

# MONITORING ALGAL BIOFILM GROWTH

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BIOLOGICAL  
ENGINEERING

BENG 3000 – Final Project

Utah State University

April 26, 2018

**SWBEC**

Raspberry Pi	Campbell CR1000
What is it?	What is it?
<ul style="list-style-type: none"> <li>④ Developed at University of Cambridge to help kids learn programming</li> <li>④ Runs Python language</li> <li>④ Popular for hobbyists and experimentation</li> </ul>	<ul style="list-style-type: none"> <li>④ Industry standard in datalogging and remote monitoring</li> <li>④ Most widely used datalogger in the world</li> <li>④ Many sensors and systems are available to use with it</li> </ul>
<b>Pros</b>	<b>Pros</b>
<ul style="list-style-type: none"> <li>④ Low cost is ideal for prototypes and experiments (\$36)</li> <li>④ Made for cloud and web integration</li> <li>④ Adaptable to many uses including environmental monitoring</li> </ul>	<ul style="list-style-type: none"> <li>④ Made for extreme conditions and remote environments</li> <li>④ Extremely easy to setup and operate</li> <li>④ Precise measurements trusted by worldwide experts</li> </ul>
<b>Cons</b>	<b>Cons</b>
<ul style="list-style-type: none"> <li>④ Slow processing and more likely to malfunction</li> <li>④ Is not ready out of the box and can take time to configure</li> <li>④ Not compatible with other operating systems</li> </ul>	<ul style="list-style-type: none"> <li>④ Expensive to purchase datalogger and all sensors to operate</li> <li>④ More difficult and costly to monitor wirelessly</li> <li>④ Limited to use with compatible devices</li> </ul>

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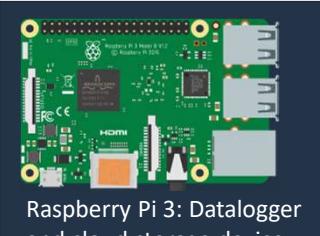
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## Raspberry Pi System 1



Raspberry Pi 3: Datalogger and cloud storage device



BME280: Atmospheric Temperature, Humidity, and Pressure Monitoring



DS3231 Real Time Clock: Keep accurate time and date



DS18B20: Air Temperature Monitoring



Raspberry Pi Camera Module V2: Visually monitor growth



Weatherproof Box: Mount and protect Pi while deployed

## Raspberry Pi System 2



Raspberry Pi 3: Datalogger and cloud storage device



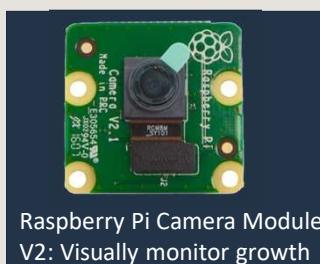
Atlas Scientific pH probe: monitor water quality



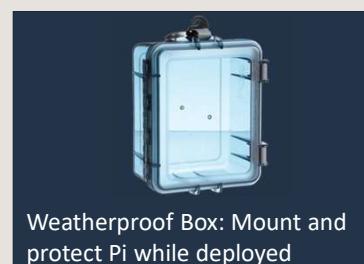
DS3231 Real Time Clock: Keep accurate time and date



