During Harvest 17 on September 5, 2019, and Harvest 21 on October 3, 2019, specific areas of the flow-way were identified containing filamentous green algae and diatoms. Samples of each type of algae were collected for laboratory analysis of the TN and TP content of the biomass to compare the nutrient content of the two competing algae types. The filamentous green sample was collected from various small patches near the top of the flow-way (in the first 20 ft from inflow). The diatoms were collected from a patch in that same general area (Figures 3-13 and 3-14).

Figure 3-13
Example of Filamentous Green Algae Material Collected for Sample

Figure 3-14
Example of Diatom Material Collected for Sample

The nutrient content for each type of algae collected can be seen in Figures 3-15 and 3-16. During Harvest 17, the TN and TP content of the filamentous green algae was 2.7% and 0.23%, respectively. The TN and TP content of the diatom algae was 1.0% and 0.13%, respectively. The filamentous green biomass therefore contained a greater concentration of both TN (2.7 times higher) and TP (1.8 times higher) than the diatom biomass. As a comparison, the TN and TP content for the entire flow-way biomass samples on this date were 1.4% and 0.14% for the surge flow-way and 1.9% and 0.15% for the continuous flow-way.

Similarly, during Harvest 21, the TN and TP content of the filamentous green algae was 1.7% and 0.76%, respectively. The TN and TP content of the diatom algae was 1.1% and 0.25%, respectively. The filamentous green biomass therefore contained a greater concentration of both TN (1.5 times higher) and TP (3.0 times higher) than the diatom biomass. TN and TP content for the entire flow-way biomass samples were not collected on this date.

Figure 3-15
Tissue Percent Nitrogen

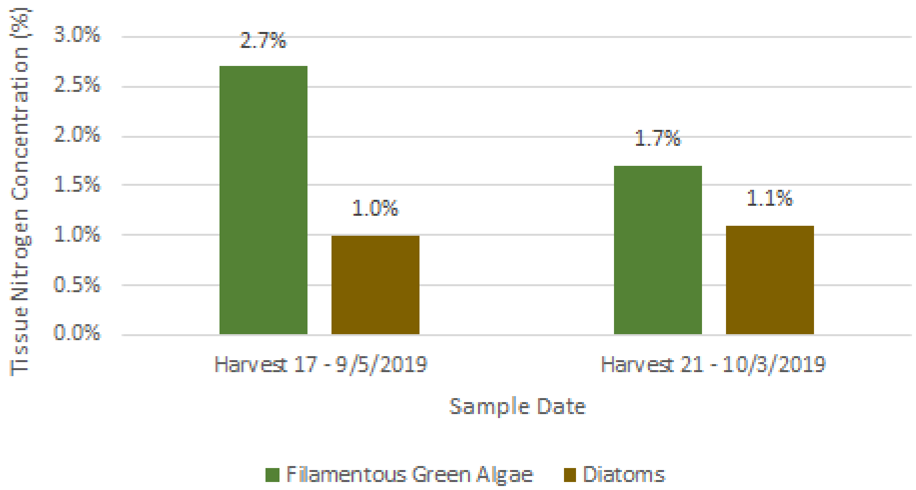
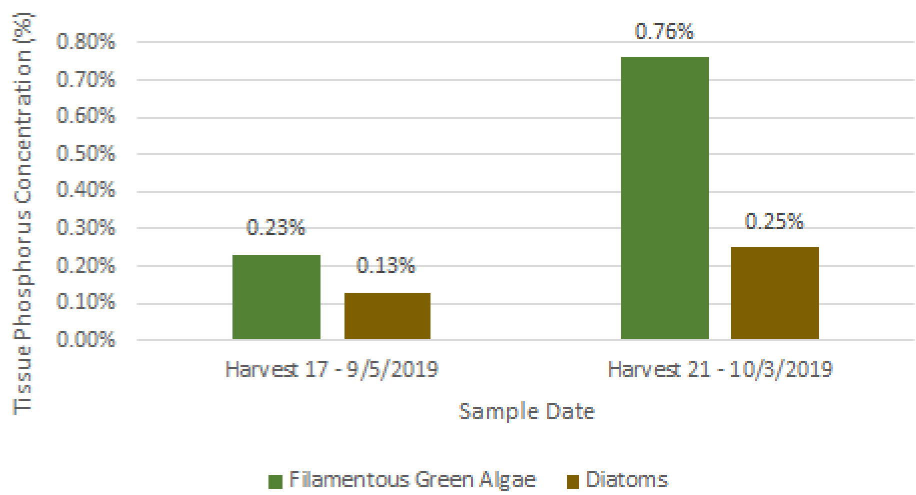


Figure 3-16
Tissue Percent Phosphorus



4 Algal Digester Testing and Biodiversity

The goal of algal digester testing for the MARAD Phase 4 project was to observe how fluctuations in biomass production from the algal flow-ways over three growing seasons impacted the production of biogas. Similar to previous phases of the project, algae biomass harvested from the algal flow-ways was used as feedstock to the digesters (Anchor QEA 2018). Anaerobic digestion (AD) of the algal biomass produced biogas, whose volume was measured in the field and quality was measured in the laboratory. The experimentation was completed between June and October 2019.

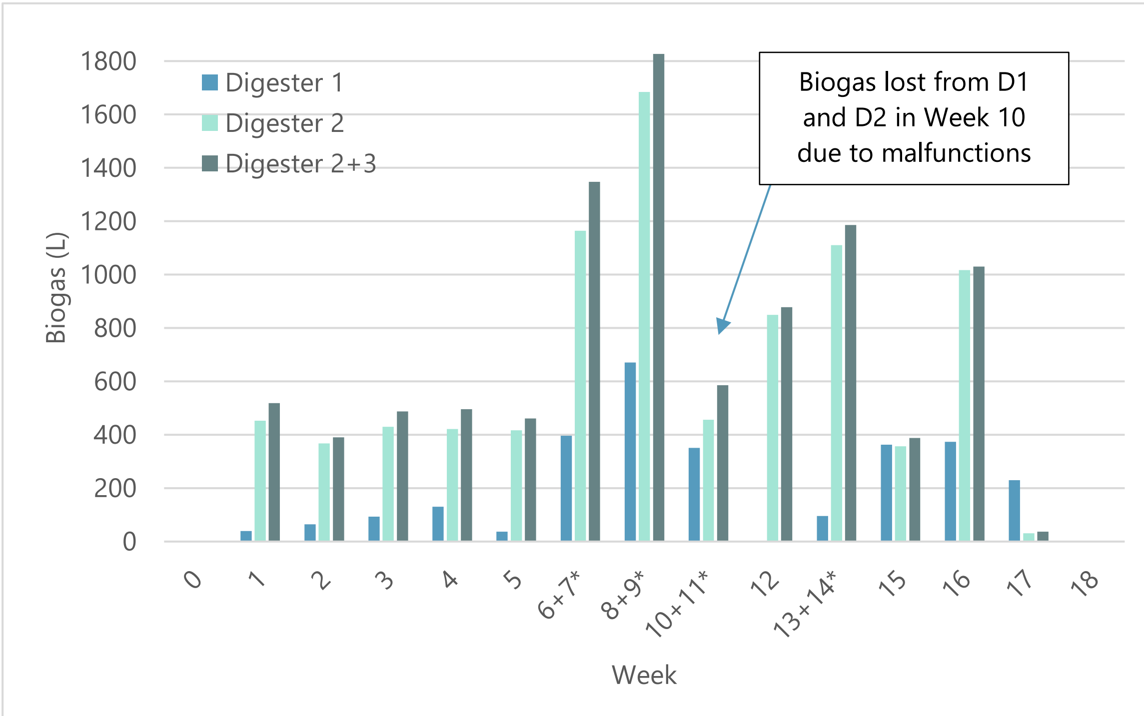
This section summarizes the results of algal digester testing as well as results from an algal biodiversity evaluation. Appendix A contains additional laboratory data from 2018 operation. Data from the 2017 flow-way digestion trials and lab-based AD results can be found in Witarsa et al. (2020).

4.1 Investigation 4: Energy Production from Harvested Algal Biomass Using Anaerobic Digestion

4.1.1 Biogas Production

A total of 12,630 L of algal biomass was supplied to the digesters as feedstock during the 18 weeks of digester operation; D1 received 6,465 L and the D2-D3 system received 6,170 L. Digestion of this algal biomass produced 12,550 L of biogas, which included 2,845 L, 8,758 L, and 951 L from D1, D2, and D3, respectively. Biogas produced from D1 had the highest concentration of methane (CH_4), with an average of 71.9 ± 1.3%. The percent CH_4 in the biogas from D2 and D3 were similar, with averages of 68.6 ± 2.4% and 67.7 ± 2.9%, respectively. The D2-D3 system produced the highest volume of biogas due to gas leaks from D1 limiting gas production in Weeks 1 to 9 (Figure 4-1).

Figure 4-1
Total Biogas Production per Week



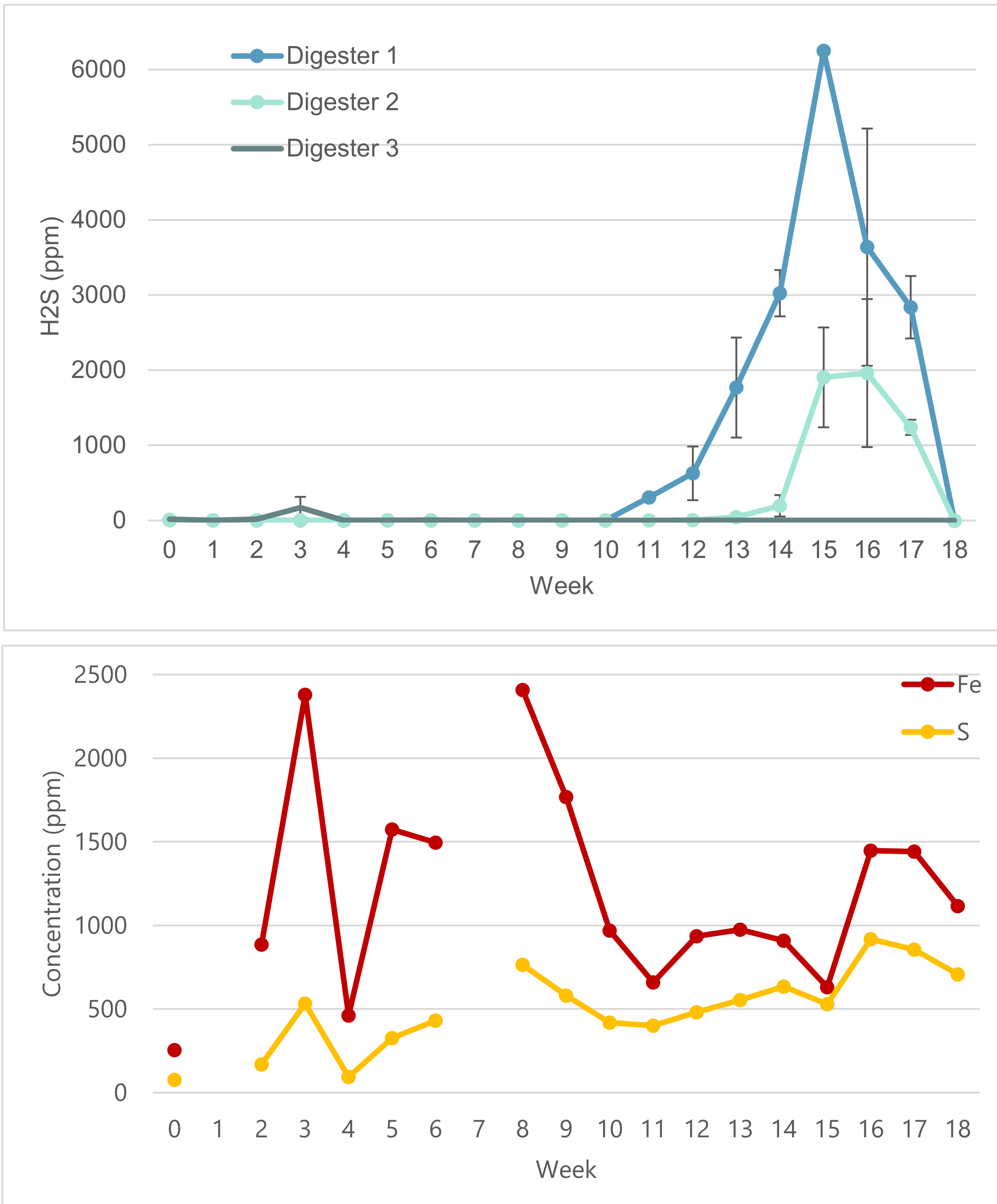
D1 and D2 both suffered structural damage during a windstorm over the 2018 to 2019 winter and were repaired in May 2019. It appears that these repairs were insufficient to maintain a completely airtight seal on D1, which caused a slow leak. Resealing was performed biweekly throughout the remainder of the study, and by Week 11 repairs were successful in preventing further biogas loss. D2 operated normally for 10 weeks until the end of August 2019, when a fluid leak occurred that resulted in the loss of most of the digester contents. The D2 digester was reinoculated in Week 11 and recovered biogas production before another leak occurred in Week 18 of operation in mid-October 2019. At that time, D2 and D3 were decommissioned. Additionally, minor leaks in D2 occurred between Weeks 13 and 15, resulting in limited effluent available for chemical analysis.

The D2-D3 system produced the highest concentrations of CH_4 even after normalizing the CH_4 data by volume of algae fed and mass of volatile solids (VS) contained in the algae. On average, the D2-D3 system produced 1.14 ± 0.23 L CH_4/L algae and 157 ± 38 L CH4/kilogram (kg) VS. The D1 digester produced 0.35 L CH_4/L algae and 40.5 L CH_4/kg VS. Highest production in all three systems was observed in Weeks 9 and 16.

4.1.2 Biogas Quality

Hydrogen sulfide (H_2S) is a common byproduct of the AD process, as sulfur (S) compounds in the feedstock are metabolized by bacteria. The produced H_2S is a human health concern and corrosive to equipment, and therefore, should be scrubbed from biogas prior to use to prevent damage to equipment. H_2S was found to increase in biogas after Week 10 (Figure 4-2, top panel). A common pretreatment method used by AD operators is the addition of iron (Fe) compounds to the feedstock or digestate prior to processing. H_2S readily bonds with Fe to form solid precipitates that are easily flushed out with the digester effluent, thereby reducing H_2S in the resulting biogas. A major goal of Phase 4 was to determine if a correlation existed between dissolved Fe and S concentrations in the algal influent and H_2S concentration in the biogas from AD.

Figure 4-2
Hydrogen Sulfide Content of Biogas and Corresponding Iron and Sulfide Content of Algal Influent



To attempt to explain the increase in H_2S content in biogas, samples of algal influent were collected weekly and analyzed for minerals and heavy metals. Analysis of the algal influent suggests similar trends in Fe and S concentration, with initially low levels (less than 500 parts per million [ppm]) of both elements early in the study, before Fe rose rapidly to a peak of 2,380 ppm in Week 3 (Figure 4-2, bottom panel). The Fe levels fluctuated between 462 and 2,408 mg/L between Weeks 4 and 10, but always remained higher than the concentration of S. The higher Fe concentration compared to the S concentration led to negligible H_2S detected in the biogas between Weeks 1 and 10 (Figure 4-2, top panel), as the dissolved S bound with Fe before it could be metabolized into H_2S. This low concentration of H_2S in the biogas was similar to levels observed during Phases 2 and 3 of the MARAD project.

When Fe levels started to decline after Week 10, a corresponding increase was observed in the concentration of S. As the two concentrations equalized, the concentration of H_2S in the biogas began to increase rapidly (Figure 4-2, top panel). This was likely due to the buffering capacity of the Fe being insufficient to bind the S in the influent, leaving sufficient free dissolved S for microbes to metabolize into H_2S. The peak of H_2S generation in Week 15 (6,250 ppm) corresponded to the lowest Fe concentration observed since Week 4 (630 mg/L) with an almost equal concentration of S (529 mg/L). H_2S in the biogas began to decline after this peak, as the Fe concentration began to rise again. S concentration began to rise as well, but the increase in Fe was more rapid, which was sufficient to restore buffering against H_2S generation until the end of the study. These results support the hypothesis that Fe and S concentrations in the algal influent were correlated to H_2S concentrations in the biogas resulting from digestion.

4.1.3 Nutrient Transformation

An unusual feature of biogas produced during Phase 4 was its relatively high nitrogen gas (N_2) content. N_2 is an inert component of biogas that is typically only a small fraction of the biogas mixture. During Phase 4, N_2 composed 10% to 20% of the biogas. To investigate this, samples of algal influent and digester effluent were analyzed for ammonium (NH_4), TKN, and TP (Table 4-1).

NH_4 was lowest in the algal influent and highest in the effluent from D3, which was expected because the AD process mineralizes NH_4 from the organically bound nitrogen in the algal biomass. It is expected that the system with the longest hydraulic retention time would have the highest NH_4 content. TKN was highest in the algal influent but declined during digestion, with the lowest TKN observed in effluent from D3. In Phase 3, this was attributed to potential solids settling in the unmixed digesters, but in Phase 4 only D3 remained unmixed. With the high N_2 content of the biogas, this suggests that another process is processing nitrogen to N_2 gas. TP was highest on average in D2 and lowest in D3, with no clear trend observed in TP concentration between the influent, D1, and D2. Because D1 and D2 were well mixed, the lower TP in the D3 effluent may be due to solids settling in D3 rather than removal through other means.

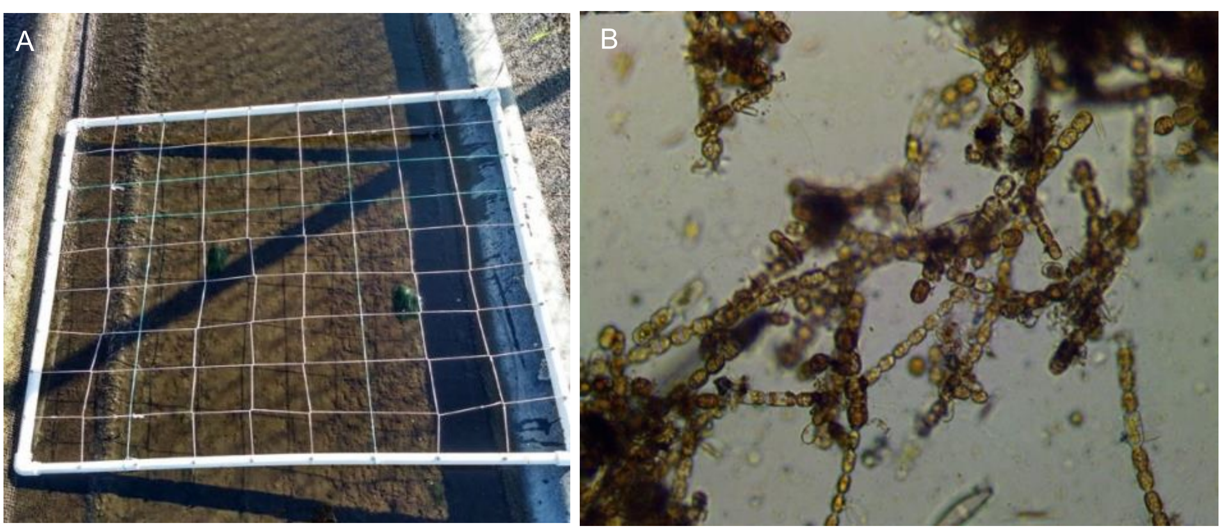
Table 4-1
Summary of Nutrient Analysis of Algal Influent and Digester Effluent

Source	NH_4 (mg N/L)	TKN (mg N/L)	TP (mg/L)
Algal influent	234 ± 18.7	794 ± 63.0	139 ± 15.2
D1 effluent	344 ± 22.1	675 ± 78.1	108 ± 15.6
D2 effluent	330 ± 23.2	661 ± 88.6	157 ± 41.9
D3 effluent	304 ± 23.6	363 ± 48.0	57.7 ± 15.4

4.2 Algal Biodiversity

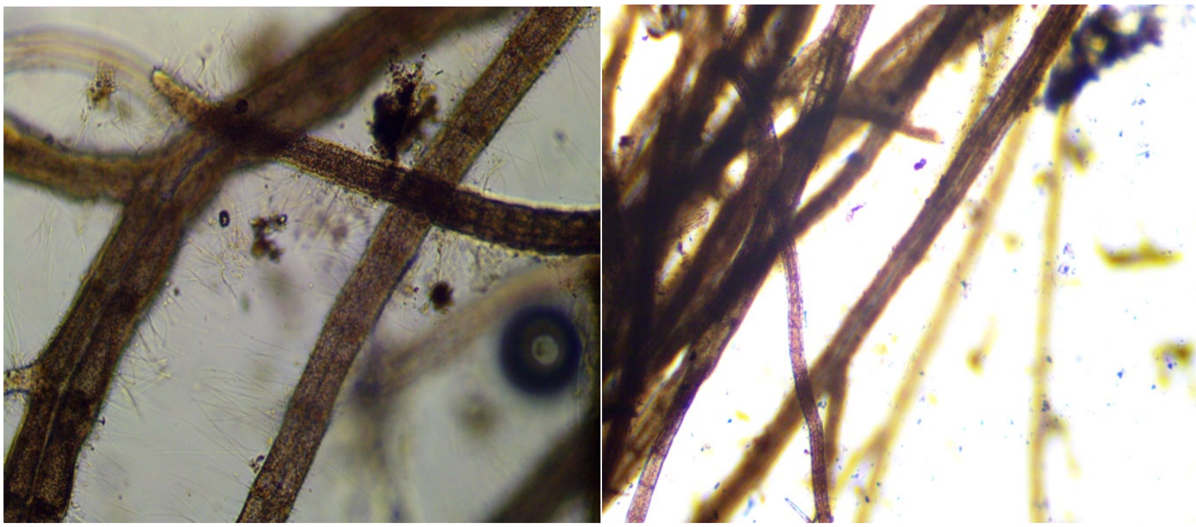
Algal biodiversity on the two flow-ways was evaluated by overlaying a 1-square-meter (m^2) quadrat divided into decimeter subunits to determine percent cover and dominant species (Figure 4-3a). Subsamples of alga of interest within the quadrat and alga of note along the flow-ways were taken to the laboratory for lowest level taxonomic determination through microscopy. The filamentous diatom *Melosira* sp., being the pioneer species of algae initially colonizing the algal flow-ways, remained the dominant alga on the algal flow-ways throughout the study, regularly forming a mat 3 to 10 millimeters (mm) thick on the flow-way screen. Thick and even *Melosira* growth was typically observed within the first 20 meters (m) of each flow-way, although the genera dominated throughout the entire length of both flow-ways during the entire operational period (Figure 4-3). Several other genera also developed within the *Melosira* algal turf during the operational period, including the red algae *Rhodocorton*, which grew in dense, hair-like clumps (Figure 4-4).

Figure 4-3
Sampling Quadrat (A) and Microscope Image of Melosira (B)



Notes:
The sampling quadrat photo was taken on October 10, 2019.
The *Melosira* sample was collected from the algal flow-way on September 12, 2019. The magnification shown is 100x.

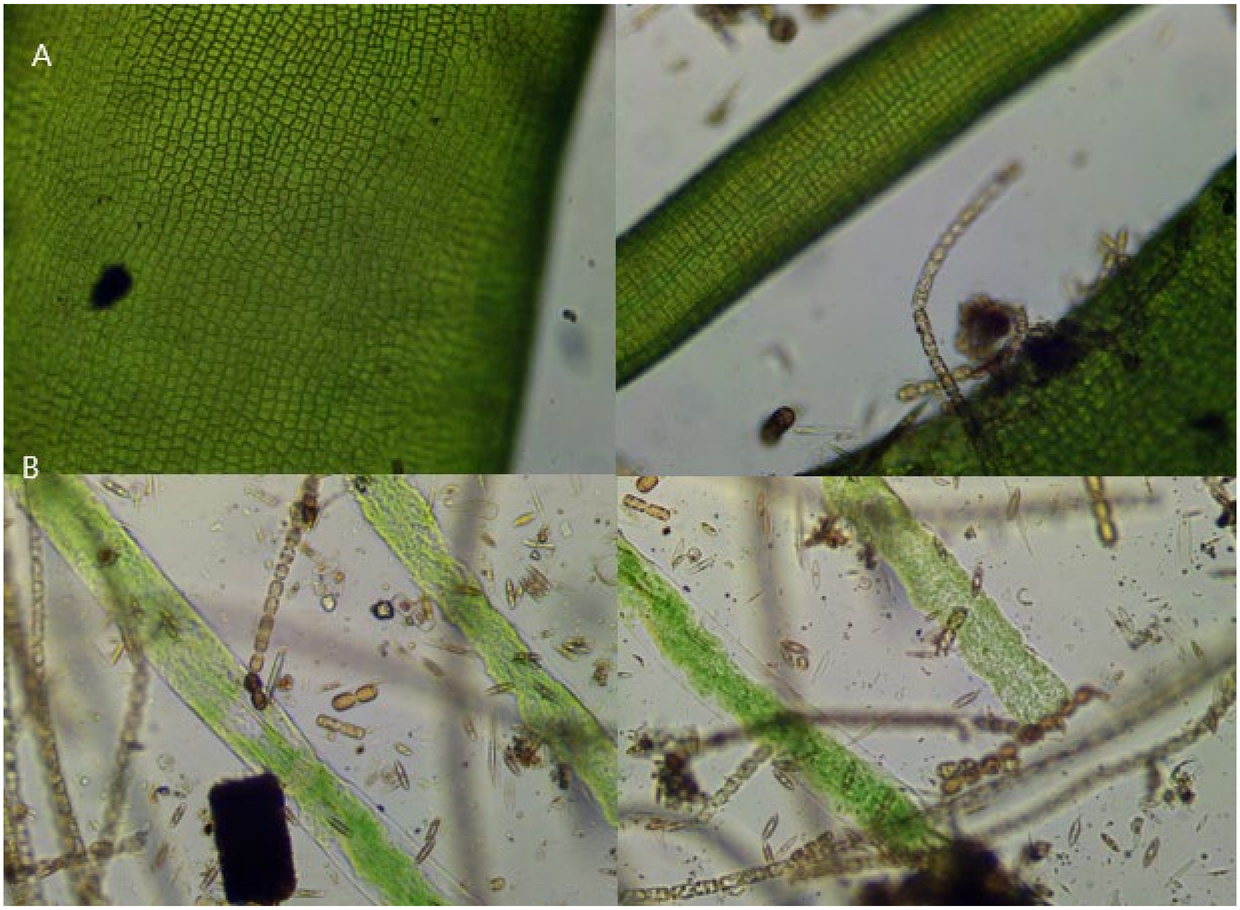
Figure 4-4
Microscopic Image of *Rhodocorton*



Note:
The *Rhodocorton* sample was collected from the algal flow-way on September 19, 2019.

The green algae *Ulva intestinalis* was also observed in the upper discharge area of each flow-way and the middle portions (1 to 40 m) of the flow-ways, typically growing in small clusters of fleshy filaments on top of the *Melosira* mat. This genera's characteristic tube-like thallus was not typically observed due to the short growth time of 7 days before harvest (Figure 4-5A). A second green alga, *Vauceria* sp., was also observed growing inside the *Melosira* mat in August and September along the lower third (40 to 60 m) of the flow-way. It was visible as fine, delicate, neon-green filaments evenly distributed in patches over the surface of the *Melosira* strands in this area of the flow-way (Figure 4-5B).

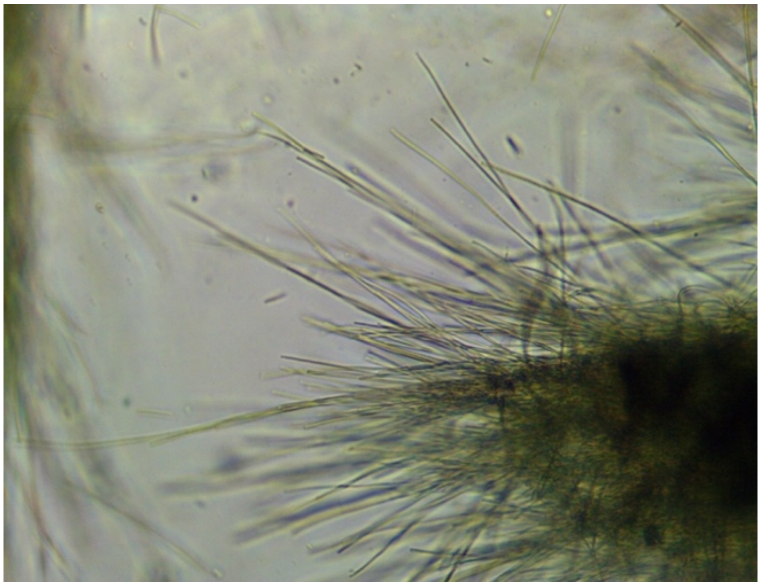
Figure 4-5
Microscopic Image of *Ulva intestinalis* (A) and *Vauceria* (B)



Notes:
The *Ulva intestinalis* sample was collected from the algal flow-way on September 12, 2019.
The *Vauceria* sample was collected from the algal flow-way on September 19, 2019. Note that green filaments are mixed with brown *Melosira* filaments.

Blue-green algae were observed infrequently throughout the Phase 4 growth season. Cyanobacteria, or blue-greens, are facilitated by high nutrients and temperatures and colonize on dead or otherwise disturbed algae growth. An early season (June 6, 2019) unanticipated system shut-down due to pump failure caused an algal die-off, which may have provided a source of necrotic algae for the cyanobacteria to feed on. Higher nutrient loads from spring and early summer rains, in addition to a mid- to late-summer drought with high temperatures, may have facilitated cyanobacteria's emergence. While their presence may be expected in small background numbers, small to moderate colonies were detected in the weeks after storm, flooding, and wind events that disrupted the regular *Melosira* growth, providing conditions for cyanobacteria emergence. When cyanobacteria did occur, they were most commonly observed in the lower two thirds (20 to 60 m) of the algal flow-ways as dark green clusters in areas of sparse *Melosira* (Figure 4-6).

Figure 4-6
Microscopic Image of *Oscillatoria*



Note:
The *Oscillatoria* sample was collected from the algal flow-way on September 26, 2019.

5 Project Findings

The objectives of Phase 4 were to investigate methods to: 1) increase algal productivity; 2) increase recovery efficiency of diatom-dominated harvested solids; and 3) increase percent solids of the harvested algae to improve systems operations and operating efficiency of the algal digesters. Two investigations, surge versus continuous flow testing and flow-way surface material testing, involved observing if variations in flow-way system design would result in a quantifiable increase in algal productivity or allow for more efficient operations and/or reduced capital and operating costs.

One additional investigation, harvest and dewatering channel testing, involved observing if an alternate biomass recovery and handling procedure would increase percent recovery of the diatom-dominated harvest, and increase the percent solids of the harvested algae without bypassing substantial biomass for recovery into the secondary biomass recovery system (e.g., sand filter). The results of these investigations were considered to recommend methods to optimize the design and operation of the algal flow-way system and potential scale-up at the Port of Baltimore.

Modifications to the flow-way system were completed to pursue these investigations, including construction of two adjacent parallel and separated flow-ways, installation of various flow-way surface materials, and construction of an adjacent dewatering channel parallel to the flow-way. Testing and sampling procedures were developed to support the investigations, and data were collected weekly over the 24 weeks of harvest.

Other testing and observations were also made throughout the course of Phase 4 to help inform the design and operation recommendations for future flow-way and digester systems. Water quality data were collected at the project site to evaluate flow-way productivity as well as at a potential future project site in the Baltimore Harbor to assess if source water for a system in that location is comparable to the current project site. Specific recommendations for algal flow-way and algal digester design and operation based on Phase 4 are detailed below.

5.1 Algal Flow-Way Design and Operation

5.1.1 Investigation 1: Surge Versus Continuous Flow

Based on the data collected during Phase 4, no significant correlation was found between surge versus continuous flow impacting system productivity. There was no quantifiable difference in the algal productivity of the surge inflow compared to the continuous inflow. The mean flow-way productivity of the surge flow-way versus the continuous flow-way was nearly identical for the weeks when this was the only investigation performed (12.4 grams dry per square meter per day [dry-g/m^2/day] for both flow-ways). Considering all harvest weeks, the mean productivity of the surge flow-way (14.7 dry-g/m^2/day) was slightly higher than the mean of the continuous flow-way (14.1 dry-g/m^2/day), but only by about 4%. Productivities determined by surface material subplots were slightly higher for all subplots on the continuous flow-way than the corresponding subplots on the surge flow-way, but these differences were less than 6%. In addition, throughout the course of the project, no major differences in algal community type were observed on the surge versus the continuous flow-way. The results of this testing may be different under different water quality conditions such as changes in nutrient or salinity concentrations, or time of continuous flow-way operation.

A larger flow-way system should be value engineered to consider if the potential increased productivity or potential difference in algal community type that could occur under different water quality conditions are worth the extra investment in infrastructure required to provide pulsed inflow. Based on the environmental conditions that occurred during Phase 4, no quantifiable difference in algal productivity was observed due to pulsed flow.

5.1.2 Investigation 2: Flow-Way Surface Material

Based on the data collected during Phase 4, a defined relationship between flow-way surface material and productivity was not consistently observed on a week-to-week basis over the course of the project. In terms of the calculated mean productivity for each subplot area over the entire testing period, slightly higher productivities were observed for all the subplots on the continuous flow-way than on the surge flow-way. Furthermore, mean productivity generally increased from Liner+Grid surface to Concrete+Grid surface to Concrete Only surface on each flow-way, but again not significantly.

In terms of the calculated mean productivity, the Concrete Only (roughened concrete) surface material had similar or better algal biomass productivity than the Liner+Grid and Concrete+Grid surface materials on the same flow-way; however, no substantial increase in algal productivity was observed for any of the surface materials tested.

Assuming that the results from Phase 4 would apply under other environmental conditions in other years of operation, a larger flow-way system should be value engineered to consider if the potential increased cost of roughened concrete surface material is worth additional capital investment to reduce the initial starting volume of harvest material and aid in biomass handling operations. Though the results of the surface material subplots in Phase 4 did not show significant differences in algal productivity, the roughened concrete subplot did show that a comparable amount of algal biomass is produced on the roughened concrete surface, and it is contained in a smaller starting volume of harvest material after the flow-way is allowed to drain prior to harvest. Other considerations include the potential soil improvements needed at the proposed site for installation of a roughened concrete surface versus a liner and grid on compacted earth. Heaving, which was experienced at this project site, or settlement, could cause damage to a concrete surface that would be more difficult to repair than an HDPE-lined surface.

5.1.3 Investigation 3: Harvest and Dewatering Channel

During Phase 3, different methods were evaluated for recovery and dewatering of the harvested algal biomass to a consistency that could be mechanically handled and transported. Several methods, including a sloped dewatering pad and an evaporation bed, were eliminated as not suitable or practical for a diatom-dominated flow-way system based on Phase 3 designs. The diatom-dominated solids at DMT and common in Chesapeake algal flow-ways consist of particles too small for standard ¼-inch bar screen harvesters employed as first-stage recovery on algal flow-ways where filamentous green algae dominate the algal community, so in Phase 3 wedge wire and sludge dewatering screens with approximate 500-µm openings were also investigated. First-stage solids recovery improved as described in previous reports; however, considerable solids continued to pass through to the sand filter second-stage recovery system.

Through an adaptive management process during Phase 3, a harvest and dewatering channel approach was recommended for further study. Phase 4 built upon this approach. A formal harvest and dewatering channel area was constructed, and harvest material was recovered and allowed to dewater in the channel over a 7-day period. The Phase 4 study allowed observation of the behavior of the harvested algal biomass over time in the harvest and dewatering channel and refinement of expectations for handling operations of a larger flow-way system.

Challenges were encountered with this investigation, including land heaving that progressively changed the slope of the harvest and dewatering channel bottom and led to poor drainage in some areas and inconsistent moisture conditions of the drying material. However, based on the data collected during Phase 4, the harvest and dewatering channel as a first-stage solids recovery approach was generally confirmed as an effective approach for recovering harvested solids without losing or bypassing substantial biomass to the second-stage recovery system (sand filter) while efficiently increasing the percent solids of the harvested algae material.

