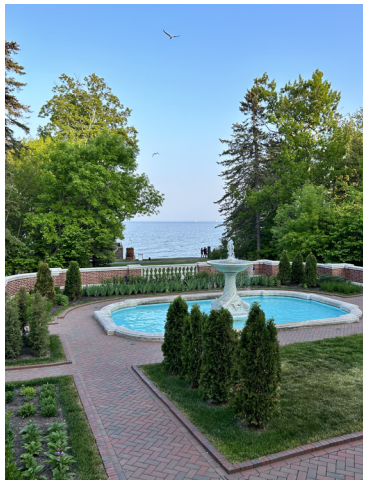
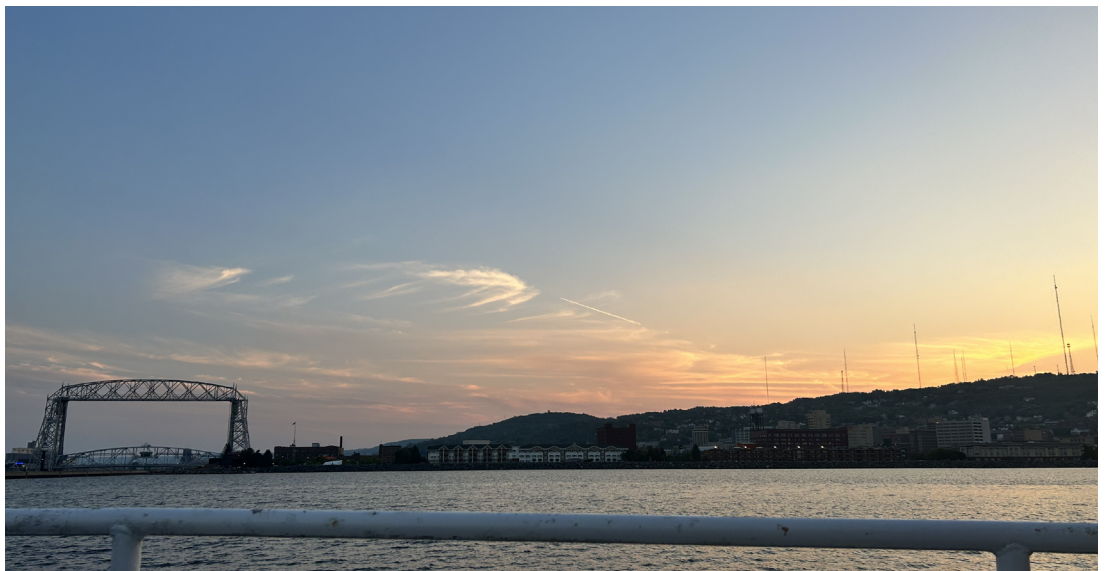


HEALTHIER HOMES

INTEGRATING EMERGING DESIGN STRATEGIES
INTO AFFORDABLE HOUSING

Graduate Design Thesis, Spring 2024 • ARCH 772





BACKGROUND



Figure 1.

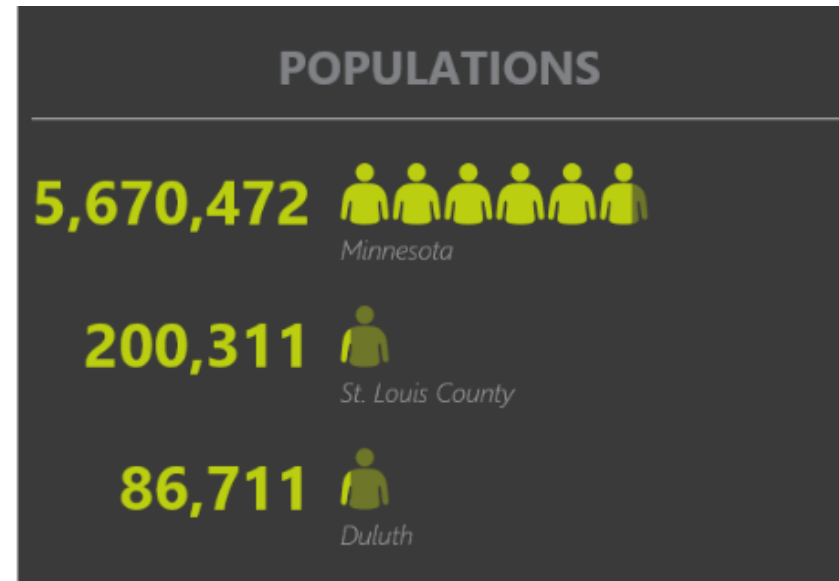
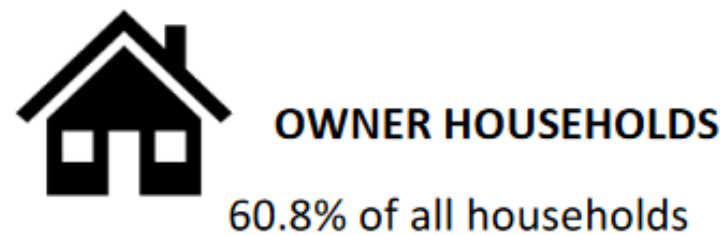


Figure 2.



Median Sale Price, 2022: \$260,000

Median Sale Price, 2021: \$240,000

Figure 4

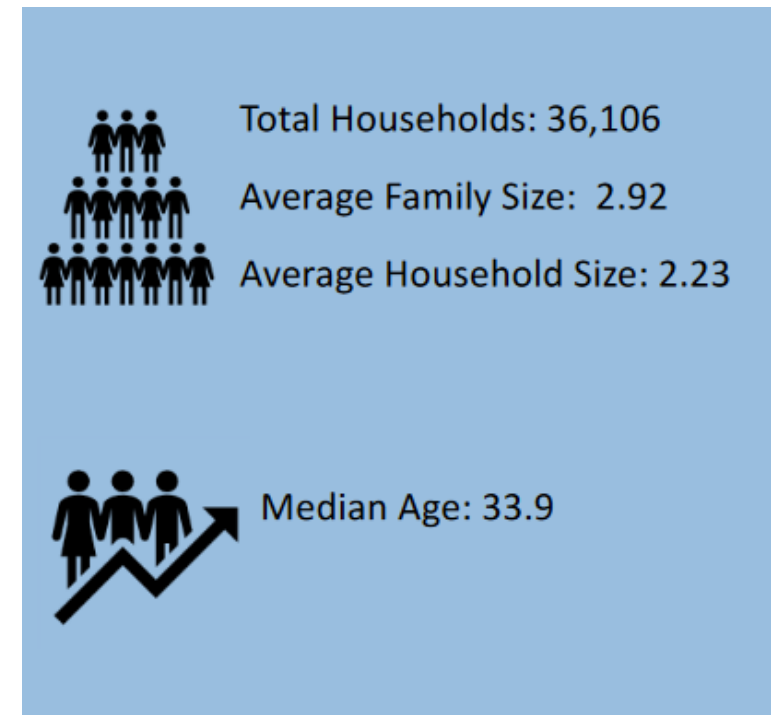
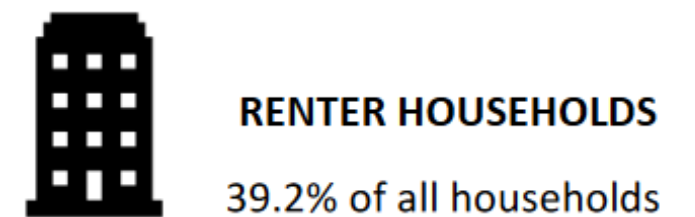


