Lafayette College Technology Clinic 2023
Green-Walk Trout Hatchery in Bangor, PA

Midterm Report - May, 2023

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Executive Summary

Green-Walk Trout Hatchery has been serving Pennsylvania and surrounding areas since 1950, providing live trout for stocking and sport as well as cleaned trout for restaurants throughout the Northeast. The 2023 Technology Clinic team has been asked to consider how Green-Walk can become an energy sustainable operation, as well as a destination for visits to observe how they are using sustainable practices to minimize their environmental impact.

The Tech Clinic team has generated several proposals for advancing the farm's sustainability:

- Harnessing the farm's constant flow of water to generate hydroelectric power, using a water wheel in order to capture the most kinetic energy and help oxygenate the water. A prototype of a suitable water wheel was built by the team.
- Using solar panels to generate electricity from sunlight. Three buildings in the main hatchery area of Green-Walk have been identified as potential sites for the installation of rooftop solar panels. Floating panels, standing panels, and bridge panels are three additional options to harness solar energy from Green-Walk's pre existing landscape.

The opportunity of an alarm system in the case of pump failure was also discussed during the team's visits to Green-Walk. We provide options for different systems and installations.

To address Green-Walk's aim of becoming an educational organization, the team has researched similar farms and provides recommendations for online educational outreach opportunities.

What is Technology Clinic?

Technology Clinic is a two-semester Lafayette College program in which teams of students from each academic division work together to find imaginative solutions for clients' real-world problems. To encourage "out-of-the-box" thinking, there are no requirements for prior experience, thus reducing incoming "prejudices" and encouraging innovative solutions. The students are nominated by professors and former Tech Clinic students and mentored by two faculty facilitators. Project teams are purposely multidisciplinary and include students and faculty mentors from the Humanities, Social Sciences, Sciences and Engineering departments. Their varieties of talent gives them the ability to assess any challenge or project from different perspectives to achieve effective results.

Meet the Tech Clinic Team

Angela Busheska '25

Angela is a sophomore pursuing a double degree in Electrical Engineering and Computer Science. Inspired by the climate situation in her home country North Macedonia, she spent the last three years working on climate-tech activism. On campus, she is performing research on brain-computer interface and is involved with the Dyer Center.

Rylee Bordwick '25

Rylee is a sophomore double majoring in Environmental Studies and Anthropology & Sociology with a minor in geology. She is involved in the Track and Field team and is a javelin thrower. On campus she works with the Nurture Nature Center as a Proctor Fellow and is the secretary of Athlete Ally. Rylee is from Lambertville, NJ.

Sean Walshe '25

Sean is a civil engineering major from Hellertown, PA. He is conducting research on concrete properties in the Lafayette College Concrete Laboratory. He has also done work with the College Writing Program as a Writing Associate. He has a passion for international arts.

Meet the Tech Clinic Team

Tara Amidon '25

Tara is a sophomore student double majoring in International Affairs and Government and Law with a minor in Spanish. She is originally from Boulder, Colorado. On campus, she is very involved in the Landis Center for Community Engagement and is a social justice peer educator with Kaleidoscope.

Wanos Bahiru '25

Wanos is a sophomore Mathematics-Economics major, born and raised in Addis Ababa, Ethiopia. She is a Resident Advisor and involved with International Student Association. She is passionate about finding creative solutions to real world problems.

Meet the Tech Clinic Team

Professor Dan Bauer

Dan is a founding member and longtime participant in the Lafayette Technology Clinic Program. His educational background is in Engineering, Journalism (BA San Jose State University), and Social Anthropology (PhD University of Rochester). He served in community development in the Peace Corps in Peru. He has conducted long-term anthropological research on community level economics and politics in Ethiopia and rural Mexico. He is a photographer and has a passionate curiosity for problem solving.

Professor Christopher Ruebeck

Chris is a member of the Department of Economics, teaching classes in game theory, firms' decision making about marketing and strategy, and the simulation of markets and behavior. He has employed community-based learning in his Marketing Research class and with student collaborators doing honors theses, EXCEL research, and independent study projects. His research is in related areas with applications to technological innovation and environmental policy.

Project Significance

Green-Walk Trout Hatchery in Bangor, PA is a successful farm that provides live trout as well as cleaned trout to restaurants throughout the Northeast. Currently, their operations require a great deal of electricity, primarily for pumping water to maintain flow rates and oxygen levels. Through partnering with the Technology Clinic team, Green-Walk hopes to make progress toward becoming an energy neutral consumer and a site that groups can visit to observe how they are using sustainable practices to minimize their environmental impact.

The solutions detailed in this report should help aid Green-Walk to reduce their environmental impact and become a model for other similar businesses, while maintaining their stream to table model and enhancing relationships with buyers.

Introduction to Green-Walk's Goals

Green-Walk is most concerned with becoming an energy neutral consumer and an organization that groups can visit to observe how they are using sustainable practices to minimize their environmental impact.

Additionally, Green-Walk wants to maintain their stream-to-table model. Longer-term goals include producing food on the farm, generating energy to charge electric vehicles to transport products from the farm to New York and other nearby buyers, building and powering a kitchen using electricity generated from hydroelectric and solar power, and finally, installing a more integrated and efficient security system to ensure minimal harm in the case of pump failures

Past Approaches

To advance Green-Walk's aim of becoming an energy neutral consumer, the organization has taken a number of steps, including only delivering their products to businesses and restaurants within driving distance, working to reduce carbon emissions overall, and attempting to generate electricity using a water wheel. The purpose of this water wheel was to churn water and introduce oxygen into the environment; however, the wheel broke down because it could not sustain the flow of water and the bearing ultimately wore out. We drew upon lessons learned from this model when designing our prototype.

Past water wheel, after bearing wore out

Current Energy Usage

Green-walk currently uses an average of 21,418 KWH per month. The electricity rate from Met-Ed is 12.57 cents per KWH. The electricity bill per month is around $3,000.

The two pumps are the main areas of electricity usage in the farm. One pump is 5 horsepower and the other is 10 horsepower.

Additionally, Green-walk has other facilities that use electricity such as the administrative building and related operations, lithium powered tools, and more.

Another major facility on the farm is the water tower for bottled water. The tower stores water to be piped out to a location where trucks pick up the storage weekly.

Hydroelectric Power

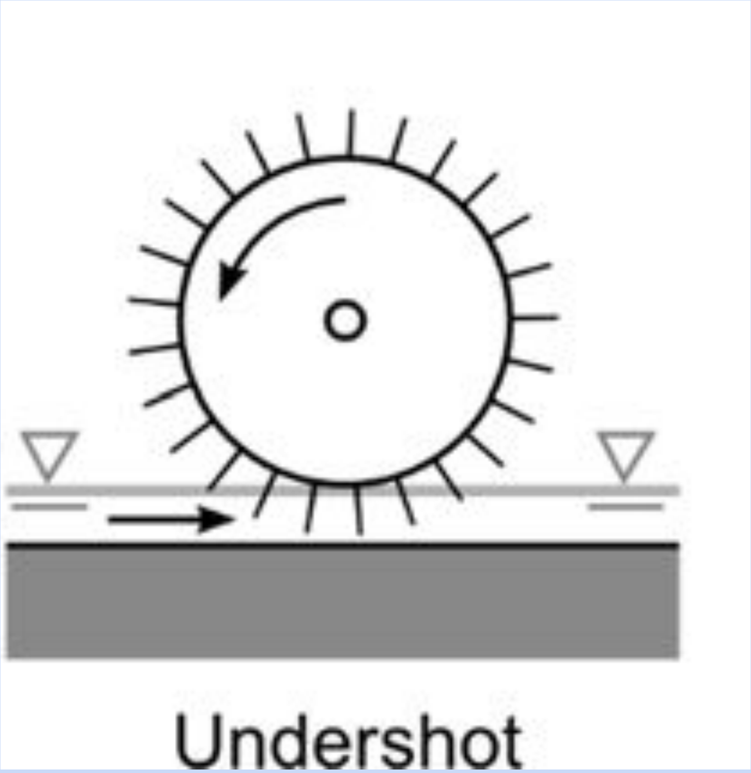
Hydropower

Energy is constantly flowing through the farm in the form of water. Though flow rates vary month-to-month, water could be a reliable source of energy, constantly supplying to the power grid of the farm. However, the flow rates do vary throughout the year. We designed a waterwheel in order to obtain the kinetic energy from the water to deliver to a generator for electricity. Additionally, water wheels also help oxygenate the due to the additional movement of water caused by its rotation.

One potential site for the installation of a water wheel

Water Wheel Type

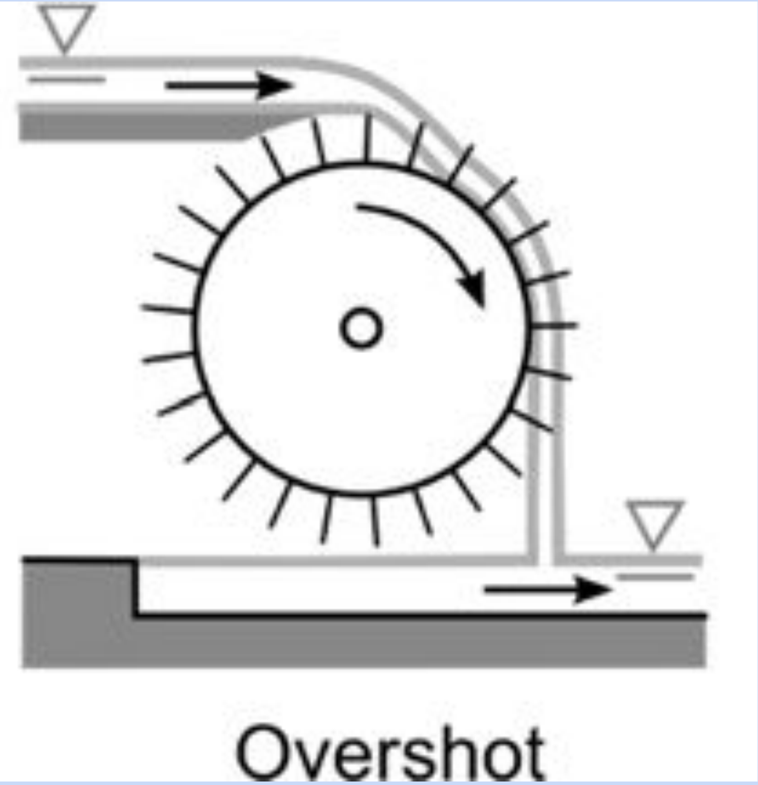
The first of three water wheel types, the undershot relies entirely on the ground flow of the stream. These can be placed anywhere along the stream. We opted to avoid using exclusively undershot wheels due to the slower flow of the stream compared to each head.



