

Redeveloping the Houseboat Community of Yellowknife:
An Exploration into the Pertinence of True Sustainability in Northern Communities

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Redeveloping the Houseboat Community of Yellowknife: An Exploration into the Pertinence of True Sustainability in Northern Communities confronts current issues surrounding climate change and the potential solutions for one northern city, Yellowknife, NT. It strives to redevelop and adapt existing housing typologies in accordance with green building certification systems to achieve true sustainability without shortchanging the North. The architecture of the North is often expensive, unsustainable, poorly constructed, and ill-suited to the climate, putting its occupants at a disadvantage. In Yellowknife, this is no different, and yet this resilient, creative, and driven community has begun to develop its own solutions. There are currently many homes that are off-grid and carry themes of material re-use, mobile architecture, and generational expansion.

In order to achieve regional relevancy, three existing housing typologies will be the focus of this thesis and serve as a basis for the design. These will be the houseboats, the manufactured home, and the “shack,” all of which are located within the neighborhood of Old Town, the oldest and most unique neighborhood in Yellowknife. The strengths and weaknesses of each one of these typologies have been analyzed, both in terms of sustainability and cultural significance.

Six of the most popular green building certification systems were analyzed using a matrix of twenty-two critical factors of sustainability to ensure that the best systems would be used for this project. The reality was that one system could not cover everything, and so Passive House and

Living Building Challenge will be used to measure the success of the sustainability of this project and guide the design. The use of a green building certification systems serves as a tool to guide future practitioners but also helps to legitimize the efforts made in the North and give them a new way to rate the local built environment.

The final design will combine all of the above to develop a renovation response for one of the existing houseboats. New construction is rare in the North, and often produces copious amounts of greenhouse gases due to travel required for both materials and personnel. There is also a great deal of sequestered carbon in the existing buildings and a long history in Yellowknife of retrofitting existing buildings throughout their lifetime. The mistakes and knowledge gained from this first exercise will be used to develop a second design, this time a new build. This will use only recycled materials accessible to the local community, challenging designers perceptions of materiality. There will also be a community component to the house design, as there has been some contention between the houseboaters and the broader community of Yellowknife with respect to local sustainability. As a whole, the main focus will be to develop a method that takes architecture that has been developed regionally and makes it as sustainable as possible. This thesis focuses on the uniqueness of this community and how a solution can be developed so that the North can come to demand more from its architecture.

Key Words: Sustainability, the North, Housing, Renovation, Recycle, Community

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This thesis is dedicated to my family. You may not have always had the answers to my questions, but you raised me to know how to find them. You taught me that life is about more than just work and that I should search for joy in everything I do. You taught me the importance of place and how to adapt and overcome, inspiring this thesis in more ways you will never know.

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Introduction

"The extreme attributes of climate, culture, and geography combine in the Canadian Arctic to produce unique infrastructures and settlements. How to document the current conditions and envision a future that reconciles progress with traditional patterns and fragile ecosystems in this complex region will be among the key questions of the 21st Century."¹

In recent years, climate change has grown to pose a severe threat to human settlements and building infrastructure, especially in the northern regions of Canada, which are currently warming three times faster than the global average.² With buildings - both during operation and construction - being responsible for 40% of greenhouse emissions worldwide, the field of architecture must begin to address this crisis.³ While there is currently work being done in Canada, most of the research and development is taking place in provinces like British Columbia and Ontario.⁴ There needs to be a conversation about the North, the region most at risk, and whether those in the North have the tools required to deal with this change. With the National Building Code set to make the shift to low energy by 2030, and net-zero soon after that, the time for the North to begin its journey into sustainability is now.⁵

Canada's North has always been several years behind the South in technological development.⁶ This has resulted in an impractical architecture that is ill-suited to climatic conditions, culturally irrelevant, highly expensive, and heavily reliant on unsustainable energy sources.⁷ Often treated as a pan-region, mythologized due to preconceived notions, the unique-

ness of each place has rarely if ever been addressed.⁸

In the face of this adversity, the North has continued to develop its own typologies, rating systems, and methods of sustainable practice. Initially, out of functional responses, these strategies can now be used as design opportunities for regionally relevant, sustainable architecture.⁹ As designers, we must ask the question, how can we begin to redevelop the existing housing typologies in Yellowknife, NWT in accordance with green building certification programs in order to achieve true sustainability, without shortchanging the North?

¹ Lola Sheppard and Mason White, *Many Norths: Spatial Practice in a Polar Territory* (Actar, 2017), X.

² Jackie Hong, "Climate Change Affecting Northern Canada Faster than Rest of the Country, Report Says" *Yukon News*, accessed December 14, 2019, <https://www.yukon-news.com/news/climate-change-affecting-northern-canada-faster-than-rest-of-the-country-report-says/>.

³ Andrea Ward and Alex Wilson, "Design for Adaptation: Living in a Climate-Changing World," *Building Green*, accessed December 14, 2019, <https://www.building-green.com/feature/design-adaptation-living-climate-changing-world/sidebar/1>.

⁴ Jenny McMinn et al., "Plenary Session: Be Smart. Build Smart." (October 18, 2019).

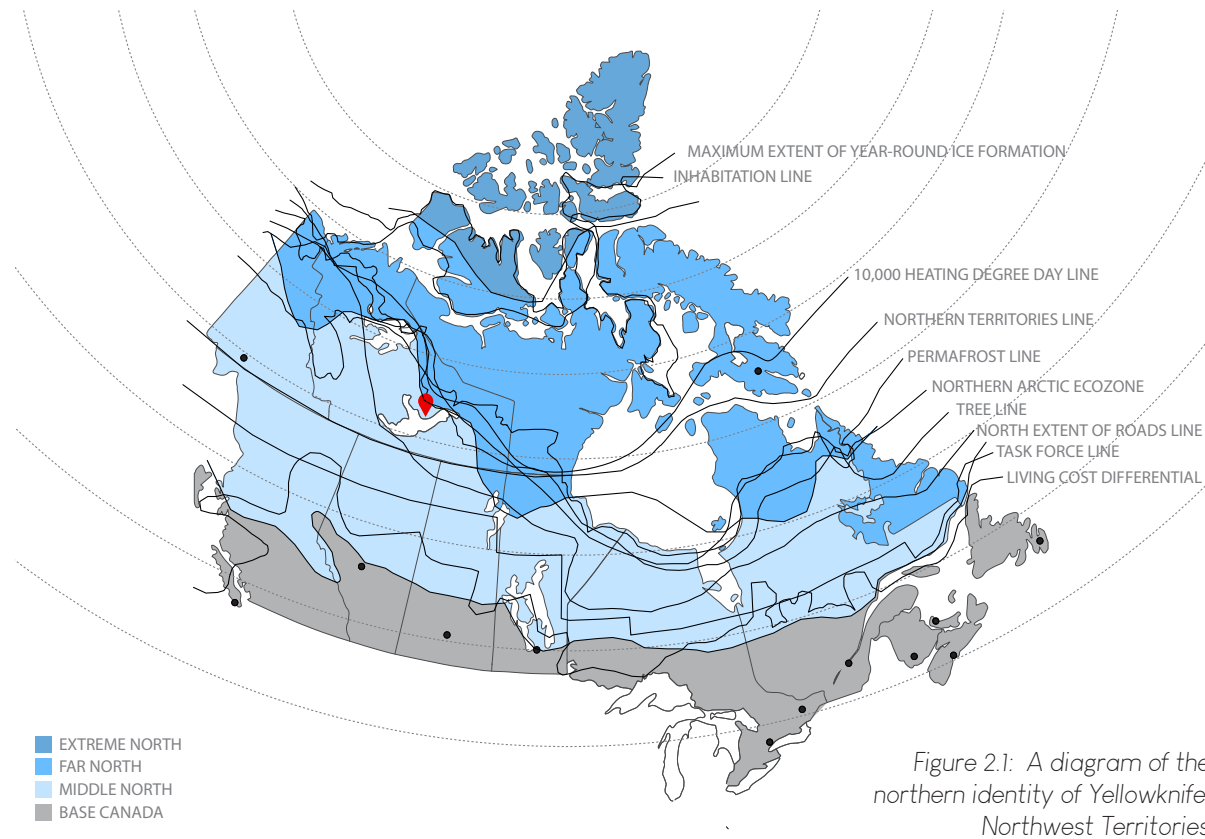
⁵ *Ibid.*

⁶ Dr. Jessica Shadian, "The Emerging Economy of the North American Arctic," *Arctic 360*, November 2018, 2.

⁷ Harold Strub, *Bare Poles: Building Design for High Latitudes*, 1st ed., Carleton Library Series 185 (Ottawa: Carleton University Press, 1996), 62.

⁸ Louis-Edmond Hamelin and William Barr, *Canadian Nordicity: It's Your North, Too, First* (Montreal, QB: Harvest House, 1999), 6-9.

⁹ Sheppard and White, *Many Norths: Spatial Practice in a Polar Territory*, X.

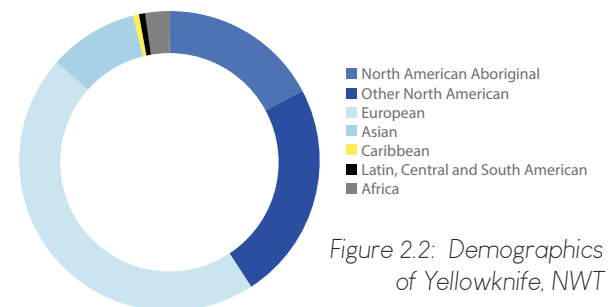


What is Yellowknife?

*“More importantly, it depends on local society, knowing itself, recognizing and understanding its preferred way of living. No society out of touch with itself can create a viable human settlement.”*¹¹

As discussed earlier, the North is not a pan-region; each city, hamlet, town, village is unique, with conditions that vary widely.² For this thesis, it was not enough to just understand arctic conditions; rather, it became a matter of understanding Yellowknife as a unique entity. The city is located at a latitude and longitude of 62.4540° N, 114.3718° W³ and is both the capital city of and the only city in the Northwest Territories.⁴ Although the Dene First Nation Community initially settled this region in the early 1930s,⁵ it has become home to a diverse ethnic population,

as seen in Figure 2.2.⁶ Full of residents who originally came to live for “a few years” and never left,⁷ it has grown to a population of 18,884 with people from all over the world, from the Philippines to Saudi Arabia, from the Czech Republic to Ireland.⁸ This old mining town has continued to grow and diversify to include tourism, transportation, and communication, as it is one of the best places in the world to see the Aurora Borealis.⁹ It is expected that



this city will continue to grow and change because as of 2012, the city became accessible by vehicle year-round with the completion of the Deh Cho bridge.¹⁰

Environment

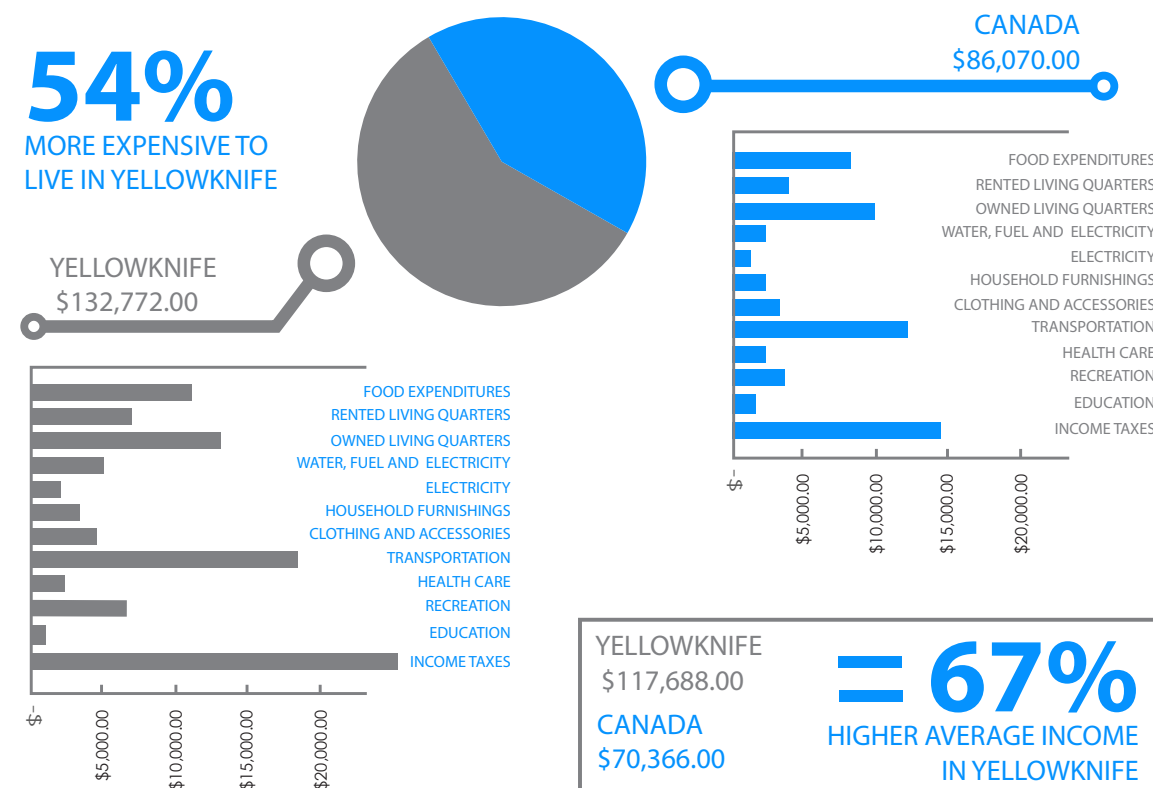
Yellowknife is a part of the Taiga biome, which is a subarctic forest lying just outside the Arctic circle. While many southerners believe this city to be above the tree line, this region is characterized by coniferous forests mainly consisting of pines, spruce, and larches.¹¹ The city is also located at the southern boundary of the Slave Structural Province of the Canadian Shield and is well known for its exposed bedrock, peatlands, and discontinuous permafrost.¹² While this can sometimes make building a challenge, Yellowknife itself does not face many of the foundation limitations of other settlements located north of the permafrost line shown in Figure 2.1.¹³



Figure 2.4: (Top) Aurora Borealis over the frozen lake in Yellowknife

Figure 2.3: (bottom) Image of Old Town, Yellowknife from the Pilot's Monument





Climate

A part of the continental subarctic climate, Yellowknife has very long cold winters, usually beginning in October and lasting until late April with temperatures reaching as low as -51°C. The summer temperatures average out at about 21°C but have been known to reach up to 30°C.¹⁴ That is an 80-degree difference in one year. This demands a lot of both the people of this region and the architecture as well. As with many other communities located in high latitudes, the daylight hours are quite limited in the winter, sometimes as few as five hours a day.¹⁵ The summers, on the other hand, can have over 20 hours of daylight. In the spring and summer, Yellowknife is known as Canada’s sunniest city as the sky is often clear.¹⁶ The amount of precipitation in this region is quite low, with only 280mm of annual precipitation, with most falling in the summer.¹⁷

Economics

One of the typical northern challenges is the high cost of living. Yellowknife, on average, is 54% more expensive for a family of four to live in than the rest of Canada. Nevertheless, it is essential to note that employers often recognize this, and therefore the average income for a household is quite high at \$117,688.00, 67% more than the average Canadian household income. Some of the most substantial differences in costs are in the shelter category, with owning a home being 73% more expensive. The cost of water, fuel, and electricity is 111% times more expensive.¹⁸ With a reduction of these costs potentially through sustainable means, especially the ones associated with home operating costs, living in this city could become much more viable.

Sun Altitude												
At noon, 3rd week of the month												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Yellowknife	8.0	17.0	28.0	39.0	48.0	51.0	48.0	39.0	28.0	17.0	8.0	4.0
Daylight Hours												
Hours per day at midmonth												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Yellowknife	6.1	8.9	11.7	14.8	17.7	20.1	19.0	16.1	13.0	10.1	7.0	5.0
Mean Daily Temperature												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Yellowknife	-24.0	-22.0	-15.6	-6.1	6.7	14.4	17.2	14.9	8.1	-0.4	-13.5	-22.0
Total Precipitation												
Millimetres												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Yellowknife	21.0	10.3	8.4	9.3	2.4	33.9	34.7	42.6	32.5	27.7	22.3	14.5
Prevailing Wind Direction												
By Month												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Yellowknife	NW	E	E	E	E	S	S	S	E	E	E	E
Relative Humidity												
Percent												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Yellowknife	73.0	73.0	70.0	70.0	61.0	57.0	60.0	69.0	76.0	84.0	82.0	75.0

Figure 2.5: (top) Household expenses for a family of four living in Yellowknife versus the rest of Canada
 Figure 2.6: (bottom) Climate averages for Yellowknife, Northwest Territories



Figures 2.7–2.12: (left to right, top to bottom) Homes located in Old Town, Yellowknife

Old Town

The oldest neighborhood in Yellowknife, Old Town, was settled by prospectors who had come to the region for gold mining in the 1930s and 40s.¹⁹ It is an area that is hard to service, and when New Town was built, many moved their homes up the hill.²⁰ Today, this community is still densely populated with both residential and commercial buildings, with float-planes taking off in people's backyards.²¹ In Yellowknife's official plan this area is designated as a unique character area with the city describing it as having "eclectic building forms, human-scale streets, modern and rustic materials, an active and natural waterfront, prominent rock outcroppings, and a diversity of people and activities that reflect the independent, industrious and artistic culture of Yellowknife."²² Therefore any future developments must conform to the uniqueness of this area and put pedestrians and people first. No building can exceed three stories, and nothing should sever the public's connection with the water, showing this community's strong ties to the natural environment.²³

While most of Yellowknife is serviced by hydroelectricity from the Snare-Bluefish systems,²⁴ there are many homes in this area that still use propane systems. Due to the shallow soil conditions, municipal water service is limited in this area. Many of the residents have large tanks to store their water, which is trucked in twice a week.²⁵ Even though this area has had one of the most tumultuous relationships with the local government and a rough history, it has become a beloved and popular neighborhood.²⁶ It also happens to be one of the most sustainable, with many people living off the grid in one way or another. All of the housing typologies that will be

discussed later are based in this neighborhood.

- ¹ Strub, *Bare Poles: Building Design for High Latitudes*, 17.
- ² Hamelin and Barr, *Canadian Nordicity: It's Your North, Too*, 46.
- ³ "Yellowknife, NT, Canada Map Lat Long Coordinates," LatLong.net, accessed December 19, 2019, <https://www.latlong.net/place/yellowknife-nt-canada-3991.html>.
- ⁴ Erik Watt, "Yellowknife," *The Canadian Encyclopedia*, March 13, 2019, <https://thecanadianencyclopedia.ca/en/article/yellowknife-nwt>.
- ⁵ "Dettah Band," ATNS - Agreements, Treaties and Negotiated Settlements project, accessed December 20, 2019, <https://www.atns.net.au/agreement.asp?EntityID=2323>.
- ⁶ Statistics Canada Government of Canada, "Census Profile, 2016 Census - Yellowknife [Census Agglomeration], Northwest Territories and Northwest Territories [Territory]," February 8, 2017, <https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CMACA&Code1=995&Geo2=PR&Code2=61&SearchText=Yellowknife&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=995&TABID=1&type=0>.
- ⁷ Donna Huffman and Peter Huffman, *Yellowknife: Diamond in the Rough*, Second (Yellowknife, NT: Ptarmigan Publishing, 2003), 1.
- ⁸ Government of Canada, "Census Profile, 2016 Census - Yellowknife [Census Agglomeration], Northwest Territories and Northwest Territories [Territory]."
- ⁹ "About Yellowknife," City of Yellowknife, November 5, 2019, <https://www.yellowknife.ca/en/discovering-yellowknife/About-Yellowknife.asp>.
- ¹⁰ Watt, "Yellowknife."
- ¹¹ "Taiga," National Geographic, accessed December 20, 2019, <https://www.nationalgeographic.org/encyclopedia/taiga/>.
- ¹² K.C. Karunaratne, Steve Kokelj, and C. Burn, "Near-Surface Permafrost Conditions near Yellowknife, Northwest Territories, Canada," vol. 9, 2008, 907-8.
- ¹³ Environment Division, "A Homeowner's Guide to Permafrost in the Northwest Territories" (Government of the Northwest Territories, 2015), <https://www.enr.gov.nt.ca/sites/enr/files/permafrost-homeowners-guide.pdf>.

- ¹⁴ Environment and Climate Change Canada, "Temperature - Monthly Data for Yellowknife," Weatherstats.ca, accessed December 14, 2019, <https://yellowknife.weatherstats.ca/charts/temperature-monthly.html>.
- ¹⁵ "Sunrise and Sunset Times in Yellowknife," Timeand-date.com, December 2019, <https://www.timeand-date.com/sun/canada/yellowknife>.
- ¹⁶ "Yellowknife the Coldest, Sunniest City in Canada | CBC News," CBC, January 16, 2014, <https://www.cbc.ca/news/canada/north/yellowknife-the-cold-est-sunniest-city-in-canada-1.2499278>.
- ¹⁷ "Yellowknife Climate," Climate-Data.org, accessed December 20, 2019, <https://en.climate-data.org/north-america/canada/northwest-territories/yellowknife-871609/>.
- ¹⁸ Government of the Northwest Territories, "NWT Bureau of Statistics - Prices & Expenditures - Household Expenditures," NWT Bureau of Statistics, 2017, https://www.statsnwt.ca/prices-expenditures/household_expenditures/.
- ¹⁹ Huffman and Huffman, *Yellowknife: Diamond in the Rough*, 17.
- ²⁰ Fran Hurcomb, *Old Town: A Photographic Journey Through Yellowknife's Defining Neighbourhood* (Yellowknife, NT: Old Town Press, 2012), 10.
- ²¹ Hurcomb, 90.
- ²² City of Yellowknife, "Consolidation of General Plan," Pub. L. No. By-Law 4656, 405394 (2012), 55, <https://www.yellowknife.ca/bylaws/Bylaw/Details/20bcec36-a6fd-472c-aa1a-e99f092d1c67>.
- ²³ City of Yellowknife, 55.
- ²⁴ "Hydro Electric," Northwest Territories Power Corporation, accessed December 19, 2019, <https://www.ntpc.com/smart-energy/how-we-supply-power/hydro>.
- ²⁵ Fran Hurcomb, November 16, 2019.
- ²⁶ Hurcomb, *Old Town: A Photographic Journey Through Yellowknife's Defining Neighbourhood*, 88-89.

Housing in Yellowknife

"Shape a critical spatial practice for a modern North, one that eschews imported southern models, and reinforces local identity and culture without nostalgia."¹

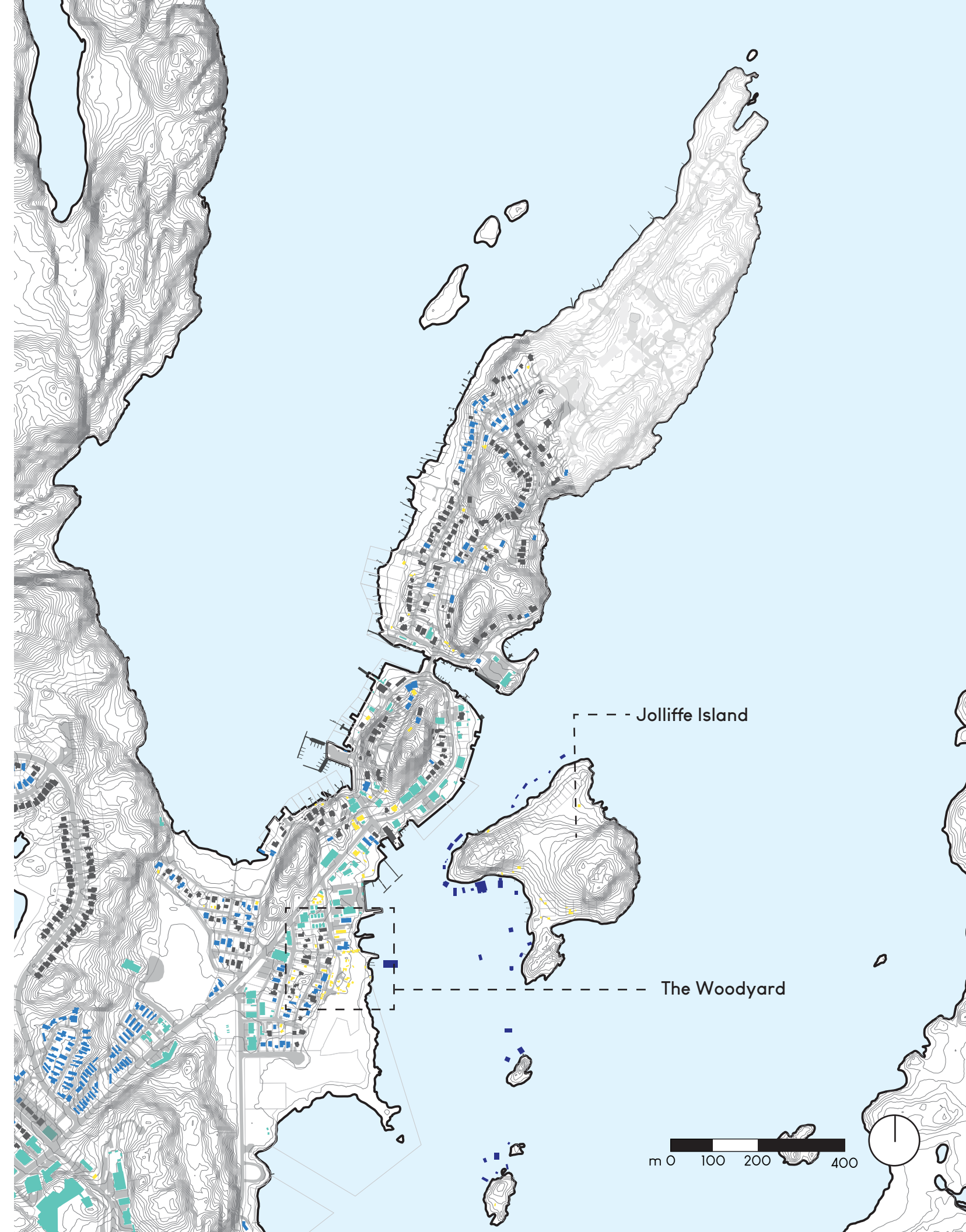
Yellowknife has 7,433 private dwellings, with the average household size being 2.7 people. Most Yellowknifers are renters, with homeownership at only 52.3%, well below the national average of 69%. This could be a response to the high cost of ownership and the even higher cost of renting, making it difficult to save money.² With the price of a manufactured home starting at \$230,000.00, and costing up to \$500,000.00, housing in Yellowknife is a challenge.³ These expenses are due to the high cost of construction, at \$204.20 per sq.ft, and the high cost of land and labor.⁴ Some people have found ways around these costs, and these local solutions - the shack, the houseboat, and the manufactured home - will be the main focus of this thesis, ensuring that the final design proposal will be regionally relevant.

Figure 3.1: (right) Map of Old Town, showing where each of the three typologies are located

AVERAGE COST OF CONSTRUCTING A 1575 sq.m (143sq.ft) HOME	
Land (500 sq.m)	\$125,000.00
Development Fees	\$3,804.96
Construction	\$100,617.00
Materials	\$84,700.00
Transportation	\$7,500.00
Total Cost	\$321,621.00
Cost per sq.ft.	\$204.20

Figure 3.2: The construction costs of building a home in Yellowknife, Northwest Territories.

- Manufactured House
- Shack
- Houseboat
- Other Construction (Stick Frame, etc.)
- Commercial



Shack

"Furthermore, despite more advanced building science and technical requirements, modest shack construction persists through informal assembly and aggregation... These structures express an inclination toward diverse typologies that are extensions of people's connection to the land."⁵

The shack typology was developed when miners first settled in Yellowknife and required shelters to be built in a very short time frame, with readily available materials, for a low cost.⁶ They were often placed close together in dense communities that

look nothing like the subdivisions of today. These conditions have created some weird, but unique building strategies, including moss for insulation, wood from a boat for flooring, packaging crates for siding, and cardboard as an air barrier.⁷ The ingenuity was high; the creativity and resourcefulness even higher.

Initially, there were over seventy-five of these shacks dotted throughout Old Town. However, only a few remain today as the government has tried to demolish them through a series of redevelopment plans. The few that remain were saved by com-



Figure 3.3: (left) Sketch of an existing shack in Old Town

munity members who thought it pertinent to preserve their history.⁸ The only full neighborhood that remains is the Woodyard shown in Figure 3.1. These homes encapsulate the pioneer spirit and the freedom of the North. Many are rich with cultural and historical significance,⁹ but they are often low on amenities. Many do not have running water, indoor plumbing, nor electricity and are heated by a wood stove. People who live in these homes still

use a honey bucket system for waste and often power their appliances by propane. They usually have relatively small footprints and teach their occupants to value all resources, all in all, making for relatively sustainable living if one can look past the discomfort.¹⁰



Figure 3.4: (left) Image of a Shack on Jolliffe Island
Figure 3.5: (right) Sketch of existing shack in Old Town





Figure 3.6: (top) Exterior image of a shack located in the Woodyard
Figure 3.7: (bottom) Exterior image of a shack located in the Woodyard

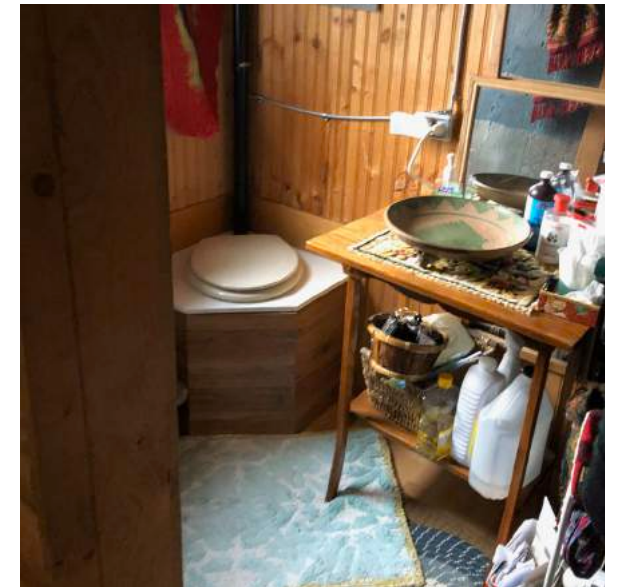
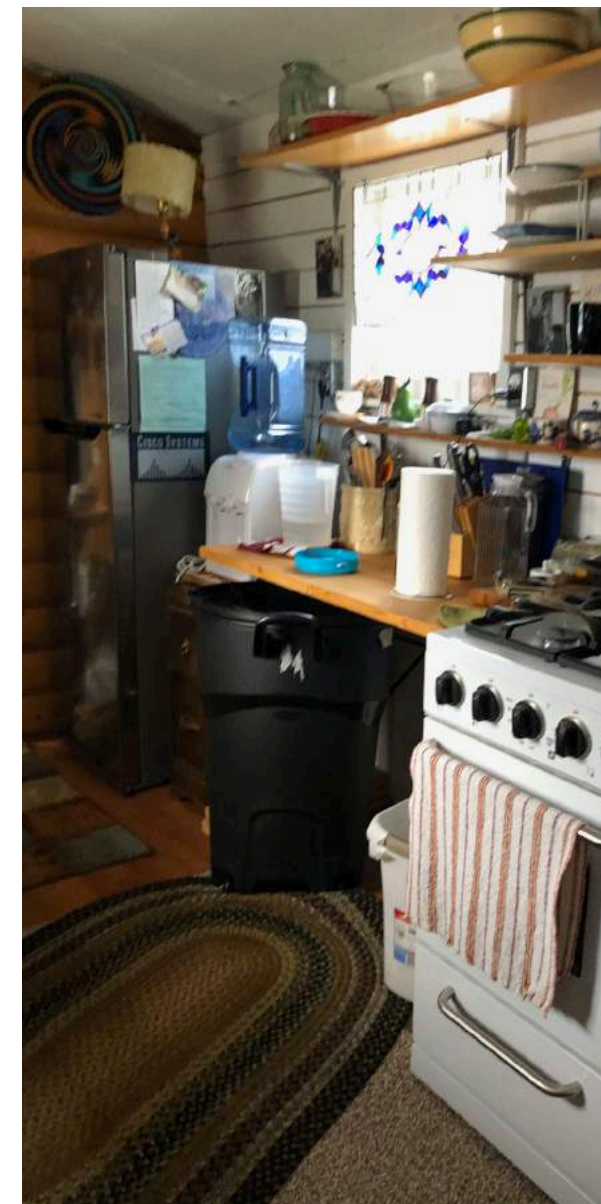


Figure 3.8: (left) Interior image of a typical kitchen in one of the shacks in the Woodyard
Figure 3.9: (top right) Interior image of a honey bucket toilet in one of the shacks in the Woodyard
Figure 3.10: (bottom right) Exterior image of a shack located in the Woodyard

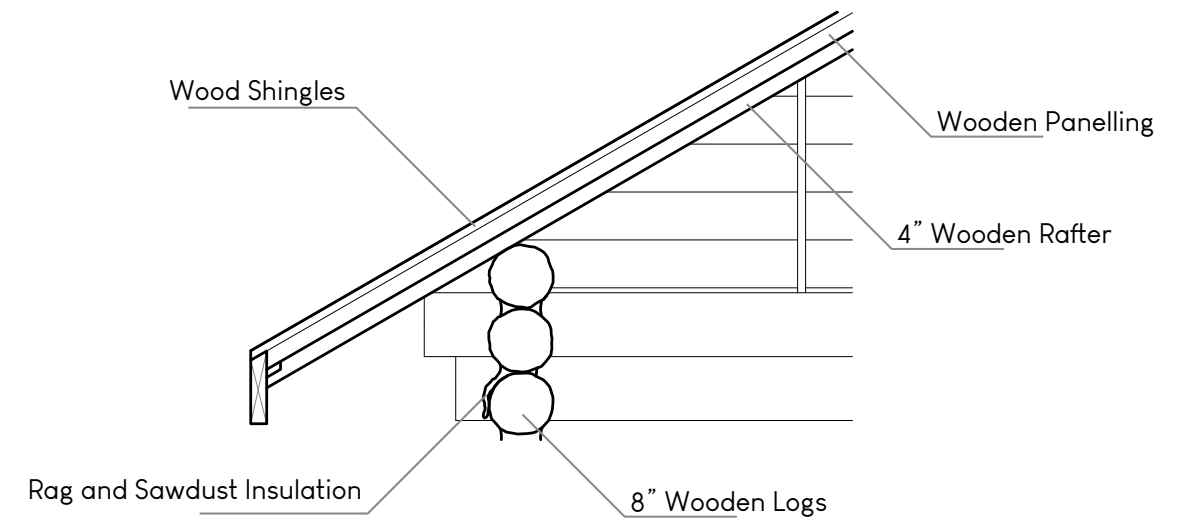
Log Cabin

3609 Franklin Ave

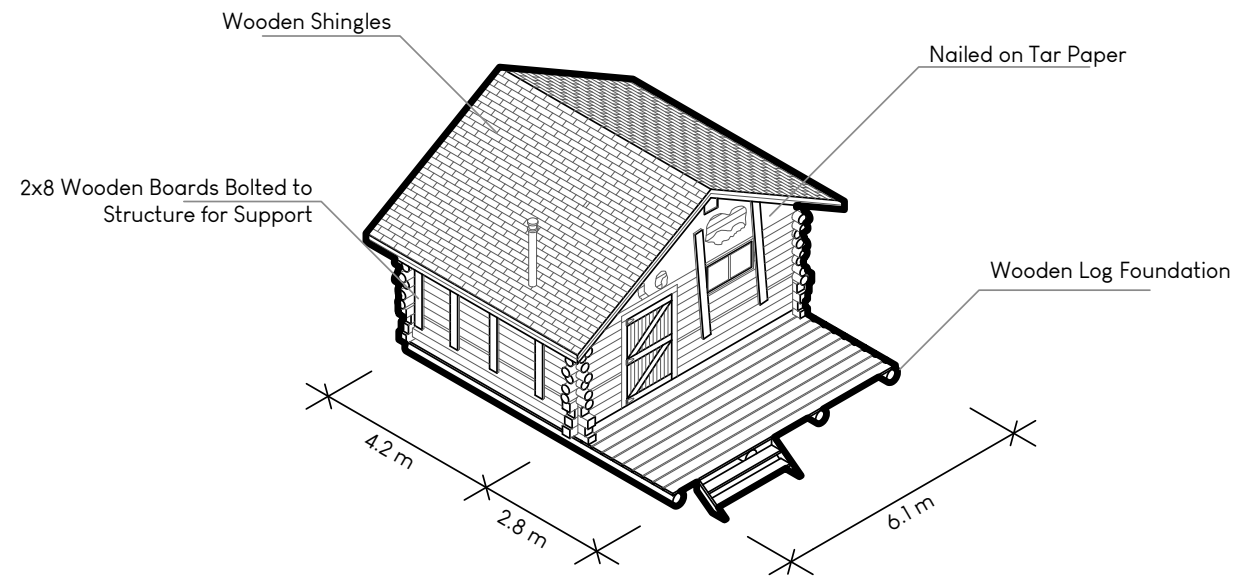


Area: 28.52 m² (307sq.ft)
Heating: Wood Stove
Electricity: None
Water: None
Waste: Outhouse

Site Plan



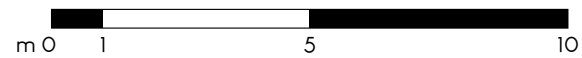
Roof Connection Detail
Scale 1:25



Floor Plan

Section

Figure 3.11: Analysis of a Log Cabin in Old Town



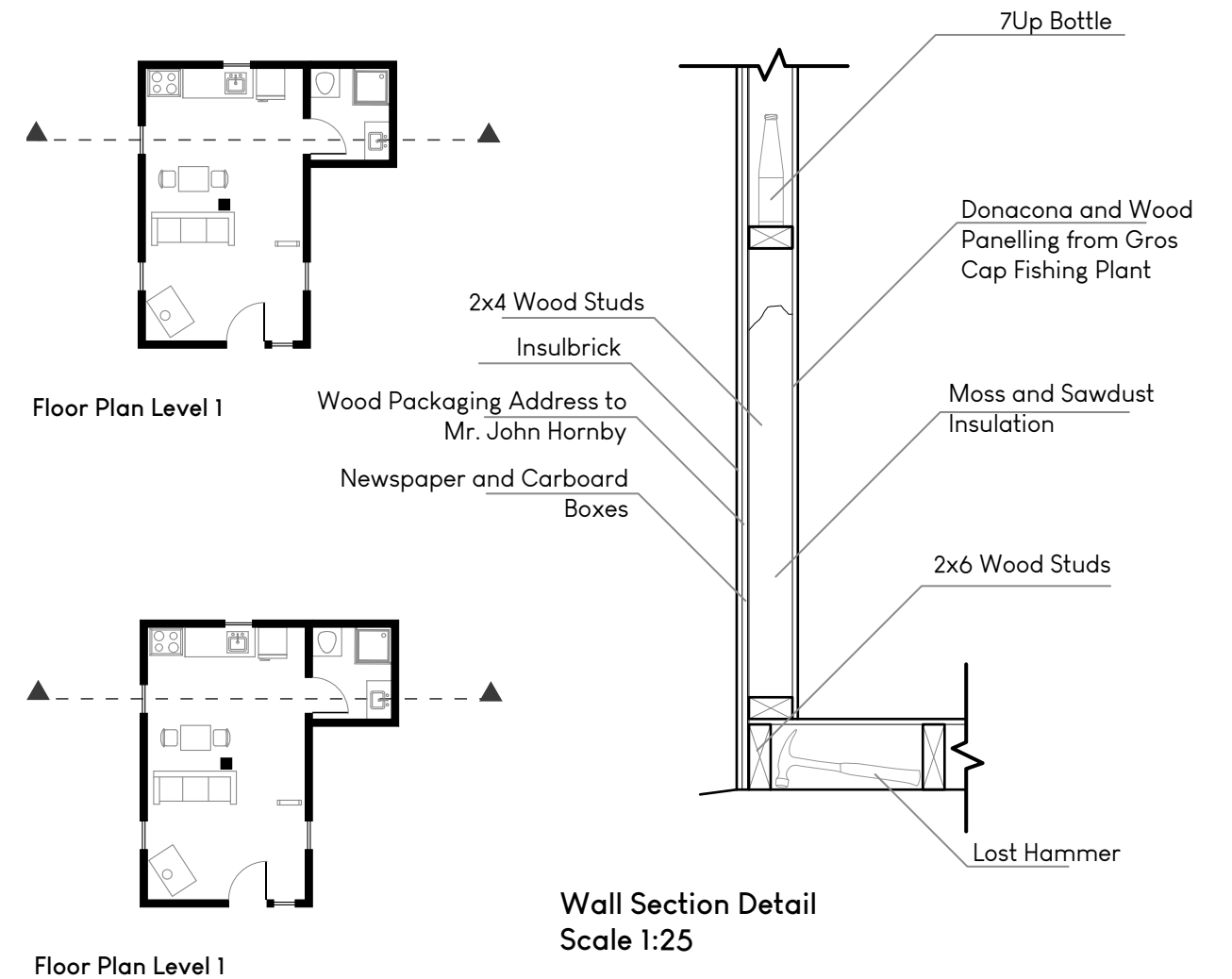
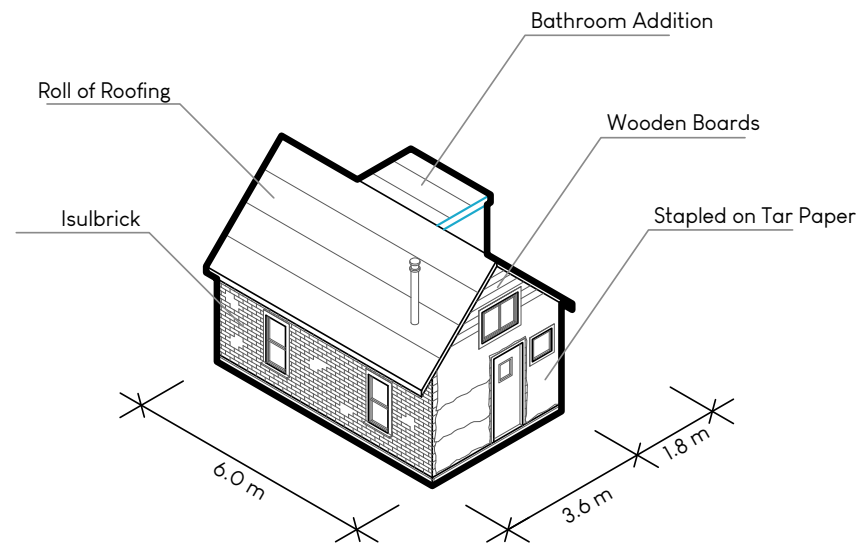
Fran's Shack