Figure 3



2022 Average Rent: \$1,329

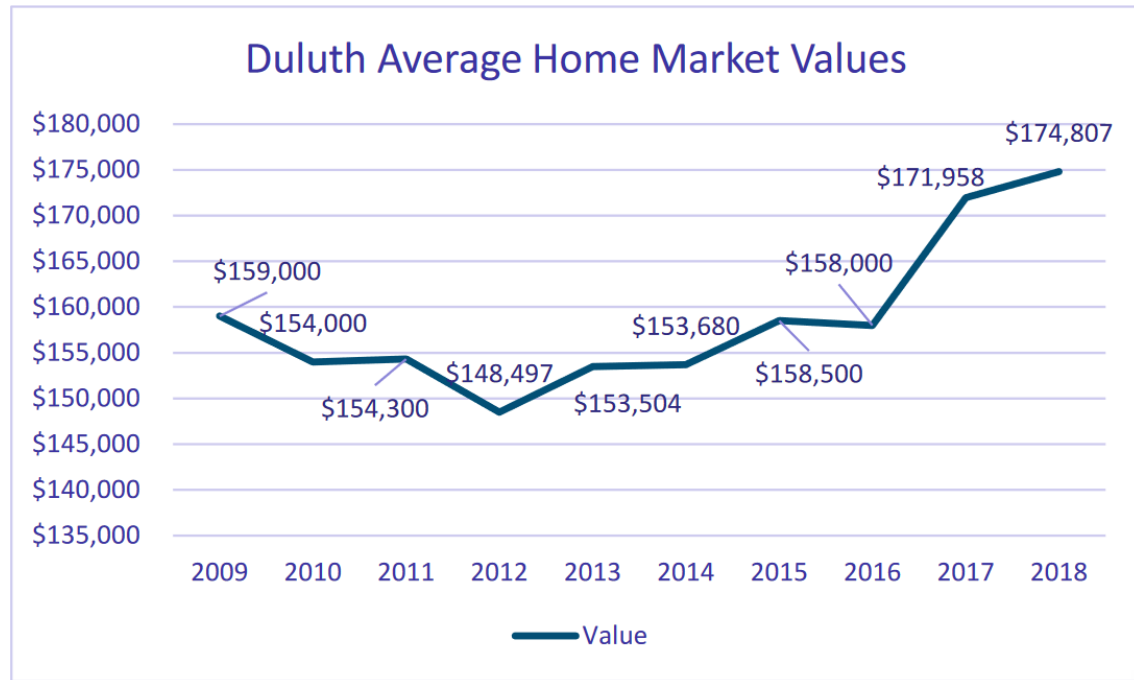
2021 Average Rent: \$1,320

2022 Median Rent: \$1,355

2021 Median Rent: \$1,274

Figure 5

CURRENT HOUSING MARKET



Source: St. Louis County Assessor's Office

Figure 6

YEAR	MEDIAN HOUSEHOLD INCOME	AVERAGE HOME PRICE
2017	\$49,078	\$174,807
2022	\$58,014 + 18%	\$260,000 + 49%

Figure 7

CURRENT HOUSING STOCK



Figure 8

- Over 65% of homes in Duluth are over 50 years old.
- “90% was built before lead-based paint was removed from the market”
- Of the 26,068 homes with lead-based paint, approximately 10,427 are occupied by low- to moderate-income households, including 3,645 households at or below poverty level

(duluthmn.gov. (2018, June 30). Housing Market Analysis. Duluth.)

WHY IS IT IMPORTANT TO INCLUDE HEALTHY MATERIALS AND SUSTAINABILITY INTO AFFORDABLE/LOW-INCOME HOUSING?

USER GROUPS AND ETHICAL RESPONSIBILITY



Figure 9



Figure 10



Figure 11

HOW CAN SUSTAINABILITY BE INTEGRATED INTO THE DESIGN OF
AFFORDABLE HOUSING?