Source: Abubakar

Water Wheel Type

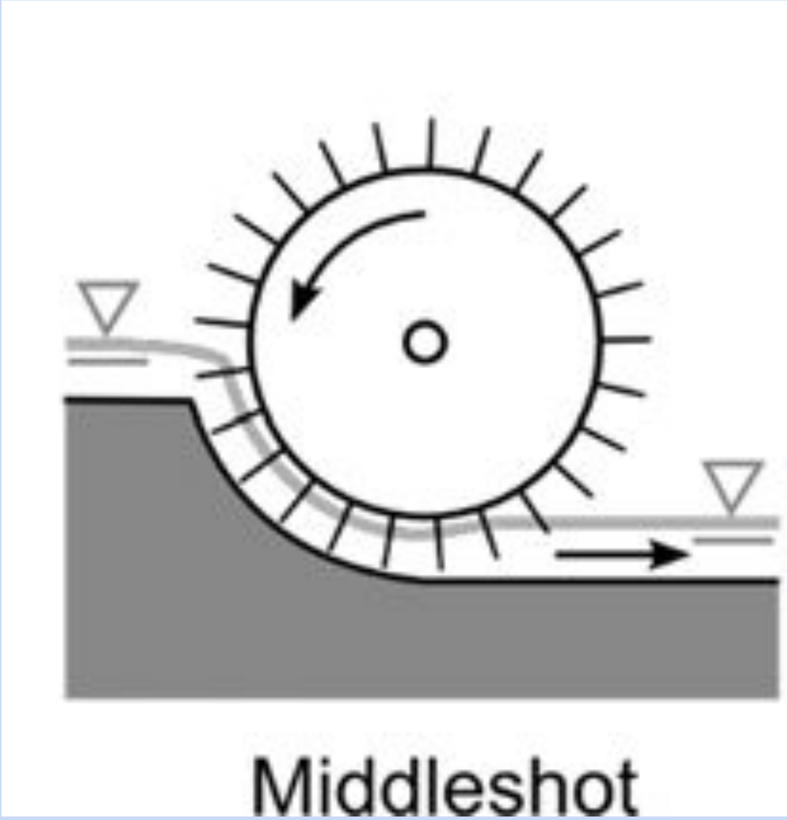
The overshot uses the weight of water from the top to the bottom of the water wheel. Due to the fixed nature of the waterfall's height, the diameter of the water wheel would need to decrease to allow the water wheel to take the weight of the water from the top, which will decrease the torque of each unit. The dimensions of the device could be modified to utilize the flow from the stream on the underside of the wheel to increase the RPM of the wheel.



Source: Abubakar

Water Wheel Type

The middleshot (or breastshot) involves utilizing the energy of the stream's flow at the side and bottom of the water wheel. In the stream, this would likely incorporate both the head from the waterfall and the general ground flow of the stream, which will increase the total energy harvested from the stream. While the overshot might carry the weight of the water for a longer duration, the middleshot allows us to create a bigger water wheel at each drop, which will improve the torque of each unit. We decided to base our design around the middleshot model.



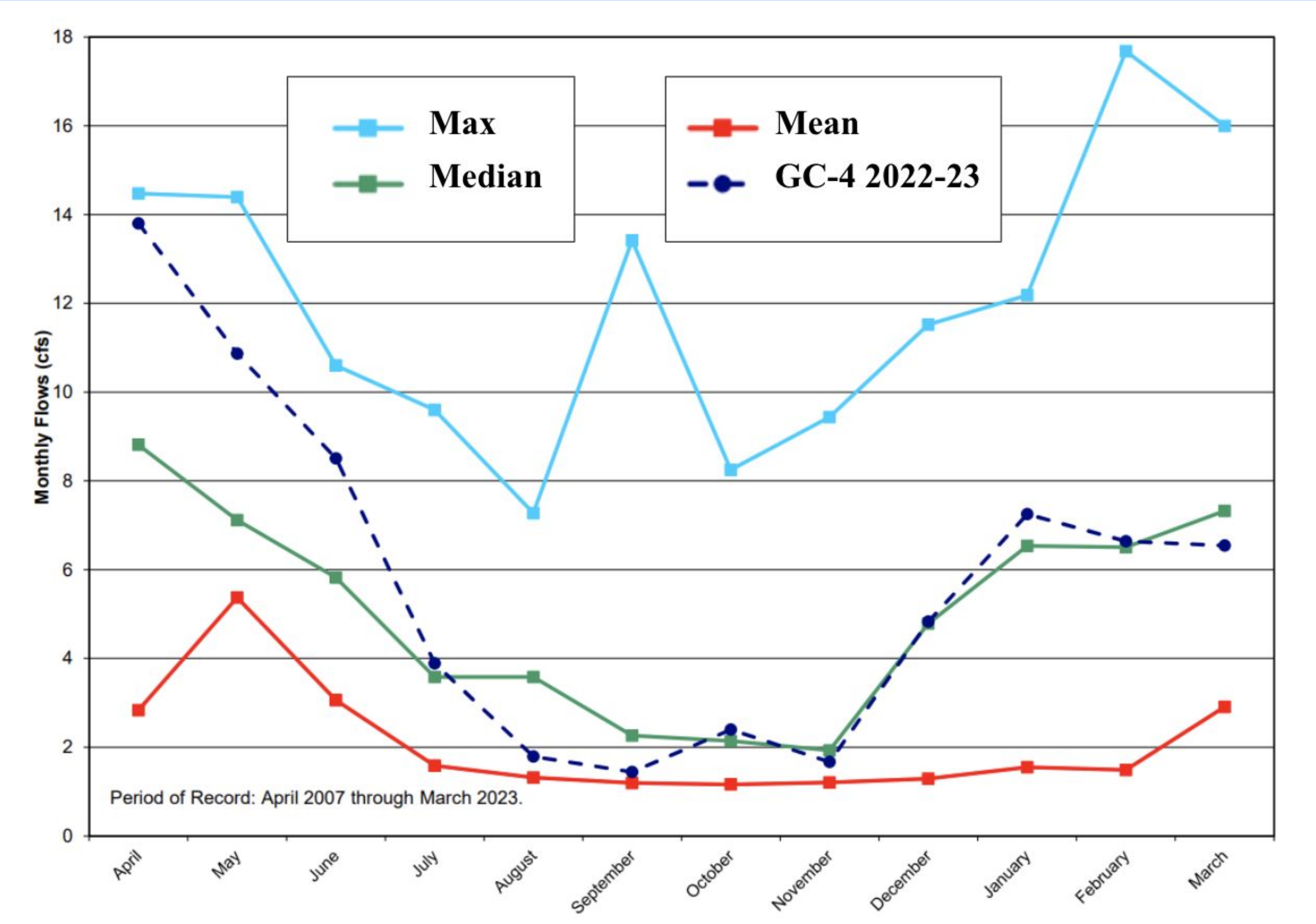
Source: Abubakar

Measuring the Stream's Flow

During a visit to the farm, the team calculated a rough estimate of the velocity of the stream by the waterfall as around 41 in/s. We calculated this by timing the distance traveled by a ping-pong ball when released into the water. We also received flow rates throughout the year measured by professional hydrologists. We will use this data to estimate the energy output of the water wheel(s).

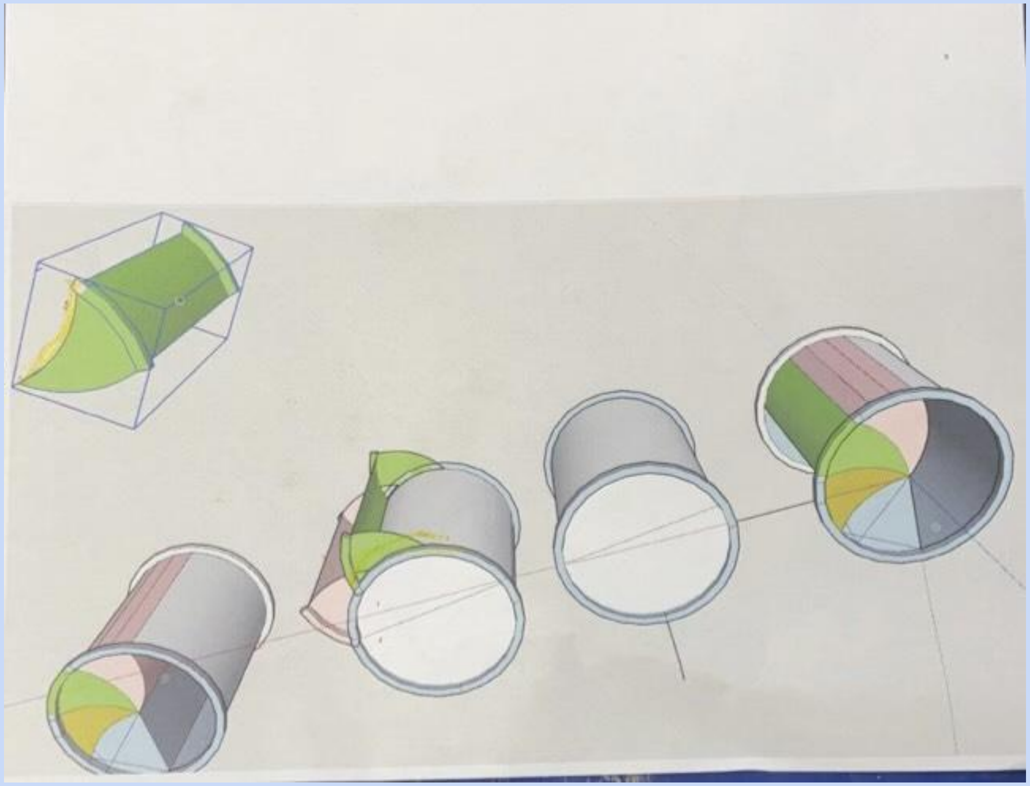
On the next page, we show the measured flow throughout the year. The maximum median flow is around 9 cfs during April, and the minimum median flow is around 2 cfs during September, October, and November. This means that there is quadruple the amount of water flowing through the farm during the best month compared to the worst month. Additionally, we can expect the flow to fluctuate around double and half the median flow throughout the farm.