Demolished - Bryson Dr



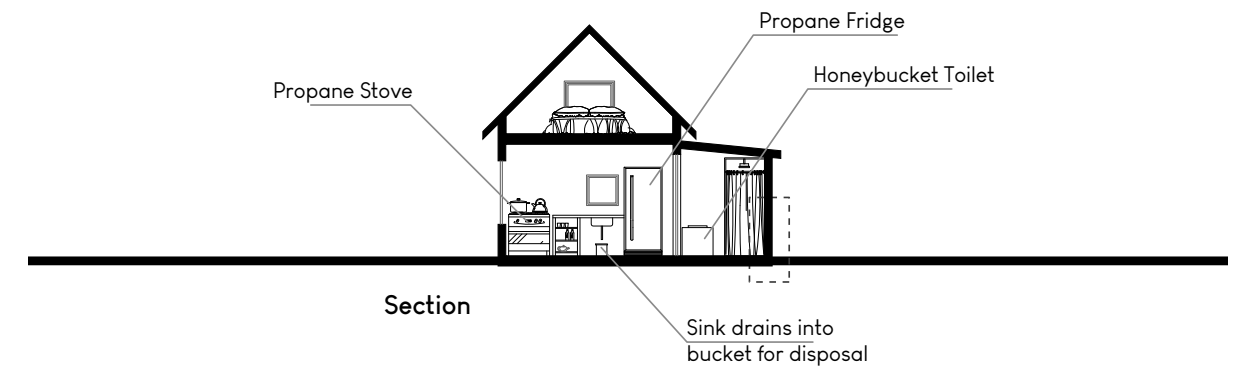
Area: 40.31 m² (435sq.ft)
 Heating: Wood Stove
 Electricity: None
 Water: Water Tank Supplying Bathroom Addition Only
 Waste: Honey Bucket System

Site Plan



Floor Plan Level 1

Wall Section Detail
Scale 1:25



Section

Figure 3.12: Analysis of Fran's old shack in Old Town



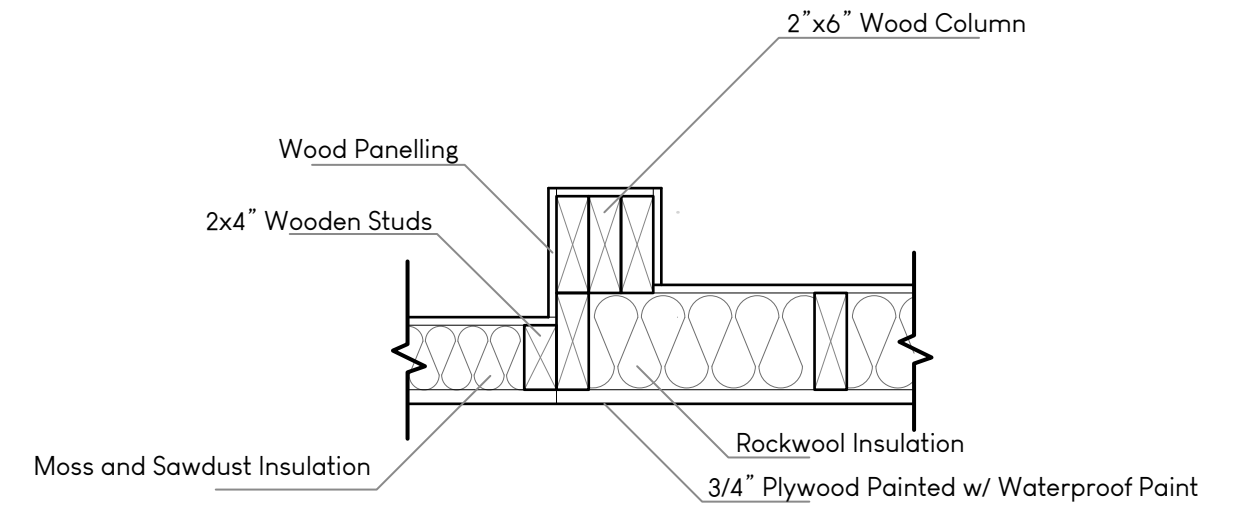
Yellowknife's Shack

3815 Bretzlaff Dr. Unit 2

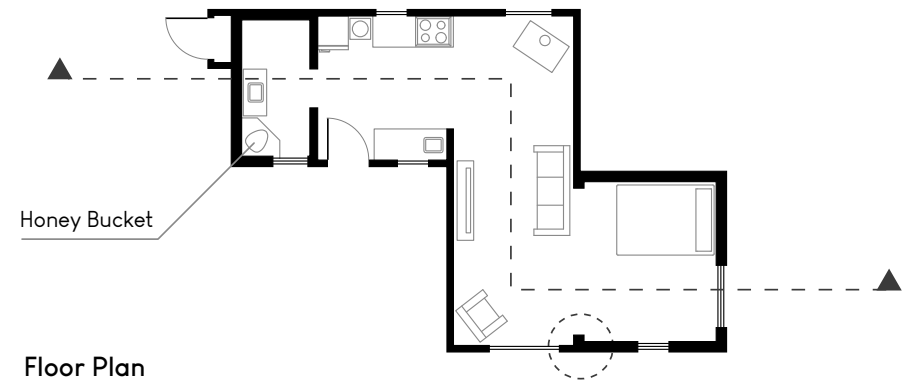
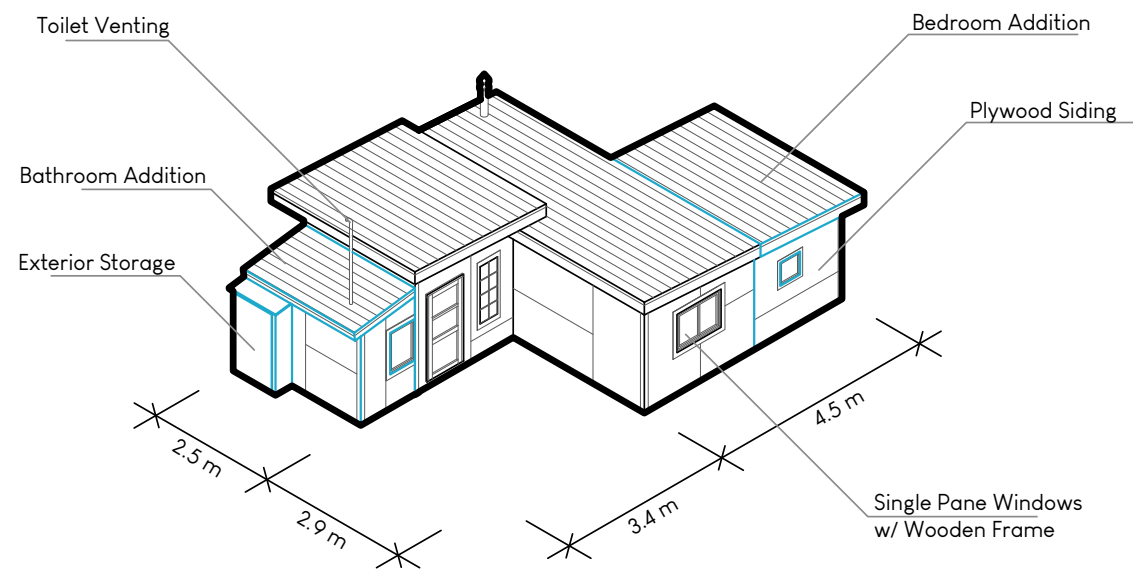


Area: 40.56 m² (435sq.ft)
Heating: Wood Stove + Back Up Propane Heater
Electricity: Extension Cord to Landlord
Water: None
Waste: Honey Bucket System

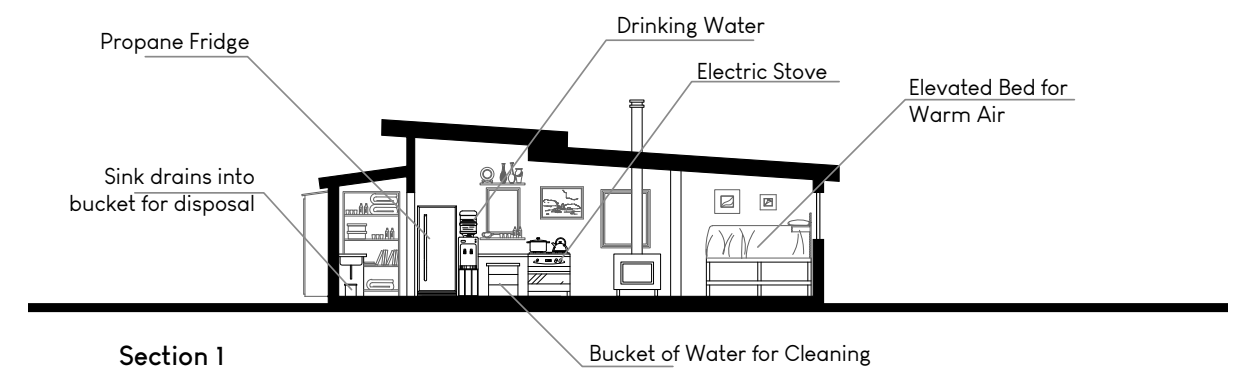
Site Plan



Column Detail
Scale 1:10



Floor Plan



Section 1

Figure 3.13: Analysis of the most famous shack in Old Town

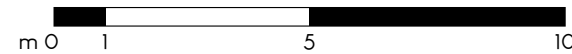




Figure 3.14: Sketch of an existing houseboat under the northern lights on Yellowknife Bay

Houseboat

A northern houseboat is a condition unique to Yellowknife, NT. This community began in the early 1980s when the cost of taxes had become unaffordable for most, and so people began relocating their homes onto barges and floating platforms. It began with only a few families but has continued to grow over the years. Today it has grown into a brightly colored, culturally rich community that attracts tourists from all over the world.¹¹

Houseboats can be incredibly challenging homes to live in as the occupant is often at the mercy of the ice and the weather, especially during freeze and thaw when the lake can be very unpredictable. Many people travel over thin ice by canoe during this time, which can be a long, tiresome trip.¹²

All of these homes are off-grid, using systems such as composting toilets, solar panels, and pellet stoves, which makes them very sustainable in terms of energy use. However, many also use propane appliances and are built with a lot of Styrofoam, showing that sustainability is about more than just total energy use.¹³ All of them discard their black-water correctly, but very few have systems in place to deal with their greywater. This has caused contention with the mainland community as the full ecological impacts of this are unknown.¹⁴

In terms of construction, wind exposure must be considered as they are often at the mercy of the elements out on the frozen lake. This means that everything must be sealed as drafts can come through even the smallest crack, including screw holes. The same goes for water protec-



Figures 3.15–3.17: (top to bottom) Exterior images of some of the different houseboats located on Yellowknife Bay



Figures 3.18–3.22: (left to right, top to bottom) Exterior images of some of the different houseboats located on Yellowknife Bay



tion with the bottom of the home having to be sealed like a boat. However, the elements have sometimes worked in favor of the occupants. Many build snowbanks around their homes and foundations to provide free insulation in the winter.¹⁵

Another important design detail that is sometimes ignored, often to the detriment of the occupant, is the aspect of balance. Houseboats should not be top-heavy as they could tip. Heavily used living spaces such as the kitchen and living room should be located on the main floor to reduce the effect of shifting live loads. Houseboats are also typically not affixed with mechanical fasteners to their floating platforms as they can warp based on ice, wind, or temperature variances.¹⁶

In terms of affordability, they can be challenging to purchase as the bank will not provide a mortgage for either the purchase or construction of one.¹⁷ However, as shown above, land purchases and taxes are quite expensive, so in that way, houseboats are much more affordable than regular homes. They also do not re-



Figures 3.23: (top) A floating fishplant located on Yellowknife Bay amongst the houseboats 3.34–3.25: (middle, bottom) Exterior images of some of the different houseboats located on Yellowknife Bay



Figure 3.26: Sketch of a man canoeing across Yellowknife Bay to his houseboat during freeze-up

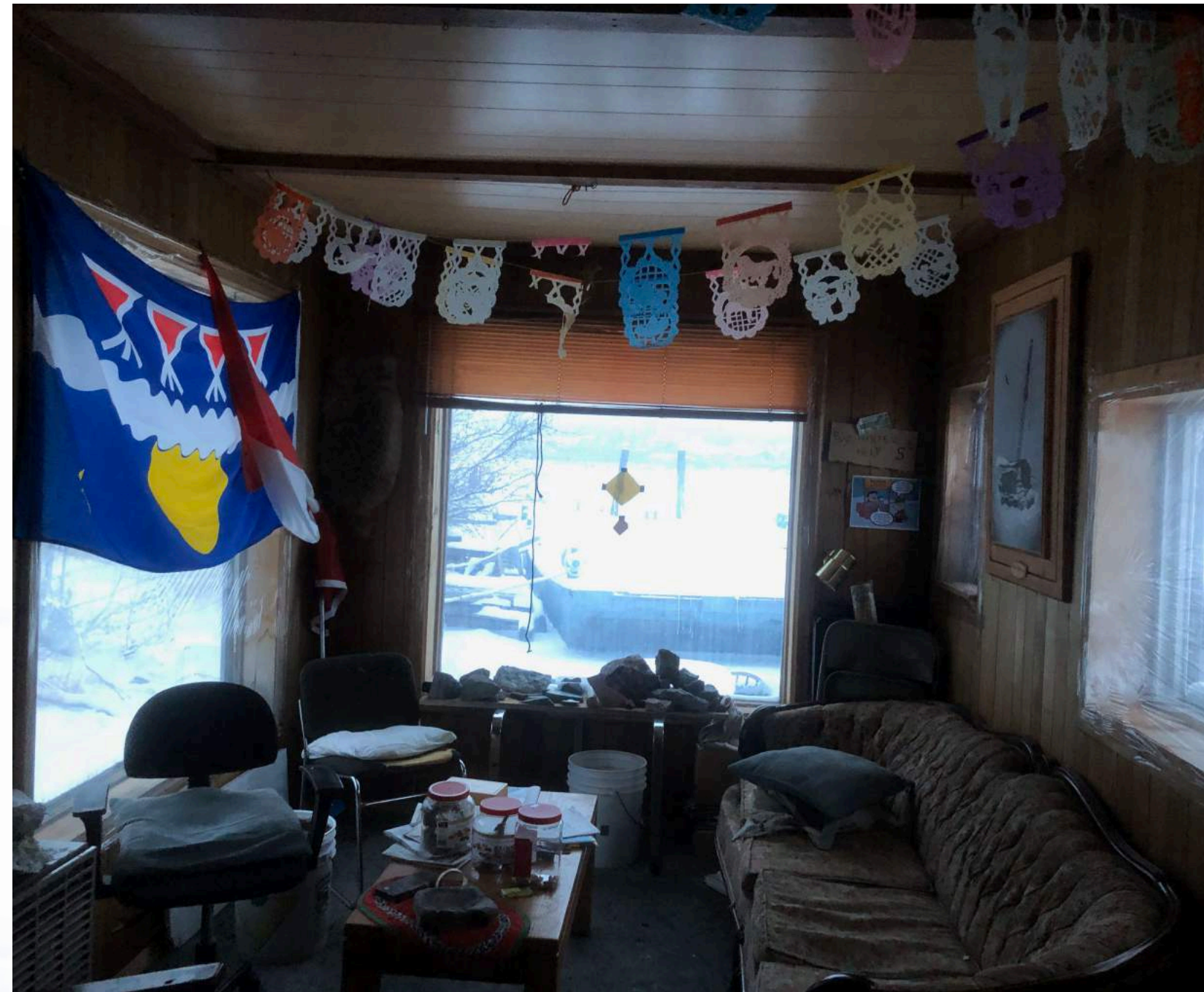


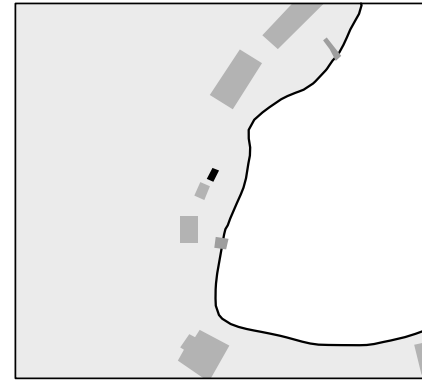
Figure 3.27: (left) An image of the living room of the "Bush Rat Cafe" on Yellowknife Bay

quire building permits, inspections, nor must they meet national building code standards, meaning there is much do-it-yourself construction, which has shown mixed results in terms of safety and quality.¹⁸ It is for these many reasons and others that these homes are uninsurable.¹⁹ However, many people love living in these

homes as they are unique, culturally rich, and located outside the realm of bureaucracy. It is this sense of freedom that many Northerners claim is the draw to this type of housing.²⁰

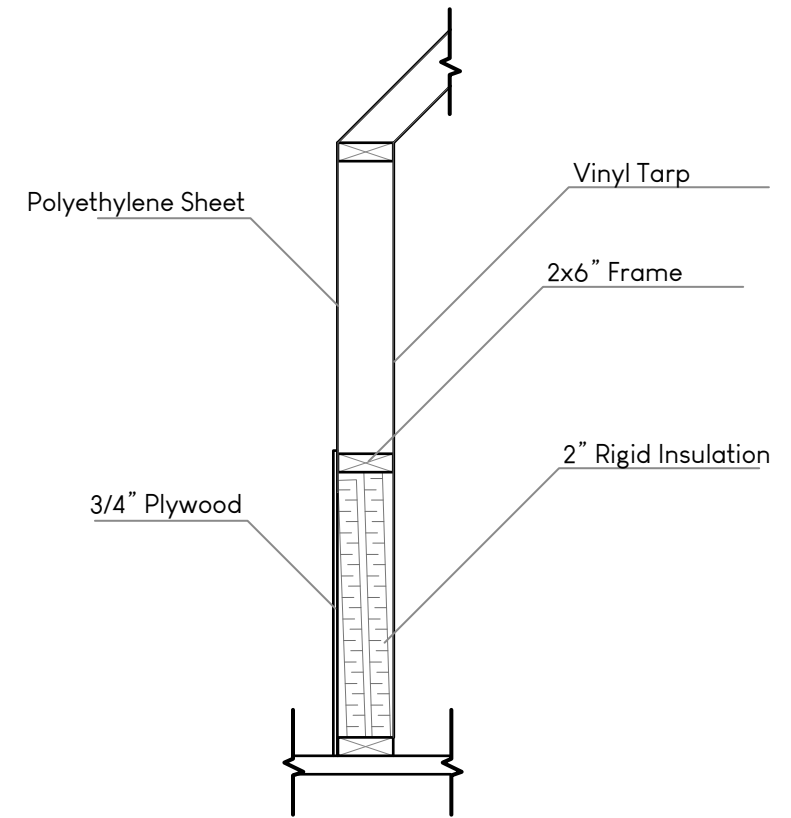
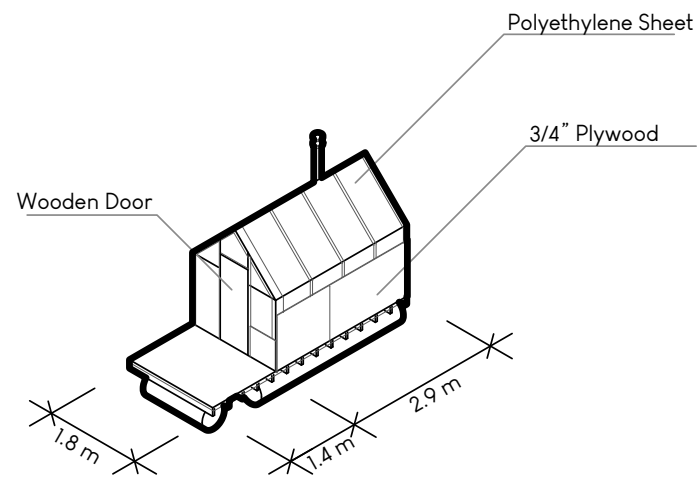
Pike Mike's Fishing Shack

62°27'47.9"N 114°20'46.3"W

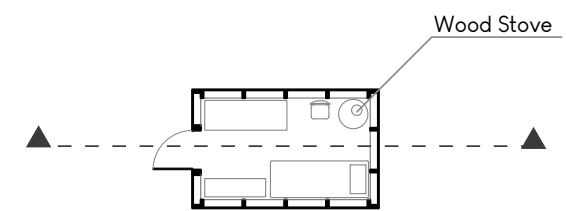


Area: 8.35m² (90 sq.ft)
Heating: Wood Stove
Electricity: None
Water: Directly From Lake
Waste: Outhouse

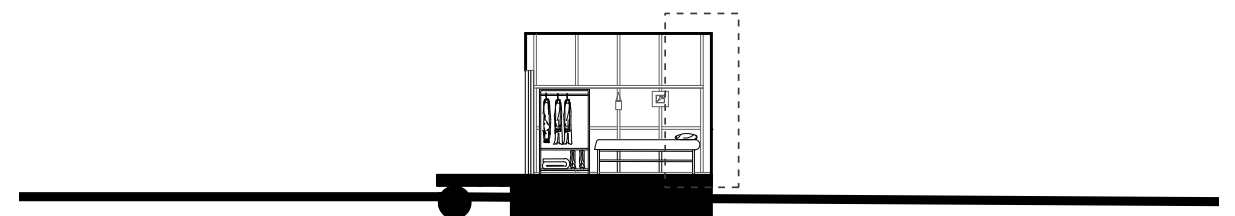
Site Plan



Wall Detail
Scale 1:20

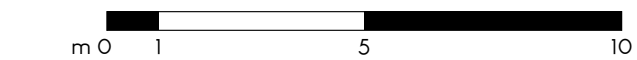


Floor Plan



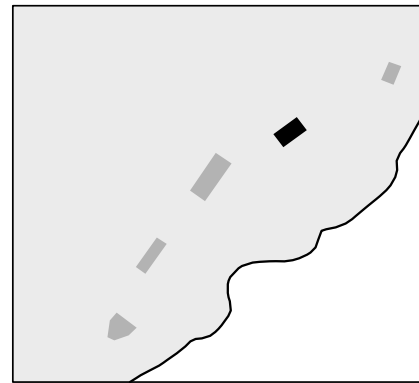
Section

Figure 3.28: Analysis of an Pike Mike's houseboat on Yellowknife Bay



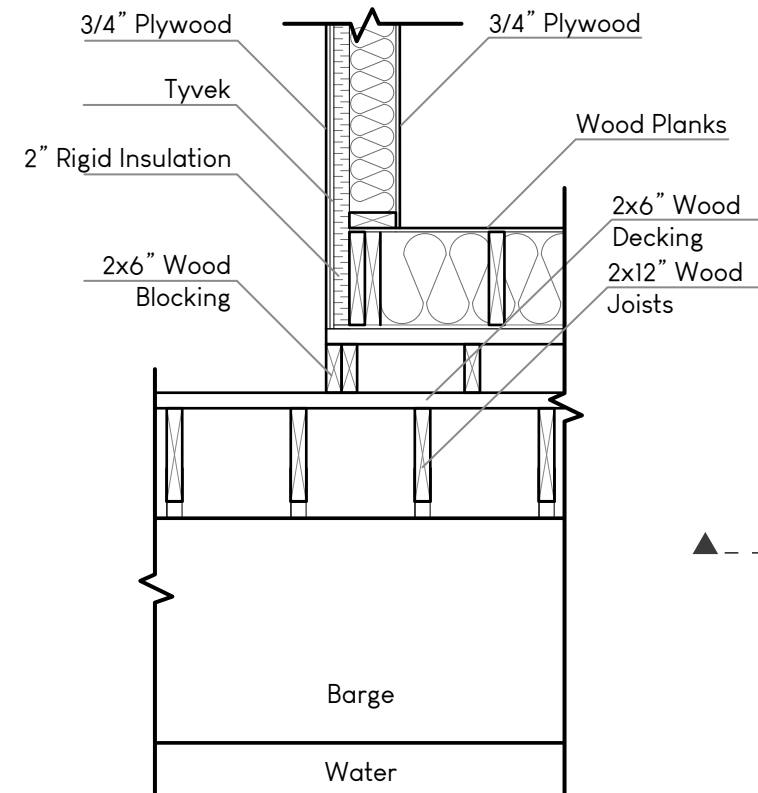
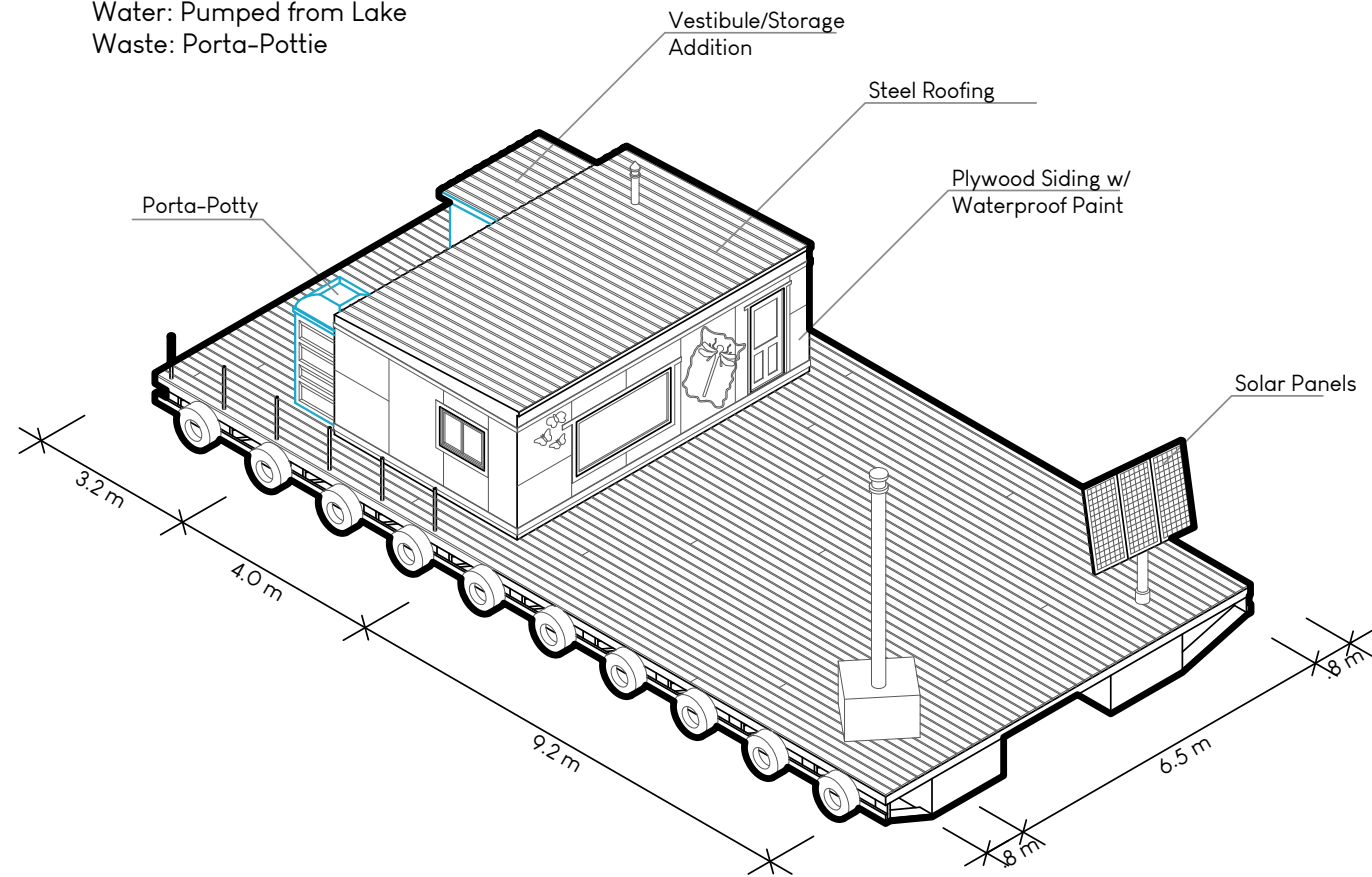
The Butterfly Home

62°27'54.1"N 114°20'33.4"W

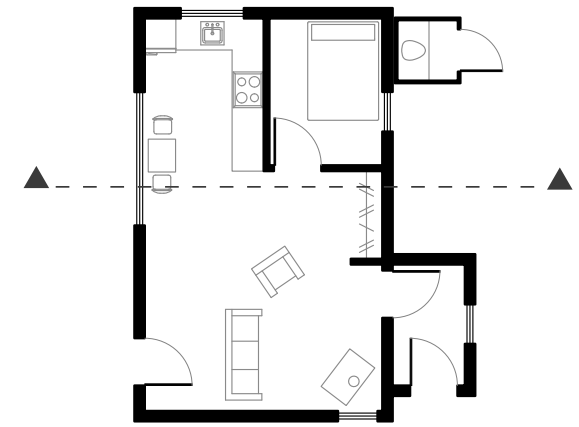


Area: 44.39 m² (475sq.ft)
 Heating: Wood Stove
 Electricity: Solar Panels
 Water: Pumped from Lake
 Waste: Porta-Pottie

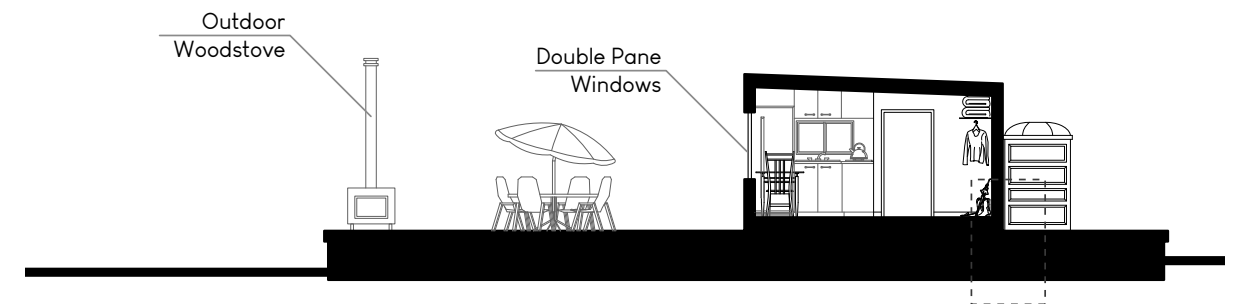
Site Plan



Floor to Barge Detail
 Scale 1:25

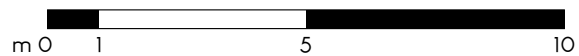


Floor Plan



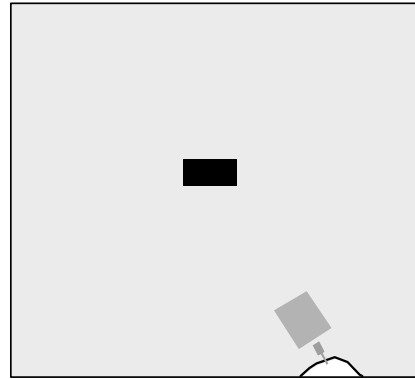
Section

Figure 3.29: Analysis of the Butterfly Houseboat on Yellowknife Bay



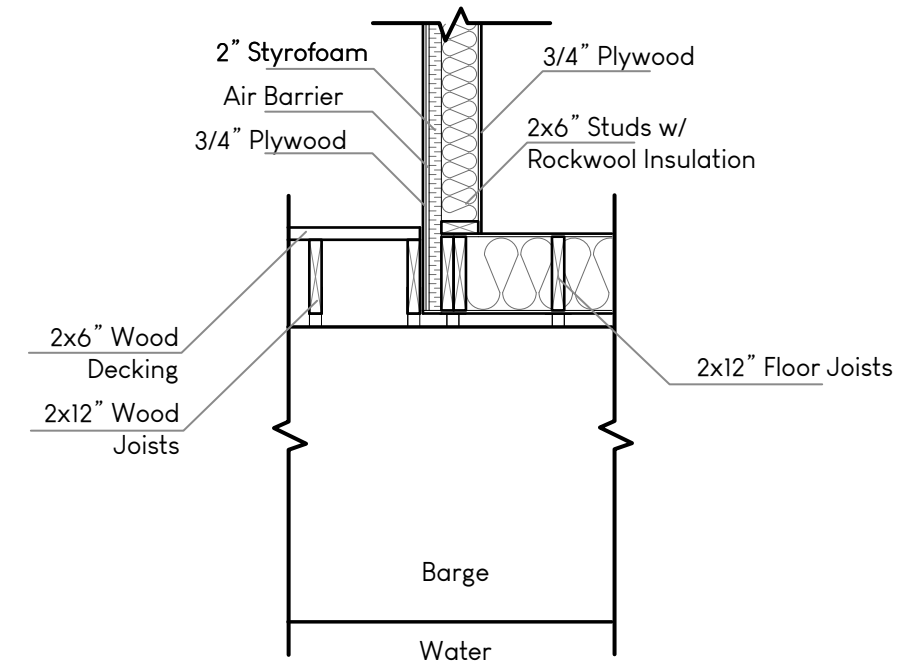
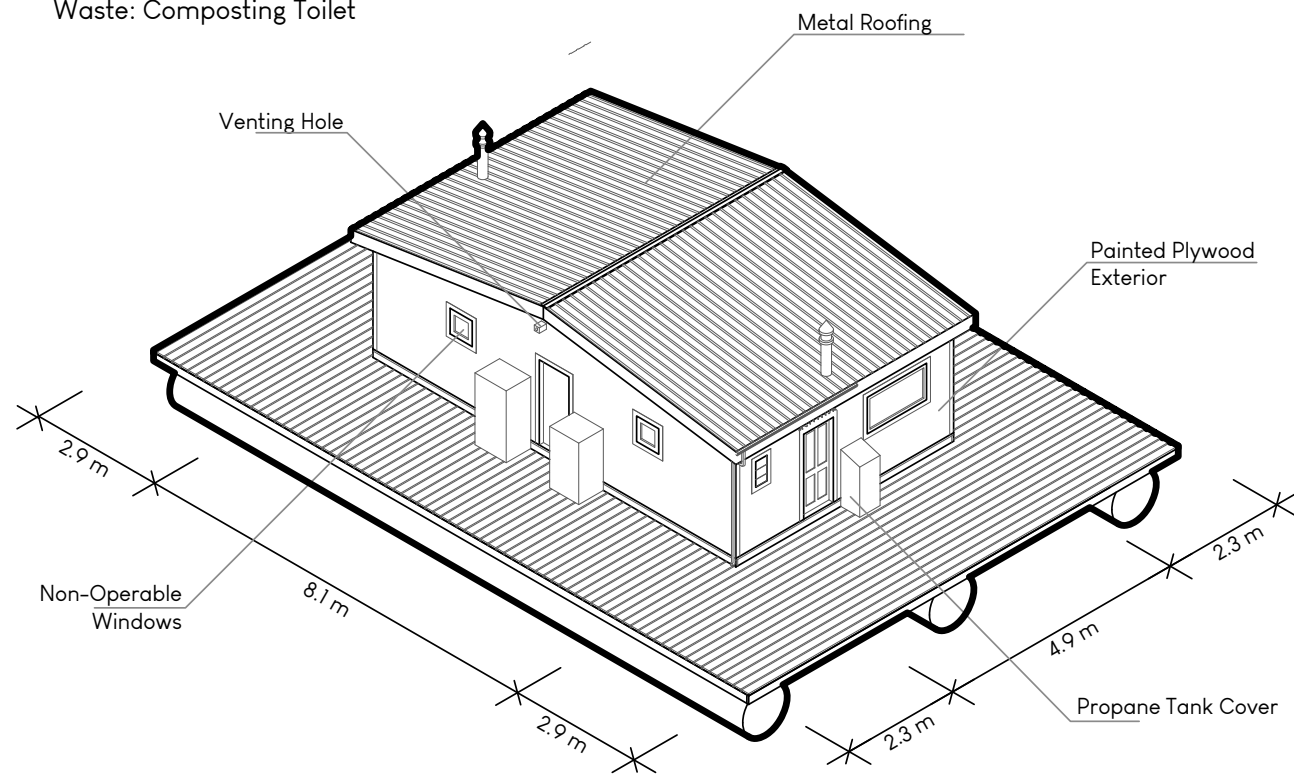
Mo's Airbnb

62°27'34.3"N 114°20'39.5"W

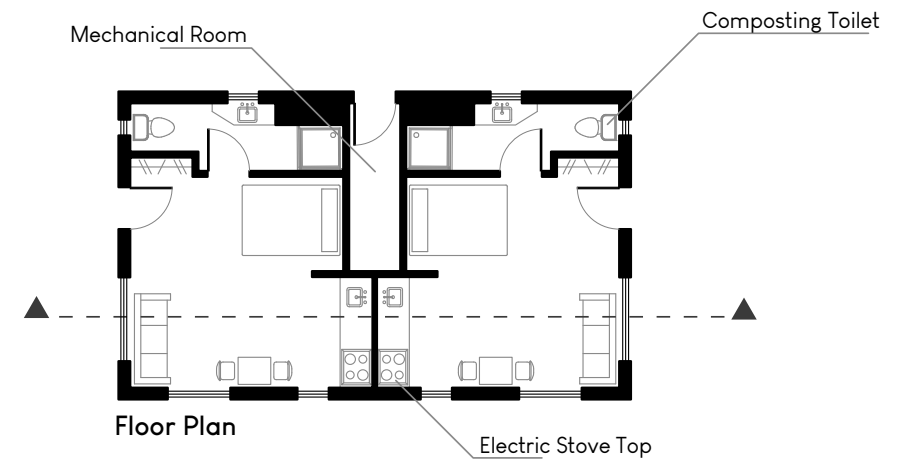


Area: 59.91 m² (645 sq.ft)
 Heating: Propane Heater
 Electricity: Solar Panels
 Water: Pumped From Lake
 Waste: Composting Toilet

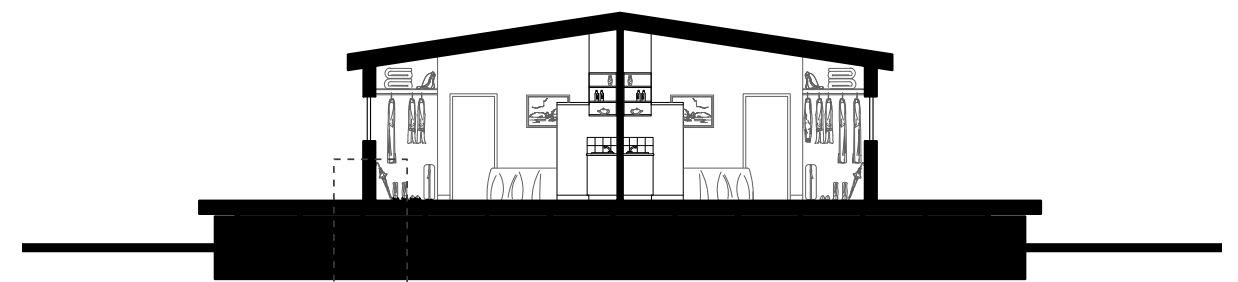
Site Plan



Floor to Deck Detail
 Scale 1:30



Floor Plan



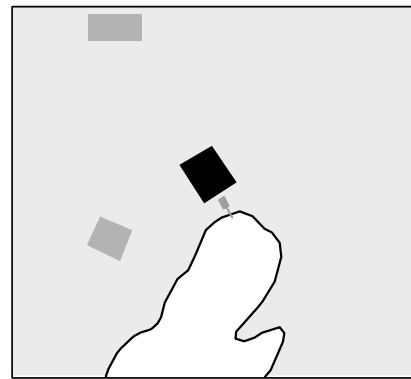
Section

Figure 3.30: Analysis of the Airbnb I stayed in on Yellowknife Bay



Mo's Houseboat

62°27'35.2"N 114°20'36.6"W



Area: 167.17 m² (1795 sq.ft)
 Heating: Pellet Stove and Propane
 Electricity: Solar Panels
 Water: Pumped from Lake
 Waste: Composting Toilet