CONSTRUCTION PROCESSES

PREFABRICATION

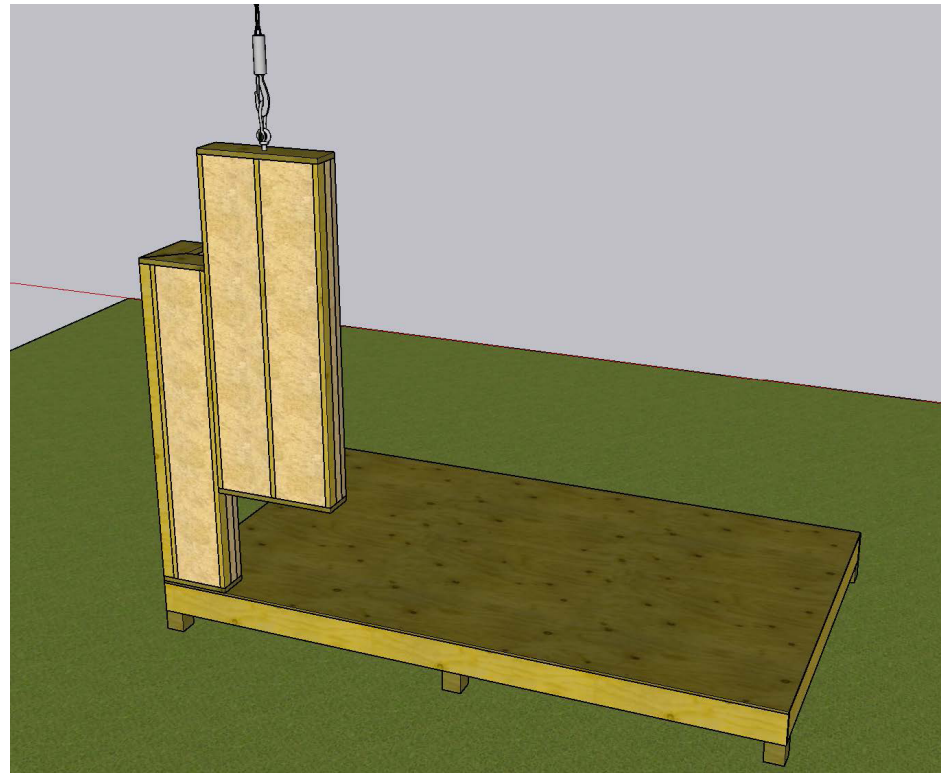


Figure 12



Figure 13

MATERIALS & BUILDING SYSTEMS

INSULATION

- Fiberglass



Figure 14

- Spray Foam



Figure 15

- Rigid Foam



Figure 16

- Structurally Insulated Panels

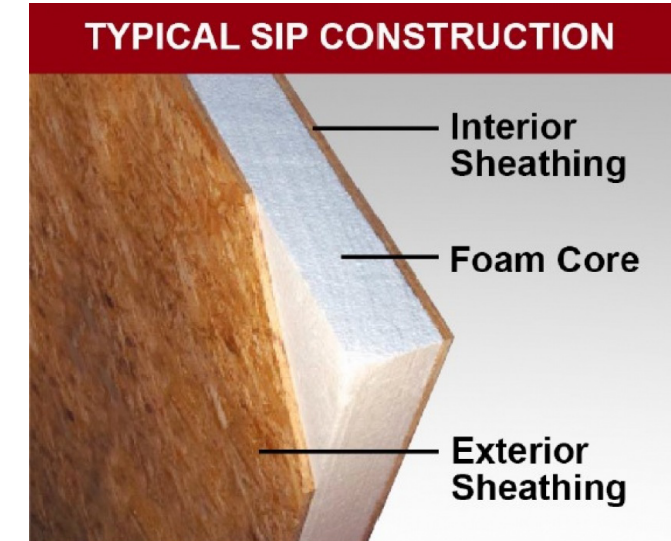


Figure 17

- Hempcrete

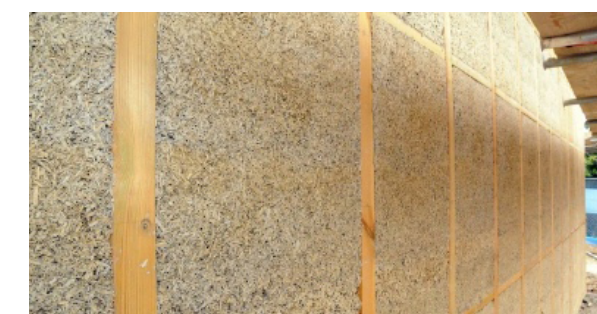


Figure 18

MATERIALS & BUILDING SYSTEMS

INTERIOR FINISHES

- Drywall



Figure 19

- Venetian Plaster



Figure 21

- Lime Plaster



Figure 20

- Gypsum Plaster



Figure 22

MATERIALS & BUILDING SYSTEMS

EXTERIOR FINISHES

- Wood Siding



Figure 23

- Metal Siding



Figure 25

- Engineered Wood Siding



Figure 26

- Vinyl Siding



Figure 24

- Fiber Cement Siding



Figure 27

MATERIALS & BUILDING SYSTEMS

FOUNDATIONS

- Monolithic Slab-on-Grade Foundation



Figure 28

MATERIALS & BUILDING SYSTEMS

ROOF SYSTEMS

- Green Roof System



Figure 29

SUSTAINABLE STRATEGIES

THERMAL MASS

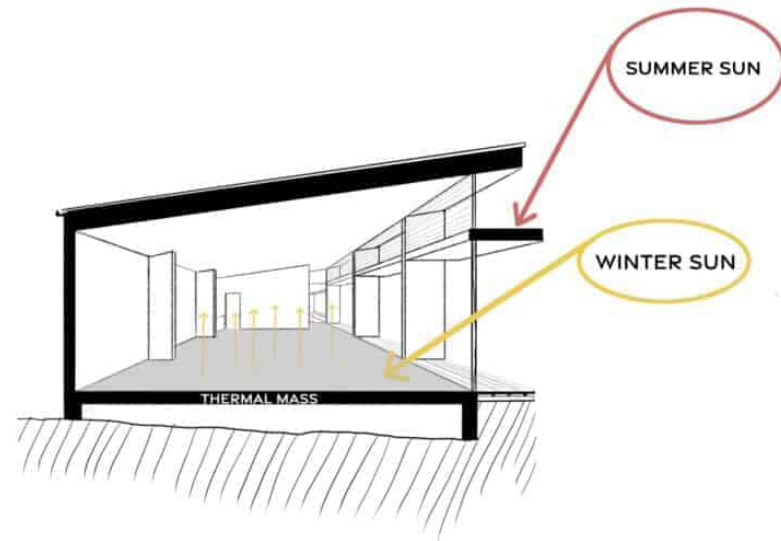


Figure 30

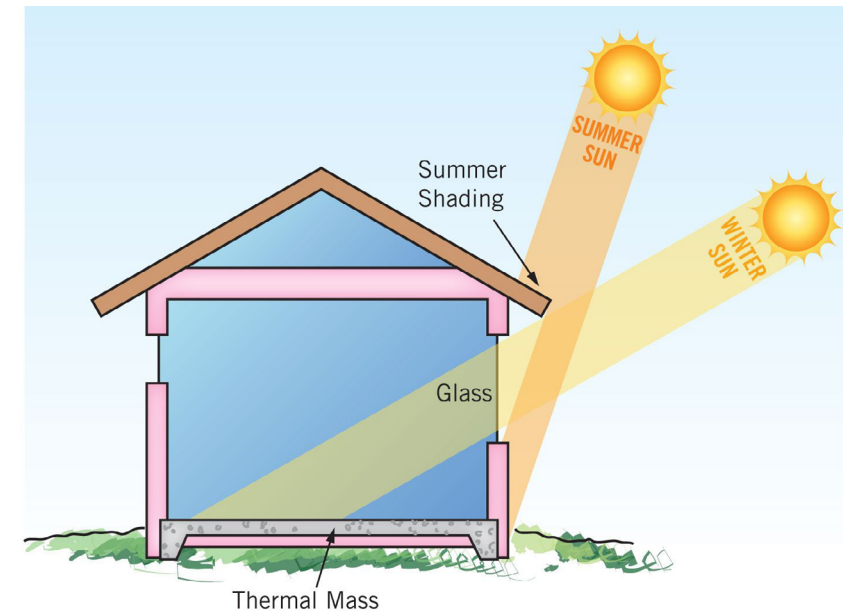
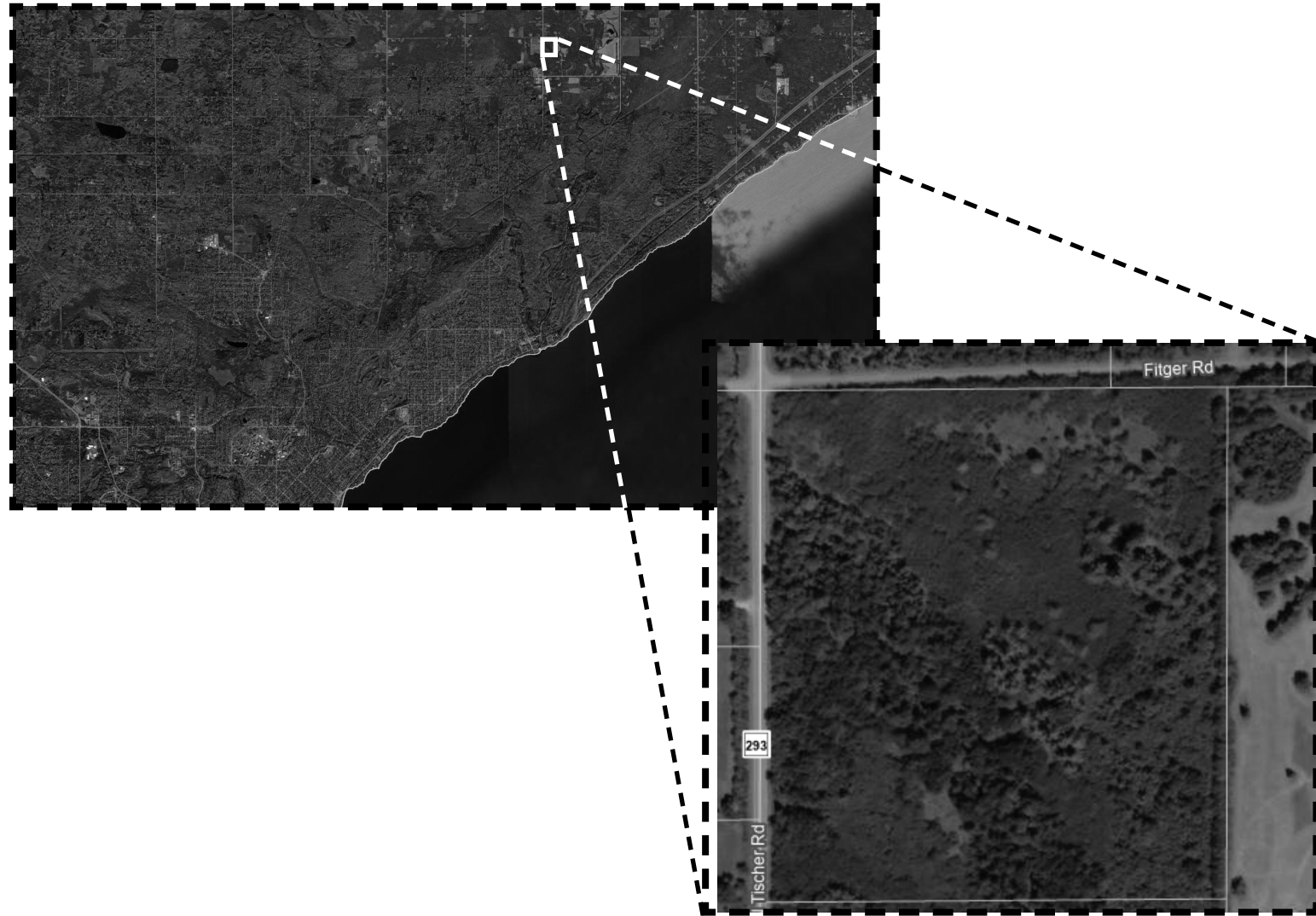