Monthly Flows of Green-Walk Trout Hatchery



Waterwheel Designs

We designed a water wheel model to be used in the stream for electricity generation. The water wheel will be attached to a generator, contributing electricity to the farm's grid. The wheel would fit into a 2.5 foot drop with a width of 4 feet. We modeled the dimensions of the wheel based on the parameters of the drop along with the constraints of a 55 gallon steel drum. We also considered adding a 1 inch diameter hole on the bottom of each bucket to prevent slowing down from trapped air.



SketchUp Prototype Design

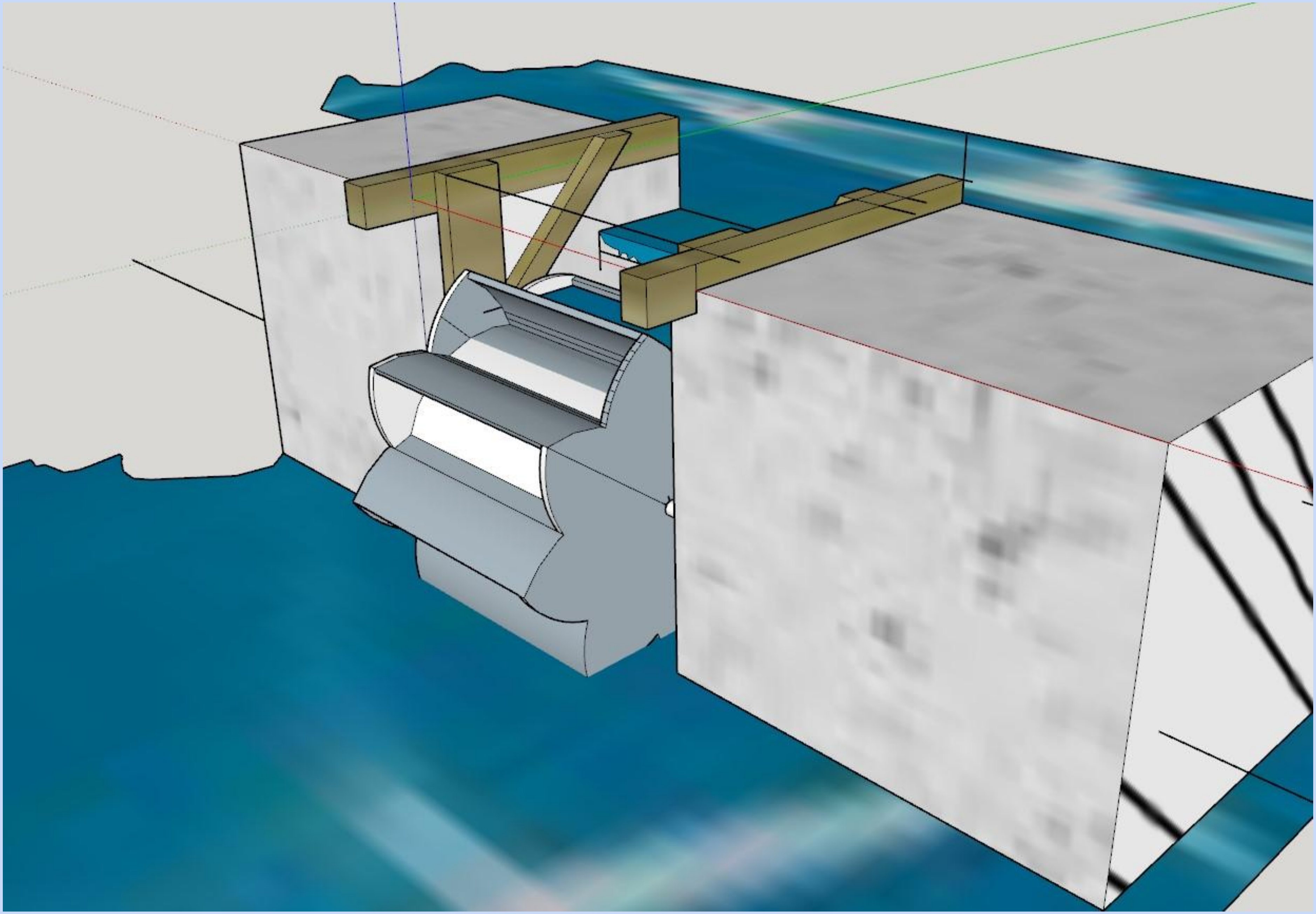
Waterwheel Location and Operation

We designed the waterwheel to fit in each drop on the main farm. Most of the dams have a head of around 2.5 feet and a width around 4 feet. The wheel will be attached to a frame that would fit on top of the concrete wall around the dam and go down. A brace would be attached to the wheel for stability. The wheel would generate power from the water through both the force of the falling water and the movement of the stream. The axle of the wheel will not move. The wheel will have a pulley system bolted to the tank of the wheel. The pulley system will rotate a belt that will rotate a smaller wheel. The wheel itself will likely have 1RPM. A smaller wheel will be attached to the belt in order to maintain a minimum of 500 RPM.

Waterwheel Location and Operation

We particularly considered installing the prototype of the water wheel at the waterfall by the main road of the farm.

A view of the considered location for installation in Google Earth Pro



SketchUp Prototype Design

Prototype

We designed and manufactured a proof-of-concept water wheel product. Dan Bauer obtained two 55 gallon steel drums that were headed for disposal. The team used power and welding tools to create a prototype of the design. One drum was cut into 8 buckets that were attached to the other untouched drum. A new stainless steel drum would require less upkeep and cost around $200

Sean and Tara measuring the buckets before cutting

Estimated Power Generation for Water Wheel

To estimate the power generation of a single water wheel unit in kilowatt hours, we used the average flow of the stream and the head of the waterfall. According to a guide for water wheel calculations by Rudy Behrens, the vertical velocity of the water at the bottom of the waterfall can be calculated by the square root of the head distance multiplied by the acceleration due to gravity. We supported this using the kinematic equations of mechanics. We also estimated the horizontal velocity of the water at the top of the stream by dividing the flow of the stream by the cross sectional area of the stream. We found that the velocity of the stream was far greater due to the falling water rather than the horizontal flow of the stream, which supported our conclusion that a water wheel using the head of the stream was the best option.

Estimated Power Generation for Water Wheel

According to Rudy Behren's guide, the estimated power that could be generated from a water wheel can be calculated by multiplying the flow (cfs) by the head (ft) divided by 11.8. By using the average flow per month and assuming that the water wheel runs constantly, we can calculate the estimated power generation in kWh for each month. The average of these values is 360 kWh/month. We also factored a 75% rate of uncertainty in our calculations, resulting in an average power generation of 270 kWh/month.

Month	Mean Flow (cfs)	Power (kW)	Power (kWh/month)
April	3	0.64	458
May	5.5	1.17	839
June	3	0.64	458
July	1.7	0.36	259
August	1.7	0.36	259
September	1.7	0.36	259
October	1.7	0.36	259
November	1.7	0.36	259
December	1.7	0.36	259
January	1.8	0.38	275
February	1.8	0.38	275
March	3	0.64	458
Average	2.4	0.5	360

Solar Power

Solar Power

Introduction:

Solar energy is the practice of converting energy from sunlight into electricity. Photovoltaic cells in solar panels are used to generate this energy. Solar energy is not only less expensive than fossil fuels, but it avoids a large portion of the externalities associated with environmental degradation as well. Solar power can save money, improve sustainability, and improve the self-sufficiency of those who choose to utilize this resource.

We have identified three buildings in the Main Hatchery area of the Green-Walk Trout Farm that would be suitable for the installation of rooftop solar panels. Rooftop solar panels are a reliable and safe way to generate energy. In the northern hemisphere solar panels should ideally face the south to be most efficient. Panels will receive the most direct light throughout the day with a southern placement, but other orientations generate a fair amount of energy as well.

Some of the ponds at Green-Walk Trout Farm are in clearings and receive relatively large amounts of sunlight daily. The fact that these areas have already been cleared of trees presents an opportunity for solar installation on top of or above the ponds. We have created three potential designs for solar panel installations that would fit with the landscape that is created by these ponds and generate energy for the hatchery in a location that is currently not producing any. This kinds of instillation has multiple uses for it would generate energy to offset the costs it takes to run the hatchery and would provide shade for the trout who prefer colder temperatures over warm ones.