Site Plan

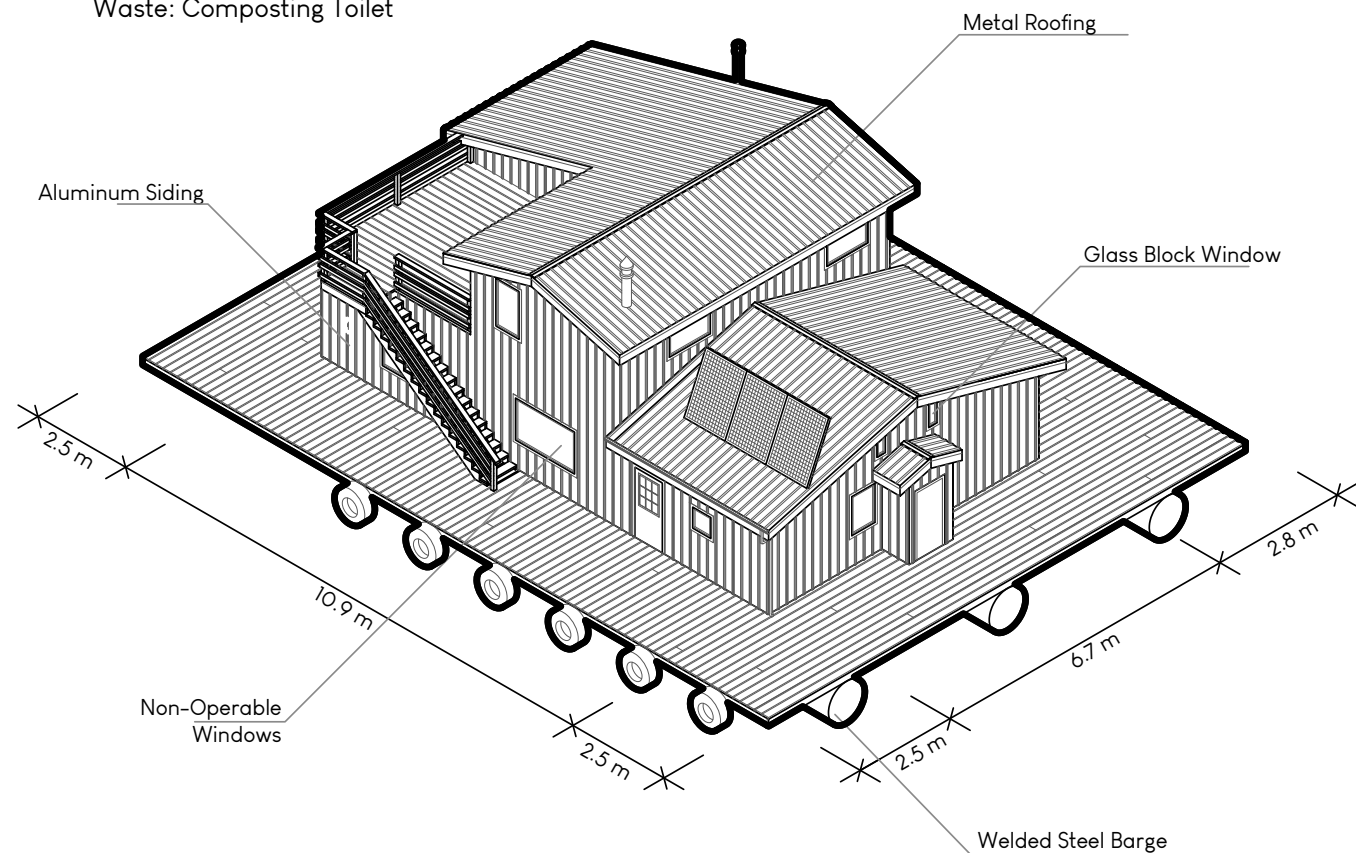
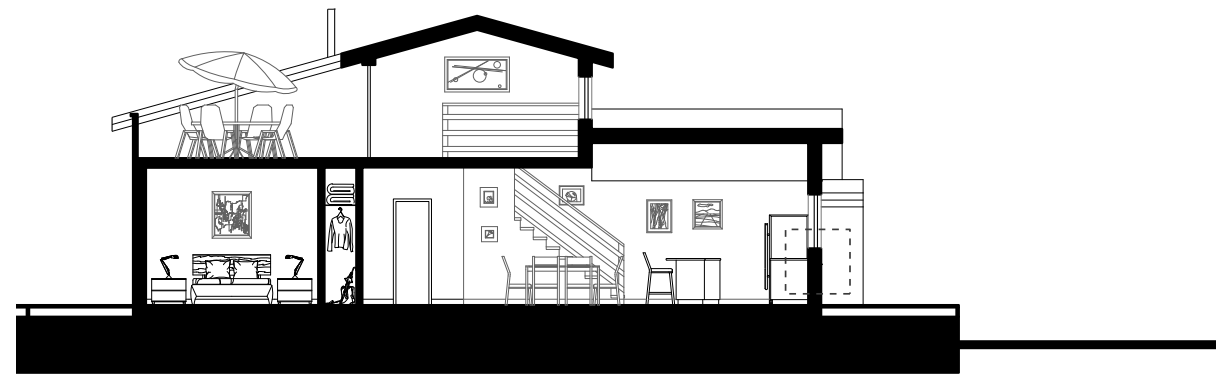
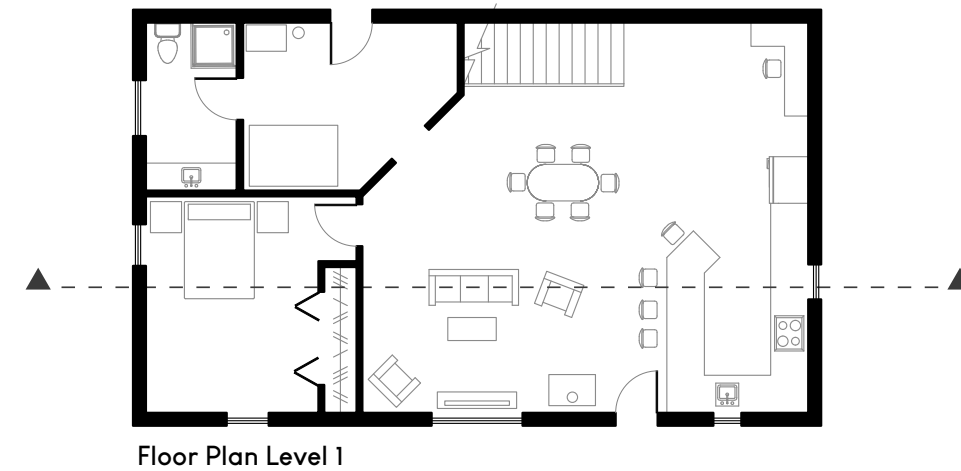
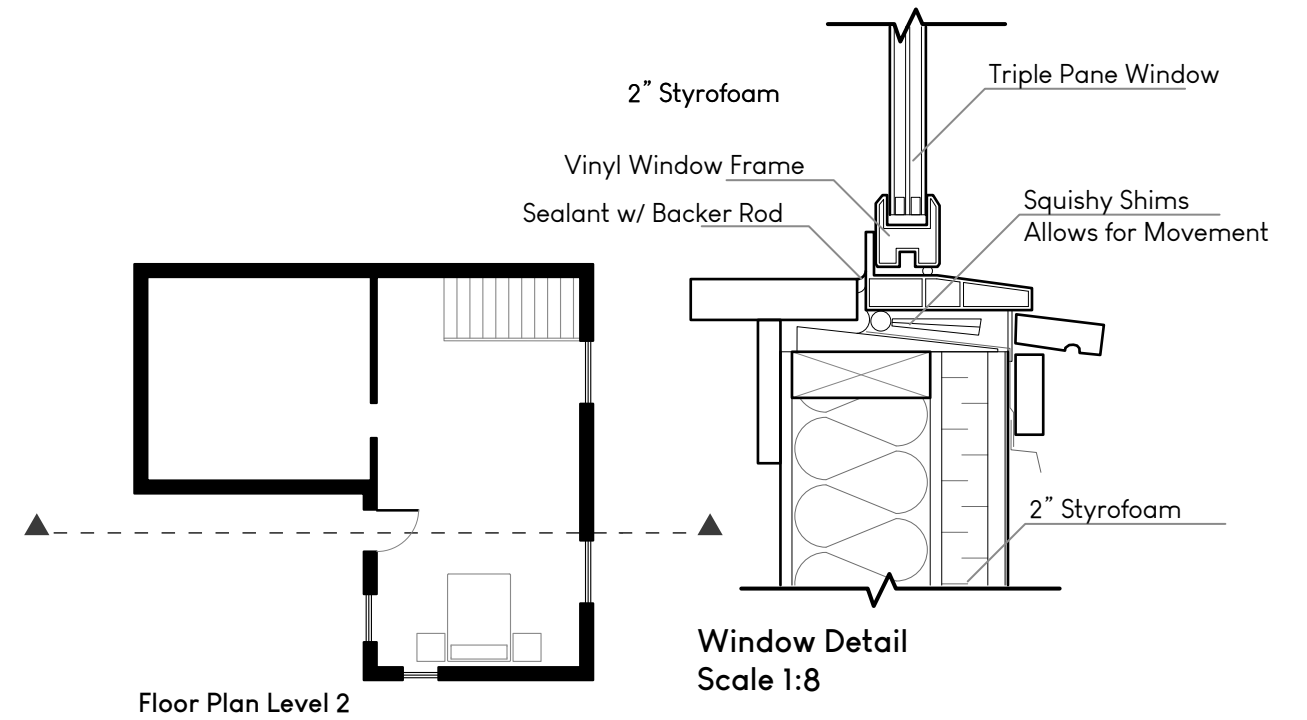
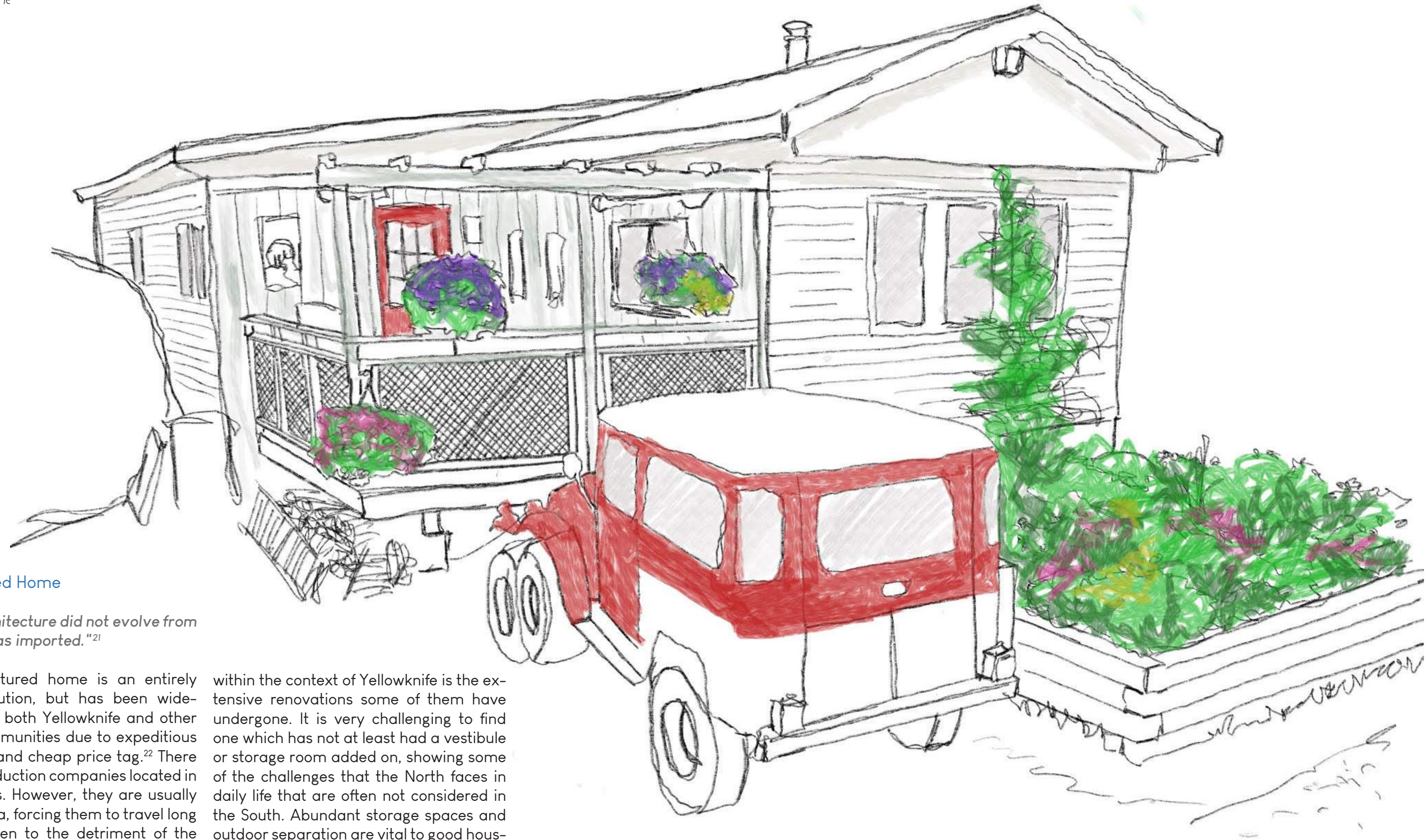


Figure 3.31: Analysis of Monique Robert's houseboat on Yellowknife Bay



Section



Manufactured Home

"Modern architecture did not evolve from within, but was imported."²¹

The manufactured home is an entirely imported solution, but has been widely adopted in both Yellowknife and other northern communities due to expeditious construction and cheap price tag.²² There are a few production companies located in the Territories. However, they are usually built in Alberta, forcing them to travel long distances, often to the detriment of the quality of their construction. Nevertheless, what makes them particularly intriguing

within the context of Yellowknife is the extensive renovations some of them have undergone. It is very challenging to find one which has not at least had a vestibule or storage room added on, showing some of the challenges that the North faces in daily life that are often not considered in the South. Abundant storage spaces and outdoor separation are vital to good housing design in the North²³.

Figure 3.2: A sketch of an existing manufactured home in Yellowknife



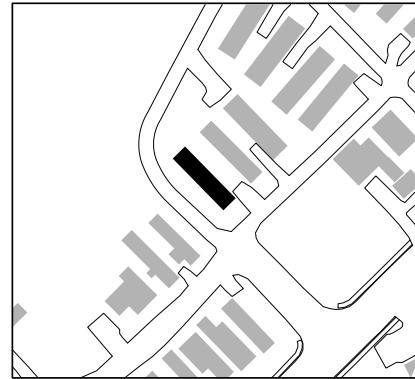
Figure 3.33-3.36: (left to right, top to bottom): Exterior images of different manufactured homes in Yellowknife



Figure 3.37-3.40: (left to right, top to bottom): Exterior images of different manufactured homes in Yellowknife

Typical Manufactured Home

4107 42nd Street



Area: 105.91 m² (1105 sq.ft)
Heating: Propane Heater
Electricity: Municipal
Water: Municipal
Waste: Municipal

Site Plan

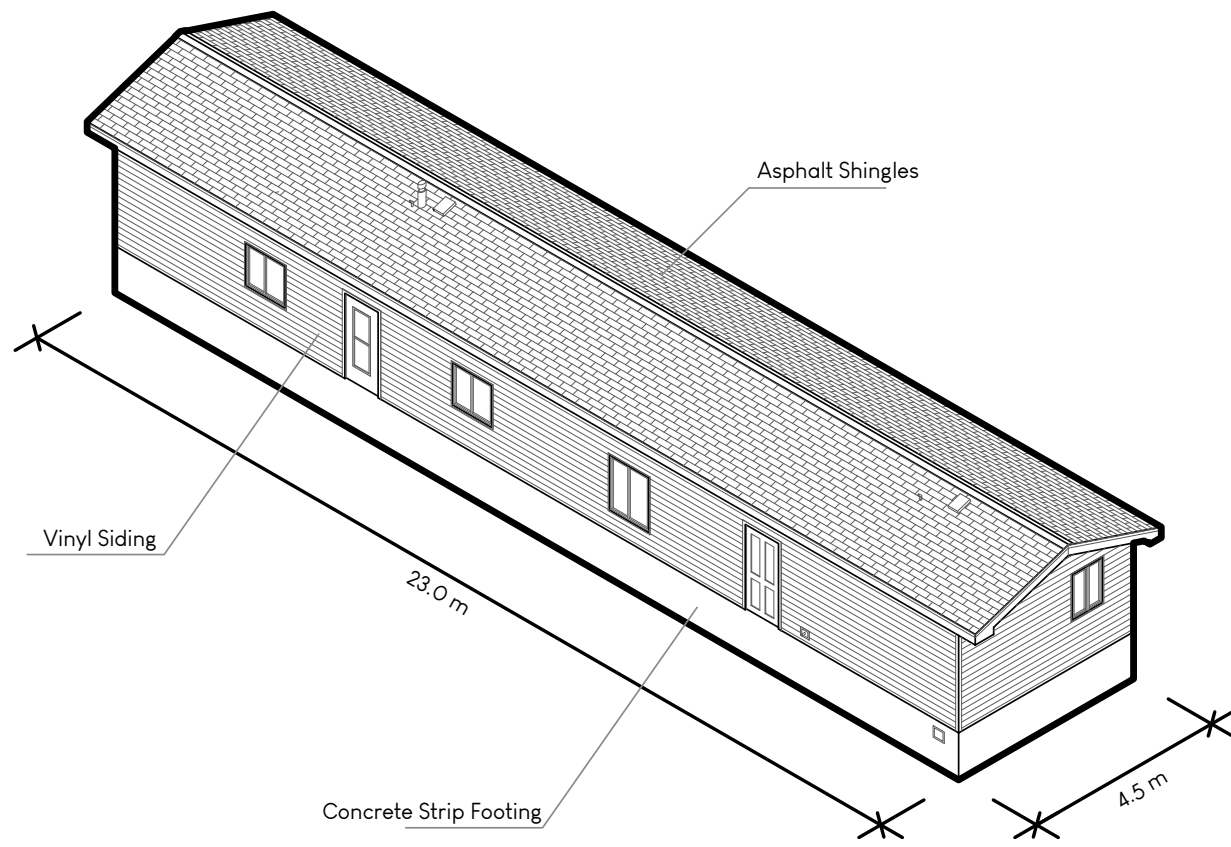
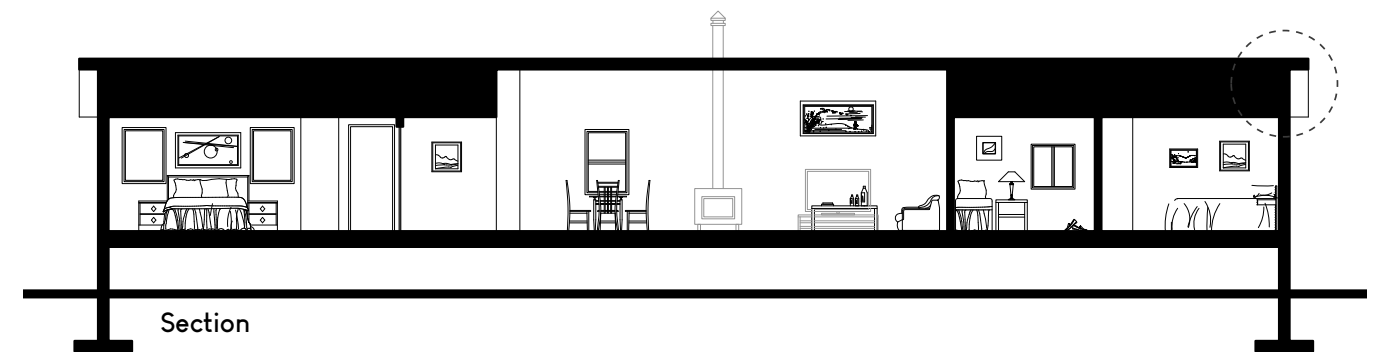
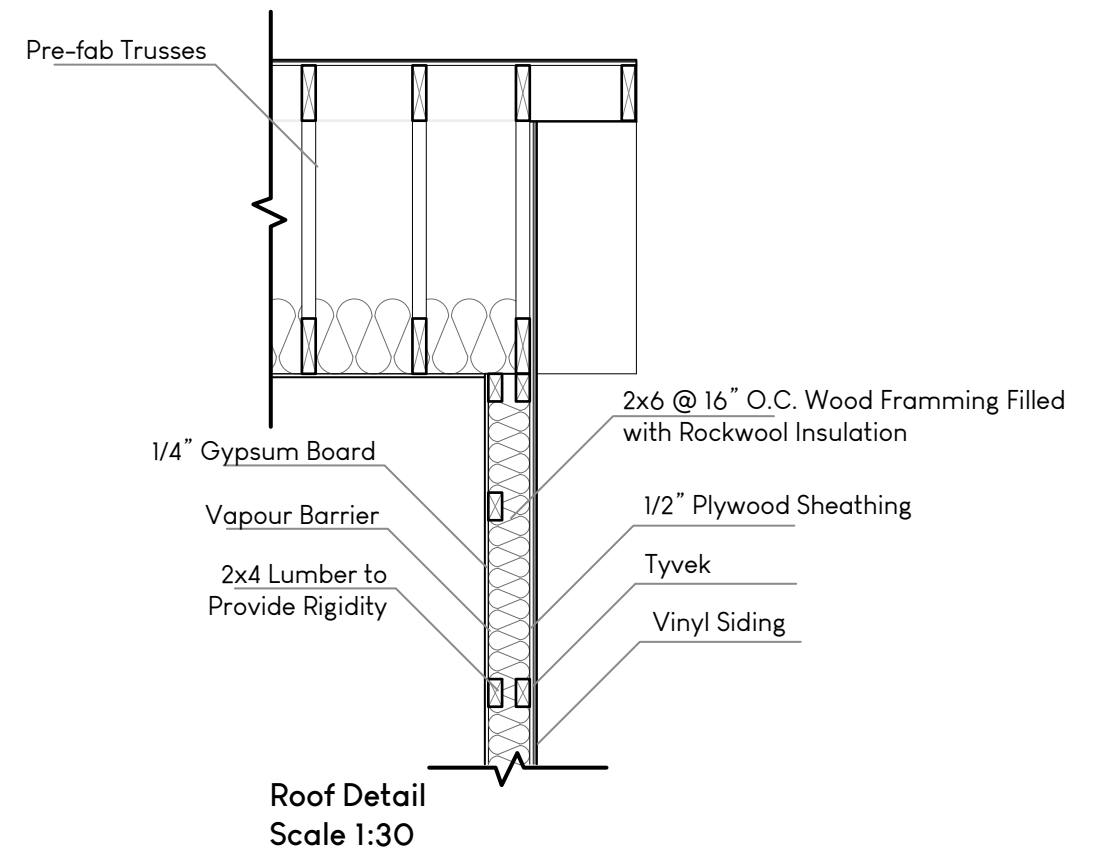
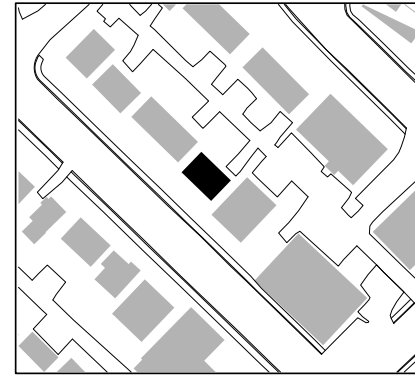


Figure 3.41: Analysis of a typical Manufactured home in Yellowknife



\$17 Smoking Addition Home

4107 42nd Street



Area: 159.00 m² (1715 sq.ft)
 Heating: Propane Furnace
 Electricity: Municipal
 Water: Municipal
 Waste: Municipal

Site Plan

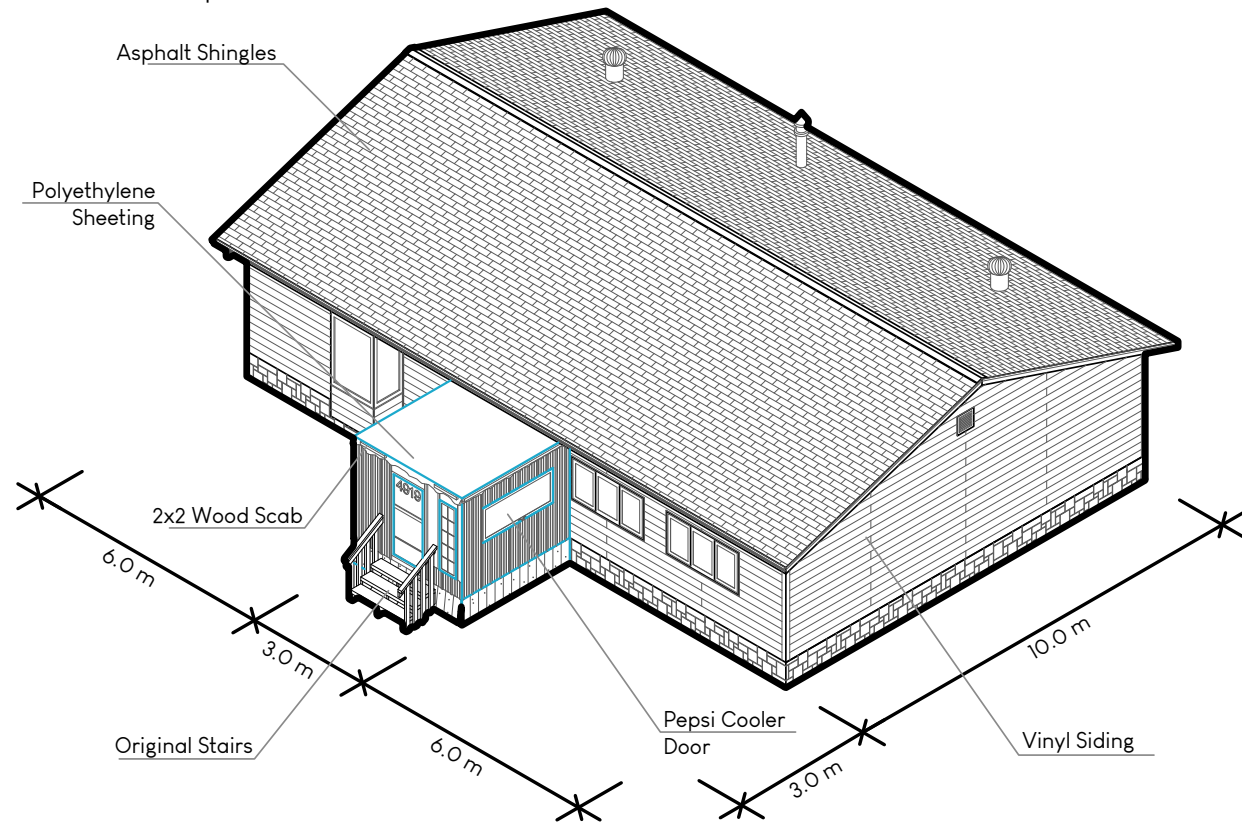
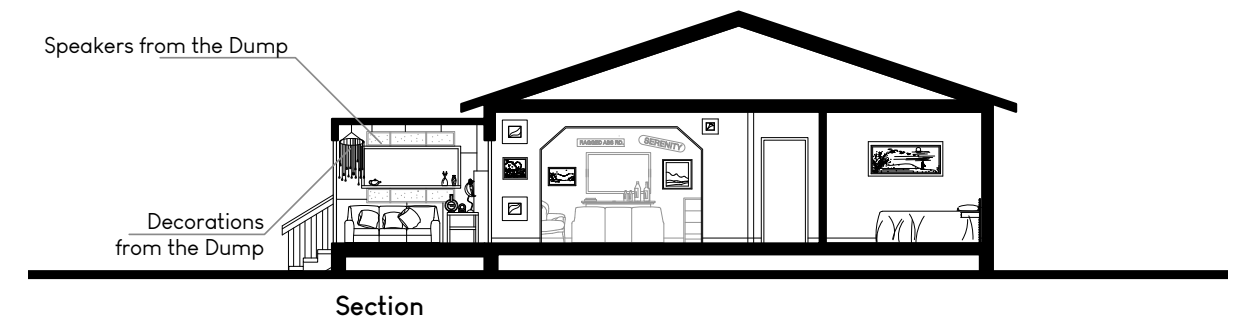
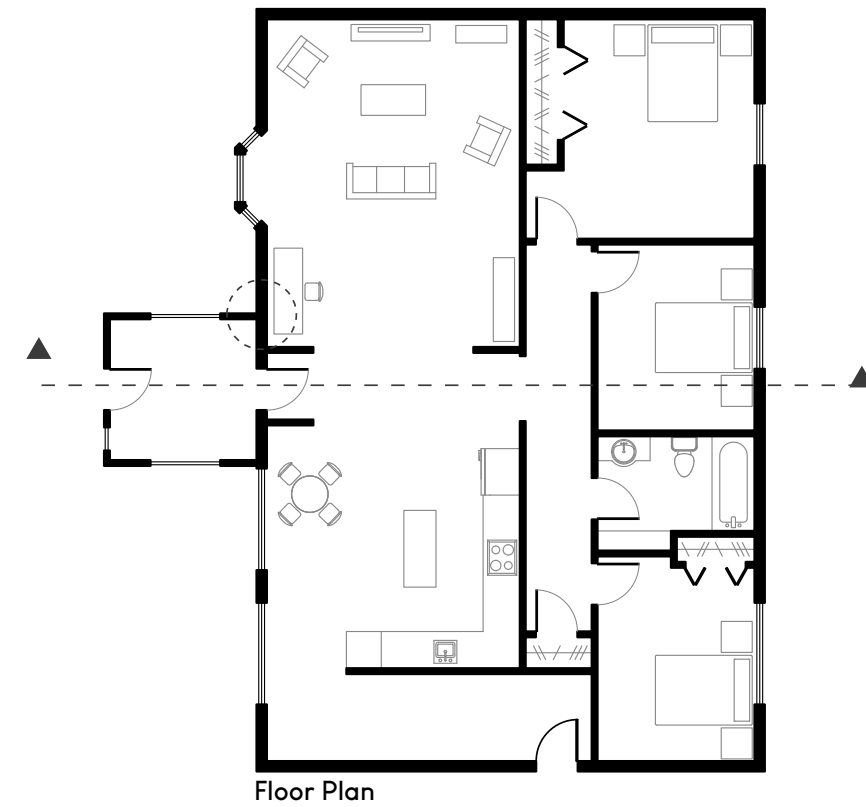
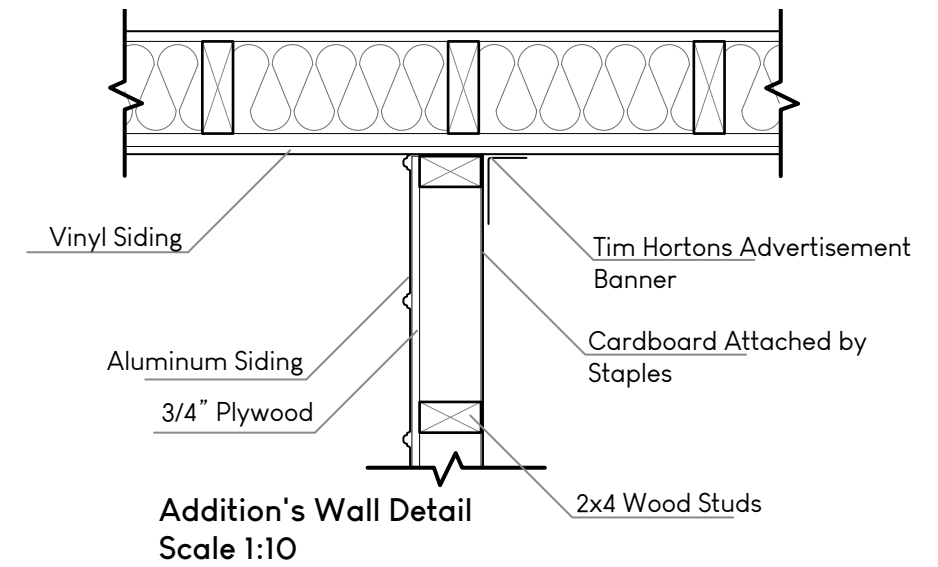


Figure 3.42: Analysis of the airbnb I stayed in while in Yellowknife



Vestibule Renovation Home

20 Trails End Crescent



Area: 122.36 m² (1315 sq.ft)
Heating: Oil Heating w/ Wood Stove
Electricity: Municipal
Water: Municipal
Waste: Municipal

Site Plan

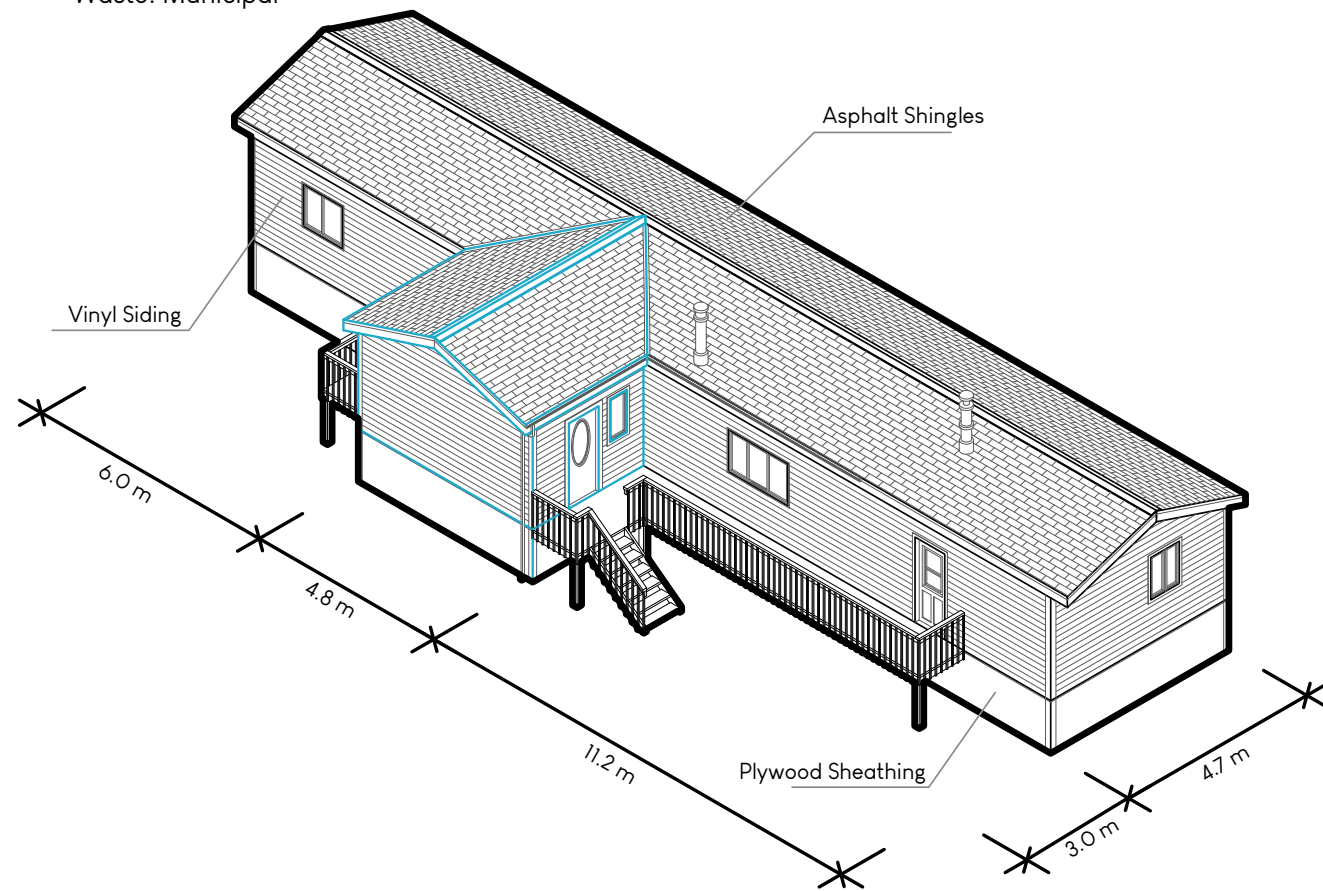
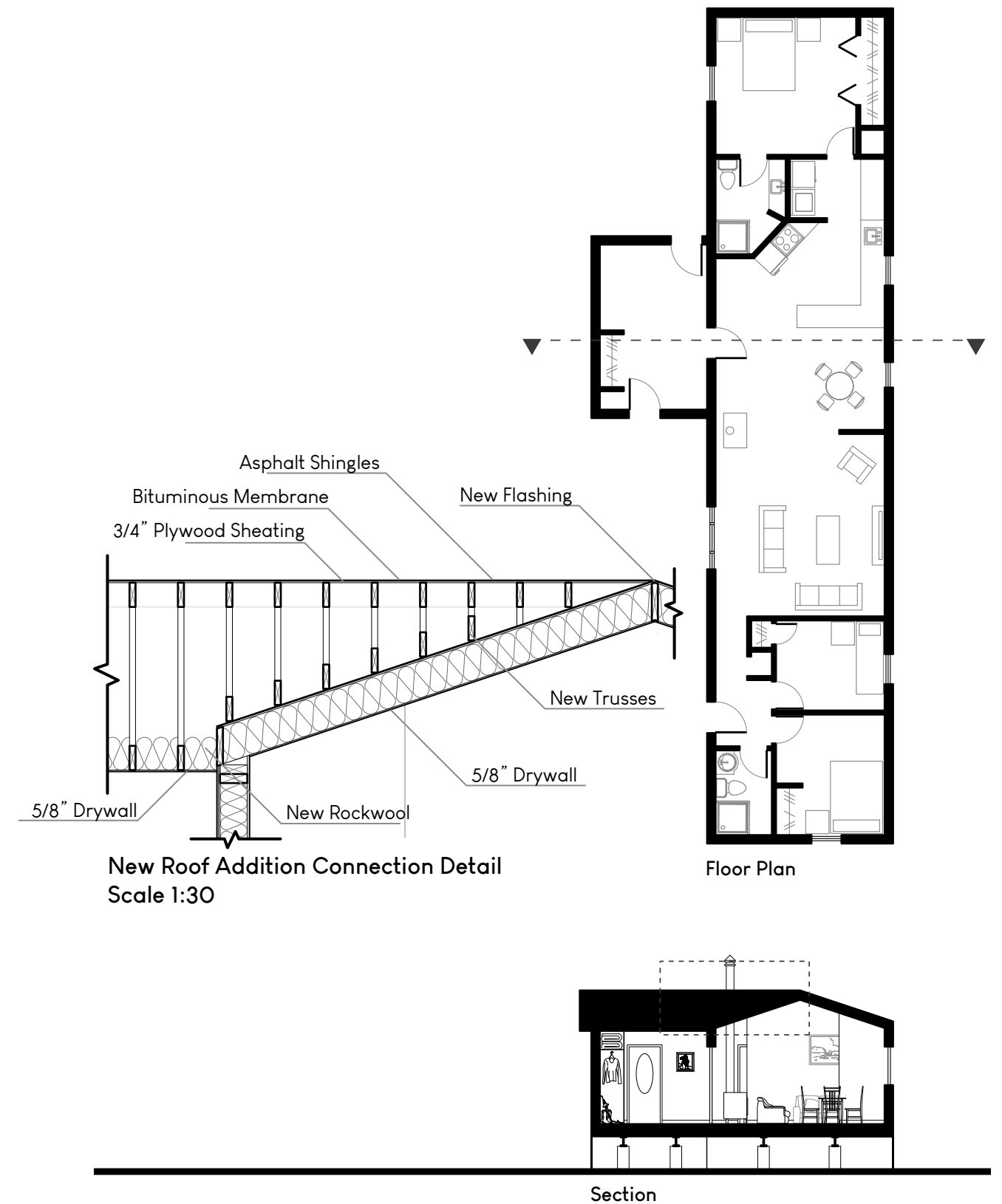
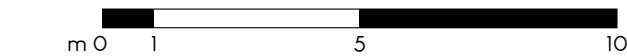
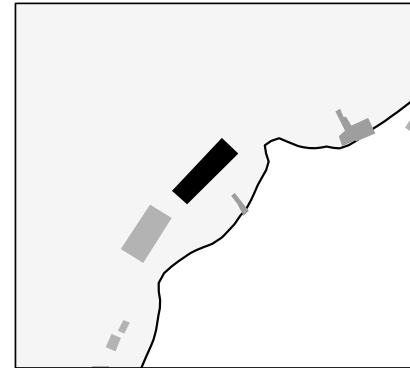


Figure 3.43: Analysis of a typical vestibule renovation on a Manufactured home in Yellowknife



Bush Rat Cafe

62°27'49.5"N 114°20'44.4"W



Area: 50.97 m² (550sq.ft)
 Heating: Wood Stove
 Electricity: Solar Panel and Wind Generation
 Water: Pumped Directly From Lake
 Waste: Honeybucket System