Figure 31

SITE VISIT

11/11/2023



SAFETY - AFFORDABILITY

* SHOWS CRIME PER 1,000 RESIDENTS

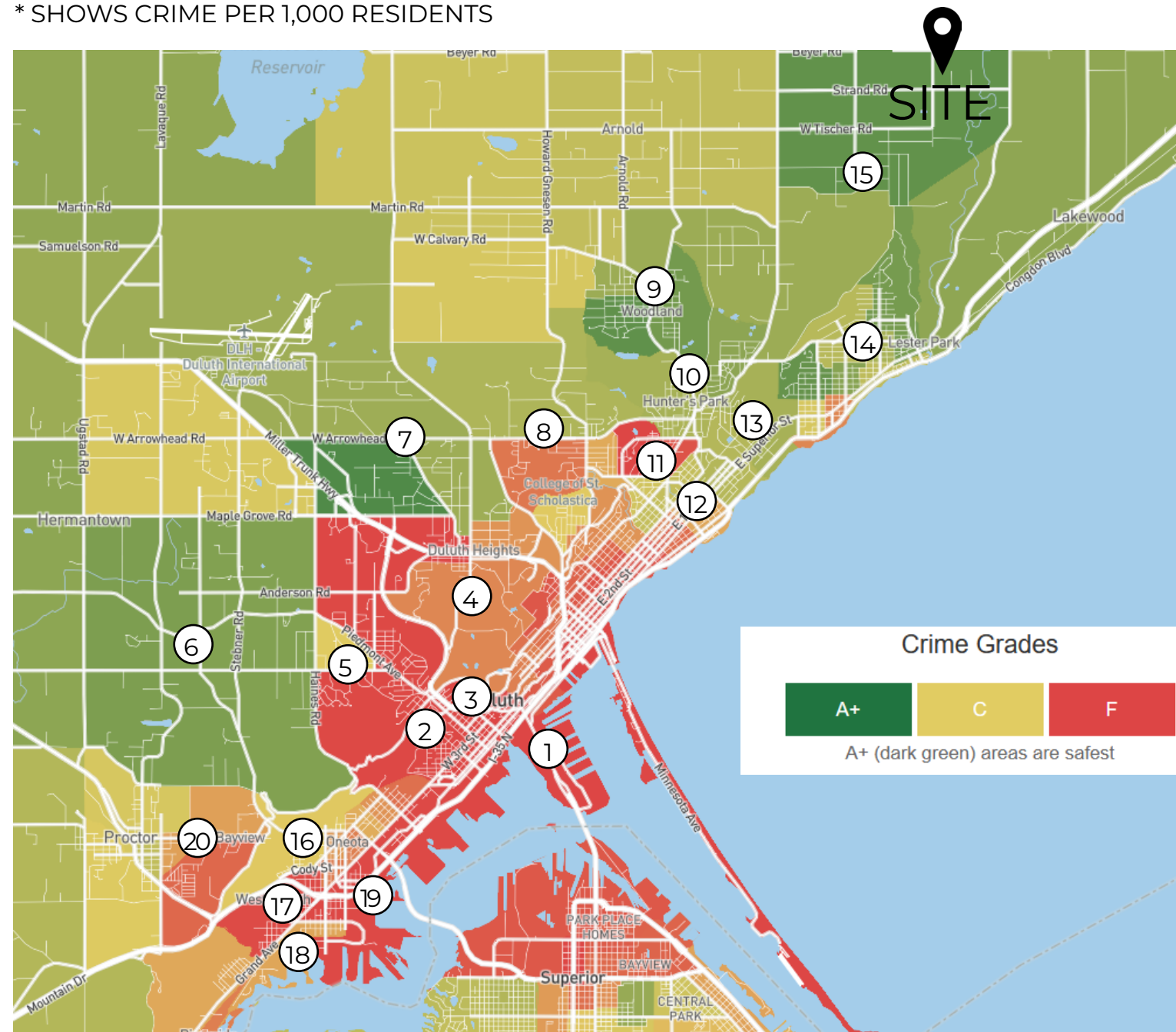


Figure 32

Median Real Estate Price per Neighborhood

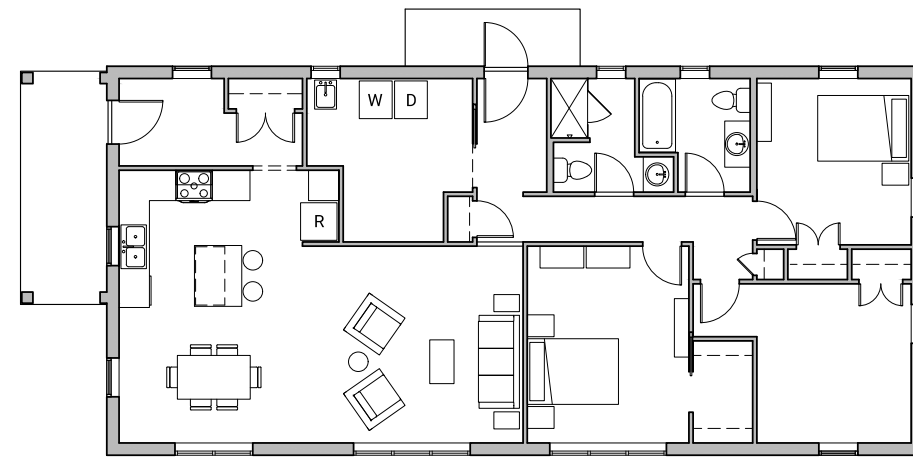
- 1 Missabe Junction - \$162,728
- 2 Lincoln Park - \$186,659
- 3 Lincoln Park East - \$195,409
- 4 Duluth Heights - \$364,159
- 5 Piedmont Heights - \$291,282
- 6 Hermantown - \$486,254
- 7 Duluth International Airport - \$308,882
- 8 Kenwood / College of St. Scholastica - \$355,268
- 9 Woodland - \$304,544
- 10 Hunter's Park - \$411,848
- 11 Chester Park / University of Minnesota Duluth - \$312,246
- 12 Endion East - \$530,025
- 13 Congon Park - \$512,245
- 14 Lakeside Lester Park - \$363,398
- 15 French River / Palmers - \$423,553
- 16 Cody - \$278,192
- 17 Fairmount - \$203,156
- 18 Irving - \$255,982
- 19 Spirit Valley - \$210,212
- 20 Bayview Heights - \$98,816