Solar Power

Our Process:

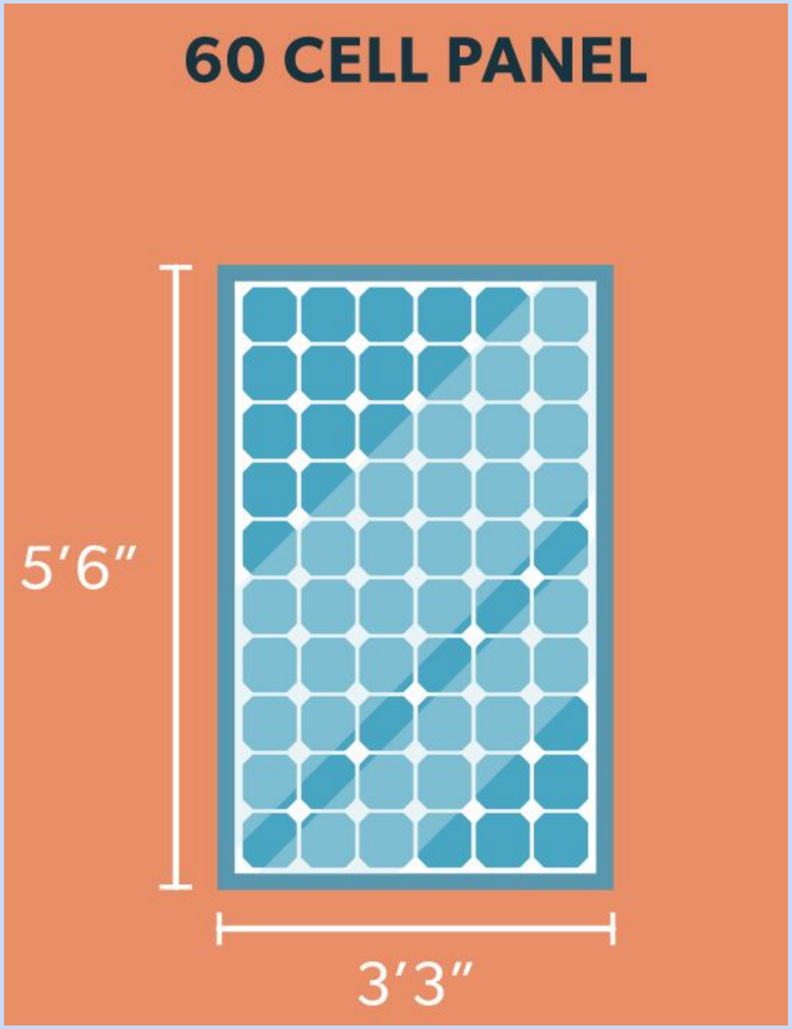
Using Google Earth and Google Earth Pro we were able to identify the buildings and ponds that would support solar installations. We were able to change the seasons on Google Earth Pro to evaluate whether the identified locations received sunlight throughout the year or if they were too shady for some parts of the year. We also considered the orientation and surface areas of the buildings roofs to help calculate their potential solar panel energy production.

Source: Google Earth Logo

Costs and Measurements

On average, solar panel installation and the system can cost from $15,000 to $25,000.

The pond-based solar installation designs were created with an average 60-cell panel that produces about 300 watts. A 300 watt panel receiving 8 hours of sunlight per day will produce almost 2.5 kilowatt-hours per day. We used an average price of $300 per panel. The prices can vary between $200 and $465. On average each panel is 5.6x3.3 ft^2 with a surface area of about 18.48 ft^2.



Source: Unbound Solar

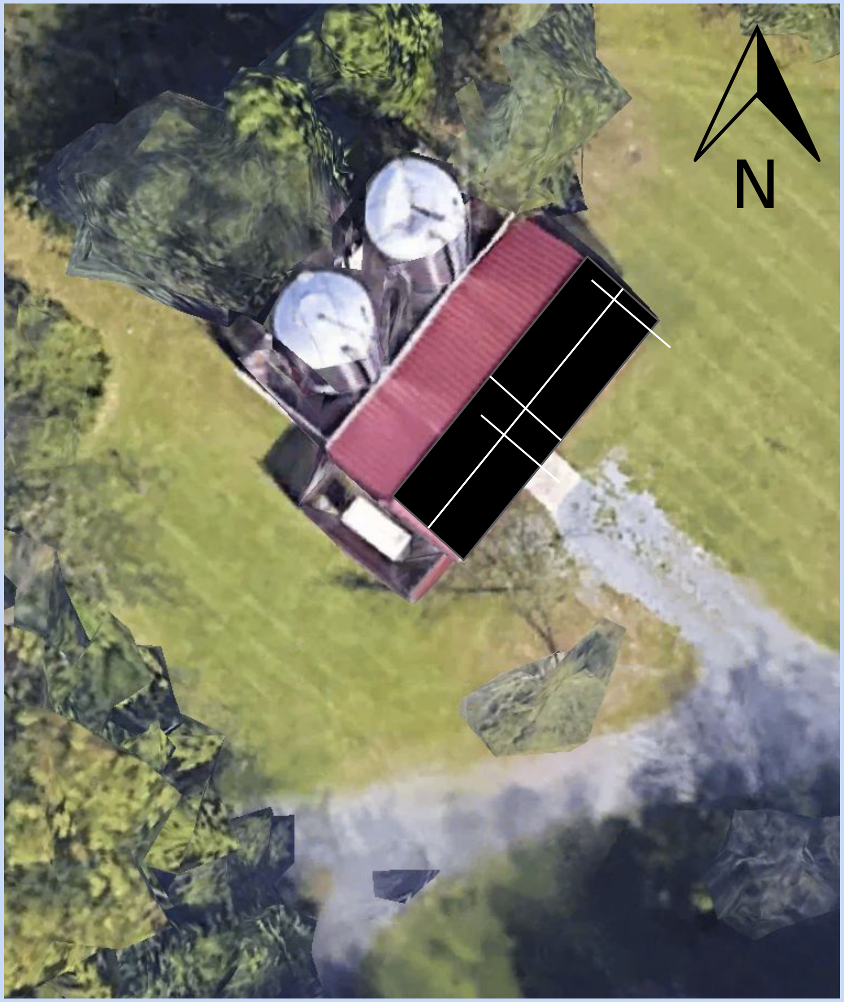
Rooftop Locations for Solar Placement

Source: Google Earth

Roof Panels: Locations 1

This location faces towards the south which makes it an ideal candidate for solar installation. This building also has a metal roof which makes the installation process easier and calls for less potential roof repairs .

This location has the smallest surface area of all the three locations at about 500 ft^2 as estimated by Google Earth. This number only account for the side of the roof that will house the solar panels. Due to this low surface area the energy output for location 1 are estimated to be the lowest. This location is connected to Dasani's water bottling operation. Installing solar panels may require permission from the company before proceeding.



Source: Google Earth

Estimated Energy Output for Location 1

RESULTS

7,751 kWh/Year*

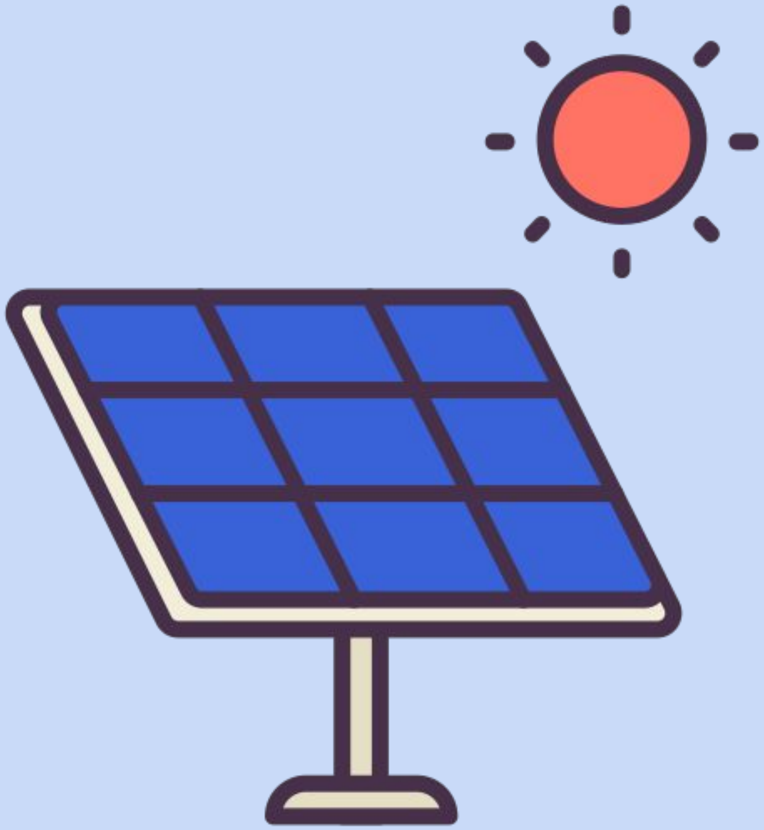
System output may range from 7,334 to 7,914 kWh per year near this location.

Month	Solar Radiation ($kWh / m^2 / day$)	AC Energy (kWh)
January	2.99	483
February	3.84	549
March	4.69	720
April	4.89	681
May	5.84	824
June	5.96	800
July	6.17	849
August	5.43	748
September	4.97	678
October	4.03	595
November	3.04	453
December	2.33	370
Annual	**4.52**	**7,750**

Source: PVWatts Calculator

Tech Clinic's Estimated Energy Output for Location 1

The latitude that Green-Walk Trout Hatchery is located on receives about 4 hours of sunlight a day that can be converted into energy from solar panels. The roof of Location 1 can hold about 20 300-watt solar panels. We calculate that this location could produce 25 kWh a day and 9,125 kWh a year.

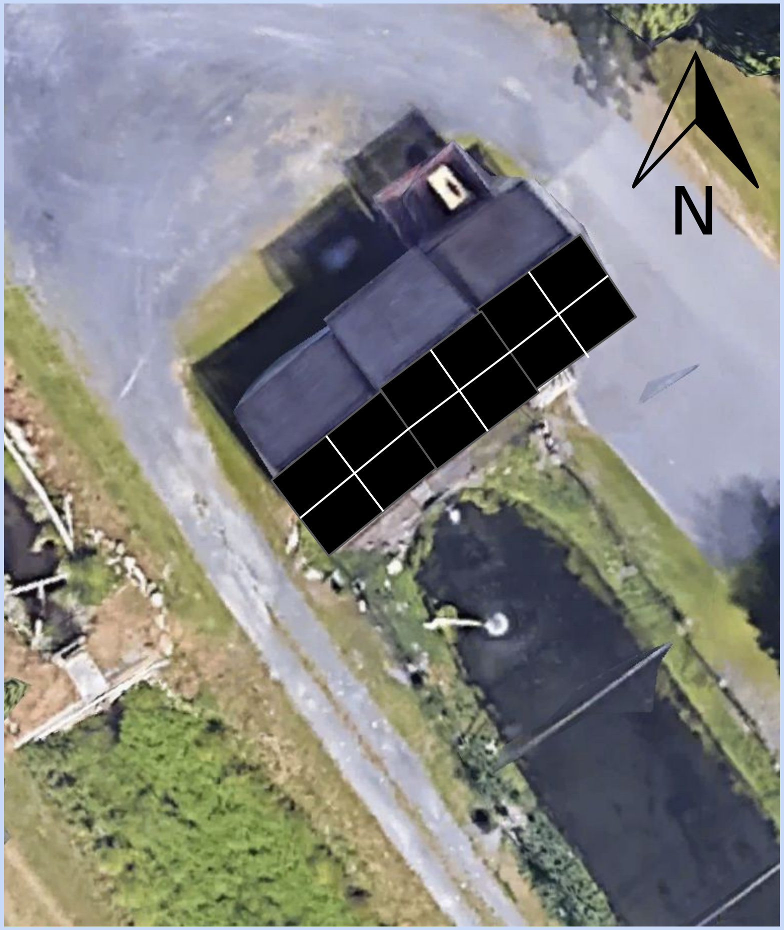


Picture Source: Flaticon

Roof Panels: Location 2

This is the best placement out of the three and faces directly south, which will allow for the best energy production. The roofs of this building are made of slate which may require current or future repairs depending on the quality of the slate. The surface area, as estimated from Google Earth, is about 670 ft^2. This number only accounts for the side of the roof that will house the solar panels.

