GNG1103

Design Project User and Product Manual

Environmental Monitoring Building

Submitted by:

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Table 1. Acronyms

Acronym	Definition
ADA Standards	Americans with Disabilities Act
AOPFN	Algonquins of Pikwakanagan First Nations
BOM	Bill of Materials
CAD	Computer Aided Design
CCOHS	Canadian Centre for Occupational Health and Safety
IES	Integrated Engineering Software
PLA	Polylactic Acid

Table 2. Glossary

Term	Acronym	Definition
AutoCAD	AutoCAD	AutoCAD is a 2D and 3D computer-aided design (CAD) software application for desktops.
SolidWorks	SolidWorks	SolidWorks is a 3D design and engineering software.
3D Printing	3D Printing	3D Printing is a method of creating a three dimensional object layer-by-layer using a computer created design.
Prototype	Prototype	A prototype is a first, typical or preliminary model of something from which other forms are developed.
Guardians	Guardians	The Guardians are the employees who will be going out into the field, gathering the samples and bringing them back to the lab to process/analyze them.

1. Introduction

The User and Product Manual for the Environmental Monitoring Building, designed for the AOPFN (Algonquin of Pikwakanagan First Nations). with considerations of cultural, social, economic, and ecological impacts. This document presents the culmination of research and development that Green Engineering Solutions did to create a feasible prototype that aligns with the clients' needs. The document's goal is to assist users in understanding the progression of the prototypes and how to utilize the various features and functionalities of the environmental monitoring building.

The environmental monitoring building is envisioned as a platform to effectively observe the environment and foster ecological and cultural sustainability and growth. Assumptions are made regarding users' familiarity with laboratory equipment and environmental monitoring practices. It is also assumed that users have access to the necessary resources and infrastructure to adequately construct and operate the facility. The clients provided their needs and suggestions for the building, however, all other features are at the discretion of Green Engineering Solutions.

This document has been organized into several sections for organizational and comprehension ease. The contents of this document include: relevant figures, tables, and acronyms; an introduction; an overview; important system-subsystem information; BOM; maintenance and support information; product documentation; conclusions and recommendations; and any external resources used that contributed to the final prototype. This manual is designed for a diverse audience, including but not limited to those who will build and operate the building. The safety of users is cardinal and all regional guidelines must be followed accordingly. Additionally, privacy considerations are addressed, as shown in the responsible handling of data collected through Green Engineering Solutions and throughout the maintenance of confidential research and findings. By following this guide, users can maximize the potential of the Environmental Monitoring Building as specified by Green Engineering Solutions.

2. Overview

A need exists for the Guardian Program to build an environmental monitoring building that provides sustainability and long-term viability. The building will be used to process and analyze plant/animal samples to monitor the health of the environment. Some requirements of the building are; a multipurpose lab space where the sample processing will take place, sufficient office/workspace for all employees and visitors, a kitchenette/breakroom for the employees, storage space (including dry/frozen storage space) for samples as well as lab equipment, a loading dock for sample transfer, and storage space for company vehicles when not in use. The client expressed the need for the building to reflect the Algonquins of Pikwakanagan First Nations culture and to have the potential to be a pillar of the community that entices government funding.

Our proposed environmental monitoring building is differentiated from other proposals by its exterior appearance. The building is designed to look like an overturned birch bark canoe, as the birch bark canoe is a pillar in the Algonquin culture. Aside from the building's aesthetics, it has been designed to function efficiently at a low cost. In the design, we have slanted the roof to provide space for solar panels as well as to provide the opportunity to install a rainwater collection system in the future. These two additions will prove to save the Guardians money and extend the building's lifespan.

Final Prototype:

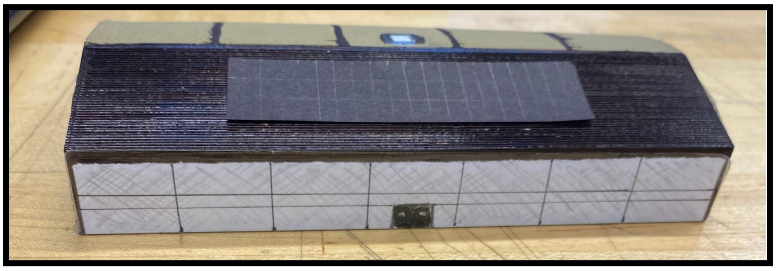

Figure 1. Front view of the building, including the complete wall of windows, solar panels on the roof and the main door.

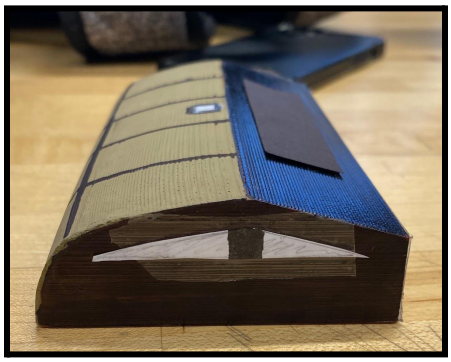

Figure 2. Side view of building demonstrating overturned canoe structure and showing the solar panels on the roof.

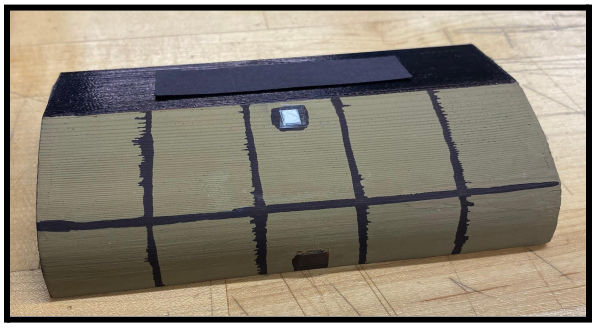

Figure 3. Back view of building demonstrating overturned canoe structure, including skylight on roof.