Site Plan

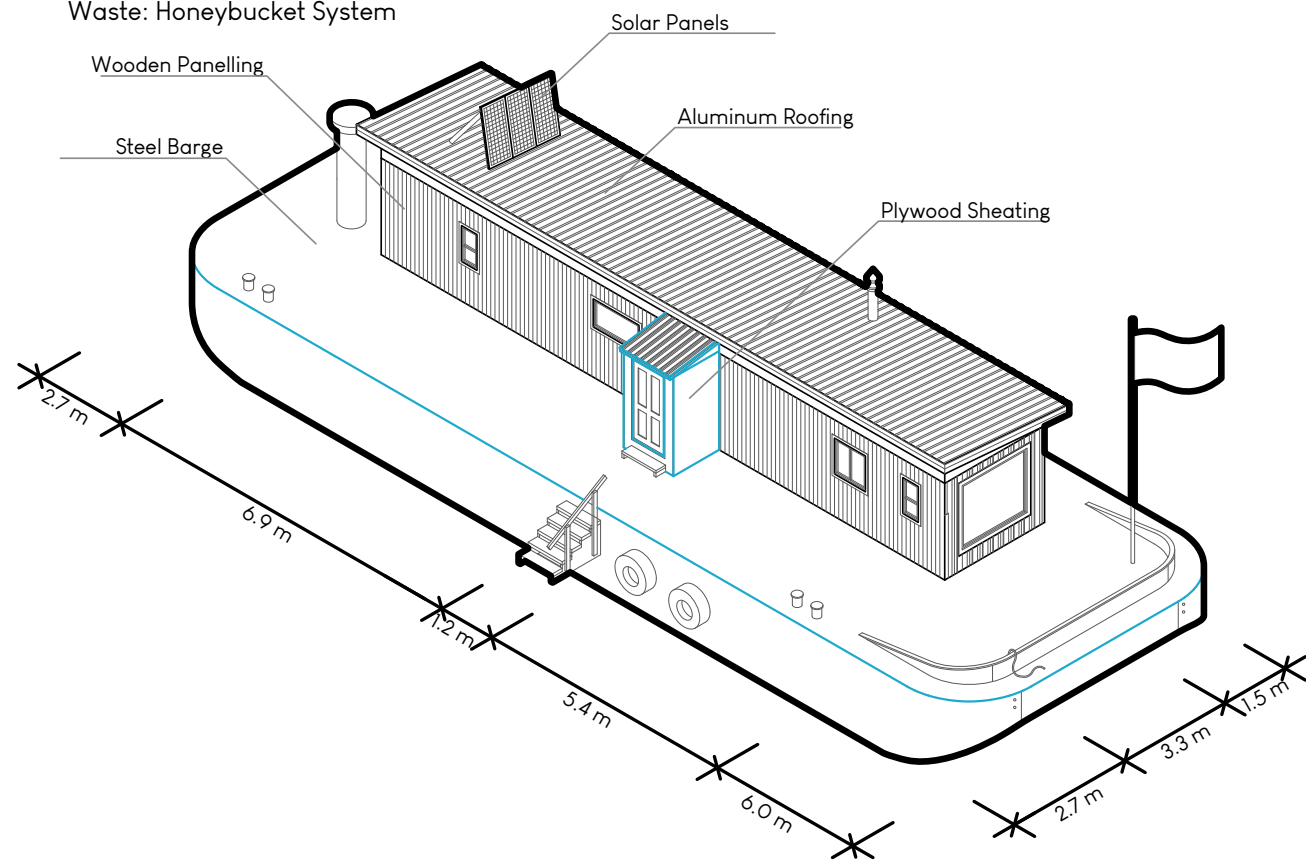
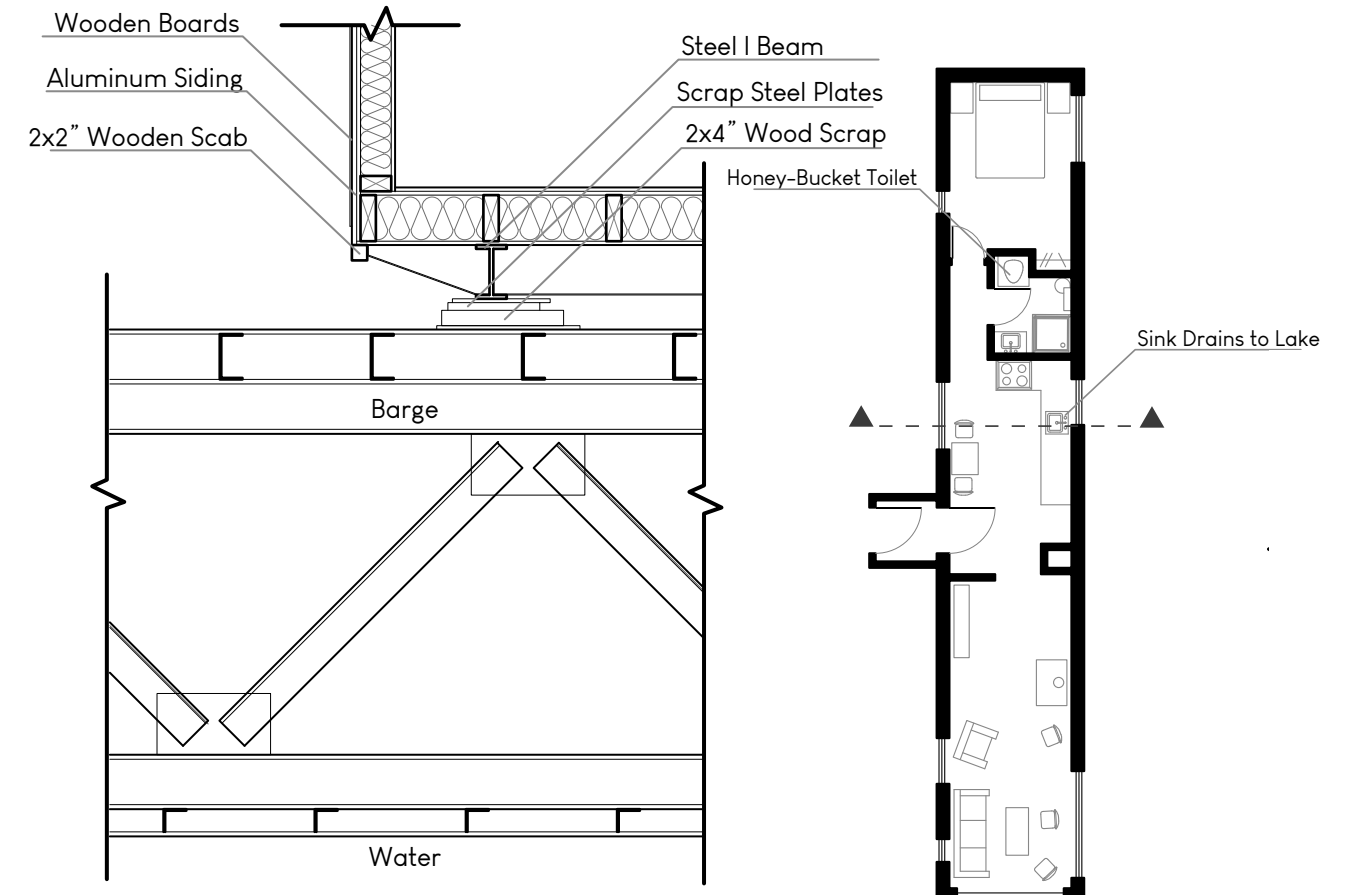
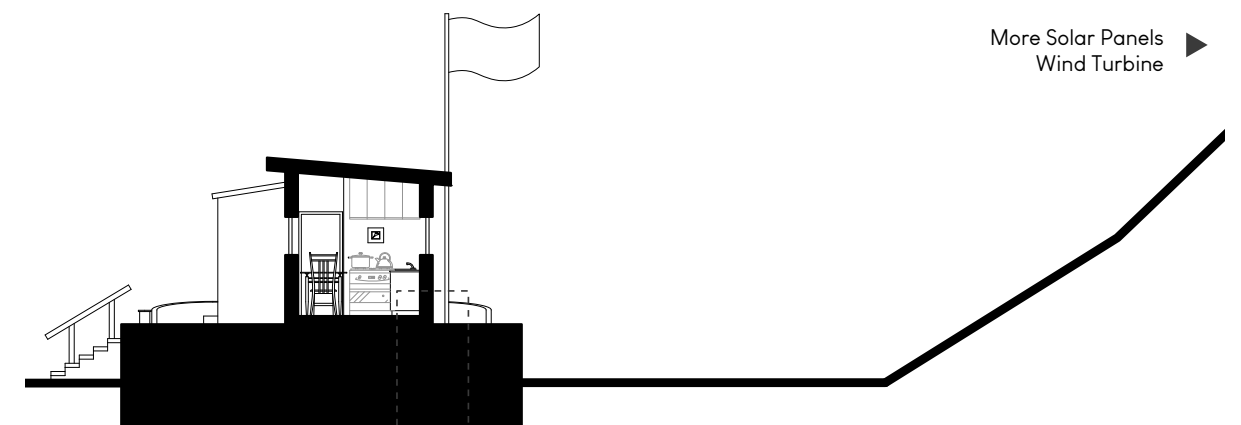


Figure 3.43: Analysis of Fran Hurcomb's Houseboat, the Bush Rat Cafe on Yellowknife Bay



Trailer's Connection to Barge Detail
 Scale 1:30

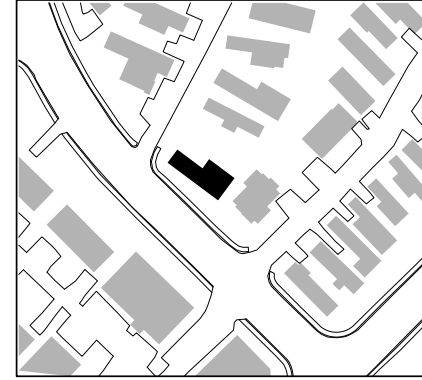
Floor Plan



Section

Mose's Home

1 Trails End Crescent



Area: 172.34 m² (1855 sq.ft.)
Heating: Electric Baseboard
Electricity: Municipal
Water: Municipal
Waste: Municipal

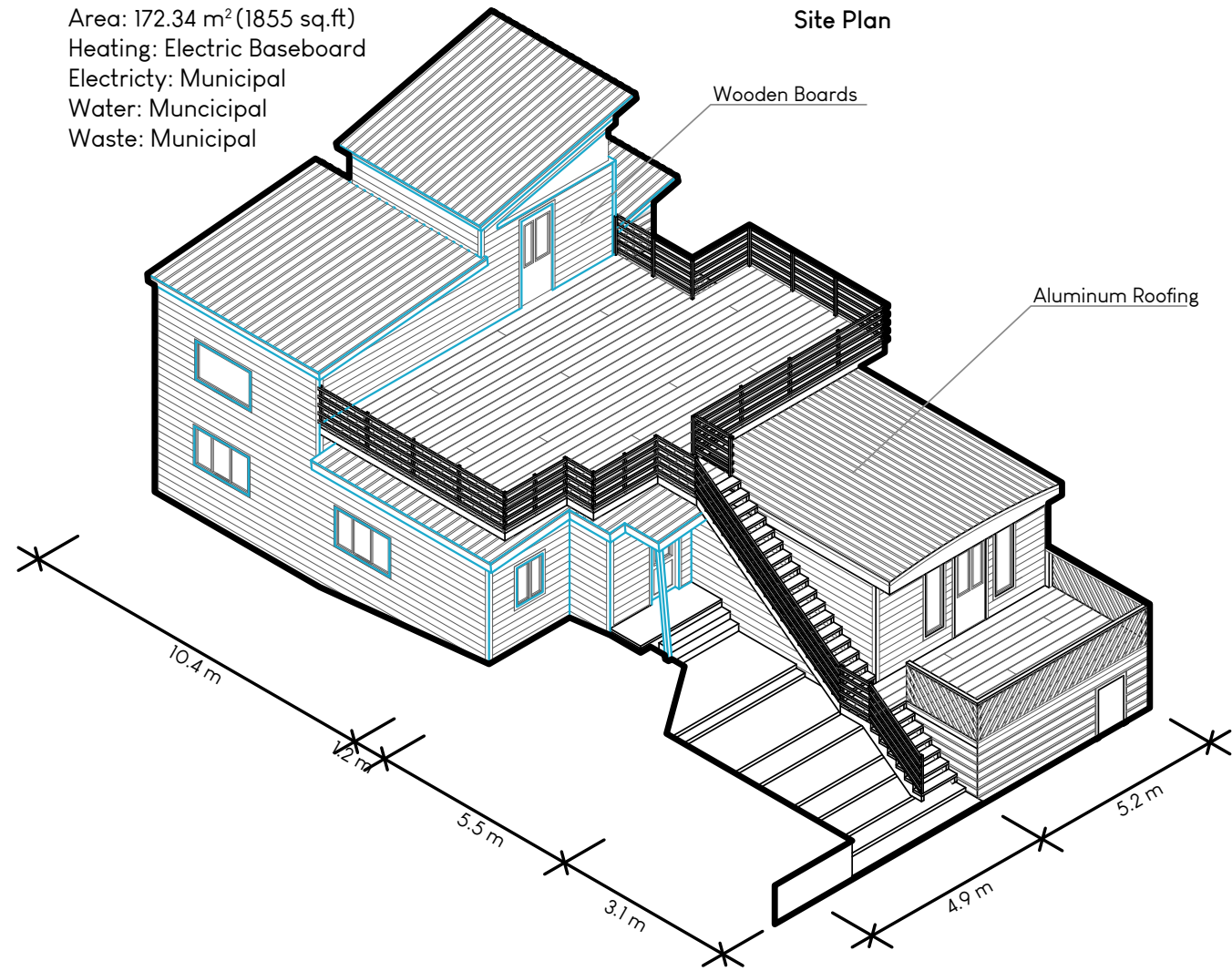
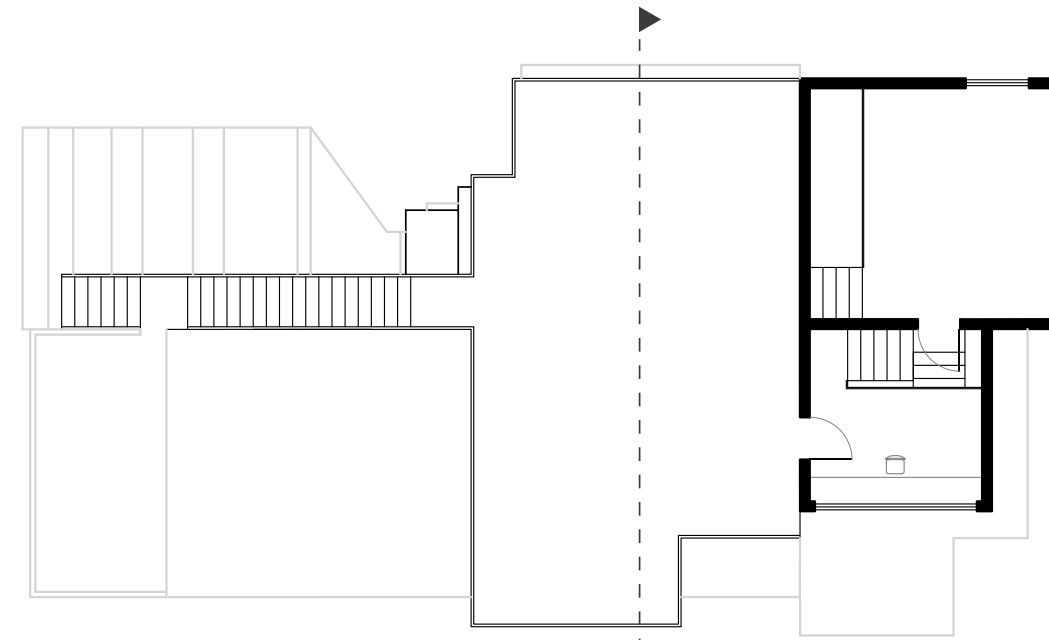
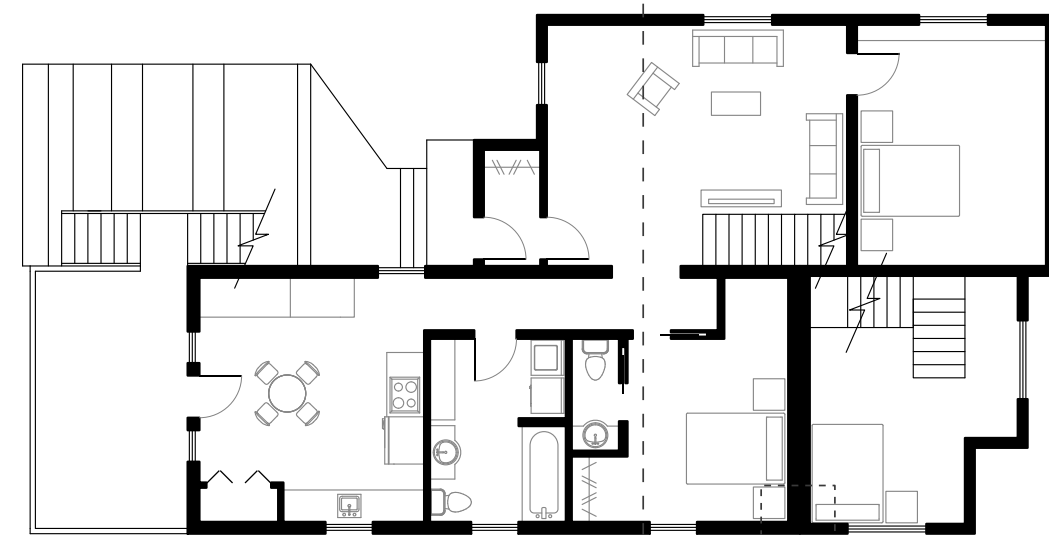


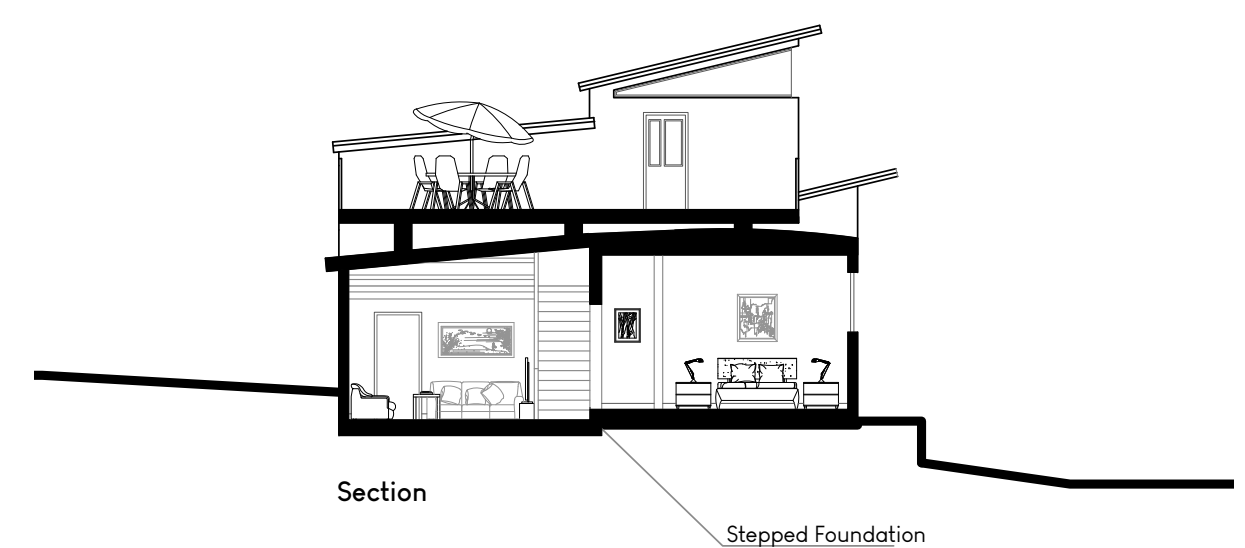
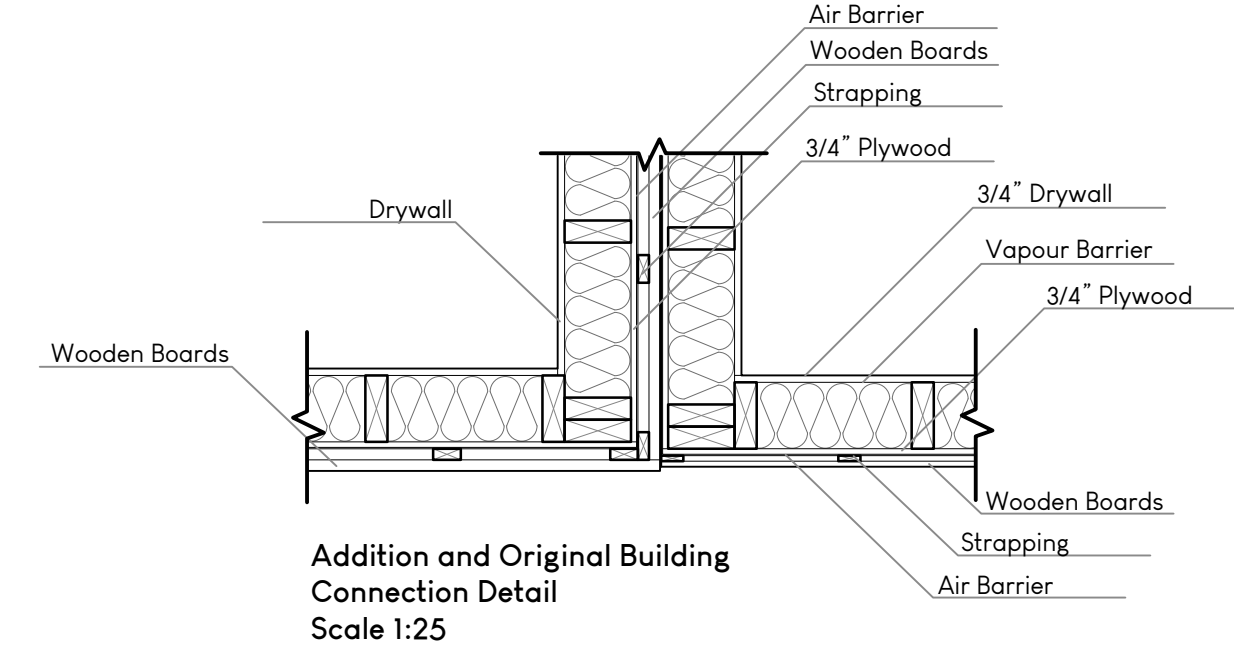
Figure 3.44: Analysis of a manufactured home that I lived in while in Yellowknife



Floor Plan Level 2



Floor Plan Level 1



Good Building Practices in the North

*"Design of northern building must strike a balance between buildings that are stylistically appropriate in small communities, and the demand for buildings that are energy-efficient and simple to build and maintain."*²⁴

While these three typologies are useful in learning how practitioners should build and design in the region, they are not the only sources of information this thesis reviewed. Based on a series of interviews with local practitioners and official documents released by the Government of the Northwest Territories, a set of recommendations for best practice within the region has been developed. These sometimes directly contradict the green building certification systems that will be discussed later. The design proposal will have to address these issues and decide what conditions are more relevant to the spatial practice within Yellowknife.

The first rule is that all aspects of a project, from systems to materials should be as simple as possible. Simplicity will help improve the speed of construction, which is essential due to the short construction season. It also helps limit the cost, the chances of material failure, and the number of specialized trades that would need to be involved.²⁵ It also makes the inevitable repairs more straightforward and therefore cheaper. It is crucial that water, in all its phases, be considered as it can cause significant damage when changing from vapor to ice, expanding and forcing materials apart.²⁶

Another important recommendation is that all essential building systems, such as heating, ventilation, and fire protection,

be reliable in the harsh winter climate of this region.²⁹ They must be easily accessible because they will eventually break. The quicker they can be accessed, the sooner they will be fixed, and the less damage the frigid temperatures will inflict on other systems. It is also crucial that back-up systems always be provided, especially for electricity and heat in homes. The power still occasionally goes out in Yellowknife, and with temperatures dropping below -30°, this can destroy systems and potentially cost residents their lives. A simple solution to this is to always provide a wood stove.³⁰

Material selection in northern climates is crucial as the extreme temperature changes and the freeze-thaw cycle can be detrimental.³¹ This is especially important when considering how the building envelope and structure work together as their contraction and expansion rates can be inconsistent in different temperatures. This is why it is best to place the structure entirely within the building envelope.³²

For exterior cladding metal or cement composite work best, except for aluminum, which is temperature-sensitive and prone to warping. Wood can also be used if proper maintenance is available. Stucco and vinyl should not be used as they struggle with the severe temperature changes and do not allow for the flexibility required to deal with foundation shifts.³³ Cladding should always be placed in the vertical position as it helps reduce the adhesion of snow and ice and reduces drying time.³⁴ Even the fasteners should be sturdier in northern climates as the weather conditions and foundation movements put more strain on these materials.³⁵

For roofing, it is not recommended to use wood shingles, and heavyweight wind-resistant asphalt shingles should only be used in low wind conditions. Metal roofing or a modified bitumen membrane is by far the most successful roofing material.³⁶ Minimal eave projections are preferred in colder, drier areas in the region, whereas an area with more rain should have more substantial eaves.³⁷

Some recommendations for indoor finishes include light colored walls as they help to reflect the limited winter light and help create a feeling of openness within the space. Wood finishes are also recommended as it is familiar to the region but some woods such as birch, which is local, work better than others.³⁸ For example, hardwood flooring is generally not recommended because of the dry conditions and the high risk of water damage in the winter.³⁹ Even casework is not safe as seasonal humidity fluctuation can cause warping in large plywood doors.⁴⁰

Often architects who are unfamiliar with designing for northern regions try to minimize the use of windows so that there is less heat loss, but this access to light is crucial, especially in the winter when daylight is minimal.⁴¹ Instead, windows should be placed in locations that provide the most light, but their purpose should be simplified. Using windows for passive ventilation is not recommended as operable windows often break, and shifting foundations can cause them to become fixed in the open position.⁴² All of these things and more need to be considered when designing housing in the North. It is a specific, local, complex environment which requires adaptable and simple designs that can

handle the extreme conditions.

¹ Sheppard and White, *Many Norths: Spatial Practice in a Polar Territory*, 15.

² Government of Canada, "Census Profile, 2016 Census – Yellowknife [Census Agglomeration], Northwest Territories and Northwest Territories [Territory]."

³ "The Largest Selection of Homes For Sale in Yellowknife – Coldwell Banker," Coldwell Banker, accessed December 19, 2019, <http://cbyk.ca/residential/>.

⁴ Sara Wilson, "Numbers Show a Different Picture: It Is More Expensive to Build a House in Yellowknife than Iqaluit, Really," *Nunavut & NWT Construction News*, March 26, 2012.

⁵ Sheppard and White, *Many Norths: Spatial Practice in a Polar Territory*, 111.

⁶ Pat Kane, "A Portrait of Life in Yellowknife's Shack Community," *VICE*, December 21, 2018, https://www.vice.com/en_ca/article/wj3a7w/a-portrait-of-life-in-yellowknifes-shack-community.

⁷ Hurcomb, *Old Town: A Photographic Journey Through Yellowknife's Defining Neighbourhood*, 94–95.

⁸ Katherine O'Neill, "Yellowknife's Shack Dwellers Hope to Stay the Axe," *The Globe and Mail*, accessed December 15, 2019, <https://www.theglobeandmail.com/news/national/yellowknifes-shack-dwellers-hope-to-stay-the-axe/article964758/>.

⁹ O'Neill.

¹⁰ Hurcomb, interview.

¹¹ Hurcomb, *Old Town: A Photographic Journey Through Yellowknife's Defining Neighbourhood*, 44–46.

¹² Hurcomb, 72.

¹³ Monique Robert, interview by Margaret Burt, *In-person Conversation*, November 17, 2019.

¹⁴ "Yellowknife Harbour Plan: Phase 1 Background Report" (Canadian Northern Economic Development Agency, April 2011), 9, <https://www.yellowknife.ca/en/doing-business/resources/harbour/april-11-yellowknife-harbour-plan-background-report.pdf>.

¹⁵ Robert, interview.

¹⁶ Robert.

¹⁷ Robert.

¹⁸ Robert.

¹⁹ "YK Mythbusters: Can Houseboaters Get Insurance?," *Edge*, August 6, 2015, <https://edgenorth.ca/article/yk-mythbusters-can-houseboaters-get-insurance>.

²⁰ Robert, interview.

- ²¹ Sheppard and White, *Many Norths: Spatial Practice in a Polar Territory*, 118.
- ²² Josh Sherman, "In This Remote Canadian Housing Market, a Mobile Home Can Cost You More than a Toronto Condo," *Libabi*, September 21, 2016. <https://www.libabi.com/2016/09/mobile-home-cost-more-than-toronto-condo.html>.
- ²³ Vince Barter, interview by Margaret Burt, In-person Conversation, November 17, 2019.
- ²⁴ Department of Public Works and Services, "Good Building Practices For Northern Facilities" (Government of the Northwest Territories, March 20, 2013), G7. https://www.inf.gov.nt.ca/sites/inf/files/good_building_practice_for_northern_facilities.pdf.
- ²⁵ Department of Public Works and Services, A1.
- ²⁶ Strub, *Bare Poles: Building Design for High Latitudes*, 49.
- ²⁷ Department of Public Works and Services, "Good Building Practices For Northern Facilities," L6.
- ²⁸ Barter, interview.
- ²⁹ Department of Public Works and Services, "Good Building Practices For Northern Facilities," A1.
- ³⁰ Strub, *Bare Poles: Building Design for High Latitudes*, 125.
- ³¹ Department of Public Works and Services, "Good Building Practices For Northern Facilities," A20-22.
- ³² Department of Public Works and Services, A19.
- ³³ Department of Public Works and Services, A20.
- ³⁴ Department of Public Works and Services, A25-26.
- ³⁵ Department of Public Works and Services, A28.
- ³⁶ Barter, interview.
- ³⁷ Department of Public Works and Services, "Good Building Practices For Northern Facilities," A47.
- ³⁸ Department of Public Works and Services, A64.
- ³⁹ Barter, interview.
- ⁴⁰ Strub, *Bare Poles: Building Design for High Latitudes*, 128.

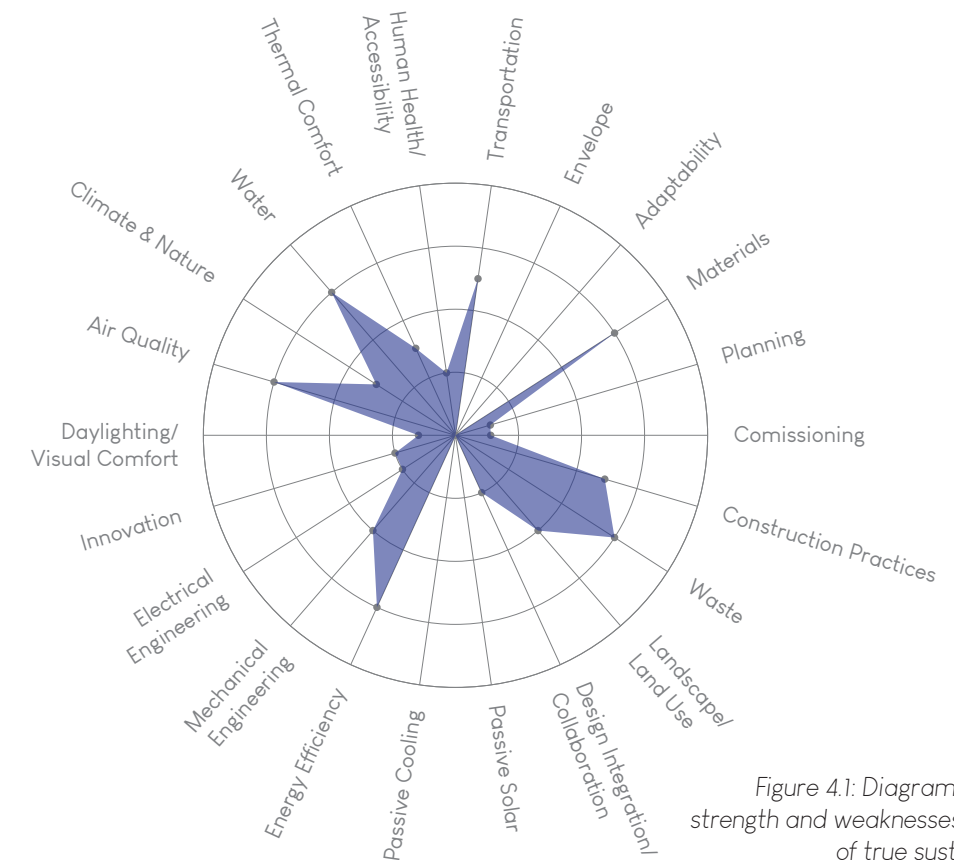


Figure 4.1: Diagram of LEED's strength and weaknesses in terms of true sustainability

Green Building Certification Systems

"When we damage nature here, it does not grow back as quickly. We need to be careful."¹

Leadership in Energy and Environmental Design

Leadership in Energy and Environmental Design was developed by the U.S. Green Building Council in the 1980s and continues to be one of the most widely used certification systems in the world.² It is broken down into eight categories – integrative process, location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation.³

LEED touches on a wide variety of categories, but some are impractical. Points are given out for using noncellulosic materials as a form of nontoxic pest control,⁴ but

this is one of the best strategies for carbon sequestering.⁵ A point is also given for reducing the annual energy uses of a building by only 1%,⁶ rewarding mediocrity, and compromising the legitimacy of the whole certification system.

LEED caters to projects built in the city as several points are based on being close to transit, bike paths, and neighborhood development, making remote projects challenging.⁷ However, LEED is one of the few systems which take regional priority into account, helping areas with more challenging climates.⁸

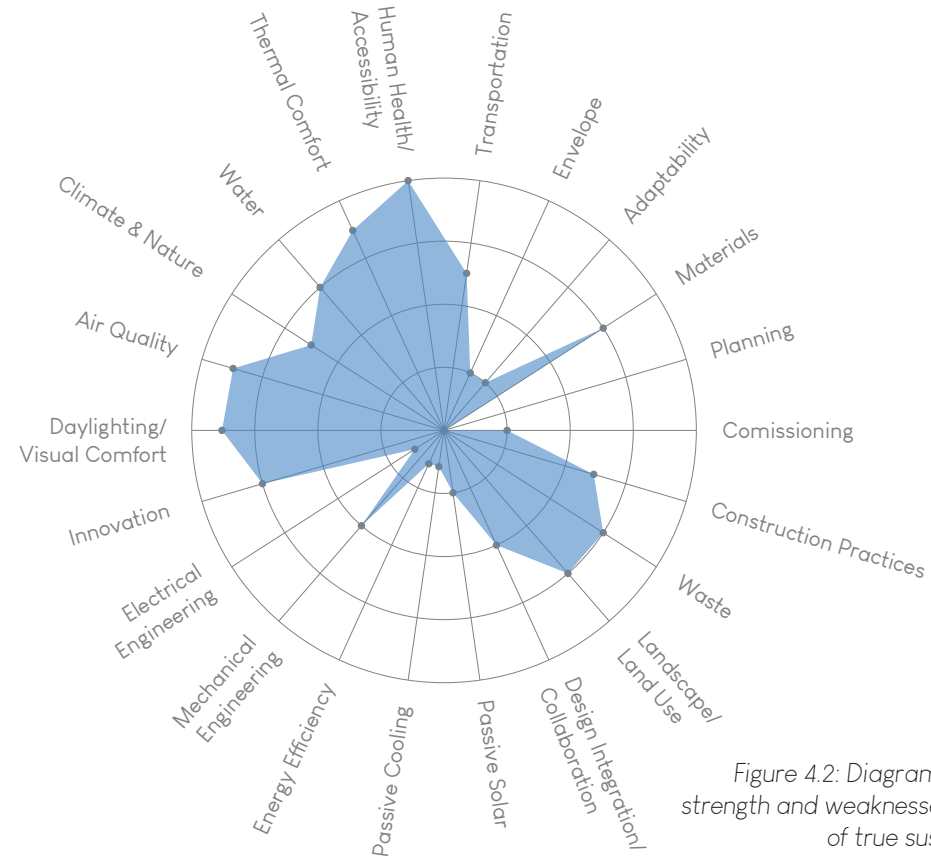


Figure 4.2: Diagram of WELL's strength and weaknesses in terms of true sustainability

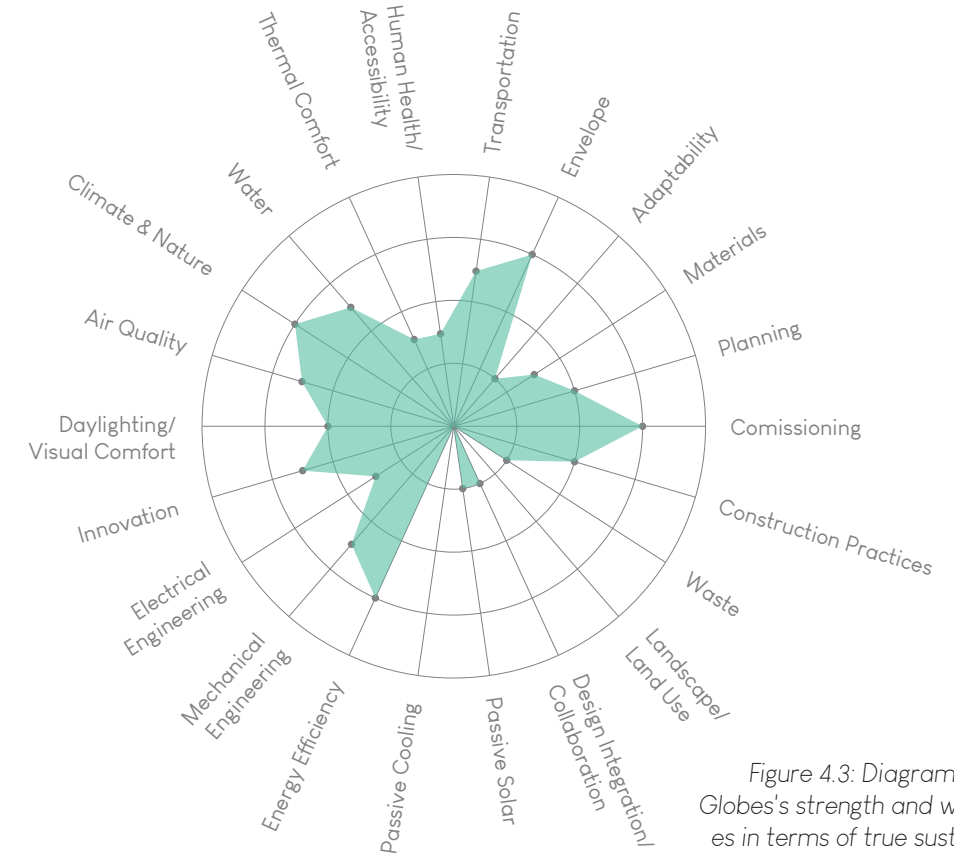


Figure 4.3: Diagram of Green Globes's strength and weaknesses in terms of true sustainability

International WELL Building Standard

Developed in 2014 by the WELL Building Institute, WELL is an international rating system based on scientific and medical research, with the primary goal being to create built environments that put people's health first.⁹ Divided into ten categories – air, water, nourishment, light, movement, thermal comfort, sound, materials, mind, and community, plus a bonus one, innovation – each one has a maximum scoring potential of twelve, forcing designers to look at each category. Each category has preconditions ensuring that a minimum quality level is guaranteed.¹⁰

WELL offers three levels of certification, the first being silver at fifty points, then gold at sixty points, and finally Platinum at eighty points. The highest rating, platinum, is only

asking people to achieve 73% of the objectives.¹¹ This just is not high enough, considering the current state of the climate crisis and is therefore rewarding mediocrity.

That said, it does address many issues that the other green building certification systems overlook such as, sleep and stress support, new parent support, pesticide use, and food advertising. It zeroes in on trying to make the healthiest environment for people, tackling obesity, healthy eating, and the opioid epidemic while still addressing water and air quality and management.¹²

Green Globes

Green Globes was created by Energy and Environmental Canada in the early 2000s and is an online process that begins with a series of self-assessments. The fact that it is entirely online means the process is streamlined, straightforward and significantly cheaper than other programs.¹³

This system is based on 1000 points and broken down into seven categories – project management, site, water, energy, emissions, materials and resources, and the indoor environment – but unlike other systems, none of these categories have minimum requirements. A designer could only focus on energy and still become certified. The minimum scoring requirements are also low, with a score of 25% achieving a 1G certification.¹⁴ This means that some

certified buildings could be very unsustainable, compromising the legitimacy of this program.