This building also holds aesthetic and sentimental value as it gives character to the hatchery character. The aesthetic value of this location must be weighed against the energy production value before decisions are made to move forward with insulation plans.



Source: Google Earth

Estimated Energy Output for Location 2

RESULTS

10,626 kWh/Year*

System output may range from 10,055 to 10,850 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	2.99	662
February	3.84	752
March	4.69	987
April	4.89	934
May	5.84	1,129
June	5.96	1,097
July	6.17	1,164
August	5.43	1,026
September	4.97	930
October	4.03	816
November	3.04	621
December	2.33	507
Annual	4.52	10,625

Source: PVWatts Calculator

Tech Clinic's Estimated Energy Output for Location 2

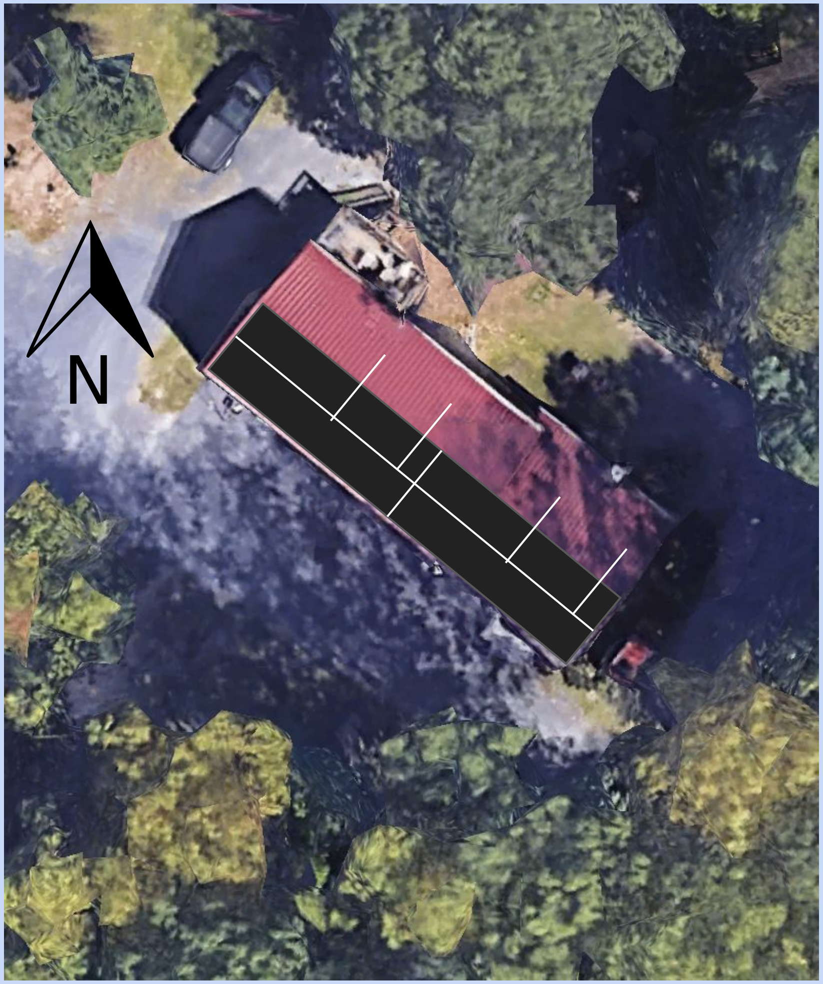
The roof of Location 2 can hold about 27 300-watt solar panels. We calculate that this location could produce about 34 kWh a day and 12,410 kWh a year.

Picture Source: EcoWatch

Roof Panels: Location 3

This location benefits from having a metal roof which will likely mean a smoother installation process. This building is not facing south but towards the east. Though this orientation is not ideal, it still receives plenty of sunlight throughout the day. The morning sun that rises in the east will be responsible for the majority of the energy production at this location.

This is also the largest surface area out of the three buildings and thus could house the most solar panels. The surface area is about 1,500 ft^2 ,as estimated by Google Earth. This number only account for the side of the roof that will house the solar panels.



Source: Google Earth

Estimated Energy Output for Location 3

RESULTS

22,245 kWh/Year*

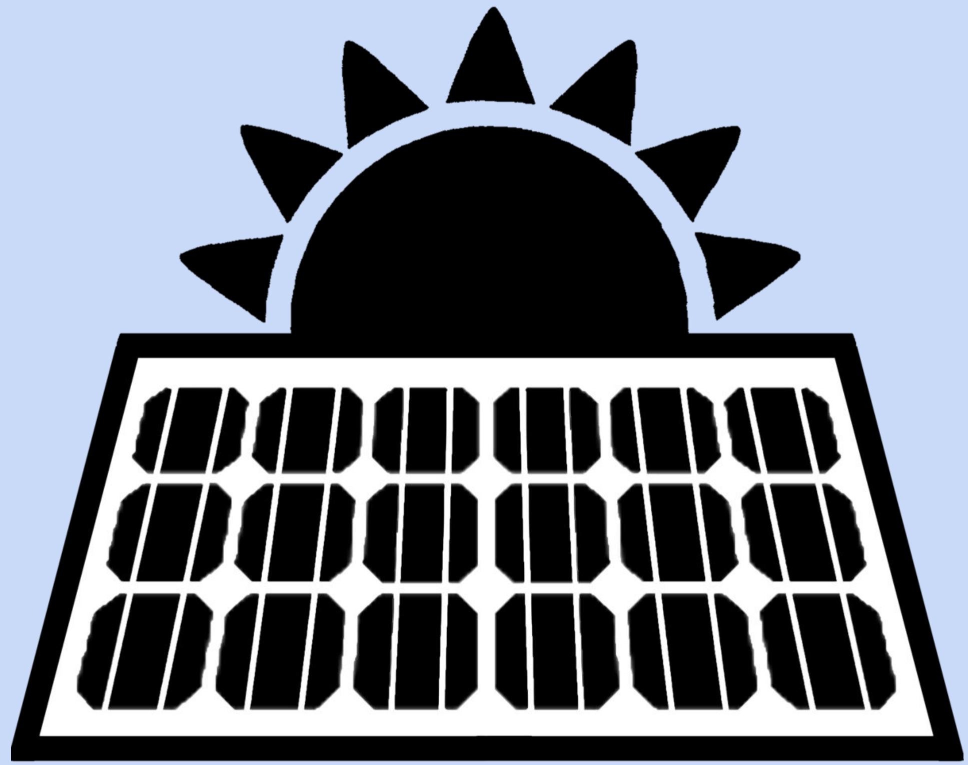
System output may range from 21,050 to 22,714 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	2.99	1,385
February	3.84	1,574
March	4.69	2,066
April	4.89	1,956
May	5.84	2,364
June	5.96	2,297
July	6.16	2,437
August	5.42	2,147
September	4.97	1,948
October	4.03	1,708
November	3.04	1,301
December	2.33	1,061
Annual	**4.51**	**22,244**

Source: PVWatts Calculator

Tech Clinic's Estimated Energy Output for Location 3

The roof of Location 3 can hold about 60 300-watt solar panels. We calculate that this location could produce about 62.5 kWh a day and 22,812 kWh a year.



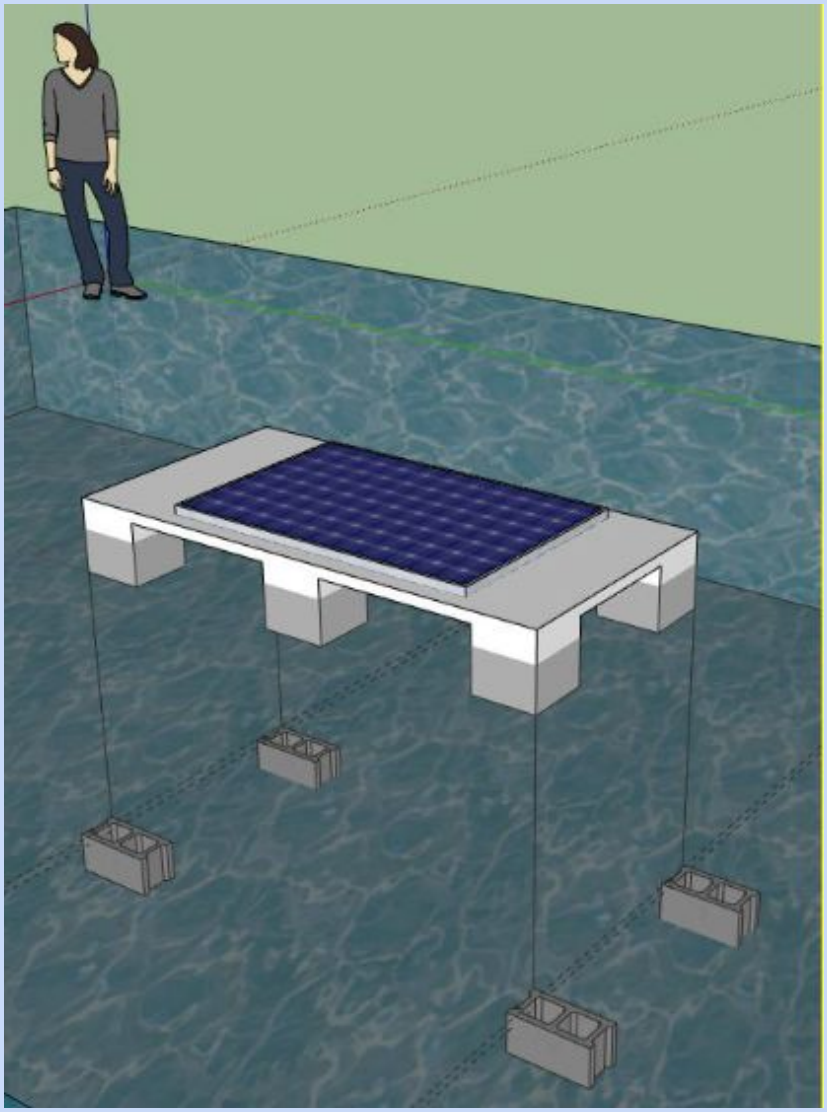
Picture Source: Wikimedia Commons

Pond Locations for Solar Panels

Source: Google Earth

Option 1: Floating Panels

Floating Solar Panels are designed to sit on top of the ponds casting shade underneath of them as oases from the sun for the trout. This design is minimally invasive and can be altered to hold one to three panels depending on the size. They would most likely need to be removed from the ponds during flooding events as a safety precaution. The surface area would vary from 18.48-55.44 ft^2 for this design.