Figure 33

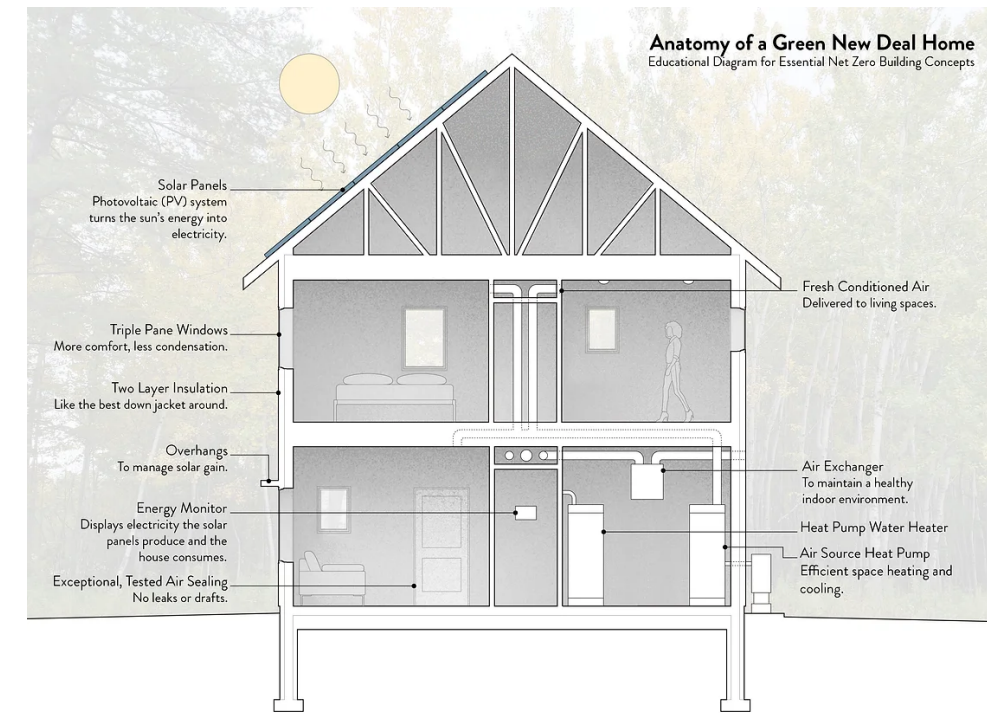
CASE STUDIES

GREEN NEW DEAL HOUSING

Superior, Wi

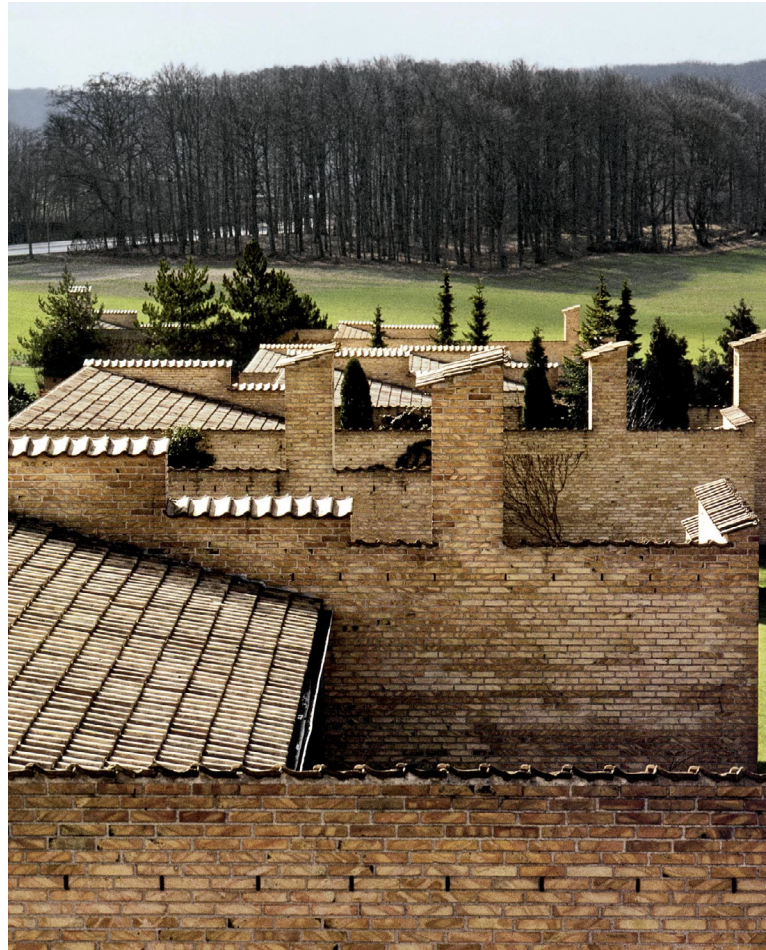


First Floor Plan
1494 square feet



KINGO AND FREDENSBURG HOUSES

Jorn Utzon
Zealand, Denmark



THE HOUSE THAT HEMP BUILT

Fargo, ND

Sydney Glup and Justin Berg



PROCESS



Hand mixing the lime and water in with the hemp shives.

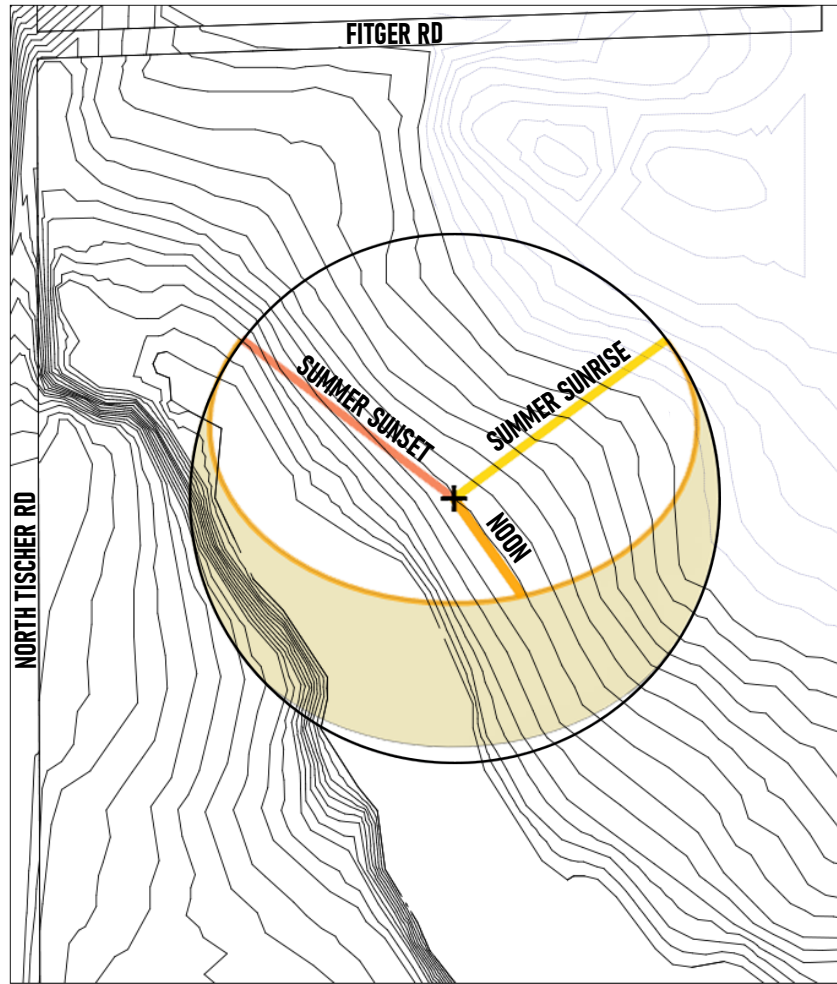


Pack the mix into the wall using slip forms and a stick to pack the mix tightly into corners.

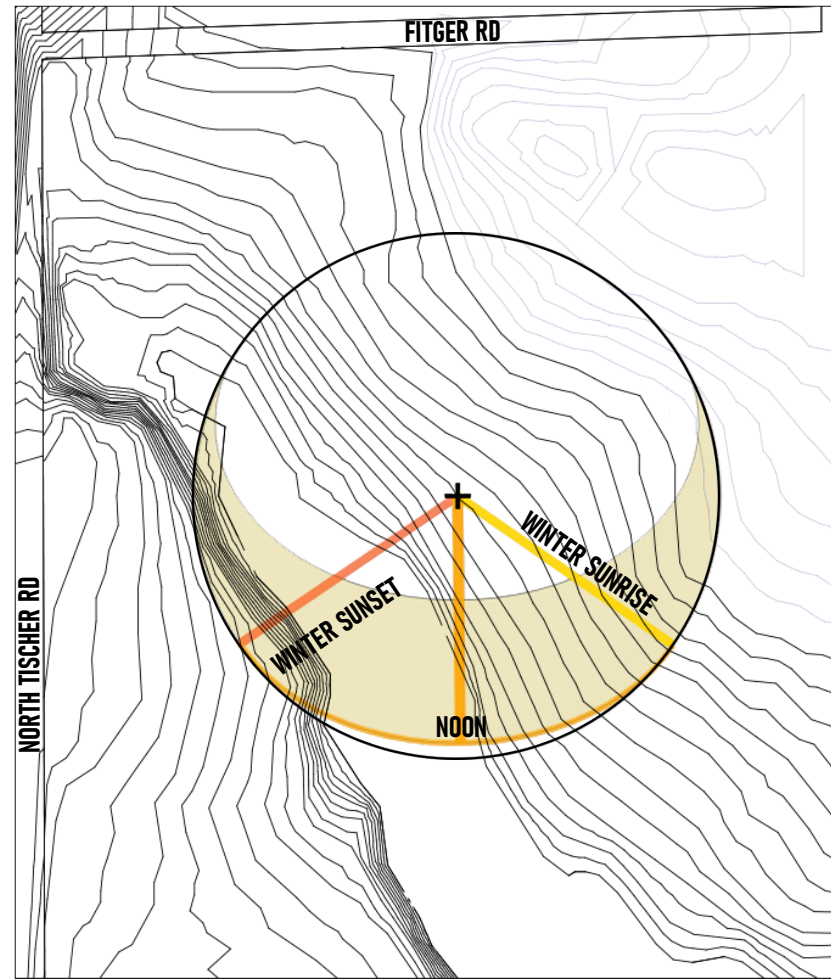


Remove formwork. Keep wrapped in plastic for 72 hours. Remove plastic and let set for 4-6 weeks so water evaporates completely.