Initial water draining from the harvested material down the harvest and dewatering channel accounted for about half of the total harvest weight. That drain water contained about 2% to 17% of the total DW of harvested biomass. Phase 3 had similar results for the drain water at 6% to 16% of the total DW of harvested biomass. Thus, less than 20% of the DW of algal biomass would bypass the first-stage biomass collection process, and those solids would be captured by a downstream second-stage sand filter or settling pond in a larger flow-way system.

The algal biomass remaining in the harvest and dewatering channel had a mean of approximately 6% TS within 1 hour and increased slightly to approximately 7% TS at 4 hours, compared to an average of about 3.0% to 3.8% TS for material harvested directly into a sump area for collection without dewatering. The algal biomass in the harvest and dewatering channel further increased to mean of approximately 11% TS in 24 hours and 53% TS in 5 days. Furthermore, after 7 days, the harvested material in the harvest and dewatering channel (in the areas with more consistent slope and positive drainage) was dried to a mean of approximately 88% TS.

Based on field monitoring of the condition of the harvested material in the harvest and dewatering channel over the 7-day cycle, the material in areas with consistent slope and positive drainage was generally dry enough to be mechanically handled and collected in 3 to 4 days, depending on weather conditions. The material would be approximately 50% TS at this time. The suitable moisture content for handling algal material is dependent on the type of algae, filamentous greens or diatoms, and on the desired end use of the biomass product (digester, composting, stockpiling, or off-site disposal). The diatom-dominated biomass harvested during Phase 4 had a consistency of and behaved more like a sludge at less than 15% TS, and it became more manageable as a solid mass at 30% to 50% TS.

A larger flow-way system should be designed with flexibility for biomass handling operations that are appropriate for a diatom-dominated system, as was experienced during Phase 3 and Phase 4, as well as a filamentous green-dominated system. A harvest and dewatering channel approach would accomplish that flexibility and addresses the challenge of increasing the solids content while reducing the volume of harvested biomass, and it does so passively in an offline channel where material could be mechanically collected at any time when the material is deemed adequately dry to transport. Type of algae and end use of the biomass product will impact the proposed mechanics of harvesting and managing solids, and the moisture content at which they should be removed from the harvest and dewatering channel. The dynamics of algal solids in a harvest and dewatering channel based on the pilot scale project (3-ft-wide flow-way, 1-ft-wide dewatering channel) and a much larger scale project would need to be considered.

If more immediate monitoring results for dryness of the material in the harvest and dewatering channel (beyond physical inspection) are desired, based on Phase 4, the desktop microwave drying procedure for determining percent solids must be further evaluated. This information could be useful for an operator to determine when to collect material from the harvest and dewatering channel, and the microwave drying procedure would give a result in minutes versus waiting weeks for a laboratory sample analysis to be processed. However, percent solids results from the microwave drying procedure in Phase 4 were typically 10% to 40% lower than the laboratory results for the comparable sample when biomass was less than 10% solids. The cause of this difference was not identified. For biomass that was above 75% solids, the microwave drying procedure results were less than 5% lower than the laboratory results for the comparable samples. To further evaluate this, a laboratory testing program is recommended to be set up to create split samples, with one part undergoing the microwave drying procedure and one undergoing the laboratory’s typical percent solids drying process at the same time.

5.1.4 *Other Testing and Observations*

Based on a single iteration test during Phase 4, the variation of biomass from different field samples of the same flow-way harvest material was examined. The lowest to highest TS values from the independent grab samples of the same harvest material were 4.7% to 5.6% (with a mean 5.3%) for the surge flow-way and 3.1% to 4.0% (with a mean 3.7%) for the continuous flow-way. The calculated difference in DW productivity at the 68% and 95% confidence level based on the variation of TS results and an average wet weight of harvest material per flow-way of 750 pounds during Phase 4 is shown in Figure 3-12. Sample collection methods, representative sampling, and potential variability in results may become more critical with larger harvest volumes from a larger flow-way system.

The differences in nutrient content of filamentous green algae versus diatoms were significant. Based on two iterations of sampling, the filamentous green algae biomass had 1.5 to 2.7 times more TN content and 1.8 to 3.0 times more TP content than the diatom biomass. If the cost effectiveness of a larger flow-way system on improving water quality is based on a diatom-dominated system, that would be a conservative approach, and effectiveness would increase when it switched to a more filamentous green-dominated system.

5.2 Algal Digestion Operation

5.2.1 *Investigation 4: Energy Production from Harvested Algal Biomass Using Anaerobic Digestion*

After 4 years of experimentation, it can be concluded that flow-way produced algae from the Patapsco River is a viable feedstock for AD. The biogas produced from AD of algae was comparable in CH_4 content to biogas derived from more traditional digestion feedstocks, with notably lower H_2S production due to the high Fe content of the feedstock. It should be noted that the algal flow-way biomass productivity is subject to variability yearly and seasonally due to precipitation, temperature, and salinity impacting algal seeding and growth, which subsequently impacts biogas production. When scaling the technologies, the size of the algal flow-way should be sufficient to provide regular feeding to the digester units or co-digestion with other substrates should be considered. It is also recommended that regular mixing of the digester units be utilized to reduce clogging. Active heating should be maintained especially to ensure proper biogas production. Continuous heating will minimize variability in biogas production and increase the reliability of renewable energy production from an algal flow-way and AD system.

For future work, use of a more durable digester design is recommended if the digestion units will be operated outside. The pilot-scale units from Puxin operated effectively during their first stages of operation, but they began to wear down quickly after the first season of overwintering. By the end of Phase 4, fluid and gas leaks were more frequent, with associated repair costs and downtime. While the initial price may be higher for a higher quality unit, it would ultimately save money over the lifetime of the unit due to increased reliability and reduced need for labor and supplies for repair. A digester supplier using standard pipe sizes and fittings is also recommended, as materials associated with the Puxin units were proprietary sizes and shipped from China, which incurred significant time and operating costs.

6 References

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Appendix A
Anaerobic Digestion of Algal Turf Scrubber Algae, University of Maryland

A.1 Introduction

Anaerobic digestion (AD) of the algal biomass grown on the algal flow-way at the Port of Baltimore was used to produce renewable energy in the form of methane (CH_4)-enriched biogas. Four experimental phases were completed between 2016 and 2020 to evaluate the feasibility of a combined algal flow-way/anaerobic digestion system. Phase I showed that the harvested algae could successfully produce biogas at batch-scale under controlled laboratory conditions, while Phases II-IV scaled up the experiments to evaluate continuous biogas production in three pilot-scale digesters over three growing seasons. Digesters 1 and 2 (D1 and D2) initially had an effective digestion capacity of 1700 L in Phases II and III, which was increased to 2000 L each in Phase IV, and Digester 3 (D3) had a 500 L capacity. These units were initially operated in series in Phase II, before being re-plumbed with D2 feeding D3 and D1 as a stand-alone unit in Phases III and IV to reduce the hydraulic retention time (HRT) of the system and allow replication of results between D1 and D2. Phase IV further refined the system design by implementing a combined recirculation-heating system in D1 and D2 to improve digestion efficiency. Information from Phases I and II are detailed in Witarsa et al. (2020).

A.2 Algae Digestion in Phase IV

Equation 1 was used to determine the amount to be fed to each system, with a resulting average HRT of 52 ± 9 days for D1 and 65 ± 12 days for the D2-D3 system over the complete study period.

Equation #1

$$\mathrm{Feed} = \mathrm{Harvest}/14 * \mathrm{x}$$

where:

Feed	=	Volume of algae to feed to digester (gal)
Harvest	=	Volume of algae harvested from the algal flow-way (gal)
x	=	Number of days before next feeding (for example, x=2 if feeding on Mon and then Wed and x=3 if feeding Tues and then Friday)

Biogas production was consistently higher in D2, while D1 produced a lower biogas volume than expected from Phase II and III operations. Since the loading rate and biogas composition was similar between the two digesters, it was concluded that the difference was due to persistent leaks in D1 between Weeks 1-10. The D2/D3 system produced the highest volume of CH_4 due to gas leaks from D1 limiting gas production in Weeks 1-9 (Table A.1).

Table A.1: Average biogas composition of Port of Baltimore digesters in Phase IV, Weeks 1-18.

	$\%CH_4$	$\%CO_2$	$\%O_2$	$\%N_2$
Digester 1	71.9 ± 1.3	18.1 ± 1.2	1.2 ± 0.7	10.3 ± 1.7
Digester 2	68.6 ± 2.4	14.9 ± 1.1	0.4 ± 0.2	16.8 ± 3.0
Digester 3	67.7 ± 2.9	10.6 ± 0.6	0.7 ±0.4	20.8 ± 3.0

Methane production data was normalized by liters (L) of algae fed and the kilograms (kg) of volatile solids (VS) contained in each liter of algae. After normalization by both metrics, biogas production was consistently highest in D2 and the D2/D3 system, even with the instability observed after Week 10. On average, the D2/D3 system produced 1.14 ± 0.23 L CH_4/L algae and 157 ± 38 L CH_4/kg VS. The D1 digester produced 0.35 L CH_4/L algae and 40.5 L CH_4/kg VS. Highest production in all three systems was observed in Weeks 9 and 16 (Figure A.1).

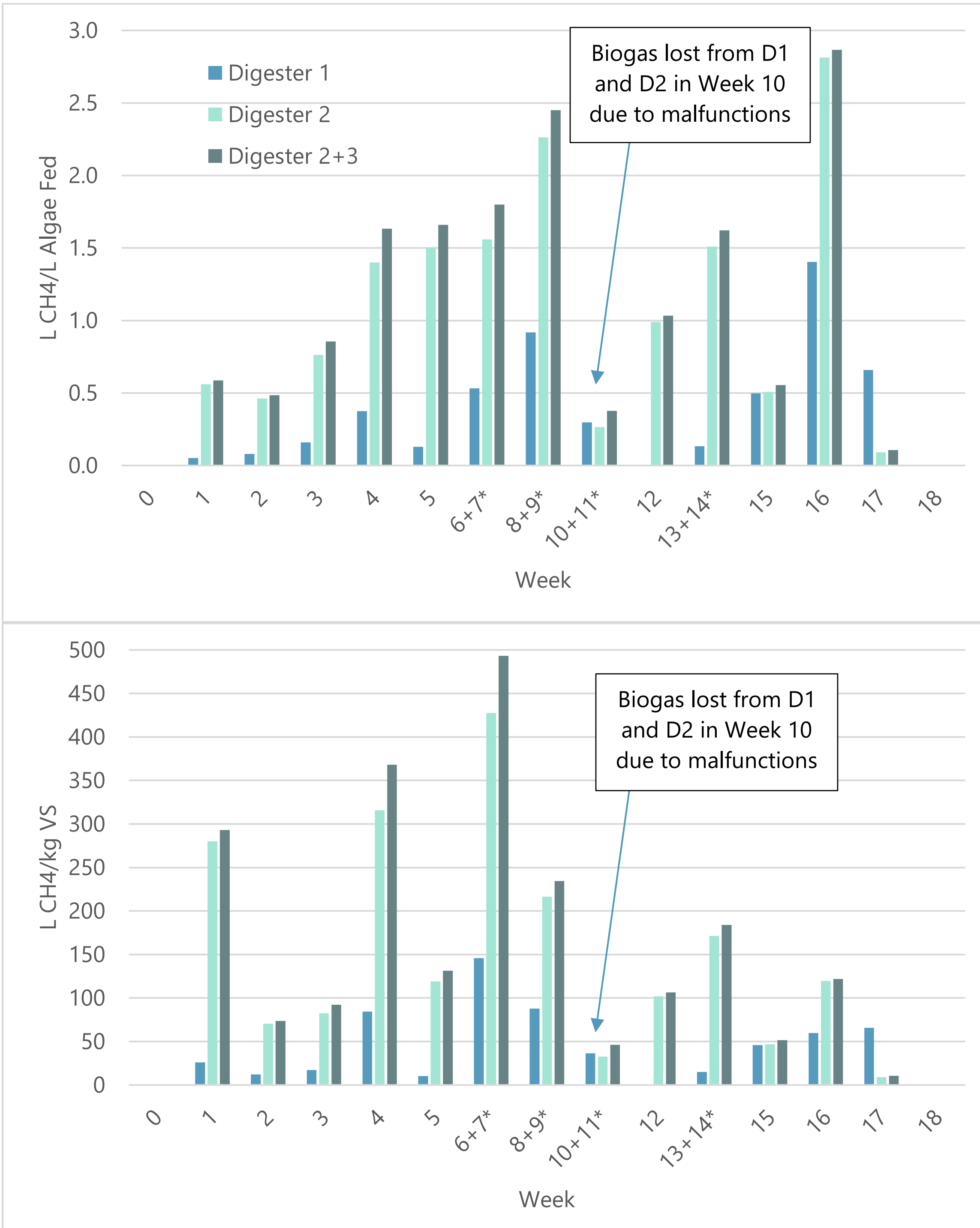


Figure A.1: Normalized methane production from the Port of Baltimore digesters in Phase IV, Weeks 1-18. *Biogas production from 2 weeks averaged due to biweekly sampling

A.3 Nutrient Transformations during Anaerobic Digestion

Ammonia was consistently lowest in the algal influent for the first 12 weeks of the study, which was anticipated since an increase in ammonia is expected during digestion. The increase in influent NH_4 concentration corresponded to an increase in total nitrogen in the influent during this time (Figure A.2). Total phosphorus (TP) was highest on average in D2 and lowest in D3, with no clear trend observed in TP concentration between the influent, D1, and D2. Since D1 and D2 were well-mixed in Phase IV, the lower TP in the D3 effluent may be due to solids settling in D3 rather than removal through other means (Figure A.3).

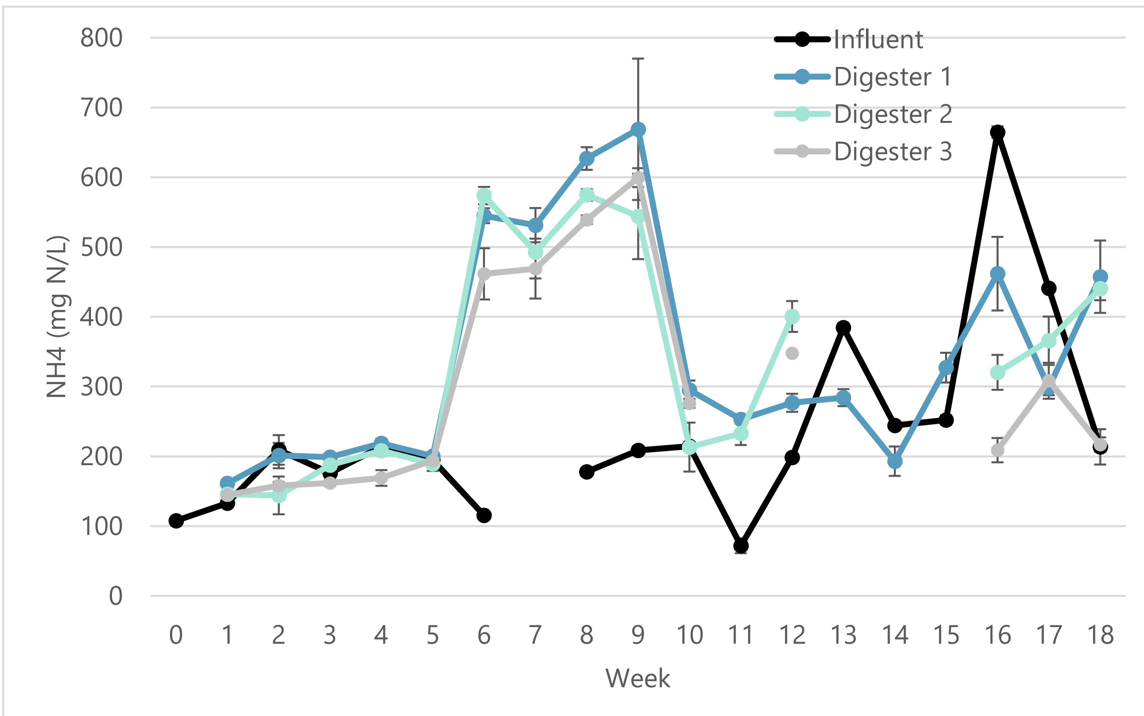


Figure A.2: Ammonium (NH_4-N) concentration in algal influent and digester effluent in Phase IV.

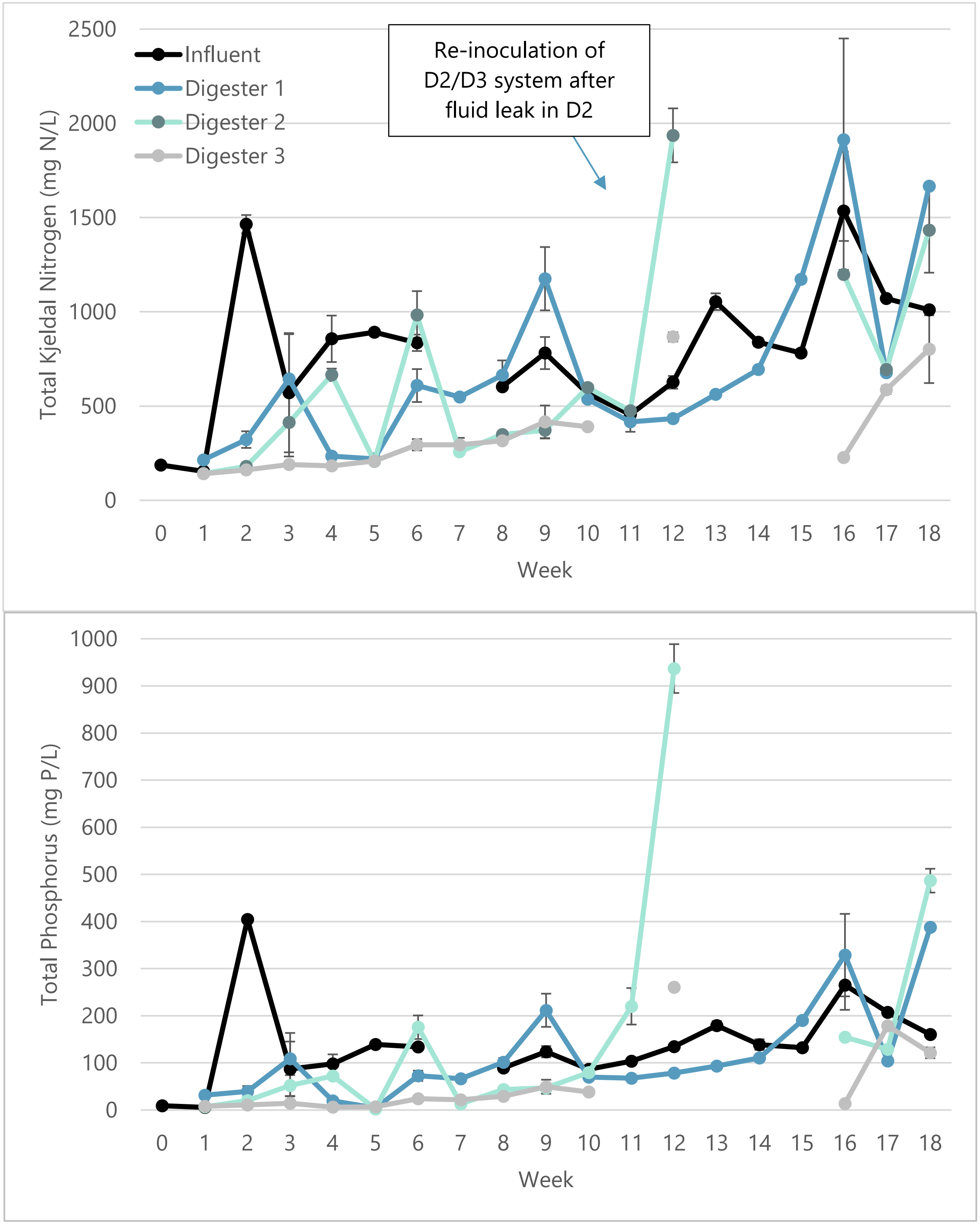


Figure A.3: Total Kjeldahl nitrogen (TKN) and total phosphorus concentrations in algal influent and digester effluent in Phase IV.

A.4 Solids Transformations during Anaerobic Digestion

Total solids (TS) content of algal influent and digester effluent was measured by drying samples at 105°C overnight, with the results summarized in Table A1. The TS of the algal influent was initially low, with 9.6 g TS/L observed, however the TS rose between Weeks 1 and 5 to 63.8 g TS/L. After this, the TS of the influent remained consistent between 30-50 g TS/L until the end of the study, with consistent production from the algal flow-way during this time (Table A.2).

Table A.2: Total solid (TS) content of algal influent and digester effluent during Phase IV, Weeks 1-18.

Week	Influent (g/L)	D1 Effluent (g/L)	D2 Effluent (g/L)	D3 Effluent (g/L)
0	9.57 ± 0.19	8.80 ± 0.40	5.13 ± 0.19	5.13 ± 0.19
1	8.57 ± 0.18	10.3 ± 0.67	12.0 ± 0.2	5.47 ± 0.18
2	23.1 ± 0.4	8.30 ± 0.30	5.53 ± 0.03	4.30 ± 0.00
3	44.7 ± 2.16	21.7 ± 4.11	10.2 ± 3.58	4.93 ± 0.15
4	16.1 ± 4.74	10.0 ± 1.8	10.3 ± 6.3	9.23 ± 2.30
5	63.8 ± 0.4	4.83 ± 0.20	4.53 ± 0.09	7.10 ± 0.32
6	12.5 ± 0.3	3.36 ± 0.21	8.27 ± 0.42	1.77 ± 0.14
7	-	19.0 ± 0.2	5.93 ± 0.09	6.93 ± 0.96
8	39.3 ± 0.2	27.3 ± 0.3	21.0 ± 0.2	11.0 ± 0.07
9	52.6 ± 0.4	68.8 ± 0.4	21.9 ± 0.3	18.2 ± 0.76
10	31.5 ± 0.3	25.3 ± 0.1	24.6 ± 0.4	10.7 ± 0.79
11	29.0 ± 0.4	21.4 ± 0.1	19.5 ± 0.9	-
12	35.8 ± 0.4	23.3 ± 0.1	71.1 ± 0.4	32.7 ± 0.38
13	22.4 ± 10.5	7.15 ± 0.27	-	-
14	41.9 ± 1.0	30.8 ± 0.1	-	-
15	37.8 ± 0.3	52.8 ± 0.34	-	-
16	81.9 ± 3.2	72.5 ± 0.9	34.0 ± 0.32	21.4 ±13.90
17	49.4 ± 3.19	29.7 ± 0.4	29.3 ± 0.55	34.7 ± 4.13
18	36.1 ± 0.0	-	-	27.00 ±
Average	35.3 ± 4.5	24.7 ± 4.9	18.9 ± 4.5	13.40 ± 2.79

The volatile solid (VS) content of the algal influent followed a similar trend to the TS, with a steady increase between Weeks 1 and 10, followed by a consistent VS content between Weeks 11 and 18. The highest VS was observed in Week 16 with 23.5 g VS/L measured, which corresponded to the spike in nutrients and an increase in biogas production at this time (Table A.3).

Table A.3: Volatile solid (VS) content of algal influent and digester effluent during Phase IV, Weeks 1-18.

Week	Influent (g VS/L)	Digester 1 (g VS/L)	Digester 2 (g VS/L)	Digester 3 (g VS/L)
0	2.63 ± 0.03	4.33 ± 0.41	2.20 ± 0.25	2.20 ± 0.25
1	2.00 ± 0.20	3.03 ± 0.27	3.07 ± 0.03	1.63 ± 0.07
2	6.57 ± 0.2	2.50 ± 0.21	1.53 ± 0.03	1.33 ± 0.18
3	9.27 ± 0.39	4.87 ± 0.92	2.30 ± 0.75	1.20 ± 0.10
4	4.43 ± 1.22	2.63 ± 0.37	2.57 ± 1.52	2.33 ± 0.54
5	12.6 ± 0.09	1.03 ± 0.03	0.97 ± 0.03	1.50 ± 0.06
6	3.65 ± 0.14	0.94 ± 0.06	1.85 ± 0.07	0.27 ± 0.05
7	-	5.63 ± 0.54	3.03 ± 0.15	2.23 ± 0.17
8	8.30 ± 0.08	5.93 ± 0.03	4.57 ± 0.12	2.40 ± 0.06
9	12.6 ± 0.13	15.0 ± 0.2	5.40 ± 0.30	4.20 ± 0.26
10	-	-	14.5 ± 0.5	-
11	8.13 ± 0.08	5.60 ± 0.10	7.17 ± 0.45	-
12	9.70 ± 0.10	6.20 ± 0.17	25.7 ± 0.2	10.0 ± 0.15
13	5.90 ± 0.17	1.67 ± 0.12	-	-
14	11.7 ± 0.2	8.43 ± 0.09	-	-
15	10.8 ± 0.2	14.9 ± 0.1	-	-
16	23.5 ± 0.8	20.8 ± 0.3	18.9 ± 10.1	1.17 ± 0.03
17	10.0 ± 3.10	6.73 ± 0.12	6.67 ± 0.22	9.53 ± 1.12
18	9.00 ± 0.10	-	-	6.33 ± 1.29
Average	8.87 ± 1.21	6.49 ± 1.34	6.69 ± 1.88	3.31 ± 0.83

Volatile fatty acid (VFA) analysis of all samples was completed using a gas chromatography (GC). VFAs are produced as part of the hydrolysis processes during digestion and used by methanogens to produce CH_4. During Phase IV, acetic acid was the most common VFA in the algal influent (540 ± 66.9 mg/L), with large decreases (38%, 42%, and 72% in D1, D2, and D3, respectively) due to methanogen uptake during digestion. Butyric and propionic acids concentrations stayed consistent in the influent and effluent throughout the study, with uptake rates by methanogens similar to the production rate during hydrolysis. Valeric acid concentration increased from the influent (208 ± 18.8 mg/L) to the effluent of D1 (198 ± 21.8 mg/L), D2 (264 ± 24.6 mg/L), and D3 (340 ± 33.5 mg/L), suggesting more accumulation than utilization (Figure A.4).

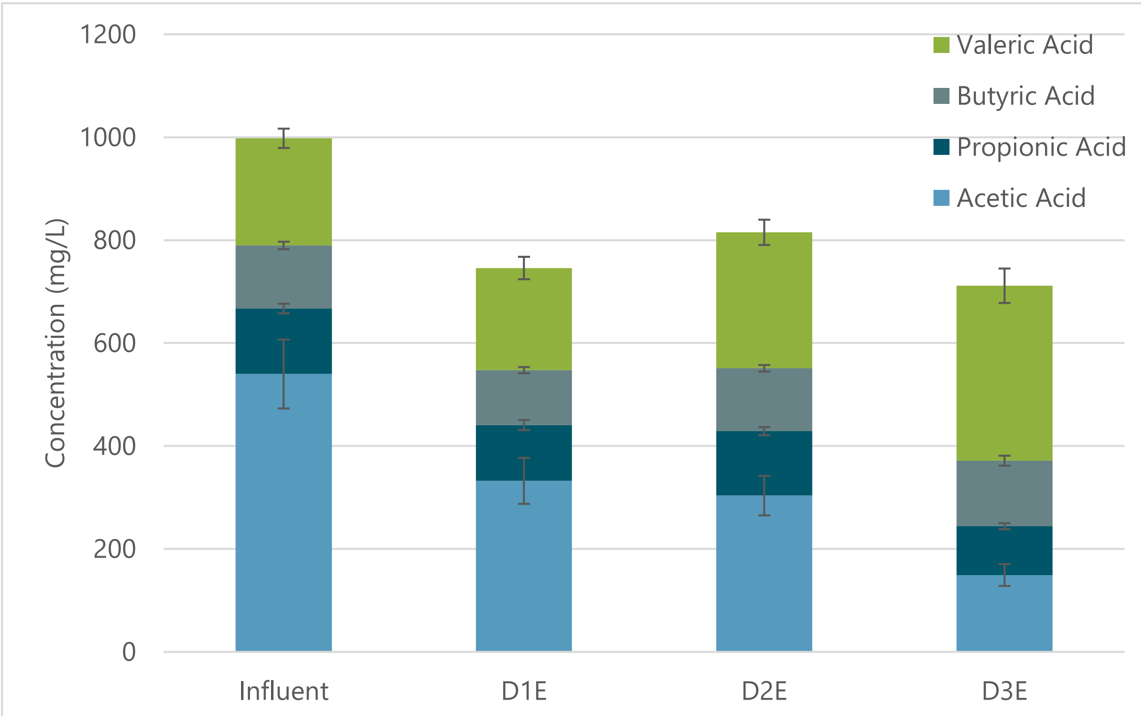


Figure A.4: Volatile fatty acid (VFA) analysis results from Phase IV, Weeks 1-18

A.5 Algal Productivity

In addition to algal speciation presented in Section 4.2, measured estimates of percent cover (%) and biomass production (dry grams/m^2/day) were conducted over the course of the 2019 operational year. Following protocols from previous UMD estimates for biomass at the Port algal flow-way, the 61 m flow-way was divided into upper (0-20 m), middle (21-40 m) and lower (41-61 m) sections. However, unlike fixed locations for biomass estimates for previous research years, in 2019 percent cover data was taken along a stratified randomized location for each sampling date. A measuring tape was laid from top (influent) to bottom (effluent) along the flow-way with a random number generated (random.org) for each of the upper, middle, and lower sections. At each randomly generated location, a 1 m^2 quadrat was laid, which was created and divided into decimeter subunits with lines of string overlaid in each section, occupying the width of the surge and direct flow-ways. Each flow-way side utilized the same randomized location for quadrat placement.

At each quadrat location, the percent cover was estimated for each block of decimeter subquadrat and recorded. While each flow-way was approximately 1 m wide, variations in flow-way barrier locations sometimes disallowed the full m^2 quadrat to be placed within the confines of each flow-way, so a maximum of 81 decimeter subquadrat percent cover estimates were made for each of the upper middle and lower sections of the surge and direct flow-way paths.

Data presented in Table A.4 shows only minor relative differences in algal percent cover between the surge and direct methods of water delivery to the algal flow-ways. Also, there appears to be only minor differences between the seasons.

Table A.4. 2019 UMD algal percent cover means seasonally represented for the surge and continuous water delivery methods.

	Summer (6/27-9/12)		**Fall (9/19-10/10)**		**Overall (6/27-10/10)**	
Surge	89.0	n=12	97.0	n=4	91.0	n = 16
Continuous	92.0	n=12	97.0	n=4	93.0	n = 16

Upon completion of algal percent cover estimates, the 1 m^2 quadrat was removed and a 0.25 m^2 quadrat was placed in the center of the location of the 1 m^2 quadrat measurement area. A battery powered wet/dry shop-vac supplied by Port/MES staff, which was used for their 1 m^2 subplot biomass collections was used for the same purpose on UMD's 0.25 m^2 quadrat locations. All algae and water were vacuumed within the quadrat and decanted into marked containers and carried directly to the UMD lab, where the biomass was refrigerated until it could be separated into solids and greenwater. Utilizing 16 micron mesh bags utilized by previous Port algal flow-way biomass work conducted by UMD, each biomass sample was filtered through the mesh and separated into solids captured by the bag and greenwater that filtered through the bag.

Collected samples were air dried under a ventilator hood to speed the drying process then subsamples of solids and greenwater were weighed and placed in a drying oven at 105°C for at least 24 hours. Final weights from the 0.25 m^2 sample area were multiplied by a factor of four to create a comparable data set of 1 m^2 to compare to previous data. The number of days between harvest were calculated and applied to achieve values in dry grams/m^2/day, which is the common biomass unit of measurement for algal flow-way data. Table A.5 represents the data for UMD as a combination of dry solids added to greenwater datasets. The presented data are means of three replicates of oven dried weights for each sampling date in the upper, middle, and lower subsections of each of the surge and direct flow-ways. Data are also separated into summer and fall sampling periods, as decreases in air and water temperatures, as well as photoperiod, drive productivity down as summer transitions to fall (Table A.5).

Table A.5. A comparison of UMD and Port/MES 2019 algal biomass value means seasonally represented for the surge and continuous water delivery methods.

2019 Algal Flow-Way Biomass (Mean dry g/m^2/day)						
	Summer		**Fall**		**Combined**	
	UMD	Port	UMD	Port	UMD	Port
	n=7	n=5	n=2	n=1	n=9	n=6
Surge	8.5	12.0	8.8	14.2	8.7	11.8
Continuous	7.1	14.2	8.5	16.4	7.8	15.3

The dataset represented in Table A.5 reveals that there appears to be little difference between the surge and direct methods of water delivery with respect to algal biomass. As with the percent cover, the relative lack of difference in biomass between the summer and fall seasonal periods may be due to an unusually long summer in terms of warmer ambient temperatures extending from late September into October. This extension of warmer temperatures would keep the influent waters warmer longer which has been known to influence algal productivity. Additionally, the continuous flow-way path may have benefitted from the slightly deeper areas along the outer edges due to the earlier mentioned offset in lateral slope.

Of particular note is that the UMD dataset reveals a somewhat lower estimate of biomass production than that of the Port/MES data set. While the data represented reflect only subplot sampling comparisons of UMD and the Port, the main differences in collection were that the Port utilized a larger 1m^2 quadrat and placed it within the same location on the flow-way on each sampling date in the upper section of each of the flow-ways. This was done to compare 3D mesh fabric algae attachment screen typically used in operations to that of a roughened concrete pad to inform a scale-up design. The smaller 0.25 m2 quadrat located within the middle of each random flow-way location would not capture the outer edges of each flow-way area as the Port/MES 1m^2 quadrat did which can have sometimes less and sometimes more algal attachment depending on wetted water width of the channel at the point of subplot location. However, UMD collected biomass data from the upper, middle and lower sections of each flow-way which were all combined to give a mean which would provide a more realistic estimate of entire flow-way production. Algal productivity generally decreases as you move downstream along the flow-way due to carbon uptake limitations, so subplots only taken in the upper flow-way will skew higher in biomass production estimates than those that sample the entire flow-way reach. This was done for UMD data collection to be comparable to previous years pilot operations and to provide a more accurate mass balance estimate of algal inputs to the digesters.

A.6 Salinity

During Phase III, the algal flow-way productivity was negatively impacted due to excessive rainfall in the Baltimore region in 2018. It was hypothesized that this was due to a decline in the salinity of the Patapsco River's to levels far below what is seasonally typical for the region. This reduced salinity was speculated to have negatively impacted the algae, which are acclimated to a specific salinity range.

Rainfall during the 2019 growing season was closer to average for the region, and the algal flow-way productivity improved as a result. To determine if salinity was correlated with an increase in total solids (TS) of the algal influent fed to the digesters, weekly samples were sent to Agrolab for sodium analysis (Figure A.5).