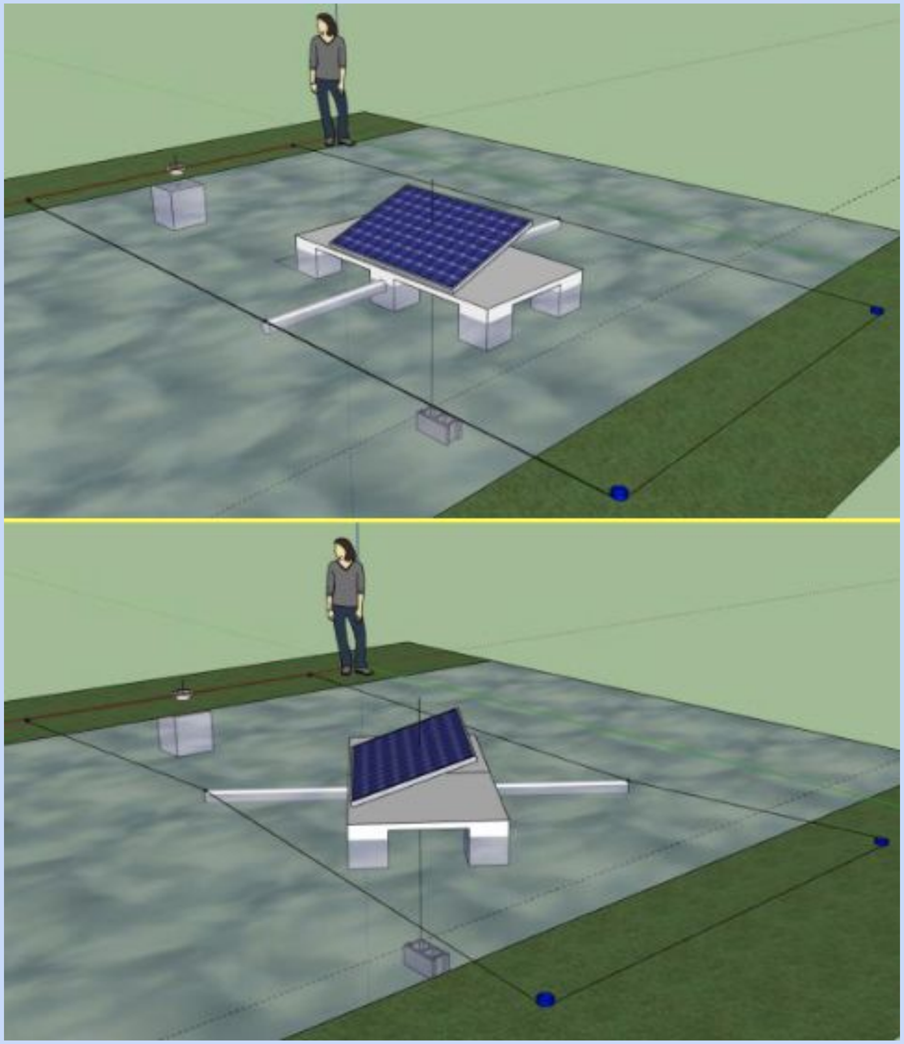


Source: Lafayette Tech Clinic 2012 Final Report

Option 1: Floating Panels

The estimated cost of the solar panels for one floating device would be between $300-$900 depending on the size. The cost of creating the frame will vary based on materials used and cost of labor. One device has the potential to generate around 300-900 watts an hour, also depending on amount of panels used. With 8 hours of sunlight they could produce 2.5-7.5 kWh a day and with 4 hours of sunlight they could produce 1.25-3.75 kWh a day.

A complication of this design is that David Due, from David and Rhonda Due's Country Springs, holds the patent for the design so he would need to be contacted.

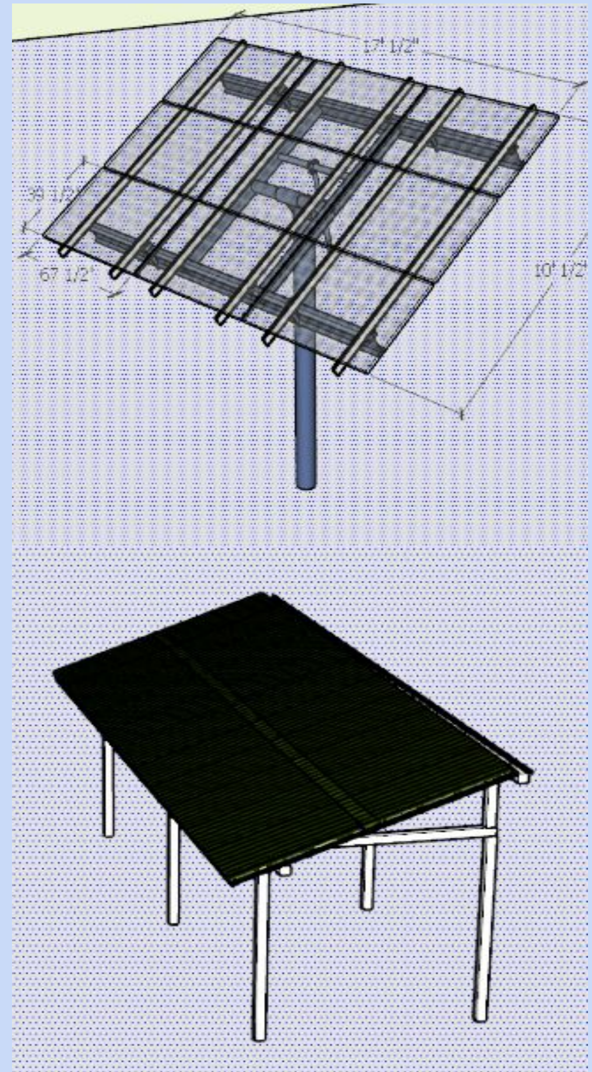


Source: Lafayette Tech Clinic 2012 Final Report

Option 2: Standing Panels

Standing Panels would be able to be positioned on the banks of the ponds so the structure casts shade onto the water. The frames could be positioned to face towards the south for optimal efficiency. Two or three panels could be placed on a structure such as this. Its surface area would be around 55.44 ft^2.

One of these stands could produce around 950 watts an hour. With 8 hours of sunlight it could produce 5-7.5 kWh a day. With 4 hours of sunlight it could produce 2.5-3.75 kWh a day.It would cost an estimated $900 for the solar panels and additional costs for the creation of the frame structure would need to be accounted for.

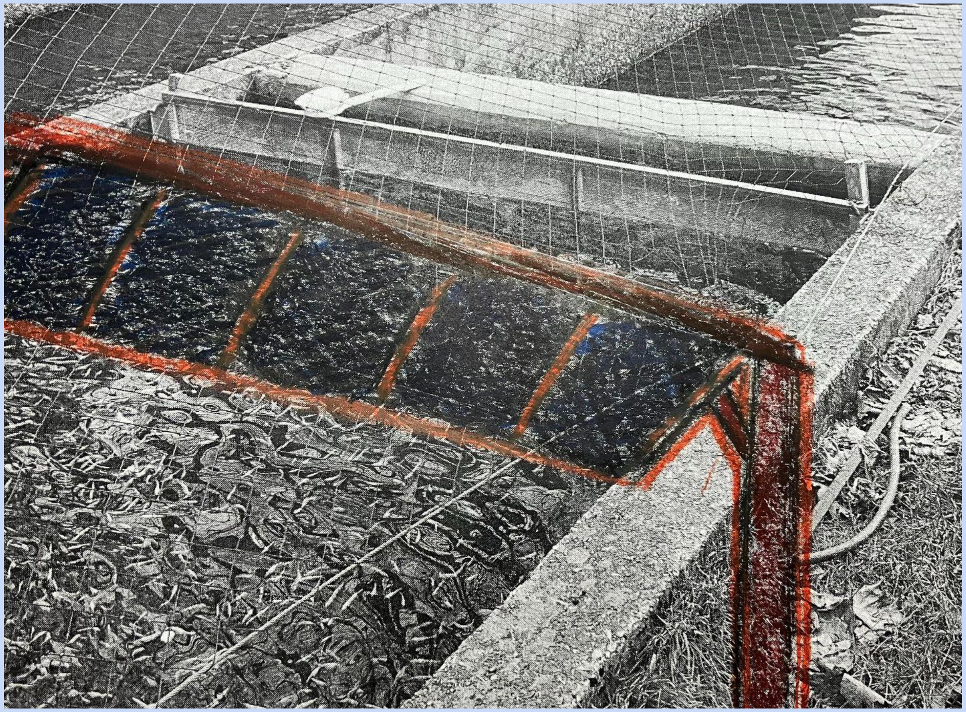


Source: SketchUp

Potential Layout of Standing Panels

Option 3: Bridge Panels

The existing concrete raceways would provide the needed support to install the Bridge Panel design without the need to build a frame. The earthen ponds have more space to place this kind of structure. The Bridge Panel design would be build to arch overtop of a pond, casting shadows below it. The solar panels could be angled to face towards the south in order to optimize energy production. The amount of panels one bridge could hold would vary based on the size of each pond.



