Santa Clara University

School of Engineering

Santa Clara University

The Forge Garden Water Feature

ENGR-110 Fall 2024

Dr. Jessica Kuczenski

Austin Kim

Dylan Olson

Erick Lopez

Tiffany Doan

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Abstract:

The Forge Garden at Santa Clara University is a shared space where students, indigenous people, and the community come together to enjoy the native plant garden but is currently lacking a water feature. Our project addresses this issue by designing and building a water feature that will live with the addition of a new native plant planter to the garden. Additionally, we would like to represent the indigenous culture to go along with the indigenous fauna of the garden. We aim to produce a product that is culturally representative of the Muwekma Ohlone culture, bringing the sounds of flowing water to the area while being fully self-sustaining through solar power. Our team's design prioritizes visual appeal, environmental sustainability, and cultural representation to create a meaningful addition to the garden.

Introduction:

We have been called forth to design and build a water feature that will live in the native plant garden at the Santa Clara University Forge Garden. Currently there is no water feature in the forge garden and with the addition of a new native plant planter to the garden, we would like to represent the indigenous culture to go along with the indigenous fauna. We are designing this water feature with sustainability and the Muwekma Ohlone Tribe in mind. We aim to produce a product that is culturally representative of the Muwekma Ohlone Culture, that will bring the sounds of flowing water to the area and that is fully self-sustaining using solar power.

When we first met with Becca from the Forge Garden, she highlighted that this water feature will occupy a small space within a native planter box. The feature itself must fit within a 96 in. (L) x 18 in. (W) x 16 in. (H) location, in the center of the plantar area, and must run without grid power, must introduce audible sounds of flowing water, must represent cultural importance of water to the Muwekma Ohlone community. Refer to Appendix I for the interview with Becca. To complete this, we as a team collaborated and came up with a design that fulfilled the initial design criteria, ensuring that the feature would be aesthetically pleasing while also providing ample water sounds. We as a team decided that the success of this project be broken into a couple different subcategories. First, how well does it look- to which this metric will be graded by Becca and the Muwekma Ohlone partners. Second, how audible the water sound is, which will be measured through an audible decibel range. Third, how long will it last, which is a factor we considered in all our product purchasing. [1]

The critical customers for this project are the Muwekma Ohlone Tribe, Forge Garden workers, Forge Garden Patrons and students and community members within the Santa Clara region that utilize this space. During the first interview with Becca, she emphasized that this water feature should be prominent during the yearly Ohlone youth camps held at the Forge.

Engineering a water feature brings awareness to the indigenous culture of the area, introduces the sound of flowing water to the serene environment, visually appealing, low cost and easy to maintain feature.

Discussion:

To tackle the absence of water in The Forge Garden, our group explored various solutions, including purchasing pre-made water features or designing one ourselves. Our initial approach involved viewing Amazon listings to find products that met our criteria of vertical falling water, a budget of $100, only source renewable energy, cultural representation, dimensions bound in plant bed, and the ability to produce sufficient sound. Unfortunately, we were unable to find a product on Amazon that met all the specified criteria. Luckily, Becca informed us that she could provide a clay pot that fits inside the plant bed, which significantly helped us stay within our budget by reducing the cost of materials. This allowed us to move forward to researching designs, regulations, and materials, to put together a vertical falling water feature.

[Talk about system design & grate design Process Here]

Based on the scope of our project we expect the EPA, California Water conservation board, City of Santa Clara, and Santa Clara County to play a role in public policy pertaining to our project. We also expect Santa Clara University to be tangentially related to the policy and regulation to this project due to the project being located on university grounds.

Based on our research the EPA has little jurisdiction over decorative water features and leaves the regulation up to local governments. Generally, the EPA will not get involved with a decorative, non-drinking fountain unless it poses a significant threat to the local environment or population. Our fountain complies with their regulation stated on page two of , "recirculating … and beneficial" water feature. The policy that applies to our project comes from Santa Clara County and California State Code regulations. Santa Clara County Regulations state, "The use of potable water in a fountain or other decorative water device that does not have a fully automatic recirculation system, or the filling or topping off of decorative lakes or ponds, except where the water is part of a recirculating system." , Santa Clara County follows guidelines issued by San Jose Water Company which considers water features that do not have a recirculation system as a wasteful use of water. Since our design pumps water in a closed loop, we are abiding by this regulation. California State Code Regulation 492.6 states,

“

(A) Recirculating water systems shall be used for water features.