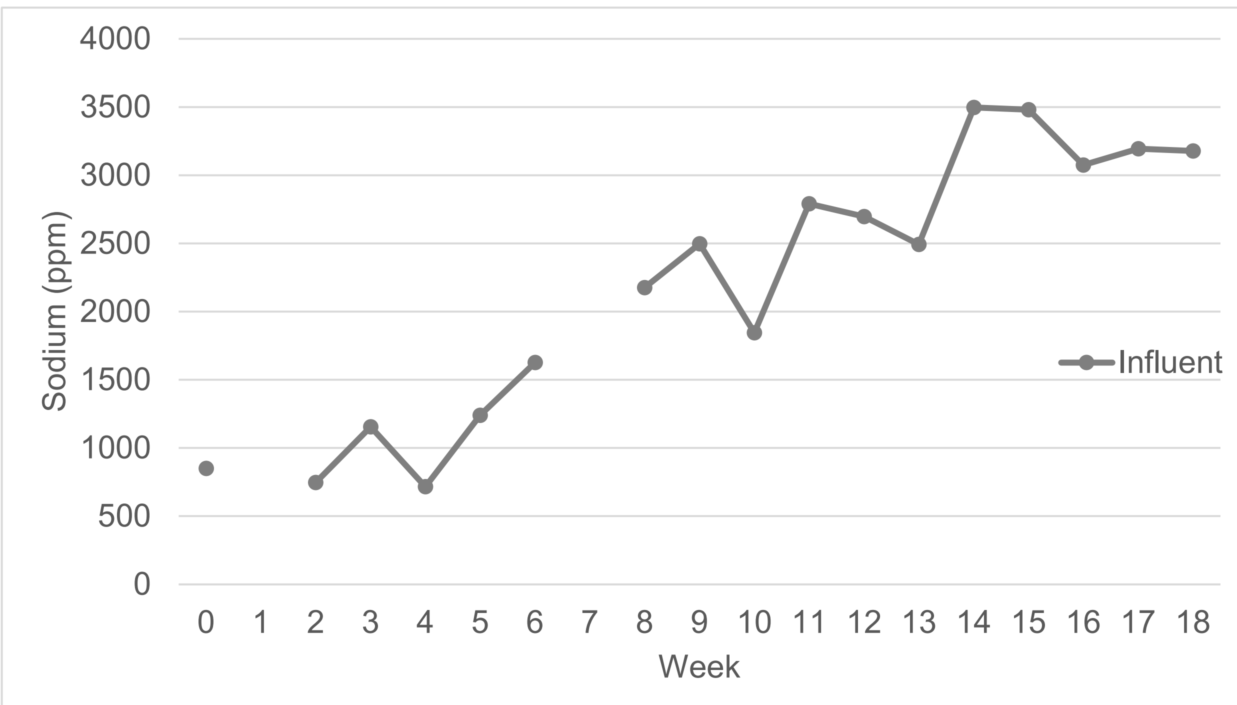


Figure A.5: Sodium (Na) concentration in algal influent during Phase IV.

The analysis suggests that sodium content of the influent rose steadily throughout the study, and was positively correlated with TS. The highest TS value was measured in Week 16 (23.5 ± 0.8 mg/L), which was correlated to the highest peak in sodium occurring between Weeks 14 and 15. This suggests that an increased salinity may be beneficial to algal flow-way growth in this area of the Patapsco River.

A.7 Scanning Electronic Microscope (SEM) Analysis

To better visualize the breakdown of the algae during anaerobic digestion and estimate the elemental composition of both influent and effluent, frozen samples of algal influent and D1 effluent from Week 3 were thawed and analyzed under a scanning electron microscope (SEM) in the UMD AIM lab (Figure A.6).

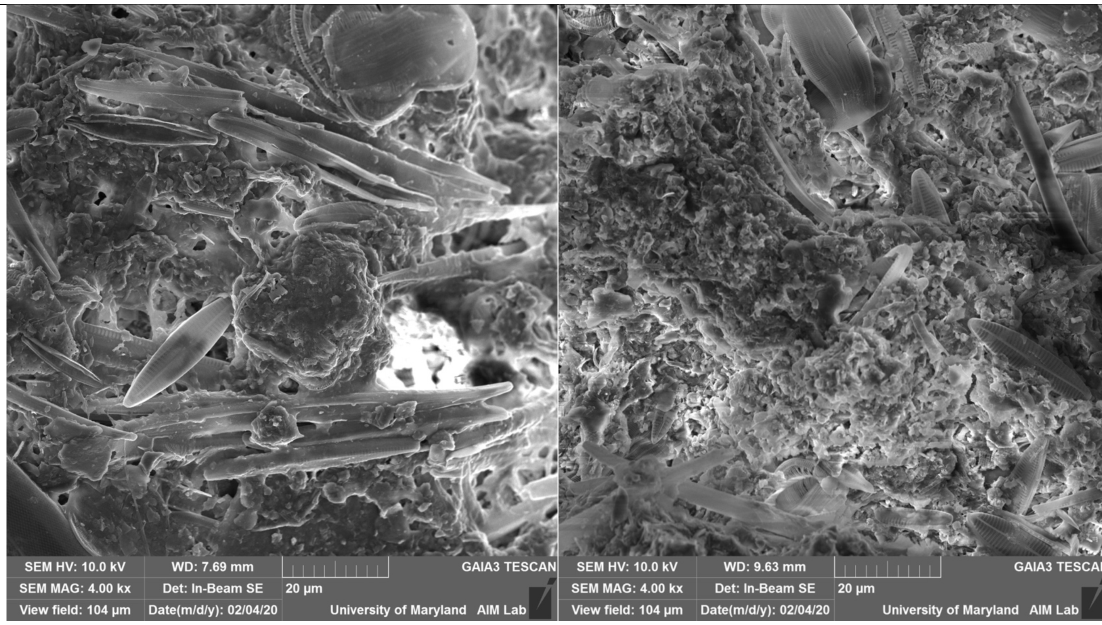


Figure A.6: SEM image of algal influent (left) and D1 effluent (right) from Week 3.

The siliceous cell walls of diatoms, or frustules, are clearly visible in both the influent and effluent imagery, which was expected based on the algal flow-way growth dominance by *Melosira* diatoms throughout the study. Elemental analysis was performed at three sites on images of the influent, which revealed large quantities of silicon (23.2 ± 1.99%) and aluminum (14.9 ± 4.04%) in the algal influent. Oxygen was also detected (32.2 ± 3.90%), which was expected. Diatom frustules are primarily composed of silica (SiO_2), with other trace elements, such as aluminum, often incorporated into the silica matrix. Carbon was also a major constituent (15.0 ± 3.14%) due to the organic fraction of the biomass.

Elemental analysis of the D1 effluent was performed at a single point on the image. This analysis revealed oxygen (45.2 ± 8.79%), carbon (13.3 ± 9.58%), and calcium (24.3 ± 4.77%) were the largest constituents of the effluent. Silicon and aluminum were also detected, with concentrations less than 4% of the sample's weight.

Appendix B
Field Data Sheets with Photographs

HARVEST DATE: 5/16/19
HARVEST NO.: 1
HARVEST TYPE (circle): **NORMAL** SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Harvest Personnel:	Water Quality Top of Flow Way		Water Quality Bottom of Flow Way		Weather Conditions Temperature and Precipitation:			
AB	Temperature (°C)	17.2	Temperature (°C)	16.7	AM:	Light rain to sun		
BS	Salinity (ppt)	2.4	Salinity (ppt)	2.5	PM:	sun		
JK	Conductivity (µS)	3851/2899	Conductivity (µS)	3844/2919	**Time of Harvest:**			
WD	Dissolved oxygen (mg/L)	7.97	Dissolved oxygen (mg/L)	8.98	From	**7:30**	To	**11:00**
	DO saturation (%)	85.5	DO saturation (%)	94.8	**Truck Weight of Harvest (lbs.)**			
	pH	7.15	pH	7.50	Direct	**800**	Surge	**660**
	TSS sample collected	No	TSS sample collected	No	Direct + Surge	25560		
Surge Totalizer: 25059256	Pre-Har turbidity (NTU)	Not taken	Pre-Har turbidity (NTU)	10.3				
Direct Totalizer: 106721	Post-Har turbidity (NTU)	7.04	Post-Har turbidity (NTU)	6.94	Empty Truck: 24100			

Summary of Work Performed on Site
Harvest surge, grab sample, truck weight, harvest direct, grab sample, truck weight
General Site Observations
Lighter growth overall, brown diatoms. Top half of flow way the algal growth looked about the same for both surge and direct.
Bottom half of flow way the direct side appeared to have slightly more growth, may be due to differential flow
Surge % Algae Cover: ___90-95___% diatoms _____% filamentous greens ___5-10__% no growth
Direct % Algae Cover: ___90-95___% diatoms _____% filamentous greens ___5-10__% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid	Concrete Only	Concrete + Grid
Surge: Harvest Bucket Weight: lbs	Surge: Harvest Bucket Weight: lbs	Surge: Harvest Bucket Weight: lbs
Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:
Direct: Harvest Bucket Weight: lbs	Direct: Harvest Bucket Weight: lbs	Direct: Harvest Bucket Weight: lbs
Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:

Notes: Biomass Handling

Side Channel (surge side only)	Sand Filter
	Input: _________NTU Weight: ___________ Date/Time:
Weights: Freewater Solids:	**Output:** _________NTU Weight: ___________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HAR19-1S	
HAR19-1D	

Sample ID Key: HAR19-
#S = week+surge LIN=liner+grid TSS = total suspended solids
#D = week+direct CON=concrete SOL=solid
#SF = week+sand filter CL=concrete+liner FW=freewater

Signature__________________________________

HARVEST DATE: 5/16/19

HARVEST NO.: 1

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Calculations

Harvest Weights					
Typical Harvest Week		Subplots Week		Side Channel Week	
A) Direct Truck	______ lbs *(into digester)*	A) Cont. Truck	______ lbs	A) Direct Truck	______ lbs *(into digester)*
B) Surg + Direct Truck	______ lbs	B) Surge + Direct Truck	______ lbs	B) Surge FW Truck	______ lbs *(into s.filter)*
C) TAR Truck	______ lbs	C) TAR Truck	______ lbs	C) TAR Truck	______ lbs
D) Net Direct (A-C)	______ **lbs**	D) Sum Direct Subplots	______ lbs	**D) Net Direct (A-C)**	______ **lbs**
E) Net Surge (B-C-D)	______ **lbs**	E) Sum Surge Subplots	______ lbs	**E) Net Surge FW (B-C)**	______ **lbs**
		F) Net Direct (A-C+D)	______ **lbs**	F) Surge solids	______ lbs *(meas. later)*
		G) Net Surge (B-C-F+E)	______ **lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP, TSS **HAR19-#S**			
	direct	% solids, TN, TP, TSS **HAR19-#D**			
Subplot	surge	% solids **HAR19-#S**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**		% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**			

Inflow (**HAR19-#IN**) and Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 50)
- Concrete + Liner subplot area
- Concrete subplot area (STA 150)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 5/16/19
HARVEST NO.: 1
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS

Inflow Area

Capt ion Photo 1

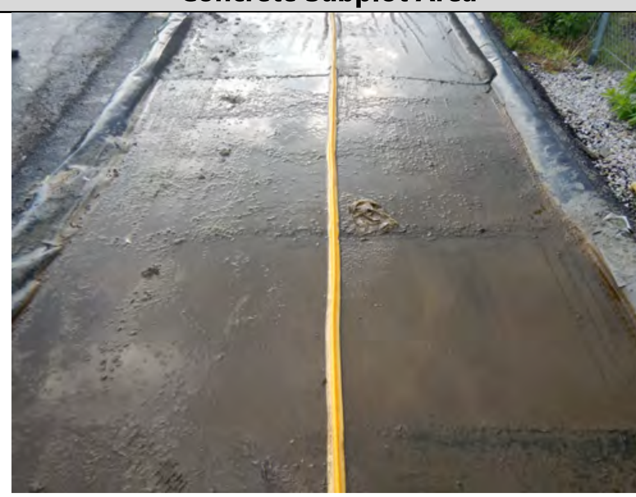
Liner Subplot Area

Caption Photo 2

Concrete + Liner Subplot Area

Caption Photo 3

Concrete Subplot Area



Caption Photo 4

Photo 5

Caption Photo 5

Photo 6

Caption Photo 6

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 5/23/19
HARVEST NO.: 2
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS	Temperature (°C)	19.8	Temperature (°C)	19.6	AM:	sun		
JK	Salinity (ppt)	2.6	Salinity (ppt)	2.6	PM:	sun		
	Conductivity (µS)	4313/3134	Conductivity (µS)	4318/3136	**Time of Harvest:**			
WT	Dissolved oxygen (mg/L)	7.95	Dissolved oxygen (mg/L)	10.00	From	**7:30**	To	**10:00**
	DO saturation (%)	87.7%	DO saturation (%)	112.4%	**Truck Weight of Harvest (lbs.)**			
	pH	7.52	pH	8.25	Direct	**320**	Surge	**480**
	TSS sample collected	HAR19-2IN	TSS sample collected	HAR19-2OUT	Direct + Surge		800	
Surge Totalizer: 25415254	Pre-Har turbidity (NTU)	S:5.97 D:6.05	Pre-Har turbidity (NTU)	S:3.81 D:3.44				
Direct Totalizer: 466985	Post-Har turbidity (NTU)	S:6.89 D:6.29	Post-Har turbidity (NTU)	S:6.16 D:3.57				

Summary of Work Performed on Site
Normal harvest, Filter bags for subplot did not arrive. Measured out station distances.
General Site Observations
Lighter growth overall, brown diatoms
Surge % Algae Cover: ___50___% diatoms ______% filamentous greens ____50__% no growth
Direct % Algae Cover: ___70___% diatoms ______% filamentous greens ___30___% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid	**Concrete Only**	**Concrete + Grid**
Surge: Harvest Bucket Weight: lbs	Surge: Harvest Bucket Weight: lbs	Surge: Harvest Bucket Weight: lbs
Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:
Direct: Harvest Bucket Weight: lbs	Direct: Harvest Bucket Weight: lbs	Direct: Harvest Bucket Weight: lbs
Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:

Notes: Biomass Handling

Side Channel (surge side only)	**Sand Filter**
	Input: _________NTU Weight: ____________ Date/Time:
Weights: Freewater Solids:	**Output:** _________NTU Weight: ____________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HAR19-2S (4)	
HAR19-2D (4)	
HAR19-2IN (2) (Microbac)	
HAR19-2OUT (2) (Mircrobac)	

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 5/23/19

HARVEST NO.: 2

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	TSS = total suspended solids
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater

Signature______________________

Calculations

Harvest Weights

Typical Harvest Week		Subplots Week		Side Channel Week	
A) Direct Truck	24720 lbs	A) Cont. Truck	______ lbs	A) Direct Truck	______ lbs *(into digester)*
B) Surg + Direct Truck	25200lbs	B) Surge + Direct Truck	______ lbs	B) Surge FW Truck	______ lbs *(into s.filter)*
C) TAR Truck	24400lbs	C) TAR Truck	______ lbs	C) TAR Truck	______ lbs
D) Net Direct (A-C)	**320lbs**	D) Sum Direct Subplots	______ lbs	**D) Net Direct (A-C)**	______ **lbs**
E) Net Surge (B-C-D)	**480lbs**	E) Sum Surge Subplots	______ lbs	**E) Net Surge FW (B-C)**	______ **lbs**
		F) Net Direct (A-C+D)	______ **lbs**	F) Surge solids	______ lbs *(meas. later)*
		G) Net Surge (B-C-F+E)	______ **lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP, TSS **HAR19-#S**			
	direct	% solids, TN, TP, TSS **HAR19-#D**			
Subplot	surge	% solids **HAR19-#S**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**		% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**			

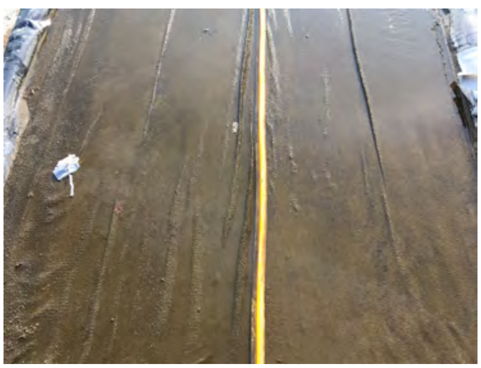
Inflow (**HAR19-#IN**) and Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 50)
- Concrete + Liner subplot area
- Concrete subplot area (STA 150)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 5/23/19
HARVEST NO.: 2
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Inflow Area	**Liner Subplot Area**
 Caption Photo 1	 Caption Photo 2
Concrete + Liner Subplot Area	**Concrete Subplot Area**
 Caption Photo 3	 Caption Photo 4
Photo 5	**Photo 6**
Caption Photo 5	Caption Photo 6

HARVEST DATE: 5/30/19

HARVEST NO.: 3

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Harvest Personnel:	Water Quality Top of Flow Way		Water Quality Bottom of Flow Way		Weather Conditions Temperature and Precipitation:			
BS	Temperature (°C)	24.4	Temperature (°C)	24.5	AM:	HOT/SUN		
AB	Salinity (ppt)	1.7	Salinity (ppt)	1.7	PM:	HOT/SUN		
JK	Conductivity (µS)	3180/ 2169	Conductivity (µS)	3189/ 2173	**Time of Harvest:**			
WT	Dissolved oxygen (mg/L)	6.83	Dissolved oxygen (mg/L)	8.33	From	**7:30**	To	**1:30**
	DO saturation (%)	84.2%	DO saturation (%)	102.2%	**Truck Weight of Harvest (lbs.)**			
	pH	7.72	pH (In mixing zone)	8.37	Surge	**300**	Direct	**340**
	TSS sample **HAR19-#IN**	YES	TSS sample **HAR19-#OUT**	Yes	Surge + Direct		640	
Surge Totalizer:	Pre-Har turbidity (NTU)	S:6.11 D:6.57	Pre-Har turbidity (NTU)	S:3.42 D:4.09				
Direct Totalizer:	Post-Har turbidity (NTU)	S:5.94 D:5.98	Post-Har turbidity (NTU)	S:5.60 D:5.16	Time of WQ Data: 7:30AM			

Summary of Work Performed on Site

Regular harvest. Very light growth. Flow way was cleared off with coarse floor brooms to remove possible dead algae from dry out.

Pump would not initially turn back on after harvest, water flow was not restored until 11:40

General Site Observations

Surge % Algae Cover: ___20_% diatoms _____% filamentous greens __80__% no growth

Direct % Algae Cover: ___20_% diatoms _____% filamentous greens __80__% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid	Concrete Only	Concrete + Grid
	H	
Surge: Harvest Bucket Weight: lbs	Surge: Harvest Bucket Weight: lbs	Surge: Harvest Bucket Weight: lbs
Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:
Direct: Harvest Bucket Weight: lbs	Direct: Harvest Bucket Weight: lbs	Direct: Harvest Bucket Weight: lbs
Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:

Notes: Biomass Handling

Side Channel (surge side only)	Sand Filter
	Input: _________NTU Weight: ___________ Date/Time:
Weights: Freewater Solids:	**Output:** _________NTU Weight: ___________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HAR19-3S	
HAR19-3D	
AFW19-3IN	
AFW19-3OUT	

HARVEST DATE: 5/30/19

HARVEST NO.: 3

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature____________________

Calculations

Harvest Weights

Typical Harvest Week			Subplot Week			Side Channel Week		
A) Surge Truck	24680	lbs	A) Surge Truck		lbs	A) Surge FW Truck		lbs *(into digester)*
B) Surg + Direct Truck	25020	lbs	B) Surge + Direct Truck		lbs	B) Direct Truck		lbs *(into s.filter)*
C) TAR Truck	24380	lbs	C) TAR Truck		lbs	C) TAR Truck		lbs
D) Net Surge (A-C)	**300**	**lbs**	D) Sum Surge Subplots		lbs	**D) Net Surge (A-C)**		**lbs**
E) Net Direct (B-C-D)	**340**	**lbs**	E) Sum Direct Subplots		lbs	**E) Net Direct FW (B-C)**		**lbs**
			F) Net Surge (A-C+D)		**lbs**	F) Surge solids		lbs *(meas. later)*
			G) Net Direct (B-C-F+E)		**lbs**	(FW = freewater)		

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

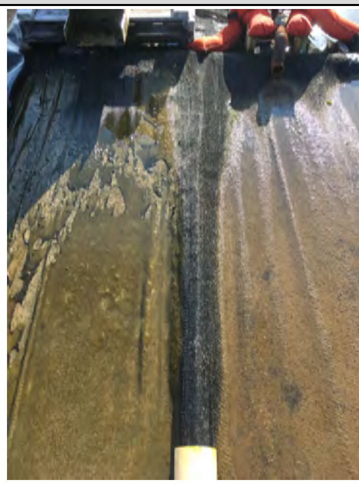
Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 30-35)
- Concrete + Liner subplot area (STA 40-45)
- Concrete subplot area (STA 45-50)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 5/30/19
HARVEST NO.: 3
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

<table>
<tr><th colspan="2">WEEKLY HARVEST PHOTOS</th></tr>
<tr><th>Inflow Area</th><th>Liner Subplot Area</th></tr>
<tr><td>
Caption Photo 1</td><td>
Caption Photo 2</td></tr>
<tr><th>Concrete + Liner Subplot Area</th><th>Concrete Subplot Area</th></tr>
<tr><td>
Caption Photo 3</td><td>
Caption Photo 4</td></tr>
</table>

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 5/30/19

HARVEST NO.: 3

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Algae came off in sheets	**Post cleaning with brooms**
 Caption Photo 5	 Caption Photo 6

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 6/12/19
HARVEST NO.: 5
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Harvest Personnel:	Water Quality Top of Flow Way		Water Quality Bottom of Flow Way		Weather Conditions Temperature and Precipitation:			
BS	Temperature (°C)	22.1	Temperature (°C)	21.8	AM:	Sunny, mild		
JK	Salinity (ppt)	3.3	Salinity (ppt)	3.3	PM:			
WT	Conductivity (µS)	5.66ms/ 3979us	Conductivity (µS)	5.64ms/ 3981us	**Time of Harvest:**			
	Dissolved oxygen (mg/L)	5.95	Dissolved oxygen (mg/L)	7.85	From	**7:45**	To	**10:15**
	DO saturation (%)	70.1%	DO saturation (%)	91.2%	**Truck Weight of Harvest (lbs.)**			
	pH	6.97	pH	7.75	Surge	**480**	Direct	**400**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct	880		
Surge Totalizer:	Pre-Har turbidity (NTU)	S:4.24 D:4.66	Pre-Har turbidity (NTU)	S:2.66 D:4.22				
Direct Totalizer:	Post-Har turbidity (NTU)	S:4.35 D:5.09	Post-Har turbidity (NTU)	S:3.77 D:3.59	Time of WQ Data: 7:45			

Summary of Work Performed on Site
Normal harvest. Harvest surge than direct side.
General Site Observations
Algae on surge side was in sheet like mats in large sections
Surge % Algae Cover: ___80___% diatoms ______% filamentous greens ___20__% no growth
Direct % Algae Cover: ___70___% diatoms ______% filamentous greens ____30__% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid	Concrete Only	Concrete + Grid
Surge: Harvest Bucket Weight: lbs	Surge: Harvest Bucket Weight: lbs	Surge: Harvest Bucket Weight: lbs
Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:
Direct: Harvest Bucket Weight: lbs	Direct: Harvest Bucket Weight: lbs	Direct: Harvest Bucket Weight: lbs
Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:	Bag Weights: Wet: Dry:

Notes: Biomass Handling

Side Channel (surge side only)	Sand Filter
	Input: __________NTU Weight: _____________ Date/Time:
Weights: Freewater Solids:	**Output:** __________NTU Weight: _____________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HAR19-5S	AFW19-5IN
HAR19-5D	AFW19-5OUT

HARVEST DATE: 6/12/19

HARVEST NO.: 5

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge LIN=liner+grid
#D = week+direct CON=concrete SOL=solid
#SF = week+sand filter CL=concrete+liner FW=freewater
#HP = Hawkins Point #IN=inflow #OUT=outflow

Signature____________________

Calculations

Harvest Weights

Typical Harvest Week			Subplot Week			Side Channel Week		
A) Surge Truck	24840	lbs	A) Surge Truck		lbs	A) Surge FW Truck		lbs *(into digester)*
B) Surg + Direct Truck	25240	lbs	B) Surge + Direct Truck		lbs	B) Direct Truck		lbs *(into s.filter)*
C) TAR Truck	24360	lbs	C) TAR Truck		lbs	C) TAR Truck		lbs
D) Net Surge (A-C)	**480**	**lbs**	D) Sum Surge Subplots		lbs	**D) Net Surge (A-C)**		**lbs**
E) Net Direct (B-C-D)	**400**	**lbs**	E) Sum Direct Subplots		lbs	**E) Net Direct FW (B-C)**		**lbs**
			F) Net Surge (A-C+D)		**lbs**	F) Surge solids		lbs *(meas. later)*
			G) Net Direct (B-C-F+E)		**lbs**	(FW = freewater)		

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 30-35)
- Concrete + Liner subplot area (STA 40-45)
- Concrete subplot area (STA 45-50)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 6/12/19
HARVEST NO.: 5
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Inflow Area	**Liner Subplot Area**
	
Concrete + Liner Subplot Area	**Concrete Subplot Area**
 Caption Photo 3	 Caption Photo 4

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 6/12/19

HARVEST NO.: 5

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Algae sheet growth	**Surge harvest**
 Caption Photo 5	 Caption Photo 6

HARVEST DATE: 6/20/19

HARVEST NO.: 6

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

Harvest Personnel:	Water Quality Top of Flow Way		Water Quality Bottom of Flow Way		Weather Conditions Temperature and Precipitation:			
BS	pH	7.60	pH	8.13	AM:	Hot, Humid, mix clouds/sun		
AB	Conductivity (µS)	5.58ms/3771	Conductivity (µS)	5.57ms/3762	PM:	Hot, sun		
JK	Salinity (ppt)	2.6	Salinity (ppt)	3.0	**Time of Harvest:**			
WT	Temperature (°C)	25.2	Temperature (°C)	25.1	From	**7:50**	To	**12:00**
PN	Dissolved oxygen (mg/L)	7.50	Dissolved oxygen (mg/L)	8.21	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	94.2%	DO saturation (%)	102.6%	Surge	**520**	Direct	**520**
	TSS sample **HAR19-#IN**	Yes 6/19	TSS sample **HAR19-#OUT**	Yes	Surge + Direct		1,040 See next page	
Surge Totalizer:	Pre-Har turbidity (NTU)	S: 5.54	Pre-Har turbidity (NTU)	S: 3.44				
		D: 5.32		D: 2.50				
Direct Totalizer:	Post-Har turbidity (NTU)	S: 3.96	Post-Har turbidity (NTU)	S: 2.49				
		D: 4.19		D: 3.08	Time of WQ Data: 8:00			

Summary of Work Performed on Site
1-hour drain down, subplots taken, surge side harvest and truck weight recorded, direct side harvest, truck weight. Subplots to filter bags and sample jars. 30-min drain down time for material in filter bags
General Site Observations
Less blue/green alge
Surge % Algae Cover: ___90__% diatoms __5__% filamentous greens __5___% no growth
Direct % Algae Cover: ___85___% diatoms __5__% filamentous greens ___10__% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)								
Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time: 9:30	Empty Bucket (lbs):	Full Bucket (lbs):	Start time: 9:40	Empty Bucket (lbs):	Full Bucket (lbs):	Start time: 9:45	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-6S	2.14	20.5	CL-6S	2.16	13.5	CON-6S	1.71	5.5
LIN-6D	2.20	16.5	CL-6D	2.18	13.5	CON-6D	1.85	7.5
Time into filter:	S: 10:40	D: 10:45	Time into filter:	S: 10:50	D: 10:55	Time into filter:	S: 11:00	D: 11:05
Surge: Harvest Bucket Weight: 18.36 lbs			Surge: Harvest Bucket Weight: 11.34 lbs			Surge: Harvest Bucket Weight: 3.79lbs		
Bag Weights: Wet: 5.46 Dry: 0.17			Bag Weights: Wet: 5.90 Dry: 0.17			Bag Weights: Wet: 2.99 Dry: 0.17		
Direct: Harvest Bucket Weight: 14.3 lbs			Direct: Harvest Bucket Weight: 11.32 lbs			Direct: Harvest Bucket Weight: 5.65lbs		
Bag Weights: Wet: 5.44 Dry: 0.17			Bag Weights: Wet: 4.69 Dry: 0.17			Bag Weights: Wet: 4.78 Dry: 0.17		

Notes: Biomass Handling	
Side Channel (surge side only)	**Sand Filter**
	Input: _________NTU Weight: ____________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ___________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)	
HAR19-6S	HAR19-CON-6S, HAR19-LIN-6S, HAR19-CL-6S
HAR19-6D	HAR19-CON-6D, HAR19-LIN-6D, HAR19-CL-6D
AFW19-Out	

HARVEST DATE: 6/20/19
HARVEST NO.: 6
HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature____________________

Calculations

Harvest Weights

Typical Harvest Week			Subplot Week			Side Channel Week		
A) Surge Truck	24140	lbs	A) Surge Truck	24140	lbs	A) Surge FW Truck		lbs *(into digester)*
B) Surg + Direct Truck	24660	lbs	B) Surge + Direct Truck	24660	lbs	B) Direct Truck		lbs *(into s.filter)*
C) TAR Truck	23620	lbs	C) TAR Truck	23620	lbs	C) TAR Truck		lbs
D) Net Surge (A-C)	**520**	**lbs**	D) Sum Surge Subplots	33.49	lbs	**D) Net Surge (A-C)**		**lbs**
E) Net Direct (B-C-D)	**520**	**lbs**	E) Sum Direct Subplots	31.27	lbs	**E) Net Direct FW (B-C)**		**lbs**
			F) Net Surge (A-C+D)	**553.49**	**lbs**	F) Surge solids		lbs *(meas. later)*
			G) Net Direct (B-C-F+E)	**551.27**	**lbs**	(FW = freewater)		

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

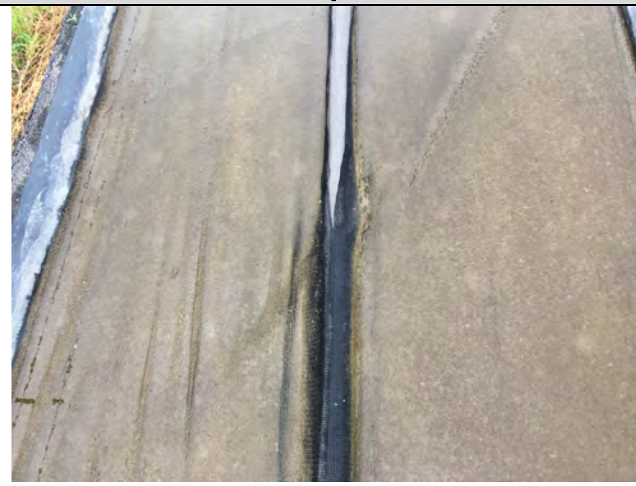
Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 6/20/19
HARVEST NO.: 6
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

<table>
<tr><th colspan="2">WEEKLY HARVEST PHOTOS</th></tr>
<tr><th>Inflow Area</th><th>Liner Subplot Area</th></tr>
<tr><td>
Caption Photo 1</td><td>
Caption Photo 2</td></tr>
<tr><th>Concrete + Liner Subplot Area</th><th>Concrete Subplot Area</th></tr>
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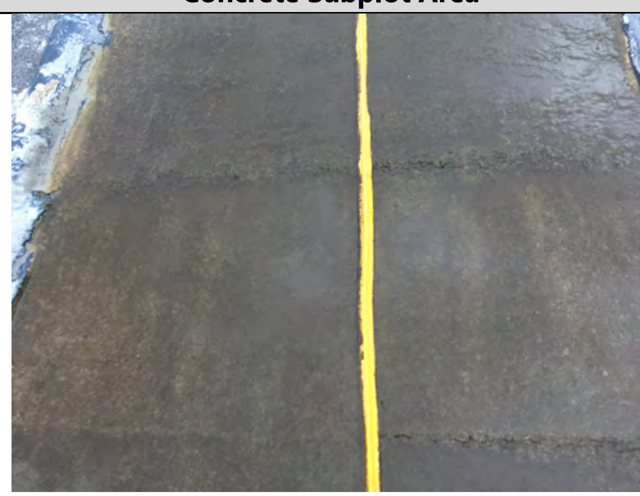
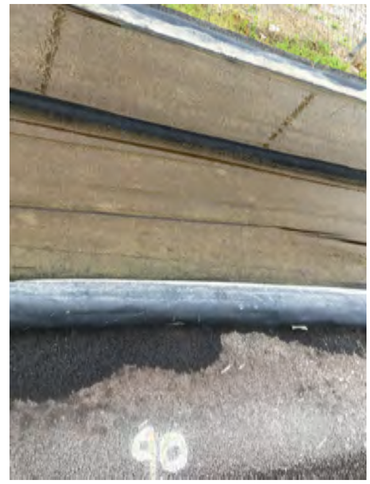
Caption Photo 3</td><td>
Caption Photo 4</td></tr>
</table>

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 6/20/19
HARVEST NO.: 6
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
STA70	**STA90**
 Caption Photo 5	 Caption Photo 6

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 6/27/19
HARVEST NO.: 7
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS	pH	7.43	pH	8.33	AM:	Hot and sunny		
JK	Conductivity (µS)	7.54/4.94ms	Conductivity (µS)	7.48/5.03ms	PM:	Hot and sunny		
WT	Salinity (ppt)	4.1	Salinity (ppt)	4.1	**Time of Harvest:**			
AB	Temperature (°C)	25.7	Temperature (°C)	25.5	From	**7:45**	To	**1100**
	Dissolved oxygen (mg/L)	7.19	Dissolved oxygen (mg/L)	8.22	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	89.8%	DO saturation (%)	103.1%	Surge	**n/a**	Direct	**760**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct		n/a	
Surge Totalizer: 27,248,485	Pre-Har turbidity (NTU)	S: 6.39 D: 6.39	Pre-Har turbidity (NTU)	S: 3.91 D: 3.00				
Direct Totalizer: 2,313,472	Post-Har turbidity (NTU)	S: 15.7 D: 11.4	Post-Har turbidity (NTU)	S: 10.4 D: 7.04	Time of WQ Data: 7:45			

Summary of Work Performed on Site
Side channel harvest. Side channel allowed great free-water separation.
General Site Observations
Diatoms and blue green algae. No filamentous green
Surge % Algae Cover: ___20_% diatoms __80__% blue green _____% no growth
Direct % Algae Cover: __20__% diatoms __80__% blue green _____% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-___S			CL-___S			CON-___S		
LIN-___D			CL-___D			CON-___D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling

Side Channel (surge side only)	**Sand Filter**
35, 35, 38, 37, 15. Empty bucket:2.13x5	
7-day weight	**Input:** ___238_____NTU Weight: 149.35_ Date/Time: 6/27. 11:11
Weights: Freewater: 149.35lbs Solids:	**Output:** __115___NTU Weight: ____69___Date/Time: 6/28 12:10

Samples Submitted to the Lab (list sample ID and describe sample)	
HAR19-7D	HAR19-SF7, HAR19-7S-S-1HR, HAR19-7S-S-4HR
HAR19-7S-S	AFW19-7IN, AFW19-7OUT
HAR19-7S-FW	

HARVEST DATE: 6/27/19

HARVEST NO.: 7

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature____________________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	______ lbs	A) Surge Truck	______ lbs	A) Surge FW	n/a____ lbs *(into s.filter)*
B) Surg + Direct Truck	______ lbs	B) Surge + Direct Truck	______ lbs	B) Direct Truck	24,340__ lbs *(into digester)*
C) TAR Truck	______ lbs	C) TAR Truck	______ lbs	C) TAR Truck	23,580__ lbs
D) Net Surge (A-C)	______ **lbs**	D) Sum Surge Subplots	______ lbs	**D) Net Surge FW (A-C)**	______ **lbs**
E) Net Direct (B-C-D)	______ **lbs**	E) Sum Direct Subplots	______ lbs	**E) Net Direct (B-C)**	**760**____ **lbs**
		F) Net Surge (A-C+D)	______ **lbs**	F) Surge solids	______ lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	______ **lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks

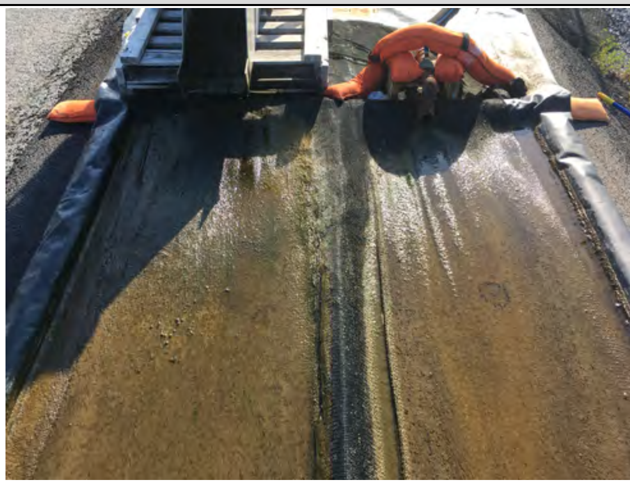
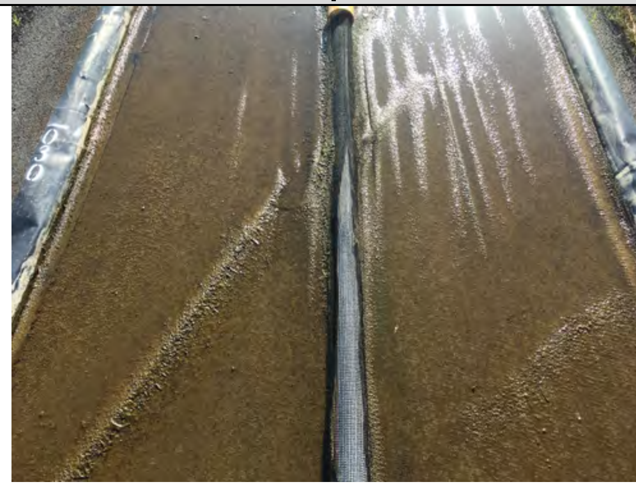
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 6/27/19
HARVEST NO.: 7
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