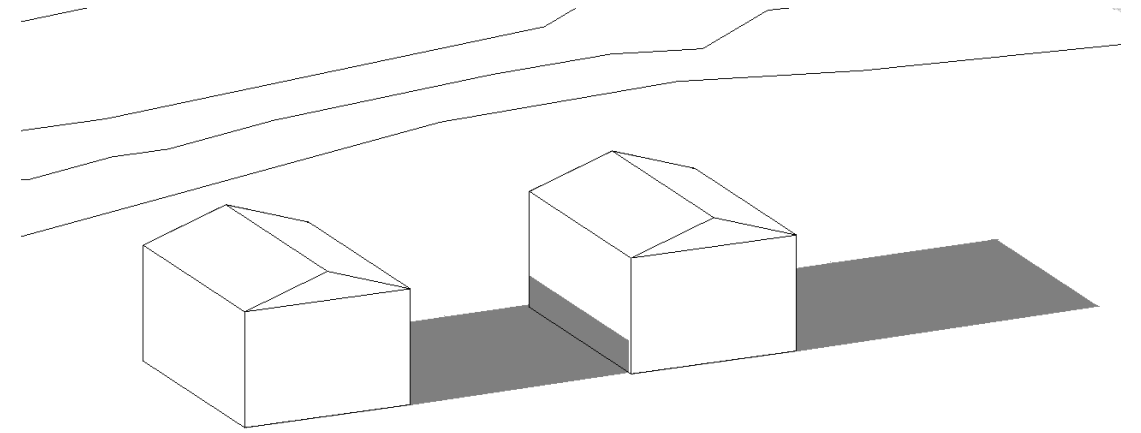
SUN PATHS



Summer Solstice

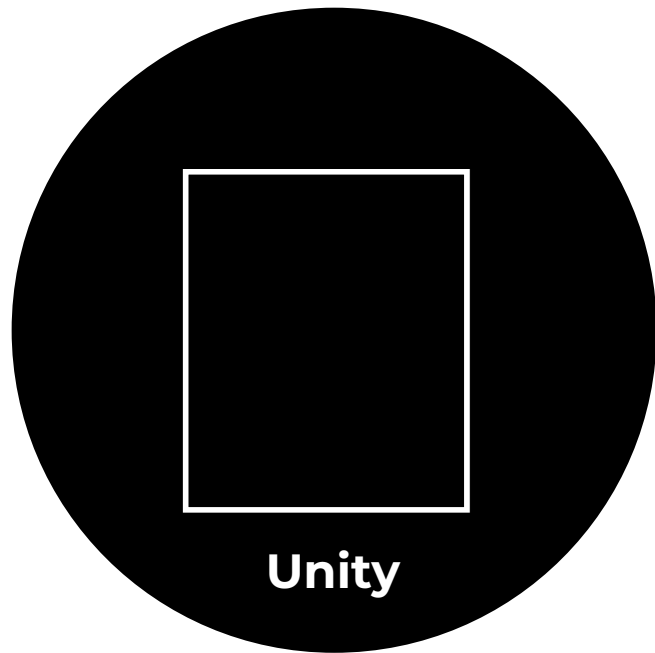


Winter Solstice

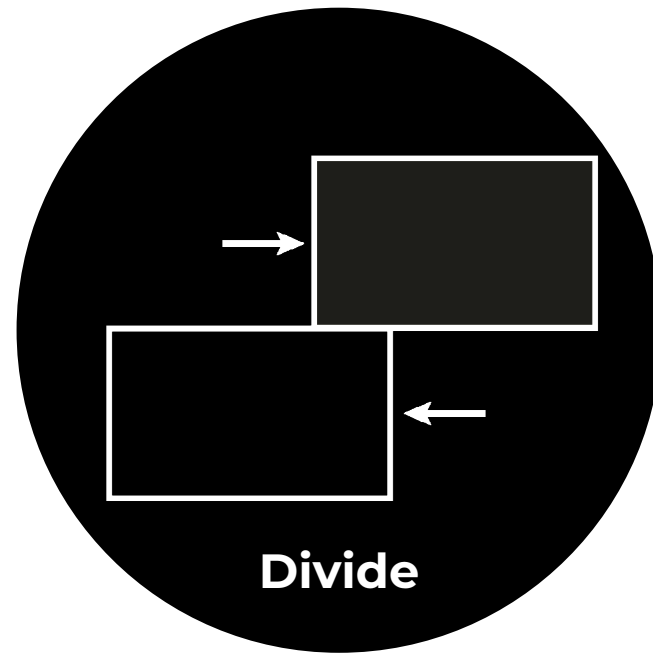


Shadow Study

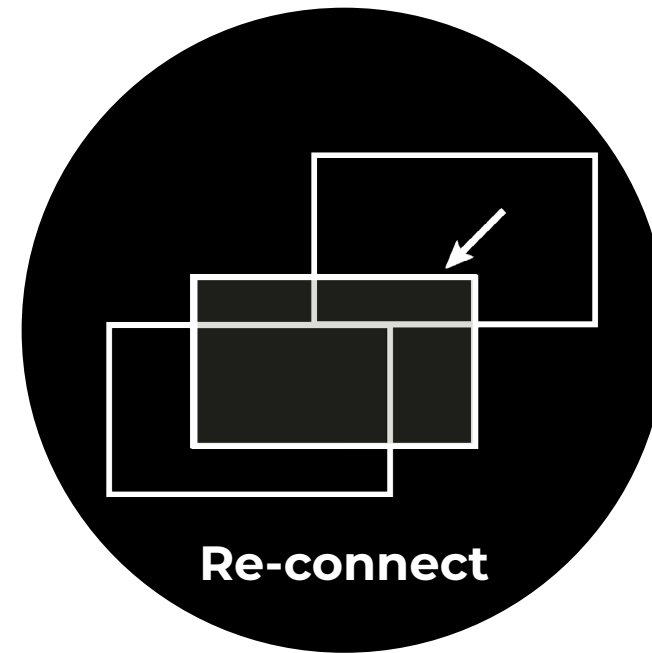
FORM