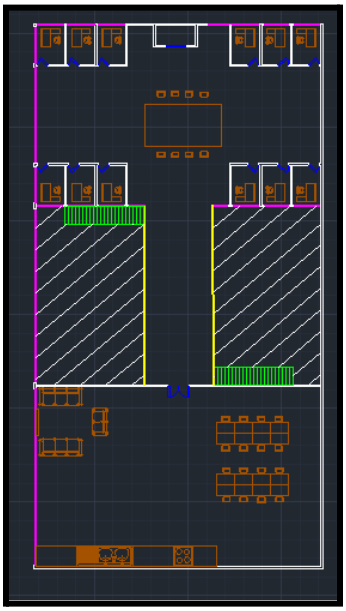

Figure 4. Second floor of building, including office spaces, elevator and kitchenette.

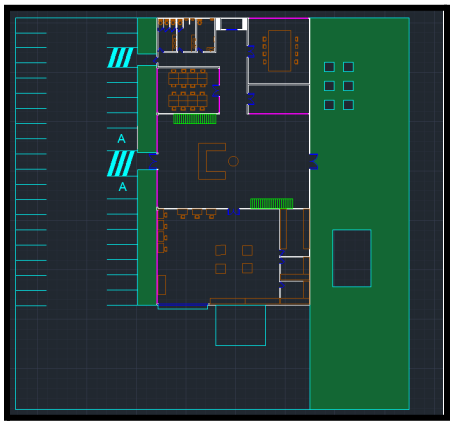

Figure 5. First floor of building, including multipurpose workspace, foyer, shared workspace, boardroom, elevator, bathrooms, parking lot and outdoor space.

One of the key features of the building is the multipurpose workspace where the Guardians will process and analyze the collected samples. The design also includes a sufficient number of private offices for employees that require an office everyday, as well as shared office spaces for employees that do not require their own office. Additionally, there is an outdoor space for large community or cultural gatherings to be hosted by the Guardian Program.

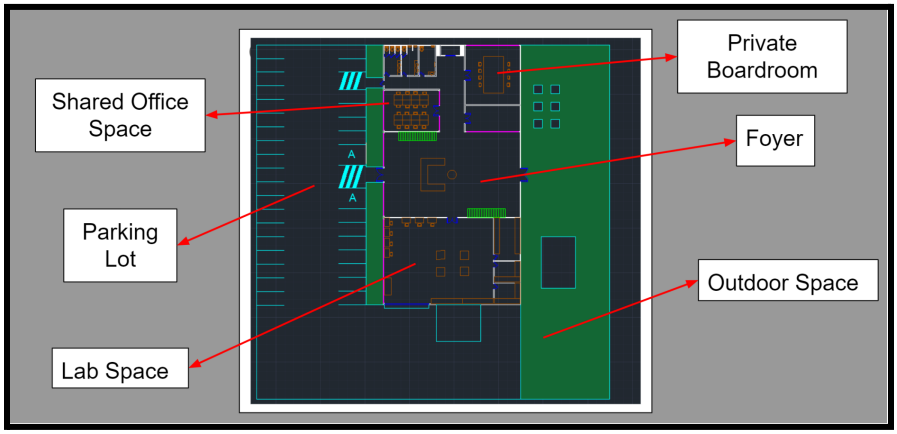

Figure 6. Labeled first floor floor plan of the Environment Research Building

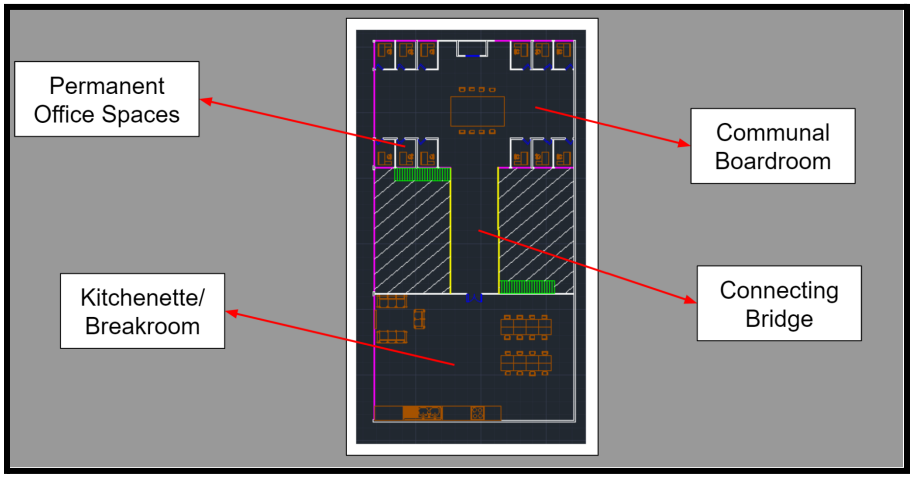

Figure 7. Labeled second floor floor plan of the Environment Research Building

2.1 Conventions

Due to this product being a building, there are no stylistic and command syntax conventions used within the document and no actions required on the part of the reader.

2.2 Cautions & Warnings

Due to this product being a building, there are no cautions or warnings that the user should know about before using the prototype.