DS18B20: Air and Water Temperature Monitoring



Raspberry Pi Camera Module V2: Visually monitor growth



Weatherproof Box: Mount and protect Pi while deployed

## Campbell CR1000



Campbell CR1000:  
Datalogger and sensor hub



CS511-L: Dissolved  
Oxygen Sensor



109SS-L Temperature Probe:  
Water Temperature



108 Temperature Probe:  
Air Temperature



CSIM11-L pH Probe:  
Monitor Water Quality



Battery Backup: 12 V Power  
Supply and Rechargeable Battery

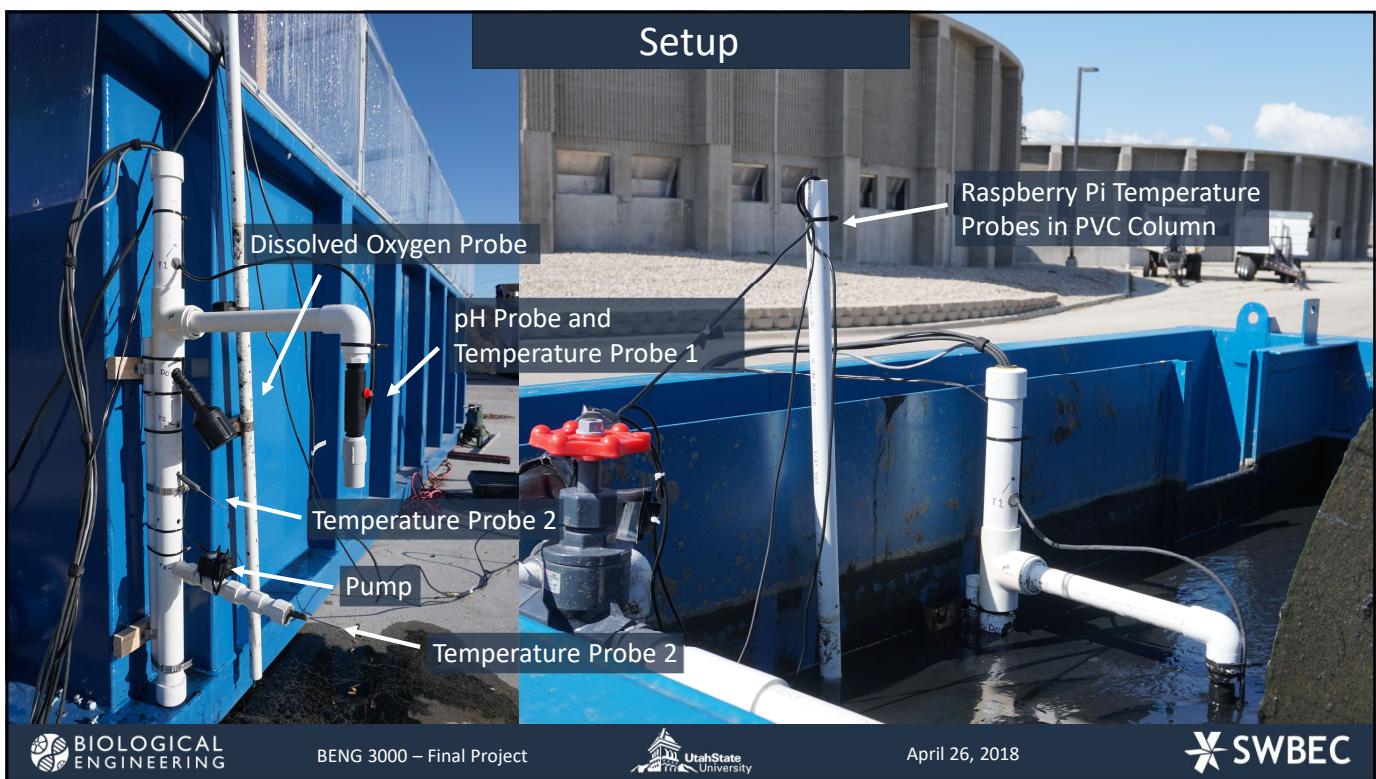
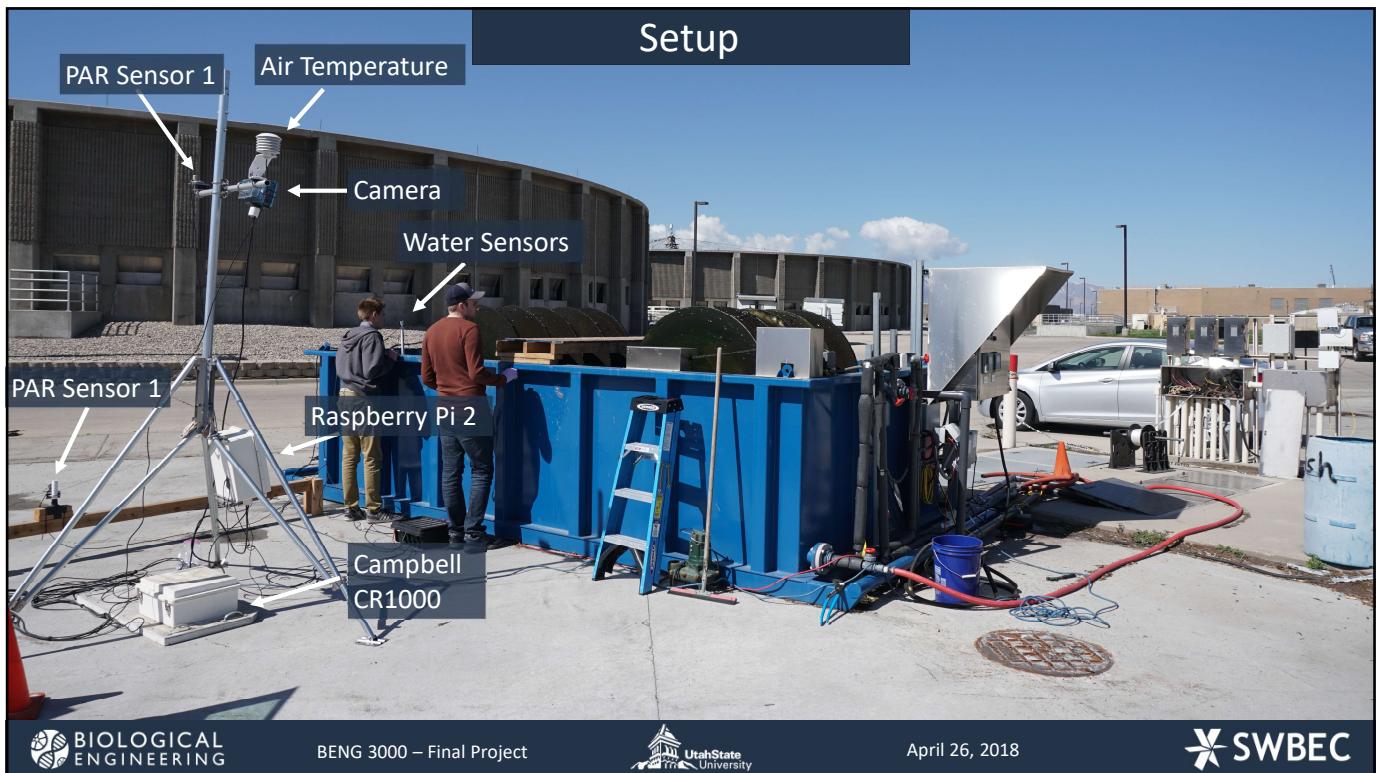
## Other Systems