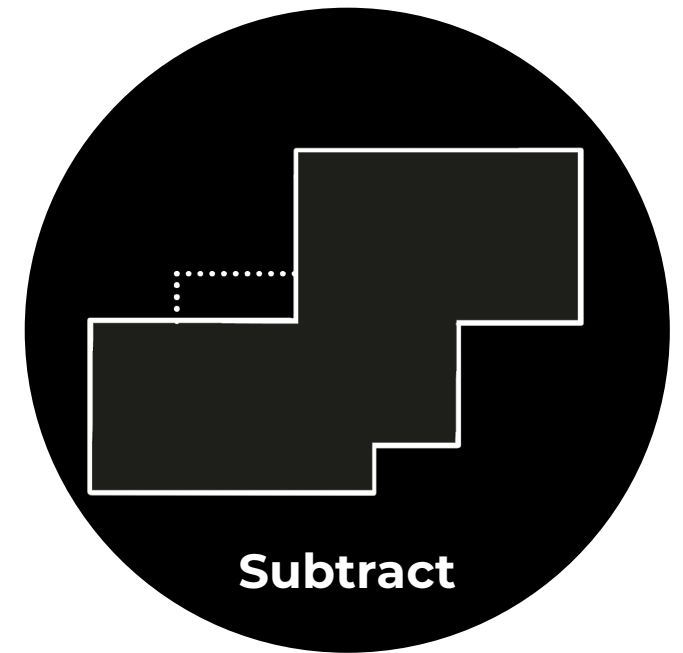
Unity



Divide

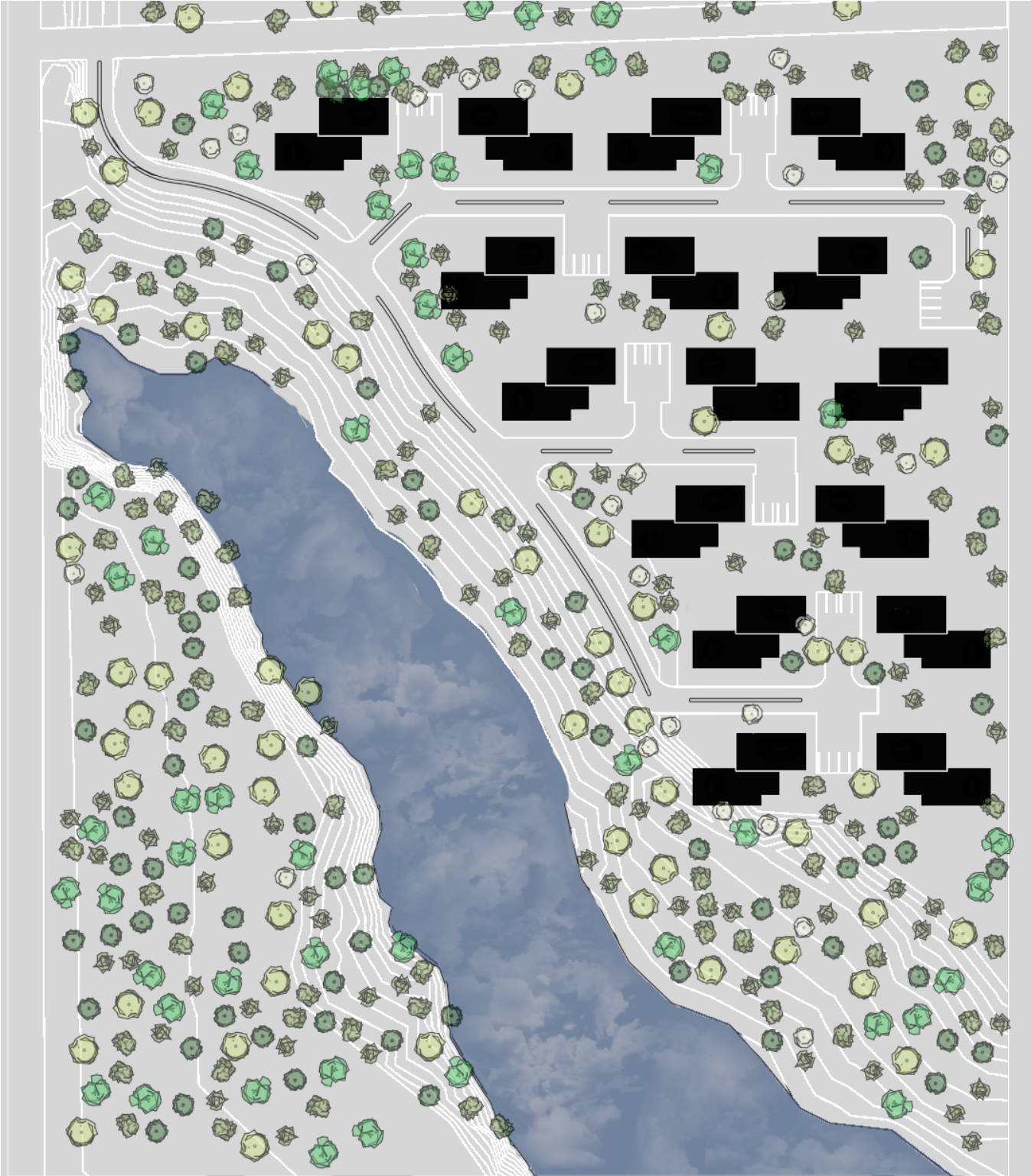


Re-connect

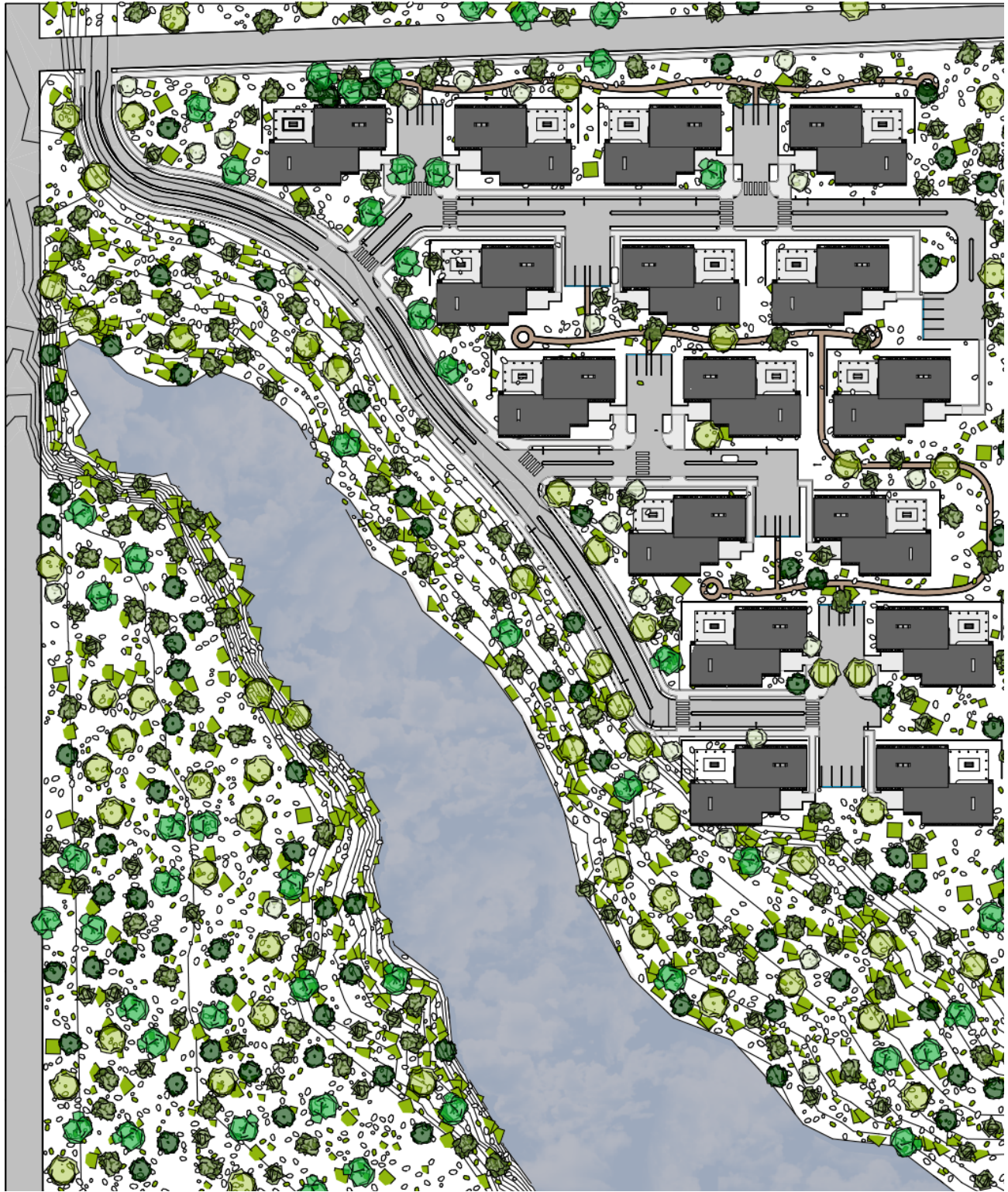


Subtract

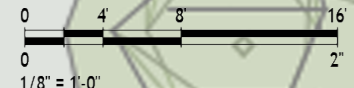
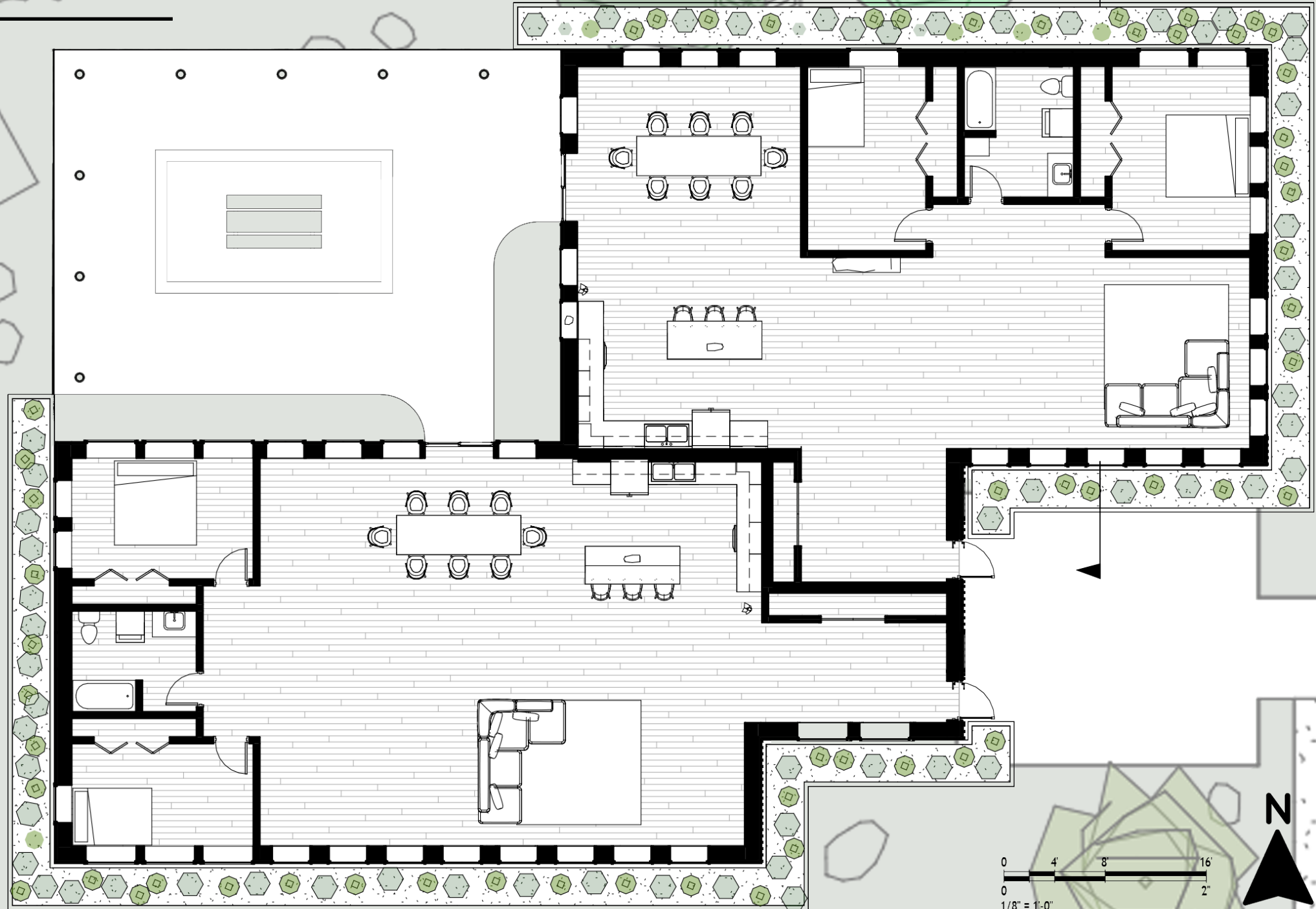
SITE