Depending on the size of the pond 5-10 solar panels could fit on this frame. The cost would vary on the number of solar panels and cost to build the frame structure. The estimated cost would be$1,500-$3,000 for just the solar panels. The surface area is between 92.4 ft^2-184.88 ft^2. This setup could produce 1,500-2,000 watts and hour. With 8 hours of sunlight it could produce 12.5-25 kWh a day and with 4 hours of sunlight it could produce 6.25-12.5 kWh a day.

Costs and Benefits

On average, about 75% of a roof surface area can be used for solar installation. If a roof has a 1000 ft^2 roof then about 45 300-watt solar panels could fit. The average solar panel output per area is 17.25 watts per square foot. The average solar installation costs between $15,000-$25,000. Though the initial cost of installing solar panels is steep, the payoff is worth it. Solar panels are greener source of energy that can greatly offset or eliminate your electric bill.

Taking advantage of government incentives is one way to lower the cost of solar installations. The Inflation Reduction Act (IRA) offers qualified homeowners a tax credit of up to 30% against the cost of installing a solar panels. Choosing a reliable company such as Lumina Solar can help you take advantage of these incentives as well is install your solar panels with relative ease.

Costs and Benefits

Based on Green-Walk's recent electric bills we have estimated that about 20,000 kWh a month and 240,000 kWh a year. MET ED charges 12.57¢ per kWh and Green-Walk pays about $3,000 a month for their electricity bill. If the rooftop solar recommendation are installed then they would collectively produce around 44,347 kWh a year which is about 18% of Green-Walk's yearly needs according to the Tech Clinic's calculations. These solar panels could produce about 3,695 kWh a month. Outside sources on the internet estimate that if the roof panels are put in place they would cover about 16% of Green-Walks yearly electricity needs. The complete solar installation is estimated to cost between $45,000-$75,000. Although large majority of the potential solar energy for Green-Walk will come from the rooftop solar panels, the pond based options are of value too. They will provide shade and a portion of energy depending on the number and type of panels installed.

Alarm System

Alarm System: General Information

Current Situation: Human Monitoring of Flow

Consequences: Need for 24/7 Human Surveillance

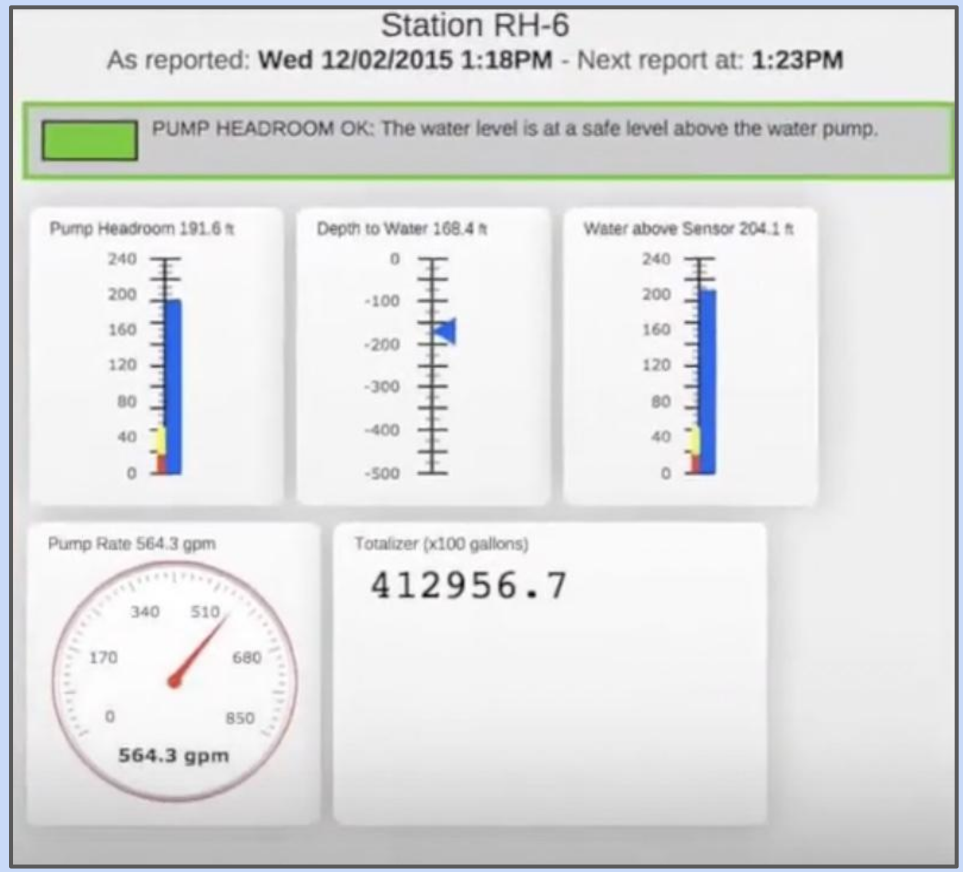
Benefits of an alarm system:

- *Quick detection of problems*: An alarm system that is set up to monitor the water flow can detect problems immediately when they occur, such as a pump going off or a drop in water pressure.
- *Remote monitoring*: The water flow can be remotely monitored from a smartphone or computer.
- *Peace of Mind*: Having a warning system to detect water flow problems, more focus can be placed on running other important part of the farm

Option 1: Dashboard (using **Seametrics**)

Five *Seametrics* alarm systems are present at the farm. If the flow meter is connected to a device (desktop, tablet, etc), an information statement will be generated. The information statement includes features and statistics of the system.

Seametrics Water Flow Meter



Information received from the seametrics device

Option 2: Alarm System with **Seametrics**

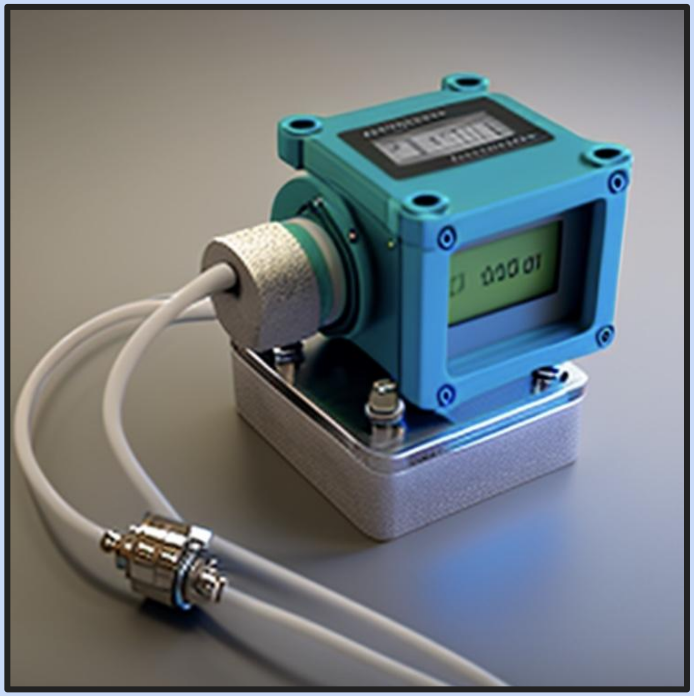
In order to turn the ***Seametrics*** Water Flow Meter into an effective alarm system, we have to connect the flow meter to the pulse water modulation sensor. This enables us to get the pulse outputs for the symmetric meter. We modify the flow meter pulse output generators to emit pulses corresponding to the desired flow rate or volume.

Seametrics Water Flow Meter

+

Pulse Water Modulation Sensor

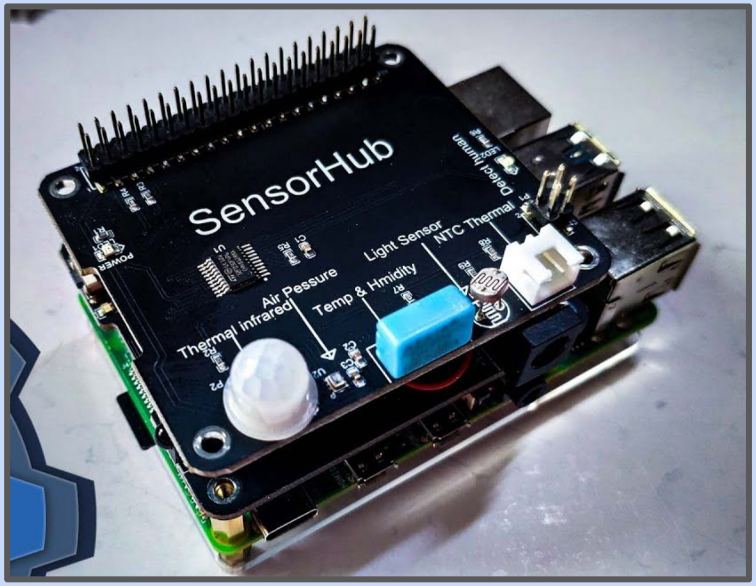
→



Prototype of the connection

Option 2: Alarm System (using **Seametrics**)

Further along we connect the output of the flow meter's pulse output generators to the sensor hub. Here we use a microcontroller or a communication protocol such as UART or I2C to transmit the pulse data. We program the sensor hub to receive and process the pulse data from the flow meter.

