Project Deliverable D: **Conceptual Design**

GNG 1103 – Engineering Design

Faculty of Engineering – University of Ottawa

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Introduction

This report documents the ideation and selection process of potential solutions for the hydroponics and interior design of the grow wall. The specific subsystems are detailed, with a concept (for each subsystem) provided by each member of this team. These ideas are then improved and combined to form three complete solutions. The desired specifications and the design criteria defined in Deliverable C are used in this report to evaluate these solutions.

Part 1 - Subsystems

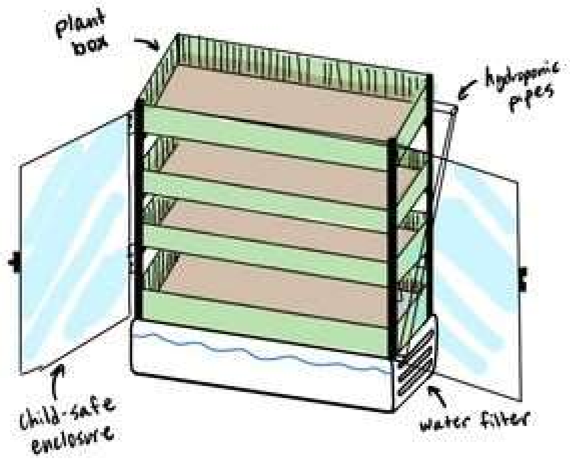
The design subsections to our possible solutions (1 diagram with comments for each subsection per team member (total of 3 diagrams per person) are the following:

- Grow Light
- Hydroponics/Irrigation
- Soil/Nutrient solution and planting setup

Below, we have defined the criteria and the boundaries of each subsystem to ensure that various solutions (from different team members) can be combined into the final solution interchangeably. Each member has provided a solution within these bounds:

Grow light:

1. Solution should provide proper light requirements to satisfy low light plants (PPF: 50-150 umol m-2s-1 / 50-250 foot-candles / 10-15 watts), medium light plants (PPF: 150-250 umol m-2s-1 / 250-1,000 foot-candles / 15-20 watts) and high light plants (PPF: 250-450 umol m-2s-1 / more than 1,000 foot-candles, more than 20 watts) https://extension.umn.edu/planting-and-growing-guides/lighting-indoor-plants. Vine plants such as tomatoes are high light plants, for example. To be safe, the rule of thumb is 20-40 watts per square foot https://www.bhg.com/gardening/houseplants/care/choosing-plant-grow-lights/ .
2. Include specification of the type of lighting used (i.e., LEDs, fluorescent bulbs…). Make sure the light source produces enough red-light waves (you should be safe if it is specifically used as a "grow light").
3. Solution should approximately complement the spatial plan/structure of the construction team's design model:



4. The light source should be at around a 6-inch distance from the plants (see how tall the client's plants generally grow and adapt for the tallest)

Hydroponics/Irrigation System:

1. Clearly state the type of hydroponic or irrigation system of your design (i.e., Drip Irrigation)
2. Provide the basic spatial/structural layout of the hydroponics system and specify materials (i.e., ABS pipes, wastewater drainage pipes?, moisture sensor?, pH sensor?, reservoirs, valves, pumps, fittings/connections). See Lab 4 instructions for guidance
3. If opting for the watering by hand with a watering can method, just indicate this in your description (and still include any sensors you may wish to install)

Soil/Nutrient Solution and Planting Setup

1. Provide a setup plan for where you intend to plant different crops requested by the client. Make sure to pair plants based on complementary or similar traits/requirements (i.e, height, water needs, light needs, nutritional needs).
2. Choose your soil and specify any fertilizers/compost you intend on using.
3. If you choose a hydroponic (no soil) system, specify the type of nutrient solution that you intend on using
4. This is where you show your chosen design for potting/trays for the plants

Part 2.A - Grow Light

Nicole

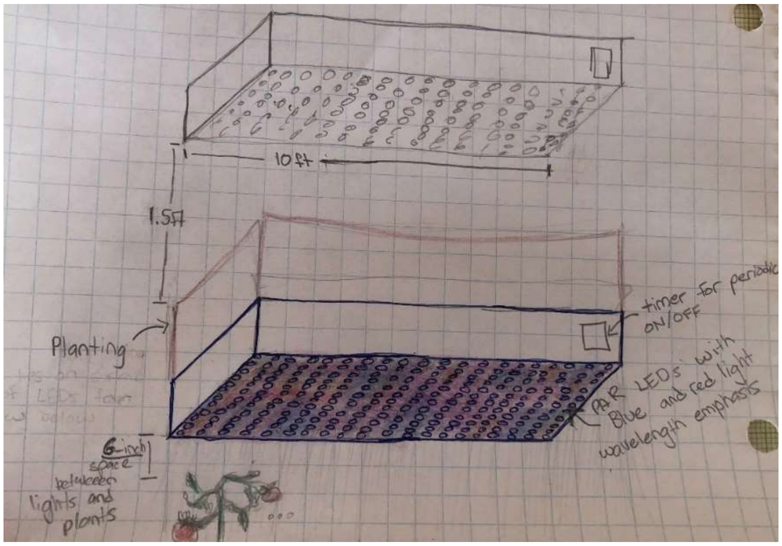


Figure 1: Grow Lights use PAR (visible light wave spectrum) LEDs, with an emphasis on red, blue and purple wavelengths to help plants grow in different stages. LEDs can get up to 6 inches away from the plants as they do not generate heat. A timer is located on the side of each light panel to allow for on and off periods of lighting (day/night cycles can be immitated).