One of the benefits of Green Globes is that it covers many topics others do not, such as clean diesel strategies for construction and visual markers for birds, as well as having four different categories for innovation.¹⁵ However, it could be argued that Green Globes just does not go far enough. It only requires that 50% of the non-potable sources of water be from on-site water collection and still allows for people to build on flood plains.¹⁶ It does not ask for more on energy use than the national energy code and does not discuss any passive strategies for heating or cooling.¹⁷

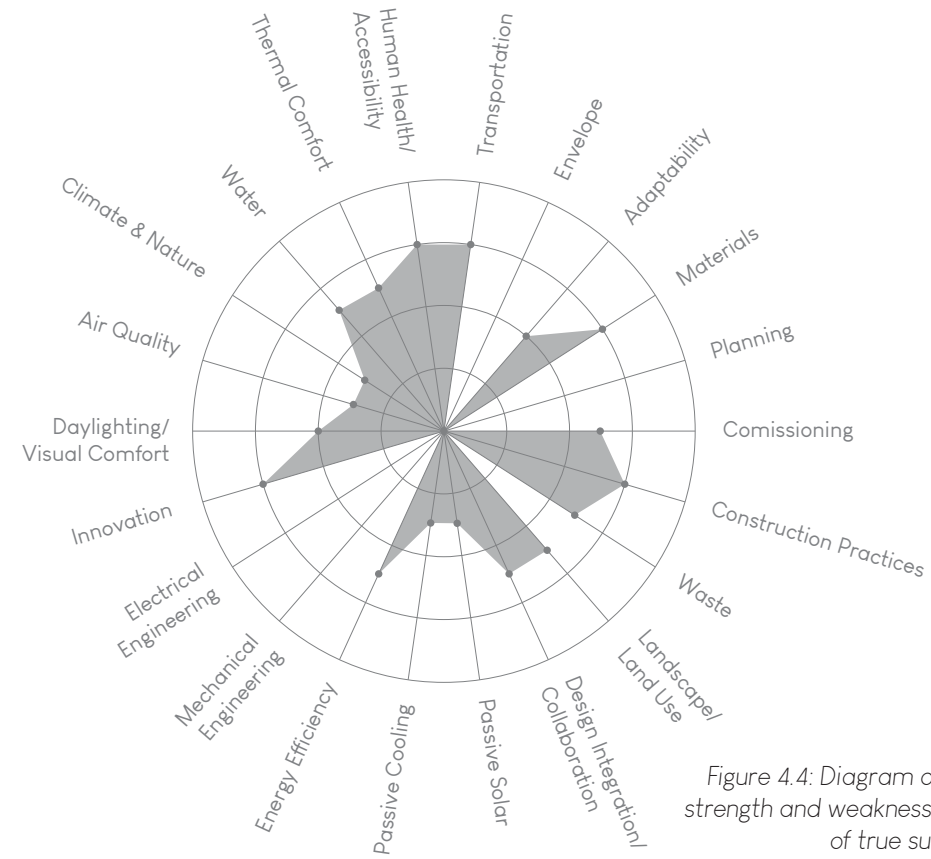


Figure 4.4: Diagram of BREEAM's strength and weaknesses in terms of true sustainability

Building Research Establishment Environmental Assessment Method

Building Research Establishment Environmental Assessment Method (BREEAM) was developed in the 1980s in the United Kingdom.¹⁸ This system breaks down into nine categories – management, health and wellbeing, energy, transport, materials, waste, land use and ecology, pollution, and innovation – offering up a total of 145 points.¹⁹ Some of the categories have mandatory requirements, such as all timber used must be legally harvested,²⁰ and a separate private space is required for occupants.²¹ It also requires space for either recycling or compost, thinking about the occupancy of the building.²²

While this system covers a lot of unique and essential topics, some of them are oddly weighted. BREEAM was the only

system to mention adapting the structure and fabric of the building for climate resiliency,²³ but this is only equal to one point, the same amount of points given for including a clothesline.²⁴ Some of the topics are also unhelpfully vague. For example, the designer could earn one point for minimizing the risk of contamination, but it does not give a minimum amount of reduction required,²⁵ and so people could minimally reduce the risk and still earn a point.

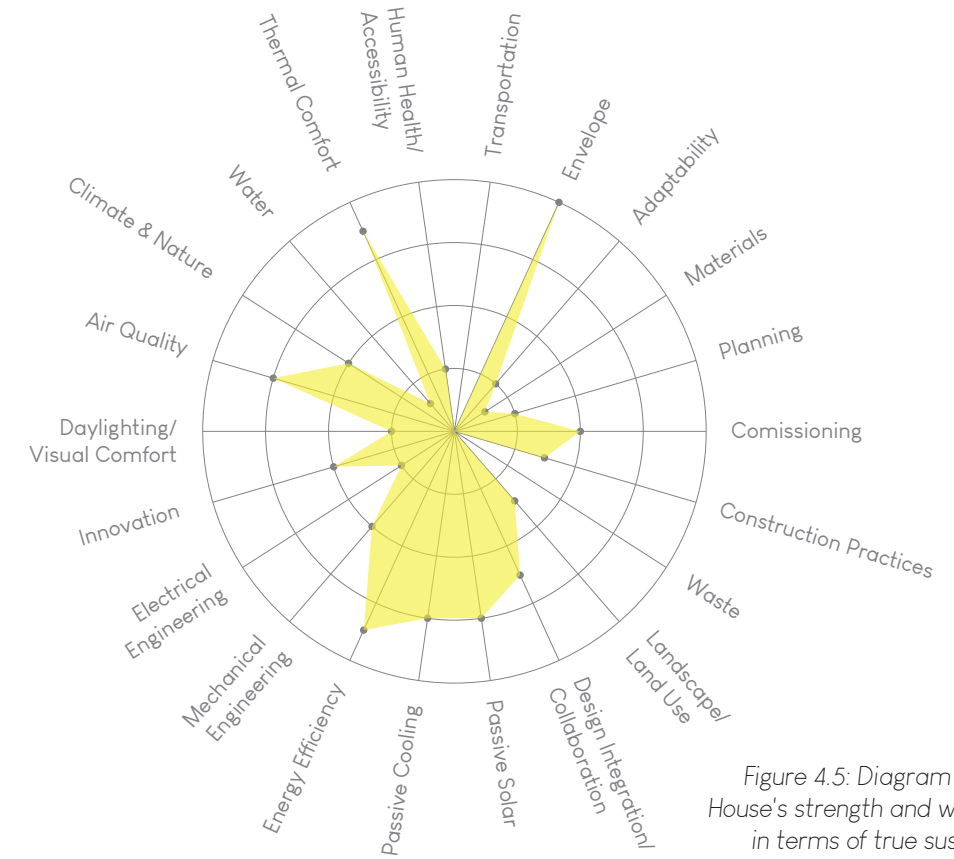


Figure 4.5: Diagram of Passive House's strength and weaknesses in terms of true sustainability

Passive House

Developed in the 1990s in Germany, the Passive House system was developed based on the principals of building physics.²⁶ Reducing energy consumption is the primary driver behind the certification process, with the maximum energy demand having to be less than 120kWh/m²a. Some of the other requirements for certification is a space heating demand of only 15kWh annually, and a maximum of 0.6 air changes per hour at 50 Pascals of pressure.²⁷ While there are not many requirements for this certification system, it serves more as a tool to achieve optimal building physics for each project, staying open-ended, allowing designers to innovate rather than follow a prescription.²⁸ They have also developed one of the most reliable energy modeling software, PHPP,

with an average accuracy of +/- 0.5kWh/m²a for energy use. Even though the energy modeling is quite accurate Passive House certification is only awarded after construction and after a post-construction inspection, proving that this system cares about actual numbers, not projected numbers.²⁹

Passive House stresses airtightness, high interior thermal comfort, and focuses on reducing energy demand through passive strategies. It also encourages the optimization of the site, efficiency of form, and careful detailing of the building envelope (airtightness and thermal bridge reduction), giving designers simple tools that are very effective in reducing the energy demand of a building.³⁰

Their newest variation has added three levels of certification - Passive House Classic, Passive House Premium, and Passive House Plus - with the highest certification level requiring the building to produce four times the energy that is required to run the building.³¹ The great thing about Passive House is that it takes the term net-zero much more seriously than other certification systems, considering when the energy is produced versus when the energy is needed. If a building is only producing energy in the summer but needs additional energy in the winter from secondary sources, then that is not net-zero, nor sustainable.³²

Passive House has been working on developing a simplified certification system for homes that will make the process more affordable and widely used. It will begin to move towards a more prescriptive system, reducing the level of customization. This new system requires designers to use pre-vetted products and wall assemblies and plans to be available by 2020.³³

However, this energy certification system has little human aspects to it. Other than thermal comfort and ventilation, it does not take into consideration human characteristics such as beauty, accessibility, health, or visual comfort, to name a few. It also does not take material selection or water usage into consideration. For these reasons, a designer should never use Passive House by itself. Energy use is not the only benchmark of a sustainable building. A study proved that a net-zero building produced with high carbon materials would produce more carbon long-term than an average energy use building made with carbon-sequestering products. This proves that energy use should never be looked at in isolation.³⁴

Living Building Challenge

Living Building Challenge was created in 2006 by the International Living Future Institute. It markets itself as a philosophy, advocacy, and certification program with very rigid standards.³⁵ The main driving argument for the Living Building Challenge is that in order to achieve true sustainability, buildings must begin to operate as if they are living things that contribute to the ecology of a place.³⁶ It uses the metaphor of a flower with each category - energy, place, water, health and happiness, materials, equity, and beauty - acting like a petal, working together to gather all they need from the site.³⁷

It offers several different paths of certification, the highest being living certification, which requires all objectives in each petal to be completed. The next level is petal certification, which requires the achievement of all requirements in one section plus the imperatives in other categories. Core Certification means that only the imperatives of each petal have been met. There is also net-zero energy certification and zero-carbon certification, which are pretty self-explanatory.³⁸

Instead of being a point-valued system, the Living Building Challenge has a set of rules that must be followed. It demands that specific measures, such as providing 105% of a building's energy on-site, must be completed to begin the certification process.³⁹ After that, each petal has objectives that must be met, or else the design cannot pass that section. A lot of these requirements are based on the belief that a building should positively impact its site's ecology rather than the typical belief that reducing harm is enough to be sustainable. For example, the Living

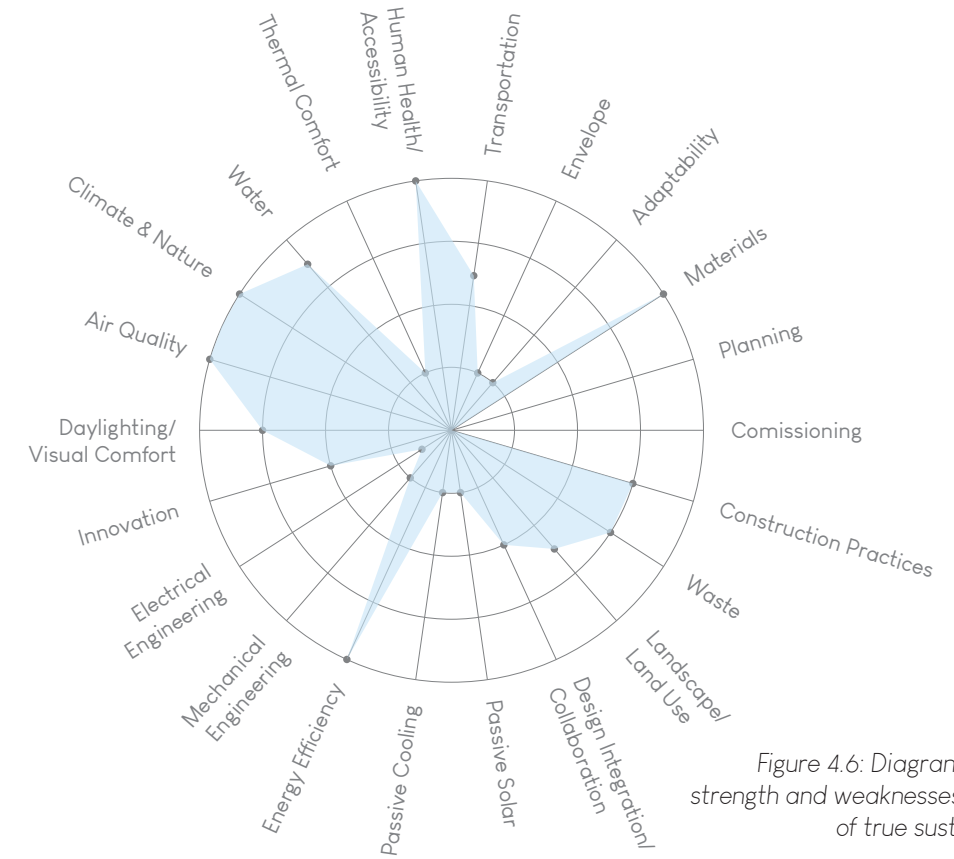


Figure 4.6: Diagram of LBC's strength and weaknesses in terms of true sustainability

Building Challenge will only allow projects to be built on previously developed sites, and they cannot be built within a 100-year flood plain. It is unsustainable to build in a location that does not facilitate construction, and this is the only certification system that holds the construction industry to such a strict sense of sustainability.⁴⁰

In terms of energy, LBC is the only one to completely outlaw combustion⁴³ as well as set an actual requirement for the reduction in the embodied carbon in primary materials (20%).⁴⁴ One of the best sections is LBC's materials section, which has a red list of products that are environmentally irresponsible and demands that manufacturers begin to label what is in their products,⁴⁵ proving that education is everything.

The real strength of LBC is that unlike many of the other systems, except for WELL, it places equal emphasis on human aspects of sustainability. It stresses a healthy interior environment, with access to views and daylight, that users can control through operable windows and access to thermostats.⁴⁶ LBC also stresses the aspect of accessibility and inclusion, trying to combat social problems that designers often do not associate as being influenced by architecture.⁴⁷ Finally, LBC is one of the only systems that have beauty as a requirement because sustainable buildings that are not beautiful have limited influence or appeal. Sustainable buildings should inspire and educate people so that they want to create more.⁴⁸

The intriguing thing is that when this system was developed, most of what was

required was illegal in most cities, such as rainwater collection for potable water filtration that did not use chemicals. LBC has forced legislation to change, refusing to settle, which is what makes this system so powerful.⁴⁹

Conclusion

After reviewing each of the energy certification systems, the ones that will be used in this thesis are the Passive House and Living Building Challenge, as the analysis has shown that by combining the two, it can provide a robust framework for achieving true sustainability. The latter will be used because of its rigid, high achieving requirements, which force designers to build truly sustainable buildings, from both a technical and human perspective.

Passive House will mainly be used as a tool with its energy modeling system, PHPP, and well developed passive strategies and building envelopes. They provide an excellent resource for reducing the energy use of a building because while renewable energy is great, the reality is in a city like Yellowknife, the winter gap between energy demand and supply will be impossible to close. Instead, this project will focus on reducing the demand first, as this is the only way to create a feasible energy solution.⁵⁰ As mentioned above, Passive House often misses the qualitative aspects of the human experience. This is where the Living Building Challenge is particularly useful. It not only focuses on energy but also health, happiness, equity, and beauty, all human experiences. It also champions the idea of regenerative design, architecture that does not stop at merely reducing harm to the environment but actively seeks to contribute positively to it.⁵¹ By combining these two systems, the project will be pro-

vided, with the best resources for achieving a holistic framework, facilitating true sustainability.

- ¹ Sheppard and White, *Many Norths: Spatial Practice in a Polar Territory*, 66.
- ² "LEED - Home," U.S. Green Building Council, accessed December 20, 2019, <https://new.usgbc.org/leed>.
- ³ U.S. Building Council, "LEED v4.1 Residential Single Family Homes" (U.S. Building Council, April 2, 2019), 2-4.
- ⁴ U.S. Building Council, 20.
- ⁵ Chris Magwood, "Real Zero Carbon Buildings by 2050" (October 18, 2019).
- ⁶ U.S. Building Council, "LEED v4.1 Residential Single Family Homes," 32-33.
- ⁷ U.S. Building Council, 7-8.
- ⁸ U.S. Building Council, 69.
- ⁹ "About I International WELL Building Institute," WELL, accessed December 20, 2019, <https://www.wellcertified.com/about-iwbi/>.
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- ¹² International WELL Building Institute.
- ¹³ "About Green Globes," Green Globes, accessed December 20, 2019, <http://www.greenglobes.com/about.asp>.
- ¹⁴ Green Globes, "Design for New Construction and Major Retrofits v.2 2014: Rating Program Summary" (ECD Energy and Environment Canada LTD., 2015), 7. http://www.greenglobes.com/newconstruction/Green_Globes_Design_for_New_Construction_v2_Summary.pdf.
- ¹⁵ Green Globes, 8-13.
- ¹⁶ Green Globes, 13-21.
- ¹⁷ Green Globes, "Design for New Construction and Major Retrofits v.2, 2014. Rating Program Summary."
- ¹⁸ BREEAM: What Is BREEAM?," BREEAM, September 23, 2015, <https://web.archive.org/web/20150923194348/http://www.breeam.org/about.jsp?id=66>.
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- ²⁰ BRE Global Ltd., 20.
- ²¹ BRE Global Ltd., 130.
- ²² BRE Global Ltd., 415.

- ²³ BRE Global Ltd., 315.
- ²⁴ BRE Global Ltd., 193.
- ²⁵ BRE Global Ltd., 133.
- ²⁶ Sarah Lewis, *PHPP Illustrated: A Designers Companion to the Passive House Planning Package*, Second (Newcastle, Tyne: Riba Publishing, 2017), 8-9.
- ²⁷ Justin Bere, *An Introduction to Passive House*, First (London, UK: Riba Publishing, 2014), 17.
- ²⁸ Bere, 16.
- ²⁹ Laidlaw, Cameron, Norrs, Neil, and Petit, Chris, "Simplified Certification Pilot for Passive House" (October 17, 2019).
- ³⁰ Bere, *An Introduction to Passive House*, (18-25).
- ³¹ "Classic, Plus, Premium: The New Passive House Classes and How They Can Be Reached," *Passipedia*, accessed December 20, 2019, https://passipedia.org/certification/passive_house_categories/classic-plus-premium.
- ³² Lewis, *PHPP Illustrated: A Designers Companion to the Passive House Planning Package*, 45-46.
- ³³ Laidlaw, Cameron, Norrs, Neil, and Petit, Chris, "Simplified Certification Pilot for Passive House" (October 17, 2019).
- ³⁴ Magwood, "Real Zero Carbon Buildings by 2050."
- ³⁵ Roddy Scheer and Doug Moss, "The Living Building Challenge I Earthtalk," *Emagazine.com*, January 6, 2013, <https://web.archive.org/web/20150923235929/http://www.emagazine.com/earth-talk/the-living-building-challenge>.
- ³⁶ Jason McLennan, "Regenerative Architecture for a Changing World" (November 5, 2019).
- ³⁷ "Living Building Challenge 4.0: A Visionary Path to a Regenerative Future" (International Living Future Institute, June 2019), 1-7, https://living-future.org/wp-content/uploads/2019/08/LBC-4_0_v13.pdf.
- ³⁸ "Living Building Challenge 4.0: A Visionary Path to a Regenerative Future," 23-25.
- ³⁹ "Living Building Challenge 4.0: A Visionary Path to a Regenerative Future," 42.
- ⁴⁰ "Living Building Challenge 4.0: A Visionary Path to a Regenerative Future," 38.
- ⁴¹ "Living Building Challenge 4.0: A Visionary Path to a Regenerative Future," 42.
- ⁴² "Living Building Challenge 4.0: A Visionary Path to a Regenerative Future," 42.
- ⁴³ "Living Building Challenge 4.0: A Visionary Path to a Regenerative Future," 53.
- ⁴⁴ "Living Building Challenge 4.0: A Visionary Path to a Regenerative Future," 47.
- ⁴⁵ "Living Building Challenge 4.0: A Visionary Path to a Regenerative Future," 60-62.
- ⁴⁶ "Living Building Challenge 4.0: A Visionary Path to a Regenerative Future," 66.

- ⁴⁷ McLennan, "Regenerative Architecture for a Changing World."
- ⁴⁸ Bere, *An Introduction to Passive House*, 8.
- ⁴⁹ McLennan, "Regenerative Architecture for a Changing World."

Design Proposal

“The best way to make something obsolete is to invent its replacement.”¹

The design project focuses on the redevelopment of the houseboat typology, both through a renovation design and a new construction project. The reasoning for selecting the houseboat over the other two typologies was that this thesis is not about developing a sustainable housing solution that can be placed within other northern communities. Rather, it is about establishing a methodology that can take a specific location’s architecture and identity; in this case, the houseboats of Yellowknife and push designers to imagine the full potential. It is about developing solutions that begin within the community, but through the use of both outside and local resources can be improved.

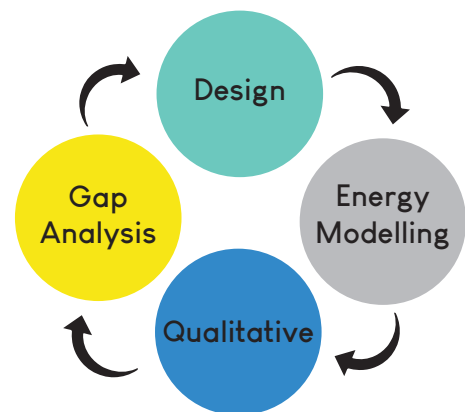


Figure 5.1: Diagram of methodology

The approach I used to accomplish this was a four tiered strategy which began with a design. The design, or individual parts of it would then be simulated using the PHPP Energy Modelling Software. The new design would then be compared to the baseline and if the result was sufficient I would then move on to the qualitative aspects of the design. This would address what the energy modeling had missed, and in

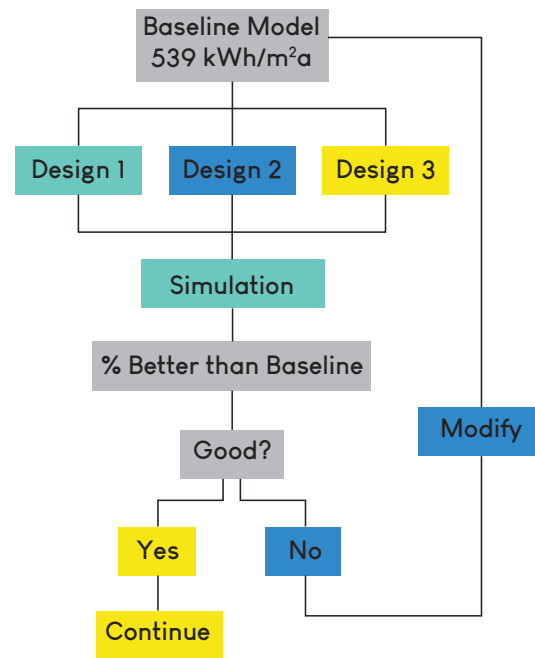


Figure 5.2: Diagram of approach

some cases justify what the energy modelling had eliminated. Finally the design would end in a gap analysis which would address how the design could be further adapted for the impending change in climate. This project was about constantly cycling through all four of these lenses so as to make sure nothing was missed, and true sustainability was addressed.

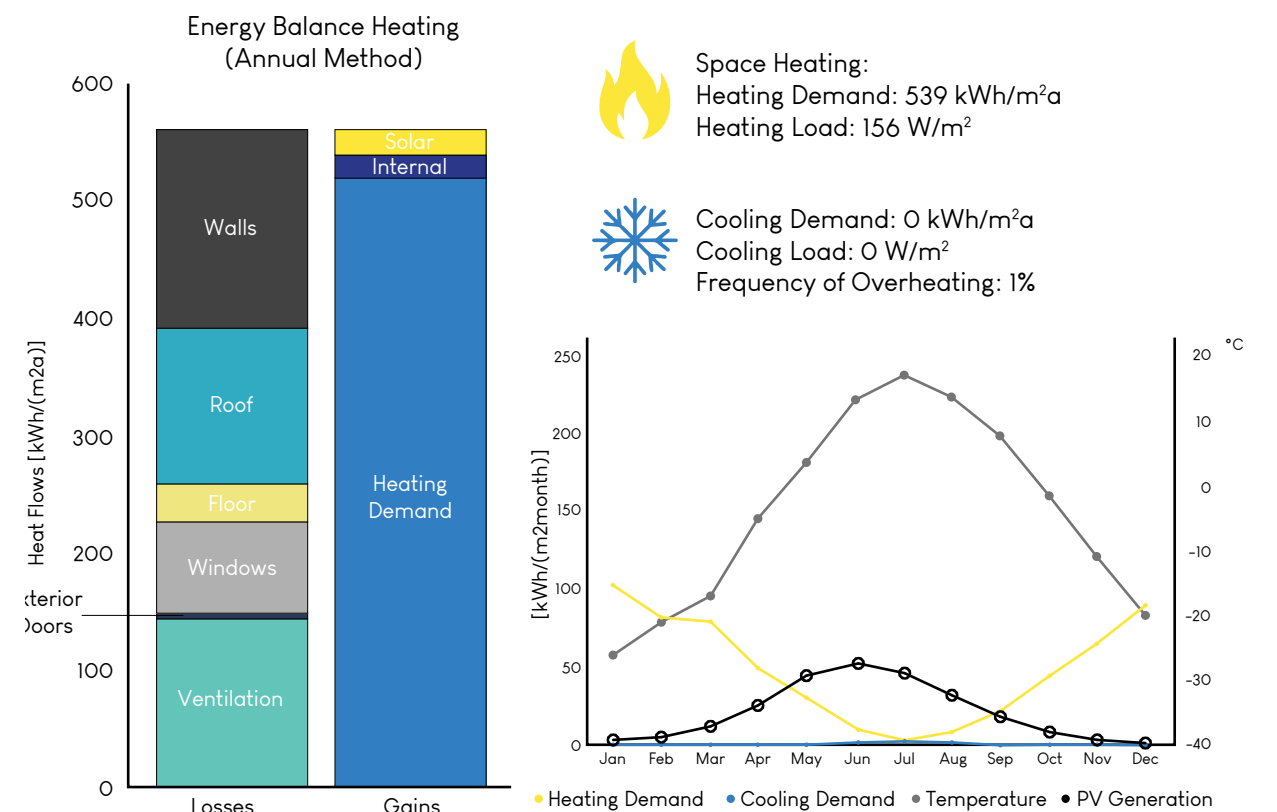
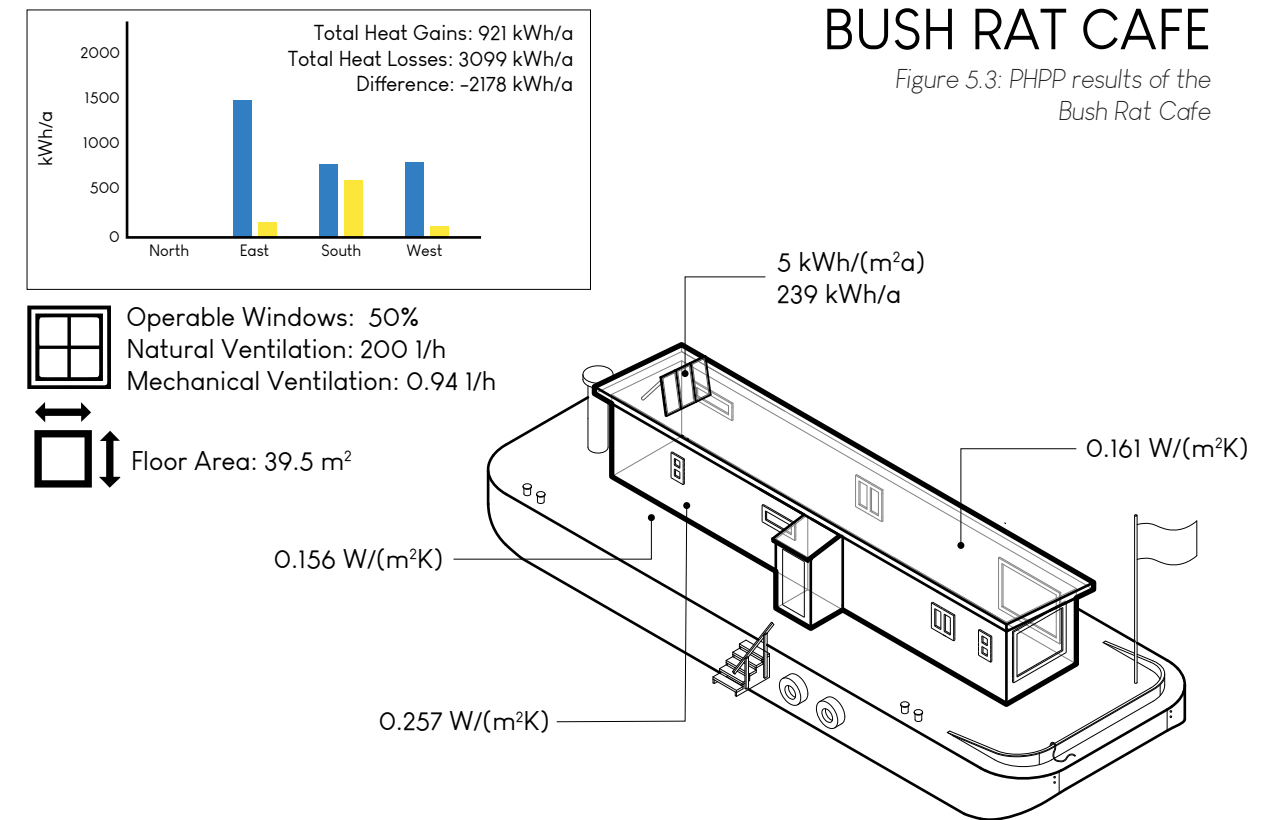
Renovation

Houseboat Selection

With the renovation design, the first step was to choose which of the houseboats previously studied was to be renovated. With this in mind, three of the five houseboats were examined using Living Building Challenge requirements as well as modelled within the PHPP software. The results, which can be seen on the following pages, were compared. (Figure 5.6) The Bush Rat Café had by far the worst score and so it was selected for this design proposal.

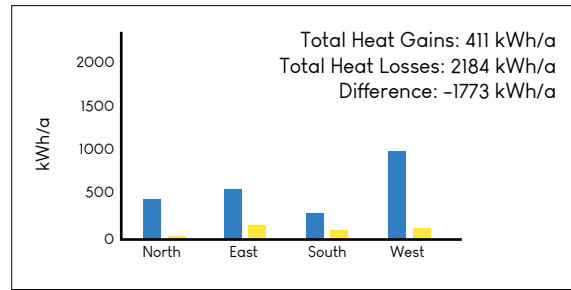
BUSH RAT CAFE

Figure 5.3: PHPP results of the Bush Rat Cafe



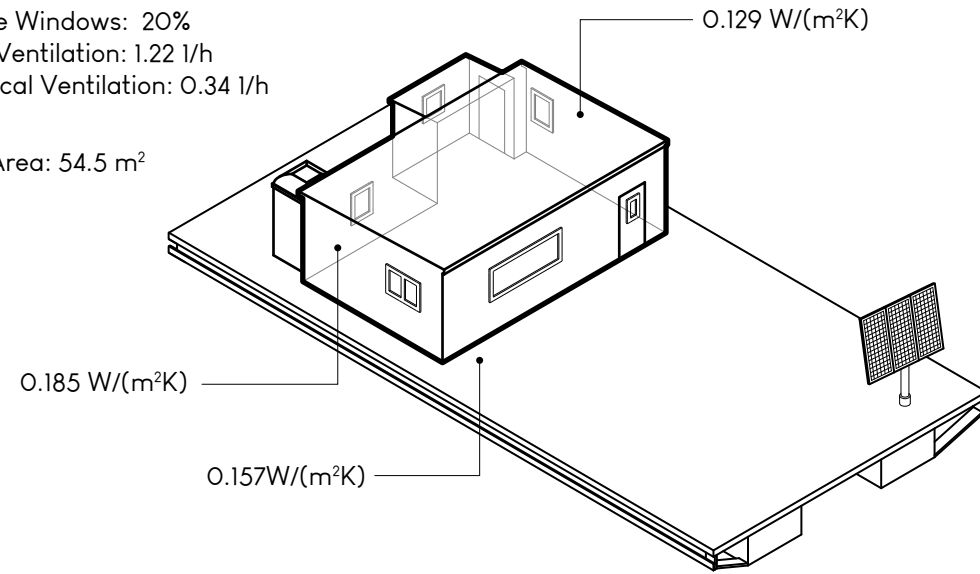
BUTTERFLY HOME

Figure 5.4: PHPP Results of the Butterfly Home



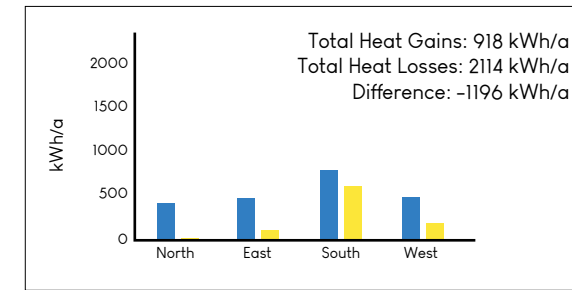
Operable Windows: 20%
Natural Ventilation: 1.22 l/h
Mechanical Ventilation: 0.34 l/h

Floor Area: 54.5 m²



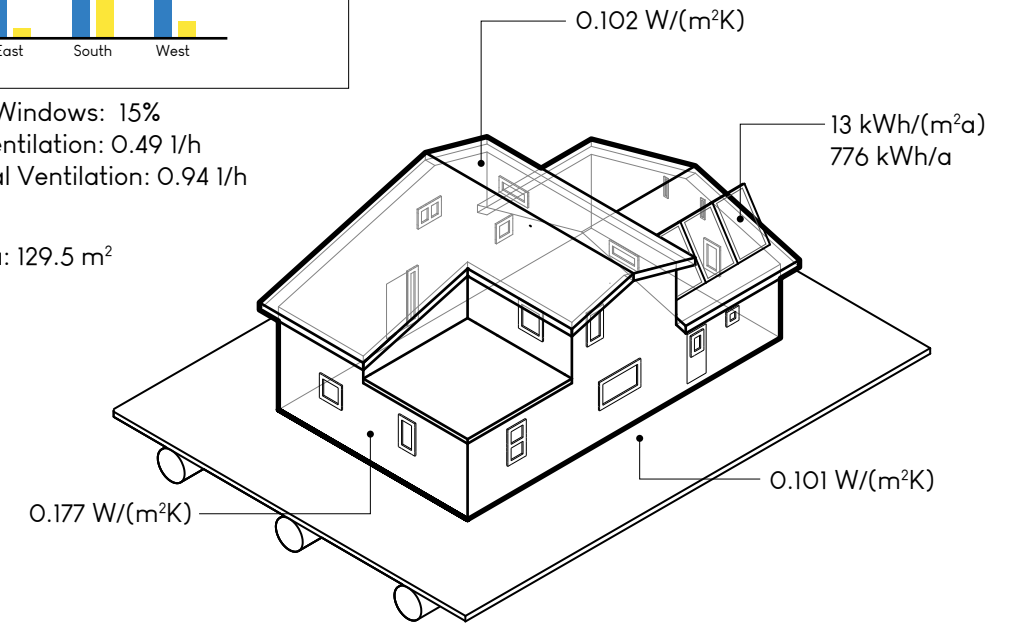
MO'S HOUSE

Figure 5.5: PHPP Results of Mo's House

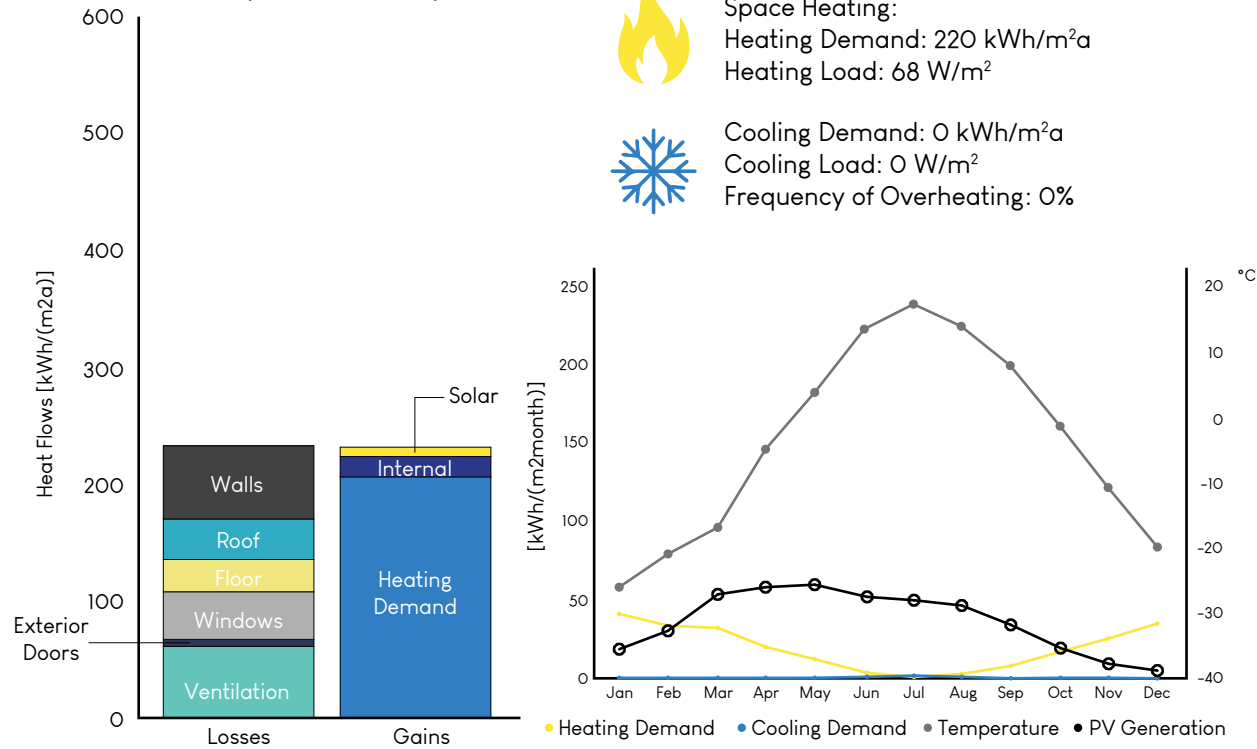


Operable Windows: 15%
Natural Ventilation: 0.49 l/h
Mechanical Ventilation: 0.94 l/h

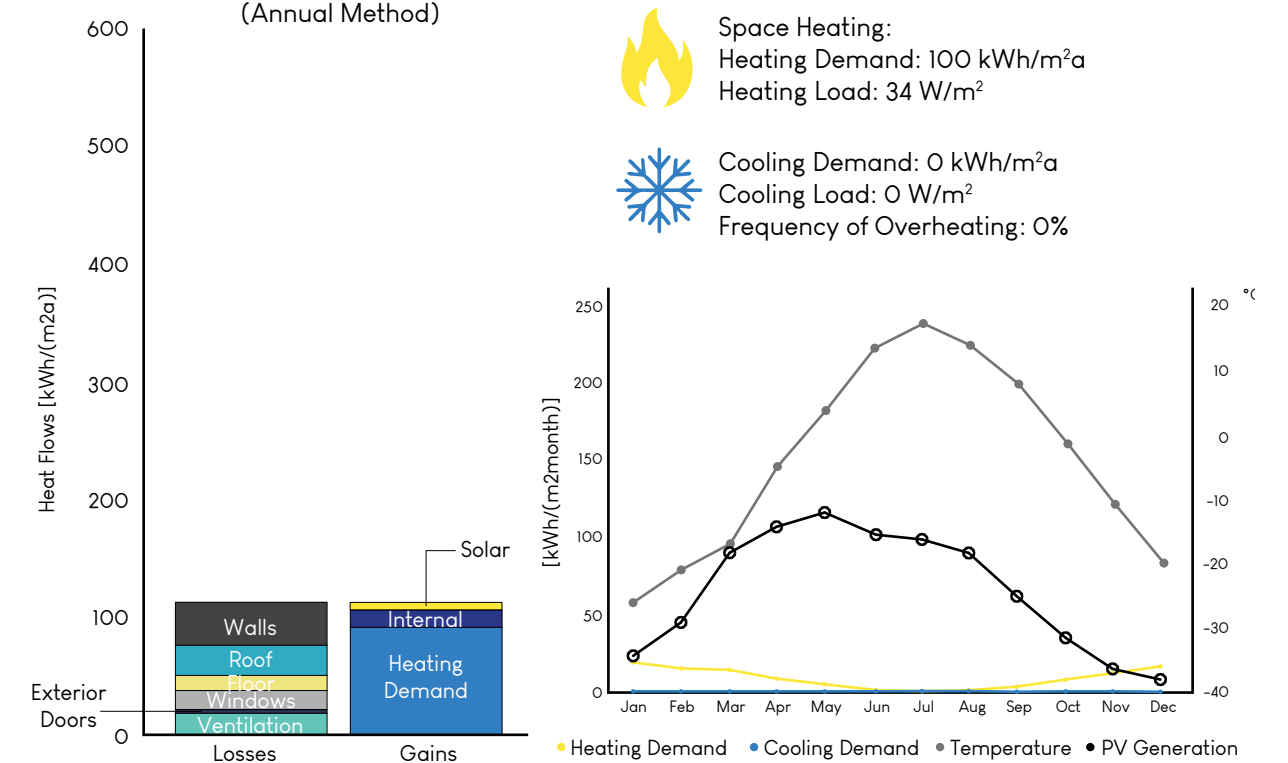
Floor Area: 129.5 m²



Energy Balance Heating (Annual Method)



Energy Balance Heating (Annual Method)



	Butterfly House	Bush Rat Café	Mo's House
Floor Area	54.5	39.5	129.5
Living Building Challenge			
Place			
Ecology of Place			
Urban Agriculture			
Human-Scaled Living			
Water			
Responsible Water Use			
Net Positive Water			
Energy			
Energy + Carbon Reduction			
Net Positive Carbon			
Combustion			
Net Zero			
Health + Happiness			
Healthy Interior Environment			
Natural Light			
Dedicated Exhausts			
Healthy Interior Performance			
Operable Windows			
Access to Nature			
Materials			
Responsible Materials			
Red List			
Natural Finishes			
Living Economy Sourcing			
Net Positive Waste			
Equity			
Universal Access			
Public Benefit			
Beauty			
Beauty + Biophilia			
Inspiration + Education			

None of the houseboats currently contribute to the lake ecosystem.