(B) Where available, recycled water shall be used as a source for decorative water features.

(C) Surface area of a water feature shall be included in the high water use hydrozone area of the water budget calculation.

(D) Pool and spa covers are highly recommended.

”

Our project is in compliance with regulation 492.6 (A), (D), since our design incorporates a recirculating water system, and our feature is neither a pool or spa there are no covers we could put on it. Our current plan does not consider using recycled water, but we can access The Forge Garden barrel, which uses rainwater, a source of recycled water. Therefore, our project could comply with 492.6 (B). We can dismiss regulation 492.6 (C) because we are not in a hydrozone area nor are we using high water.

Overall, our project is in compliance with all local and government regulations.

Gathering our core materials, we began identifying the core components needed, the provided pot, a pump, a power source for the pump, and a water source. Fortunately, another Forge Garden group was working on the water barrel feature, which would provide us with easy access to water for our project. Our group collectively decided to store the water inside our pot but was concerned to store the water directly inside the pot but had concerns that the pot would crack over time due to prolonged exposure to water residue. To address this issue, we decided to purchase transparent gorilla spray and use flex tape at the drainage hole.

For the pump, we needed a renewable power source and debate between wind or solar energy. Given Santa Clara's abundant sunlight compared to wind, it was an easy decision to use solar. [6] However, before purchasing a solar pump, we needed more information on the flow rate of our different solar pumps system, as there were different specifications of bundled solar panels and pumps on amazon. After multitudes of calculations, refer to Appendix II and Appendix III, we ultimately decided on a 25W at 8.85W solar pump system with 14.8V system, and a 2600mAh inline battery to keep the pump running overnight. Furthermore, we wanted our flow rate to be between 0.5-2.5 m/s, an average of 1.5 m/s, to have an optimal tap water flow rate. [7]

Results and Recommendations:

Final Product Design:

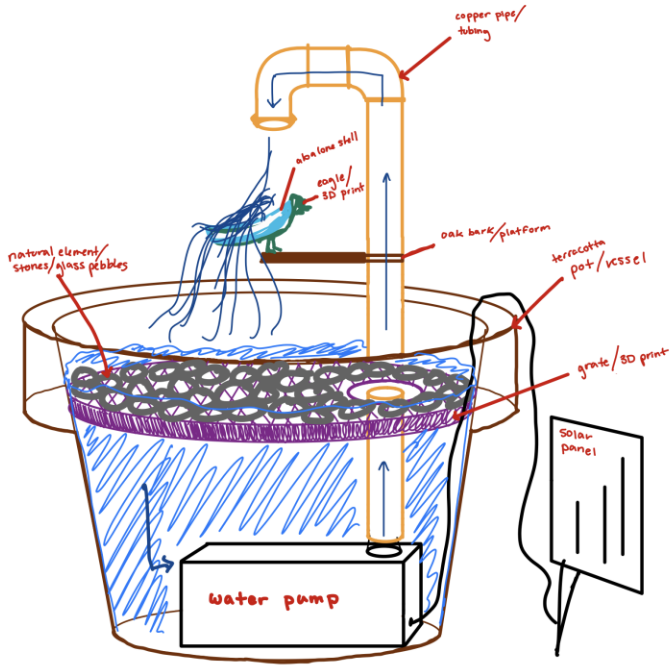

Figure 1.1: Water Feature Design

Insert thought process of this design

CAD Grate Design:

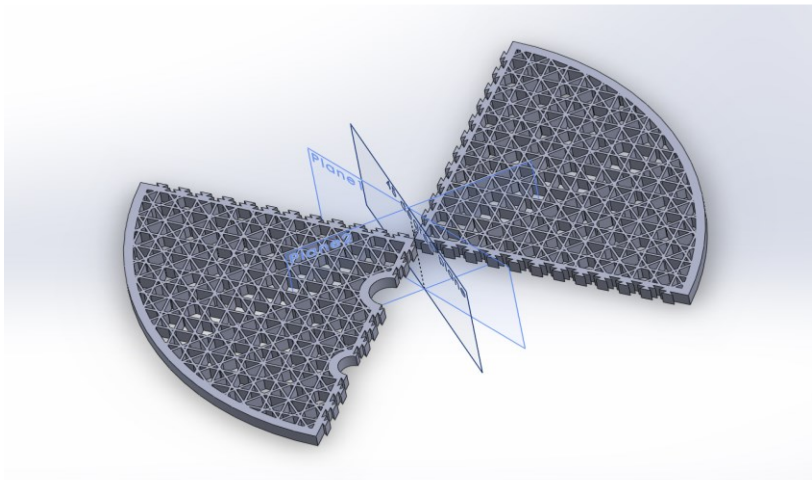

Figure 1.2: CAD Grates (Interlocking teeth outline)