Team comments: Very good, simple solution. Emphasis on certain wavelengths is a good feature you thought of adding.

Alec

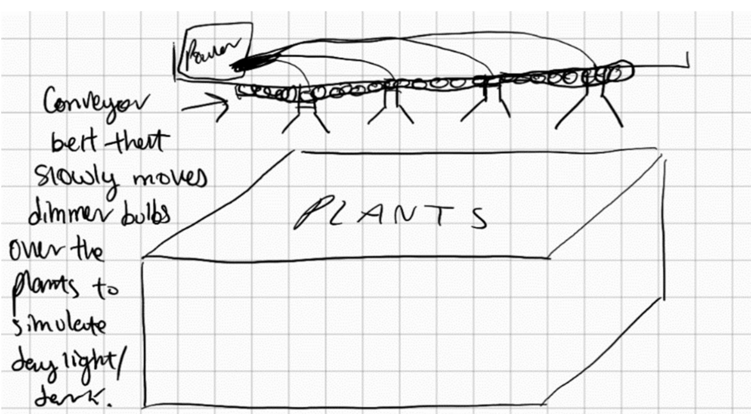


Figure 2: My grow light design is very simple. Basic LED’s will be arranged along a very-low speed “conveyor belt”, or simply a string being rotated by some small motor. This will simulate daylight and sunlight, as at the end of the day the part of the string with no lights on it will be displayed, and leading up to this the lights will be dimmer and dimmer. Every LED will have a constant “dimness”.

Team comments: Very interesting design idea and interesting concept of sunrise and sunset. This design may require more space to be taken up and more power usage for the lights and motor to function which may not be desired.

Khalid

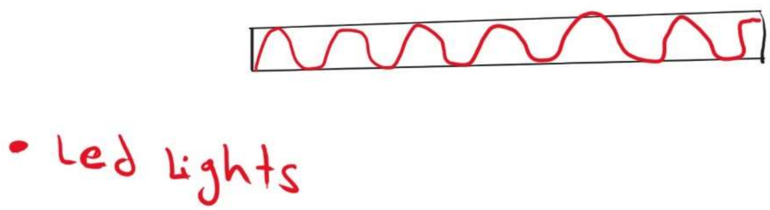


Figure 3: The light will be above each raw of the plants and will supply them enough light energy to survive

Team comments: The LED is a very good light source for plants. Perhaps a bit more detail could be added to the diagram.

Matas

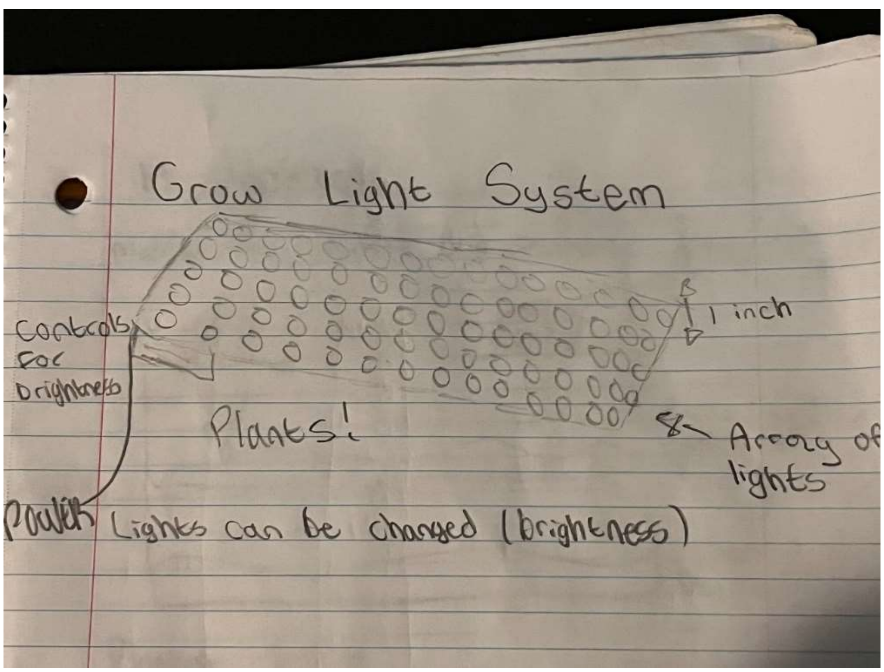


Figure 4: Grow light with controls for power. Light brightness can be controlled by user to fit the needs of the plants. LEDs will be used.

Team comments: Great design but won't it use so much electricity to light all these lights up? And maybe it will be more than enough