Many of the homes on the mainland have greenhouses to grow their own produce and yet none of the houseboats do.

The smaller the houseboat the better, as they encourage a minimalist, sustainable lifestyle and are also more stable on the floating platform.

All houseboats harvest their water from the lake but only one has a greywater filtration system and this has caused a lot of contention with the larger Yellowknife community.

All of the homes have woodstoves as this is a lifesaver in situations of system failures.

Only the butterfly home is net zero (the others use propane) but that is because it lacks many of the amenities that would require power.

Windows placed in shade from trees.

No dedicated outdoor space.

VOCs not even considered.

A lot of the materials used are purchased locally or are scrap from the dump.

Only accessible by stairs.

Bushrat Cafe is open to the public.

Lack of cultural representation.

Exposed systems and owners are happy to educate others.

	Butterfly House	Bush Rat Café	Mo's House
Passive House			
Space Heating			
Heating Demand			
Heating Load			
Space Cooling			
Cooling Load			
Frequency of Overheating			
Windows			
Heat Gains (kWh/a)			
Heat Loss (kWh/a)			
Difference			
Window Thermal Comfort			
Air Quality			
Passive Ventilation			
Mechanical Ventilation			
Energy			
Primary Energy Renewable			
PV Electricity			
Personal			
Waste Management			
Human			
Liveability			
Running Water			
Bedrooms			
Hot Water			
Adaptability/ Resiliency			
Totals	16	26	14

The heating demand of the Bush Rat Cafe was significantly higher than any of the other homes, especially when square footage and compact design was considered.

None of the homes had cooling requirements.

Better windows and better window location will have to be considered as the ratio of heat loss to heat gain from the windows, especially for the Bush Rat Cafe is unsustainable.

The air quality of these spaces will have to improve as currently not all of them have proper ventilation systems and the ones that do, do not have operable windows. This is especially crucial considering the popularity of propane.

There is potential to diversify renewable energy production and optimize the size.

The porta-potty and honeybucket system are both inconvenient for the user and are less sustainable than a composting toilet.

In Yellowknife the average household size is 2.7 people so the one bedroom homes would not be ideal for many community members.

None of the homes are designed to adapt to the changes that the North will see with the coming of climate change.

The Bush Rat Cafe was the least sustainable existing houseboat and so it will serve as a base model for the renovation design.

Figure 5.6: Comparison of the sustainable elements of the existing houseboats studied

GOALS:

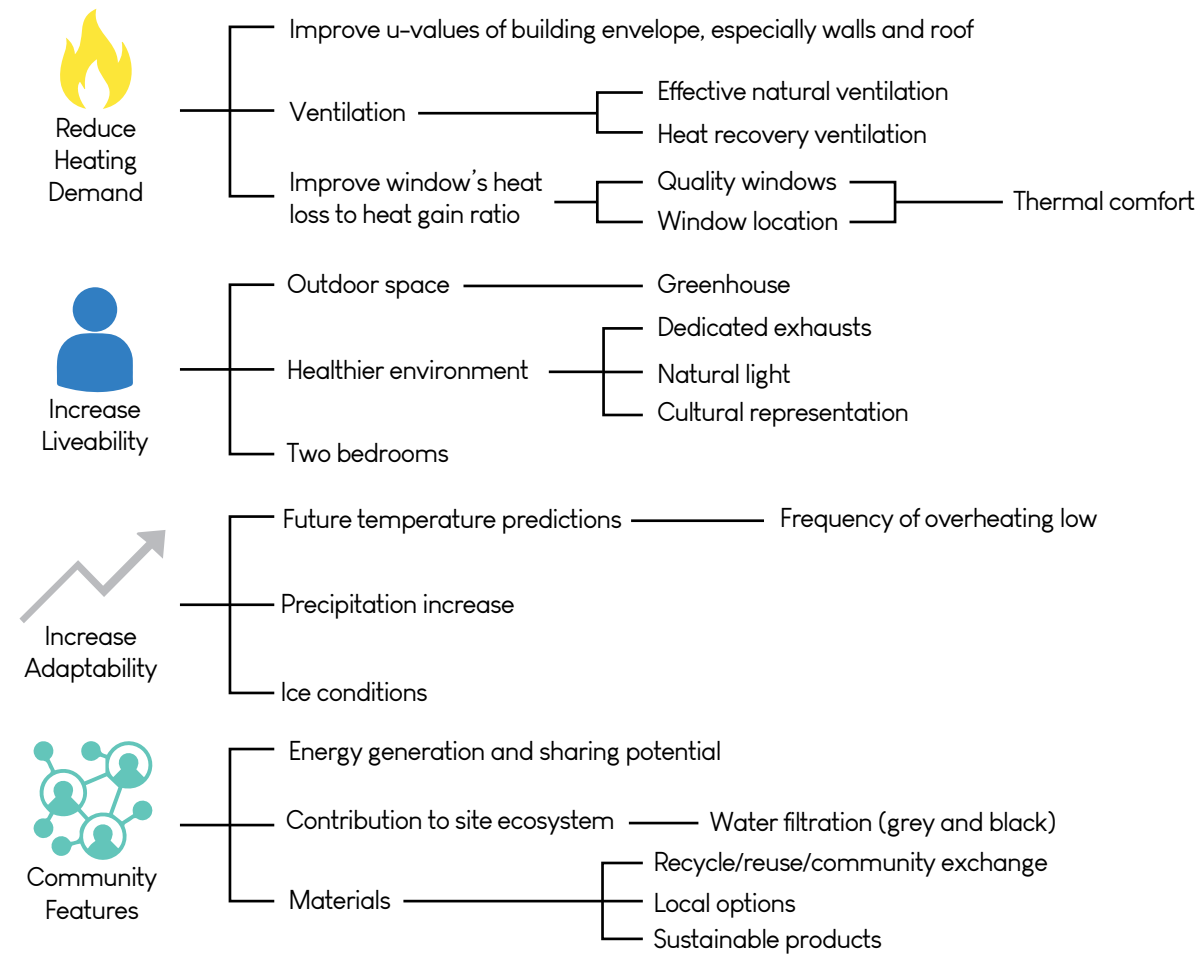


Figure 5.7: Goals to increase sustainability of existing houseboats.

Design

Through previous analysis, a list of objectives was developed, which, in combination with site analysis, began to drive the preliminary renovation design. As mentioned earlier, the average household size in Yellowknife is 2.7 persons,² and so the inclusion of a second bedroom became key to increasing the livability of the home. As the barge had little extra space, the only option was to go up. A houseboat should never be taller than its floatation is wide³, and so the width of the barge determined the maximum height. Then PHPP results were used to refine the final second-story height and roof design.

A small extension on the north side of the building was added as a mudroom, as Yellowknifers' have a large amount of winter and summer gear that needs to be stored. The sectioning off of this room reduced drafting to the rest of the home, and by having it located on the north side, it would not impede on the living spaces. It was also one of the few spaces where natural light was not a necessity. Locating the bathroom next to the mudroom was in part because that was where the existing plumbing was. However, it allows the user to clean up before entering the livable spaces, something recommended by Vince Barter.⁴

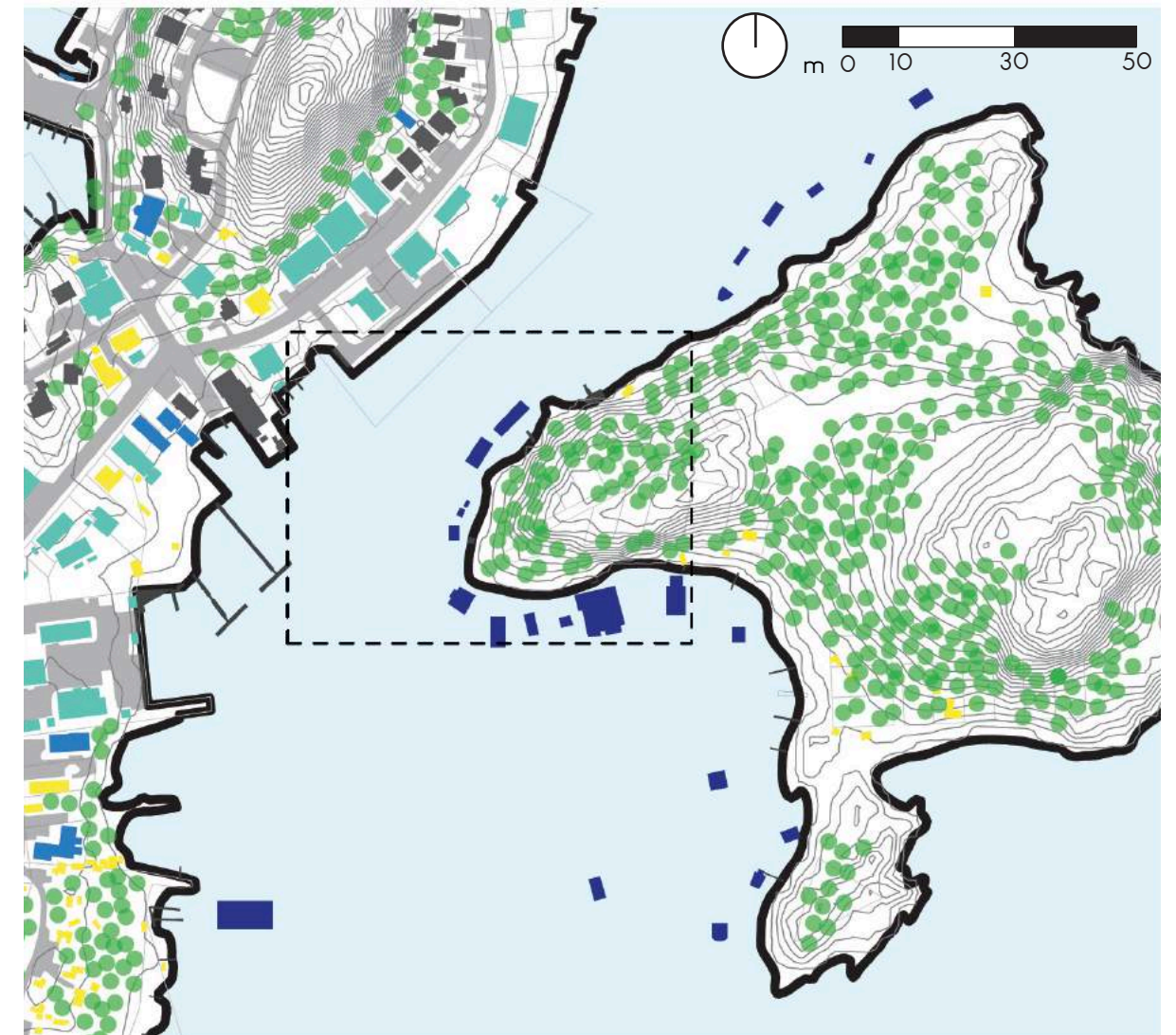


Figure 5.8: (top) Site map of houseboats around Jolliffe Island

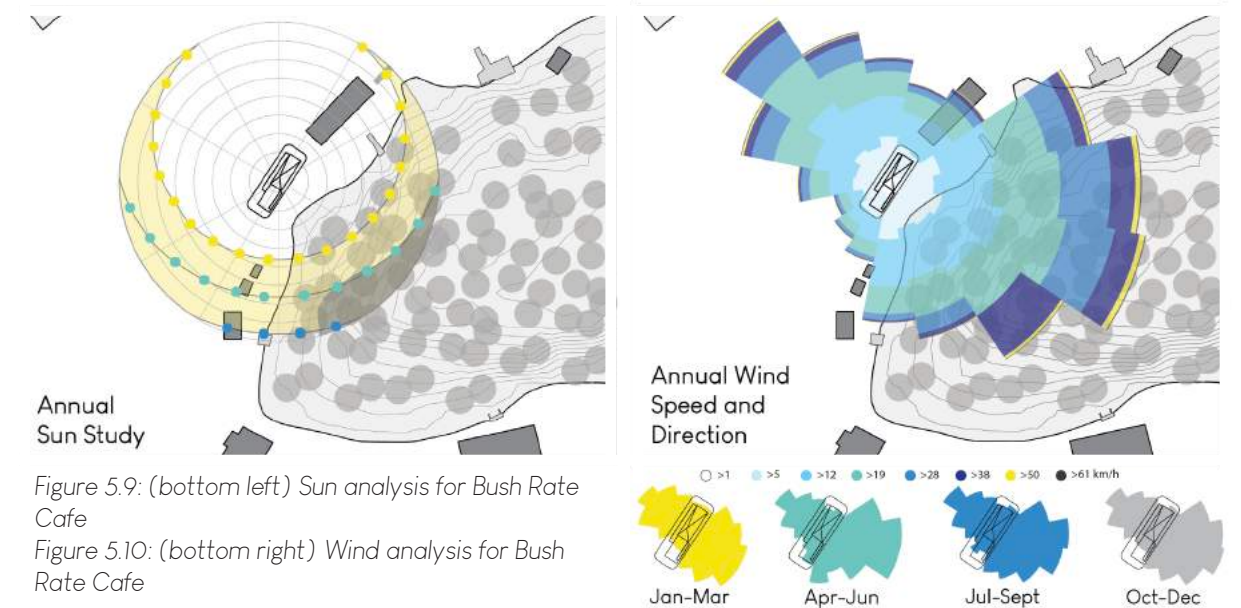


Figure 5.9: (bottom left) Sun analysis for Bush Rate Cafe

Figure 5.10: (bottom right) Wind analysis for Bush Rate Cafe

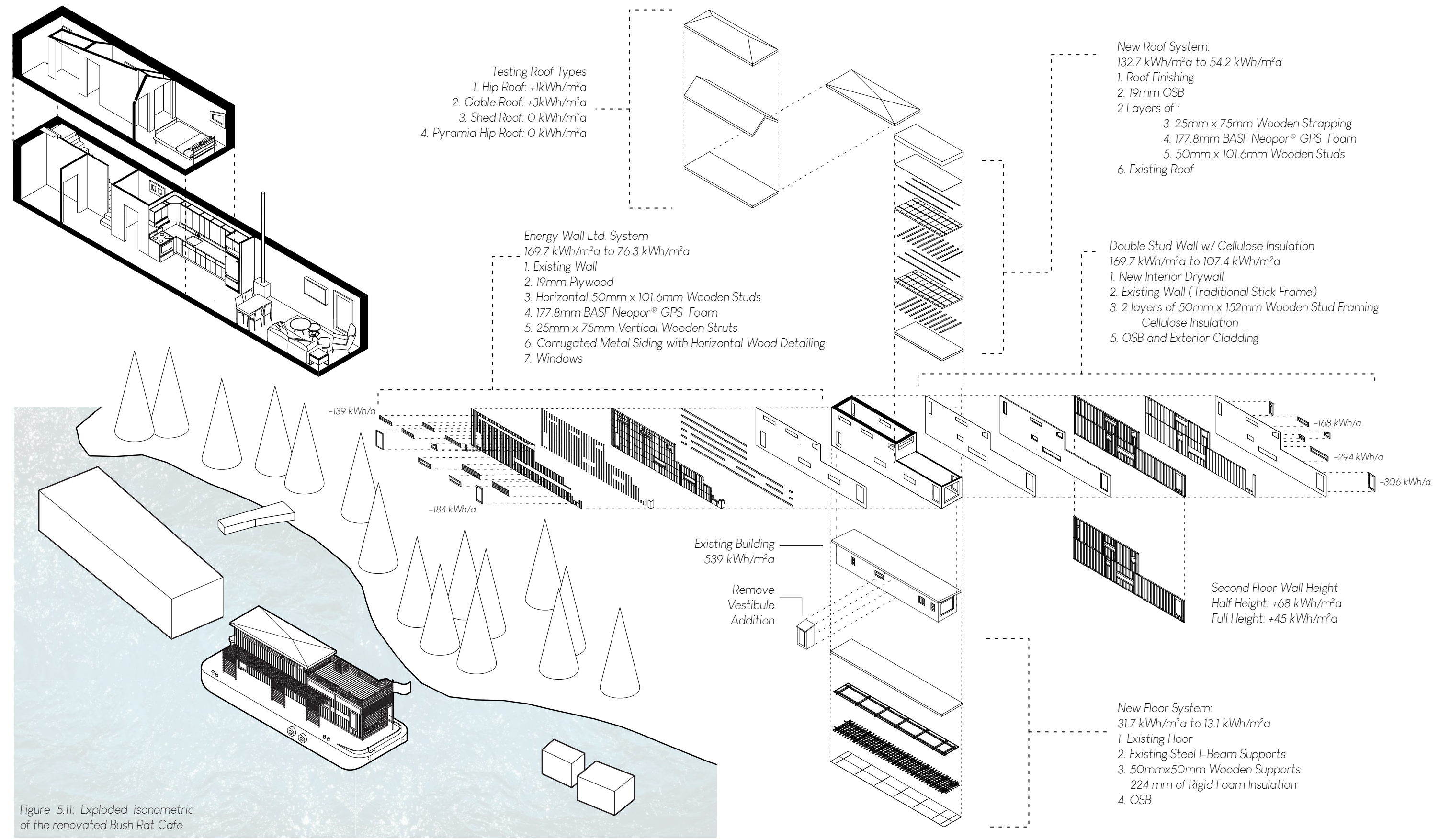
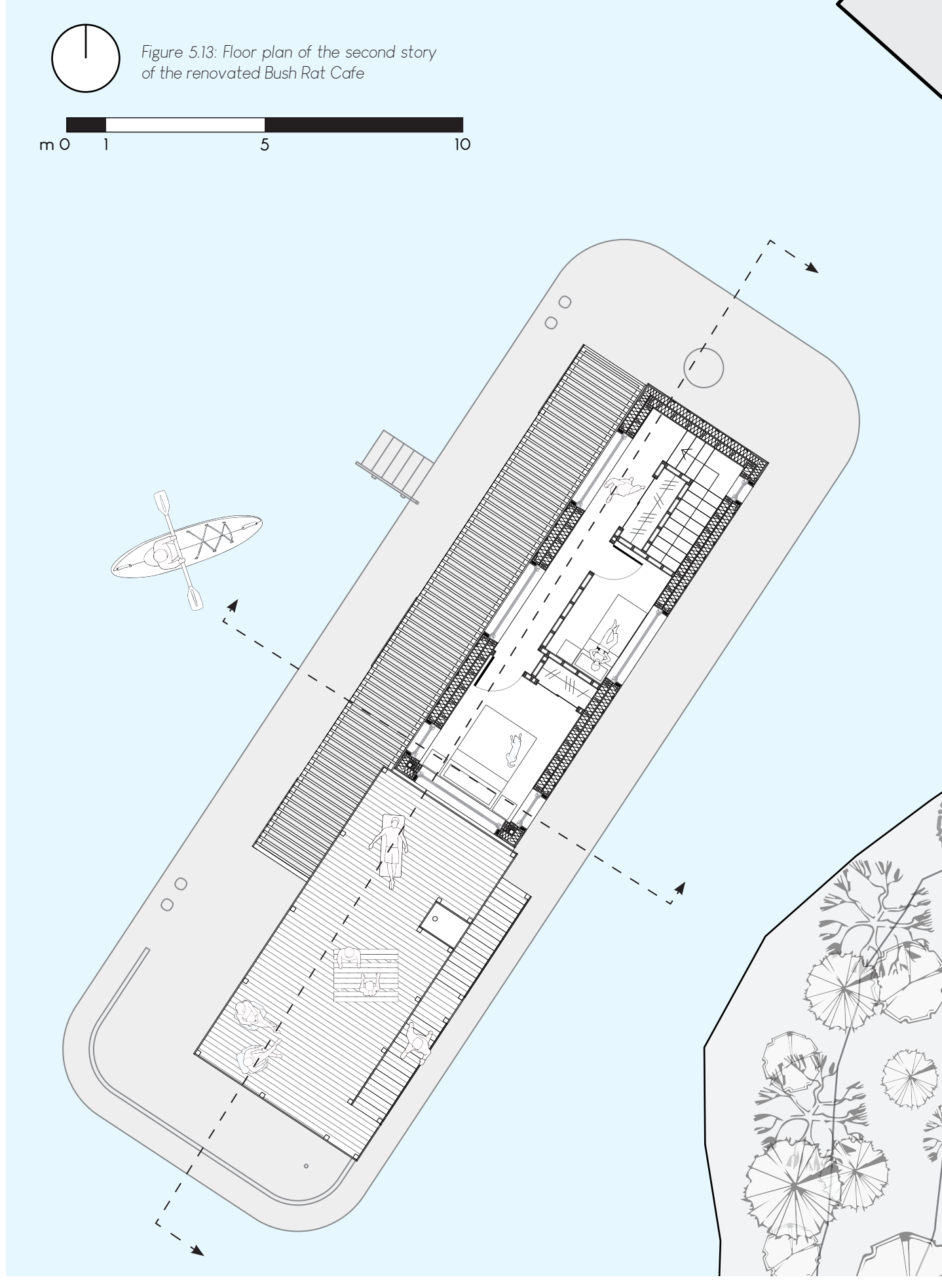
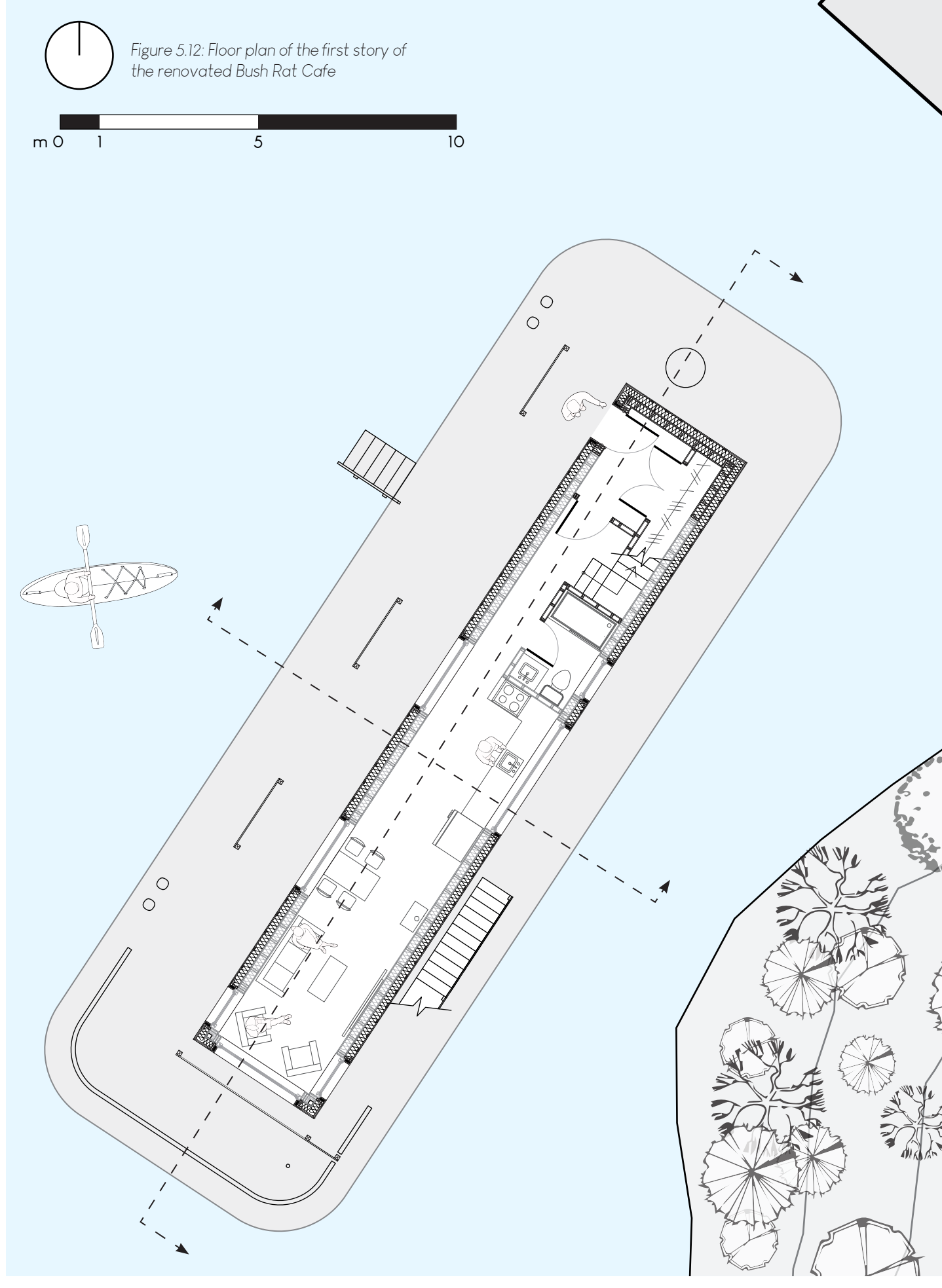


Figure 5.11: Exploded isometric of the renovated Bush Rat Cafe



The living room and kitchen were left open, as these small homes can begin to feel claustrophobic when spaces are sectioned off, especially when contrasted the large open spaces of the North. The openness of these spaces also encouraged flexibility and maximum daylighting capabilities. The bedrooms and more storage are located on the second floor as these spaces require less headspace and typically carry less weight, and therefore keep the center of gravity in the houseboat low. As most Yellowknifers love entertaining, it was also essential to have the bedrooms separate from the living spaces.

Technical

A double wall system was selected early on as this was a renovation project, and the current U-values of the walls, roof, and floor were inadequate. The double-wall system reduces thermal bridging, especially with the addition of the second story, and by having it on the exterior, did not reduce the dimensions of the interior spaces. A few different building envelopes were tested, but the local Energy Wall Ltd.

system was selected due to PHPP performance, ease of construction and it was from a local business.

As with any design that considers energy use, window placement for the renovation became very important. The east windows were incredibly inefficient due to the shading from the trees located on the neighbouring island. The east kitchen and living room windows were the most inefficient at a -306 kWh and -294 kWh respectively, but this is where the balance between the human experience and performance data is considered. By including these two windows, the homeowner can experience this fantastic 180-degree view, which provides them with two completely different ecosystems, the lake, and the forest. However, this equals about $600 \text{ kWh/m}^2\text{a}$ or $\$183.02$ annually.⁵ So it would be up to the homeowner to decide what they value more.

The inclusion of ample outdoor space for the homeowners and guests to gather was another essential objective. Not only is it a Living Building Challenge requirement,

but many Yellowknifers love sitting out on their patios in the spring, summer, and fall. Nevertheless, there was little room on the barge, and so again, a second level was incorporated. It is not uncommon to see roof patios in Yellowknife, and this one was directly inspired by Moses's House (Figure 3.44.)

The wooden lattice was added as a way to protect the entrance from the strong west wind and reduce the glare from the high summer sun. Being located in an area that not only has to combat glare from the sun, but from water and snow, led to the inclusion shading elements in front of key windows.

Figure 5.15: Section west to east through the renovated Bush Rat Cafe

m 0 1 5 10

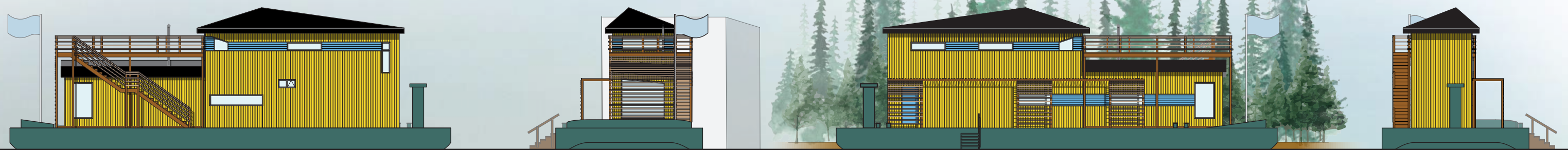
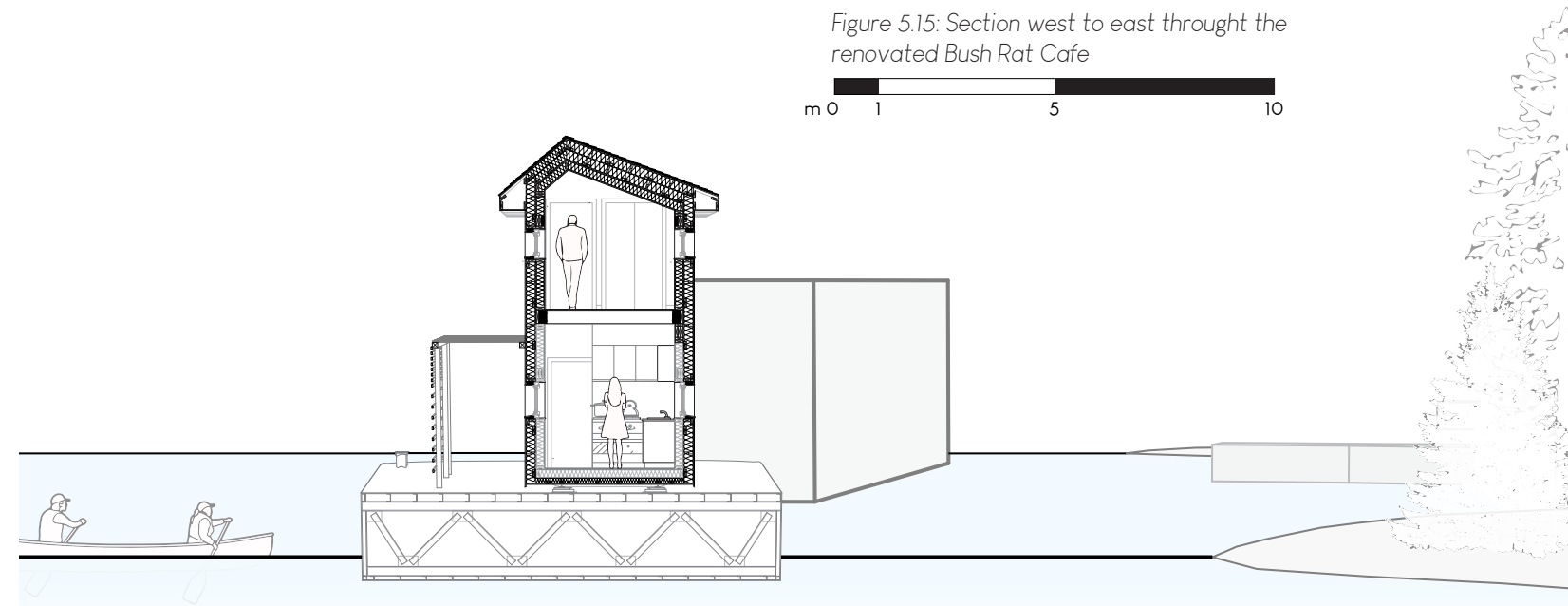


Figure 5.14: Elevations of the renovated Bush Rat Cafe

m 0 1 5 10

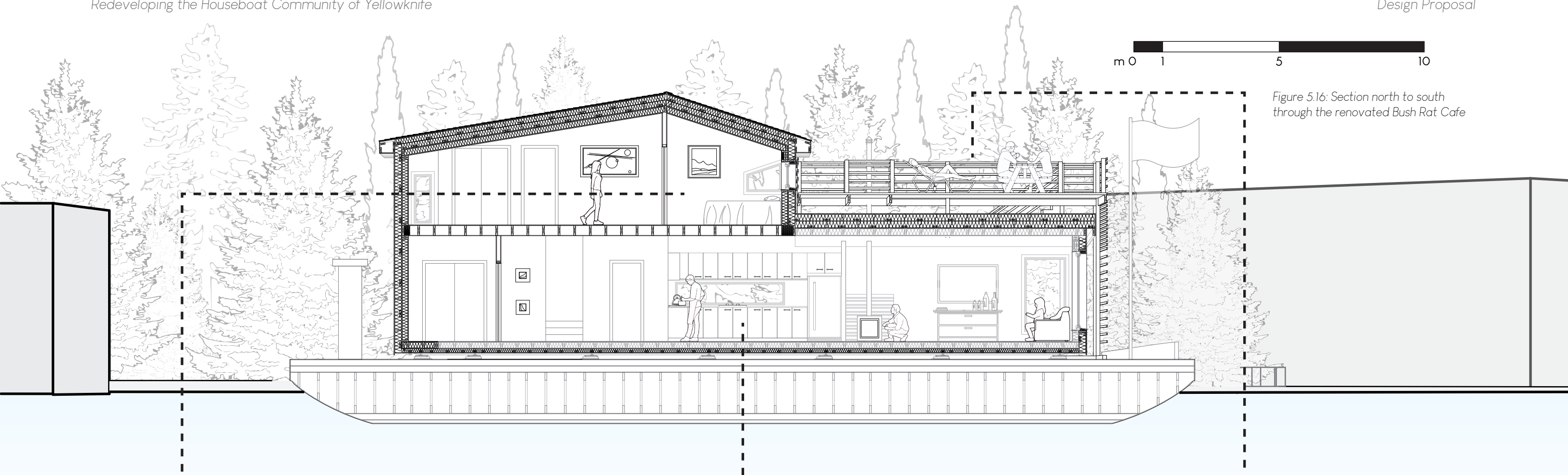


Figure 5.16: Section north to south through the renovated Bush Rat Cafe

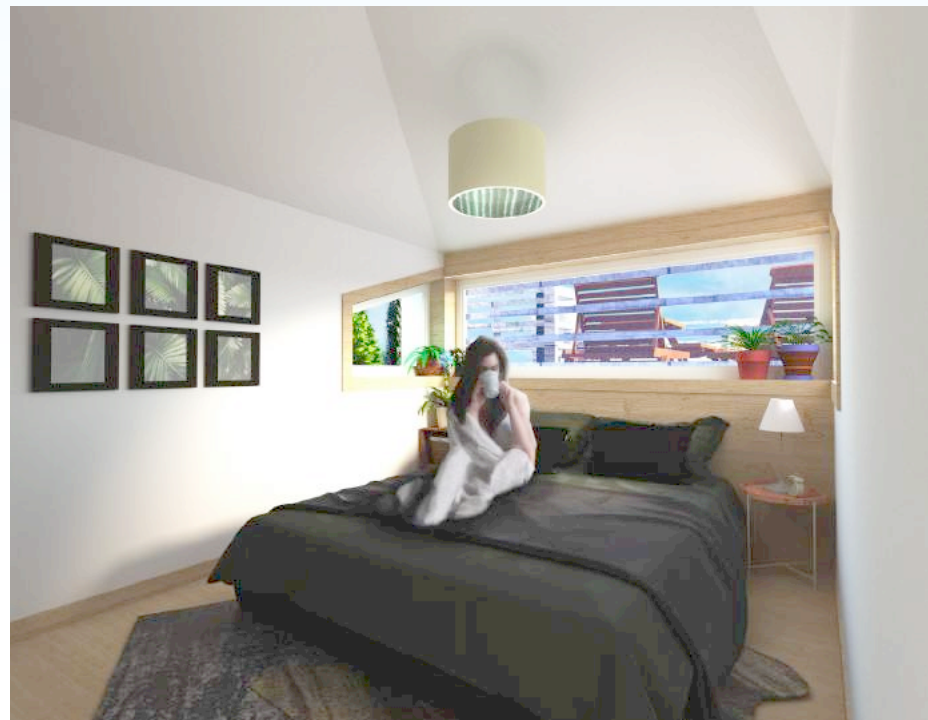


Figure 5.17: An interior render of the master bedroom of the renovated Bush Rat Cafe



Figure 5.18: An interior render of the kitchen of the renovated Bush Rat Cafe



Figure 5.19: An exterior render of the second level deck of the renovated Bush Rat Cafe



Figure 5.20: An exterior render of the renovated Bush Rat Cafe under the Northern Lights

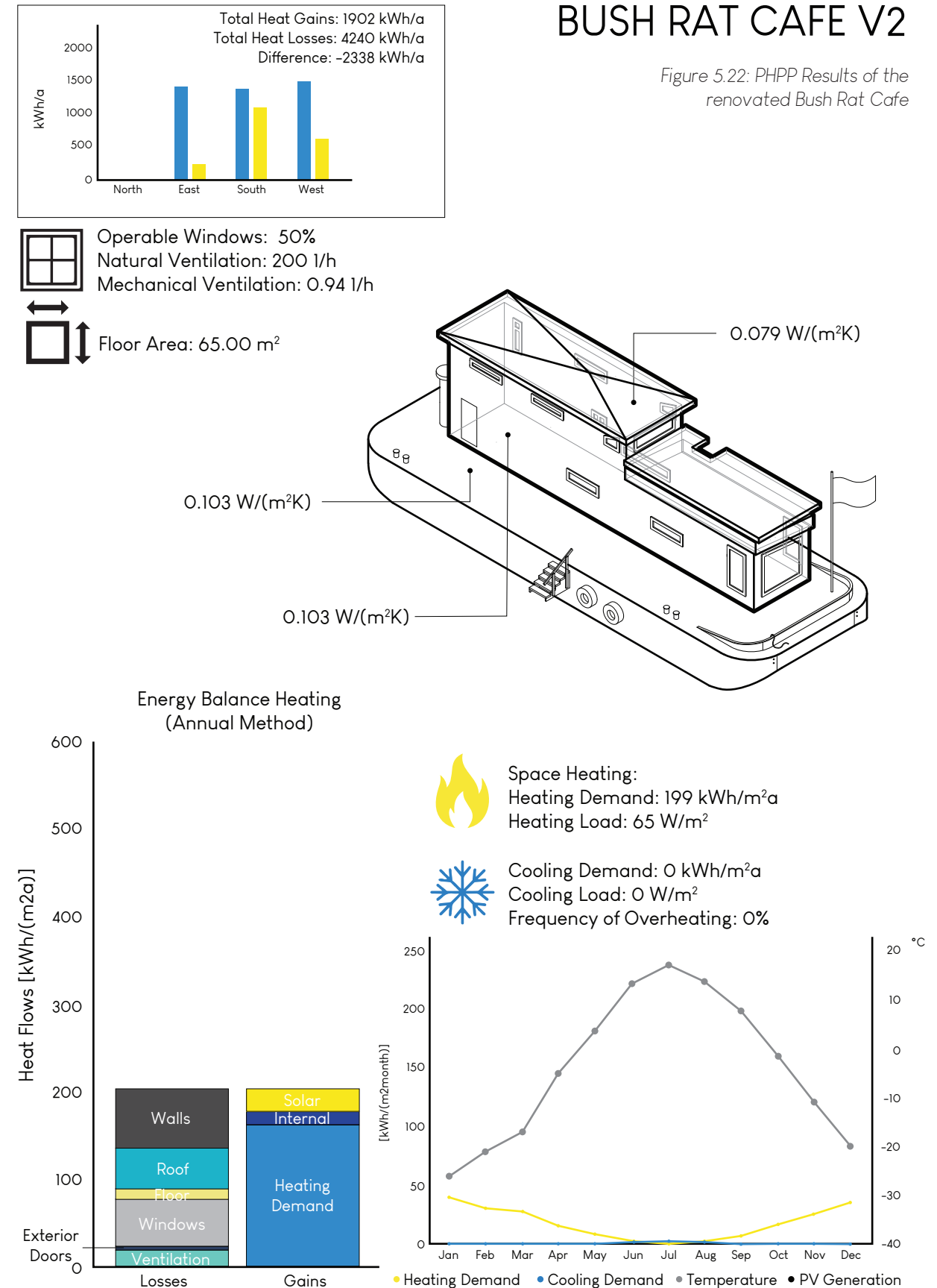
Through this exercise, the heating demand was reduced from 539 kWh/m²a to 199 kWh/m² and the frequency of overheating went from 0% to 1%. Although the ratio for window gain versus heat loss increased, the windows are now better located and allow for more of a connection with the surrounding environment. The exterior aesthetic is now more in line with other houseboats and the overall Yellowknife style, while the interior layout has become an increasingly livable space which showcases some of the differences between northern living conditions and the south.