Talk about something here

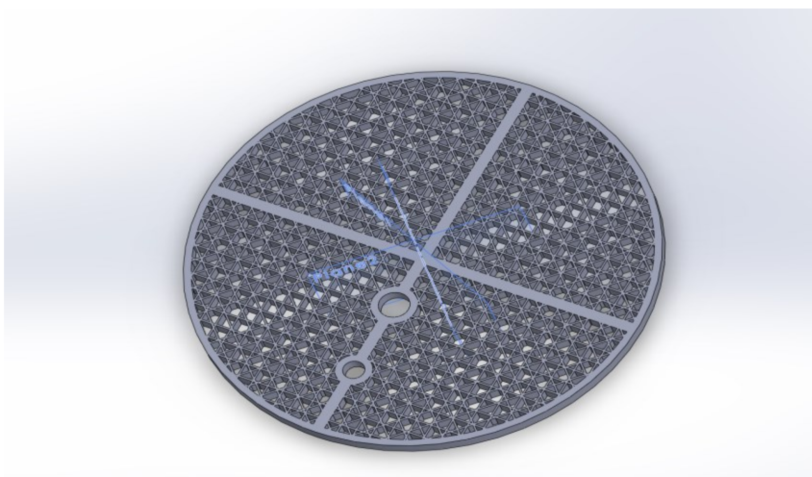

Figure 1.3: All four grates interlocking

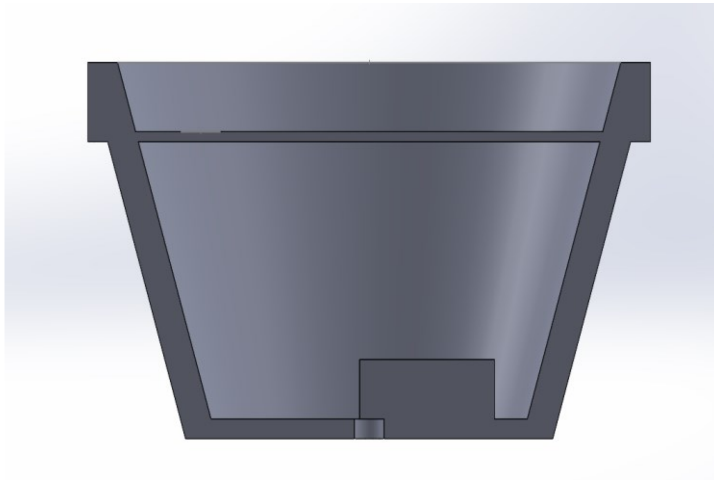

Figure 1.4: Minatare Pot

We conducted a flow test using the 4 different grate models we developed. Our flow test consisted of a timed test that measured how quickly each grate would evacuate 2 cups of water through its surface when poured from 6 inches above and a qualitative examination of the sound of water flow each grate made. Our goal was to weed out any grate designs that had poor flow or had a very quiet noise profile. Our results in Appendix IV demonstrate that the small square hole design was too restrictive and had poor flow. The large square design had the best flow but a very quiet noise profile. The hashmark design had the 2nd best flow and was decently loud and exhibited a lot of water splatter. The radial circular design had good flow and was the loudest with some splatter. This allowed us to narrow down our choices to 3 designs that met our criteria.

These results ultimately led us to go with the hashmark grate pattern for our final design, we wanted a good balance of flow and noise and although the radial pattern was louder and had similar flow, the scale model seemed less structurally rigid than any of the other designs making us question the longevity of that particular design.

Fountain Results:

Figure 1.5: Final Product

[Talk about the fountain here]

Budget Summary:

To build our water feature, we needed to purchase a solar panel with battery backup ($108.82), Waterproof Patch Rubber Sealant ($16.31), Abalone Shells 50 count ($10.90), and Maritime JB weld ($7.94). We were provided with a Terracotta pot, but a similar one comes out to around $29. Our total cost came to $143.18 including tax and shipping. A full bill of materials and links can be found in Appendix V.