Cyrille

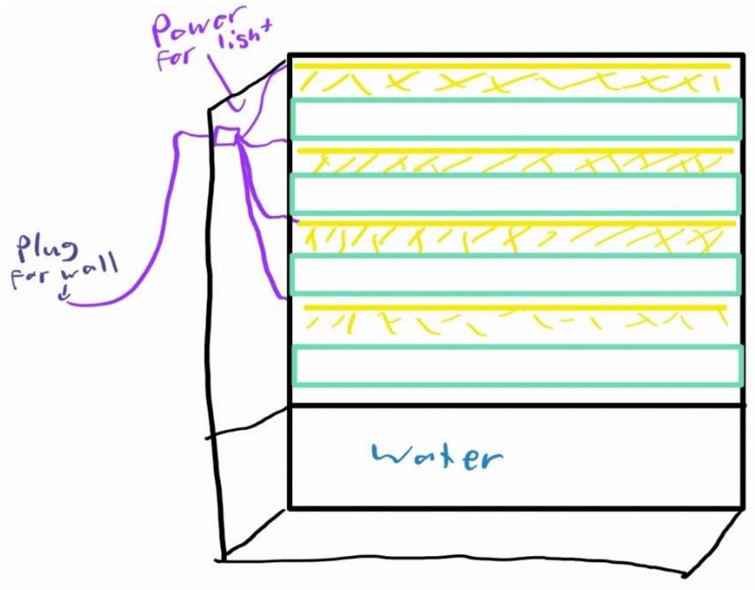


Figure 5: The lights (yellow part of the diagram) will be over each container. Each will be dimmable and can be turned on/off separately. They also have a timer feature. They will be remote controlled. The electricity will come from a 120 V wall plug.

Team comments: The design is clean and simple just how the client wants. The remote-control feature would be useful for the client. There could be a little more detail on how the lights is fitted onto the shelve or level.

Jacob

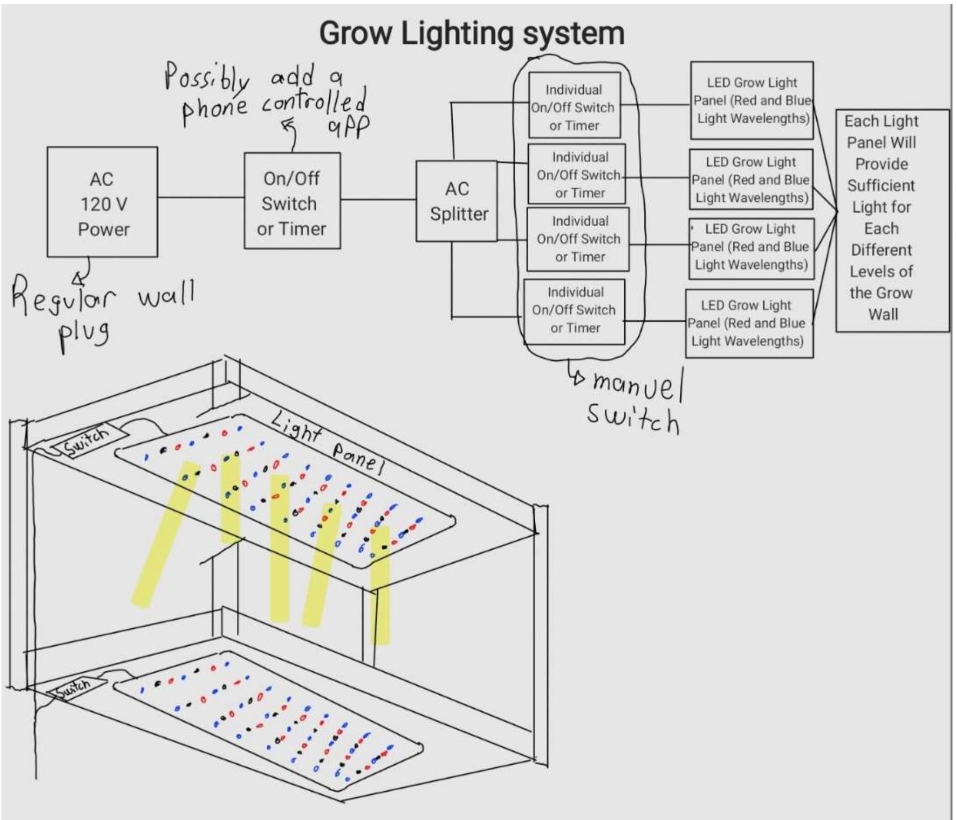


Figure 6: This grow wall lighting system allows for artificial light to get to the plants easily. This system begins in a wall outlet and splits off into different levels of the grow wall to provide light for a whole level of plants. The LEDs are on a panel slightly smaller than the area of a level and they have a manual switch nearby to individually control. There could also be an application that could help control the lighting system if enough money and design time is spared.

Team comments: Design is simple and well drawn. Timer and switch could be hard to reach especially on the highest level of the grow wall. It is nice to have both a master and individual switch and timer for ease of use.