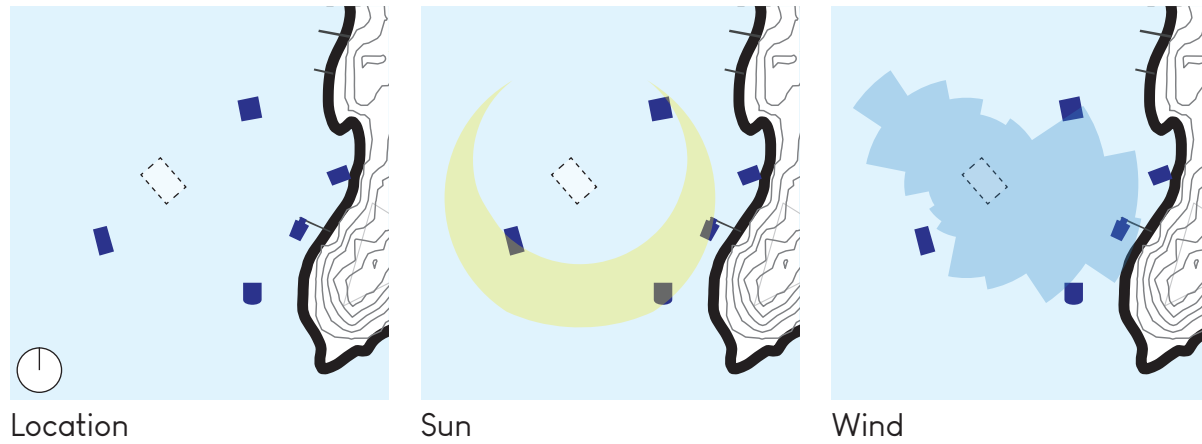
Figure 5.21: An interior render of the living room of the renovated Bush Rat Cafe

BUSH RAT CAFE V2

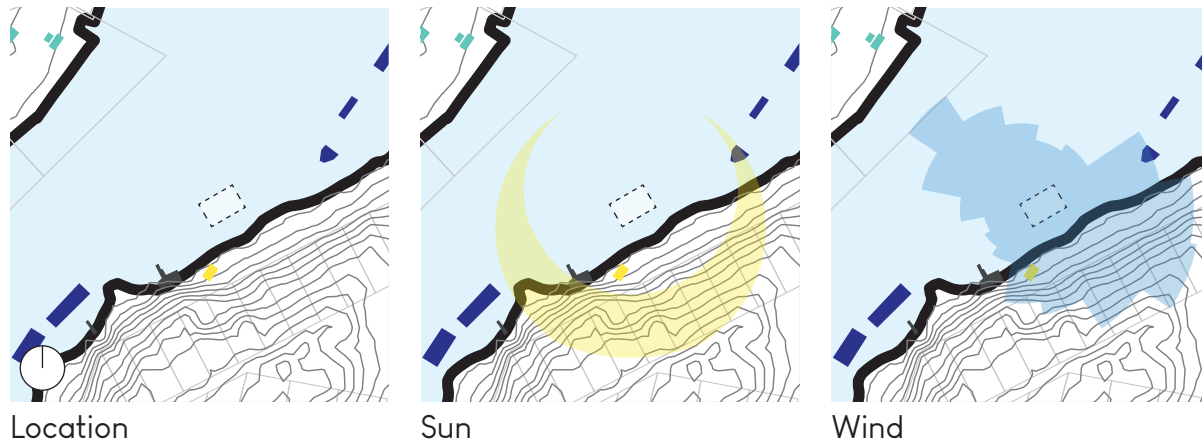
Figure 5.22: PHPP Results of the renovated Bush Rat Cafe



SITE 1



SITE 2



SITE 3



New Construction

Site Selection

After reviewing the site map for a potential site for the new construction proposal, only three options were adequate, as the shoreline around Jolliffe Island is already heavily populated with houseboats. After analyzing these three sites through their potential in terms of wind, sun, protection from the elements, and proximity to other houseboaters, it became clear that site number three offered the greatest potential.

Site 1:

- | | |
|---|--|
| <p>Pros:</p> <ul style="list-style-type: none"> • Protected from a strong east wind • Sheltered from the elements (ice damming) | <p>Cons:</p> <ul style="list-style-type: none"> • Minimal sun potential |
|---|--|

Site 2:

- | | |
|---|---|
| <p>Pros:</p> <ul style="list-style-type: none"> • Protected from a strong east wind • Full sun exposure | <p>Cons:</p> <ul style="list-style-type: none"> • In relatively open water • May anger other houseboaters (ruin their view) |
|---|---|

Site 3: Selected

- | | |
|--|---|
| <p>Pros:</p> <ul style="list-style-type: none"> • Full sun exposure • Nice views of open water and forested area • Potential for community sharing (located beside two houseboats that already do that) | <p>Cons:</p> <ul style="list-style-type: none"> • Less wind protection |
|--|---|

Figure 5.23: Potential Site Analysis for New Houseboat Design

Material

*"Waste is what you call something when you have no idea what to do with it. The fact that waste exists anywhere is more of a testament to our lack of imagination than it is to the inherent value of any material."*⁶

Often when starting new construction projects that are meant to be sustainable, the design team will start setting goals for energy and water use, energy production, and often search for answers in high tech solutions. Little thought is given to the fact that while energy for the sun is an unlimited source, the materials being harvested to make these products are not. The supply chains are running out, and that is why anyone looking to practice sustainable architecture must now look to new supply chains in the form of local material reuse.⁷ Yellowknife has a rich history of reuse and so this solution made sense for the story of this place. It helped not only the community but would give the architecture an aesthetic that was unique to this place and the materials there.

These environmental, economic, and local conditions, in conjunction with the waste problem of Yellowknife, led to the idea that the most sustainable way to build a new home would not be to use newly manufactured high-end products. Instead, it would be to look within the community and to salvage materials already located there. This would remove them from landfill, reduce the carbon footprint of transportation, and speak to the culture of this place.

At the beginning of this design, it was hard to shift from a traditional approach to one of uncertainty, but through the use of blogs, interviews, images, Kijiji, and City Reports, a database of potential waste

products began to develop. The materials available, or rather lack thereof, began to have a significant impact on the design, precisely what the dimensions of it could be. Instead of form following function, it began the following availability.⁸

One of the most substantial impacts was the main structure, the shipping container, and the precise dimensions in which they come. The available shipping containers came in 45' and 20' lengths with a width of 8' and a height of 8.5'. Even after combining the width of two, the largest living space possible was only 16' in width, which is rather small. This meant that the insulation was going to have to be on the outside of the shipping container. Nevertheless, it was important that this project not hide that it was made of reusable materials as this could serve as an education beacon for the community. So, since an office does not require a substantial amount of space, the shipping container could be on the outside of the second story.

Originally for insulation, the idea of straw bale housing was brought up. However, as agriculture is not as well established in the Northwest Territories as it is in other parts of Canada, this was not feasible. That being said, the idea of using a baled insulated product persisted, and through referencing the City of Yellowknife Strategic Waste Management Plan, it was discovered that there was an exorbitant amount of cardboard within the community.⁹ So the idea of cardboard bales as insulation was proposed. Like straw, corrugated cardboard can trap air amongst its tightly packed fibers, and so it transfers heat very slowly, making it an excellent insulator.¹⁰ Other recycled materials and their uses can be seen in Figure 5.29.



Figure 5.24: Exterior Render of outdoor deck space of the new construction design Reference Fran Hurcomb



Figure 5.25: Elevations of the new construction design

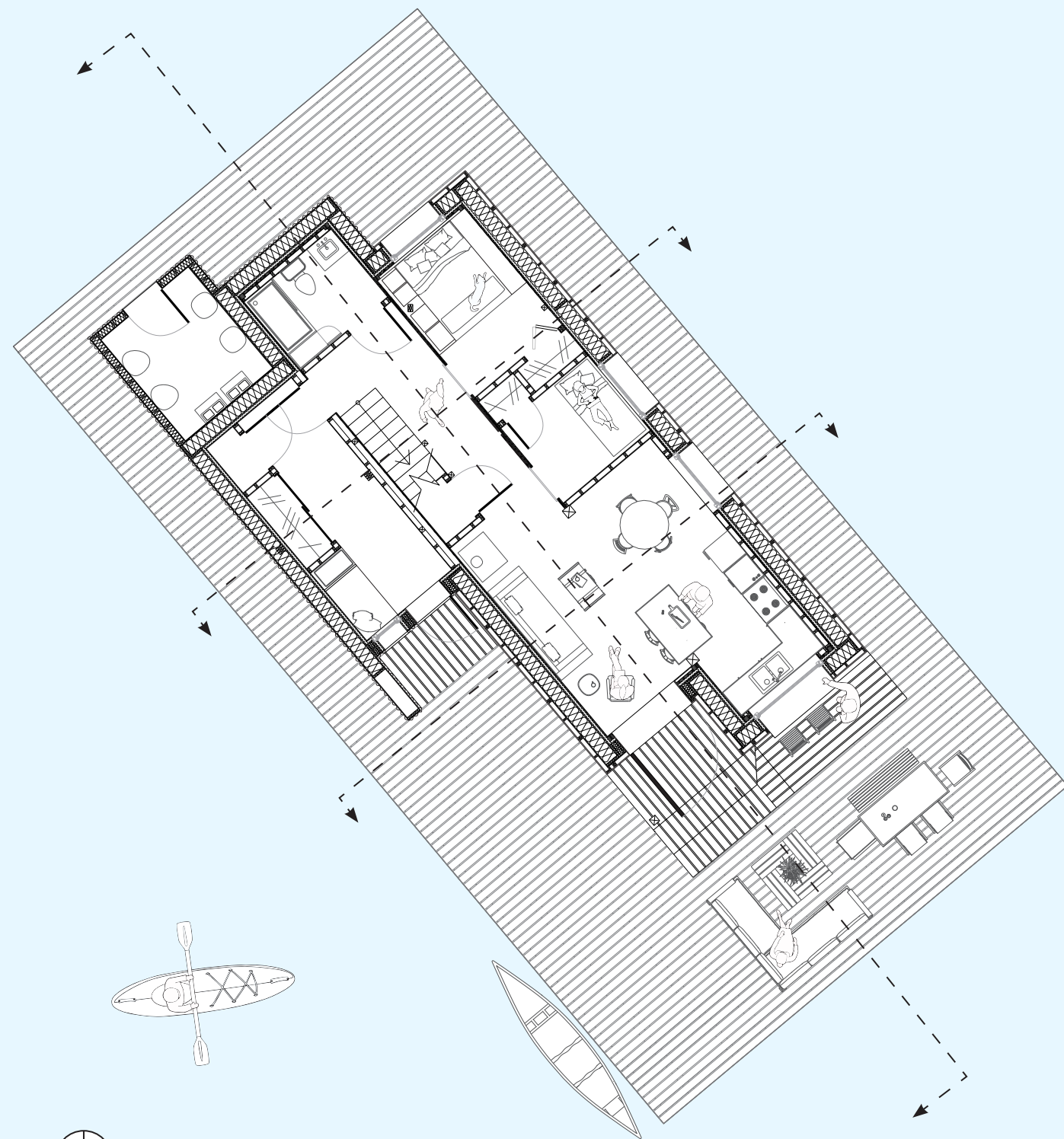


Figure 5.26: Floor plan of first story of the new construction design

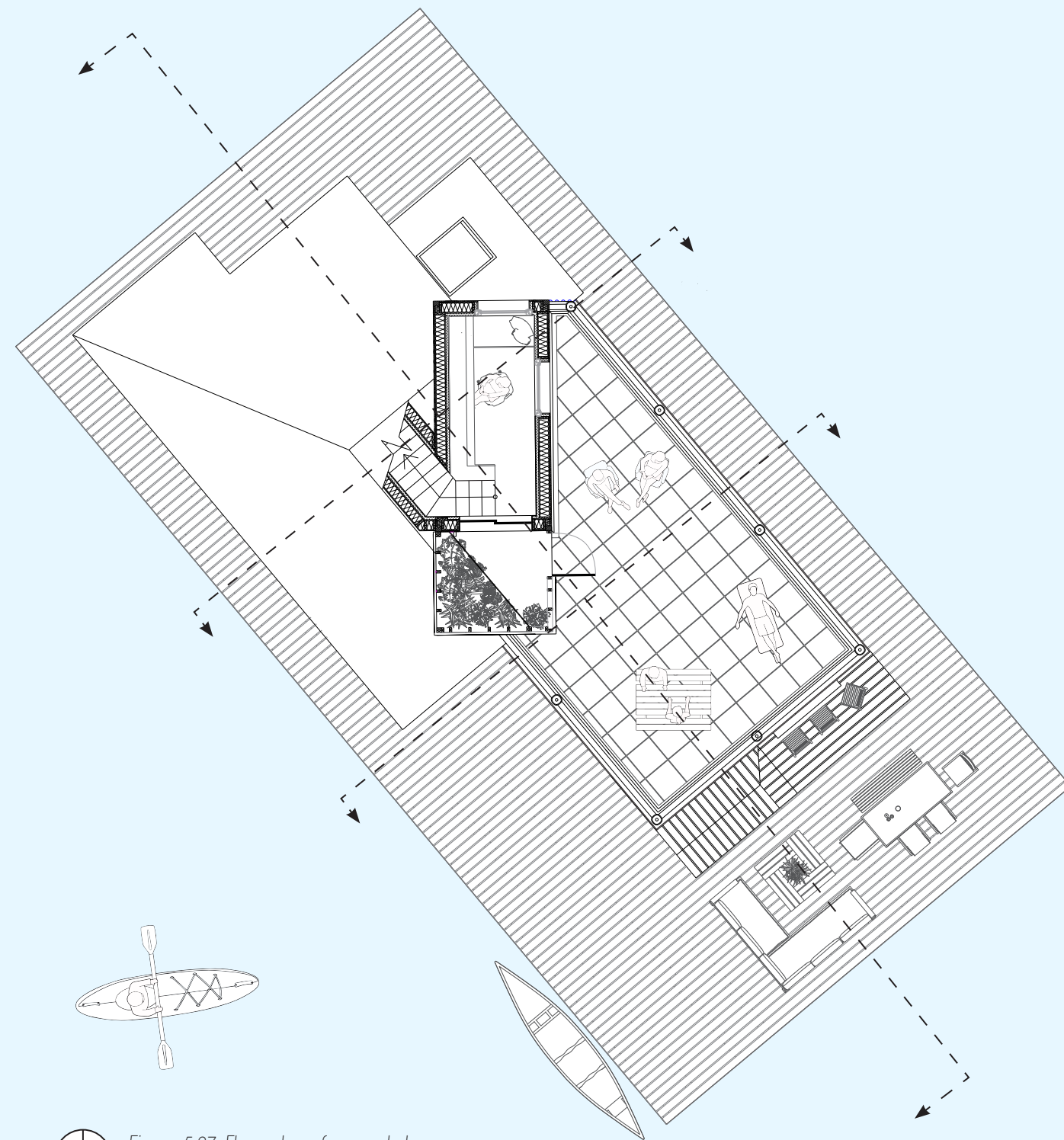


Figure 5.27: Floor plan of second story of the new construction design



Figure 5.28: (top) Exterior render of the first story deck of the new construction design

Figure 5.29: (bottom) Interior render of the kitchen and dining room of the new construction design

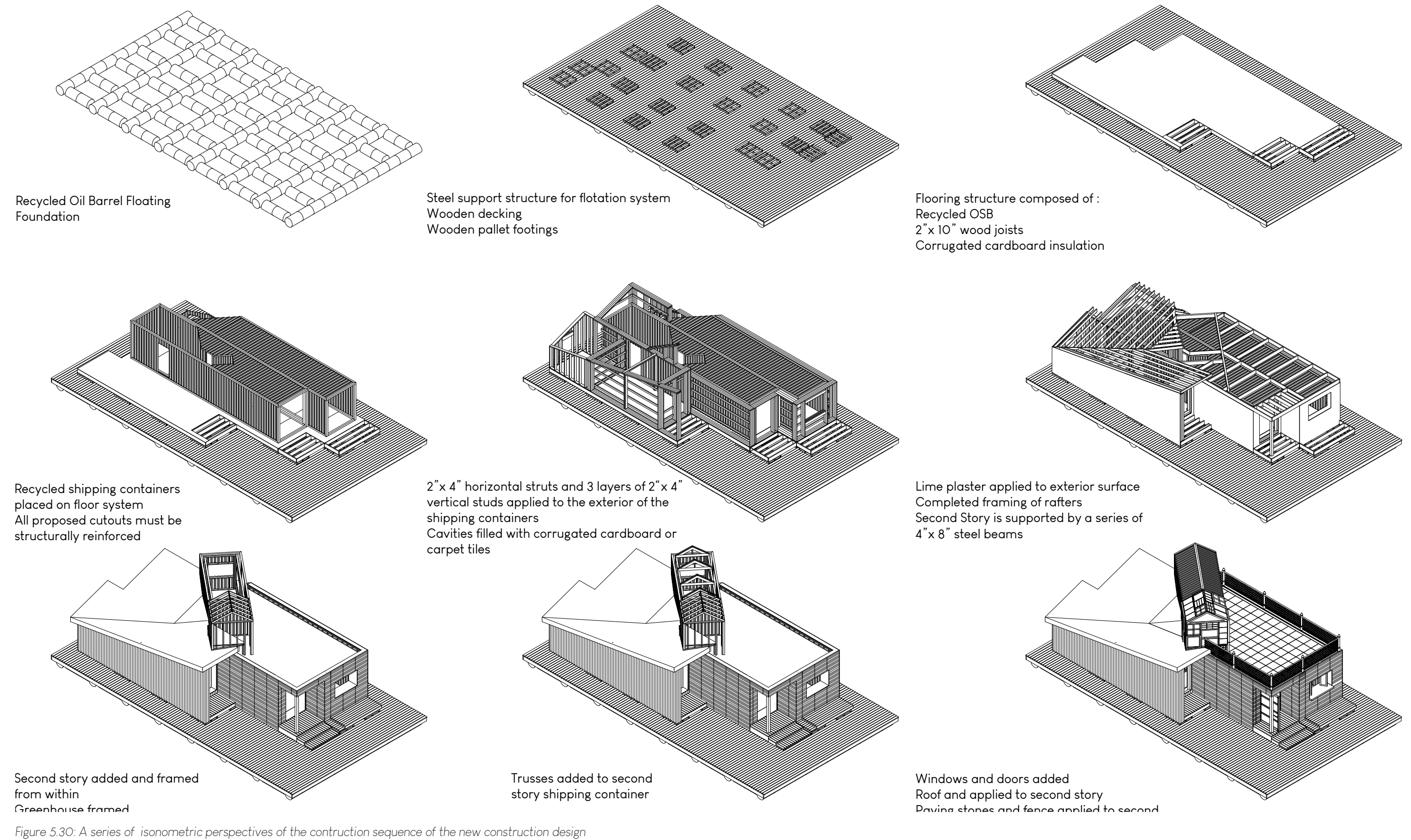


Figure 5.30: A series of isometric perspectives of the construction sequence of the new construction design

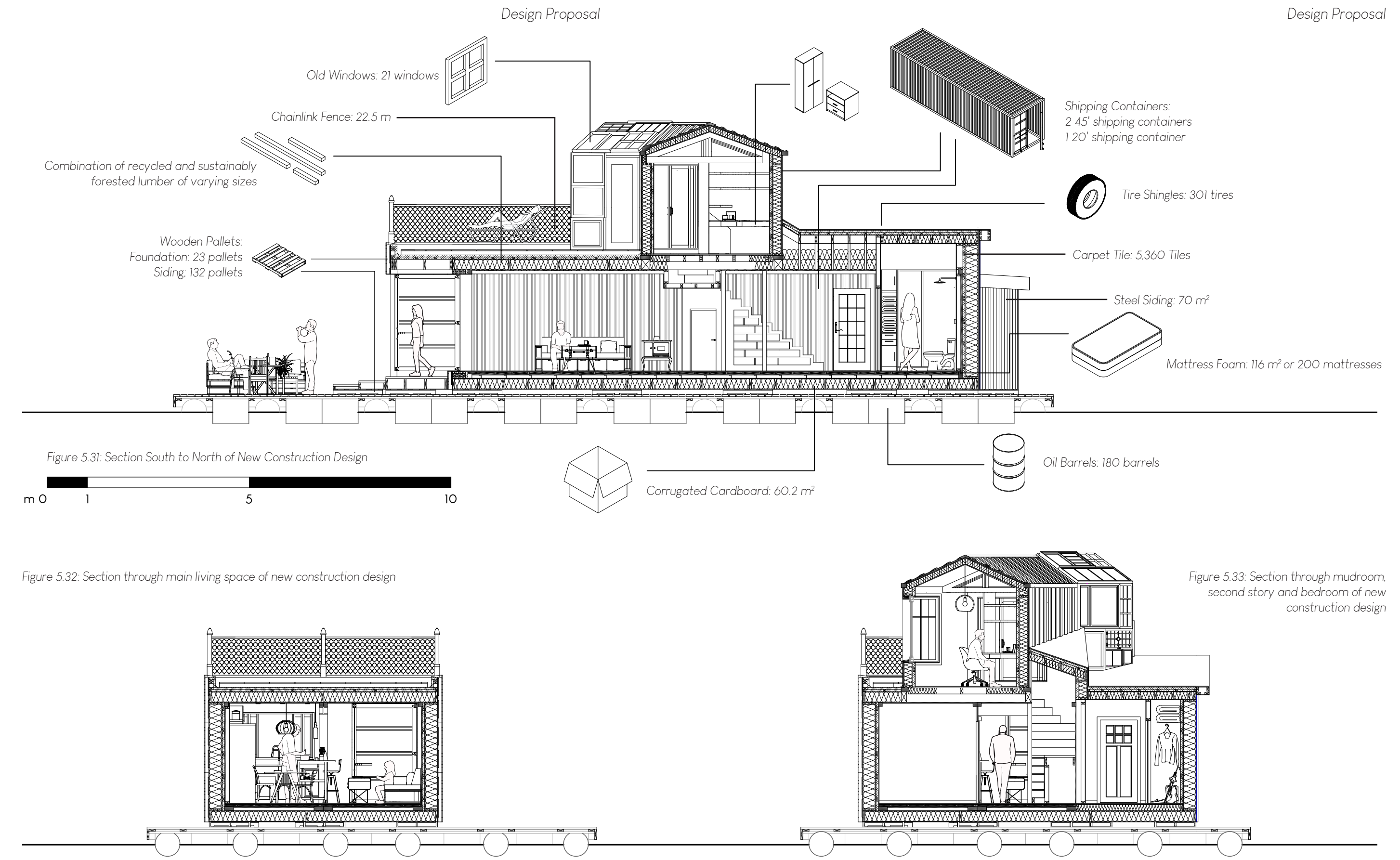




Figure 5.34: Interior render of the master bedroom of the new construction design



Figure 5.35: Interior render of the mudroom of the new construction design



Figure 5.36: Interior render of the office of the new construction design

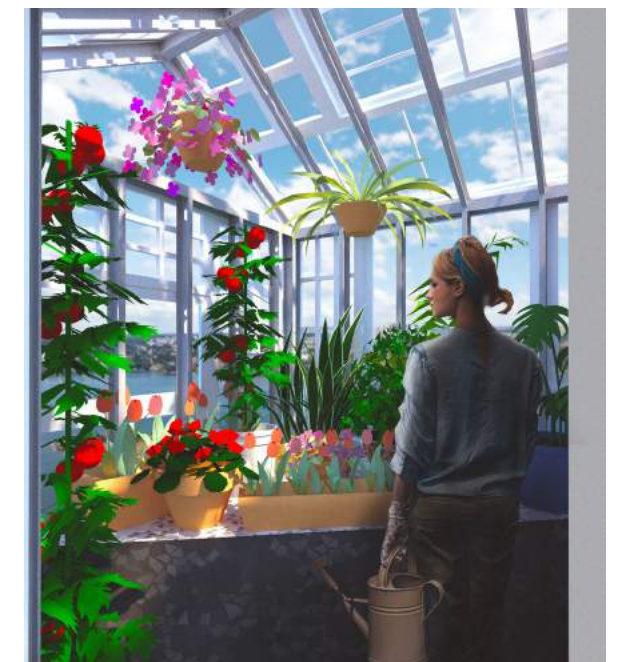


Figure 5.37: Interior render of the greenhouse of the new construction design

Culture

This thesis started with the idea of what makes living in the North different and what makes Yellowknife in particular special. So not only was the construction of the building envelope to be different, but the day to day differences of the North and South needed to manifest in this design. Yellowknifers' lives revolve around a constant balance between the human-made and natural world, the idea of freedom and isolation while remaining close to friends and family. They still cling to the idea of the pioneer spirit. This houseboat not only tries to give the user plenty of access to nature through large outdoor spaces, but it also tries to facilitate connections between the interior space and the outside world.

Some examples of this can be seen in the placement of windows, such as the skylight over the bedroom. This allows the sun and sky to be the first thing northerners see in the morning. The connection to

the sun continues throughout the building, with the programmatic spaces placed based on time of use. Many northerners enjoy waking up with the sun and so that is where the bedrooms have been placed. They are also protected from the late-night summer sun coming from the northwest, allowing the occupants to sleep. The home office also gets the morning and midday sun, facilitating a regular workday in a healthy interior environment. The entertaining spaces such as the living room and kitchen get most of the midday and evening sun as most Yellowknifers like to entertain late into the night. In the winter, these spaces also get most of the winter sun as they are the most important spaces and where Northerners spend most of their time.

The living spaces such as the kitchen, the dining room, and the living room are essential in any home but arguably more important in Northern homes as nightlife in the North often means being entertained at someone's house rather than going to a

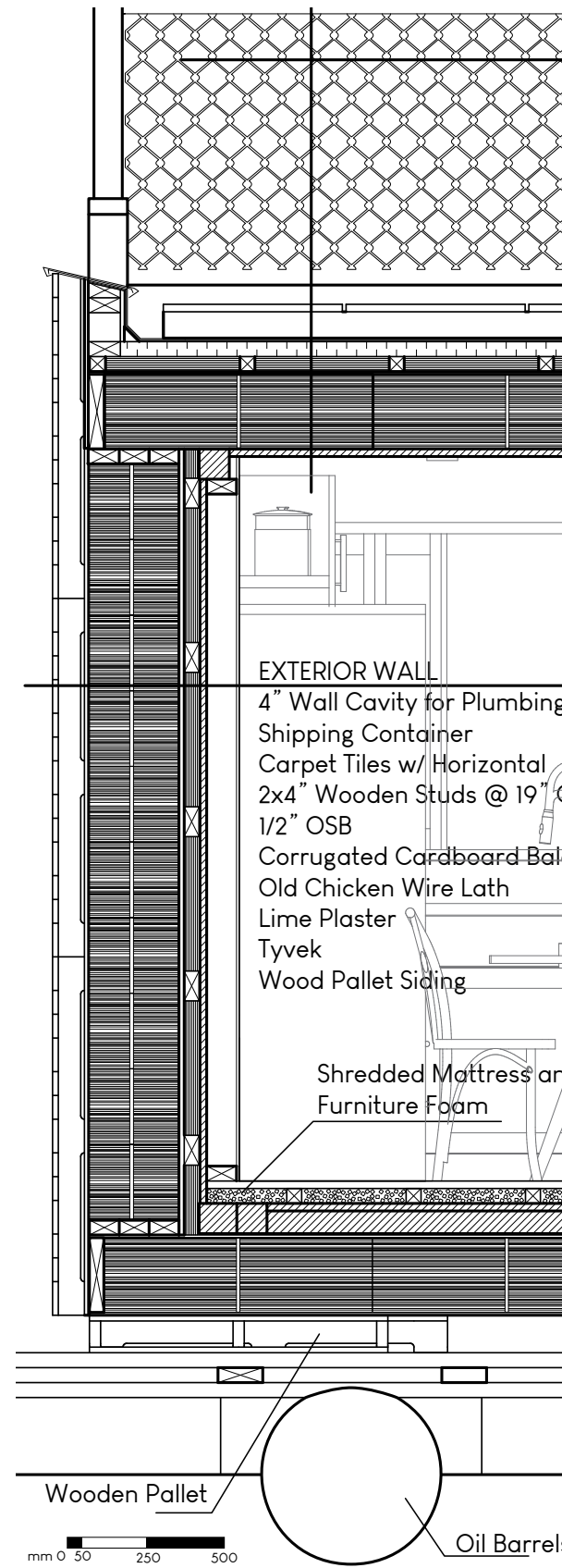
restaurant. While these spaces can rarely be as large as many southern homes, they need to be open, flexible spaces that can adapt to a two-person date-night or a surprise party with twenty people. The moveable island is one way in which this can be achieved, but also by the flexibility of being able to open the southern wall side to the outside world, doubling the entertaining space.

The mudroom, one of the most critical spaces in Northern homes, was inspired by the manufactured homes. Their mudrooms are always placed as a central addition to the exterior of the home. The entrance is protected from the strong winds of the east and west by a covered porch. This not only helps protect the door and hardware from the elements, but it gives users a moment to find their keys without having to face extreme elements. The mudroom has a small sitting area to allow people to remove their boots and then has extensive storage for all their winter and summer gear. The bathroom was placed

close enough to this space to allow people to clean up before entering the home, but it is still reasonably accessible to the other living spaces.

It was important that this home remains small and scaled not only for the people who are living in it but for the ecosystem on which it floats. So, the size of some of the rooms had to be compromised. The bedrooms are not where the majority of Yellowknifers spend their time, and so they were made smaller. Many people prefer to be outdoors or hanging out with friends and family in other living spaces. Nevertheless, it was still important that these rooms serve their function and the Master bedroom is an exceptional place with great views of the sky and water, and ample storage.

Many Northerners, especially ones who live on houseboats often work from home as the weather can be unpredictable and often the cost of renting office space is a luxury many businesses cannot afford.



FLAT ROOF
 Shipping Container
 Corrugated Cardboard Bales
 1/2" OSB
 Old Chicken Wire used as Lath
 Lime Plaster
 Carpet Tiles w/ Horizontal Strapping @ 19" O.C.
 2" Recycled Rigid Insulation
 Bitumen Water Proof Membrane
 Protective Membrane
 Crushed Plastic Aggregate
 Paving Stones

EXTERIOR WALL
 4" Wall Cavity for Plumbing
 Shipping Container
 Carpet Tiles w/ Horizontal
 2x4" Wooden Studs @ 19" O.C.
 1/2" OSB
 Corrugated Cardboard Bales
 Old Chicken Wire Lath
 Lime Plaster
 Tyvek
 Wood Pallet Siding

Shredded Mattress and
 Furniture Foam

Wooden Pallet

Oil Barrels

Figure 5.38: Wall section of the new construction design

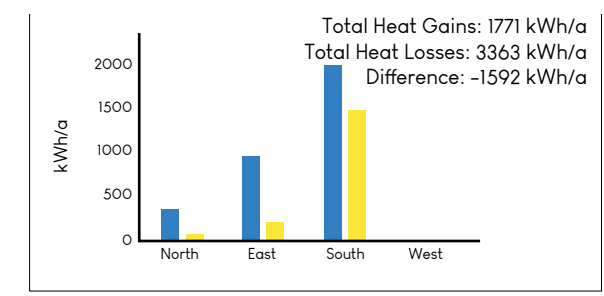
Many people also work for the government which is starting to encourage working from home. That is why it was integral that a home office be offered, one with a different view and experience from the regular living spaces.

One of Living Building Challenge's one requirement was for urban agriculture, which has manifested in a greenhouse located on the second story, composed out of recycled windows and wood. While this was a great idea from a sustainability perspective, it also speaks to the place. Several homes in Yellowknife have greenhouses, many of which are built onto their home as a sunroom. The houseboats also exhibit the idea of being self-sufficient in many ways, so why not in food production as well? Especially in a place with such high food costs.

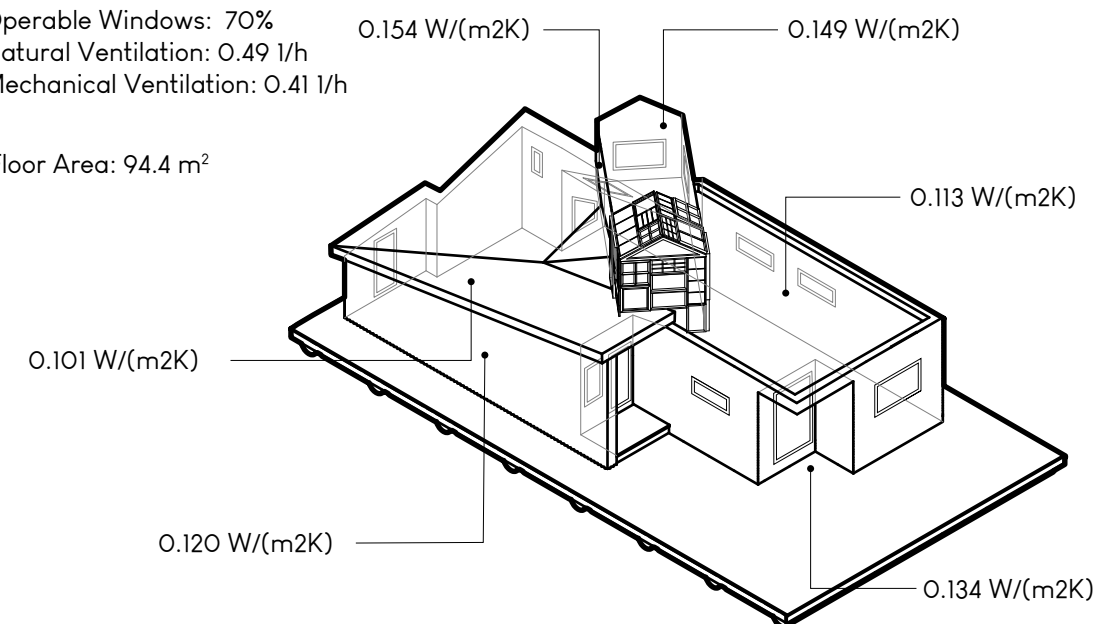
Overall this home exhibits the quirky, décollage style of Yellowknife that was previously seen in both the houseboat and shack studies. However, it also contributes to many positive ways the sustainability of this city. It works for the lifestyle of the Yellowknifers', and above all, it is beautiful and inspiring, what Jason McLennan argues is an essential part of sustainable architecture.

TRASH HOME

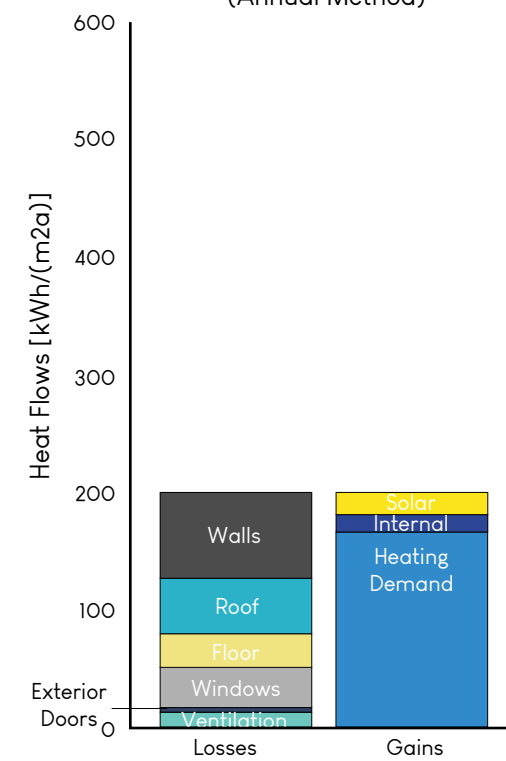
Figure 5.39: PHPP results of the new construction design



Operable Windows: 70%
 Natural Ventilation: 0.49 l/h
 Mechanical Ventilation: 0.41 l/h
 Floor Area: 94.4 m²

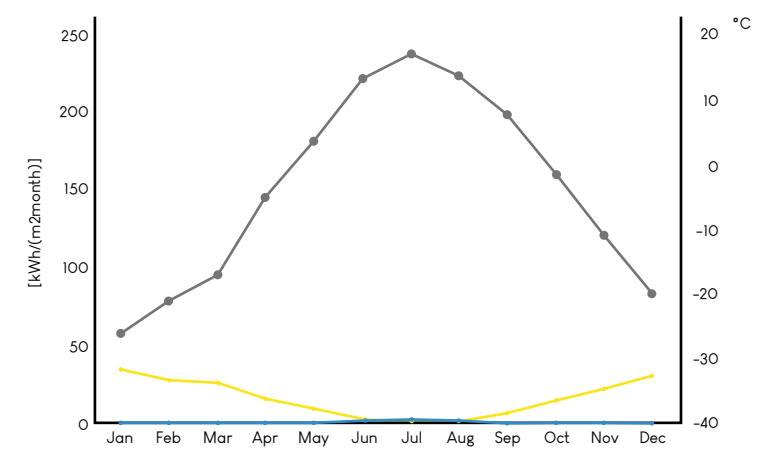


Energy Balance Heating (Annual Method)



Space Heating:
 Heating Demand: 197 kWh/m²a
 Heating Load: 60 W/m²

Cooling Demand: 0 kWh/m²a
 Cooling Load: 0 W/m²
 Frequency of Overheating: 0%



Community Solutions

The quest for a sustainable future is not one that can be accomplished alone, nor should it be. Just like most municipalities are tied into a grid system, this project proposes the development of a miniature grid system of utilities for the houseboat-ers.

Water:

A significant complaint from the broader Yellowknife community is the dumping of greywater into Great Slave Lake by houseboat-ers, but the feasibility of each houseboat purchasing and installing filtration systems is unrealistic. The cost alone would deter many, but there is a concern over weight and space as well. Houseboats are usually no more than floating shacks, and they do not have extensive mechanical rooms if they even have one at all. Many houseboats are not even equipped with running water, and so there is the belief that what they do use, they can just dump

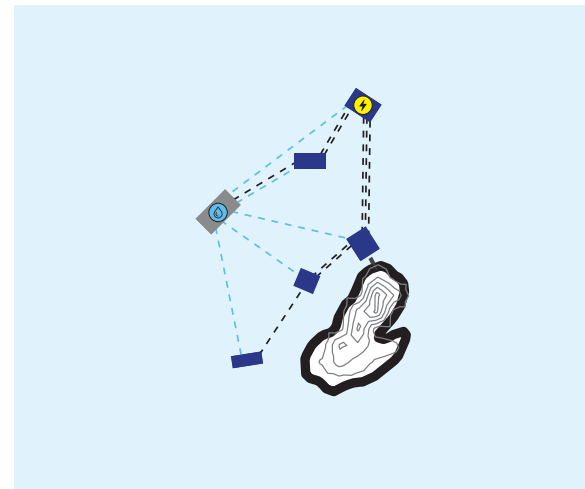


Figure 5.40: Proposed houseboat utilities grid

back into the lake with no repercussions.