Sound Testing Result:

Tests:	Long LM1	Long EBU	TruePeak	Adjusted Long EBU	To Reference
Low Reference	-38.9	-39.9	-26.4	-68.1	47 dB
Low Water	-34.8	-34.4	-17.1	-53.1	62 dB
Results					62 dB @ 1m
Ear Reference	-39.0	-37.8	-24.9	-64.4	51 dB
Ear Water	-33.6	-34.4	-16.3	-51.1	64 dB
Results					60 dB @ 2m
Angled Reference	-37.3	-36.1	-24.2	-62.0	53 dB
Angled Water	-34.4	-34.6	-14.6	-50.0	65 dB
Results					59 dB @ 2m

Figure 1.6: Sound Testing Result

Note that “Low Reference” was sampled a standard meter away. Ear reference and angled reference were sampled two meters away.

We went to Forge Garden to measure the sound data. A typical creek ranges from 40dB to 60 dB [8] but the environmental noise at The Forge Garden was significantly contributing to the intensity of sound. I took samples of reference sound then averaged the results to contrast it with my water feature sound.

The sound of water is prominent as all levels of sound intensity exceeded the mean intensity of a typical creek. Note that a typical outdoor environment where vehicles are not present will produce near 40 dB. Accounting to this environment, we can interpret the results of our creek to be 55 dB from a standard meter away and 53 dB from 2 meters away.

For more information view Appendix V, Sound Measurement Data.

Conclusion:

- NO NEW INFORMATION IN THIS SECTION! Should follow logically from discussion and results - simply highlight primary results
- Statement of primary issues covered in the discussion – state concisely
- Provides judgments about subject based on evidence explained
    - Was the project successful? Why or why not?
- Recommendations are proposed actions based on conclusions, ideas for enhancements, next steps, etc.

Bibliography:

[1] "https://www.dropbox.com/scl/fi/bfzjcbiiiaz1ayq7zrz3d/Partner_Interview.pdf," The Forge Garden: Water Feature Team, Santa Clara, 2024.

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[5] Cornell Law School LLI, "Cornell LII / Legal Information Institute," 10 09 2009. [Online]. Available: https://www.law.cornell.edu/regulations/california/23-CCR-492.6 . [Accessed 12 11 2024].

[6] Gaisma, "Gaisma," 10 06 2024. [Online]. Available: https://www.gaisma.com/en/location/santa-clara-california.html. [Accessed 10 12 2024].

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Appendix I (Interview Documentation):

a) Do you have an idea of where the water is going to flow? Specifically, where is the site of Forge Garden?

Becca had mentioned the water feature will be in a garden centered raised flower bed that is 8'x18"x16" and the feature itself would be in the middle of this bed.

b) What kind of water feature would the Muwekma Ohlone Tribe be looking for?

Becca had reiterated the importance of the sound of water, therefore it should be a more vertical fountain to have the sound of water falling. It doesn't need to be that tall, she wants something small. Additionally, there needs to be an incorporation of abalone shells on the fountain, which she will see if the Muwekma Ohlone community can provide.

c) When should the water flow? Daylight? As needed? 24/7?

If we could use a recycled water system powered by solar energy, the water would flow during the day when it is bright out. Totally up to us though, she hadn't thought about that. She doesn't want us to hook it up to the basin.

d) What conveying message should we keep in mind when building the water feature?

Becca had emphasized the importance of a robust system that can weather the elements. Something that is easy to repair if it is damaged while remaining completely self sustaining.

e) Is there anything that you don't see this project being, or any image that you want to be avoided?

Becca had stated with hesitation that there isn't really anything that they are ruling out at the moment. The end goal of this project is truly open to our [1]creativity and what will be deemed aesthetically pleasing and acceptable through Becca and to the Muwekma Ohlone community.

f) Who are the representatives within the Muwekma Ohlone community you are partnered with?

Monica and Gloria (no last names given) are the people who will most likely be involved with this project.

g) What is your preferred mode of communication moving forward?

Google chat works best- emails are good but the responses may be slow, but if you send a Google chat I will get the notification on my phone and be able to respond much more quickly.