Part 2.B - Hydroponics/Irrigation

Nicole

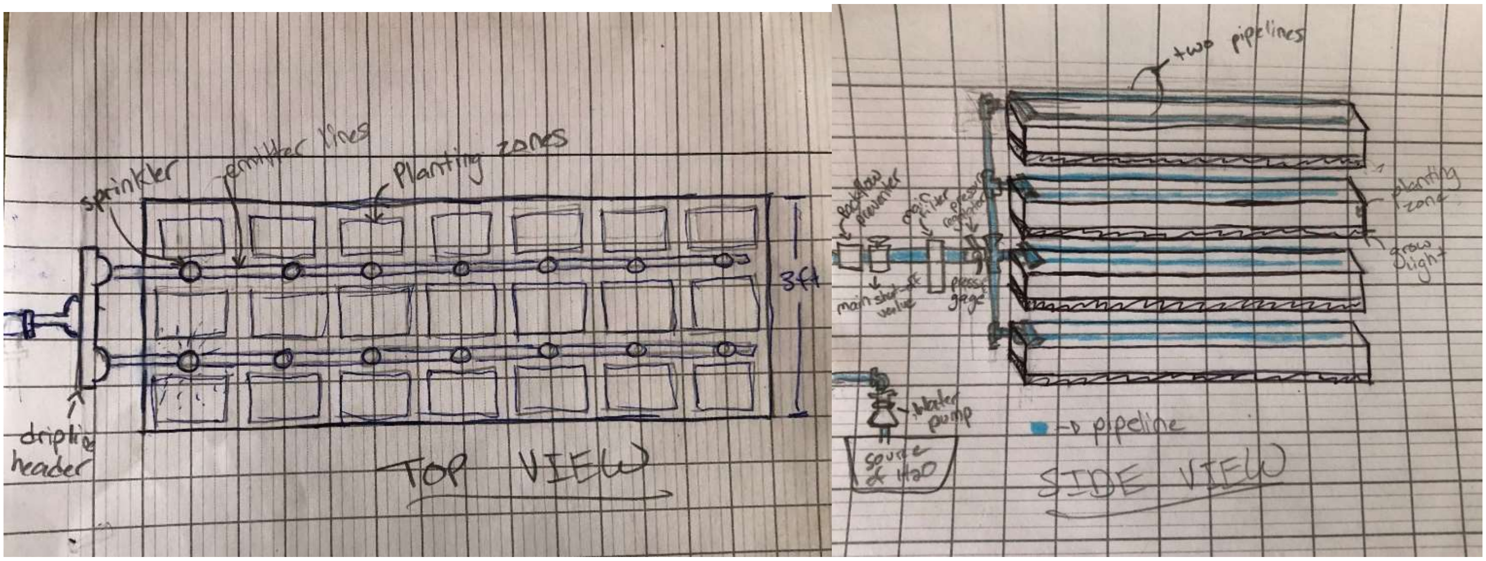


Figure 7: The system will use ABS pipes and ABS cement (slip connection) due to the toxin debree produced by PVC pipes. The pump is an aquarium pump. A gate valve is responsible for turning the system on and off. The pipes are connected to the sprinkler systems with brass fittings.

Team comments: My only concern is the complexity of maintenance for the client. Otherwise very good design.

Alec

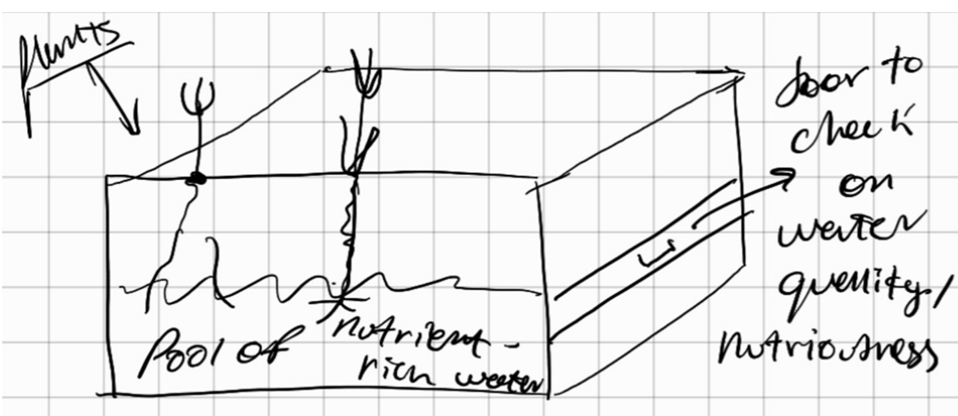


Figure 8: This typical “Ebb and Flow” hydroponics is my solution to the hydroponics aspect of this project. The system includes a tub of nutrient-rich water, maintained manually by adding more nutrients in through the door shown in the figure. Then, the plants will grow in this water, with the grow light overhead. A plastic or wood layer with cut outs will have holes for plant insertion and support, and will also prevent the water from getting too hot from the light.

Team comments: Very fond of the Ebb and Flow design and you have thought of some of the drawbacks of this system and how you will redesign it.

Khalid

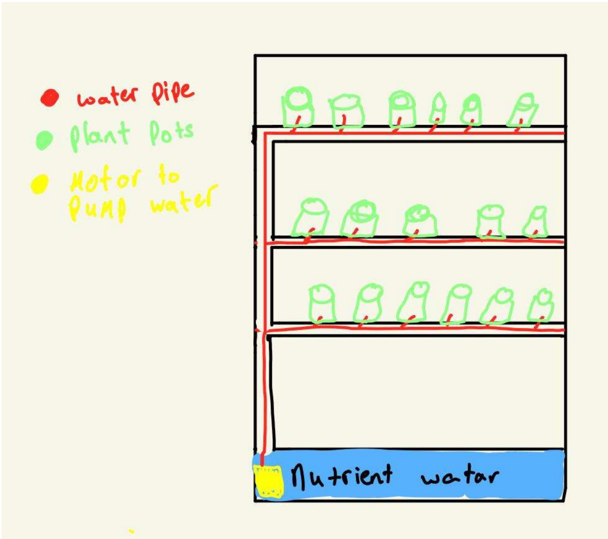


Figure 9: The water gets pumped by the motor from the bottom to the upper part which contains the plants

Team comments: The idea is nice with the pump/wick system. Where would the excess water go?