This has created immense tensions within the community, and so I propose creating a specific water filtration room within one of the newer houseboats, in this case, the one which was proposed in this thesis. The filtration system shown here is a GWTS500, but really any filtration system that does not use chemicals could be used.¹¹ This size was chosen so that it was

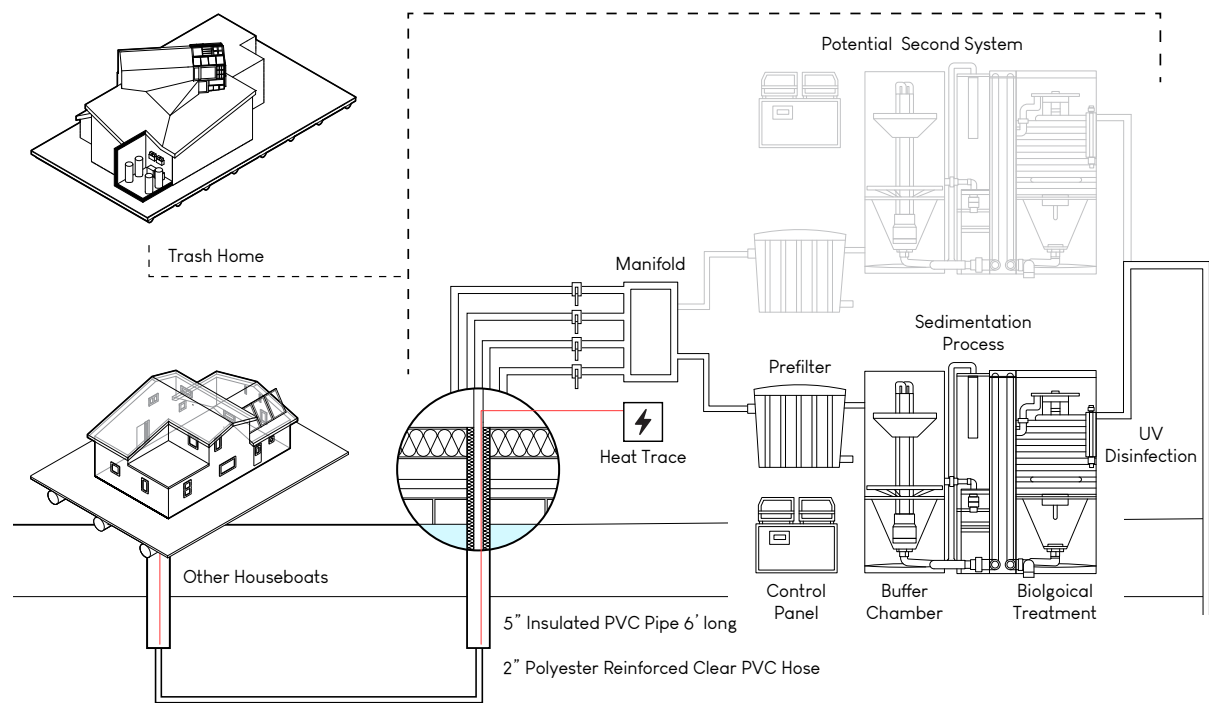


Figure 5.41: Diagram of proposed grey water filtration system

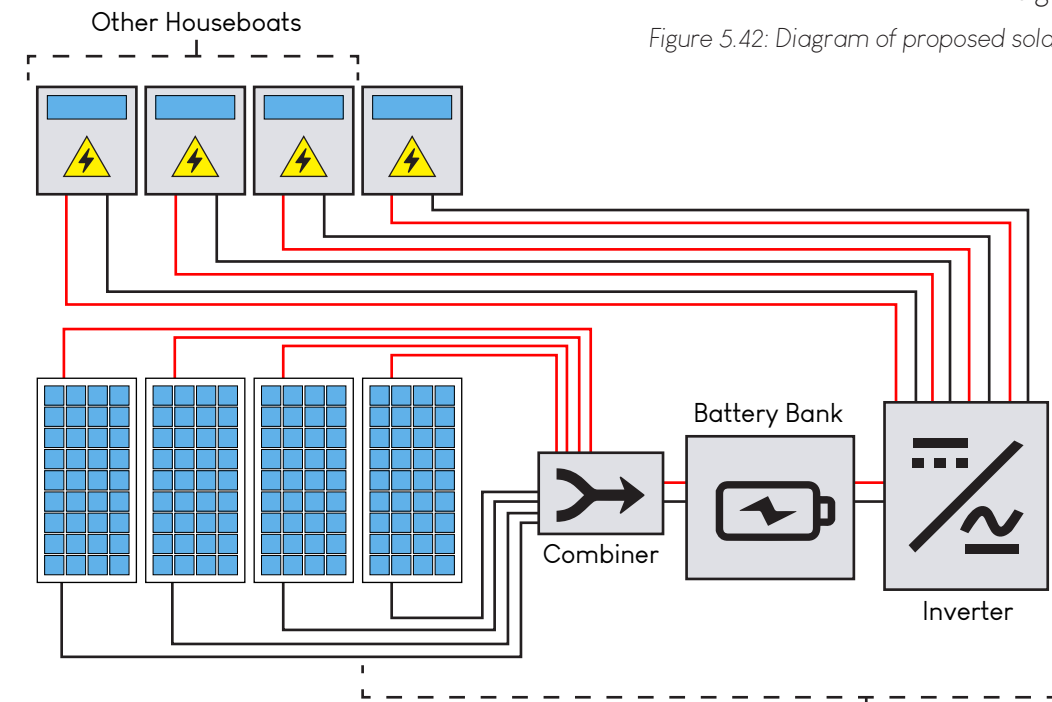
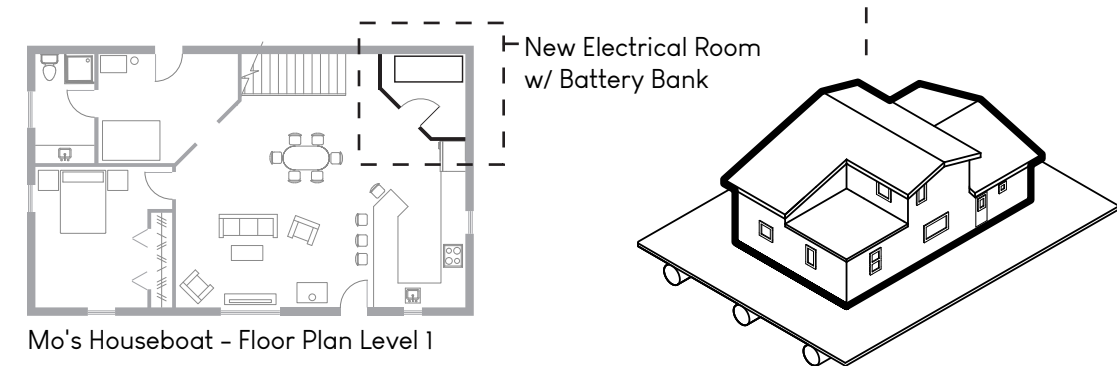


Figure 5.42: Diagram of proposed solar generation system



affordable, but a larger system would not really be required as many houseboats do not have water using appliances found in traditional homes. The mechanical room has been designed with additional space so that later on, a second system could be added. This could either be due to the addition of other houseboats or to increase the longevity of the equipment and allow for easy repairs without shutting the whole system down.

Each boathouse has a greywater pipe that is transported in an underwater cable to the water filtration room. These pipes are sealed in an insulated pipe for the first 5'

of water, as that is the depth that the ice freezes to in this region. The pipes would also be equipped with heat trace up until this 5' mark in order to ensure no freezing.

Solar:

Like with the greywater filtration system, this thesis proposed creating an electrical grid as well. There are already two houseboats on the water which do this, and so I propose that this system should be expanded. The batteries are currently housed in Mo's Houseboat as it is one of the larger, more well-designed ones on the water and so could facilitate this addition.

All houseboats would have their own solar and electrical panels. However, Mo's would have the converter and the battery bank, allowing users to share energy depending on a wide variety of situations. Maybe someone was in a better spot for that day, or one house boater is away from their home and therefore is not using their electricity. This idea of sharing helps keep everyone accountable for the amount of electricity they use, helps offset costs, and it also contributes to the idea that this is a neighborly community where people help one another.

Waste:

Yellowknife has a significant waste problem, with an annual disposal rate of 1100kg per capita. That is 401kg more than the national average, with around 35% coming from the construction and demolition sector.¹² This is a huge problem as this waste rarely ever gets shipped out to the proper recycling plants, and so it remains in a landfill just outside the community. Many people have taken this as an opportunity to scavenge for materials. This project seeks not only to continue and encourage this cultural phenomenon but also to contribute positively to a solution for waste within this community. True sustainability should be about creating closed-loop systems. So this map shows where in the community many of the materials used for the new houseboat construction were gathered from. This shows other places how they can begin to create a data system of their own community's resources and make partnerships with local businesses.

- ¹ Jason McLennan, *Zugunruhe: The Inner Migration to Profound Environmental Change* (Kansas City, MO: Ecotone, 2011), 144.
- ² Statistics Canada Government of Canada. "Census Profile, 2016 Census - Yellowknife [Census Agglomeration], Northwest Territories and Northwest Territories [Territory]." February 8, 2017. <https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=C-MACA&Code1=995&Geo2=PR&Code2=61&Search-Text=Yellowknife&SearchType=Begins&SearchPR=01&B1=A11&GeoLevel=PR&GeoCode=995&TABID=1&type=0.Demographics>.
- ³ Ted Laturnus, *Floating Homes: A Houseboat Handbook*, First (Harbour Pub Co., 1987), 57.
- ⁴ Vince Barter, interview by Margaret Burt, In-person Conversation, November 17, 2019.
- ⁵ Government of Northwest Territories, "Energy Prices and Costs in the NWT May 2016" (www.NWTenergy.ca, May 2016), https://www.inf.gov.nt.ca/sites/inf/files/resources/energy_prices_and_costs_in_the_nwt.pdf.
- ⁶ Mark Gorgolewski, *Resource Salvation: The Architecture of Reuse* (Wiley-Blackwell, 2017), 11.
- ⁷ Gorgolewski, 5.
- ⁸ Gorgolewski, 104.
- ⁹ "City of Yellowknife Strategic Waste Management Plan" (Sonnevera International Corp, April 2018), <https://www.yellowknife.ca/en/city-government/resources/Reports/Public-Works/City-of-Yellowknife-Strategic-Waste-Management-Plan-April-2018.pdf>.
- ¹⁰ "The Complete Guide to Cardboard Insulation," Carboard Help, accessed March 30, 2020, <http://cardboardhelp.com/the-complete-guide-to-cardboard-insulation/>.
- ¹¹ Water Wise Group, "Aqua2use GWTS 500: Installation and Operation Manual," accessed March 10, 2019, <http://waterwisegroup.com/wp-content/uploads/2016/08/Aqua2use-GWTS-500-Instructions-manual-for-Installation-and-Operation.pdf>.
- ¹² "Garbage," City of Yellowknife, accessed March 30, 2020, <https://www.yellowknife.ca/en/living-here/garbage.asp>.

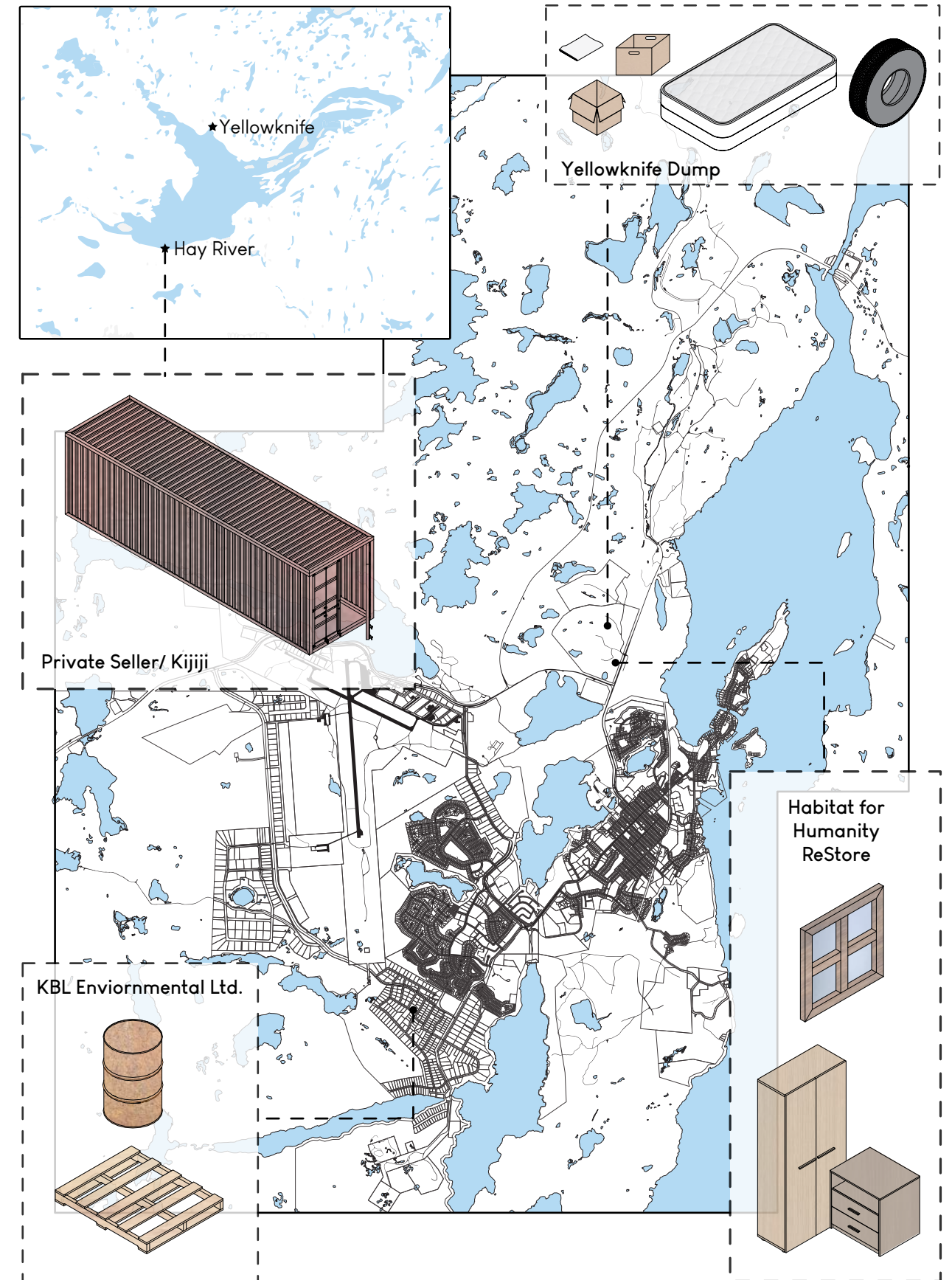


Figure 5.43: (left) Diagram of recycled material harvesting locations

BUSH RAT CAFE V2

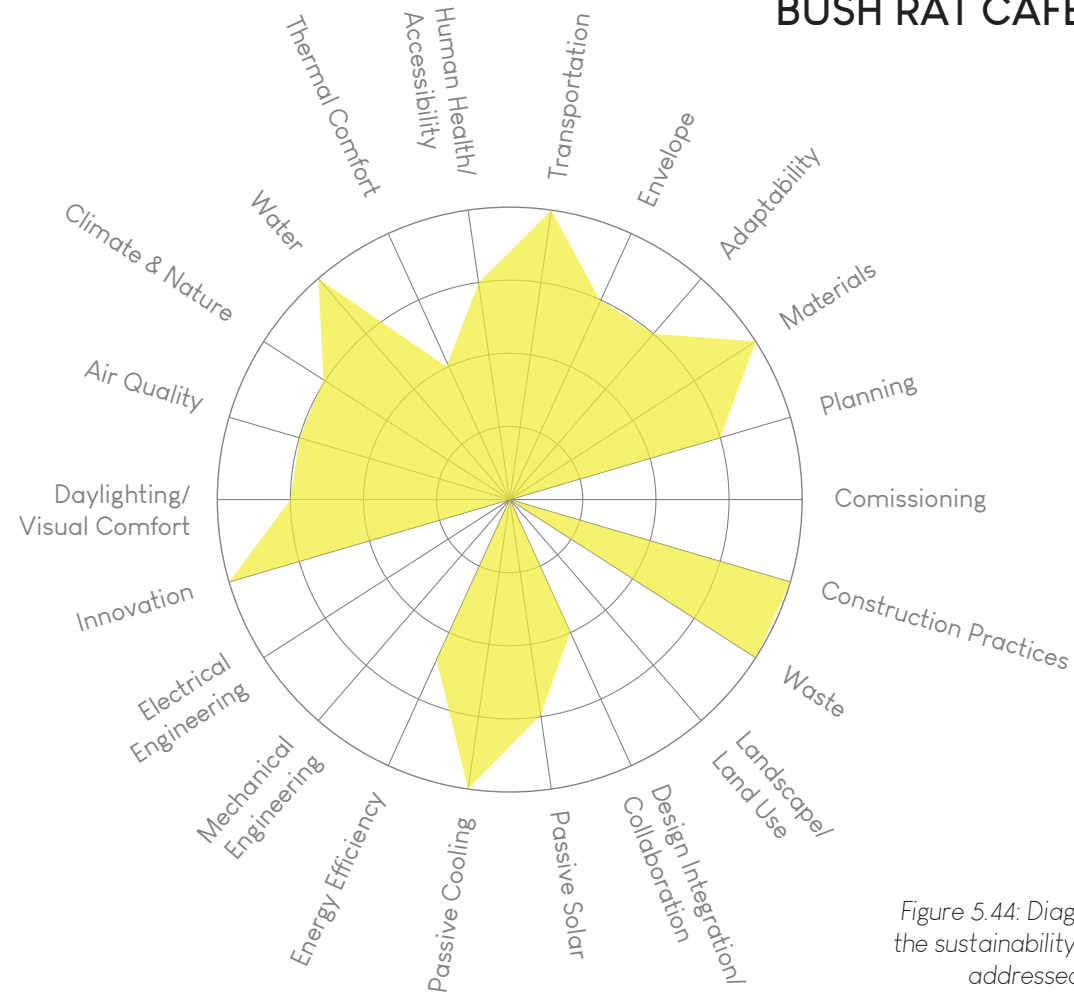


Figure 5.44: Diagram of the sustainability topics addressed in the Renovation Design.

Conclusion

At the beginning of this thesis it was asked, how can we as designers begin to redevelop the existing housing typologies in Yellowknife, NWT in accordance with green building certification programs in order to achieve true sustainability, without shortchanging the North? The answer presented here took the philosophies and principles found in both Passive House and Living Building Challenge as well as Yellowknife's unique housing typology of houseboats. It developed a methodology to redevelop housing in a truly sustainable way.

Each one of the design proposals offered a different approach to achieving genuinely

sustainable housing in Yellowknife, NWT. One of them used existing building stock in combination with newer technologies to create a solution that achieves significantly better energy use. The other combined recycled community waste and culture, contributing extensively to the local place but the achieved energy use performance, was not as good. There may have been better products that could have been used, but the amount of greenhouse gases that would have been generated from producing and transporting these products has been eliminated. Community solutions showed what is possible when people work together and share responsibilities. It created solutions for waste, wa-

TRASH HOME

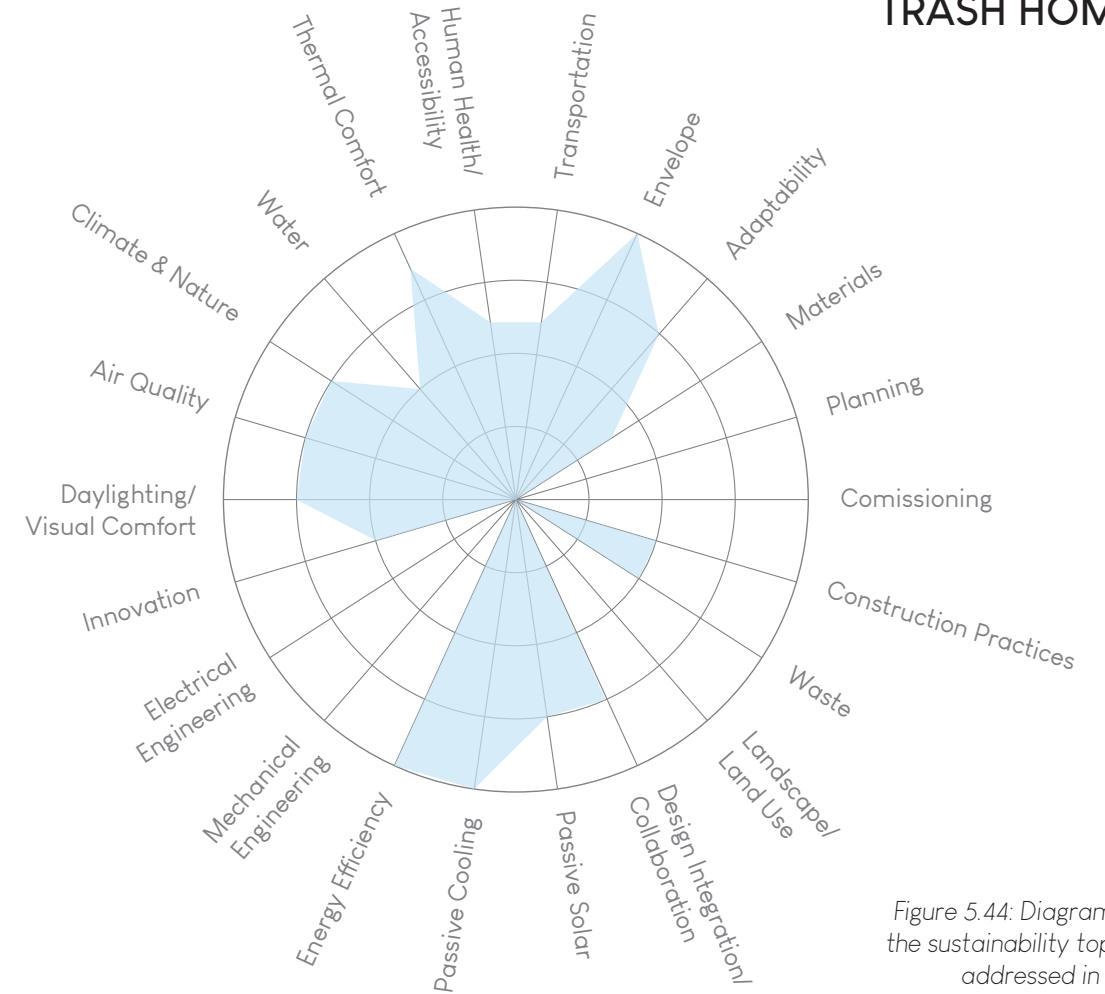


Figure 5.44: Diagram of the sustainability topics addressed in the New Build Design.

ter, and solar energy, solutions that could never be accomplished on an individual scale. True sustainability is no single person's journey; rather, it is only achievable when communities work together.

The reality is that sustainability is not a linear approach with only one right answer; rather there are several paths which a designer can choose to follow. There are so many other ways to approach true sustainability, but this thesis showed a way to study the housing in a place and their culture and then how to manifest it in design. It showed how to use an alternative approach to design, one that is grounded in materiality, and it showed how to make

community connections and address community problems. What works in Yellowknife will not necessarily work in other places. Furthermore, this is why it is the methodology and approach that can be translated to other northern communities, rather than the physical design. True sustainability, especially in Northern communities, is not a straight line with only one right answer. It is essential to look at several different solutions for each and every project, and this thesis has offered just a few. There is still more work and research to do, but the hope is that this will begin to generate a conversation and interest.

Appendix A - Case Studies

Local Solution: Manuel Jorge

One example of a sustainable building system solution that is currently being developed in the region is by Manuel Jorge at Energy Wall & Building Products Ltd. He has developed a wall system that is pursuing Passive House certification and follows a lot of the principals set out in the good design practices referenced earlier. He has created a simple design that can be completed at any temperature.

has shown to reduce the heating costs of a home by up to 80%.¹

¹ Manuel Jorge, In-person Conversation, November 18, 2019.

As seen in Figure 6.1, the system is composed of a typical two by six wall and plywood sheathing. Then, in the same manner that humans apply jackets to our exterior for warmth, the insulation is applied to the exterior of the structure. First, the vapor barrier, a 10mil sheet of polyethylene is applied. This is fastened in place by a series of three two by fours, which are bolted to the structure. Then a layer of BASF Neopor® GPS - which was chosen due to its efficiency, cost, and sustainable characteristics - is placed straddling the two by fours. One by three struts are placed within the precut notches in the foam insulation. They are used to affix any type of exterior siding that is to be used, including cement board. While it is recommended that insulation be placed within the central wall cavity, it is not required. This frees up space for any mechanical or electrical systems required. By having both the insulation and vapor barrier on the exterior of the structure, it reduces puncture holes, drafts, and structural vulnerabilities.

This system has been tested extensively in the area and has been shown to work well for both new construction and renovations. It is a durable approach which

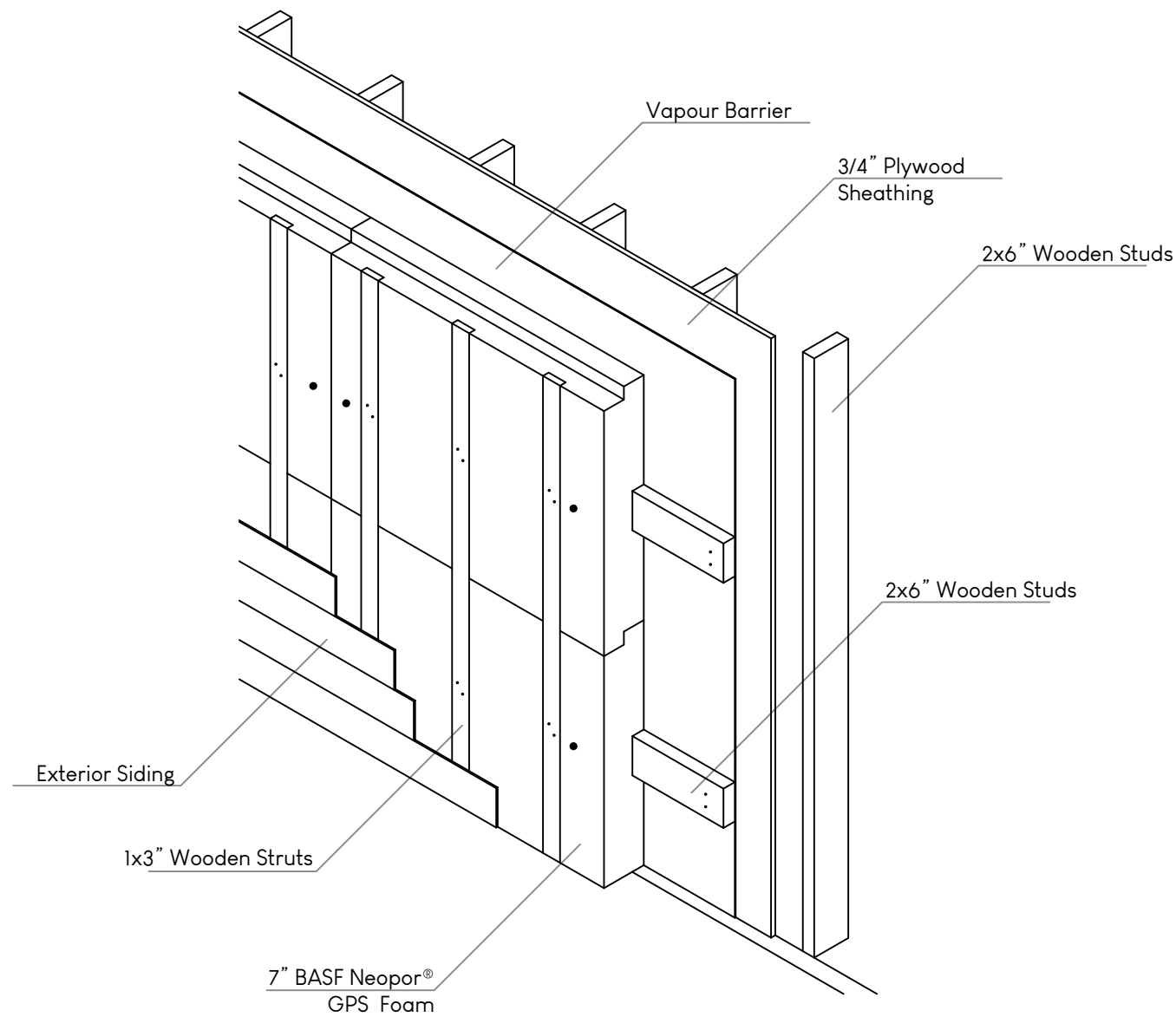


Figure 6.1: Diagram of Manuel Jorge's Energy Wall Design

Appendix B - Model Photos

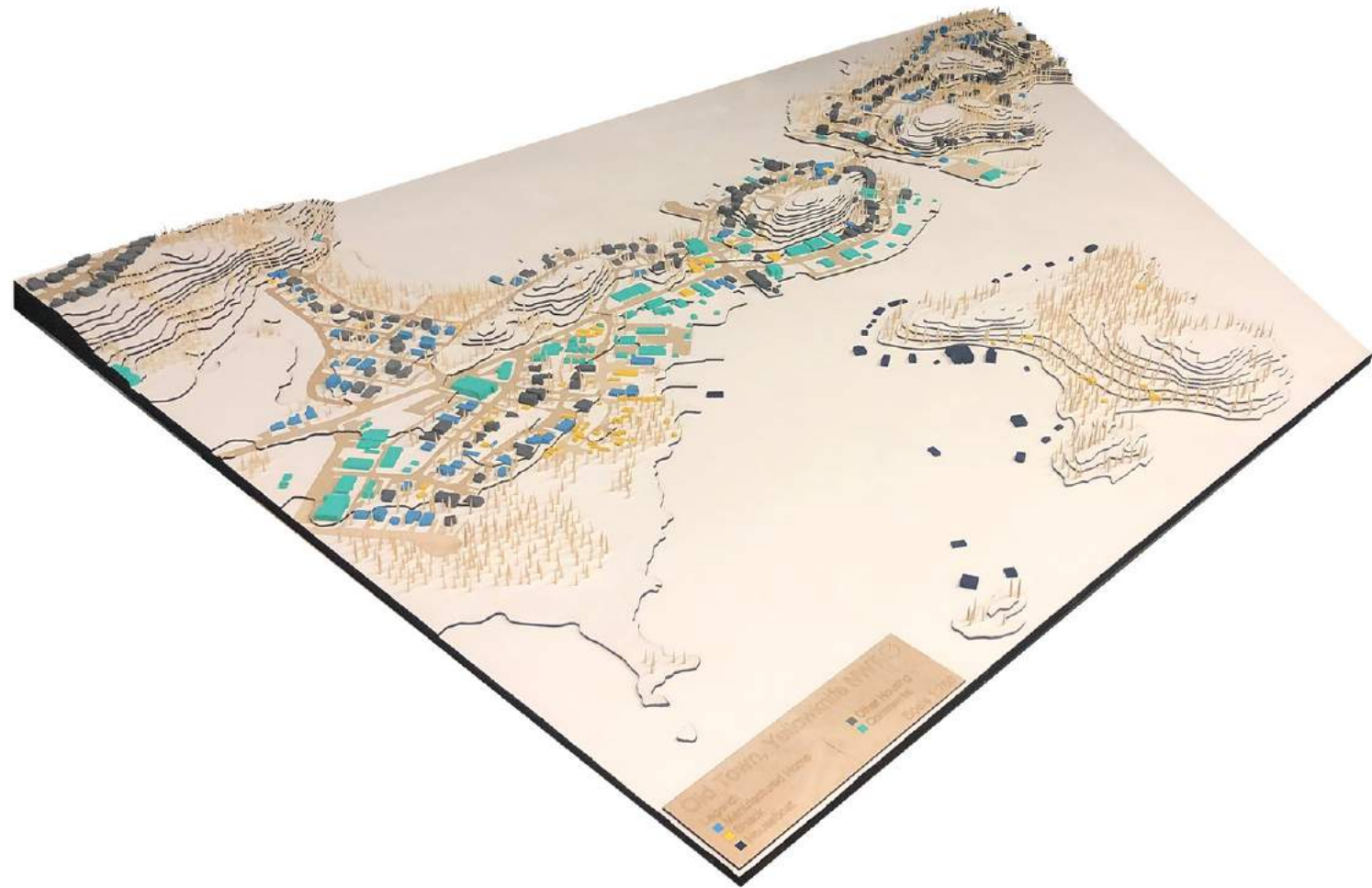


Figure 7.1: Site Model

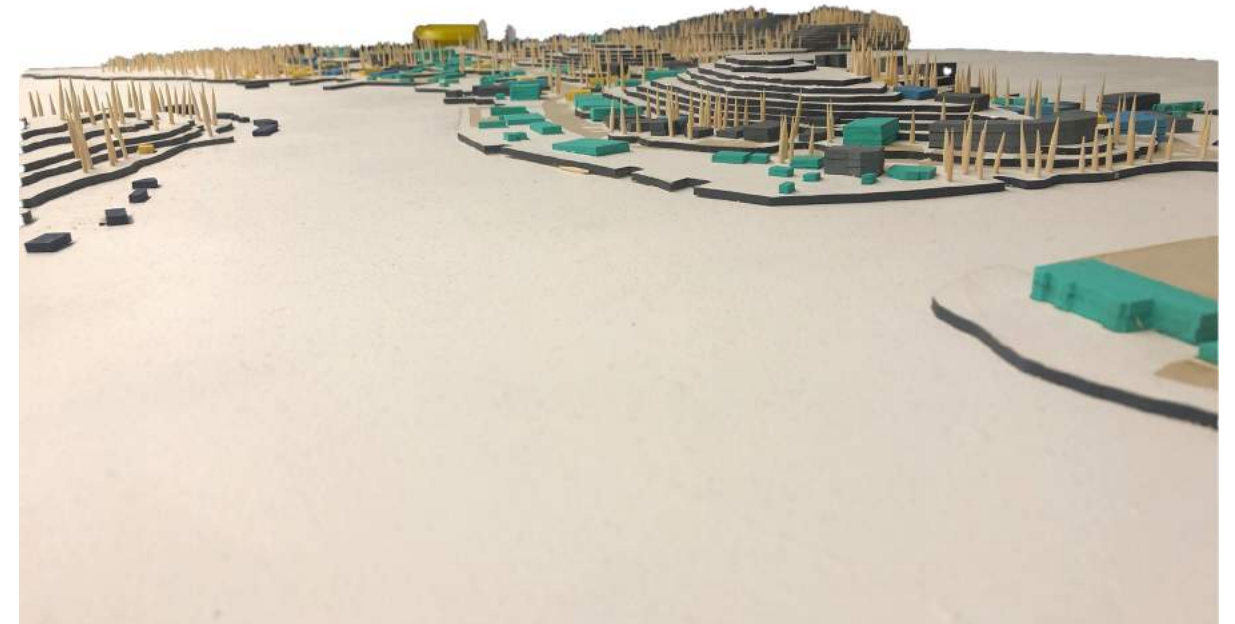


Figure 7.2: Site Model - View of Pilots Monument



Figure 7.3: Site Model - Aerial View of Old Town from the Northeast

Appendix C - Corrugated Cardboard

Cardboard is a lightweight, cheap, and recyclable material that serves as an excellent insulator because of its poor thermal conductivity. The combination of tightly packed fibers and air pockets means that heat transfers very slowly through it. Corrugated cardboard is estimated to be about 1/3 the value of water's conductivity¹ and has an R-value of around 3 or 4.² This is similar to many types of insulation on the market today, including fiberglass.³

However, cardboard is not without its downfalls, which include its vulnerability to moisture and fire. Lab tests have shown that there are ways around both of these issues. Exposure to moisture can significantly reduce the effectiveness of the insulating properties of cardboard and create mold, but through an application of paint, varnish, or lime plaster to the outermost surface. This was found to be the most effective solution to reduce moisture vulnerability, and so it was the solution used in this thesis. Some other solutions were to minimize edges between cardboard panels, use solid cardboard for the first and last layer, or to cover the cardboard with plastic. But these either significantly reduced the ability to use recycled cardboard or complicated future recycling processes.⁴

There are also several different ways to reduce flammability. One way is to use a borax dissolution, similar to what is used with wool insulation. Tests have also shown that at a specific thickness, cardboard begins to behave like wood, charring on the exterior and protecting the interior from burning. This is the method used for this thesis. There is also the potential to clad the cardboard with a protecting board

that is less flammable.⁵

While not perfect, research has clearly shown that cardboard has the potential to become a great insulation option for sustainable projects and one that will become more viable with research.

¹ "OUT OF THE BOX - INSULATION VOL. 2," Critical Concrete, March 20, 2018, <https://criticalconcrete.com/out-of-the-box-insulation-2/>.

² "The Complete Guide to Cardboard Insulation," Carboard Help, accessed March 30, 2020, <http://cardboardhelp.com/the-complete-guide-to-cardboard-insulation/>.

³ "OUT OF THE BOX - INSULATION VOL. 2,"

⁴ "OUT OF THE BOX - INSULATION VOL. 2,"

⁵ "OUT OF THE BOX - INSULATION VOL. 2,"

Appendix D - Artifact

During this project each student was charged with creating an artifact which symbolised and manifested the ideas of the thesis. Since this thesis' primary focus was on how Yellowknife practices sustainability, materiality rather than a specific object became the primary inspiration and driver behind this artifact. Yellowknife has a rich culture of reuse, used for a wide array of projects, from decorations to construction materials, art supplies, and even furniture making. Thus, the materials used for this artifact were scavenged from my local dump.

The focus was on materials that were attainable under the circumstances and already had built-in characteristics of a home. A wide variety of materials – wood, metal, fibreglass – as well as materials which have different levels of ageing, not only reveals the reality of what it means to use second hand materials but also reflects the demographics of Yellowknife. Just like the city itself, this artefact could never have been created from only one object or one material, its collaging is what makes it so unique and effective.

The wide variety of possible uses for discarded materials made the selection of a specific object challenging. In the end the focus became how the everyday life of people in Yellowknife is different from their southern counterparts. It was at this time that it became apparent how much more time people from northern cities spend outside, especially in the summer. Homes often have large patios where people gather with friends and families under the midnight sun, trying to take in as much sunlight as possible before the extended, long dark winter returns. It was this cultural phenomenon that led to the

selection of a patio chair as the artifact to be constructed out of reused materials. It will be placed on the second-floor deck of a houseboat – a unique architectural vernacular found in Yellowknife – overlooking the lake, the forest, and the city.

Once a chair was selected, research was conducted into the connection between architecture and chair design. Previous famous architect's chairs have served as models for understanding architecture, allowing them to test their ideas, material, fabrication, and form on a workable scale.¹ In this case, to test the idea of bringing together objects, many of which were not a chair in their former life, the focus was to develop connections between materials which were never meant to go together. The strategy was not predetermine anything, but rather let the shape of the materials and the limited way in which they can come together influence the form. It is not always about clean edges or manufactured and controlled solutions. Rather the North, and Yellowknife, in particular, is about resourcefulness and ingenuity and how materiality and the limitations of what is available can inform architecture.

This chair serves as an expression of the cultural fabric of Yellowknife, and an exploration into how these ideas manifest in architectural principles such as form, connections, and materiality. The hope is to take the lessons learned from this chair design and translate it into the final design proposal for a houseboat which exemplifies what it means to live in Yellowknife and still achieve true sustainability.

¹ "The Chair." Yale Architecture. Yale School of Architecture. Accessed March 3, 2020. <https://www.architecture.yale.edu/courses/13710-the-chair>.

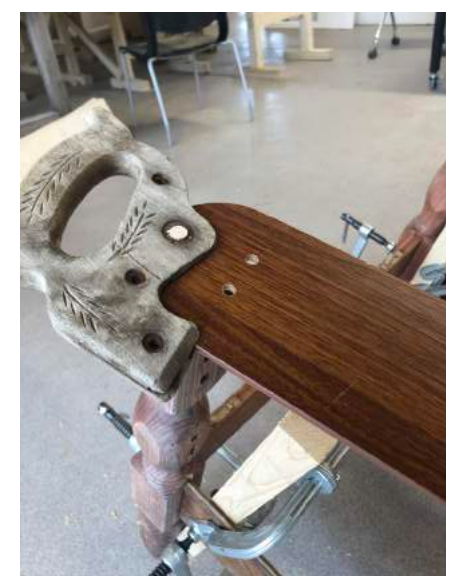
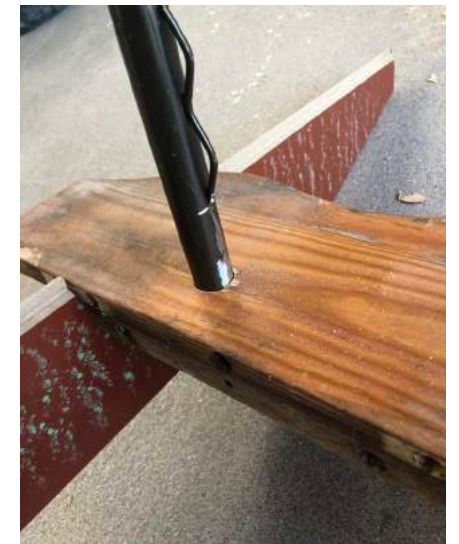
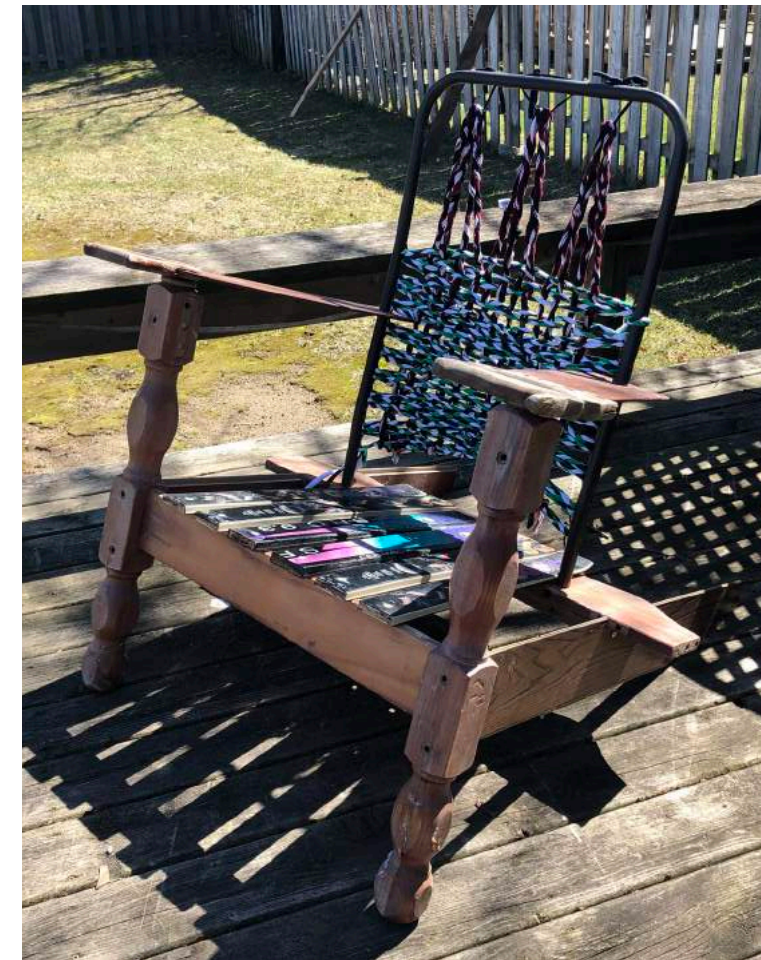


Figure 9.1: (top left) Final completed artifact
 Figure 9.2: (bottom right) Chair from above showing ski seating
 Figure 9.3: (top left) Connection of back rest to frame
 Figure 9.4: (middle left) Mortise and tenon connection of frame
 Figure 9.5: (bottom right) Detail of arm rest saw handle and fan blade dowel connection

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