Appendix II (Flow Calculations):

Volumetric Flow Rate Equation: $Q = \frac{V}{T}[G/H]$
General Area Formula: $A = \pi r^2$
Let $x[GPH]$ my volumetric flow rate, converting from

$$Q = \frac{x[G]}{[H]} \cdot \frac{1\ [\mathrm{H}]}{60\ [\mathrm{M}]} \cdot \frac{1[M]}{60[s]} \cdot \frac{0.00378541\ [m^3]}{1\ [G]} = x \cdot \frac{0.00378541[m^3]}{3600[s]} \quad (1)$$

From the flow rate equation, we can expand and derive the velocity: $\frac{V}{t} = \frac{A \cdot d}{t} = v \cdot A$

$$\Rightarrow v \cdot A = \frac{Q[m^3]}{951022[s]} \to v = \frac{Q}{951022 \cdot A} \quad (2)$$

Bernoulli's equation: $P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$
Our condition: 1) The pipe's diameter does not change throughout the pipe.
2) The atmosphere pressure acts on both intake and outtake.
3) Friction is negligible, and we are not considering it.
$\therefore \rho g h_1 = \rho g h_2$
Speed is independent of height.
And if we consider the external energy of the pump from $\Delta E = W$,
$\Delta P = \rho g \, \Delta h$
The height only influences the pressure of our water.
This is used to verify that the pump can support the lift height of our traveling height if needed.
The flow rate Q assumes that the pump can maintain the exit velocity at a certain height which is provided in the listing.

This tells me that the change of pressure is related to the change of height.
So, I know the speed stays the same from the intake to outtake which means:

$$Q = \frac{V}{t}\left[\frac{m^3}{s}\right] = \frac{A \cdot d}{t} = A \cdot v$$

$$\Rightarrow v_f = \frac{Q}{A} = \frac{Q}{\pi \cdot \frac{\mathrm{d}^2}{4}}$$

Note: Absolute value comes from the fact that the water's output is at the bottom of the bending tube. We are taking the average of the top to the faucet bottom height.
Q – Flow Rate in (GPH); D – Diameter of pipe;

D **Q[G/H]** **Q[G/s]**$\cdot 10^4$	**32** **0.034**	**80** **0.084**	**120** **1.26**	**160** **1.68**	**320** **3.36**	**410** **4.31**	**480** **5.04**	**900** **9.46**
0.5" (1.27 cm)	0.27	0.66	1.00	1.33	2.66	3.40	3.98	7.47
0.65" (1.65 cm)	0.16	0.39	0.59	0.79	1.57	2.01	2.36	4.42
0.75" (1.91 cm)	0.12	0.30	0.44	0.59	1.18	**1.51**	1.77	3.32
0.85" (2.16 cm)	0.09	0.23	0.35	0.46	0.92	1.18	1.38	2.59
1.00" (2.54 cm)	0.07	0.17	0.25	0.33	0.66	0.85	1.00	1.87

Appendix III (Solar Panel Power Calculation)

Solar Panel Input W	**3 W**	**10 W**	**12 W**	**25 W**	**35 W**
Battery Charging Time					
of 24.00 Wh Capacity	9.6 h	2.4 h	2.0 h	1.0 h	0.7 h
of 36.00 Wh Capacity	14.4 h	3.6 h	3.0 h	1.4 h	1.0 h
of 38.48 Wh Capacity	15.4 h	3.8 h	3.2 h	1.5 h	1.1 h
Battery Charging Time while pump running @ 5 W					
of 24.00 Wh Capacity	-	4.8 h	3.4 h	1.2 h	0.8 h
of 36.00 Wh Capacity	-	7.2 h	5.1 h	1.8 h	1.2 h
of 38.48 Wh Capacity	-	7.7 h	5.5 h	1.9 h	1.3 h
Battery Charging Time while pump running @ 8.85 W					
of 24.00 Wh Capacity	-	20.9 h	7.6 h	1.5 h	0.9 h
of 36.00 Wh Capacity	-	31.3 h	11.4 h	2.2 h	1.4 h
of 38.48 Wh Capacity	-	33.5 h	12.2 h	2.4 h	1.5 h
Battery Charging Time while pump running @ 10 W					
of 24.00 Wh Capacity	-	-	12.0 h	1.6 h	1.0 h
of 36.00 Wh Capacity	-	-	18.0 h	2.4 h	1.4 h
of 38.48 Wh Capacity	-	-	19.2 h	2.6 h	1.5 h
Fall/Winter Daily Sun Amount Energy Charge	19 Wh	76 Wh	91 Wh	190 Wh	266 Wh
Spring/Summer Daily Sun Energy	25 Wh	101 Wh	121 Wh	253 Wh	354 Wh
Fall/Winter Efficiency					
of 24.00 Wh Capacity	-	68%	74%	87%	91%
of 36.00 Wh Capacity	-	53%	61%	81%	86%
of 38.48 Wh Capacity	-	49%	58%	80%	86%
Spring/Summer Efficiency					
of 24.00 Wh Capacity	5%	76%	80%	90%	93%
of 36.00 Wh Capacity	-	64%	70%	86%	90%
of 38.48 Wh Capacity	-	62%	68%	85%	89%