Matas

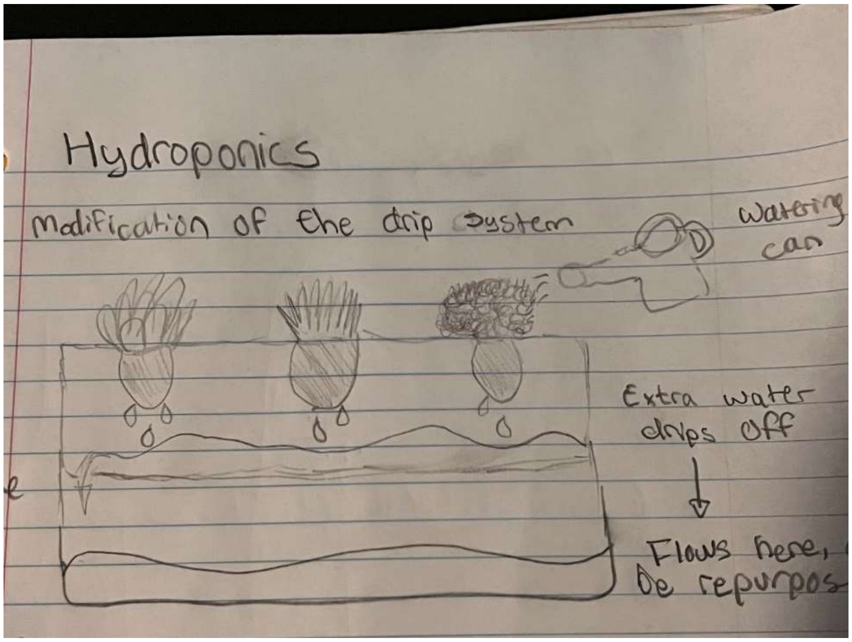


Figure 10: A drip style system will be used where the excess water will drip from the plants and into a reservoir. This water could then be reused/repurposed. The water will be done manually by the user.

Team comments: Nice and simple and saves the water

Cyrille

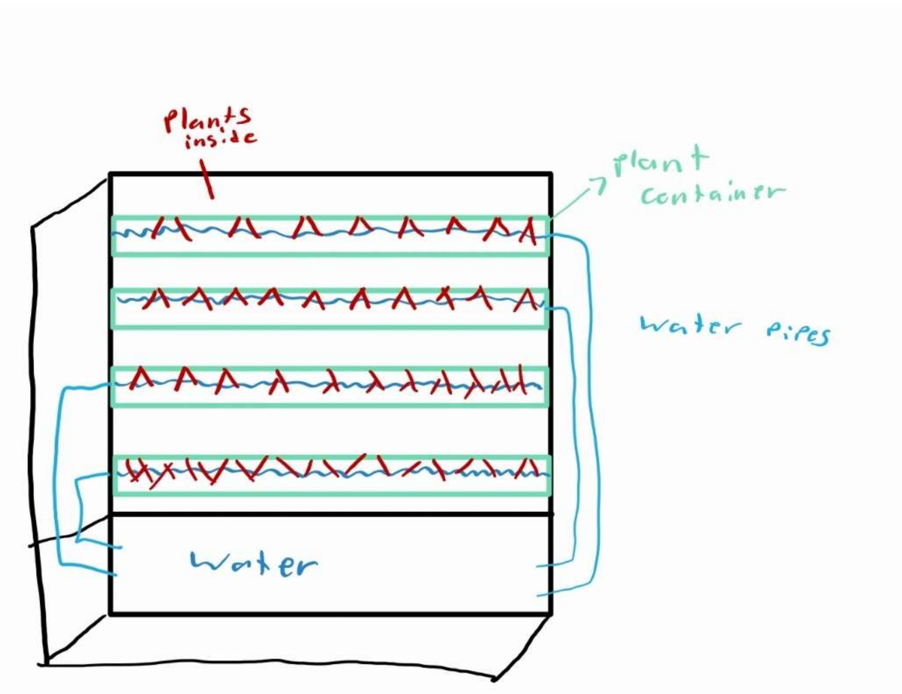


Figure 11: Using a pump, the water will automatically go through the hoses up to the plant containers once they are at a certain level. Each container can be filled individually. The nutriments will all be in the big water container at the bottom so that all containers can get the needed nutriments.

Team comments: Very interesting design and cool concept, however I believe this would be an expensive project to keep the water levels at the require height. Also, if something were to go wrong, there is a lot of water that could cause a mess or hard to repair.