3. Getting Started

3.1. Configuration Considerations

For the physical prototype, the 3D printed model of our building captures only the exterior aesthetics and sustainability features of our proposed design. The exterior showcases a contemporary architectural style, enhanced by carefully applied paint to simulate the envisioned colour scheme. Solar panels are integrated into the model emphasizing our commitment to sustainability. Also one side of the building features a distinctive canoe-shaped roof with a skylight, adding a culturally inspired and visually striking element to the design. Please reference figure 1, 2 and 3 for pictures of our final prototype

For the final software prototypes, we designed our building's floor plan using AutoCAD to create a dynamic and functional environment. The lab space features a garage door for outdoor access to the lean-to along with collaborative workstations and an extra storage room for equipment along with a freezer room for samples. The lobby area, designed to be welcoming, serves as a central hub for visitors and to the side there are private boardrooms with audio-visual equipment for meetings and presentations. On the second floor, a collaborative workspace with an open layout fosters creativity, complemented by private offices along the contour for focused work. Additionally, across the connecting bridge there is a versatile kitchenette, serving as both a functional kitchen and a breakroom, encouraging informal communication and relaxation. The configuration of these spaces is purposely designed to optimize collaboration, productivity, and comfort throughout the building. We also created a 3D model for our building using solid works so the client could see what the interior of the building would look like.

3.2. User access Considerations

The building prototype prioritizes inclusivity by incorporating a range of accessibility features tailored to diverse user groups. For employees with mobility challenges, elevators and ramps are provided, with wide doorways to accommodate mobility aids. Since this building is also meant to be a place where the community can gather, we accommodate parents with strollers by incorporating wide entrances and family-friendly spaces, and elderly employees benefit from handrails and strategically placed seating. These features ensure that the building is accessible to all, fostering a welcoming and inclusive environment where users with different abilities can navigate.

3.3. Accessing/Setting up the System

To activate the building's systems, the users would need to power on the main source and follow instructions on the central control panel, this would typically be located in the lobby or a designated area. For user access, new individuals would need to contact the building administrator or IT department to obtain a unique user ID, providing required information for registration. Logging in involves inputting the assigned user ID and initial password on a

computer terminal or connected device. Password management includes the ability to change passwords through the system settings, requiring users to input the current password and create a new one following specified complexity requirements.

3.4. System Organization and Navigation

As you enter the building, the lobby serves as a central hub, featuring clear signage directing you to key areas such as the lab space and private boardrooms. On the first floor, accessible via the two staircases or the elevator located on the side of the building, you'll find the high-tech lab and its connected storage room, while private boardrooms and a shared office space are conveniently located on the side of the lobby area opposite to the lab space. The building's only restrooms are situated on the first floor and are easily accessible. To reach the collaborative workspace and private offices on the second floor, use the designated staircases or the elevator. Additionally, the kitchenette and break room are located on the second floor.. Throughout the building, the staircases and the elevator ensure accessibility for everyone, including those with mobility challenges. Emergency exits and safety information are clearly marked, and digital displays or interactive kiosks provide real-time information on room bookings and events. A user-friendly building map is available near elevators and in the lobby, offering a comprehensive overview of the building layout.

3.5. Exiting the System

Exiting the building is a straightforward and secure process with multiple exit points strategically placed for convenience and safety. The main lobby boasts two well-marked exits, providing occupants with direct outdoor access. An additional emergency exit, located near the elevator and boardrooms, offers an alternative route in case of emergencies or obstruction of the main exits. For those in the lab space, a garage door facilitates quick outdoor access, serving as a convenient exit point. Clear signage throughout the building guides individuals to the nearest exit, and ramps, along with a centrally located elevator, ensure accessibility for everyone, including those with mobility challenges.

4. Using the System

4.1. Lobby

From the parking lot, employees and visitors enter the lobby of the Environmental Monitoring Building. The overall design of the lobby is meant to be an open concept floor plan in order to create an inviting space for guests entering the building. From the main area of the lobby, there is a set of stairs on either side which can be used to access the second floor. The stairs lead to a connecting bridge on the second floor that overlooks the entirety of the lobby. To the right of the lobby is the access to the lab space. To the left of the lobby is a hallway from which one can access the bathrooms, the shared office space and the main boardroom. At the end of this hallway is an accessible elevator that leads to the second floor. Opposite to the front entrance, is the exit of the building which leads to the multipurpose outdoor space.

4.2. Lab Space

In this Environment Monitoring Building, the lab space is the primary work area for the Guardians. In this space, Guardians can load and unload samples via the loading dock which is located outdoors, adjacent to the parking lot. It provides direct and efficient access into the lab and it is large enough to accommodate two Chevrolet 1500 trucks at a given time. In order to safely and effectively transfer the contents from the trucks to the lab space, there are four, 5 ft x 5 ft, mobile tables. These tables can be attached to one another using a locking mechanism to provide more workspace. Once the samples are processed, if needed, they can be sterilized and stored in a 24 ft x 15 ft walk-in freezer. Additionally, there are two smaller, 12 ft x 15 ft, storage rooms 12 ft x 15 ft designated for handheld lab equipment, automotive accessories, as well as samples. During processing and experimentation, if there is a need to document data or access digital files, there are 7 workstations with monitors that line the perimeter of the lab.

4.3. Outdoors

4.3.1. Multipurpose Outdoor Space

Found behind the building, is the multipurpose outdoor space. It can be accessed through the lobby or by the parking lot. The space is designed to be used by the Guardians for any experiments or tasks that need to be done outside, for example fur handling which is the process of removing the hide from the jacket. This space is equipped with a pavilion which offers a sheltered space to work, as well as 6 public picnic tables. Furthermore, this space can be used by the community of Pikwakanagan for cultural events and community gatherings.

4.3.2. Parking Lot

For employees and visitors who choose to drive to the building, a parking lot has been included into the design of the building. The parking lot is adjacent to the front of the Guardian

Building. The lot includes 32 regular parking spots as well as 2 accessible parking spots. For company vehicles, a lean-to is found next to the loading dock, by the lab. The lean-to is large enough to store both of the Chevrolet 1500 trucks owned by the Guardian Program and provides shelter from the elements when the vehicles are not in use.

4.4. Shared Office Space

The shared office space is available for employees who do not come into work everyday. This space can accommodate 16 people and contains desks and chairs that employees can utilize for the day. The shared office space can be accessed from the main floor.