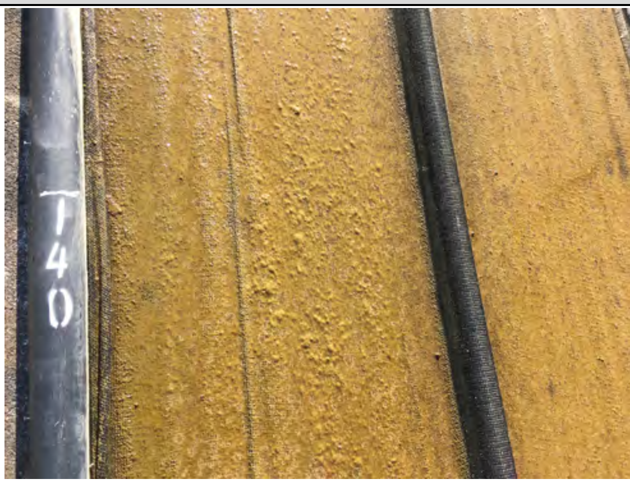
WEEKLY HARVEST PHOTOS	
Inflow Area	**Liner Subplot Area**
 Caption Photo 1	 Caption Photo 2
Concrete + Liner Subplot Area	**Concrete Subplot Area**
 Caption Photo 3	 Caption Photo 4

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 6/27/19

HARVEST NO.: 7

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
STA 140	**Side channel 4 hr**
 Caption Photo 5	 Caption Photo 6

HARVEST DATE: 7/3/19

HARVEST NO.: 8

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

Harvest Personnel:	Water Quality Top of Flow Way		Water Quality Bottom of Flow Way		Weather Conditions Temperature and Precipitation:			
AB, JK, PM, BT	pH	7.68	pH	8.32	AM:	Warm, partly cloudy 85		
	Conductivity (mS)	8.67/5.74	Conductivity (MS)	8.60/5.68	PM:	Hot, sunny 95		
	Salinity (ppt)	4.6	Salinity (ppt)	4.6	**Time of Harvest:**			
	Temperature (°C)	27.0	Temperature (°C)	27.1	From	**9:30**	To	**11:00**
	Dissolved oxygen (mg/L)	6.62	Dissolved oxygen (mg/L)	8.69	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	85.5%	DO saturation (%)	112.0	Surge		Direct	
	TSS sample **HAR19-#IN**		TSS sample **HAR19-#OUT**		Surge + Direct			
Surge Totalizer: 27,595,813	Pre-Har turbidity (NTU)	S: 9.28 D: 9.91	Pre-Har turbidity (NTU)	S: 3.10 D: 4.55	Volumes: 180 gal surge, 60 gal direct = 240gal total ***See Update**			
Direct Totalizer: 2,695,678	Post-Har turbidity (NTU)	S: 12.0 D: 12.1	Post-Har turbidity (NTU)	S: 5.42 D: 5.59	Time of WQ Data: 7:45			

Summary of Work Performed on Site
Collected side channel material and sampled for analysis. Normal harvest w/HAR samples. Truck scales not working at DMT.
Recorded volumes for each harvest, but not weights. Representative 5 gal sample weighed 43lbs from direct flow harvest.
Update: Harvest volume for surge was measured in digester feed tank and appears inaccurate. Use same volume as direct for approximation.
General Site Observations
Surge % Algae Cover: _____% **diatoms** _____% **filamentous greens** _____% **no growth**
Direct % Algae Cover: _____% **diatoms** _____% **filamentous greens** _____% **no growth**

Observations: Productivity of Different Surfaces (include approximate % cover)								
Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-___S			CL-___S			CON-___S		
LIN-___D			CL-___D			CON-___D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling	
Side Channel (surge side only)	**Sand Filter**
After 7 days drying: Top (station 100-130)= 24-2.16=21.84lbs	
Bottom (station130-200)= 29.5-2.16 = 27.34lbs	
Bucket weight 2.16lbs	**Input:** _________NTU Weight: ___________ Date/Time:
Weights: Freewater: Solids: 49.18lbs	**Output:** _________NTU Weight: ___________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)	
HAR19-8S-S-TOP-7DAY (2)	HAR19-8S (3)
HAR19-8S-S-BOTTOM-7DAY (2)	HAR19-8D (3)

HARVEST DATE: 7/3/19

HARVEST NO.: 8

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge LIN=liner+grid

#D = week+direct CON=concrete SOL=solid

#SF = week+sand filter CL=concrete+liner FW=freewater

#HP = Hawkins Point #IN=inflow #OUT=outflow

Signature____________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	____ lbs	A) Surge Truck	____ lbs	A) Surge FW Truck	____ lbs *(into digester)*
B) Surg + Direct Truck	____ lbs	B) Surge + Direct Truck	____ lbs	B) Direct Truck	____ lbs *(into s.filter)*
C) TAR Truck	____ lbs	C) TAR Truck	____ lbs	C) TAR Truck	____ lbs
D) Net Surge (A-C)	____ **lbs**	D) Sum Surge Subplots	____ lbs	**D) Net Surge (A-C)**	____ **lbs**
E) Net Direct (B-C-D)	____ **lbs**	E) Sum Direct Subplots	____ lbs	**E) Net Direct FW (B-C)**	____ **lbs**
		F) Net Surge (A-C+D)	____ **lbs**	F) Surge solids	____ lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	____ **lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks

TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 7/3/19
HARVEST NO.: 8
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

<table>
<tr><th colspan="2">WEEKLY HARVEST PHOTOS</th></tr>
<tr><th>Inflow Area</th><th>Liner Subplot Area</th></tr>
<tr><td>
Caption Photo 1</td><td>
Caption Photo 2</td></tr>
<tr><th>Concrete + Liner Subplot Area</th><th>Concrete Subplot Area</th></tr>
<tr><td>
Caption Photo 3</td><td>
Caption Photo 4</td></tr>
</table>

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 7/3/19

HARVEST NO.: 8

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Photo 5	**Photo 6**
 Caption Photo 5	 Caption Photo 6

HARVEST DATE: 7/11/19

HARVEST NO.: 9

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Harvest Personnel:	Water Quality Top of Flow Way		Water Quality Bottom of Flow Way		Weather Conditions Temperature and Precipitation:			
BS	pH	7.39	pH	7.85	AM:	Cloudy humid		
AB	Conductivity (mS)	7.47/4.89	Conductivity (mS)	7.40/4.87	PM:	Rain/clouds/hot		
PN	Salinity (ppt)	3.9	Salinity (ppt)	3.9	**Time of Harvest:**			
KIR	Temperature (°C)	27.6	Temperature (°C)	27.2	From	**7:40**	To	**12:00**
	Dissolved oxygen (mg/L)	5.72	Dissolved oxygen (mg/L)	6.60	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	74.6%	DO saturation (%)	86.0%	Surge	**560**	Direct	**620**
	TSS sample **HAR19-#IN**	yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct		1180 See next page	
Surge Totalizer:	Pre-Har turbidity (NTU)	S: 10.4	Pre-Har turbidity (NTU)	S: 5.38				
		D: 11.1		D: 6.65				
Direct Totalizer:	Post-Har turbidity (NTU)	S: 10.4	Post-Har turbidity (NTU)	S: 7.34				
		D: 11.5		D: 7.34	Time of WQ Data: 7:45			

Summary of Work Performed on Site

UMD performed subplot samples and observations. Subplot samples and filter bag data gathered.

2hr settling of subplot samples, 30 min drain down in filter bags. 2-3 buckets of material/water collected from sump kept separate (sloughed material)

General Site Observations

Surge % Algae Cover: __18__% diatoms __80__% blue greens __2_% no growth

Direct % Algae Cover: ____18__% diatoms __80__% blue greens ____2_% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid			Concrete + Grid			Concrete Only		
Start time: 9:00	Empty Bucket (lbs):	Full Bucket (lbs):	Start time: 9:10	Empty Bucket (lbs):	Full Bucket (lbs):	Start time: 9:20	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-9S	1.78	23.5	CL-9S	2.15	17	CON-9S	2.14	8.5
LIN-9D	2.15	20.0	CL-9D	2.14	16	CON-9D	2.10	10.5
Time into filter:	S: 10:56	D: 11:01	Time into filter:	S: 11:06	D: 11:11	Time into filter:	S: 11:16	D: 11:21
Surge: Harvest Bucket Weight: 21.72 lbs			Surge: Harvest Bucket Weight: 14.85lbs			Surge: Harvest Bucket Weight: 6.36lbs		
Bag Weights: Wet: 7.14 Dry: 0.17			Bag Weights: Wet: 7.92 Dry: 0.17			Bag Weights: Wet: 4.69 Dry: 0.17		
Direct: Harvest Bucket Weight: 17.85lbs			Direct: Harvest Bucket Weight: 13.86lbs			Direct: Harvest Bucket Weight: 8.40lbs		
Bag Weights: Wet: 6.54 Dry: 0.17			Bag Weights: Wet: 5.97 Dry: 0.17			Bag Weights: Wet: 5.88 Dry: 0.17		

Notes: Biomass Handling

Side Channel (surge side only)	Sand Filter
	Input: _________NTU Weight: ____________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ____________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HARVEST DATE: 7/11/19
HARVEST NO.: 9
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature________________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	______ lbs	A) Surge Truck	24,320lbs	A) Surge FW Truck	______ lbs *(into digester)*
B) Surg + Direct Truck	______ lbs	B) Surge + Direct Truck	24,940lbs	B) Direct Truck	______ lbs *(into s.filter)*
C) TAR Truck	______ lbs	C) TAR Truck	23,760lbs	C) TAR Truck	______ lbs
D) Net Surge (A-C)	______ **lbs**	D) Sum Surge Subplots	42.93lbs	**D) Net Surge (A-C)**	______ **lbs**
E) Net Direct (B-C-D)	______ **lbs**	E) Sum Direct Subplots	40.11lbs	**E) Net Direct FW (B-C)**	______ **lbs**
		F) Net Surge (A-C+D)	**602.93lbs**	F) Surge solids	______ lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	**660.11lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

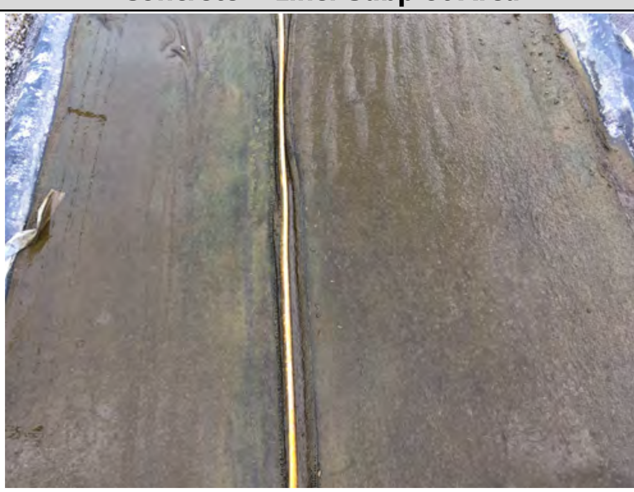
Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

HARVEST DATE: 7/11/19
HARVEST NO.: 9
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

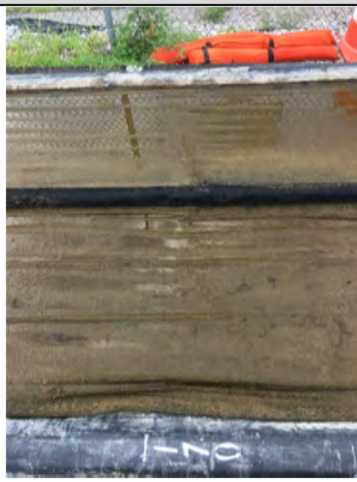
WEEKLY HARVEST PHOTOS	
Inflow Area	**Liner Subplot Area**
 Caption Photo 1	 Caption Photo 2
Concrete + Liner Subplot Area	**Concrete Subplot Area**
 Caption Photo 3	 Caption Photo 4

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 7/11/19

HARVEST NO.: 9

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Station 170	**Photo 6**
	
Caption Photo 5	Caption Photo 6

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 7/18/19
HARVEST NO.: 10
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS, AB, PN, KR, PM, DD	pH	7.27	pH	8.31	AM:	HOT, sun, humid		
	Conductivity (mS)	8.26/5.31	Conductivity (mS)	8.12/5.22	PM:	HOT, sun, humid		
	Salinity (ppt)	4.2	Salinity (ppt)	4.1	**Time of Harvest:**			
	Temperature (°C)	29.3	Temperature (°C)	29.2	From	**7:40**	To	**11:00**
	Dissolved oxygen (mg/L)	5.31	Dissolved oxygen (mg/L)	8.05	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	71.7%	DO saturation (%)	108.7%	Surge	**n/a**	Direct	**760**
	TSS sample **HAR19-#IN**	YES	TSS sample **HAR19-#OUT**	YES	Surge + Direct			
Surge Totalizer: 28,450,120	Pre-Har turbidity (NTU)	S: 28.0 D: 33.0	Pre-Har turbidity (NTU)	S: 8.6 D: 12.9				
Direct Totalizer: 3,677,268	Post-Har turbidity (NTU)	S: 12.7 D: 11.4	Post-Har turbidity (NTU)	S: 8.60 D: 6.05	Time of WQ Data: 7:40			

Summary of Work Performed on Site
Cleared sump prior to harvest. Harvested surge into side channel than direct channel into sump for vac truck. Samples taken and
Free water added to sand filter.
General Site Observations
Still almost no filamentous green algae except right at inflow.
Surge % Algae Cover: ___60__% diatoms __38__% blue greens __2__% no growth
Direct % Algae Cover: __60___% diatoms __38__% blue greens ___2__% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)								
Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-____S			CL-____S			CON-____S		
LIN-____D			CL-____D			CON-____D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling	
Side Channel (surge side only)	**Sand Filter**
Bucket weight: 2lbs	
32, 35, 7, 36, 35, 37, 42.5	
	Input: ____442___NTU Weight: ___210.5___ Date/Time: 7/18 ~10:45
Weights: Freewater: 210.5 Solids: 60.40	**Output:** ___78.9___NTU Weight: _____98.5_____Date/Time: 7/19 2:00

Samples Submitted to the Lab (list sample ID and describe sample)	
HAR19-10D	HAR19-10S-FW, HAR19-SF10
HAR19-10S-S	HAR19-10-S-4H

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 7/18/19

HARVEST NO.: 10

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Sample ID Key: HAR19-

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature______________________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	______ lbs	A) Surge Truck	______ lbs	A) Surge FW	n/a______ lbs *(into s.filter)*
B) Surg + Direct Truck	______ lbs	B) Surge + Direct Truck	______ lbs	B) Direct Truck	24,420 lbs *(into digester)*
C) TAR Truck	______ lbs	C) TAR Truck	______ lbs	C) TAR Truck	23,660 lbs
D) Net Surge (A-C)	______ **lbs**	D) Sum Surge Subplots	______ lbs	**D) Net Surge FW (A-C)**	______ **lbs**
E) Net Direct (B-C-D)	______ **lbs**	E) Sum Direct Subplots	______ lbs	**E) Net Direct (B-C)**	**760______ lbs**
		F) Net Surge (A-C+D)	______ **lbs**	F) Surge solids	______ lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	______ **lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks

TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 7/18/19
HARVEST NO.: 10
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

<table>
<tr><th colspan="2">WEEKLY HARVEST PHOTOS</th></tr>
<tr><th>Inflow Area</th><th>Liner Subplot Area</th></tr>
<tr><td>
Caption Photo 1</td><td>
Caption Photo 2</td></tr>
<tr><th>Concrete + Liner Subplot Area</th><th>Concrete Subplot Area</th></tr>
<tr><td>
Caption Photo 3</td><td>
Caption Photo 4</td></tr>
</table>

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 7/18/19

HARVEST NO.: 10

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
3-hr side channel	**3-hr side channel**
 Caption Photo 5	 Caption Photo 6

2019 DMT ALGAL FLOW WAY
SIDE CHANNEL DEWATERING OBSERVATIONS

INITIAL HARVEST DATE: 7-18-2019

Days Since Harvest		Temperature (degrees C)		General Weather Conditions	Humidity	Rain (check if applicable)	
	Date	Daily High	Daily Low	Sun/Overcast/Rain	High or Low	Day	Overnight
Harvest	**7/18**	90-95	70	Sun, Hot, Humid	high	☐	☐
Day 1	**7/19**	95	75	Sun, Hot, Humid	High	☐	☐
Day 2	**7/20**	95	75	Sun, Hot, Humid	High	☐	☐
Day 3	**7/21**	97	75	Sun, Hot, Humid	High	☐	☐
Day 4	**7/22**	90		Sun, Hot, Humid	High	☐	☐
Day 5	**7/23**	80	65	Rain, clouds, cooler	High	☒	☒
Day 6	**7/24**	90	68	Sunny, warm	Med-low	☐	☐
Day 7	**7/25**	90	68	Sunny, warm	Med-low	☐	☐

Daily Observations – Including these examples: *Relative dryness of material (is it handleable, will finger leave an impression, significant changes from prior day)? How thick is material in different locations? Did rain rehydrate or mobilize the material?*
Upload photos and videos from each day to OneDrive. Note time of day observations were made.

Harvest: Collect HAR19-(10)S-S-1H & HAR19-(10)S-S-4H
4hr- sections of pasty algae and sections of watery mix.

Day 1: Collect HAR19-(10)S-S-1D
Continued drying, pasty algae and sections of wet. Sand filter effluent taken

Day 2: weekend

Day 3: weekend

Day 4: half fully dry, low spots wet but shovelable.

Day 5: rain, wind, some thin dried solid chips mobilized from wind/water

Day 6: sunny, warm, mild, algae drying back out. Dried algae retained its general form

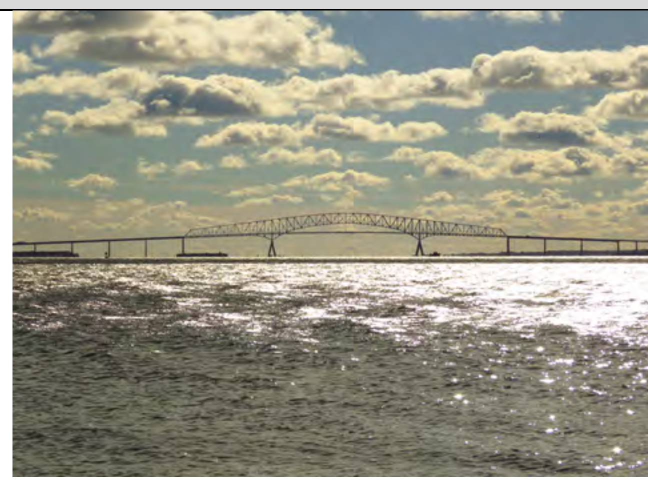
Day 7: Collect HAR19-(10)S-S-7D
Mostly dry. Low spots still damp, one section (5 feet) sloppy wet. Bucket weights: 12.15(dry), 9.33(dry), 7.37(mix wet/dry), 30.50(wet), 11.70(dry)
Empty buckt: 2.13lbs

Final Dry Weight of Harvest from Side Channel: 60.4lbs

SIDE CHANNEL DEWATERING PHOTOS HTTPS://ANCHORQEA-MY.SHAREPOINT.COM/:F:/R/PERSONAL/ECHEN_ANCHORQEA_COM/DOCUMENTS/HAWKINS%20POINT%20AFT%20SCALE-UP/2019%20AFW%20TESTING/2019%20HARVEST%20PHOTOS/HARVEST%2010%20-%2018JULY2019/SIDE%20CHANNEL%20HARVEST%2010?CSF=1&E=YV0H4O	
HARVEST	**DAY 1**
 Caption Photo 1	 Caption Photo 2
DAY 2	**DAY 3**
 Caption Photo 3	 Caption Photo 4

INITIAL HARVEST DATE: 7-18-2019

SIDE CHANNEL DEWATERING PHOTOS HTTPS://ANCHORQEA-MY.SHAREPOINT.COM/:F:/R/PERSONAL/ECHEN_ANCHORQEA_COM/DOCUMENTS/HAWKINS%20POINT%20AFT%20SCALE-UP/2019%20AFW%20TESTING/2019%20HARVEST%20PHOTOS/HARVEST%2010%20-%2018JULY2019/SIDE%20CHANNEL%20HARVEST%2010?CSF=1&E=YV0H4O	
DAY 4	**DAY 5**
 Caption Photo 5	 Caption Photo 6

SIDE CHANNEL DEWATERING PHOTOS (continued)	
DAY 6	**DAY 7**
 Caption Photo 1	 Caption Photo 2

HARVEST DATE: 7/25/19

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

HARVEST NO.: 11

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS, AB, JK, KIR, PM,	pH	7.05	pH	8.71/ 8.15MIXING	AM:	SUNNY, WARM		
DD	Conductivity (MS)	10.23/6.77	Conductivity (MS)	10.00/6.71	PM:	SUNNY, WARM		
	Salinity (ppt)	5.5	Salinity (ppt)	5.5	**Time of Harvest:**			
	Temperature (°C)	26.8	Temperature (°C)	25.8	From	**7:40**	To	**10:20**
	Dissolved oxygen (mg/L)	6.34	Dissolved oxygen (mg/L)	9.38	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	82.3%	DO saturation (%)	119.7%	Surge	**600**	Direct	**660**
	TSS sample **HAR19-#IN**	YES	TSS sample **HAR19-#OUT**	YES	Surge + Direct		1260	
Surge Totalizer:	Pre-Har turbidity (NTU)	S: 11.5 D: 10.8	Pre-Har turbidity (NTU)	S: 4.66 D: 7.12				
Direct Totalizer:	Post-Har turbidity (NTU)	S: 10.3 D: 11.7	Post-Har turbidity (NTU)	S: 8.50 D: 5.49	Time of WQ Data: 7:40			

Summary of Work Performed on Site
Normal harvest, day 7 side channel sample and final weights
General Site Observations
More filamentous diatoms, few patches of filamentous greens
Surge % Algae Cover: ___90___% diatoms ___10___% blue greens ____0__% no growth
Direct % Algae Cover: ____90__% diatoms ___10___% blue greens _____0_% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-____S			CL-____S			CON-____S		
LIN-____D			CL-____D			CON-____D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling

Side Channel (surge side only)	**Sand Filter**
	Input: _________NTU Weight: ____________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ____________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HAR19-11S, HAR19-11D	AFW19-11IN, AF19-11OUT
HAR19-11S-1, 2, 3, 4	HAR19-10S-S-7D
HAR19-11D-1, 2 , 3, 4	

HARVEST DATE: 7/25/19
HARVEST NO.: 11
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature____________________

Calculations

Harvest Weights

Typical Harvest Week			Subplot Week			Side Channel Week		
A) Surge Truck	24280	lbs	A) Surge Truck		lbs	A) Surge FW Truck		lbs *(into digester)*
B) Surg + Direct Truck	24940	lbs	B) Surge + Direct Truck		lbs	B) Direct Truck		lbs *(into s.filter)*
C) TAR Truck	23680	lbs	C) TAR Truck		lbs	C) TAR Truck		lbs
D) Net Surge (A-C)	**600**	**lbs**	D) Sum Surge Subplots		lbs	**D) Net Surge (A-C)**		**lbs**
E) Net Direct (B-C-D)	**660**	**lbs**	E) Sum Direct Subplots		lbs	**E) Net Direct FW (B-C)**		**lbs**
			F) Net Surge (A-C+D)		**lbs**	F) Surge solids		lbs *(meas. later)*
			G) Net Direct (B-C-F+E)		**lbs**	(FW = freewater)		

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

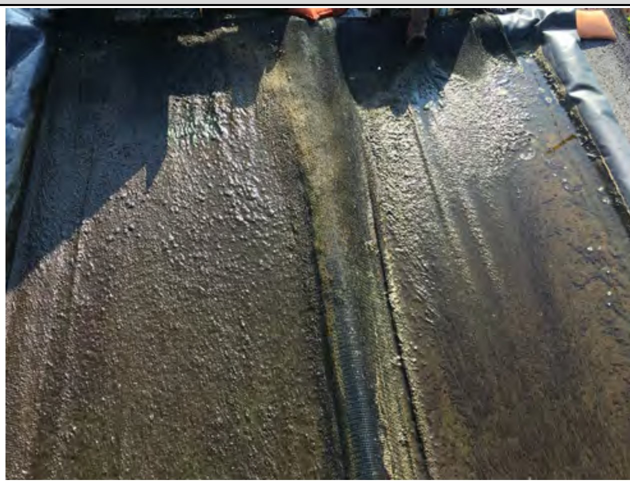
2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 7/25/19

HARVEST NO.: 11

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

WEEKLY HARVEST PHOTOS

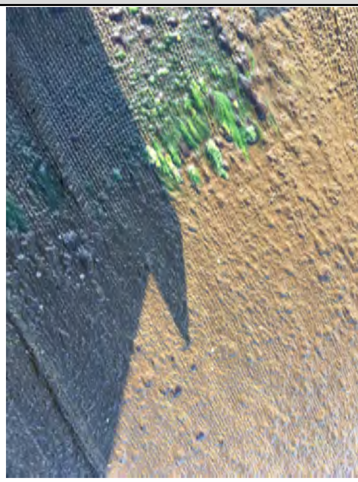
Inflow Area	Liner Subplot Area
 Caption Photo 1	 Caption Photo 2
Concrete + Liner Subplot Area	**Concrete Subplot Area**
 Caption Photo 3	 Caption Photo 4

HARVEST DATE: 7/25/19

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST NO.: 11

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Inflow detail	**Photo 6**
 Caption Photo 5	 Caption Photo 6

HARVEST DATE: 8-1-19

HARVEST NO.: 12

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

Harvest Personnel:	Water Quality Top of Flow Way		Water Quality Bottom of Flow Way		Weather Conditions Temperature and Precipitation:			
BS, AB, JK, WT, DD	pH	7.64	pH	8.41mixing z	AM:	Sunny, hot		
	Conductivity (mS)	8.51/5.54	Conductivity (mS)	8.44/5.52	PM:	Sunny, hot		
	Salinity (ppt)	4.4	Salinity (ppt)	4.4	**Time of Harvest:**			
	Temperature (°C)	28.2	Temperature (°C)	27.8	From	**7:40**	To	**11:45**
	Dissolved oxygen (mg/L)	6.35	Dissolved oxygen (mg/L)	8.36	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	86.0%	DO saturation (%)	110.1%	Surge	**500**	Direct	**680**
	TSS sample **HAR19-#IN**	yes	TSS sample **HAR19-#OUT**	yes	Surge + Direct		1,180 See next page	
Surge Totalizer: 28,831,270	Pre-Har turbidity (NTU)	S: 9.18 D: 8.74	Pre-Har turbidity (NTU)	S: 3.72 D: 5.00				
Direct Totalizer: 4,625,589	Post-Har turbidity (NTU)	S: 5.68 D: 6.50	Post-Har turbidity (NTU)	S: 14.9 D: 3.26	Time of WQ Data: 7:40			

Summary of Work Performed on Site
Shop vac stopped working, subsamples taken with squeegee and dust pan.
Normal subplot week otherwise.
General Site Observations
Lots of filamentous diatoms. Some filamentous green at inflow zone.
Surge % Algae Cover: _100___% diatoms _____% filamentous greens _____% no growth
Direct % Algae Cover: ___100__% diatoms _____% filamentous greens _____% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid			Concrete + Grid			Concrete Only		
Start time: 8:40	Empty Bucket (lbs):	Full Bucket (lbs):	Start time: 8:50	Empty Bucket (lbs):	Full Bucket (lbs):	Start time: 9:00	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-12S	2.13	23	CL-12S	2	12.69	CON-12S	2	6.91
LIN-12D	2.14	22	CL-12D	2	19.38	CON-12D	2	7.86
Time into filter:	S: 10:31	D: 10:36	Time into filter:	S: 10:41	D: 10:46	Time into filter:	S: 10:51	D: 10:56
Surge: Harvest Bucket Weight: 20.87 lbs			Surge: Harvest Bucket Weight: 10.69 lbs			Surge: Harvest Bucket Weight: 4.91 lbs		
Bag Weights: Wet: 6.91 Dry: 0.17			Bag Weights: Wet: 4.77 Dry: 0.17			Bag Weights: Wet: 3.02 Dry: 0.17		
Direct: Harvest Bucket Weight: 19.86 lbs			Direct: Harvest Bucket Weight: 17.38 lbs			Direct: Harvest Bucket Weight: 5.86 lbs		
Bag Weights: Wet: 5.07 Dry: 0.17			Bag Weights: Wet: 4.74 Dry: 0.17			Bag Weights: Wet: 3.69 Dry: 0.17		

Notes: Biomass Handling

Side Channel (surge side only)	Sand Filter
	Input: _________NTU Weight: ____________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ____________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HAR19-12S, HAR19-12D	HAR19-CL-12S, HAR19-LIN-12D
HAR19-CON-12S, HAR19-CON-12D	
HAR19-LIN-12S, HAR19-LIN-12D	

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8-1-19

HARVEST NO.: 12

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature______________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	___ lbs	A) Surge Truck	24,220 lbs	A) Surge FW Truck	___ lbs *(into digester)*
B) Surg + Direct Truck	___ lbs	B) Surge + Direct Truck	24,900 lbs	B) Direct Truck	___ lbs *(into s.filter)*
C) TAR Truck	___ lbs	C) TAR Truck	23,720 lbs	C) TAR Truck	___ lbs
D) Net Surge (A-C)	___ **lbs**	D) Sum Surge Subplots	36.47 lbs	**D) Net Surge (A-C)**	___ **lbs**
E) Net Direct (B-C-D)	___ **lbs**	E) Sum Direct Subplots	43.1 lbs	**E) Net Direct FW (B-C)**	___ **lbs**
		F) Net Surge (A-C+D)	**536.47 lbs**	F) Surge solids	___ lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	**723.1 lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

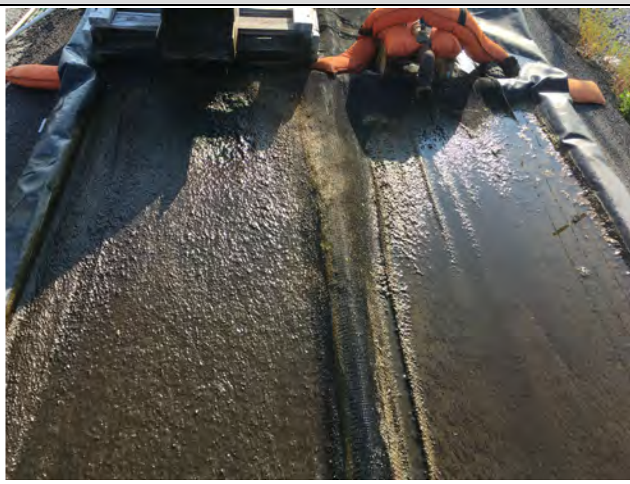
- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8-1-19
HARVEST NO.: 12
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

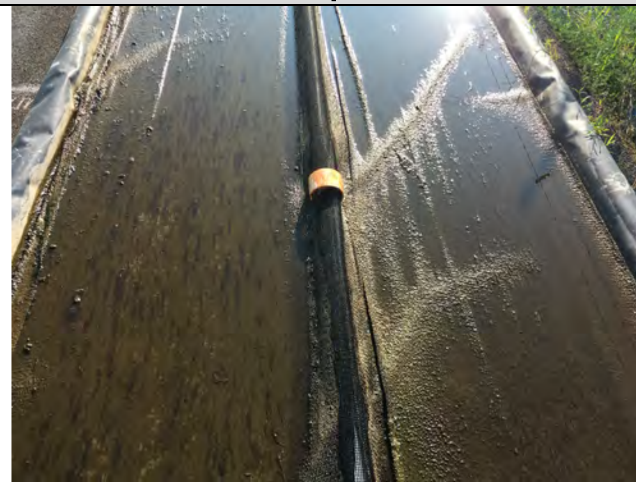
WEEKLY HARVEST PHOTOS

Inflow Area



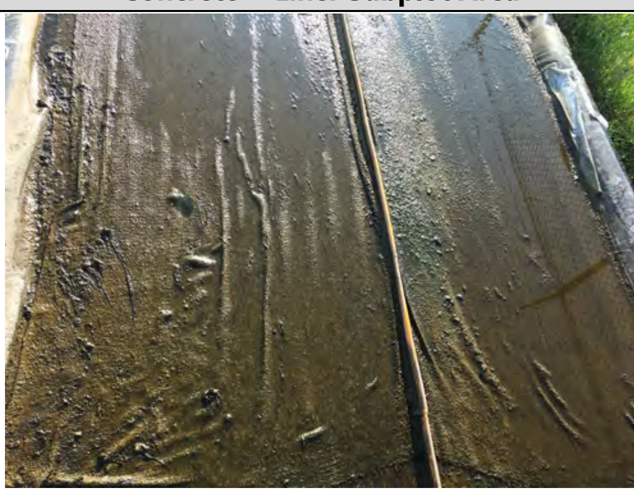
Caption Photo 1

Liner Subplot Area



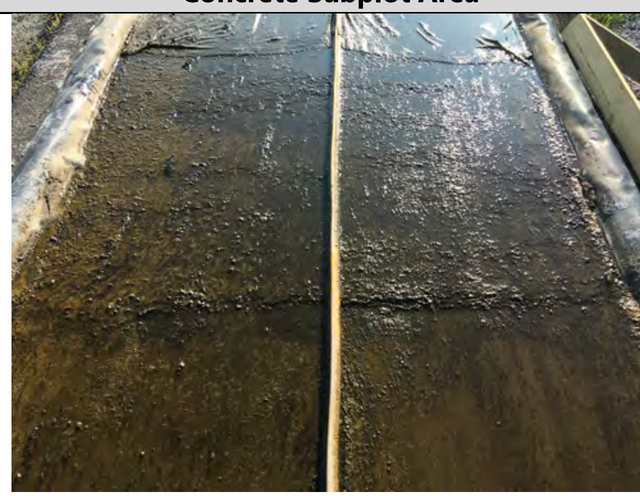
Caption Photo 2

Concrete + Liner Subplot Area



Caption Photo 3

Concrete Subplot Area



Caption Photo 4

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8-1-19
HARVEST NO.: 12
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Photo 5	**Photo 6**
 Caption Photo 5	 Caption Photo 6

HARVEST DATE: 8/8/19

HARVEST NO.: 13

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS, AB, JK, BT	pH	7.20	pH	8.09	AM:	Sunny, hot		
	Conductivity (mS)	9.27/6.35	Conductivity (mS)	9.64/6.33	PM:	Sunny, hot		
	Salinity (ppt)	5.1	Salinity (ppt)	5.1	**Time of Harvest:**			
	Temperature (°C)	27.9	Temperature (°C)	27.4	From	**7:40**	To	**10:45**
	Dissolved oxygen (mg/L)	5.62	Dissolved oxygen (mg/L)	8.22	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	74.8%	DO saturation (%)	107.2%	Surge	**n/a**	Direct	**840**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct			
Surge Totalizer:	Pre-Har turbidity (NTU)	S: 8.87	Pre-Har turbidity (NTU)	S: 3.34				
		D: 9.94		D: 4.70				
Direct Totalizer:	Post-Har turbidity (NTU)	S: 5.78	Post-Har turbidity (NTU)	S: 3.63				
		D: 7.18		D: 5.26	Time of WQ Data: 7:40			

Summary of Work Performed on Site

Standard Side channel harvest. Larger amount of free water than before. Growth visually better with filamentous diatoms prevalent on surge side.