Jacob

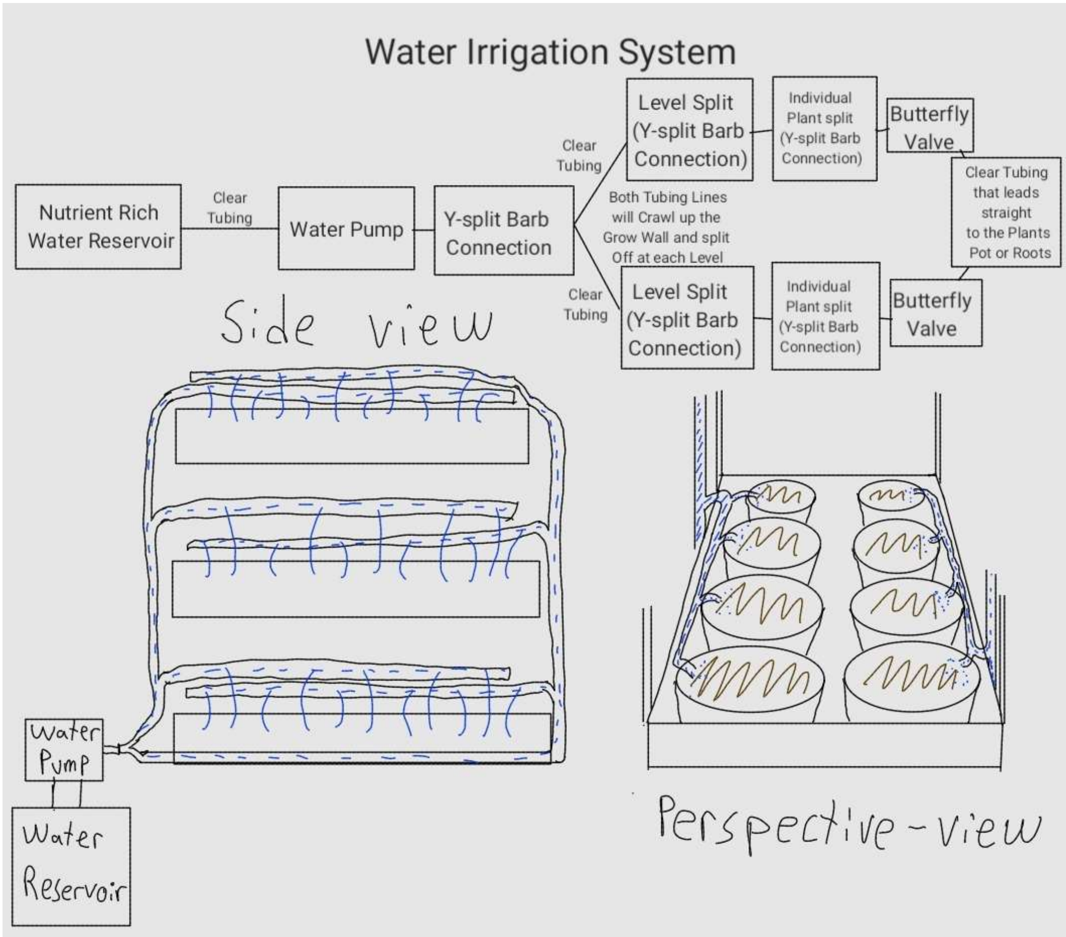


Figure 12: This water irrigation system allows for 2 tubes to climb up the grow wall and water each individual plant for a dispersed watering system. After the water pump, each tube branches off on either side of the grow wall and at each level they split onto each side of the level to water each plant. This also allows for enough room to manually water plants in case the system fails.

Team comments: Simple system for soil-based plating (which is what the client wants).

Part 2.C - Soil/Nutrient Solution and Planting Setup

Nicole

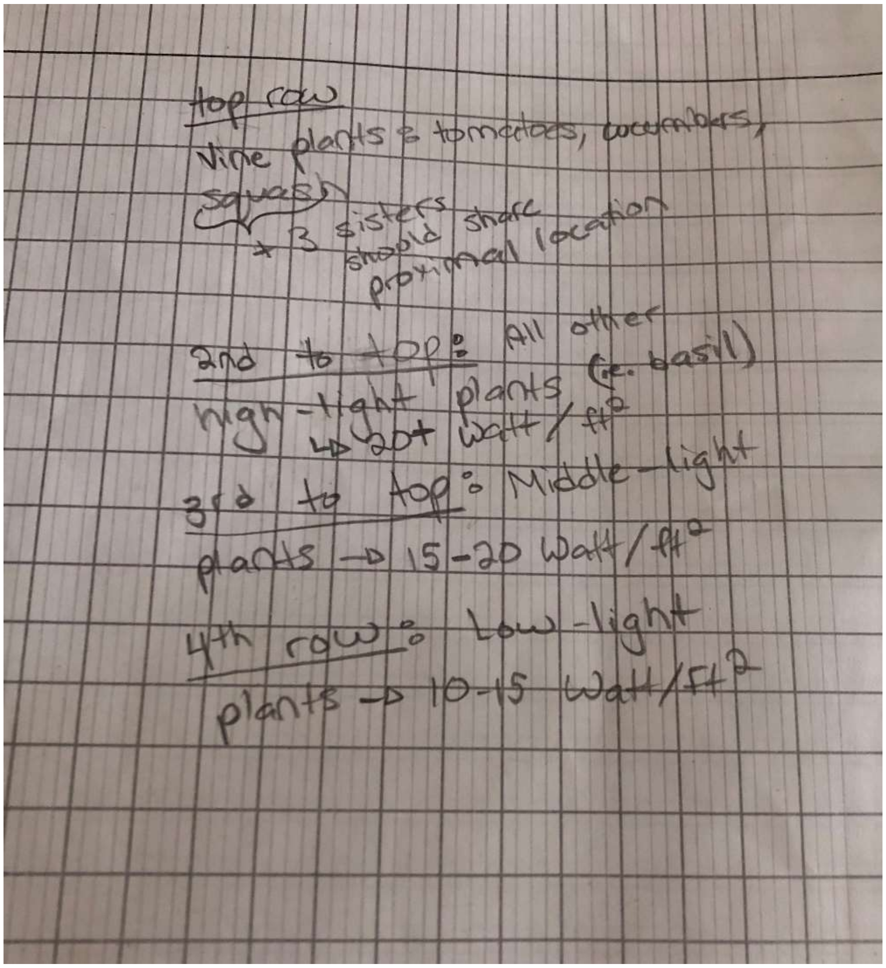


Figure 13: This is a description of the plant distribution among the four rows of the grow wall. The plants have been separated by light requirements, seeing as the watering frequency and pressure can be altered for individual sprinkler. Additionally, vine plants will be installed on the top row because they can grow up to 20 inches in height. Potting arrangements consist of one large pot/tray per row of the grow wall. One tray can typically fit three planting zone columns (zones per row vary largely depending on the plant type in question).