Battery Capacity Discharge Time	**24.00 Wh**	**36.00 Wh**	**38.48 Wh**
of 05.00 W Pump	4.8 h	7.2 h	7.7 h
of 08.85 W Pump	2.7 h	4.1 h	4.3 h
of 10.00 W Pump	2.4 h	3.6 h	3.8 h

Common Value Chart:

Battery Voltage	**Battery Cap (mAh)**	Watt Hours		**Panel Recharge**	**@ Voltage**		**Pump**	**@ Voltage**
7.4	4400	32.56		8 W	10.0 V		8.00 W	10.0 V
10	2400	24		10 W	10.0 V		8.85 W	14.8 V
12	2000	24		25 W	14.8 V		10.0 W	10.0 V
12	3000	36						
14.8	2600	38.48						
15.8	2200	34.76						

Battery Voltage	**Battery Cap (mAh)**	**Watt Hours**
7.4	4400	32.56
10	2400	24
12	2000	24
12	3000	36
14.8	2600	38.48
15.8	2200	34.76

Appendix IV (Grate Test Results):

Grate Type	Time start (sec)	Time end (sec)	Total time (sec)	Notes
Small Square	2.75	31.07	28.32	Holes too small, started to overflow. noise is a quiet ripple
Large Square	21.11	33.76	12.65	Smooth, quiet sharp noise
Hashmark	15.88	29.77	13.89	Louder noise, lots of splatter
Radial, circles	19.16	33.40	14.24	Smooth, loudest, splatter
Constraints:				
2 cups of water being poured				
Pour directed towards center of grate				
Pouring 6 inches above grate				

Appendix V (Bill of Materials):

Product	Link	Cost	Total Cost	Notes
Solar Panel w Battery	Amazon	$ 98.99	$ 108.02	
Waterproof Patch Rubber Sealant	Amazon	$ 14.95	$ 16.31	Sealant if we're storing the water in the pot to prevent cracking
Abalone Shells 50 ct	Etsy	$ 9.99	$ 10.90	Some decorative
Maritime JB weld	Amazon	$ 7.28	$ 7.94	Copper pipe welding
Total Costs		**$ 131.21**	**$ 143.18**	

Appendix VI (Sound Measurement Data):

Tests:	Short LM1	Long LM1	Short EBU	Long EBU	TruePeak	Adjusted Long EBU	To Reference
Low Reference	-39.9	-38.9	-44.4	-39.9	-26.4	-68.1	47 dB
Low Water	-34.5	-34.8	-34.9	-34.4	-17.1	-53.1	62 dB
Results							62 dB @ 1m
Ear Reference	-38.7	-39.0	-34.7	-37.8	-24.9	-64.4	51 dB
Ear Water	-34.3	-33.6	-34.8	-34.4	-16.3	-51.1	64 dB
Results							60 dB @ 2m
Angled Reference	-36.9	-37.3	-34.6	-36.1	-24.2	-62.0	53 dB
Angled Water	-34.7	-34.4	-34.8	-34.6	-14.6	-50.0	65 dB
Results							59 dB @ 2m

Data taken using SoundID Reference Microphone and processed through Waves WLM Plus Loudness Meter. Reference dB that was used to calibrate levels from iPhone app, *dB Meter*.
Microphone measurements ± 0.9 dB error.
$\alpha = 1.07$ True peak coefficient.
$\sigma = 115.1$ Meter offset

Important Definitions:
Long EBU: A loudness over long durations using EBU R128 guidelines.
Adjusted Long EBU: Considers True Peak Calculations.

My reference values were taken from the first two measurements through *dB Meter* and calculated α to account for the true peak accurately.