4.5. Permanent Office Space

In the Environmental Monitoring Building there are 12 permanent office spaces found on the second floor. These office spaces are designated for employees who come into work everyday and who require a private space to complete their tasks. Each office has a desk and chair, along with a monitor and storage space. To promote group work, a shared workspace in the centre of the office area has been included.

4.6. Break room & Kitchenette

Opposite to the permanent office spaces is the break room and kitchenette. This space is available for the employees for their breaks. The goal of having this space on the second floor is to be in close proximity to the offices and to provide a certain degree of privacy from activities on the main floor. Included in the break room is a kitchenette, equipped with a hot plate, refrigerator, sink and storage space. There is also available seating where employees can eat or socialize.

5. Building Maintenance

5.1. Solar panel maintenance (Emerick 2023)

5.1.1. Keep solar panels clean,

Make sure dirt,snow, and other debris are removed from your solar panels in order to keep them running.

5.1.2. Trim trees,

Trees and other foliage in the nearby area may need to be trimmed periodically so that they do not block the sun from reaching the solar panels.

5.1.3. Observe solar panels for deterioration,

Damage to the solar panels and other components (wires,fixtures etc…) because of any reason should be fixed by contacting a professional solar installer so that you can arrange for repairs and replacement of broken solar panels.

5.1.4. Monitor performance,

If a noticeable drop in performance is noted which can be observed by looking at electricity bills, monitor system, etc… If a drop in performance is noted, it's recommended to contact a professional solar installer to schedule maintenance.

5.1.5. Scheduled Maintenance,

Schedule regular Maintenance every 2-4 years with a professional solar installer so that it is ensured that your solar system is working to its best possible degree, and so that any problems are found early.

5.2. Building Maintenance

5.2.1. Parking Lot and outdoor areas,

The parking lot should be observed for any cracks and holes that might appear, if cracks and holes do appear, contact a professional contractor

who specializes in tar repair so that holes and cracks can be filled so as to avoid damage to cars and other vehicles. Outdoor grass areas should be trimmed to a height determined by the owner of the building, weeds should be removed to avoid the risk of potential damage to employees and pedestrians walking in the outdoor area. Landscaping Professionals are recommended for maintenance of the outdoor area.

5.2.2. Common spaces,

Common spaces such as offices, lobby areas, and kitchens should be regularly cleaned so that clutter and debris are not present in the common spaces. It is important that windows are cleaned and that food stuffs stay within the kitchen area so that if a mess occurs it can be cleaned without the risk of contaminating offices and lobby spaces as well as the lab. Trash and recycling should be stored in their own separate bins and left out for collection

5.2.3. Lab space,

The lab should be regularly maintained so that it is up to the safety standards required for its operations which can be referenced from the government of Canada's website under *Canadian Biosafety Standard,Third edition* which will cover required safety and maintenance protocols needed.

6. Production Documentation

6.1. Bill of Materials

Table 3. Bill Of Materials for the Environment Monitoring Building

Item (Quantity)	Description	Cost (CAD)
Cost of Environment Monitoring Building/ft^2 (12,316.5 ft^2)	Average cost to build the building.	$3,694,950.00
Cost of Pavement/ft^2 (18,238.37 ft^2)	To pave the parking lot.	$173,575.55
Road Paint (19 L)	Used to create the parking spaces.	$500.00
Garage Door (2)	For access to the lab from the garage door	$3000.00
Pavilion (600 ft^2)	For sheltered outdoor workspace.	$103, 290.00
Lean-to (559ft^2)	For company vehicle storage.	$83,258.00
Solar Panels (72 - 6 x 12 grid)	To provide the building with renewable energy.	$120,000.00
Doors (34)	For the rooms (offices, bathrooms, storage spaces, etc in the building.	$37,400.00
Windows/Glass	For the wall of windows on the front of the building, the skylight as well as any other glass panels.	$263,600.00
Total		$4,479,573.55

Table 4. Bill Of Materials for The Prototype

Item (Quantity)	**Description**	**Cost (CAD)**
AutoCAD	Software used to make the floor plans	$0.00
SolidWorks	Software used to make the 3D renderings of the interior and	$0.00

	exterior	
PLA filament (111g)	Material used by the 3D printer (10 cents/gram)	$11.10
Krylon Spray Paint Primer (1)	Used to paint the 3D model	$13.97
Crayola Paint Kit (1)	Used to paint the 3D model	$8.98
Black Construction Paper (1)	Used to make solar panels for the 3D model.	$6.26
Total:		$40.31

6.2. Equipment List

Table 5. Equipment List

Equipment	Prototype (I, II or III)	Use (Purpose for creating the prototype)
AutoCAD	Prototype I	To create the floor plans in 3D for the first prototype
Goodnotes	Prototype I	To create a conceptual drawing of the exterior of the building
Solidworks	Prototype II & Prototype III	To create the floor plans in 3D for the second prototype
Ultimaker 3D Printer	Prototype III	To print the physical 3D model of the final prototype

6.3. Instructions

To make the 2D floor plans of the Environmental Monitoring Building, AutoCAD, a modeling software, can be used. There are many softwares that can be used to create floor plans, however AutoCAD is the preferred choice as it is used in the industry and has tools such as auto dimensioning, layering, and many command shortcuts that make the modeling process organized and efficient. Found below are the major dimensions of the floor plan. Use figures 4 and 5 as references when creating the floor plan.