Team comments: Ordering in terms of light is a good idea. We will however need to make sure that plants like squash are not too elevated or awkward to remove once fully grown.

Alec

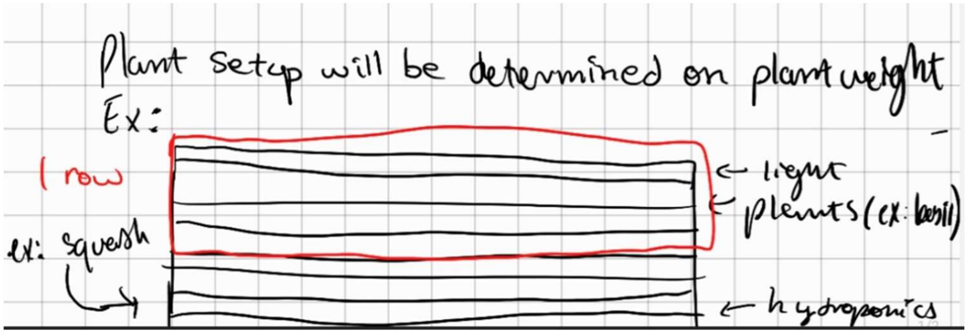


Figure 14: As mentioned in Figure 14, the plants will be arranged in terms of weight in my solution. This will be much more convenient for the crew to take care of and eventually removing these plants, that can get quite heavy. For example, the bottom layer (which again consists of the hydroponics layer, a gap for plant growth and the grow light layer) will contain vegetables like squash and perhaps the upper one could have basil, both plants that are very important to the client.

Team comments: Very smart and simple design which will help satisfy the client

Khalid

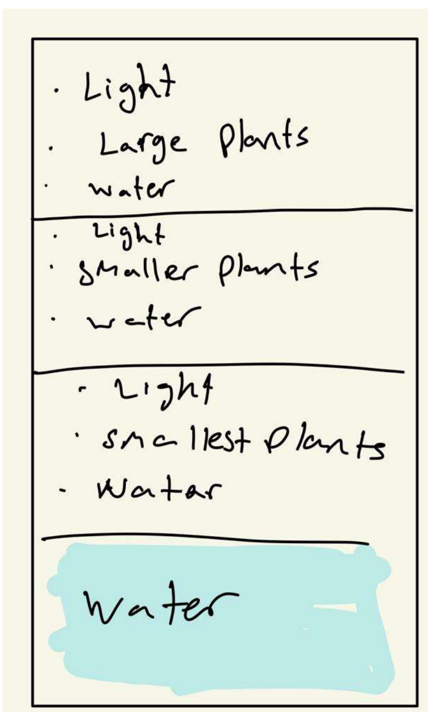


Figure 15: The largest plant will have the largest space to grow in the top of the wall and as we go down the space decreases.

Team comments: This idea is good because it allows for large growth room for large plants. A strong base would have to be added to support the heavier plants though.

Matas

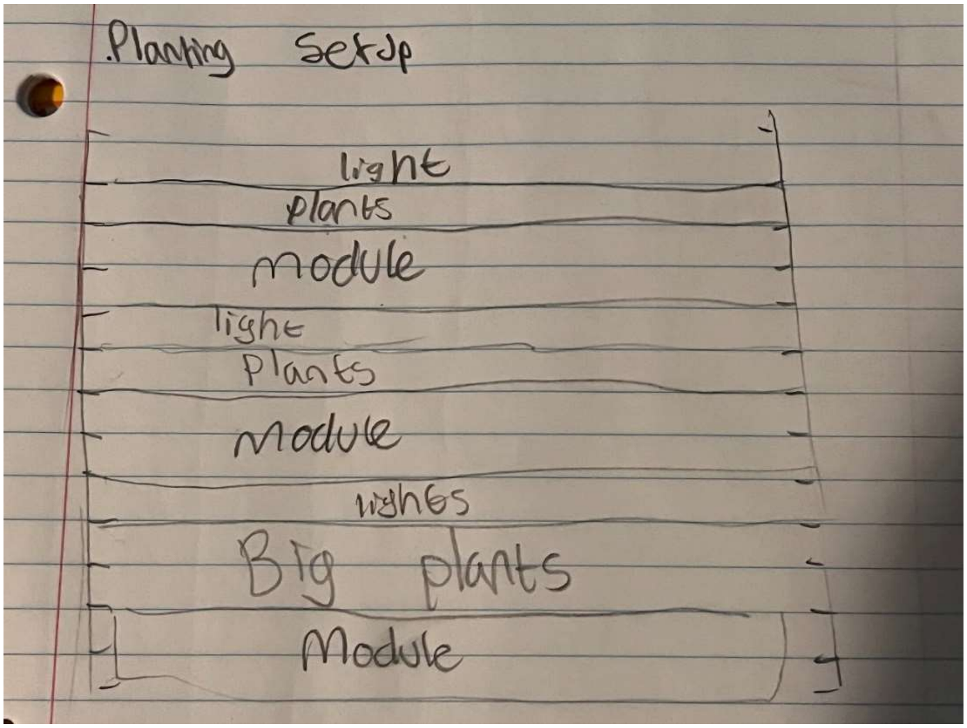


Figure 16:

This is an example setup for the grow wall. Since the modules are modular, the user can use any amount of modules they want. If the user wants to grow smaller plants (herbs), they would be able to use more modules to fit more plants. If they wanted to grow larger plants, less modules could be used.