Sand filter basin broken, volume out of sand filter not obtained.

General Site Observations

Surge side filamentous diatoms to station 30. Good growth overall

Surge % Algae Cover: ___100__% diatoms ______% filamentous greens ______% no growth

Direct % Algae Cover: __100_% diatoms ______% filamentous greens ______% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-____S			CL-____S			CON-____S		
LIN-____D			CL-____D			CON-____D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling

Side Channel (surge side only)	**Sand Filter**
32, 27, 32, 29, 29, 32, 36= 217	
Bucket: 2lb	
	Input: __overrange_ NTU Weight: ______203lbs__ Date/Time: 10:30 8/8
Weights: Freewater: 203lbs Solids:	**Output:** ___196____NTU Weight: ____________Date/Time: 10:40 8/8

Samples Submitted to the Lab (list sample ID and describe sample)

HAR13-13D, AFW 19-13IN	HAR19-13S-FW
AFW19-13OUT	HAR19-SF13
HAR19-13S-S	HAR19-13S-4HR

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8/8/19

HARVEST NO.: 13

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature______________________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	____ lbs	A) Surge Truck	____ lbs	A) Surge FW	n/a____ lbs *(into s.filter)*
B) Surg + Direct Truck	____ lbs	B) Surge + Direct Truck	____ lbs	B) Direct Truck	24460___ lbs *(into digester)*
C) TAR Truck	____ lbs	C) TAR Truck	____ lbs	C) TAR Truck	23620____ lbs
D) Net Surge (A-C)	____ **lbs**	D) Sum Surge Subplots	____ lbs	**D) Net Surge FW (A-C)**	____ **lbs**
E) Net Direct (B-C-D)	____ **lbs**	E) Sum Direct Subplots	____ lbs	**E) Net Direct (B-C)**	**840**____ **lbs**
		F) Net Surge (A-C+D)	____ **lbs**	F) Surge solids	____ lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	____ **lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks

TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

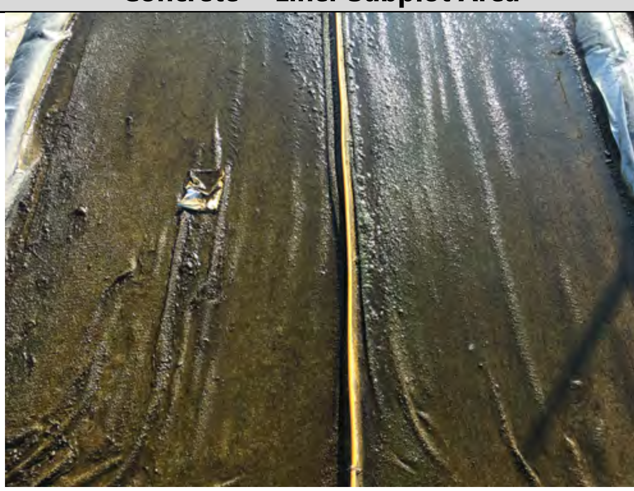
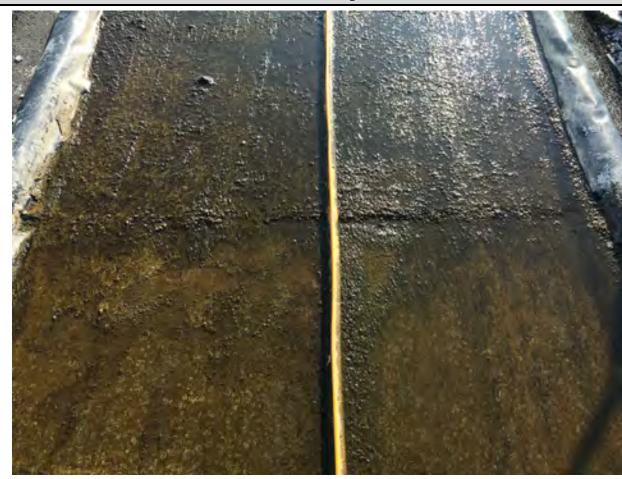
- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- <u>Subplot Weeks</u>: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- <u>Side Channel Weeks</u>: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8/8/19

HARVEST NO.: 13

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Inflow Area	**Liner Subplot Area**
	 Caption Photo 2
Concrete + Liner Subplot Area	**Concrete Subplot Area**
 Caption Photo 3	

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8/8/19

HARVEST NO.: 13

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Inflow detail	**Initial side channel free water**
 Caption Photo 5	 Caption Photo 6

2019 DMT ALGAL FLOW WAY
SIDE CHANNEL DEWATERING OBSERVATIONS

INITIAL HARVEST DATE: 8/8/19

Days Since Harvest		Temperature (degrees C)		General Weather Conditions	Humidity	Rain (check if applicable)	
	Date	Daily High	Daily Low	Sun/Overcast/Rain	High or Low	Day	Overnight
Harvest	8/8/19	90	70	Sun, warm	Med	☐	☐
Day 1	8/9	90	70	Sun, warm	Med	☐	☐
Day 2	8/10	90	65	Sun, warm	Low	☐	☐
Day 3	8/11	90	65	Sun, warm	Low	☐	☐
Day 4	8/12	95	70	Sun, warm	Med	☐	☐
Day 5	8/13	95	75	Cloudy, warm, intermittent rain	High	☒	☒
Day 6	8/14	95	70	Cloudy, mix of sun	High	☐	☐
Day 7	8/15	95	70	cloudy	high	☐	☐

Daily Observations – Including these examples: ***Relative dryness of material (is it handleable, will finger leave an impression, significant changes from prior day)? How thick is material in different locations? Did rain rehydrate or mobilize the material?*** **Upload photos and videos from each day to OneDrive. Note time of day observations were made.**
Harvest: Collect HAR19-(13)S-S-1H & HAR19-(13)S-S-4H
Day 1: Collect HAR19-(13)S-S-1D Microwave testing done on this sample
Day 2: weekend
Day 3: weekend
Day 4: Low spots wet paste to peat consistency. 10% fully dry to flaking
Day 5: PM rain, cloudy
Day 6: cloudy, low spots still wet, rain did not dislodge much material. Appears to have just moistened dried algae.
Day 7: Collect HAR19-(13)S-S-7D Microwave test. Cloudy, consistent sloped areas fully dried to flake. 3 buckets of dry and damp material: 13, 25, 14lbs 1bucket of slop from sump: 37lbs Final Dry Weight of Harvest from Side Channel:

2019 DMT ALGAL FLOW WAY
SIDE CHANNEL DEWATERING OBSERVATIONS

INITIAL HARVEST DATE: 8/8/19

SIDE CHANNEL DEWATERING PHOTOS	
HARVEST	**DAY 1**
 Caption Photo 1	 Caption Photo 2
DAY 2	**DAY 3**
 Caption Photo 3	 Caption Photo 4
DAY 4	**DAY 5**
 Caption Photo 5	 Caption Photo 6

SIDE CHANNEL DEWATERING PHOTOS (continued)	
DAY 6	**DAY 7**
  Caption Photo 1	  Caption Photo 2

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8/16/19
HARVEST NO.: 14
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS, PN, PM	pH	7.52	pH	7.95	AM:	Cloudy, warm		
	Conductivity (mS)	11.73/7.13	Conductivity (µS)	11.64/7.74	PM:	Cloudy, warm		
	Salinity (ppt)	6.5	Salinity (ppt)	6.4	**Time of Harvest:**			
	Temperature (°C)	26.6	Temperature (°C)	26.4	From	**7:40**	To	**10:45**
	Dissolved oxygen (mg/L)	6.46	Dissolved oxygen (mg/L)	7.91	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	83.1%	DO saturation (%)	101.4%	Surge	**660**	Direct	**900**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct		1,560	
Surge Totalizer: 29,677,368	Pre-Har turbidity (NTU)	S: 6.22 D: 4.23	Pre-Har turbidity (NTU)	S: 2.75 D: 6.58				
Direct Totalizer: 5,569,293	Post-Har turbidity (NTU)	S: 4.52 D: 4.91	Post-Har turbidity (NTU)	S: 7.04 D: 3.63	Time of WQ Data: 7:50			

Summary of Work Performed on Site
Clean up side channel material and weigh/microwave. Surge side harvest noticeably thicker in sump and while pushing compared to direct
General Site Observations
Large number of filamentous diatoms on surge side inflow to station 30.
Surge % Algae Cover: __100% diatoms _____% filamentous greens _____% no growth
Direct % Algae Cover: __100_% diatoms _____% filamentous greens _____% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)								
Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-____S			CL-____S			CON-____S		
LIN-____D			CL-____D			CON-____D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling	
Side Channel (surge side only)	**Sand Filter**
	Input: _________NTU Weight: ____________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ____________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)	
HAR19-14S	HAR19-13S-7D
HAR19-14D	

HARVEST DATE: 8/16/19

HARVEST NO.: 14

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature____________________

Calculations

Harvest Weights

Typical Harvest Week			Subplot Week			Side Channel Week		
A) Surge Truck	19,160	lbs	A) Surge Truck		lbs	A) Surge FW Truck		lbs *(into digester)*
B) Surg + Direct Truck	20,060	lbs	B) Surge + Direct Truck		lbs	B) Direct Truck		lbs *(into s.filter)*
C) TAR Truck	18,500	lbs	C) TAR Truck		lbs	C) TAR Truck		lbs
D) Net Surge (A-C)	**660**	**lbs**	D) Sum Surge Subplots		lbs	**D) Net Surge (A-C)**		**lbs**
E) Net Direct (B-C-D)	**900**	**lbs**	E) Sum Direct Subplots		lbs	**E) Net Direct FW (B-C)**		**lbs**
			F) Net Surge (A-C+D)		**lbs**	F) Surge solids		lbs *(meas. later)*
			G) Net Direct (B-C-F+E)		**lbs**	(FW = freewater)		

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks

TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8/16/19
HARVEST NO.: 14
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS

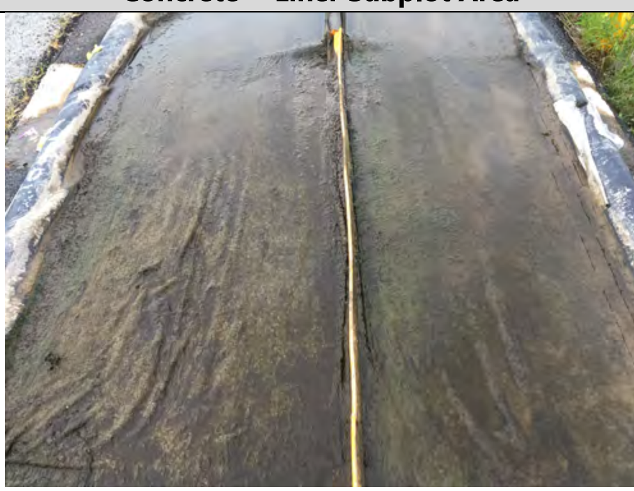
Inflow Area


Caption Photo 1

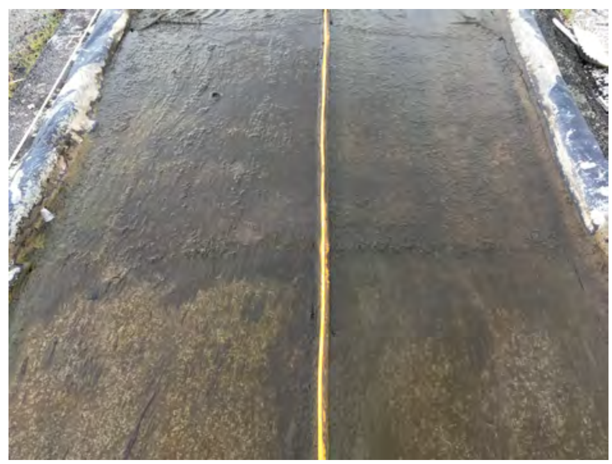
Liner Subplot Area


Caption Photo 2

Concrete + Liner Subplot Area


Caption Photo 3

Concrete Subplot Area


Caption Photo 4

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8/16/19

HARVEST NO.: 14

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Surge inflow detail	**Photo 6**
 Caption Photo 5	 Caption Photo 6

HARVEST DATE: 8/22/19
HARVEST NO.: 15
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS, JK, WT	pH	7.51	pH	7.57	AM:	Sunny, warm		
	Conductivity (mS)	10.86/7.01	Conductivity (mS)	10.59/6.93	PM:	Sunny, hot		
	Salinity (ppt)	5.7	Salinity (ppt)	5.7	**Time of Harvest:**			
	Temperature (°C)	28.6	Temperature (°C)	27.5	From	**7:50**	To	**12:00**
	Dissolved oxygen (mg/L)	4.75	Dissolved oxygen (mg/L)	5.52	**Total Weight of Harvest (lbs.)**			
	DO saturation (%)	64.5%	DO saturation (%)	72.6%	Surge	**640**	Direct	**1,180**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct		1,820 See next page	
Surge Totalizer: 29,779,142	Pre-Har turbidity (NTU)	S: 7.35 D: 6.98	Pre-Har turbidity (NTU)	S: 2.27 D: 3.32				
Direct Totalizer: 6,030,149	Post-Har turbidity (NTU)	S: 5.72 D: 8.24	Post-Har turbidity (NTU)	S: 2.76 D: 3.88	Time of WQ Data: 7:50			

Summary of Work Performed on Site
Green mat-forming algae sta-130 down, especially on direct side. Pulled off in sheets, did not tear easily.
General Site Observations
Concrete direct had thick bio-mat that was not easily removed, even with shop vac subplot sample. Some filamentous greens mixed in.
Surge % Algae Cover: _80_% diatoms ___5_% filamentous greens __0__% no growth 5% blue/green
Direct % Algae Cover: __80__% diatoms __5__% filamentous greens _0___% no growth 5% blue/green

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time: 9:20	Empty Bucket (lbs):	Full Bucket (lbs):	Start time: 9:30	Empty Bucket (lbs):	Full Bucket (lbs):	Start time: 9:40	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-15S	2.13	16.95	CL-15S	2.13	14.08	CON-15S	2.13	11.75
LIN-15D	2.13	34.0	CL-15D	2.13	25.0	CON-15D	1.67	12.42
Time into filter:	S: 10:35	D: 10:40	Time into filter:	S: 10:45	D: 10:50	Time into filter:	S: 10:55	D: 11:00
Surge: Harvest Bucket Weight: 14.82lbs			Surge: Harvest Bucket Weight: 11.95lbs			Surge: Harvest Bucket Weight: 9.62lbs		
Bag Weights: Wet: 8.15 Dry: 0.17			Bag Weights: Wet: 5.03 Dry: 0.17			Bag Weights: Wet: 4.26 Dry: 0.17		
Direct: Harvest Bucket Weight: 31.87lbs			Direct: Harvest Bucket Weight: 22.87lbs			Direct: Harvest Bucket Weight: 10.75lbs		
Bag Weights: Wet: 11.83 Dry: 0.17			Bag Weights: Wet: 7.50 Dry: 0.17			Bag Weights: Wet: 3.40 Dry: 0.17		

Notes: Biomass Handling

Side Channel (surge side only)	**Sand Filter**
	Input: _________NTU Weight: ____________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ___________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HARVEST DATE: 8/22/19

HARVEST NO.: 15

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge
#D = week+direct
#SF = week+sand filter
#HP = Hawkins Point

LIN=liner+grid
CON=concrete
CL=concrete+liner
#IN=inflow

SOL=solid
FW=freewater
#OUT=outflow

Signature______________________

Calculations

Harvest Weights								
Typical Harvest Week			Subplot Week			Side Channel Week		
A) Surge Truck	____	lbs	A) Surge Truck	24,340	lbs	A) Surge FW Truck	____	lbs *(into digester)*
B) Surg + Direct Truck	____	lbs	B) Surge + Direct Truck	25,520	lbs	B) Direct Truck	____	lbs *(into s.filter)*
C) TAR Truck	____	lbs	C) TAR Truck	23,700	lbs	C) TAR Truck	____	lbs
D) Net Surge (A-C)	____	**lbs**	D) Sum Surge Subplots	36.39	lbs	**D) Net Surge (A-C)**	____	**lbs**
E) Net Direct (B-C-D)	____	**lbs**	E) Sum Direct Subplots	65.49	lbs	**E) Net Direct FW (B-C)**	____	**lbs**
			F) Net Surge (A-C+D)	**676.39**	**lbs**	F) Surge solids	____	lbs *(meas. later)*
			G) Net Direct (B-C-F+E)	**1,245.49**	**lbs**	(FW = freewater)		

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8/22/19
HARVEST NO.: 15
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

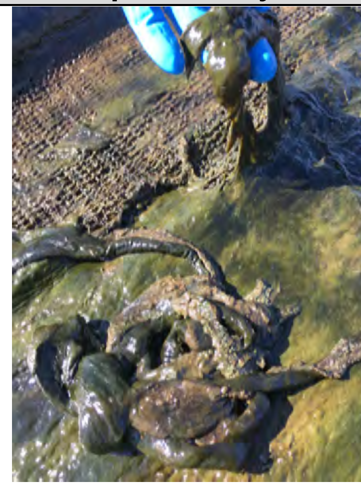
WEEKLY HARVEST PHOTOS	
Inflow Area	**Liner Subplot Area**
 Caption Photo 1	 Caption Photo 2
Concrete + Liner Subplot Area	**Concrete Subplot Area**
 Caption Photo 3	 Caption Photo 4

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 8/22/19

HARVEST NO.: 15

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Thick bio-mat attached	**Bio-mat peeled away in sheet**
 Caption Photo 5	 Caption Photo 6

HARVEST DATE: 8/29/19

HARVEST NO.: 16

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Harvest Personnel:	Water Quality Top of Flow Way		Water Quality Bottom of Flow Way		Weather Conditions Temperature and Precipitation:			
BS, JK, WT, DD, PM	pH	6.95	pH	8.11	AM:	Sunny, mild, (70s)		
	Conductivity (mS)	12.44/8.47	Conductivity (mS)	12.08/8.40	PM:	Sunny, warm,		
	Salinity (ppt)	7.2.	Salinity (ppt)	7.2	**Time of Harvest:**			
	Temperature (°C)	24.6	Temperature (°C)	23.1	From	**7:40**	To	**11:15**
	Dissolved oxygen (mg/L)	4.56	Dissolved oxygen (mg/L)	8.01	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	56.8%	DO saturation (%)	98.1%	Surge	**n/a**	Direct	**1,400**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct			
Surge Totalizer:	Pre-Har turbidity (NTU)	S: 4.89	Pre-Har turbidity (NTU)	S: 2.88				
		D: 4.67		D: 2.69				
Direct Totalizer:	Post-Har turbidity (NTU)	S: 5.01	Post-Har turbidity (NTU)	S: 6.64				
		D: 6.98		D: 3.74	Time of WQ Data: 7:50			

Summary of Work Performed on Site
Direct harvest filled the entire sump up to the level of the flow way

General Site Observations
Increasing standing water and depth of direct channel. Visibly more growth in the deeper water.
Less energy for sloughing?
Surge % Algae Cover: __95__% diatoms ___5__% filamentous greens ___0__% no growth
Direct % Algae Cover: __95__% diatoms ___5__% filamentous greens ___0__% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)								
Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-____S			CL-____S			CON-____S		
LIN-____D			CL-____D			CON-____D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling	
Side Channel (surge side only)	**Sand Filter**
8 buckets @2.13lbs = 17.04	
32, 36, 38, 28, 35, 37, 37, 36 = 279	
	Input: Over range NTU Weight: 261.96 Date/Time: 8/29 10:45
Weights: Freewater: 261.96lbs Solids:	**Output:** 119 NTU Weight: N/A Date/Time: 8/29 11:10

Samples Submitted to the Lab (list sample ID and describe sample)	
HAR19-16D	HAR19-16S-FW
HAR19-16S-S	HAR19-16SF
HAR19-16S-4HR	

HARVEST DATE: 8/29/19

HARVEST NO.: 16

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature______________________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	lbs	A) Surge Truck	lbs	A) Surge FW	n/a lbs *(into s.filter)*
B) Surg + Direct Truck	lbs	B) Surge + Direct Truck	lbs	B) Direct Truck	24,980 lbs *(into digester)*
C) TAR Truck	lbs	C) TAR Truck	lbs	C) TAR Truck	23,580 lbs
D) Net Surge (A-C)	**lbs**	D) Sum Surge Subplots	lbs	**D) Net Surge FW (A-C)**	**lbs**
E) Net Direct (B-C-D)	**lbs**	E) Sum Direct Subplots	lbs	**E) Net Direct (B-C)**	**1,400 lbs**
		F) Net Surge (A-C+D)	**lbs**	F) Surge solids	lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	**lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks

TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

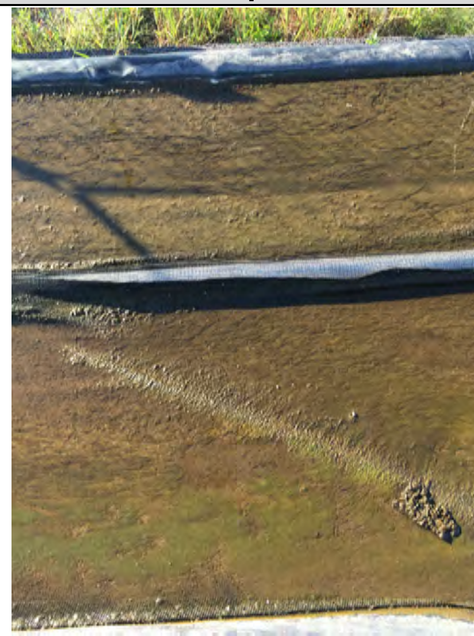
- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

HARVEST DATE: 8/29/19

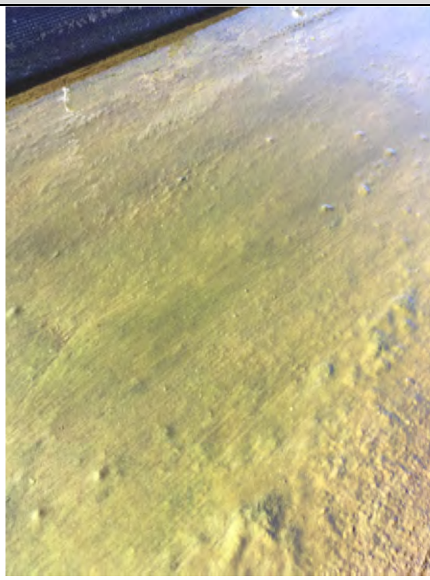
HARVEST NO.: 16

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

<table>
<tr><th colspan="2">WEEKLY HARVEST PHOTOS</th></tr>
<tr><th>Inflow Area</th><th>Liner Subplot Area</th></tr>
<tr><td>
Caption Photo 1</td><td>
Caption Photo 2</td></tr>
<tr><th>Concrete + Liner Subplot Area</th><th>Concrete Subplot Area</th></tr>
<tr><td>
Caption Photo 3</td><td>
Caption Photo 4</td></tr>
</table>

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

WEEKLY HARVEST PHOTOS	
Detail ~STA 150	**Photo 6**
 Caption Photo 5	 Caption Photo 6

2019 DMT ALGAL FLOW WAY
SIDE CHANNEL DEWATERING OBSERVATIONS

INITIAL HARVEST DATE: 8/29/19

Days Since Harvest		Temperature (degrees C)		General Weather Conditions	Humidity	Rain (check if applicable)		Rain
	Date	Daily High	Daily Low	Sun/Overcast/Rain	High or Low	Day	Overnight	Gauge
Harvest	8/29/19	85	60	Sunny	Low	☐	☐	
Day 1	8/30	95	75	Sunny/ warm	Med	☐	☐	
Day 2	8/31	90	70	Sunny/warm	High	☐	☐	
Day 3	9/1	90	70	Sunny/warm	High	☐	☐	
Day 4	9/2	90	70	Sunny/warm, PM showers	High	☒	☐	trace
Day 5	9/3	90	70	Sunny/hot	High	☐	☐	
Day 6	9/4	95	75	Sunny/hot	High	☐	☐	
Day 7	9/5	80	65	Mixed sun clouds/ mild	low	☐	☐	

Daily Observations – Including these examples: ***Relative dryness of material (is it handleable, will finger leave an impression, significant changes from prior day)? How thick is material in different locations? Did rain rehydrate or mobilize the material?***
Upload photos and videos from each day to OneDrive. Note time of day observations were made.

Harvest: Collect HAR19-(16)S-S-1HR & HAR19-(16)S-S-4HR

Day 1: Collect HAR19-(16)S-S-1DAY (microwave test)
Sludge/water consistency

Day 2: sat

Day 3: sun

Day 4: Monday holiday

Day 5: start to sta-120 damp but breaks off in flakes. Remainder of channel mixed watery sludge. Sump shows mobilized solids accumulation

Day 6: dry from sta 100120. Wet mix remainder

Day 7: Collect HAR19-(16)S-S-7DAY TYPE A, HAR19-(16)S-S-7DAY TYPE B

Material	Moisture Condition	Approximate Stations	Weight including Bucket (lbs)	Empty Bucket Weight (lbs)
Type A	Dry	Start to 120	10	2
Type B	Wet sloppy mix	120-sump	30, 21, 36 ,29	2
Type C	(None)			

SIDE CHANNEL DEWATERING PHOTOS	
HARVEST	**DAY 1**
 Caption Photo 1	 Caption Photo 2
DAY 2	**DAY 3**
 Caption Photo 3	 Caption Photo 4
DAY 4	**DAY 5**
 Caption Photo 5	 Caption Photo 6

SIDE CHANNEL DEWATERING PHOTOS (continued)	
DAY 6	**DAY 7**
 Caption Photo 1	 Caption Photo 2

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT	HARVEST DATE: 9/5/19 HARVEST NO.: 17 HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS, PM, JK, WT	pH	7.16	pH	7.88	AM:	Cool, mixed cloud/sun		
	Conductivity (mS)	14.26/9.57	Conductivity (mS)	13.85/9.44	PM:	Mild, mostly sunny		
	Salinity (ppt)	8.1	Salinity (ppt)	8.1	**Time of Harvest:**			
	Temperature (°C)	25.6	Temperature (°C)	24.3	From	**8:00**	To	**1:00**
	Dissolved oxygen (mg/L)	4.78	Dissolved oxygen (mg/L)	7.47	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	61.1%	DO saturation (%)	95.0%	Surge	**720**	Direct	**1,480**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct		2,200	
Surge Totalizer:	Pre-Har turbidity (NTU)	S: 10.8	Pre-Har turbidity (NTU)	S: 3.68				
		D: 11.0		D: 3.74				
Direct Totalizer:	Post-Har turbidity (NTU)	S: 7.40	Post-Har turbidity (NTU)	S: 3.51				
		D: 7.34		D: 4.46	Time of WQ Data: 8:00			

Summary of Work Performed on Site
Normal harvest, side channel day 7 collection and microwave testing
General Site Observations
More water depth and subsequent growth throughout the direct side channel length.
Surge % Algae Cover: _75_% diatoms __5_% filamentous greens __20__% blue/greens
Direct % Algae Cover: _75_% diatoms __5_% filamentous greens __20__% blue/greens

Observations: Productivity of Different Surfaces (include approximate % cover)								
Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-___S			CL-___S			CON-___S		
LIN-___D			CL-___D			CON-___D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling	
Side Channel (surge side only)	**Sand Filter**
	Input: _________NTU Weight: ___________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ___________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)	
HAR19-17S	HAR19-17-FILGREEN
HAR19-17D	HAR19-16S-7D-A
HAR19-17-DIATOM	HAR19-16S-7D-B

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 9/5/19

HARVEST NO.: 17

HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature____________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	25,740 lbs	A) Surge Truck	lbs	A) Surge FW Truck	lbs *(into digester)*
B) Surg + Direct Truck	24,260 lbs	B) Surge + Direct Truck	lbs	B) Direct Truck	lbs *(into s.filter)*
C) TAR Truck	23,540 lbs	C) TAR Truck	lbs	C) TAR Truck	lbs
D) Net Surge (A-C)	**720 lbs**	D) Sum Surge Subplots	lbs	**D) Net Surge (A-C)**	**lbs**
E) Net Direct (B-C-D)	**1,480 lbs**	E) Sum Direct Subplots	lbs	**E) Net Direct FW (B-C)**	**lbs**
		F) Net Surge (A-C+D)	**lbs**	F) Surge solids	lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	**lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

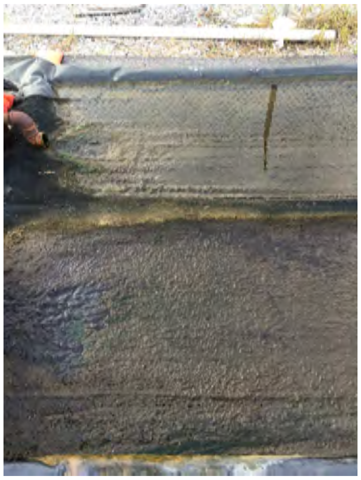
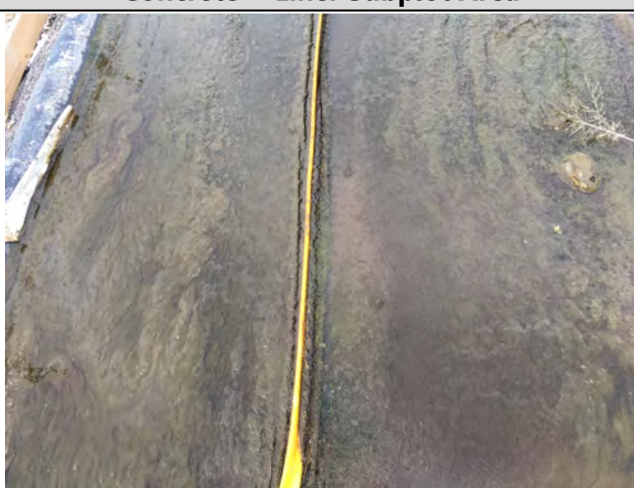
Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 9/5/19
HARVEST NO.: 17
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

<table>
<tr><th colspan="2">WEEKLY HARVEST PHOTOS</th></tr>
<tr><th>Inflow Area</th><th>Liner Subplot Area</th></tr>
<tr><td>
Caption Photo 1</td><td>
Caption Photo 2</td></tr>
<tr><th>Concrete + Liner Subplot Area</th><th>Concrete Subplot Area</th></tr>
<tr><td>
Caption Photo 3</td><td>
Caption Photo 4</td></tr>
</table>

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 9/5/19
HARVEST NO.: 17
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Photo 5	**Photo 6**
 Caption Photo 5	 Caption Photo 6

HARVEST DATE: 9/12/19

HARVEST NO.: 18

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Harvest Personnel:	Water Quality Top of Flow Way		Water Quality Bottom of Flow Way		Weather Conditions Temperature and Precipitation:			
BS, AB, JK, WT	pH	7.05	pH	6.50	AM:	Hot, sunny		
	Conductivity (µS)	12.05/8.38	Conductivity (µS)	14.08/9.48	PM:	Hot, sunny		
	Salinity (ppt)	7.9	Salinity (ppt)	8.1	**Time of Harvest:**			
	Temperature (°C)	25.7	Temperature (°C)	25.5	From	**7:50**	To	**11:45**
	Dissolved oxygen (mg/L)	5.10	Dissolved oxygen (mg/L)	6.57	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	65.7%	DO saturation (%)	84.5%	Surge	**740**	Direct	**1,300**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct			
Surge Totalizer: not recorded	Pre-Har turbidity (NTU)	S: 4.52 D: 4.78	Pre-Har turbidity (NTU)	S: 2.30 D: 2.83				
Direct Totalizer: not recorded	Post-Har turbidity (NTU)	S: 4.51 D: 4.45	Post-Har turbidity (NTU)	S: 8.69 D: 4.73	Time of WQ Data: 7:50			

Summary of Work Performed on Site

Standard subplot harvest day. Samples and weights taken of subplot filter bag effluent in addition to regular samples

General Site Observations

Surge % Algae Cover: __85__% diatoms __5__% filamentous greens __10__% no growth

Direct % Algae Cover: __85__% diatoms __5__% filamentous greens __10__% no growth

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid			Concrete + Grid			Concrete Only		
Start time: 9:20	Empty Bucket (lbs):	Full Bucket (lbs):	Start time: 9:30	Empty Bucket (lbs):	Full Bucket (lbs):	Start time: 9:35	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-18S	2.13	35	CL-18S	2.13	17.45	CON-18S	2.4	15.97
LIN-18D	2.13	28	CL-18D	2.13	24	CON-18D	2.4	10.45
Time into filter:	S: 10:30	D: 10:35	Time into filter:	S: 10:40	D: 10:45	Time into filter:	S: 10:50	D: 10:55
Surge: Harvest Bucket Weight: 32.87 lbs			Surge: Harvest Bucket Weight: 15.32 lbs			Surge: Harvest Bucket Weight: 13.57 lbs		
Bag Weights: Wet: 4.83 Dry: 0.17			Bag Weights: Wet: 5.01 Dry: 0.17			Bag Weights: Wet: 5.93 Dry: 0.17		
Direct: Harvest Bucket Weight: 25.87 lbs			Direct: Harvest Bucket Weight: 21.87 lbs			Direct: Harvest Bucket Weight: 8.05 lbs		
Bag Weights: Wet: 6.69 Dry: 0.17			Bag Weights: Wet: 4.40 Dry: 0.17			Bag Weights: Wet: 3.62 Dry: 0.17		

Notes: Biomass Handling

Side Channel (surge side only)	Sand Filter
	Input: _________NTU Weight: ____________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ____________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HARVEST DATE: 9/12/19

HARVEST NO.: 18

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature______________________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	lbs	A) Surge Truck	24,220 lbs	A) Surge FW Truck	lbs *(into digester)*
B) Surg + Direct Truck	lbs	B) Surge + Direct Truck	25,520 lbs	B) Direct Truck	lbs *(into s.filter)*
C) TAR Truck	lbs	C) TAR Truck	23,480 lbs	C) TAR Truck	lbs
D) Net Surge (A-C)	**lbs**	D) Sum Surge Subplots	61.76 lbs	**D) Net Surge (A-C)**	**lbs**
E) Net Direct (B-C-D)	**lbs**	E) Sum Direct Subplots	55.79 lbs	**E) Net Direct FW (B-C)**	**lbs**
		F) Net Surge (A-C+D)	**801.76 lbs**	F) Surge solids	lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	**1,355.79 lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks

TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

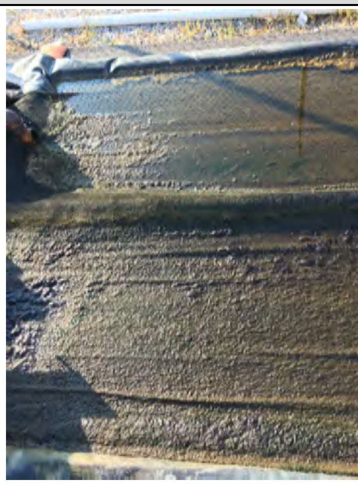
- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 9/12/19

HARVEST NO.: 18

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

<table>
<tr><th colspan="2">WEEKLY HARVEST PHOTOS</th></tr>
<tr><th>Inflow Area</th><th>Liner Subplot Area</th></tr>
<tr><td>
Caption Photo 1</td><td>
Caption Photo 2</td></tr>
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<tr><td>
Caption Photo 3</td><td>
Caption Photo 4</td></tr>
</table>