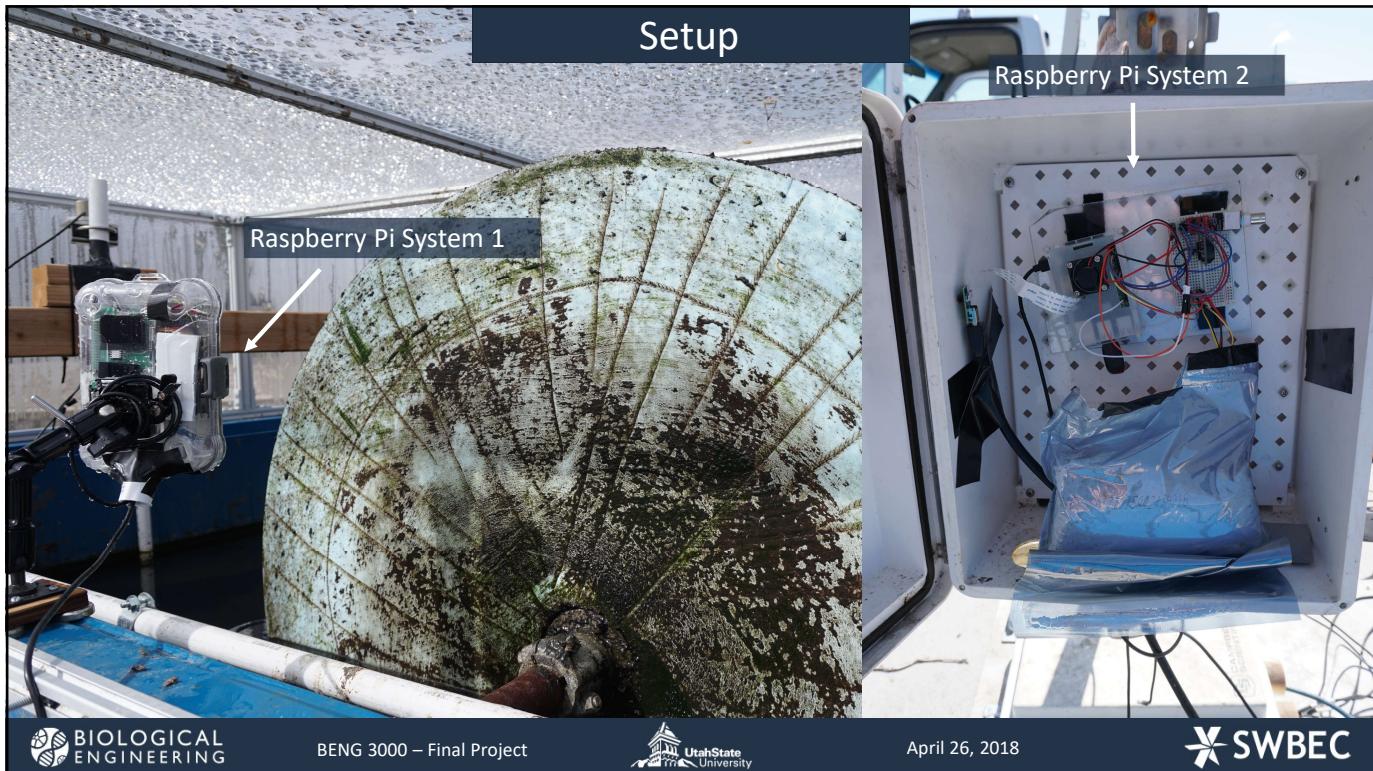


Apogee Scientific SQ-520: Full-Spectrum Smart  
Quantum Sensor for photosynthetically active  
radiation (400-700 nm)



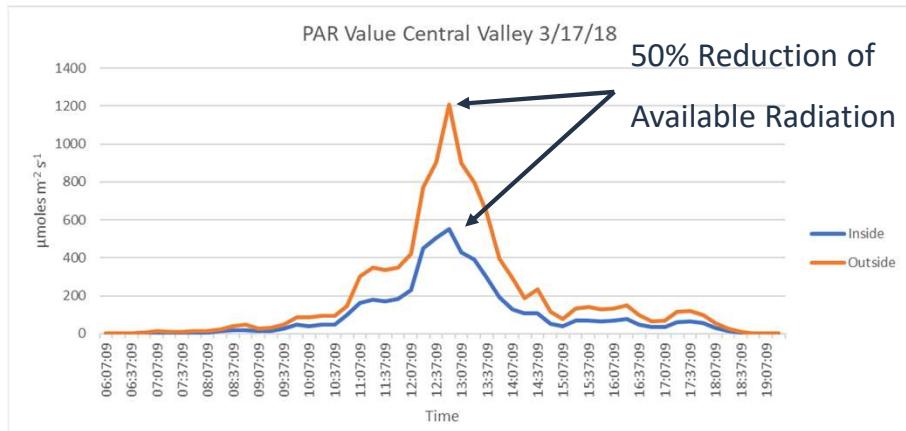
ProODO Optical Dissolved Oxygen Instrument:  
Water Dissolved Oxygen, Temperature, and  
Barometric Pressure