Table 6. Dimensions for the Floor Plan

First Floor		***Overall***	
Description	**Dimensions**	**Description**	**Dimensions**
Lab Space	50 ft x 80 ft	Doors	3ft x 8 ft
Freezer Space	24 ft x 15 ft	Stair (length x depth x height of each step)	5 ft x 1 ft x 1 ft
Equipment Storage Space (x2)	12 ft x 15 ft	Overall Building Length	150 ft
Multipurpose Work Tables	5 ft x 5 ft	Overall Building Width	80 ft
Exhibit Room	15 ft x 32 ft	Overall floor height	10 ft
Lean To	21.5 ft x 26 ft	***Second Floor***	
Loading Dock	3 ft x 26 ft	Office (x12)	11 ft x 8 ft
Shared Office Space	24 ft x 32 ft	Kitchenette & Break room	50 ft x 80 ft
Main Parking Lot	152 ft x 64 ft	Connecting Bridge	50 ft x 18 ft
Parking Lot by the Lab	54 ft x 154 ft	Office (x12)	11 ft x 8 ft
Parking Spaces	8 ft x 16 ft (regular) 12 ft x 16 ft (accessible)		
Outdoor Space	206 ft x 52 ft		

For the 3D renderings of the interior and exterior of the building, a different CAD software called SolidWorks can be used. Solidworks is known to be compatible with 3D printers and, as with AutoCAD and floor plans, it is efficient and user friendly when it comes to creating 3D models. The 3D model of the exterior of the building can be printed using an Ultimaker 2+ printer. First, the model must be downloaded as a STL file and sliced using Cura, a 3D slicer. The model shown below is printed using PLA and a 0.8 nozzle.

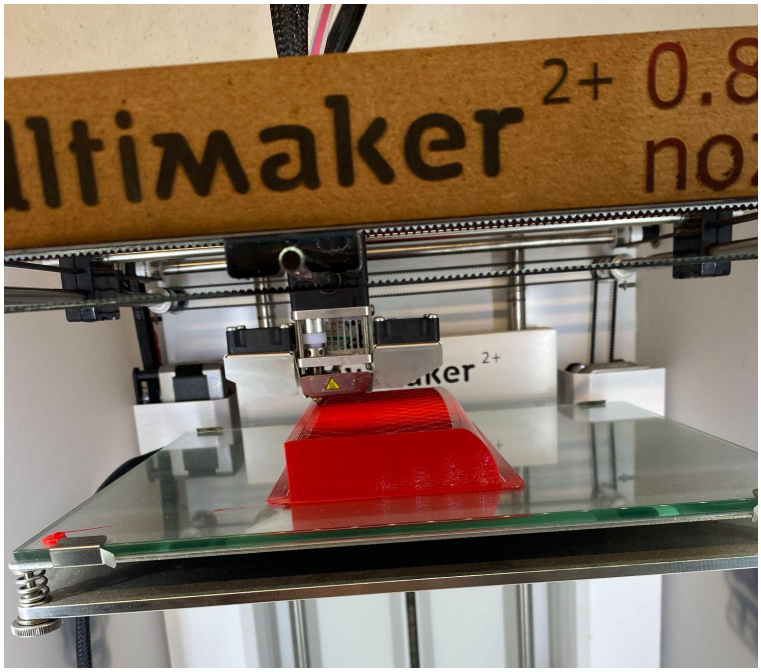

Figure 8. Exterior 3D model of the building in the process of being printed using an Ultimaker 2+ printer.

6.4. Testing & Validation

Building Capacity Test: This test was conducted on the detailed design drawing. The goal of the test was to see if 20 people could comfortably fit inside of the building. To determine the amount of people that could fit inside the building, the total square footage of each space inside the building was divided by the amount of space 1 person takes up, with the assumption that 1 person needs a minimum of 3 ft^2 of space.

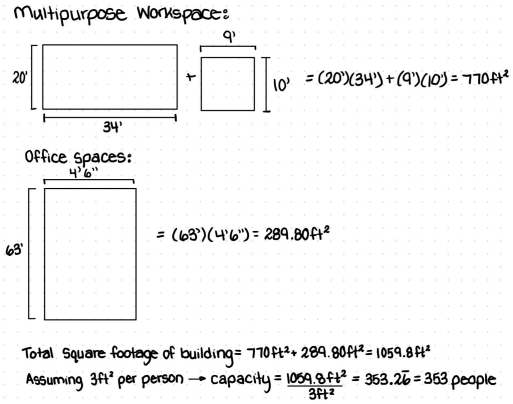

Figure 9. Schematic for Building Capacity Test

From this calculation, it was determined that the building could fit a maximum of 353 people inside. Therefore, the building could easily fit 20 people inside comfortably. Later iterations of the floor plan had a much larger square footage compared to the detailed design drawing, so the building capacity of the final prototype is much larger than the detailed design drawing.

Surveying:

Survey 1: This survey was conducted on the detailed design drawing. For this survey, we asked for each 2D design of the layout to be ranked, and for the participants to elaborate on the reasoning behind their ranking.

Link to survey: Green Engineering Solutions - Survey 1

Question 1: How would you rank the layout of the parking lot? (ie. the convenience of the layout)

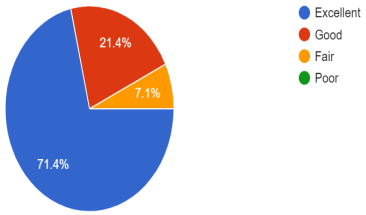

Figure 10. Survey 1, Question 1 responses

Many participants supported the layout of the parking lot, the number of parking spots, as well as the logical placement of the accessibility parking spot. One participant commented in support of the accessibility of the loading dock to the building.

Question 2: How would you rank the general floor plan? (ie. the convenience of the placement of each room).

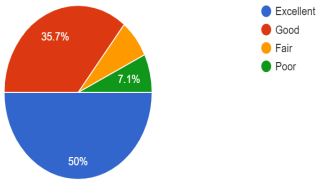

Figure 11. Survey 1, Question 2 responses

Many participants supported the general floor plan, however one participant emphasized the lack of bathrooms. Additionally, another participant said that the layout of the rooms gives a positive, communal feel to the building.

Question 3: How would you rank the layout of the laboratory? (ie. the convenience of the layout).