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 9/12/19

HARVEST NO.: 18

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Photo 5	**Photo 6**
	
Caption Photo 5	Caption Photo 6

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 9/19/19

HARVEST NO.: 19

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS, JK, AB, WT	pH	6.74	pH	7.79	AM:	Cool, sunny		
	Conductivity (mS)	15.12/10.42	Conductivity (mS)	14.78/10.36	PM:	Cool, sunny		
	Salinity (ppt)	9.0	Salinity (ppt)	9.1	**Time of Harvest:**			
	Temperature (°C)	23.7	Temperature (°C)	22.3	From	**7:50**	To	**11:30**
	Dissolved oxygen (mg/L)	5.84	Dissolved oxygen (mg/L)	9.60	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	72.8%	DO saturation (%)	116.2%	Surge	**n/a**	Direct	**1,300**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct			
Surge Totalizer: 31,545,369	Pre-Har turbidity (NTU)	S: 5.22 D: 5.70	Pre-Har turbidity (NTU)	S: 2.19 D: 2.18				
Direct Totalizer: 7,940,648	Post-Har turbidity (NTU)	S: 6.02 D: 4.47	Post-Har turbidity (NTU)	S: 3.28 D: 3.87	Time of WQ Data: 7:50			

Summary of Work Performed on Site
Standard side channel harvest
For HAR samples used 5 gal bucket from the sump, mix well, and fill our two sample containers from that
General Site Observations
Surge box was in constant surge keeping up with pump inflow. Biofouling likely was constricting flow through the siphon.
Surge % Algae Cover: __75__% diatoms _5_% filamentous greens __20% blue greens
Direct % Algae Cover: __75__% diatoms __5% filamentous greens __20_% blue greens

Observations: Productivity of Different Surfaces (include approximate % cover)								
Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-____S			CL-____S			CON-____S		
LIN-____D			CL-____D			CON-____D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling	
Side Channel (surge side only)	**Sand Filter**
Full: 36, 37, 38, 38, 35, 36, 41, 42, 33, 25 = 361	
Empty: 2.4, 2.13, 2.4, 2.13, 2.13, 2.13, 2.4, 2.4, 4.13, 2.13 = 24.38	
7day-A dry: 8.7lbs, 7day-B wet: 200lbs(vermeer)	**Input:** _over range NTU Weight: _336.62_ Date/Time: 10:30
Weights: Freewater: 336.62lbs Solids:	**Output:** ___85.9 NTU Weight: ____________Date/Time: 10:50

Samples Submitted to the Lab (list sample ID and describe sample)	
HAR19-19S-S	HAR19-SF19
HAR19-19D	HAR19-19S-4HR
HAR19-19S-FW	

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 9/19/19

HARVEST NO.: 19

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature______________________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	lbs	A) Surge Truck	lbs	A) Surge FW	n/a lbs *(into s.filter)*
B) Surg + Direct Truck	lbs	B) Surge + Direct Truck	lbs	B) Direct Truck	24,740 lbs *(into digester)*
C) TAR Truck	lbs	C) TAR Truck	lbs	C) TAR Truck	23,440 lbs
D) Net Surge (A-C)	**lbs**	D) Sum Surge Subplots	lbs	**D) Net Surge FW (A-C)**	**lbs**
E) Net Direct (B-C-D)	**lbs**	E) Sum Direct Subplots	lbs	**E) Net Direct (B-C)**	**1,300 lbs**
		F) Net Surge (A-C+D)	**lbs**	F) Surge solids	lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	**lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

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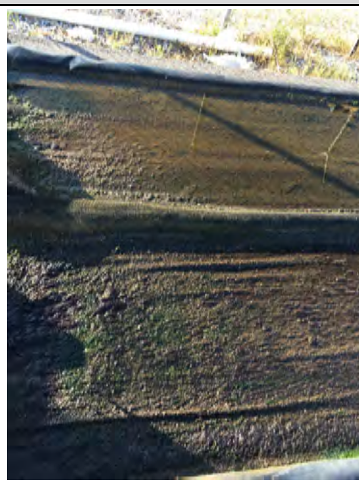
<tr><td>
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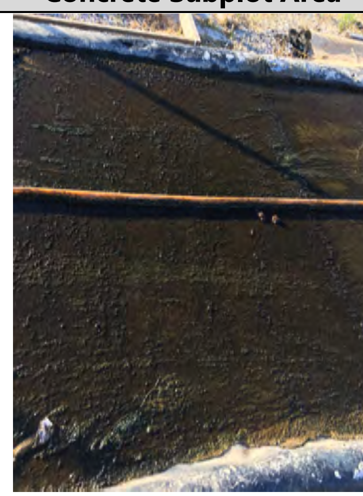
Caption Photo 3</td><td>
Caption Photo 4</td></tr>
</table>

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 9/19/19
HARVEST NO.: 19
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Side channel 4 hr	**Photo 6**
 Caption Photo 5	 Caption Photo 6

2019 DMT ALGAL FLOW WAY
SIDE CHANNEL DEWATERING OBSERVATIONS

INITIAL HARVEST DATE: 9/19/19

Days Since Harvest		Temperature (degrees C)		General Weather Conditions	Humidity	Rain (check if applicable)		Rain
	Date	Daily High	Daily Low	Sun/Overcast/Rain	High or Low	Day	Overnight	Gauge
Harvest	9/19/19	80s	60	Sunny, mild	Med	☐	☐	
Day 1	9/20/19	80s	65	Sunny, mild	med	☐	☐	
Day 2	9/21/19	95	70	Sunny, hot	Med	☐	☐	
Day 3	9/22/19	95	70	Sunny, hot	Med	☐	☐	
Day 4	9/23/19	80s	68	Sunny, warm	med	☐	☐	
Day 5	9/24/19	80s	68	Sunny, warm	Med	☐	☐	
Day 6	9/25/19	85	64	Sunny, mild	Low	☐	☐	
Day 7	9/26/19	85	64	Sunny, mild	Low	☐	☐	

Daily Observations – Including these examples: ***Relative dryness of material (is it handleable, will finger leave an impression, significant changes from prior day)? How thick is material in different locations? Did rain rehydrate or mobilize the material?***
Upload photos and videos from each day to OneDrive. Note time of day observations were made.

Harvest: Collect HAR19-(19)S-S-1HR & HAR19-(#)S-S-4HR

4hr had less residual water.

Day 1: Collect HAR19-(19)S-S-1DAY
Sludgy mix

Day 2: weekend

Day 3: weekend

Day 4: damp but dry enough to crumble

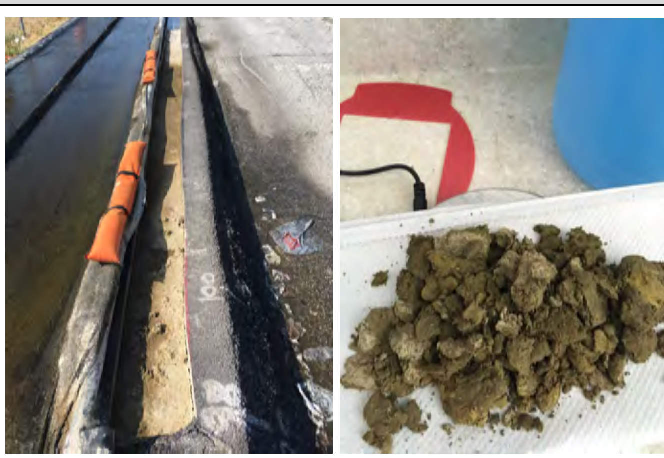
Day 5: fully dry and crumbling

Day 6: fully dry and crumbling

Day 7: Collect HAR19-(#)S-S-7DAY TYPE A, HAR19-(#)S-S-7DAY TYPE B, & HAR19-(#)S-S-7DAY TYPE C

Material	Moisture Condition	Approximate Stations	Weight including Bucket (lbs)	Empty Bucket Weight (lbs)
Type A	Fully dry	98-120	13.5	4.8
Type B	Standing water	120-bottom	300	n/a(Vermeer weight)
Type C	n/a	n/a	n/a	n/a

INITIAL HARVEST DATE: 9/19/19

SIDE CHANNEL DEWATERING PHOTOS	
4-hr	**DAY 1**
 Caption Photo 1	 Caption Photo 2
DAY 2	**DAY 3**
 Caption Photo 3	 Caption Photo 4
DAY 4	**DAY 5**
 Caption Photo 5	 Caption Photo 6

2019 DMT ALGAL FLOW WAY
SIDE CHANNEL DEWATERING OBSERVATIONS

INITIAL HARVEST DATE: 9/19/19

SIDE CHANNEL DEWATERING PHOTOS (continued)	
DAY 6	**DAY 7**
 Caption Photo 1	 Caption Photo 2

HARVEST DATE: 9/26/19

HARVEST NO.: 20

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Harvest Personnel:	Water Quality Top of Flow Way		Water Quality Bottom of Flow Way		Weather Conditions Temperature and Precipitation:			
BS, AB, JK, WT	pH	7.28	pH	7.85	AM:	SUNNY, MILD		
	Conductivity (mS)	16.40/11.26	Conductivity (mS)	16.35/11.38	PM:	SUNNY, WARM		
	Salinity (ppt)	9.8	Salinity (ppt)	10.1	**Time of Harvest:**			
	Temperature (°C)	23.5	Temperature (°C)	22.8	From	**8:00**	To	**11:00**
	Dissolved oxygen (mg/L)	6.28	Dissolved oxygen (mg/L)	6.91	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	78.5%	DO saturation (%)	84.8%	Surge	**900**	Direct	**1,200**
	TSS sample **HAR19-#IN**	YES	TSS sample **HAR19-#OUT**	YES	Surge + Direct		2,100	
Surge Totalizer: 32,029,506	Pre-Har turbidity (NTU)	S: 4.72 D: 4.97	Pre-Har turbidity (NTU)	S: 2.16 D: 1.95				
Direct Totalizer: 8,436,905	Post-Har turbidity (NTU)	S: 3.95 D: 3.89	Post-Har turbidity (NTU)	S: 7.75 D: 5.23	Time of WQ Data: 8:00			

Summary of Work Performed on Site
Normal harvest and side channel final day
For HAR samples used 5 gal bucket from the sump, mix well, and fill our two sample containers from that
7 day type "B" material vacuumed up and weighed in Vermeer truck
General Site Observations
GOOD GROWTH, ALGAE STRANDS BREAKING THE WATER SURFACE ON PARTS OF THE FLOW WAY
Surge % Algae Cover: _80_% diatoms __10_% filamentous greens __10_% Blue greens
Direct % Algae Cover: __80_% diatoms _10__% filamentous greens ___10_% Blue Greens

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid			Concrete + Grid			Concrete Only		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-___S			CL-___S			CON-___S		
LIN-___D			CL-___D			CON-___D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling

Side Channel (surge side only)	Sand Filter
7day-A har19 Dry10, 3.5	
Bucket: 2.4, 2.4	
7day-B har19 wet (Vermeer): 200lbs	**Input:** _________NTU Weight: ____________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ____________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HAR19-20S	AFW19-20OUT
HAR19-20D	AFW19-20HP
AFW19-20IN	

HARVEST DATE: 9/26/19
HARVEST NO.: 20
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature______________________________

Calculations

Harvest Weights

Typical Harvest Week			Subplot Week			Side Channel Week		
A) Surge Truck	24,520	lbs	A) Surge Truck		lbs	A) Surge FW Truck		lbs *(into digester)*
B) Surg + Direct Truck	25,720	lbs	B) Surge + Direct Truck		lbs	B) Direct Truck		lbs *(into s.filter)*
C) TAR Truck	23,620	lbs	C) TAR Truck		lbs	C) TAR Truck		lbs
D) Net Surge (A-C)	**900**	**lbs**	D) Sum Surge Subplots		lbs	**D) Net Surge (A-C)**		**lbs**
E) Net Direct (B-C-D)	**1,200**	**lbs**	E) Sum Direct Subplots		lbs	**E) Net Direct FW (B-C)**		**lbs**
			F) Net Surge (A-C+D)		**lbs**	F) Surge solids		lbs *(meas. later)*
			G) Net Direct (B-C-F+E)		**lbs**	(FW = freewater)		

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

HARVEST DATE: 9/26/19
HARVEST NO.: 20
HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

WEEKLY HARVEST PHOTOS

Inflow Area	Liner Subplot Area
 Caption Photo 1	 Caption Photo 2
Concrete + Liner Subplot Area	**Concrete Subplot Area**
 Caption Photo 3	 Caption Photo 4

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 9/26/19
HARVEST NO.: 20
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Photo 5	**Photo 6**
 Caption Photo 5	 Caption Photo 6

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 10/3/19

HARVEST NO.: 21

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS, AB, JK, WT	pH	6.95	pH	6.99	AM:	Cloudy, cool, breezy		
	Conductivity (mS)	16.88/11.55	Conductivity (µS)	17.33/11.93	PM:	Cloudy, cool, mist		
	Salinity (ppt)	10.2	Salinity (ppt)	10.5	**Time of Harvest:**			
	Temperature (°C)	24.1	Temperature (°C)	23.7	From	**8:00**	To	**11:15**
	Dissolved oxygen (mg/L)	5.54	Dissolved oxygen (mg/L)	3.94	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	69.5	DO saturation (%)	48.5%	Surge	**800**	Direct	**1,040**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	Yes	Surge + Direct		1,840	
Surge Totalizer: 32,571,817	Pre-Har turbidity (NTU)	S: 5.05 D: 3.94	Pre-Har turbidity (NTU)	S: 1.86 D: 2.15				
Direct Totalizer: 8,971,905	Post-Har turbidity (NTU)	S: 3.34 D: 4.28	Post-Har turbidity (NTU)	S: 7.22 D: 7.91	Time of WQ Data: 8:00			

Summary of Work Performed on Site
Subplot harvest. Surge box has been in constant flow since previous harvest. Sample Cl-S only one bottle.
Surge side still operating under direct flow regime
Post harvest flow rate on surge side increased to 60 gpm
General Site Observations
Surge % Algae Cover: _85_% diatoms _10_% filamentous greens ___5___% blue greens
Direct % Algae Cover: _85__% diatoms 10% filamentous greens ___5___% blue greens

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-21S	2.13	24	CL-21S	2.13	10.62	CON-21S	2.4	11.23
LIN-21D	2.13	31	CL-21D	2.13	25	CON-21D	2.4	11.40
Time into filter:	S: 10:15	D: 10:20	Time into filter:	S: 10:25	D: 10:30	Time into filter:	S: 10:35	D: 10:40
Surge: Harvest Bucket Weight: 21.87lbs			Surge: Harvest Bucket Weight: 8.49lbs			Surge: Harvest Bucket Weight: 8.83lbs		
Bag Weights: Wet: 4.68 Dry: 0.17			Bag Weights: Wet: 2.45 Dry: 0.17			Bag Weights: Wet: 3.76 Dry: 0.17		
Direct: Harvest Bucket Weight: 28.87lbs			Direct: Harvest Bucket Weight: 22.87lbs			Direct: Harvest Bucket Weight: 9.0lbs		
Bag Weights: Wet: 3.99 Dry: 0.17			Bag Weights: Wet: 2.92 Dry: 0.17			Bag Weights: Wet: 3.80 Dry: 0.17		

Notes: Biomass Handling

Side Channel (surge side only)	**Sand Filter**
	Input: _________NTU Weight: ____________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ____________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

HAR19-21DIATOM, HAR19-21FILGREEN	HAR19-LIN-21S, HAR19-LIN-21D
HAR19-21S(D2), HAR19-21D	HAR19-CL-21S, HAR19-CL-21D
AFW19-21IN, AFW19-21OUT	HAR19-CON-21S, HAR19-CL-21D

2019 DMT ALGAL FLOW WAY WEEKLY HARVEST REPORT

HARVEST DATE: 10/3/19

HARVEST NO.: 21

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Sample ID Key: **HAR19-**

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature________________________

Calculations

Harvest Weights

Typical Harvest Week		Subplot Week		Side Channel Week	
A) Surge Truck	___ lbs	A) Surge Truck	24,460 lbs	A) Surge FW Truck	___ lbs *(into digester)*
B) Surg + Direct Truck	___ lbs	B) Surge + Direct Truck	25,500 lbs	B) Direct Truck	___ lbs *(into s.filter)*
C) TAR Truck	___ lbs	C) TAR Truck	23,660 lbs	C) TAR Truck	___ lbs
D) Net Surge (A-C)	___ **lbs**	D) Sum Surge Subplots	39.19 lbs	**D) Net Surge (A-C)**	___ **lbs**
E) Net Direct (B-C-D)	___ **lbs**	E) Sum Direct Subplots	60.74 lbs	**E) Net Direct FW (B-C)**	___ **lbs**
		F) Net Surge (A-C+D)	**839.19 lbs**	F) Surge solids	___ lbs *(meas. later)*
		G) Net Direct (B-C-F+E)	**1,100.74 lbs**	(FW = freewater)	

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks

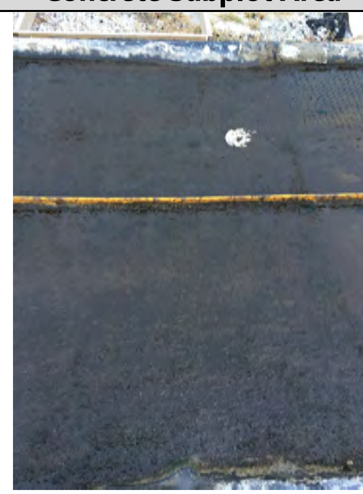
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 10/3/19
HARVEST NO.: 21
HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

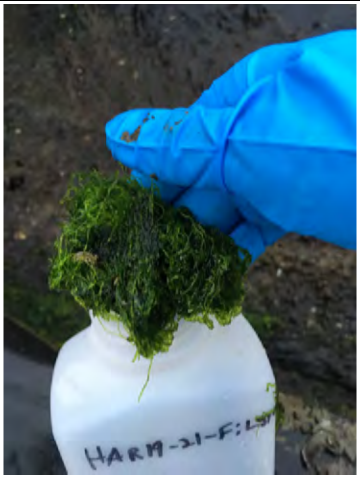
WEEKLY HARVEST PHOTOS	
Inflow Area	**Liner Subplot Area**
 Caption Photo 1	 Caption Photo 2
Concrete + Liner Subplot Area	**Concrete Subplot Area**
 Caption Photo 3	 Caption Photo 4

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 10/3/19

HARVEST NO.: 21

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Filgreen sample	**Diatom sample**
 Caption Photo 5	 Caption Photo 6

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 10/24/19

HARVEST NO.: 24 (final)

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

Harvest Personnel:	**Water Quality Top of Flow Way**		**Water Quality Bottom of Flow Way**		**Weather Conditions Temperature and Precipitation:**			
BS, WT, PM	pH	7.96	pH	8.06	AM:	40s, sunny		
	Conductivity (µS)	15.45/11.50	Conductivity (µS)	16.68/12.86	PM:	60s, sunny		
	Salinity (ppt)	10.8	Salinity (ppt)	12.2	**Time of Harvest:**			
	Temperature (°C)	16.5	Temperature (°C)	15.5	From	**8**	To	**1130**
	Dissolved oxygen (mg/L)	8.58	Dissolved oxygen (mg/L)	9.3	**Truck Weight of Harvest (lbs.)**			
	DO saturation (%)	94.1%	DO saturation (%)	100.4%	Surge	***340**	Direct	**820**
	TSS sample **HAR19-#IN**	Yes	TSS sample **HAR19-#OUT**	yes	Surge + Direct			
Surge Totalizer:	Pre-Har turbidity (NTU)	S: n/a D: n/a	Pre-Har turbidity (NTU)	S: n/a D: n/a				
Direct Totalizer:	Post-Har turbidity (NTU)	S: n/a D: n/a	Post-Har turbidity (NTU)	S: n/a D: n/a	Time of WQ Data: 8:00			

Summary of Work Performed on Site

*Forgot to plug sump during surge harvest. Some harvest lost before plugs added. Weight is remainder.

General Site Observations

Noticeable decline in growth.

Surge % Algae Cover: ___80___% **diatoms** ____20__% **filamentous greens** _____% **no growth**

Direct % Algae Cover: ___80___% **diatoms** __20___% **filamentous greens** _____% **no growth**

Observations: Productivity of Different Surfaces (include approximate % cover)

Liner + Grid			**Concrete + Grid**			**Concrete Only**		
Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):	Start time:	Empty Bucket (lbs):	Full Bucket (lbs):
LIN-___S			CL-___S			CON-___S		
LIN-___D			CL-___D			CON-___D		
Time into filter:	S:	D:	Time into filter:	S:	D:	Time into filter:	S:	D:
Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs			Surge: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		
Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs			Direct: Harvest Bucket Weight: lbs		
Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:			Bag Weights: Wet: Dry:		

Notes: Biomass Handling

Side Channel (surge side only)	**Sand Filter**
	Input: _________NTU Weight: ____________ Date/Time:
Weights: Freewater: Solids:	**Output:** _________NTU Weight: ____________Date/Time:

Samples Submitted to the Lab (list sample ID and describe sample)

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 10/24/19
HARVEST NO.: 24 (final)
HARVEST TYPE (circle): NORMAL SUBPLOT SIDE CHANNEL

Sample ID Key: HAR19-

#S = week+surge	LIN=liner+grid	
#D = week+direct	CON=concrete	SOL=solid
#SF = week+sand filter	CL=concrete+liner	FW=freewater
#HP = Hawkins Point	#IN=inflow	#OUT=outflow

Signature____________________

Calculations

Harvest Weights

Typical Harvest Week			Subplot Week			Side Channel Week		
A) Surge Truck	23,940	lbs	A) Surge Truck		lbs	A) Surge FW Truck		lbs *(into digester)*
B) Surg + Direct Truck	24.760	lbs	B) Surge + Direct Truck		lbs	B) Direct Truck		lbs *(into s.filter)*
C) TAR Truck	23,600	lbs	C) TAR Truck		lbs	C) TAR Truck		lbs
D) Net Surge (A-C)	**340***	**lbs**	D) Sum Surge Subplots		lbs	**D) Net Surge (A-C)**		**lbs**
E) Net Direct (B-C-D)	**820**	**lbs**	E) Sum Direct Subplots		lbs	**E) Net Direct FW (B-C)**		**lbs**
			F) Net Surge (A-C+D)		**lbs**	F) Surge solids		lbs *(meas. later)*
			G) Net Direct (B-C-F+E)		**lbs**	(FW = freewater)		

General Guide – Sampling and Sample IDs (#= harvest week)

Type	Water Flow	Harvest	Inflow Water	Outflow Water	Side Channel	Subplots	Sand Filter
Harvest	surge	% solids, TN, TP **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**			
	direct	% solids, TN, TP **HAR19-#D**					
Subplot	surge	% solids **HAR19-#S**	TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**		% solids (3) **HAR19-#S-CON** **HAR19-#S-LIN** **HAR19-#S-CL**	
	direct	% solids **HAR19-#D**				% solids (3) **HAR19-#D-CON** **HAR19-#D-LIN** **HAR19-#D-CL**	
Side Channel	surge		TN, TP, TSS, chl a **AFW19-#IN**	TSS **AFW19-#OUT**	% solids (2) **HAR19-#S-SOL** **HAR19-#S-FW**		total solids **HAR19-#SF** turbidity (NTU)
	direct	% solids **HAR19-#D**					

Hawkins Point (**HAR19-#HP**) samples will be collected by MES every two weeks
TSS will analyzed on the inflow (**HAR19-#IN**) and outflow (**HAR19-#OUT**) samples. 1x 500mL bottles should be submitted for each TSS sample

Weekly Photos (pictures should include both sides of the flow way for comparison)

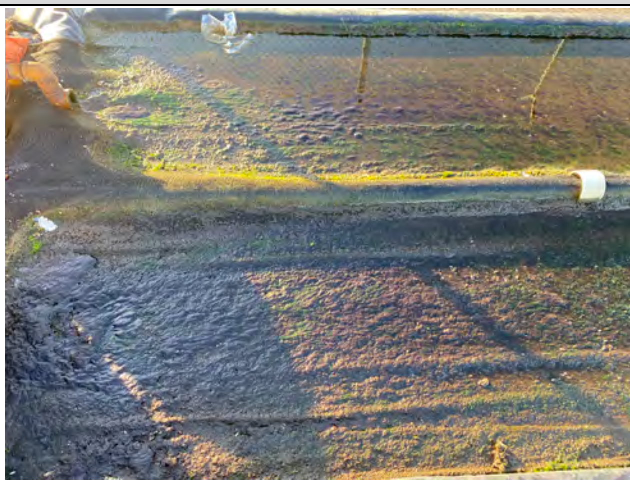
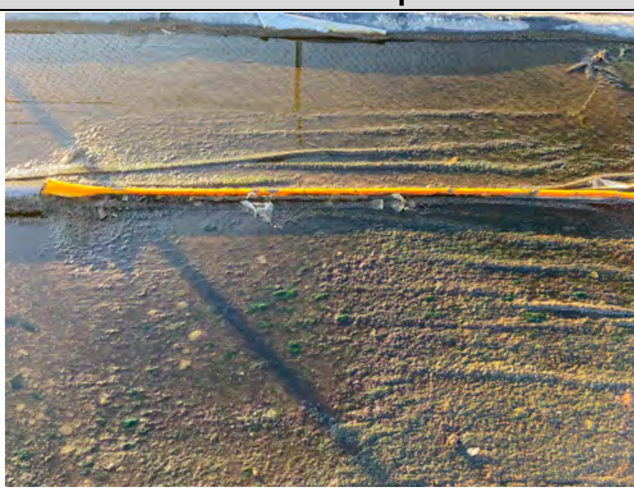
- Inflow area
- Liner subplot area (STA 25-29.5)
- Concrete + Liner subplot area (STA 38-42.5)
- Concrete subplot area (STA 45-49.5)
- Subplot Weeks: Mesh bags at initiation (1 photo) and after dewatering (1 photo)
- Side Channel Weeks: Sand filter inflow (1 photo) and outflow (1 photo)
- Other photos and videos are optional as needed; save in project folder

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST DATE: 10/24/19

HARVEST NO.: 24 (final)

HARVEST TYPE (circle): **NORMAL** SUBPLOT SIDE CHANNEL

WEEKLY HARVEST PHOTOS	
Inflow Area	**Liner Subplot Area**
 Caption Photo 1	 Caption Photo 2
Concrete + Liner Subplot Area	**Concrete Subplot Area**
 Caption Photo 3	 Caption Photo 4

HARVEST DATE: 10/24/19

2019 DMT ALGAL FLOW WAY
WEEKLY HARVEST REPORT

HARVEST NO.: 24 (final)

HARVEST TYPE (circle): **NORMAL** **SUBPLOT** **SIDE CHANNEL**

WEEKLY HARVEST PHOTOS	
Inflow detail	**Standing water after drain down**
 Caption Photo 5	 Caption Photo 6

Appendix C
Analytical Data for Algal Flow-Way Testing

Table C-1
Analytical Data for Weekly Harvest Samples from Surge Flow-Way

Harvest	Date	Harvest Type	Sample Name	Total Solids (mg/L)	Percent Moisture (%)	Percent Solids (%)	Nitrate Nitrite as N (mg/kg)	Total Kjeldahl Nitrogen (mg/kg)	Total Nitrogen (mg/kg)	Phosphorus (mg/kg)
1	5/16/19	Normal	HAR19-1S	56,000 E	93.7	6.3	6.5	9,400	9,400	470
2	5/23/19	Normal	HAR19-2S	33,000 E	97.1	2.9	2.1	1,700	1,700	770
3	5/30/19	Normal	HAR19-3S	8,900 E	98.4	1.6	2.5	13,000	13,000	900
4	6/6/19	No Harvest								
5	6/12/19	Normal	HAR19-5S	18,000 E	98.5	1.5	2.3 B	16,000	16,000	1,000
6	6/20/19	Subplot	HAR19-6S	26,000 E	97.1	2.9				
7	6/27/19	Dewatering Channel								
8	7/3/19	Normal	HAR19-8S	34,000 E	96.9	3.1	1.7 B	8,700	8,700	880 B
9	7/11/19	Subplot	HAR19-9S	45,000 E	95.9	4.1				
10	7/18/19	Dewatering Channel								
11	7/25/19	Normal	HAR19-11S	53,000 E	94.3	5.7	1.6 B	11,000	11,000	1,100
12	8/1/19	Subplot	HAR19-12S	45,000 E						
13	8/8/19	Dewatering Channel								
14	8/16/19	Normal	HAR19-14S	95,000 E	95.7	4.3	1.4	11,000	11,000	910
15	8/22/19	Subplot	HAR19-15S	19,000 E						
16	8/29/19	Dewatering Channel								
17	9/5/19	Normal	HAR19-17S	24,000 E	96.5	3.5	29	14,000	14,000	1,400
18	9/12/19	Subplot	HAR19-18S	38,000 E						
19	9/19/19	Dewatering Channel								
20	9/26/19	Normal	HAR19-20S	25,000 E	94.5	5.5	19	17,000 H	17,000	2,300
21	10/3/19	Subplot	HAR19-21S(D2)	26,000 E	95.6	4.4				
22	10/10/19	Normal (extra)	HAR19-22S	42,000 E	95.4	4.6	21	14,000	14,000	1,800
23	10/17/19	Normal (extra)	HAR19-23S	39,000 E	96.2	3.8	120 B	13,000	13,000	1,700
24	10/24/19	Normal (extra)	HAR19-24S	56,000 E	94.9	5.1	2.1	13,000	13,000	530

Table C-1
Analytical Data for Weekly Harvest Samples from Surge Flow-Way

Notes:

Shaded cells indicate that no data were collected for these samples.

B: compound was found in the blank and sample

E: result exceeded calibration range

kg: kilogram

L: liter

mg: milligram

Table C-2
Analytical Data for Weekly Harvest Samples from Continuous Flow-Way

Harvest	Date	Harvest Type	Sample Name	Total Solids (mg/L)	Percent Moisture (%)	Percent Solids (%)	Nitrate Nitrite as N (mg/kg)	Total Kjeldahl Nitrogen (mg/kg)	Total Nitrogen (mg/kg)	Phosphorus (mg/kg)
1	5/16/19	Normal	HAR19-1D	55,000 E	94.9	5.1	7.1	10,000	10,000	840
2	5/23/19	Normal	HAR19-2D	29,000 E	96.6	3.4	2	11,000	11,000	890
3	5/30/19	Normal	HAR19-3D	11,000 E	98.2	1.8	2	9,100	9,100	810
4	6/6/19	No Harvest								
5	6/12/19	Normal	HAR19-5D	16,000 E	98.6	1.4	2.2 B	12,000	12,000	890
6	6/20/19	Subplot	HAR19-6D	42,000 E	96.7	3.3				
7	6/27/19	Dewatering Channel	HAR19-7D	25,000 E	94.2	5.8				
8	7/3/19	Normal	HAR19-8D	28,000 E	95.9	4.1	1.3 B F1	9,000	9,000	960 B
9	7/11/19	Subplot	HAR19-9D	31,000 E	95.2	4.8				
10	7/18/19	Dewatering Channel	HAR19-10D	39,000 E	96.9	3.1				
11	7/25/19	Normal	HAR19-11D	40,000 E	96.5	3.5	1.4 B	10,000	10,000	970
12	8/1/19	Subplot	HAR19-12D	52,000 E						
13	8/8/19	Dewatering Channel	HAR19-13D	35,000 E	97	3				
14	8/16/19	Normal	HAR19-14D	17,000 E	97.5	2.5	1.2	9,900	9,900	830
15	8/22/19	Subplot	HAR19-15D	15,000 E						
16	8/29/19	Dewatering Channel	HAR19-16D	31,000 E						
17	9/5/19	Normal	HAR19-17D	26,000 E	97.1	2.9	18	19,000	19,000	1,500
18	9/12/19	Subplot	HAR19-18D	21,000 E						
19	9/19/19	Dewatering Channel	HAR19-19D	23,000 E	98.1	1.9				
20	9/26/19	Normal	HAR19-20D	19,000 E	96.1	3.9	13	20,000 H	20,000	2,100
21	10/3/19	Subplot	HAR19-21D	28,000 E	95.8	4.2				
22	10/10/19	Normal (extra)	HAR19-22D	39,000 E	96.8	3.2	35	12,000	12,000	1,800
23	10/17/19	Normal (extra)	HAR19-23D	32,000 E	96.1	3.9	86 B	15,000	15,000	1,500
24	10/24/19	Normal (extra)	HAR19-24D	43,000 E	95.1	4.9	3.2	13,000	13,000	450

Table C-2
Analytical Data for Weekly Harvest Samples from Continuous Flow-Way

Notes:

Shaded cells indicate that no data were collected for these samples.

B: compound was found in the blank and sample

E: result exceeded calibration range

F1: matrix spike and/or matrix spike duplicate recovery is outside acceptable limits

H: sample was prepped or analyzed beyond the specified holding time

kg: kilogram

L: liter

mg: milligram

Table C-3
Analytical Data for Subplot Samples

Harvest	Date	Flow-Way	Liner + Grid		Concrete + Grid		Concrete	
			Sample Name	Total Solids (%)	Sample Name	Total Solids (%)	Sample Name	Total Solids (%)
6	6/20/19	Surge	HAR19-LIN-6S	8.9% E	HAR19-CL-6S	8.1% E	HAR19-CON-6S	8.2% E
		Continuous	HAR19-LIN-6D	11% E	HAR19-CL-6D	7.8% E	HAR19-CON-6D	9.4% E
9	7/11/19	Surge	HAR19-LIN-9S	12% E	HAR19-CL-9S	10% E	HAR19-CON-9S	16% E
		Continuous	HAR19-LIN-9D	12% E	HAR19-CL-9D	9.9% E	HAR19-CON-9D	11% E
12	8/1/19	Surge	HAR19-LIN-12S	7.8% E	HAR19-CL-12S	10% E	HAR19-CON-12S	12% E
		Continuous	HAR19-LIN-12D	12% E	HAR19-CL-12D	22% E	HAR19-CON-12D	13% E
15	8/22/19	Surge	HAR19-LIN-15S	5.4% E	HAR19-CL-15S	11% E	HAR19-CON-15S	15% E
		Continuous	HAR19-LIN-15D	4.2% E	HAR19-CL-15D	6.5% E	HAR19-CON-15D	21% E
18	9/12/19	Surge	HAR19-LIN-18S	12% E	HAR19-CL-18S	13% E	HAR19-CON-18S	14% E
		Continuous	HAR19-LIN-18D	4.4% E	HAR19-CL-18D	13% E	HAR19-CON-18D	16% E
21	10/3/19	Surge	HAR19-LIN-21S	6.2% E	HAR19-CL-21S	11% E	HAR19-CON-21S	13% E
		Continuous	HAR19-LIN-21D	13% E	HAR19-CL-21D	13% E	HAR19-CON-21D	17% E

Notes:

E: result exceeded calibration range

Table C-4
Analytical Data for Harvest and Dewatering Channel Samples

Harvest	Date	Description	Sample Name	Total Suspended Solids (mg/L)	Total Solids (mg/L)	Percent Moisture (%)	Percent Solids (%)
7	6/27/19	Drain Water	HAR19-7S-FW	580			
		1-Hour Sample	HAR19-7S-S		51,000 E	93.2	6.8
			HAR19-7S-S 1HR		43,000 E	93.9	6.1
		4-Hour Sample	HAR19-7S-S 4HR		89,000 E	91.6	8.4
		7-Day Sample (Type A)	HAR19-8S-S-TOP-7DAY DRY			40.1	59.9
		7-Day Sample (Type B)	HAR19-8S-S-BOTTOM-7DAY		240,000 E	83.1	16.9
10	7/18/19	Drain Water	HAR19-10S-FW		6,000 E		
		1-Hour Sample	HAR19-10S-S		89,000 E	92.9	7.1
		4-Hour Sample	HAR19-10S-S 4HR		78,000 E	89.9	10.1
		7-Day Sample	HAR19-10S-S-7D			21.9	78.1
13	8/8/19	Drain Water	HAR19-13S-FW		7,000 E		
		1-Hour Sample	HAR19-13S-S BAG A		74,000 E		
			HAR19-13S-S BAG B		77,000 E		
		4-Hour Sample	HAR19-13S-4HR		85,000 E		
			HAR19-13S-4HR BAG C		100,000 E		
		7-Day Sample (Type A)	HAR19-13S-7D			22.1	77.9
16	8/29/19	Drain Water	HAR19-19S-FW		12,000 E		
		1-Hour Sample	HAR19-16S-S		37,000 E		
		4-Hour Sample	HAR19-16S-4HR		61,000 E		
		7-Day Sample (Type A)	HAR19-16S-7D-A			5.8	94.2
		7-Day Sample (Type B)	HAR19-16S-7D-B		96,000 E	88.8	11.2

Table C-4
Analytical Data for Harvest and Dewatering Channel Samples

Harvest	Date	Description	Sample Name	Total Suspended Solids (mg/L)	Total Solids (mg/L)	Percent Moisture (%)	Percent Solids (%)
19	9/19/19	Drain Water	HAR19-19S-FW	2,300	15,000 E		
		1-Hour Sample	MAR19-19S-S		59,000 E	94.2	5.8
		4-Hour Sample	HAR19-19S-4HR		52,000 E	93.5	6.5
		7-Day Sample (Type A)	HAR19-19S-7D-A			19.4	80.6
		7-Day Sample (Type B)	HAR19-19S-7D-B		37,000 E	91.1	8.9

Notes:

Shaded cells indicate that no data were collected for these samples.