Team comments: Great idea, adding a storage would be nice and more helpful

Cyrille

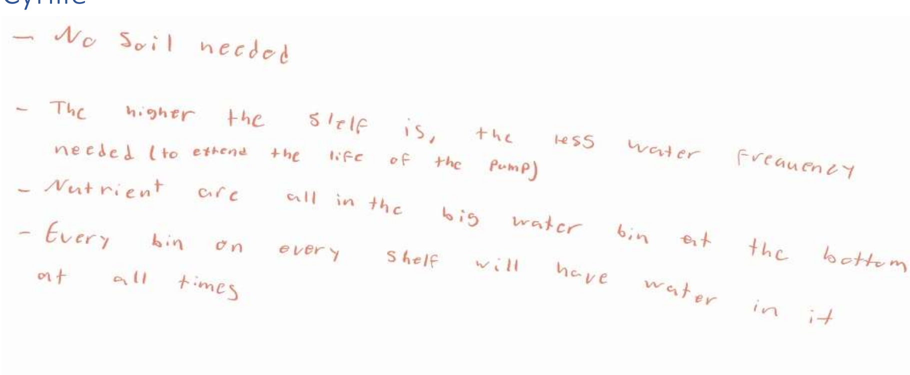


Figure 17: These are optional rules to follow for ease of use. Water frequency = times needed to add water per week. Some plants need to be watered every day and some every week. This is to extend the life of the pump (especially since it's one pump for all shelfs)

Team comments: This idea looks practical but could mean high maintenance and attention

Jacob

Planting setup

Top Row: plants in small pots that do not need much light. ie ; herbs and spices

2nd Row: plants in medium sized pots that do not grow too tall (past 2ft) and that could invade other plants. ie; zucchini, small tomatoe plants.

3rd Row: plants in medium sized pots that do not grow too tall (past 2ft) and that could invade other plants. ie; cabbage, cucumbers, carrots.

Bottom Row: plants are in a planters box with lots of room for roots to grow and sufficient height to grow. ie; big tomatoe plants, squash, melons.

Figure 18: Since the client wants simplicity and a great variety of plants to grow, certain plants need more room than others. Therefore, in this design there is dedicated planters' box on the bottom row to combine all the larger plants that the client wants. In the other levels, the medium plants have 2 levels with sufficient light and individual pots. And the top row is meant for smaller plants that may not require as much light.

Team comments: Easy and simple design.

Part 3 – Solution Combinations

The following three solutions are combinations of the designs above. The part that is utilized from the previous design is stated by the authors' name and the labelled part.

Solution 1:

Grow Light: Nicole and Jacob

Hydroponics/Irrigation: Alec

Soil/nutrient solution and planting: Matas

Solution 2:

Grow Light: Cyrille

Hydroponics/Irrigation: Matas

Soil/nutrient solution and planting: Jacob

Solution 3:

Grow Light: Alec

Hydroponics/Irrigation: Khalid and Nicole

Soil/nutrient solution and planting: Cyrille

Selection:

Better	Midrange	Worse	Satisfies	Does Not Satisfy

Table 1: Selection matrix for the 3 solutions presented above

Specifications	Solution 1	Solution 2	Solution 3
Modular hydroponics	Midrange	Better	Better
Water requirements of each plant is met	Better	Midrange	Midrange
Expandable system	Better	Better	Midrange
Cost-friendly	Worse	Midrange	Better
User friendly and child-safe	Midrange	Better	Worse
Environment friendly	Midrange	Better	Midrange
Transportable (i.e. parts easily carried by 2 people and a minivan)	Midrange	Midrange	Worse
Dimensions within range	Satisfies		
No fertilizer (Natural)	Better	Midrange	Worse
“three-sisters” vegetables and other plant compatibility respected	Worse	Better	Midrange
Manual operating system	Better	Better	Midrange
Traditional Gardening practices	Does not satisfy	Better	Does not satisfy
Aesthetic	Better	Worse	Midrange

Part 5

Better	Midrange	Worse

Table 2: A weighted selection matrix for the 3 solutions presented above

Specifications	Weight	Solution 1	Solution 2	Solution 3
Modular hydroponics	5	4	5	5
Water requirements of each plant is met	5	5	4	4
Expandable system	1	1	1	0
Cost-friendly	3	1	2	3
User friendly and child-safe	3	2	3	1
Environment friendly	2	1	2	0
Transportable (i.e. parts easily carried by 2 people and a minivan)	5	4	4	3
Dimensions within range	4		2	
No fertilizer (Natural)	5	5	4	3
"three-sisters" vegetables and other plant compatibility respected	4	2	4	3
Manual operating system	3	3	3	3
Traditional Gardening practices	5	1	5	1
Aesthetic	3	3	1	2
	Weighted Sum (48)	35	**39**	31

Final Solution Concepts

We have decided to come up with a solution for both systems to show the client on her next meeting for her to pick the best one.

Fully Hydroponic system

Grow Light: Mix of Jacob, Matas and Cyrille

Hydroponics/Irrigation: Mix of Nicole, Khalid and Alec

Soil/nutrient solution and planting: Mix of Alec and Nicole

Traditional automated system

Grow Light: Mix of Nicole and Alec

Hydroponics/Irrigation: Mix of Jacob and Matas

Soil/nutrient solution and planting: Mix of Jacob, Matas and Alec

References

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