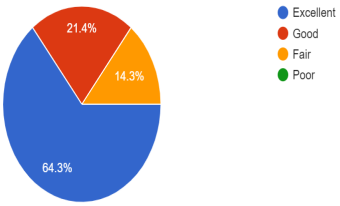

Figure 12. Survey 1, Question 3 responses

Most participants supported and commented on the mobile workstations, saying that they are very versatile. One participant emphasized the convenience of the large garage door connecting the workspace to the outdoor space. However, another participant suggested expanding the loading dock to accommodate more than one truck at a time.

Question 4: How would you rank the layout of the offices? (ie. the convenience of the layout).

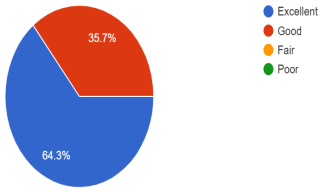

Figure 13. Survey 1, Question 4 responses

Many participants commented in support of having an open concept board room in the center of the offices, saying that it would initiate collaboration. Other participants stated their support for the extra work spaces for employees to use when necessary.

Survey 2: This survey was conducted on prototype 1. For this survey, we asked participants to rank the 2D design of the layout (floorplans) from excellent to poor. We also asked participants what they liked/disliked about the floorplans and what changes/improvements they would make. Finally we asked participants what they thought about the exterior design/architectural style and what changes/improvements they would make.

Link to survey: Green Engineering Solutions - Survey 2

Question 1: How would you rank the general floor plan? (i.e. the convenience of the placement of each room).

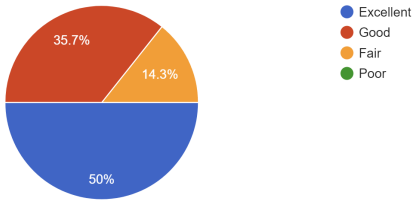

Figure 14. Survey 2, Question 1 responses

Most of the participants supported the layout of the general floor plan. A few participants felt as though there was a decent amount of wasted space. Other comments included possibly having a bathroom upstairs, having another set of stairs, and the breakroom being too big.

Question 2: How would you rank the layout of the offices? (i.e. the convenience of the layout)

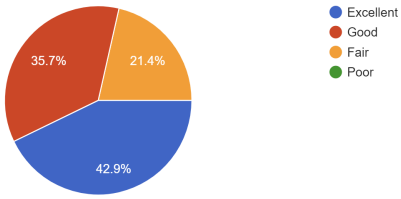

Figure 15. Survey 2, Question 2 responses

Most of the participants supported the layout of the upstairs offices and the meeting area. Most participants liked the central meeting area and thought it was great for collaboration while a few others were unsure about it. Other comments were made about liking all the windows and having a lot of wasted space.

Question 3: How would you rank the layout of the laboratory? (i.e. the convenience of the layout).

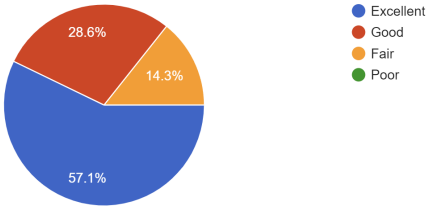

Figure 16. Survey 2, Question 3 responses

Most of the participants supported the layout of the laboratory. Comments were made about liking the mobile workstations, if there are any safety kits, fire extinguishers, moving the loading dock, and if there is enough storage.

Question 4: What do you like/dislike about this design and its architectural style? Do you think that this exterior design will mesh together well with the interior design (the floor plans shown above in a previous question)?

If you do not think that this exterior design will work well with the interior design, what would you change to improve the exterior design?

Responses:

- ➔ - I think it looks good. I just think perhaps it should not be as flat on the side with the glass windows(maybe have a slanted roof part to it?)
- ➔ - This design is a great representation of the Algonquin culture! Very unique and interesting exterior design.
- ➔ - Yes I think it's a great concept!
- ➔ - Maybe add a skylight at the top to let in more light on the other side
- ➔ - I like the canoe style and the glass wall. A unique mix of modern and traditional architectural styles. My only concern is with the ceiling height of the second floor on the side with the roof slant.
- ➔ - I really like that it's supposed to represent a canoe. I also like how the front of the building it glass so it lets in a lot of natural sunlight
- ➔ - Love the canoe aspect, not sure if having an all glass front is smart tho, if there is a storm or something it would be very vulnerable.

Carbon Emissions Test: This test was conducted on the detailed design drawing to determine the amount of carbon emissions that the building would produce.

https://www.istructe.org/IStructE/media/Public/TSE-Archive/2020/Carbon-footprint-benchmarking-data-for-buildings.pdf

Based on our research from the site stated above, the average carbon footprint for a commercial building is 100-600 kg of carbon emissions per meter squared. This building was calculated to be approximately 1059.80ft^2, converting to 98.46m^2. This means that the carbon emissions of this building will likely range from 9846-59076kg.

Duration of Completion Test: To test the expected duration of the construction of this building, we will research the construction duration of other buildings similar in size and function. This will give us realistic expectations regarding our design process' length and our date of completion.

Based on our research, the average expected duration for constructing a commercial building is 2 to 8 months. However, a building of this size and function will take closer to 8 months to build.

Accessibility Test: For this test, certain accessibility requirements needed to be satisfied. In the parking lot, there needed to be at least 1 accessible parking space for every 25 parking spaces. It needed to be ensured that the building's entrances and room doorways were sufficiently wide to accommodate accessibility for individuals using wheelchairs, walkers, and other mobility aids. There needed to be an accessible washroom in the building. All facilities of the environmental monitoring building including the parking lot, outside area, first floor, and second floor needed to be connected by an accessible route for anyone to access.