E: result exceeded calibration range

L: liter

mg: milligram

Table C-5
Analytical Data for Sand Filter Samples

Harvest	Date	Input			Output		
		Sample Name	Total Suspended Solids (mg/L)	Total Solids (mg/L)	Sample Name	Total Suspended Solids (mg/L)	Total Solids (mg/L)
7	6/27/19	HAR19-7S-FW	580		HAR19-7S-SF7	79	
10	7/18/19	HAR19-10S-FW		6,000 E	HAR19-10S-SF10		5,400 E
13	8/8/19	HAR19-13S-FW		7,000 E	HAR19-SF13		5,300 E
16	8/29/19	HAR19-19S-FW		12,000 E	HAR19-SF16		9,800 E
19	9/19/19	HAR19-19S-FW	2,300	15,000 E	HAR19-SF19	29	13,000 E

Notes:

Shaded cells indicate that no data were collected for these samples.

L: liter

mg: milligram

E: result exceeded calibration range

Table C-6

Analytical Data for Surface Water Samples at Inflow and Outflow of Algal Flow-Way

Date	Inflow										Outflow
	Nitrate as N (mg/L)	Nitrite as N (mg/L)	Nitrate+Nitrite (mg/L)	Ammonia as N (mg/L)	Organic Nitrogen as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Nitrogen as N (mg/L)	Total Phosphorus as P (mg/L)	Chlorophyll a (µg/L)	Total Suspended Solids (mg/L)	Total Suspended Solids (mg/L)
5/22/19	0.14	<0.012	0.143	<0.20	0.43	0.428	0.570	0.022	3.2	7.5	
5/23/19										5.2	2.8
5/30/19	0.12	<0.012	0.123	<0.20	<0.20	<0.200	<0.200	0.025	2.0	4.4	6.8
6/5/19	0.57	<0.012	0.567	<0.20	0.47	0.467	1.03	0.019	14	7.6	5.6
6/12/19	<0.10	<0.012	<0.100	0.26	0.52	0.779	0.779	0.027	12	5.0	7.2
6/19/19	<0.10	<0.012	<0.100	<0.20	1.2	1.17	1.17	0.045	16	10	1.8
6/27/19	<0.10	<0.012	<0.100	<0.20	0.81	0.813	0.813	0.028	6.2	8.0	6.5
7/2/19	<0.10	<0.012	<0.100	<0.20	0.63	0.628	0.628	0.030	18	12	<5.0
7/11/19	<0.10	<0.012	<0.100	<0.20	0.62	0.617	0.617	0.039	3.8	11	5.8
7/17/19	<0.10	0.033	<0.100	0.26	1.6	1.85	1.85	0.066	12	27	13
7/25/19	<0.10	0.075	<0.100	0.27	0.80	1.06	1.06	0.039		8.0	3.3
7/29/19	<0.10	<0.012	<0.100	<0.20	0.65	0.647	0.647	0.031	10	10	7.2
8/8/19	<0.10	<0.012	<0.100	0.28	0.38	0.658	0.658	0.042	2.1	11	9.4
8/14/19	<0.10	<0.012	<0.100	0.21	0.60	0.808	0.808	0.056	28	6.4	17
8/22/19	<0.10	<0.012	<0.100	<0.20	2.6	2.58	2.58	0.045	23	24	12
8/28/19	<0.10	<0.012	<0.100	<0.20	1.5	1.53	1.53	0.12	24	8.0	4.4
9/5/19	<0.10	<0.012	<0.100	<0.20	0.62	0.621	0.621	0.048	11	12	14
9/11/19	<0.10	<0.012	<0.100	<0.20	0.96	0.960	0.960	0.096	27	14	12
9/19/19	<0.10	0.016	<0.100	<0.20	0.65	0.648	0.648	0.048	6.0	8.0	6.8
9/26/19	<0.10	0.083	<0.100	<0.20	0.82	0.824	0.824	0.058	15	<5.0	<5.0
10/3/19	<0.10	0.054	<0.100	<0.20	0.65	0.652	0.652	0.065	2.0	14	16
10/10/19	0.14	0.13	0.266	<0.20	0.48	0.483	0.749	0.078	6.8	6.4	8.6
10/17/19	<0.10	<0.012	<0.100	<0.20	1.3	1.29	1.29	0.18	38	69	31

Table C-6

Analytical Data for Surface Water Samples at Inflow and Outflow of Algal Flow-Way

Notes:

Shaded cells indicate that no data were collected for these samples.

µg: microgram

L: liter

mg: milligram

N: nitrogen

P: phosphorus

Table C-7
Analytical Data for Surface Water Samples at Hawkins Point

Date	Nitrate as N (mg/L)	Nitrite as N (mg/L)	Nitrate+ Nitrite (mg/L)	Ammonia as N (mg/L)	Organic Nitrogen as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Nitrogen as N (mg/L)	Total Phosphorus as P (mg/L)	Chlorophyll a (µg/L)	Total Suspended Solids (mg/L)
5/22/19	0.16	<0.012	0.161	<0.20	0.57	0.567	0.728	0.026	6.4	6.5
6/5/19	0.53	<0.012	0.533	<0.20	0.59	0.595	1.13	0.016	6.8	8.8
6/19/19	<0.10	0.014	<0.100	<0.20	0.99	0.994	0.994	0.025	11	9.6
7/2/19	<0.10	<0.012	<0.100	<0.20	0.67	0.673	0.673	0.032	23	16
7/17/19	<0.10	0.012	<0.100	0.23	0.90	1.13	1.13	0.026	15	9.0
7/29/19	<0.10	<0.012	<0.100	<0.20	0.87	0.874	0.874	0.046	16	13
8/14/19	<0.10	<0.012	<0.100	<0.20	0.70	0.702	0.702	0.025	9.4	8.4
8/28/19	<0.10	<0.012	<0.100	<0.20	3.4	3.36	3.36	0.056	22	15
9/11/19	<0.10	<0.012	<0.100	<0.20	0.68	0.685	0.685	0.17	11	19
9/26/19	<0.10	0.026	0.106	<0.20	1.8	1.80	1.90	0.029	11	9.5

Notes:

µg: microgram

L: liter

mg: milligram

N: nitrogen

P: phosphorus

Appendix D

Data to Support Investigations

Table D-1

Investigation 1 – Surge Versus Continuous Flow

Harvest	Date	Harvest Type	Surge Flow-way			Continuous Flow-way		
			Totalizer Calculated Weekly Flow Rate (gpm)	Algal Biomass Dry Weight (lbs)	Algal Productivity (dry-g/m2/day)	Totalizer Calculated Weekly Flow Rate (gpm)	Algal Biomass Dry Weight (lbs)	Algal Productivity (dry-g/m2/day)
Harvest 1	5/16/2019	Normal (1st)	---	36.96	---	---	44.00	---
Harvest 2	5/23/2019	Normal	35	15.84	8.9	36	9.28	5.24
Harvest 3	5/30/2019	Normal	32	2.67	1.5	32	3.74	2.11
Harvest 4	6/6/2019	No Harvest	18	---	---	18	---	---
Harvest 5	6/12/2019	Normal	43	8.64	5.7	39	6.40	4.21
Harvest 6	6/20/2019	Subplot	41	14.39	7.1	45	23.15	11.43
Harvest 7	6/27/2019	Side Channel	44	17.70	10.0	46	19.00	10.72
Harvest 8	7/3/2019	Normal	40	17.54	11.6	44	14.45	9.51
Harvest 9	7/11/2019	Subplot	42	27.13	13.4	46	20.46	10.10
Harvest 10	7/18/2019	Side Channel	36	48.44	27.3	45	29.64	16.73
Harvest 11	7/25/2019	Normal	7	31.80	17.9	47	26.40	14.90
Harvest 12	8/1/2019	Subplot	31	24.14	13.6	47	37.60	21.22
Harvest 13	8/8/2019	Side Channel	40	64.11	36.2	47	29.40	16.59
Harvest 14	8/16/2019	Normal	44	62.70	31.0	47	15.30	7.55
Harvest 15	8/22/2019	Subplot	15	12.85	8.5	46	18.68	12.30
Harvest 16	8/29/2019	Side Channel	40	22.78	12.9	46	43.40	24.49
Harvest 17	9/5/2019	Normal	44	17.28	9.8	47	38.48	21.71
Harvest 18	9/12/2019	Subplot	45	30.47	17.2	48	28.47	16.07
Harvest 19	9/19/2019	Side Channel	46	29.86	16.9	49	29.90	16.87
Harvest 20	9/26/2019	Normal	48	22.50	12.7	49	22.80	12.87
Harvest 21	10/3/2019	Subplot	54	20.80	11.7	53	29.12	16.43
Harvest 22	10/10/2019	Normal (extra)	64	26.04	14.7	56	34.32	19.37
Harvest 23	10/17/2019	Normal (extra)	64	42.12	23.8	54	34.56	19.50
Harvest 24	10/24/2019	Normal (extra)	70	19.04	10.7	52	35.26	19.90

Table D-1
Investigation 1 – Surge Versus Continuous Flow

Notes:
---: not available
dry-g/m2/day: grams dry per square meter per day
gpm: gallons per minute
lbs: pounds

Table D-2a
Investigation 2 – Subplot Harvest Weights

		Liner + Grid								Concrete + Grid								Concrete Only				Concrete Only - Continuous			
		Surge Flow-Way				Continuous Flow-Way				Surge Flow-Way				Continuous Flow-Way				Surge Flow-Way				Continuous Flow-Way			
Harvest	Date	Biomass Weight of Full Subplot (lbs)	Biomass Weight after Filter Bag (lbs)	Total Solids after Filter Bag (%)	Biomass Dry Weight (lbs)	Biomass Weight of Full Subplot (lbs)	Biomass Weight after Filter Bag (lbs)	Total Solids after Filter Bag (%)	Biomass Dry Weight (lbs)	Biomass Weight of Full Subplot (lbs)	Biomass Weight after Filter Bag (lbs)	Total Solids after Filter Bag (%)	Biomass Dry Weight (lbs)	Biomass Weight of Full Subplot (lbs)	Biomass Weight after Filter Bag (lbs)	Total Solids after Filter Bag (%)	Biomass Dry Weight (lbs)	Biomass Weight of Full Subplot (lbs)	Biomass Weight after Filter Bag (lbs)	Total Solids after Filter Bag (%)	Biomass Dry Weight (lbs)	Biomass Weight of Full Subplot (lbs)	Biomass Weight after Filter Bag (lbs)	Total Solids after Filter Bag (%)	Biomass Dry Weight (lbs)
Harvest 6	6/20/2019	18.36	5.29	8.9%	0.47	14.30	5.27	11%	0.58	11.34	5.73	8.1%	0.46	11.32	4.52	7.8%	0.35	3.79	2.82	0.08	0.2	5.65	4.61	0.09	0.43
Harvest 9	7/11/2019	21.72	6.97	12%	0.84	17.85	6.37	12%	0.76	14.85	7.75	10%	0.78	13.86	5.80	9.9%	0.57	6.36	4.52	0.16	0.7	8.4	5.71	0.11	0.63
Harvest 12	8/1/2019	20.87	6.74	7.8%	0.53	19.86	4.90	12%	0.59	10.69	4.60	10%	0.46	17.38	4.57	22%	1.01	4.91	2.85	0.12	0.3	5.86	3.52	0.13	0.46
Harvest 15	8/22/2019	14.82	7.98	5.4%	0.43	31.87	11.66	4.2%	0.49	11.95	4.86	11%	0.53	22.87	7.33	6.5%	0.48	9.62	4.09	0.15	0.6	10.75	3.23	0.21	0.68
Harvest 18	9/12/2019	32.87	4.66	12%	0.56	25.87	6.52	4.4%	0.29	15.32	4.84	13%	0.63	21.87	4.23	13%	0.55	13.57	5.76	0.14	0.8	8.05	3.45	0.16	0.55
Harvest 21	10/3/2019	21.87	4.51	6.2%	0.28	28.87	3.82	13%	0.50	8.49	2.28	11%	0.25	22.87	2.75	13%	0.36	8.83	3.59	0.13	0.5	9	3.63	0.17	0.62
	MEAN	21.75	6.03	9%	0.52	23.10	6.42	9%	0.53	12.11	5.01	11%	0.52	18.36	4.87	12%	0.55	7.85	3.94	0.13	0.5	7.95	4.03	0.15	0.56

Note:
lbs: pounds

Table D-2b

Investigation 2 – Subplot Versus Entire Flow-Way Productivity

Harvest	Date	Surge Flow-Way Productivity (dry-g/m^2/day)				Continuous Flow-Way Productivity (dry-g/m^2/day)			
		Liner + Grid	Concrete + Grid	Concrete Only	Entire Flow-Way	Liner + Grid	Concrete + Grid	Concrete Only	Entire Flow-Way
Harvest 6	6/20/2019	26.69	26.32	13.11	7.1	32.9	19.99	24.57	11.43
Harvest 9	7/11/2019	47.42	43.94	41.00	13.4	43.3	32.56	35.61	10.10
Harvest 12	8/1/2019	34.07	29.81	22.16	13.6	38.1	65.15	29.65	21.22
Harvest 15	8/22/2019	27.92	34.64	39.75	8.5	31.7	30.87	43.95	12.30
Harvest 18	9/12/2019	36.24	40.77	52.25	17.2	18.6	35.63	35.77	16.07
Harvest 21	10/3/2019	18.12	16.25	30.24	11.7	32.2	23.17	39.99	16.43
	MEAN	31.7	32	33.10	11.9	32.8	34.6	34.90	14.60

Note:

dry-g/m^2/day: grams dry per square meter per day

Table D-3a
Investigation 3 – Harvest and Dewatering Channel Performance

Harvest	Date	DW Mass of Solids in Drain Water Fraction (lbs)	DW Mass of Solids in Retained Fraction (lbs)	% Mass lost to Drain Water (%)	Drain Water			Solids (In-Channel)									
					Drain Water Weight (lbs)	Total Suspended Solids (mg/L)	Total Solids (mg/L)	Type A Dewatering Material Weight (lbs)	Type A Description	Percent Moisture (%)	Percent Solids (%)	Type B Dewatering Material Weight (lbs)	Type B Description	Total Solids (mg/L)	Percent Moisture (%)	Percent Solids (%)	Notes
Harvest 10	7/18/2019	1.26	47.17	2.61%	210.50	---	6,000	60.40	Composite of wet and dry (see field notes sheet)	21.9	78.1						Mostly dry. Low spots still damp, one section (5 feet) sloppy wet. 3 buckets dry, 1 mix wet/dry, 1 wet.
Harvest 13	8/8/2019	1.42	62.69	2.22%	203.00	---	7,000	80.48	Composite of wet and dry (see field notes sheet)	22.1	77.9						3 buckets dry and damp, 1 bucket of wet
Harvest 16	8/29/2019	3.14	19.63	13.80%	261.96	---	12,000	8.00	Dry	5.8	94.2	108	Wet sloppy mix	96,000	88.8	11.20	1 bucket dry (Type A), 4 buckets wet (Type B)
Harvest 19	9/19/2019	5.05	24.81	16.91%	336.62	2,300	15,000	8.70	Fully dry	19.4	80.6	200	Standing water	37,000	91.1	8.90	1 bucket dry (Type A), wet (Type B) collected with Vermeer

Notes:
Shaded cells indicate that Type B samples were not collected for these weeks.
---: not available
DW: dry weight
lbs: pounds
mg/L: milligrams per liter

Table D-3b
Investigation 3 – Sand Filter

Harvest	Date	Input					Output				
		Drain Water Weight (lbs)	Total Suspended Solids (mg/L)	Total Solids (mg/L)	Drain Water Field NTU Reading	Time Into Sand Filter	Sand Filter Discharge Weight (lbs)	Total Suspended Solids (mg/L)	Total Solids (mg/L)	Field NTU Reading	Time
Harvest 10	7/18/2019	210.5	---	6,000	442	7/18/19 10:45	98.5	---	5,400	78.9	7/19/19 14:00
Harvest 13	8/8/2019	203.00	---	7,000	overrange	8/8/19 10:30	broken basin	---	5,300	196	8/8/19 10:40
Harvest 16	8/29/2019	261.96	---	12,000	overrange	8/29/19 10:45	---	---	9,800	119	8/29/18 11:10
Harvest 19	9/19/2019	336.62	2,300	15,000	overrange	9/19/19 10:30	---	29.0	13,000	85.9	9/19/19 10:50

Notes:
---: not available
lbs: pounds
mg/L: milligrams per liter
NTU: nephelometric turbidity unit

Table D-3c

Investigation 3 – Harvest and Dewatering Channel Samples

<table>
<tr><th rowspan="2">Harvest</th><th rowspan="2">Date</th><th colspan="3">1-Hour Sample</th><th colspan="3">4-Hour Sample</th><th colspan="4">7-Day Sample</th></tr>
<tr><th>Total Solids (mg/L)</th><th>Percent Moisture (%)</th><th>Percent Solids (%)</th><th>Total Solids (mg/L)</th><th>Percent Moisture (%)</th><th>Percent Solids (%)</th><th>Total Solids (mg/L)</th><th>Percent Moisture (%)</th><th>Percent Solids (%)</th><th>Field Sheet Notes About Sample Area</th></tr>
<tr><td>Harvest 7</td><td>6/27/2019</td><td>43,000</td><td>93.9</td><td>6.1</td><td>89,000</td><td>91.6</td><td>8.4</td><td>---[b]</td><td>---[b]</td><td>---[b]</td><td>Dewatering channel was flooded due to flow-way damage.</td></tr>
<tr><td>Harvest 10</td><td>7/18/2019</td><td>89,000</td><td>92.9</td><td>7.1</td><td>78,000</td><td>89.9</td><td>10.1</td><td>---</td><td>21.9</td><td>78.1</td><td>Composite of wet and dry areas; collected equal portions of material about every 10 feet.</td></tr>
<tr><td>Harvest 13[a]</td><td>8/8/2019</td><td>75,500</td><td>---</td><td>---</td><td>92,500</td><td>---</td><td>---</td><td>---</td><td>22.1</td><td>77.9</td><td>Composite of wet and dry areas; collected equal portions of material about every 10 feet.</td></tr>
<tr><td rowspan="2">Harvest 16</td><td rowspan="2">8/29/2019</td><td rowspan="2">37,000</td><td rowspan="2">---</td><td rowspan="2">---</td><td rowspan="2">61,000</td><td rowspan="2">---</td><td rowspan="2">---</td><td>---</td><td>5.8</td><td>94.2</td><td>Type A Material (drier areas of channel)</td></tr>
<tr><td>96,000</td><td>88.8</td><td>11.2</td><td>Type B Material (wetter areas of channel)</td></tr>
<tr><td rowspan="2">Harvest 19</td><td rowspan="2">9/19/2019</td><td rowspan="2">59,000</td><td rowspan="2">94.2</td><td rowspan="2">5.8</td><td rowspan="2">52,000</td><td rowspan="2">93.5</td><td rowspan="2">6.5</td><td>---</td><td>19.4</td><td>80.6</td><td>Type A Material (drier areas of channel)</td></tr>
<tr><td>37,000</td><td>91.1</td><td>8.9</td><td>Type B Material (wetter areas of channel)</td></tr>
</table>

Notes:

a. For Harvest 13, results for 1-Hour and 4-Hour samples are each the mean of two samples collected (smaller containers were used that day).

b. For Harvest 7, results from 7-Day samples were excluded from investigation because damage to the flow-way caused flooding in the harvest and dewatering channel.

---: not available

mg/L: milligrams per liter

Table D-3d
Investigation 3 – Microwave Percent Solids

Harvest	Date	Microwave Drying Procedure Results									Comparable Laboratory Results				
		1-Hour	4-Hour	1-Day	4-Day	5-Day	6-Day	7-Day (Composite)	7-Day A (Dry Section)	7-Day B (Wet Section)	1-Hour	4-Hour	7-Day (Composite)	7-Day A (Dry Section)	7-Day B (Wet Section)
Harvest 10	7/18/2019	5.6%	7.0%	13.5%				53.3%	94.1%	22.7%	8.9%	7.8%	78.1%		
Harvest 13	8/8/2019	5.0%	8.4%	9.6%				47.1%			7.6%	9.3%	77.9%		
Harvest 16	8/29/2019	4.8%	4.5%	9.5%		34.2%	73.0%		90.1%	9.1%	3.7%	6.1%		94.2%	11.2%
Harvest 19	9/19/2019	3.8%	5.4%	9.9%	46.4%	71.9%	89.1%		78.2%		5.9%	5.2%		80.6%	8.9%

Notes:

Shaded cells indicate that no data were collected.

Appendix E
Comparisons of Water Quality, Algal Biomass Nutrients, and Productivity Measured Historically at DMT Flow-Ways and Nearby Surface Water Stations

10320 Little Patuxent Parkway, Suite 1140
Columbia, Maryland 21044
410.715.0824

Memorandum

February 28, 2020

To: Bill Richardson, MDOT MPA; Dan Yuska, MARAD; Bryce Selby, MES

From: Mark Zivojnovich, HydroMentia

cc: Paul Nevenglosky, NMP; Walt Dinicola, Anchor QEA; Emily Chen, Anchor QEA

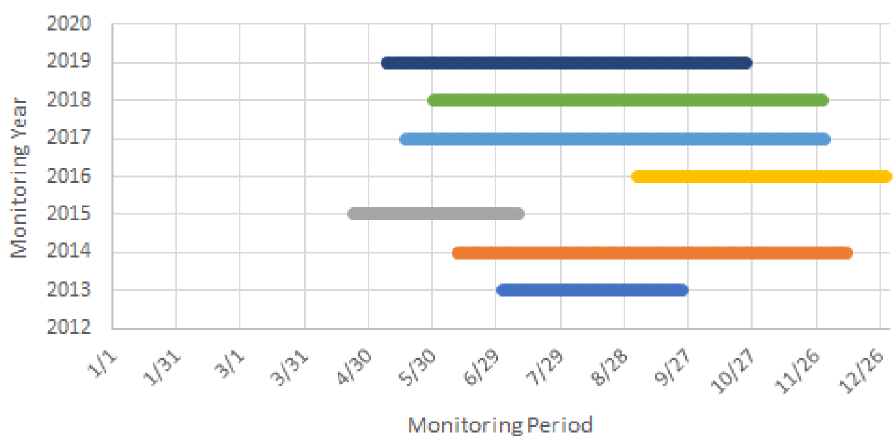
Re: Comparisons of Water Quality, Algal Biomass Nutrients, and Productivity Measured Historically at DMT Flow-Ways and/or Nearby Surface Water Stations

Historical Dundalk Marine Terminal Flow-Way Monitoring Periods

The dates of the monitoring periods of the Dundalk Marine Terminal (DMT) algal flow-ways have varied since pilot testing was initiated in 2013. The following list and Figure E-1 provide monitoring periods for 2013 through 2019:

- 2013 Monitoring Period: July 2 to September 24 (84 days)
- 2014 Monitoring Period: June 11 to December 10 (182 days)
- 2015 Monitoring Period: April 23 to July 9 (77 days)
- 2016 Monitoring Period: September 3 to December 29 (117 days)
- 2017 Monitoring Period: May 18 to November 30 (196 days)
- 2018 Monitoring Period: May 31 to November 29 (182 days)
- 2019 Monitoring Period: May 9 to October 24 (168 days)

Figure E-1
DMT Pilot Monitoring Periods 2013 Through 2019



When comparing data from different monitoring periods and within the same monitoring periods, several differences are important to be aware of, including the following:

- Water temperature and water quality typically vary seasonally, and can impact algal productivity and nitrogen, phosphorus, and sediment removal rates depending on season.
- The physical set-up and operations for the flow-ways varied year to year and can impact the data. See Section 1.2 of the *Phase 4 Algal Flow-Way Pilot Testing Program at Dundalk Marine Terminal* for more details.
- Relative to interrupted or seasonal pilot testing, it is also important to note the difference in algal productivity during initial start-up and stabilization phases,[1] or following a system dryout. The durations of the start-up and stabilization phases are difficult to predict, and the duration will vary according to water quality and ambient environmental conditions that include solar radiation, water temperature, hydraulic loading rates, and nutrient concentration.

Dundalk Marine Terminal Water Quality Proxy

To understand the likely water quality conditions and corresponding algal productivity associated with operation of the DMT flow-ways during 2013 through 2018 when inflow water quality was not analyzed, water quality data from nearby monitoring stations were reviewed in an effort to identify an appropriate water quality proxy. This analysis can also potentially inform water quality and treatment performance for potential algal flow-way scale-up sites like at Hawkins Point. Water quality parameters potentially impacting algal productivity include total nitrogen (TN), total phosphorus (TP), water temperature, and salinity.

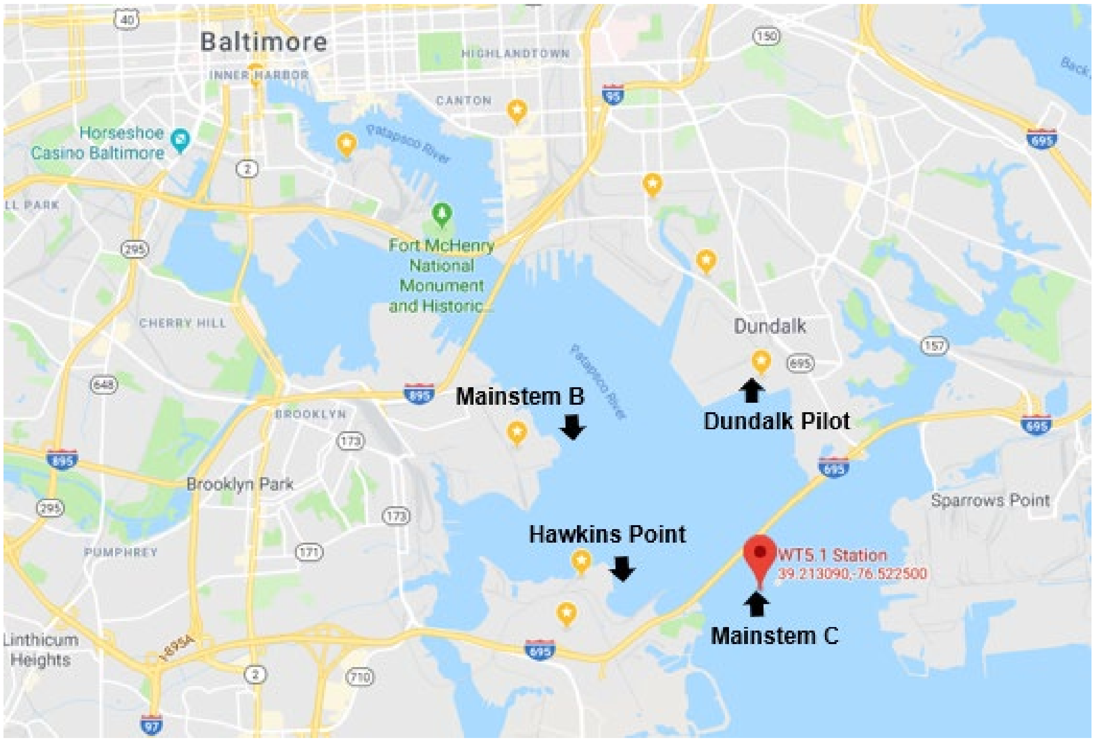
The following three nearby monitoring stations were identified:

- Maryland Department of Natural Resources (MDNR) Station WT5.1 (0.5 meter depth) for the Chesapeake Bay Program's DataHub (MDNR 2020)
- Blue Water Baltimore Monitoring Stations (BWB; 2020) Mainstem B and Mainstem C

Monitoring data for 2013 through 2018 were available for all three sites; however, 2019 data were only available for Station WT5.1. The location of these monitoring sites relative to the DMT flow-ways and Hawkins Point site are illustrated in Figure E-2. Monitoring Stations Mainstem C and WT5.1 are located less than 50 feet apart.

[1] System start-up is initiated with the introduction of continuous flow to the algal flow-way. During the start-up phase, an initial algal turf community is established on the flow-way. During the stabilization phase, the start-up algal turf community proceeds through ecological succession toward a sustained algal turf community.

Figure E-2
Locations of MDNR WT5.1 and BWB Mainstem B and Mainstem C Monitoring Stations



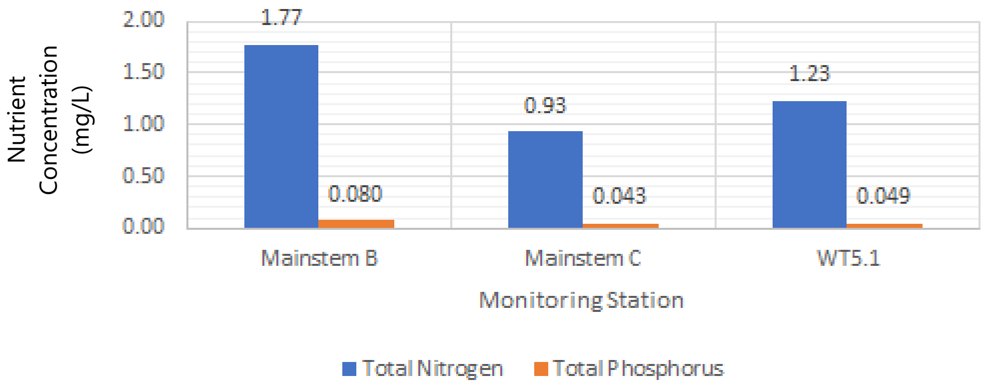
Basemap Source: Google Maps

Proxy Total Nitrogen and Total Phosphorus

Figures E-3 provides mean nitrogen and phosphorus concentrations for the 2013 through 2018 monitoring period for monitoring stations in relative proximity to DMT. Upgradient Mainstem B site had higher TN and TP concentrations than Mainstem C and WT5.1. The elevated Mainstem B nutrient concentrations may be correlated with the nearby wastewater treatment facility; however, the point of discharge for said facility is not known.

Concentrations for Mainstem C and WT5.1 were relatively consistent as expected due to their proximity.

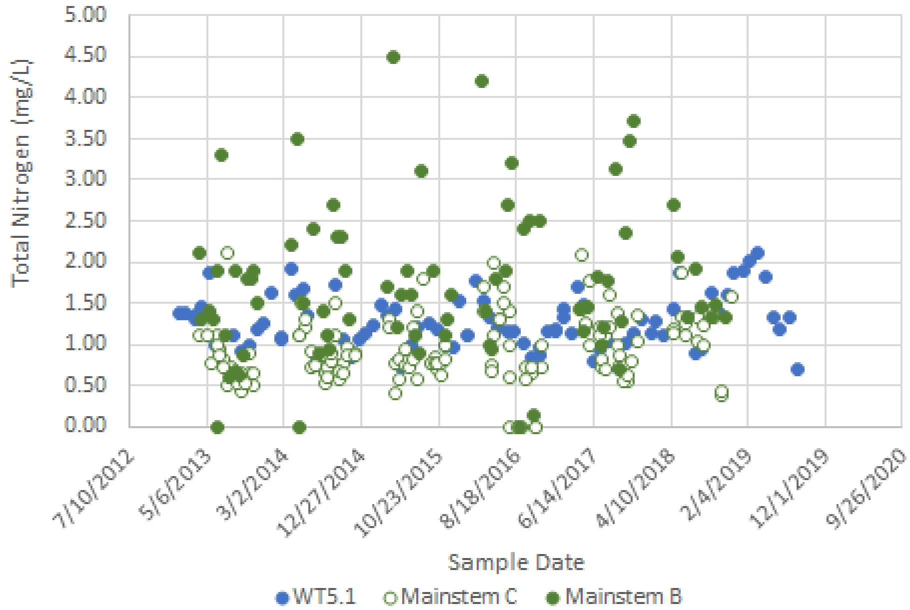
Figure E-3
Mean Total Nitrogen and Phosphorus Concentrations at MDNR WT5.1 and BWB Mainstem B and BWB Mainstem C Monitoring Stations (2013 Through 2018)



Notes:
MDNR WT5.1 data are from MDNR 2020.
Mainstem B and C data are from BWB 2020.

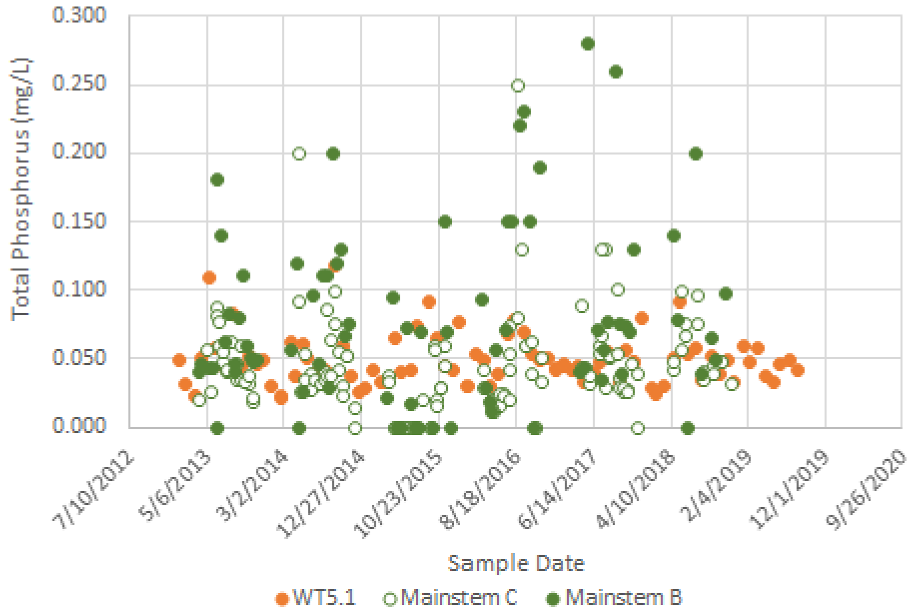
Figures E-4 and E-5 illustrate individual TN and TP concentrations for the three referenced sites showing the range of concentrations and seasonal changes over time.

Figure E-4
Total Nitrogen at MDNR WT5.1 and BWB Mainstem B and C Monitoring Stations for the 2013 Through 2019 Monitoring Period



Notes:
MDNR WT5.1 data are from MDNR 2020.
Mainstem B and C data are from BWB 2020.
mg/L: milligrams per liter

Figure E-5
Total Phosphorus at MDNR WT5.1 and BWB Mainstem B and C Monitoring Stations for the 2013 Through 2019 Monitoring Period



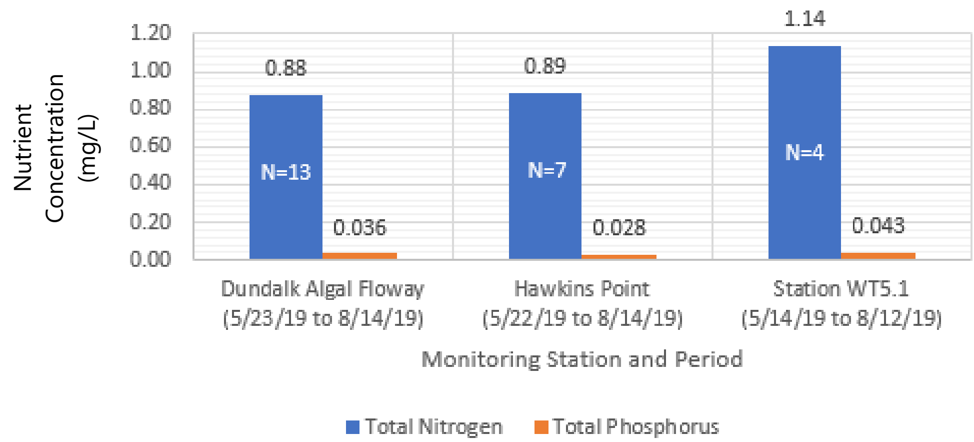
Notes:
MDNR WT5.1 data are from MDNR 2020.
Mainstem B and C data are from BWB 2020.