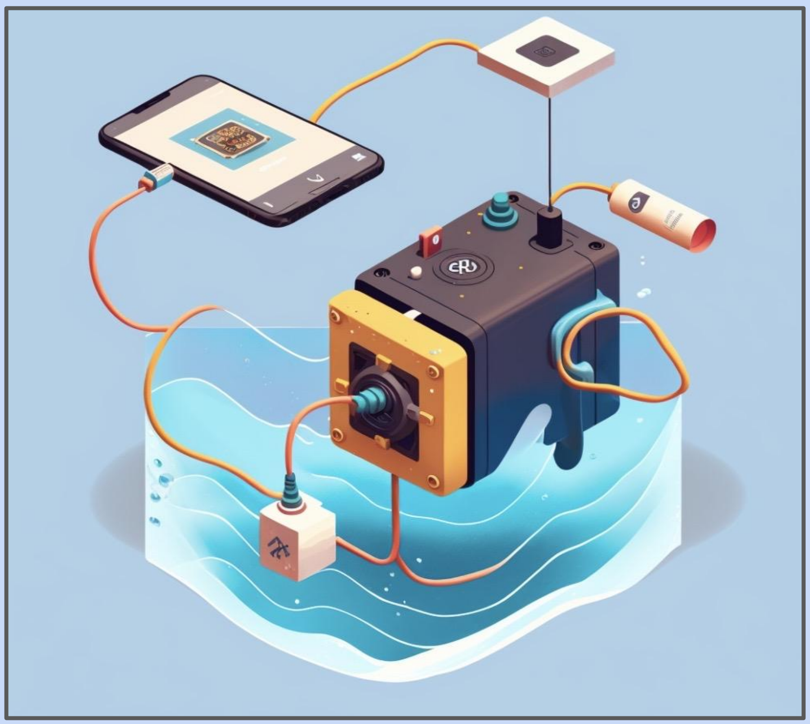


Example of a Sensor Hub

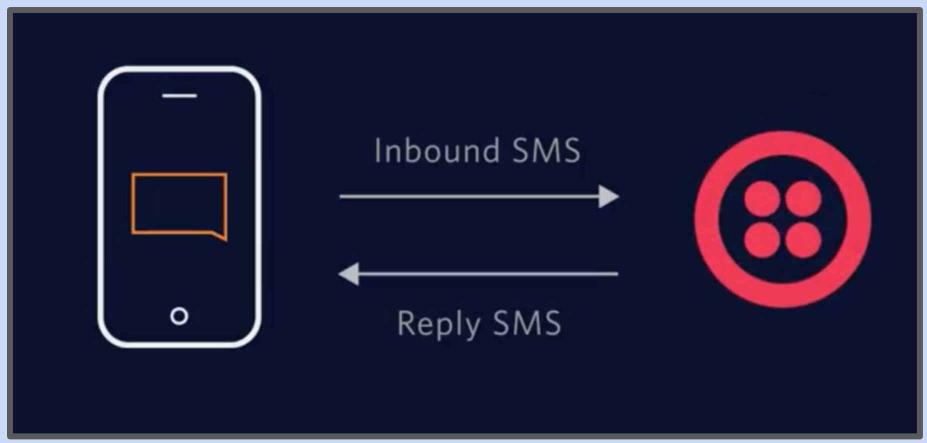
Prototype of the connection

Option 2a: Connection to Phone

We can program the sensor hub to send information regarding relevant changes to our phone using a third-party service such as Twilio. By setting up a communication protocol between the sensor hub and Twilio, we can configure the system to trigger specific actions when certain conditions are met, such as sending an alert message to our phone if the flow rate exceeds a certain threshold. This way, we can stay informed about changes in our system in real-time and take action if necessary, no matter where we are.



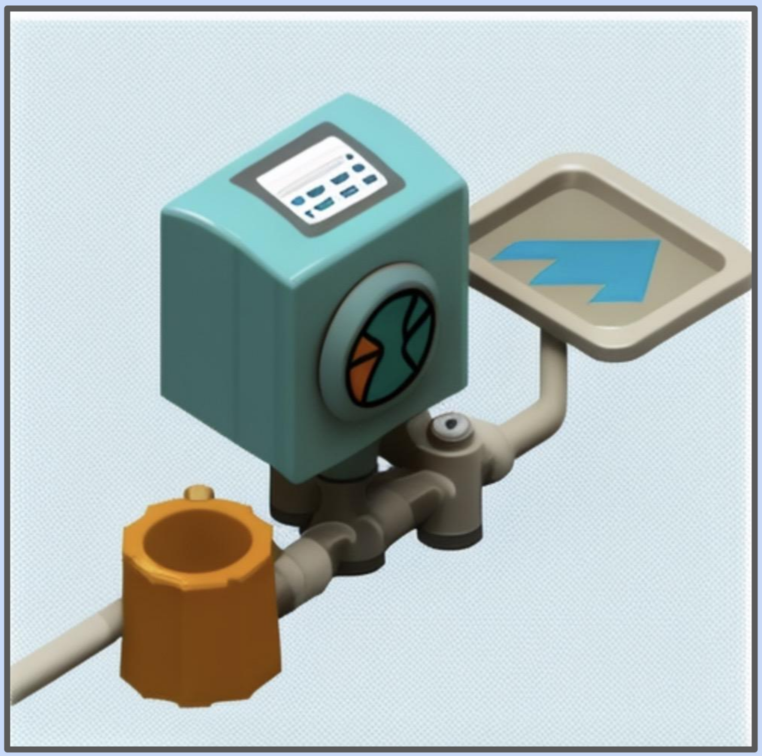
Prototype of the connection



Twilio Connection

Option 2b: Connection to Email

If we have a sensor hub that collects important data, we can set it up to send email notifications to our inbox whenever specific events occur. By configuring a communication protocol between the sensor hub and the email service, we can customize the system to trigger specific actions, such as sending an email alert if the water level drops below a certain threshold. To ensure that we receive the notifications promptly, we can also configure the email account to send alerts to our phone or other mobile devices.



Prototype of the connection

SendGrid

SendGrid Connection

Option 2c: Flashing Light System

Prototype of the connection

Rather than using third-party services, we can build the connection between the sensor hub and the flashing alarm system, so that it alerts the people who need to know when one of the pumps goes out.

To implement this solution, we will first identify a compatible device, which could be a relay or a Programmable Logic Controller (PLC), that can serve as an intermediary between the sensor hub and the flashing alarm system. We will then establish a physical connection between the device and the hub using an interface that is compatible with both devices.

Option 3: Ultrasonic Technology to Measure Flow

Prototype of the connection

More enhanced than the Seametric meter is the ultrasound meter that helps us to measure flow by clamping on to the outside of the pipe. The substantial benefit of this is flexibility because bluebot clips onto the outside of any Copper, PVC, Galvanized or PEX pipe from ¾”to 2” all with the same meter. No pipe cutting or water shutoff is needed. All other water flow meters get bigger and more expensive the the pipe gets larger.

Comparison between the options

Options	Pros	Cons
Dashboard (Option 1)	● No additional costs (as the meters are already present) ● Information Statements to track the water flow automatically	● Limited alerts and notifications ● Limited access from other device rather than computer or screen
Message Alarm System (Option 2a)	● Real-time Alerts (getting a message alert for every significant change)	● Additional price for the API ● Reliance on Third - Party Services
Email Alarm System (Option 2b)	● Real-time Alerts (getting a email alert for every significant change) ● Can be free if the number of emails stays within the range (effective for smaller teams)	● Reliance on email as the primary communication channel may not be ideal for urgent or time-sensitive alerts ● Limited support for the free plan.
Flashing Light System (Option 2c)	● Immediate, on-site alert system ● No ongoing subscription fees	● Forefront cost to set up the alarm ● Once set-up the location is hard to change
Ultrasonic Technology (Option 3)	● Increased flexibility and ease of installation	● More expensive to set up - compared to the other options.

Price Information

	Twilio (Message Alerts)	**Send Grid (Email Alerts)**	**Flashing Alert System**	**Ultrasonic Technology for Flow**
Base Price	**Pay-As-You-Go** Pricing Information: $0.0075 per message	**Free Plan:** 100 emails per day	The **alarm** takes around $225 for the materials and variable amount for the labor and configuration	The cost is $250 to $300 per unit
Additional Information or Case Study	If the owner wants to receive alerts for every significant change in the water flow, and they receive 10 alerts per day, the cost would be $0.075 per day or approximately $2.25 per month.	SendGrid's paid plans start at $14.95 per month and increase in price based on the volume of emails being sent and the specific features required.	A potential breakdown for building the alarm. • Four relays at $25 each: $100 • Wiring and connectors: $50 • Raspberry Pi or other compatible controller: $75	

Education and Awareness

Education and Awareness

Green-Walk as it stands today isn't explicitly open to the public, however it had once been open to the public. There have been some scheduled visits by local schools. The aim is to expand the community outreach of Green-Walk without compromising the ecological health of the farm.

To accomplish this goal we can look at similar institutions that have found good ways to open their businesses out to the community.

One method used by a large number of farms is incorporating a virtual tour into the website. This makes Green-Walk accessible to classrooms and other interested parties regardless of distance and time constraints.

Education and Awareness

As an example, Green-Walk's website can be modelled after the New Jersey Fish and Wildlife website (NJFW).

NJFW's website gives the user an option to use an interactive map to see the water bodies. The site also gives an attached file to give the user directions for how to use the website and how to access specific features.

Green-Walk already has an instagram page where pictures of trout and the farm are posted. This site can be used to base the website.

Green-Walk's current homepage has information about the diversity of trout species, delivery service information and contact address. Adding a page to the website that shows the owners of the farm and personal stories of how the farm is a family owned business would benefit Green-Walk.

Education and Outreach

Enjoying the story on Instagram

Restaurant Purpose

Green-Walk started supplying fresh trout to restaurants around six years ago. It supplies about a thousand fish per week. The clientele includes Michelin star restaurants in Philadelphia and in New York.

This purpose of Green-Walk can greatly benefit from a new website. The page can feature the trout starting from their early stage of development. This would further reinforce the stream-to-table model of Green-Walk. The Green-Walk kitchen can be a great place to focus on this particular subtopic on the website.

Additionally, the website can feature reviews from the chefs and kitchen staff themselves as Ty has a personal relationship with these individuals.

Sport Fishing Purpose

Another purpose of Green-Walk is sport fishing. The sport fishing function takes place downstream, and adult fish are the ones available for this activity. Even though the farm has reduced this function consistently, it is still available for interested customers.

The NJFW has a lot of resources as to what type of fish are found in which part of the water body, the cost of the activity, and when such leisure activities can take place.

A page on Green-Walk's website featuring catches by previous visitors can go a long way to bring more customers to the farm, and showcase the overall property.

What comes next?

Second Half

Some of the activities for the project in the second half of our project: Fall 2023

- Water Wheel Installation
- Measurements of energy generation
- Creation of Solar Prototypes
- Consultation with Solar Companies ex: Lumina Solar
- Updating the website to make it more accessible and appealing

We look forward to further discussion during the presentation

Acknowledgements

Thank you to…

Ty Bartosh, for the generosity of his time

Michelle Harrison, for constantly working with us

Dr. Lawrence Malinconico, Director of Technology Clinic

Professor Kelleher, for assistance in calculating hydroelectric power

Resources

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