## Results – PAR Data

- Major factor in algal growth
- Helped to quantify problems with reactor cover
- Will help to see if light is causing photooxidation in microalgae during summer



## Results – Raspberry Pi

- Helped to identify when pump went out by looking temperature drops
- Allows for basic analysis from Utah State without traveling
- Can remotely see if some algal growth is occurring

	T1 (°C)	T1 (°C)	T1 (°C)	pH	T4 (°C)	
1/27/18 12:10 PM	5.062	6.062	6.812	5.96	6.625	Low Temperature Noticed
1/27/18 1:10 PM	5.75	7.062	7.687	6.128	8.25	
1/27/18 2:10 PM	7.187	10.187	10.75	5.892	9.125	
1/27/18 3:10 PM	9	12.562	13.062	5.901	7.687	
1/27/18 4:10 PM	10.562	14.312	14.75	5.863	6.687	
1/27/18 5:10 PM	11.812	15.437	15.75	5.537	5.875	
1/27/18 6:10 PM	12.687	16	16.25	5.527	4.25	
1/27/18 7:10 PM	13.375	16.437	16.687	5.668	4.125	
1/27/18 8:10 PM	13.875	16.75	17	5.625	3.625	
1/27/18 9:10 PM	14.25	17	17.25	5.702	3.937	
1/27/18 10:10 PM	14.562	17.25	17.5	5.718	3.5	
1/27/18 11:10 PM	14.875	17.437	17.687	5.446	3.375	
1/28/18 12:10 AM	15.062	17.5	17.75	5.637	3.625	

## Results – DO Probe

- Major factor in algal growth
- Helped to quantify problems with reactor cover
- Will help to see if light is causing photooxidation in microalgae during summer

YSI ProODO Optical Dissolved Oxygen	
Temperature (°C)	21.4
Pressure (kPa)	87.88
Dissolved Oxygen (%)	3.7
Dissolved Oxygen (mg/L)	0.32

## Problems Encountered

### Biofouling



Accumulation of microorganisms and sludge on electrode of pH probe caused readings to be inaccurate.

### Broken Sensors



The pH probe's main body broke and leaked the inner electrode solution and data was unusable.

### Initial Setup of Raspberry Pi



Initial setup of Raspberry Pi, connecting to internet, linking to Google Drive, and inputting programs took much longer than expected..

## Future Goals

### Water Level Sensing



Add a ultrasonic sensor (HC-SR04) to measure water level and send email alerts if it drops.

### Analyze Data



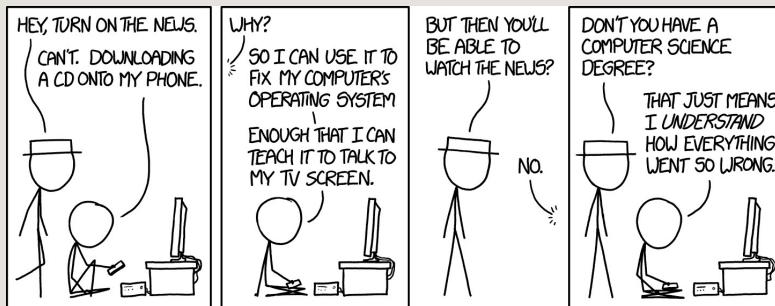
Analyze results of data logging information and algal biofilm measurements using JMP® Data analysis software for Windows

### Connect Campbell CR1000 to Internet



Use a NL240 is a wireless networking peripheral connected to the CR1000 to allow for internet access and remote monitoring functionality.

## Lessons Learned



- Working with dataloggers and sensors is often troubleshooting problems.
- Each sensor and device has many pros and cons that need to be looked at.
- There is equipment for every need, budget, and project if you're willing to be flexible.

## Questions