According to ADA Accessibility Standards, the following requirements are satisfied by the environmental monitoring building:

- ➔ Total number of parking spaces provided in the parking facility (1 accessible parking space per 25 parking spaces)
- ➔ Accessible route to connect accessible facilities within the site (elevator)
- ➔ Accessible washroom
- ➔ Minimum door width of 32 inches

Storage Test: The storage test was conducted to determine how much handheld lab equipment can be stored in the storage rooms in the laboratory.

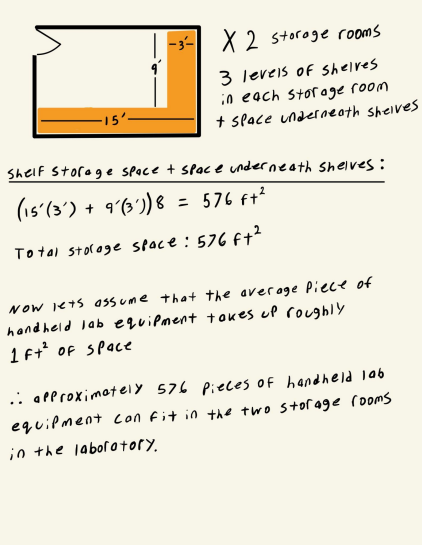

Figure 17. Schematic for Storage Test

Exterior Guardian Accessibility Test: The client expressed the need for there to be enough room for two trucks at a given time to pull into the loading dock with sufficient space to

load/unload samples. The client also expressed the need for both trucks to be able to park under the lean to with ample space for parking and getting in and out of the vehicle. There also needed to be enough space in the parking lot for both trucks to easily maneuver around the space to be able to pull into the loading dock and park under the lean to. This test was conducted on prototype 2 using the dimensions of a Chevrolet 1500 pickup truck.

Dimensions of a 2022 Chevrolet Silverado 1500 with a regular cab and a long box:

- ➔ Length: 229.7”
- ➔ Width without mirrors: 81.1”
- ➔ Likely around 130” if towing mirrors are being used. Minimum width will be at least 105.1” since truck mirrors are at least a foot wide.

Width of loading dock: 11’ 4” = 136”
Width of lean to: 19’ = 228”
Length of lean to: 14’ = 168”

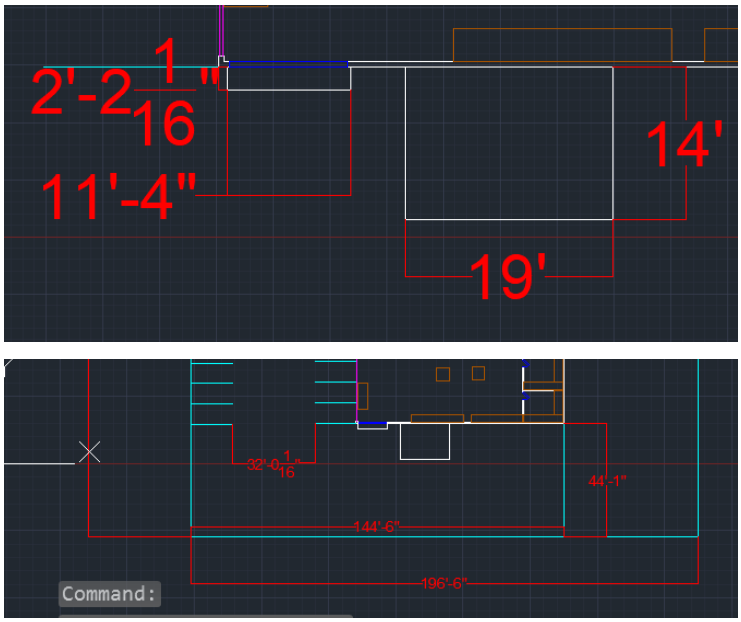

Figure 18. Schematic of Loading Dock for Accessibility Test

Comparing the width of the loading dock with the width of a Chevrolet 1500, only one truck at a time will be able to pull into the loading dock. Therefore the width of the loading dock will need to be increased to at least 25’ or even 26’ for sufficient space for two trucks to load/unload samples.

For the lean to, currently only one truck will be able to fit under it horizontally in the orientation shown above.

For the layout of the parking lot, it would be ideal for both trucks to park under the lean to horizontally in the orientation shown above.

Therefore a few changes need to be made. First the lean to needs to be moved to the right to allow for maneuver space between it and the loading dock. Secondly, the width of the lean to needs to be increased to around 21' 6" or 258" to allow the lean to to completely cover the trucks while parked and to make parking easier. Thirdly, the length of the lean to needs to be increased to around 26' or 312" to allow the lean to to completely cover the trucks while parked and to make parking easier.

The width of this portion of the parking lot will also need to be increased by 10' to allow for increased maneuverability.

Fire Safety Standards Test: For this test the layout of the building of prototype 2 was evaluated using the Ontario Building Code to ensure that there are "barrier free paths", and sufficient emergency exits to make sure that the environmental monitoring building adheres to fire safety standards in Ontario.

Barrier free paths:
The layout of the building is up to Ontario Building Code.

Sufficient emergency exits:
The layout of the building is up to Ontario Building Code.

Solar Panel Array Test: This test was used to evaluate the quantity of solar energy we expected to harness from the solar panel array on the roof.

Test results:

We plan to use standard 72 cell solar panels laid out in a 6 x 12 grid (72 total solar panels) on the roof. Individual solar cells are 6" x 6" squares, and 72 cell solar panels are laid out in a 6 x 12 grid. So the dimensions of 72 cell solar panels are roughly 39" x 77". These dimensions are not exact because they depend on the frame size of the solar panel used by the manufacturer.

Let's assume we are using 72 cell solar panels with an output rating of 375 watts (J/s) when direct sunlight is shining on the entire solar panel.

On a yearly average, Ottawa gets roughly 5.5 hours of sunlight every day. Since the latitude of Pikwakanagan First Nation is practically the same as Ottawa, let's assume that Pikwakanagan First Nation also gets roughly 5.5 hours of daily sunlight.