To determine if the nearby water monitoring stations may be used as a water quality proxy for DMT and Hawkins Point Site, in Figure E-6 mean TN and TP concentrations at the Patapsco River Monitoring Station WT5.1 are compared with the DMT and Hawkins Point Sites for the mid-May through mid-August 2019 sample collection period in which water quality data was available for all three sites.

While both DMT and Hawkins Point TN and TP concentrations were lower than the concentrations recorded at WT5.1, only Hawkins Point TP was significantly lower at P=0.05 than WT5.1, as evaluated employing Welch's *t*-test (t-Test: Two-Sample Assuming Unequal Variances).

While 2019 water quality data from Monitoring Station Mainstem B data was not available for this effort, as Mainstem B for the 2013 through 2018 monitoring period consistently had higher concentrations than WT5.1, it was not considered a suitable proxy. Mainstem C, which had lower TN and TP concentrations for the 2013 through 2018 period, may be a good proxy; however, without having 2019 comparable data, a decision was made to use water quality date from WT5.1 as the proxy for further analysis relative to 2013 through 2018 DMT algal productivity data.

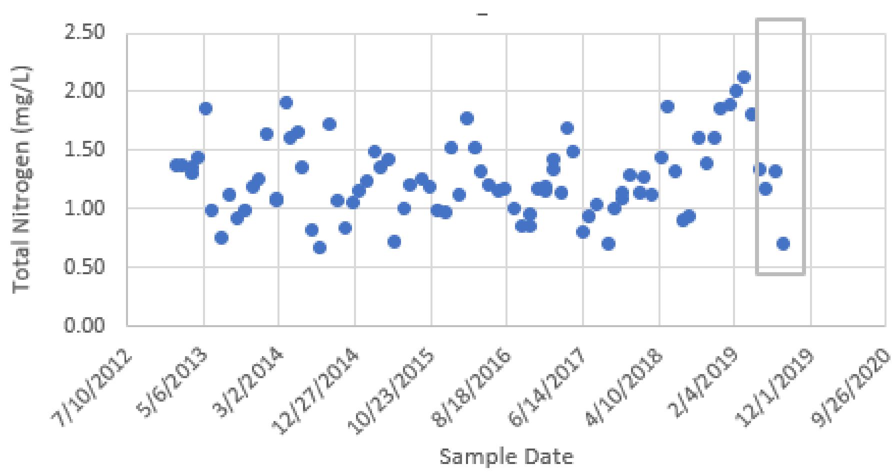
Figure E-6
Mean Total Nitrogen and Total Phosphorus at DMT Algal Flow-Ways, Hawkins Point, and Monitoring Station WT5.1 from Mid-May to Mid-August 2019



Notes:
Station WT5.1 data are from MDNR 2020.

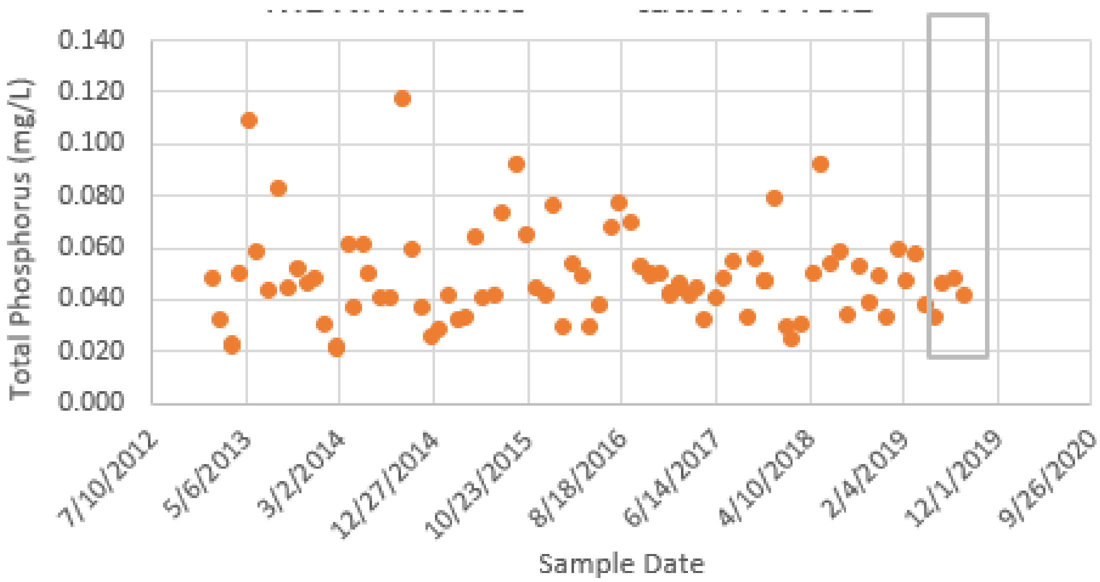
Figures E-7 and E-8 illustrate Monitoring Station WT5.1 TN and TP concentrations for individual samples collected during DMT flow-way 2013 through 2019 operating periods. Data from the 2019 monitoring period data in the charts are enclosed in a gray box. Figures E-9 and E-10 illustrate Monitoring Station WT5.1 TN and TP mean annual concentrations for samples collected during DMT flow-way operating periods for 2013 through 2019.

Figure E-7
Total Nitrogen at MDNR Monitoring Station WT5.1 for 2013 Through 2019 DMT Monitoring Periods



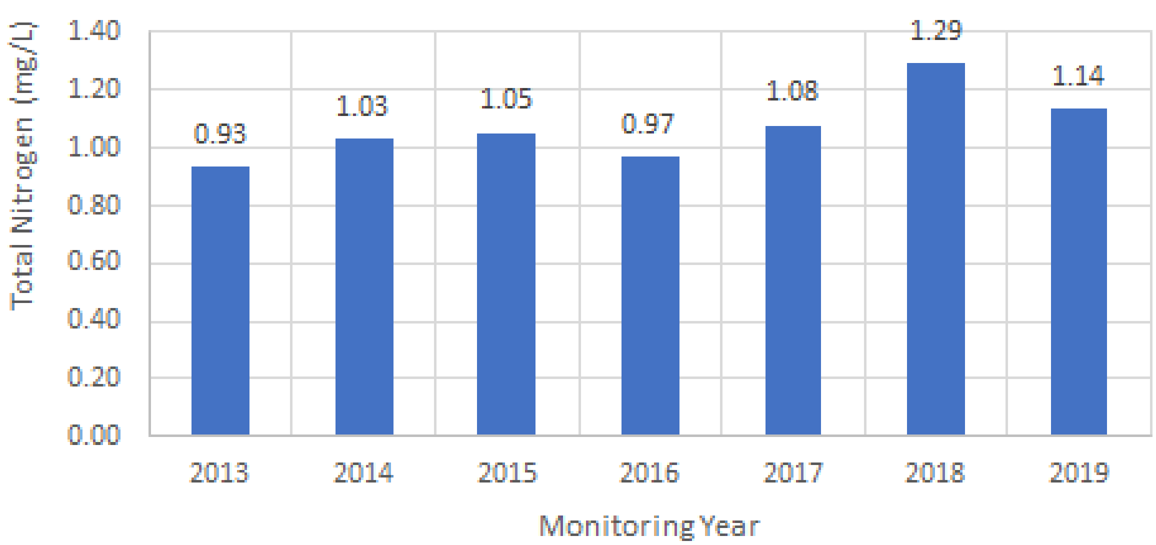
Notes:
The grey box indicates data collected in 2019.
Data are from MDNR 2020.

Figure E-8
Total Phosphorus at MDNR Monitoring Station WT5.1 for 2013 Through 2019 DMT Monitoring Periods



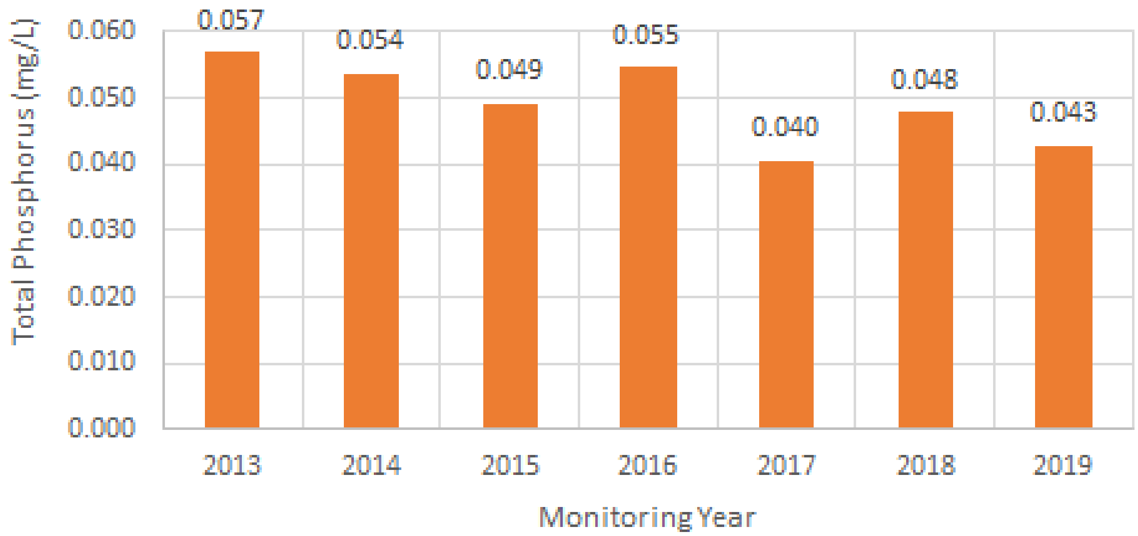
Notes:
The grey box indicates data collected in 2019.
Data are from MDNR 2020.

Figure E-9
Mean Total Nitrogen at Monitoring Station WT5.1 During DMT Flow-Way Operations



Notes:
Data are from MDNR 2020.

Figure E-10
Mean Total Phosphorus at Monitoring Station WT5.1 During DMT Flow-Way Operations

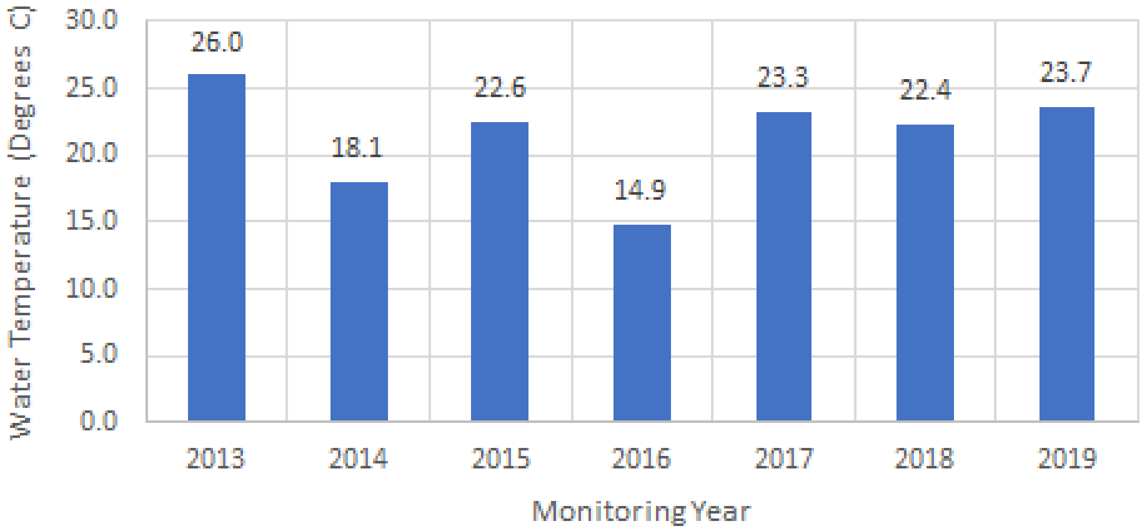


Notes:
Data are from MDNR 2020.

Proxy Water Temperature and Salinity

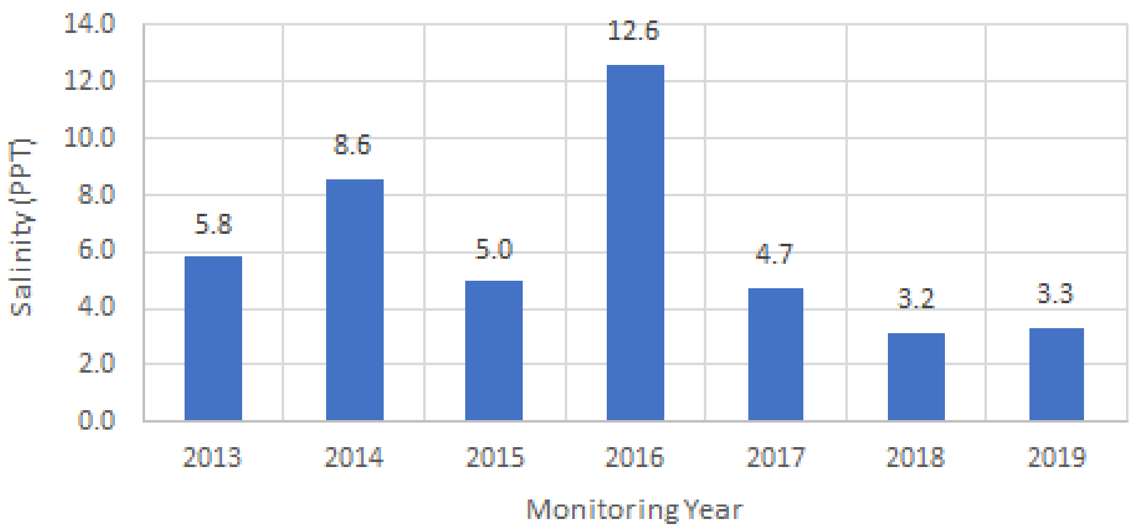
Figures E-11 and E-12 illustrate Monitoring Station WT5.1 mean annual water temperature and salinity for samples collected during DMT flow-way operating periods for 2013 through 2019.

Figure E-11
Mean Water Temperature at Monitoring Station WT5.1 During DMT Flow-Way Operations for 2013 Through 2019



Notes:
Data are from MDNR 2020.
C: Celsius

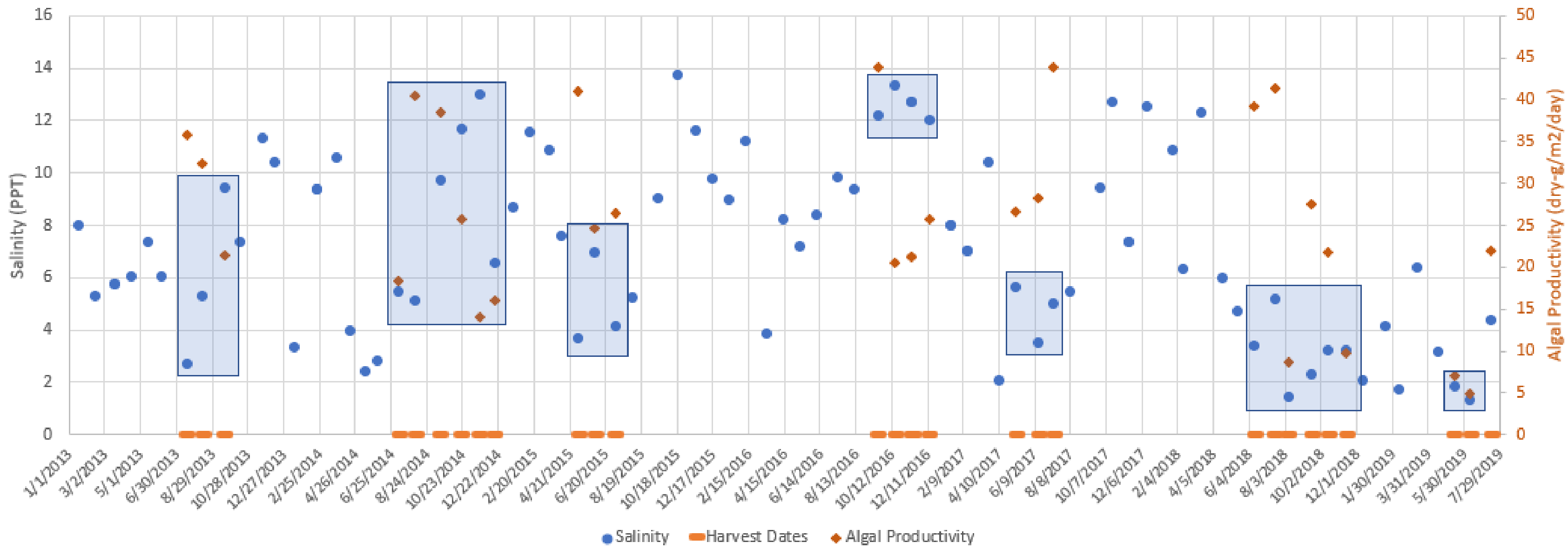
Figure E-12
Mean Salinity at Monitoring Station WT5.1 During DMT Flow-Way Operations for 2013 Through 2019



Notes:
Data are from MDNR 2020.
PPT: parts per thousand

As discussed in Section 2 of the *Phase 4 Algal Flow-Way Pilot Testing Program at Dundalk Marine Terminal*, salinity concentrations and changes in salinity over time and the salinity rate of change impact algal community diversity and dominance. As shown in Figure E-13, over the 2013 through 2019 monitoring periods, salinity from WT5.1 in the region of DMT has fluctuated significantly for the various DMT operating periods.

Figure E-13
Salinity at Monitoring Station WT5.1 and and Algal Productivity at DMT Flow-Ways from 2013 Through 2019



Proxy Water Quality and Algal Productivity Correlation

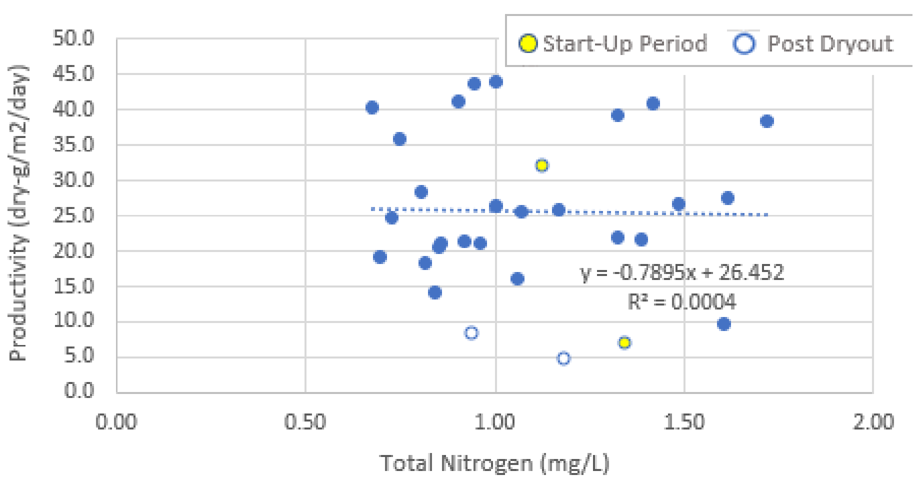
Figures E-14, E-15, E-16, and E-17 illustrate TN, salinity, TP, and water temperature data at Monitoring Station WT5.1 plotted against algal productivity at the DMT flow-way for 2013 through 2019 operating periods. The 2019 start-up and post-dryout data points are identified.

If data collected at Monitoring Station WT5.1 are assumed to be representative of water quality trends at the DMT Pilot Study location for the reference period, it can be inferred from the data that TN concentrations and salinity have minimal impact on algal productivity at the concentrations observed (Figures E-14 and Figure E-15) with regression coefficients of R2 = 0.0004 and R2 = 0.0081.

TP concentrations and water temperature are more correlated with changes in algal productivity (Figures E-16 and E-17) with regression coefficients of R2 = 0.2502 and R2 = 0.1509.

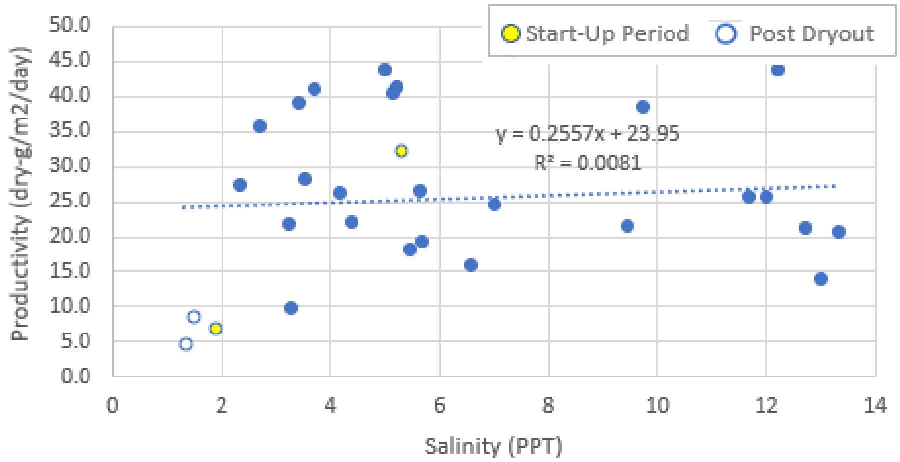
These findings are consistent with Monod relationship regarding TP, adjusted for temperature via the V'ant Hoff-Arrhenius relationship. Based on the regressions analysis and the assumptions discussed, DMT algal production and treatment performance appear primarily impacted by water temperature and TP concentrations.

Figure E-14
Total Nitrogen at Monitoring Station WT5.1 Versus DMT Flow-Way Algal Productivity for 2013 Through 2019



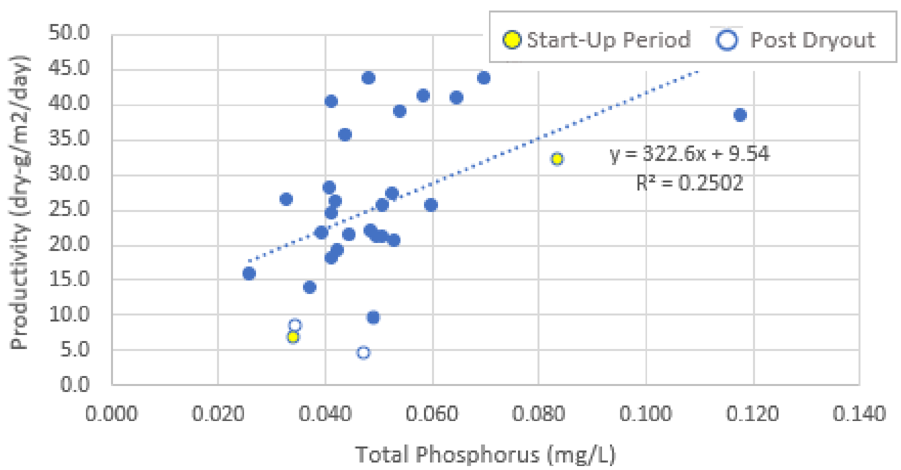
Note:
dry-g/m2/day: dry grams per square meter per day
Start-up period begins with initial flow and ends with a sustained algal community.
Post dryout period identified as first harvest after flow-way dryout due to pump failure or shutdown.

Figure E-15
Salinity at Monitoring Station WT5.1 Versus DMT Flow-Way Algal Productivity for 2013 Through 2019



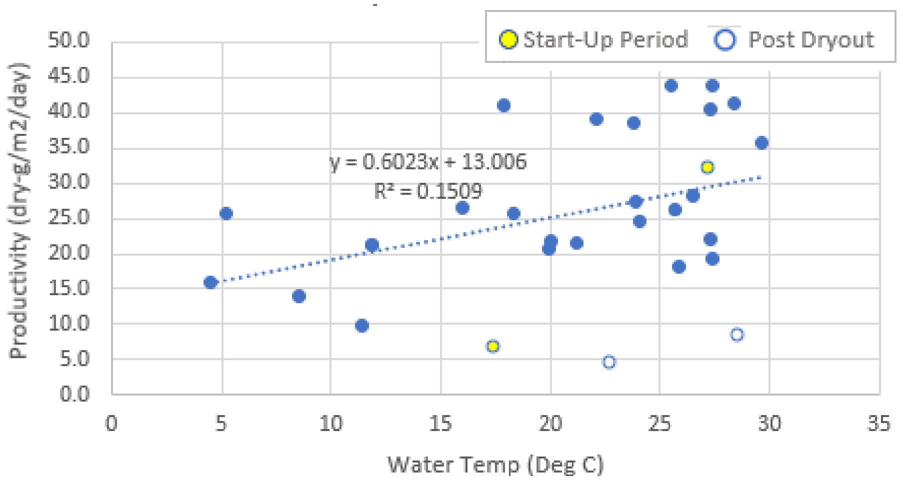
Notes:
Start-up period begins with initial flow and ends with a sustained algal community.
Post dryout period identified as first harvest after flow-way dryout due to pump failure or shutdown.

Figure E-16
Total Phosphorus at Monitoring Station WT5.1 Versus DMT Flow-Way Algal Productivity for 2013 Through 2019



Notes:
Start-up period begins with initial flow and ends with a sustained algal community.
Post dryout period identified as first harvest after flow-way dryout due to pump failure or shutdown.

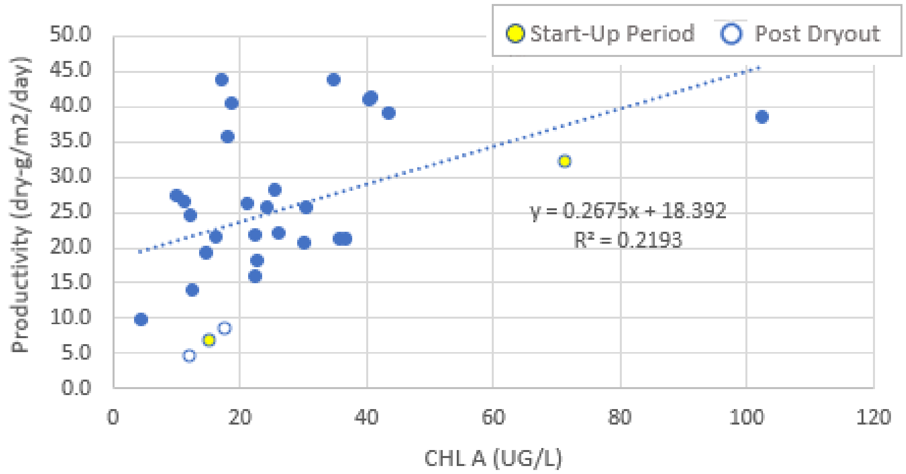
Figure E-17
Water Temperature at Monitoring Station WT 5.1 Versus DMT Flow-Way Algal Productivity for 2013 Through 2019



Notes:
deg C: degrees Celsius
Start-up period begins with initial flow and ends with a sustained algal community
Post dryout period identified as first harvest after flow-way dryout due to pump failure or shutdown

Chlorophyll a is a measure of phytoplankton biomass. Phytoplankton productivity like periphyton responds to changes in water temperature and nutrient concentrations; therefore, it is projected that phytoplankton productivity response to water temperature and nutrient concentrations would be similar to algal productivity at DMT. When plotting chlorophyll a values at Monitoring Station WT5.1 for the 2013 through 2019 DMT operating periods, chlorophyll a correlated to algal productivity at DMT as illustrated in Figure E-18.

Figure E-18
Chlorophyll a Versus DMT Flow-Way Algal Productivity for 2013 Through 2019



Notes:
Start-up period begins with initial flow and ends with a sustained algal community.
Post dryout period identified as first harvest after flow-way dryout due to pump failure or shutdown.

DMT Biomass Nutrient Concentration and Productivity

Algal biomass nutrient concentrations are positively correlated to water nutrient concentrations. As productivity and biomass nutrient concentrations change, a corresponding change in nutrient removal occurs. Accordingly, biomass TN and TP concentrations serve as a proxy for incoming water quality for operating periods in which inflow water quality was not analyzed.

Figures E-19 illustrates DMT algal biomass TN and TP concentrations for individual samples collected 2013 through 2019 operating periods. Figures E-20 and E-21 illustrate DMT algal biomass TN and TP mean annual concentrations for samples collected 2013 through 2019.

As discussed above, increases in inflow TP are associated with increases in algal productivity. Correspondingly, other factors being consistent, lower concentrations of TP are likely to result in lower productivity rates.

As referenced, 2019 DMT algal biomass had the lowest mean annual tissue phosphorus concentration as shown in Figure E-20. This correlates with the 2019 DMT low mean annual productivity as shown in Figure E-22. Accordingly, 2019 DMT productivity is likely reflective of lower inflow phosphorus concentrations than prior DMT monitoring periods.

Figure E-19
Mean Tissue Total Phosphorus Concentration

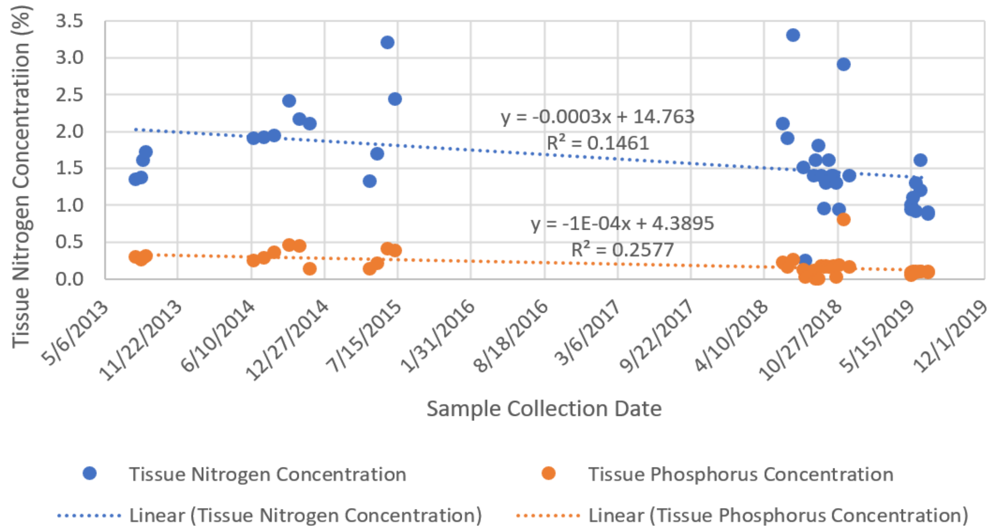
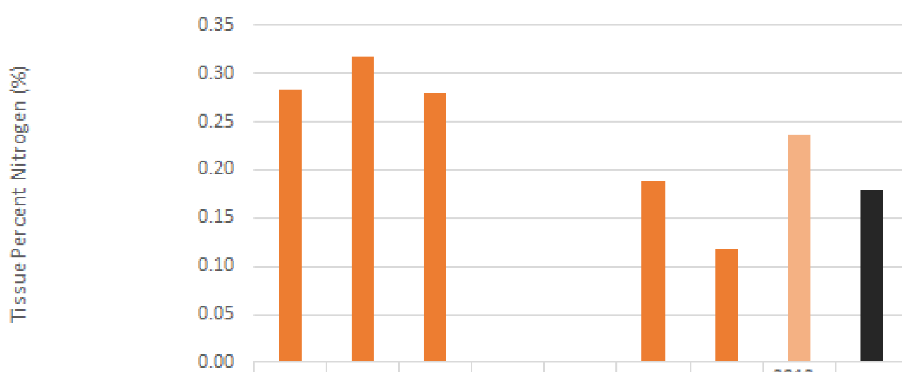


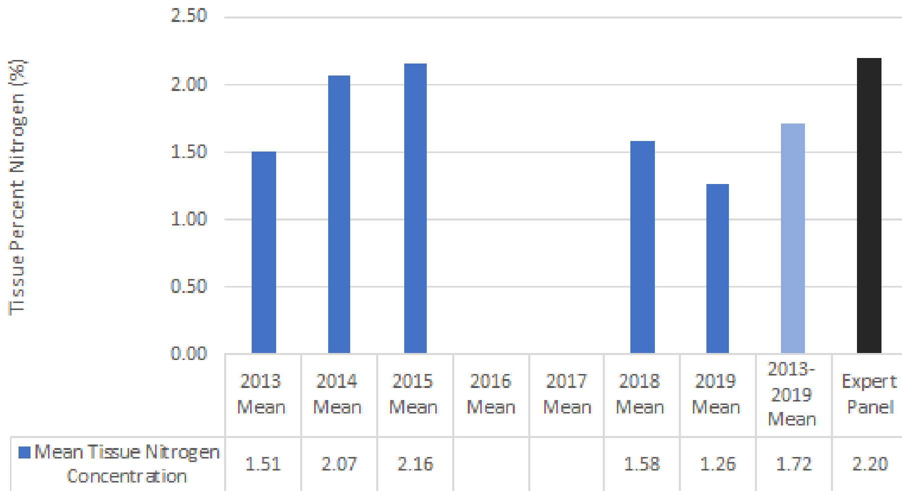
Figure E-20
Mean Tissue Total Phosphorus Concentration



	2013 Mean	2014 Mean	2015 Mean	2016 Mean	2017 Mean	2018 Mean	2019 Mean	2013-2019 Mean	Expert Panel
Mean Tissue Phosphorus Concentration	0.28	0.32	0.28			0.19	0.117	0.24	0.18

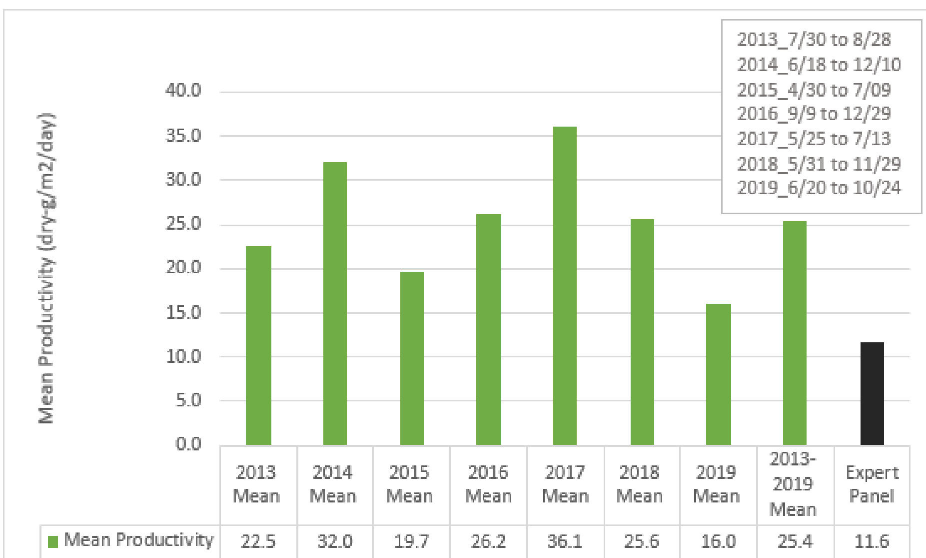
Note:
The Expert Panel value is from Bott et al. 2015.

Figure E-21
Mean Tissue Nitrogen Concentration



Note:
The Expert Panel value is from Bott et al. 2015.

Figure E-22
Mean Algal Productivity During DMT Flow-Way Operation



Notes:
The Expert Panel value is from Bott et. al 2015.

References

BWB (Blue Water Baltimore), 2020. “Baltimore Water Watch.” Accessed February 18, 2020. Available at: https://baltimorewaterwatch.org/.

Bott et al., 2015. *Nutrient and Sediment Reductions from Algal Flow-way Technologies: Recommendations to the Chesapeake Bay Program's Water Quality Goal Implementation Team from the Algal Flow-way Technologies BMP Expert Panel*. October 21, 2015.

MDNR, 2020. “Water Quality.” Accessed February 15, 2020. Available at: http://data.chesapeakebay.net/WaterQuality/.