Appendix VII (Assembly Instructions):

FORGE GARDEN ENGINEERING 110

Owners Manual
WATER FEATURE

General Use and Care

Contents:

By: Dylan, Austin, Erick, Tiffany

About Materials

What is included:

【Water Pump /Solar Panel】
1 x 360GPH Water Pump
1 x 25 Watt Solar Panel
3 x Solar Panel Stakes
4 x Extension Rod
2 x Nozzles
1 x 2600 mAh Battery
1 x Battery Charger with 1.2 m Charging Cable

【Terracotta Pot】
1 x pot (xxx)
4 x grate pieces

【Copper Pipe】
2 x straight pipe (xxx)
2 x corner pipe (xxx)

【Decorative】
1 x oak platform
1 x abalone shell
1 x 3D printed eagle

ENGENEERING 110 X FORGE GARDEN

IMPORTANT! INSTALLER PLEASE NOTE
THIS PRODUCT INCLUDES MATERIALS THAT CAN BE HAZARDOUS WHEN IN CERTAIN CLIMATES ETC.

About Materials

Technical Details

【25 Watt Mono Solar Panel】
Monocrystalline solar panels is higher cost, better quality, photoelectric conversion efficiency increased by 5-10%, the service life is more than 15 years if in proper use and storage.

【410GPH Pump】
Max flow rate: 410 GPH (1550 L/H). Max lift height: 6.9 FT (2.1m). Cord length: 16.4 FT (5m). Detachable, safer,Reduce dry rotation to protect pump longer service life.

【2600 mAh Battery】
Included battery, charger with 1.2 m charging cable, more than 5 years lifespan, cycle more than 2000 times.

Brand	ECO-WORTHY
Style	Water Fountain Pump Kit 25W with 2600mah battery
Power Source	Solar Powered
Maximum Flow Rate	6.83 Gallons Per Minute
Maximum Lifting Height	6.9 Feet
Voltage	18 Volts
Manufacturer	ECO-WORTHY

ENGENEERING 110 X FORGE GARDEN

IMPORTANT! INSTALLER PLEASE NOTE
THIS PRODUCT INCLUDES MATERIALS THAT CAN BE HAZARDOUS WHEN IN CERTAIN CLIMATES ETC.

How to: Install the grate

【Step 1】 Construct the Grate
- Check that all the teeth are interlocking to create a flush connection between the grate pieces

【Step 2】 Position the Grate
- Place the 3D-printed grate over the top of the water reservoir. It should sit securely in the pot without gaps around the edges.

【Step 3】 Align Openings
- Ensure the grate has an opening for the copper pipe and enough clearance for water flow back into the reservoir.

【Step 4】 Test Flow
- Turn on the pump to verify water circulates freely without obstruction.

【Optional】 Add Mesh
- Lay a piece of screen mesh beneath the grate to filter smaller debris before it reaches the water.

ENGENEERING 110 X FORGE GARDEN

IMPORTANT! INSTALLER PLEASE NOTE
THIS PRODUCT INCLUDES MATERIALS THAT CAN BE HAZARDOUS WHEN IN CERTAIN CLIMATES ETC.

How to: Assembly Instructions

【Step 1】 Prepare the Copper Pipe Fountain
- Check that copper pipes are securely fastened and water-tight.
- Test water flow through the fountain before installing other components.

【Step 2】 Install the Water Pump
- Submerge the water pump in the reservoir, ensuring it is fully covered.
- Attach tubing from the pump outlet to the copper pipe fountain's inlet.
- Secure the pump to the bottom of the reservoir if needed (e.g., with suction cups).

【Step 3】 Position the Solar Panel
- Place the solar panel in direct sunlight using the adjustable mount. Angle it for maximum daily exposure.

【Step 4】 Power and Test
- Connect the pump to the solar panel and battery.
- Ensure water flows smoothly through the fountain and adjust as necessary.

ENGENEERING 110 X FORGE GARDEN

IMPORTANT! INSTALLER PLEASE NOTE
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How to: Algae and Water Care

【Algae Prevention】
Keep the fountain out of direct sunlight or partial shade to reduce algae growth. You may use a water-safe algaecide every 2-4 weeks, following product instructions.

【Regular Cleaning】
Remove leaves or debris weekly from the grate. Rinse the grate with water as needed.

【Deep Cleaning】
Remove the grate and pump from the terracotta pot. Scrub the reservoir and copper pipes with a mild vinegar solution to remove algae buildup. Clean the pump and tubing thoroughly before reassembling.