It is also important to note the orientation of the solar panels. Since we are in the northern hemisphere, the sun sits in the southern sky. So the solar panels on our roof need to be facing south to maximize their power output. The angle of the solar panels will also affect their power output.

$$375\ W\ (5.5\ h)\ =\ 2062.5\ Wh\ =\ 2.0625\ kWh$$

(average maximum daily energy output of one solar panel)

$$2.0625\ kWh\ (72)\ =\ 148.5\ kWh$$

(average maximum daily energy output of 72 solar panels)

$$148.5\ kWh\ (365)\ =\ 54,202.5\ kWh$$

(average maximum yearly energy output of 72 solar panels)

Therefore, the 6 x 12 solar panel array on the roof has an average maximum yearly energy output capacity of 54,202.5 kWh. In contrast, 10,000 kWh is around the energy required by a typical American household for all of its needs. So the solar panel array on the roof has the potential to power the Guardian building for all of its needs year round.

Keep in mind that this is the absolute maximum yearly energy output of this solar panel array. Solar panels are very inconsistent in their power output because of how many inconsistent factors play into the amount of sunlight that directly shines on the solar panels. Daily sunshine here in Canada can vary an incredible amount due to our position on the globe and the weather. In the summer days are long, so there is lots of potential for solar power. However, in the winter days are quite short and on top of that the sun rarely shines, so little solar energy can be harnessed. For maximum energy output, the ability to change the angle of the solar panels is very important in order to face the solar panels in the direction of the sun. In the summer the sun sits high in the sky, so the solar panels need to be flat with the roof. In the winter the sun sits low in the sky, so the angle between the solar panels and the roof needs to be increased. The solar panels also need to be clear of any obstructions such as trees to prevent shading.

Roof Drainage Test: This test was used to obtain a valuable preliminary insight of the roof's drainage capabilities based on the design and shape of the roof.

Test Results:

On one side our roof is angled down, while on the other side our roof is curved (concave down). As long as our roof is waterproofed appropriately, rainwater will consistently drain off the roof because of its shape. As for where rainwater will drain off after it drains off the roof, there are multiple options. For the non-curved side of the roof, rainwater could run directly off the roof onto the parking lot and then into storm drains. An eavestrough could also be installed and rainwater could either run into the sewer system or a rainwater collection device. A large eavestrough-style runoff that drains into the sewer system or the ground away from the building will need to be installed on the ground right at the bottom of the curved section of the exterior of the building. This is absolutely necessary because of the way rainwater will drain off the curved roof and the fact that there is no parking lot on this side of the building. Rainwater will drain directly into the ground right next to the foundation of the building here without proper drainage runoff. This would be a serious problem as rainwater would seep into the foundation and severely affect the structural integrity of the building.

7. Conclusions & Recommendations for Future Work

In all, making the Environmental Monitoring Building was a learning experience for Green Engineering Solutions that ultimately culminated in a final prototype that effectively included the clients' needs. It is evident that cultural, environmental, accessibility, and feasibility were greatly taken into consideration when developing the final prototype. Going forward, Green Engineering Solutions will no longer be contributing to the Environmental Monitoring Building. However, we encourage future groups that may work on this project to reinforce the strong conceptual foundation that has been built. Starting with the exterior, the rainwater collection system, lean-to, and outdoor pavilion have not been finalized. There is an opportunity to change the designs in the spaces that we have designated for them respectively. We suggest incorporating local artists and craftspersons so that the community furthermore engages in the building. Additionally, the interior of the building does not have any wall/ceiling colours or designs other than the ribs inside of the canoe section. We endorse experimenting with different art work, paints, colours and designs that properly suit the building's purpose. Moreover, interior furniture and decorations have not been finalized and are up to the discretion of future groups in strong collaboration with the AOPFN guardians. Although time was a constraint, given the scope and depth of our project, Green Engineering Solutions completed the task at hand. If the group had a few more months to work on the project, we would have planned a field day, in-person or via video-call, to connect with local residents and get a tour from the clients of the proposed property. We believe that one more iteration of the floor plan and exterior after this 'field day' would have helped us get even closer to aligning our designs with the clients' vision. In conclusion, Green Engineering Solutions proudly presents their final prototype of an Environmental Research Building that reflects our best efforts to align designs with clients' needs.

8. Bibliography

Emerick Dean. (2023, April 25). Ontario Solar Installers: Benefits, Process, And Maintenance *link*

9. APPENDIX I: Design Files

Table 7. Referenced Documents

Document Name	Document URL	Issuance Date
Link to Makerepo	GNG1103- Green Engineering Solutions | MakerRepo (makerepo.com)	
Deliverable A: Team Contract & Project Management Template	Deliverable A	24 September, 2023
Deliverable B: Needs Identification & Problem Statement	Deliverable B	29 September, 2023
Deliverable C: Design Criteria	Deliverable C	8 October, 2023
Deliverable D: Conceptual Design	Deliverable D	20 October, 2023
Deliverable E: Project Plan & Cost Estimate	Deliverable E	3 November, 2023
Deliverable F: Prototype I & Customer Feedback	Deliverable F	9 November, 2023
Deliverable G: Prototype II & Customer Feedback	Deliverable G	12 November. 2023
Deliverable H: Prototype III & Customer Feedback	Deliverable H	26 November, 2023
Deliverable I: Design Day	Deliverable I	29 November, 2023
Detailed Design Drawing	Detailed Design Drawing	20 October, 2023
Prototype I floor plan	Prototype I floor plan	9 November, 2023
Prototype II floor plan	Prototype II floor plan	12 November, 2023
Exterior 3D model	Found in Makerepo	26 November, 2023
Interior 3D model	Found in Makerepo	26 November, 2023