ENGENEERING 110 X FORGE GARDEN

IMPORTANT! INSTALLER PLEASE NOTE
THIS PRODUCT INCLUDES MATERIALS THAT CAN BE HAZARDOUS WHEN IN CERTAIN CLIMATES ETC.

Troubleshoot

IMPORTANT! INSTALLER PLEASE NOTE
THIS PRODUCT INCLUDES MATERIALS THAT CAN BE HAZARDOUS WHEN IN CERTAIN CLIMATES ETC.

Issue	Possible Cause	Solution
Weak Water Flow	Dirty Pump intake or grate	Clean the pump and grate
Clogged grate openings	Debris accumulation	Rinse or scrub the grate.
No water flow	Low sunlight or dead battery	Charge in direct sunlight
Algae buildup	Excess sunlight or poor cleaning	Use algaecide and clean regularly

Safety Notes

- Disconnect the pump from solar panel before maintenance
- Use only water-safe cleaning agents and algaecides
- Avoid running the pump dry to prevent damages

ENGENEERING 110 X FORGE GARDEN

II. ***Conclusions and Recommendations*** - *can be same (combined) section or two sections, usually no more than 1 page*

- NO NEW INFORMATION IN THIS SECTION! Should follow logically from discussion and results - simply highlight primary results
- Statement of primary issues covered in the discussion – state concisely
- Provides judgments about subject based on evidence explained
    - Was the project successful? Why or why not?
- Recommendations are proposed actions based on conclusions, ideas for enhancements, next steps, etc.

III. Bibliography

- APA or IEEE format - usually a minimum of 3 sources, though some projects will have many more!
    - Full reference section
        - Also need to cite references within the text – usually at the end of the sentence
        - Include full citations in References section, e.g. do not just use a URL link
    - Use sources that have been reviewed by experts – not simply John Doe's website
    - Compare the information found to another site to verify!

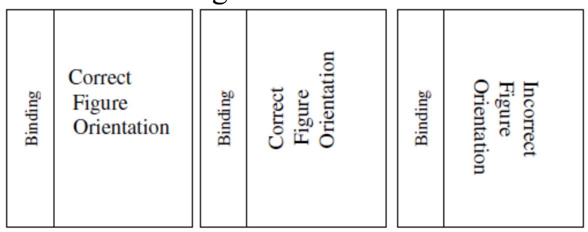
IV. ***Appendices*** - Information and data that was not essential (or too lengthy) to put into the body of the report. Be sure to format neatly and organize. List in order of appearance IN TEXT (if it doesn't appear in the main text, then it shouldn't appear here)

- Sample and/or lengthy calculations (error analysis, economic analysis, etc.)
- Full testing results or tables of data for charts presented in main text
- Bill of materials (including cost)
    - Include part numbers, hyperlinks, etc. as relevant for ease of finding replacement parts
- Assembly instructions and Operations (if applicable)
    - Operation and/or maintenance of project
    - Location and ownership of relevant items (passwords, prototype storage, etc)
- Team and project management
    - Project challenges and constraints and how they were dealt with
    - Team management (approach, issues, responses)
    - Time log of members outside of class

General Guidelines

- Reports should use 12 point serif font (like Times New Roman) and 1.5 line spacing with 1" margins (**everywhere**, including graphics and tables!)
- Logic of discussion should be evident from headings/subheadings
    - Define terms – anything that might be unfamiliar to a reader, including acronyms
    - Present facts – avoid personal feelings or opinions, back up data
    - Be clear and efficient without losing meaning
- Paragraphs should contain a topic sentence followed by supporting sentences, data, and visuals
    - Prefer past tense verbs (keep verb tenses in agreement within a paragraph)

  - Maintain a professional tone
- All figures in the body of the text should be numbered, captioned, and referred to in the text by number
  - In order of appearance – keep lists numerically separate
  - Table captions ABOVE table
  - Figure captions BELOW figure



- Number all pages in the main body of the report (all prefatory elements are unnumbered or numbered using Roman numerals rather than Arabic numbers; page numbering begins with the Introduction)
- All references must be properly cited (including in the main text using APA format) and shown in a bibliography
- Proofread and edit several times – read it through at least twice! Look for and remove unnecessary words, sentences, paragraphs, etc. (Use the HUB!)
  - Keep the leading zero with a decimal
  - Watch for significant figures
  - Separate a number from its unit with a space