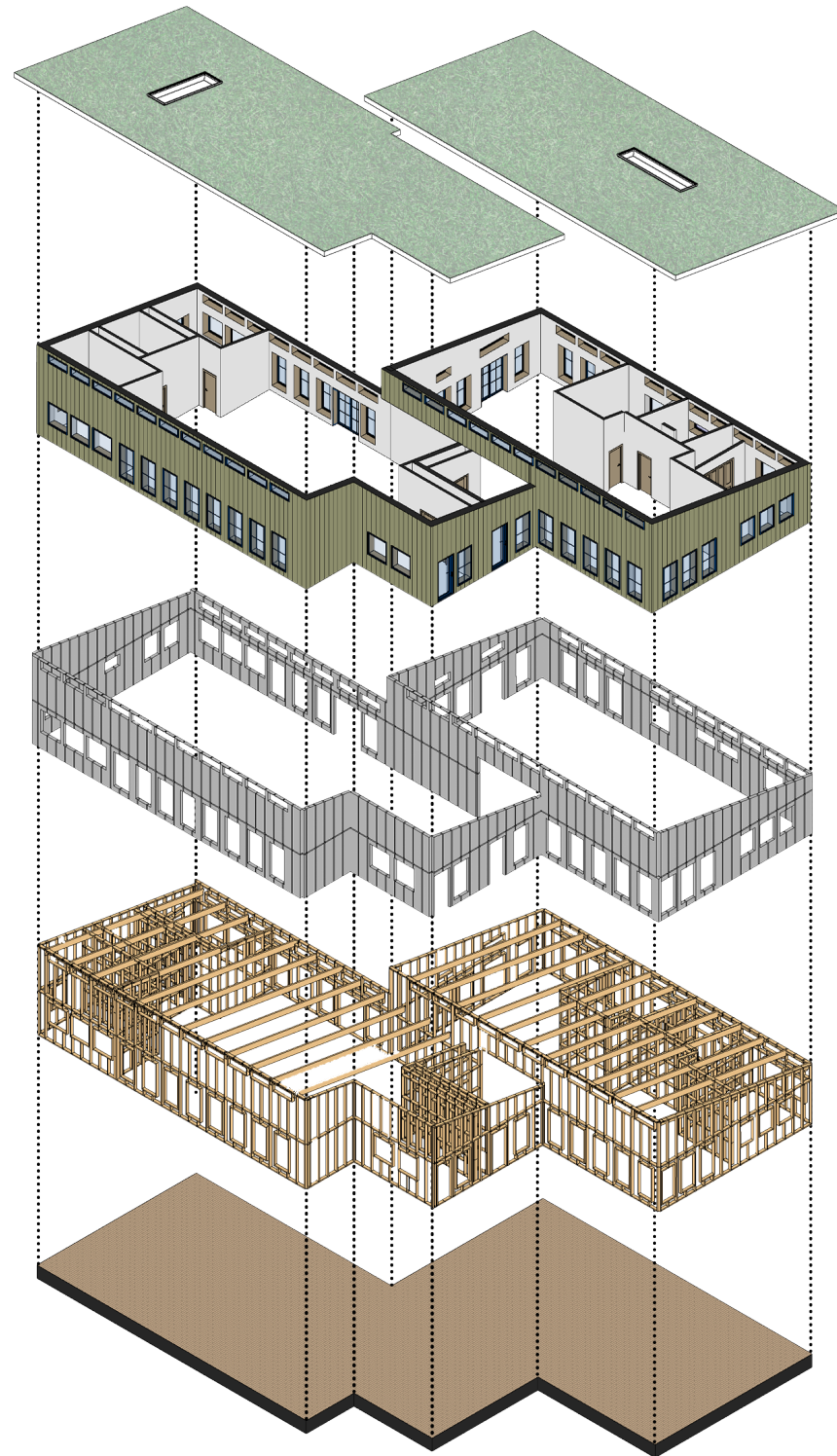


SITE

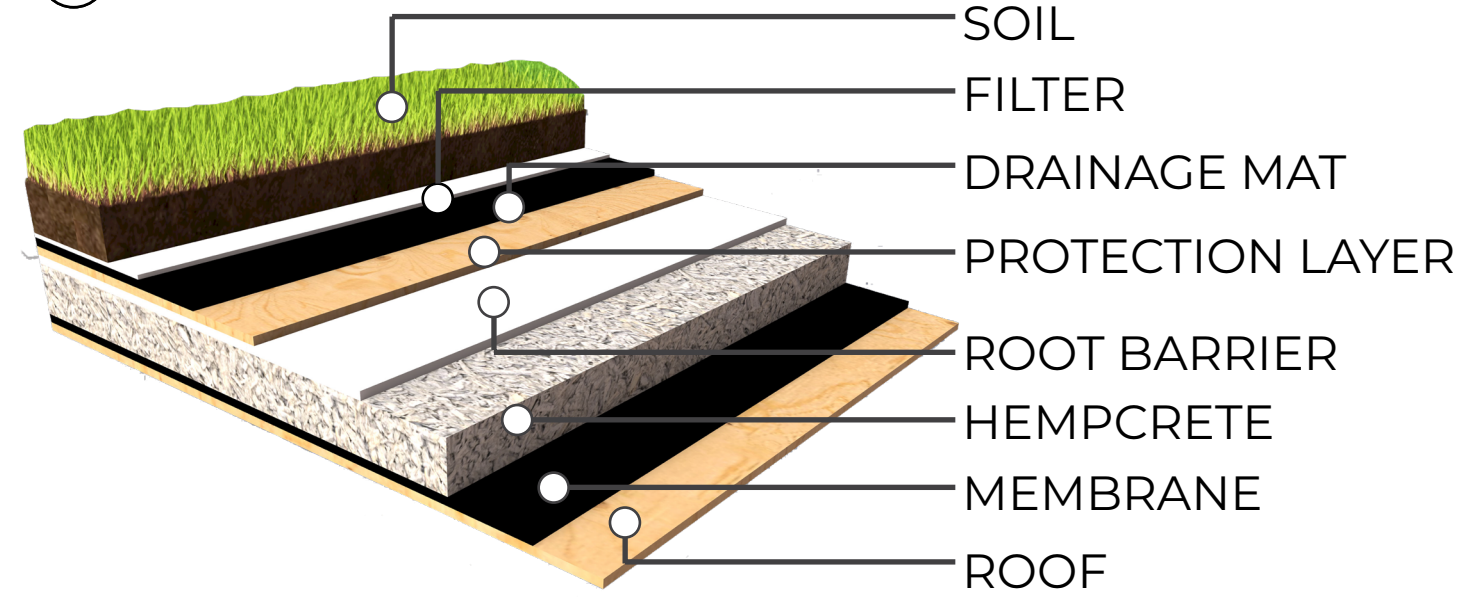


FLOOR PLAN

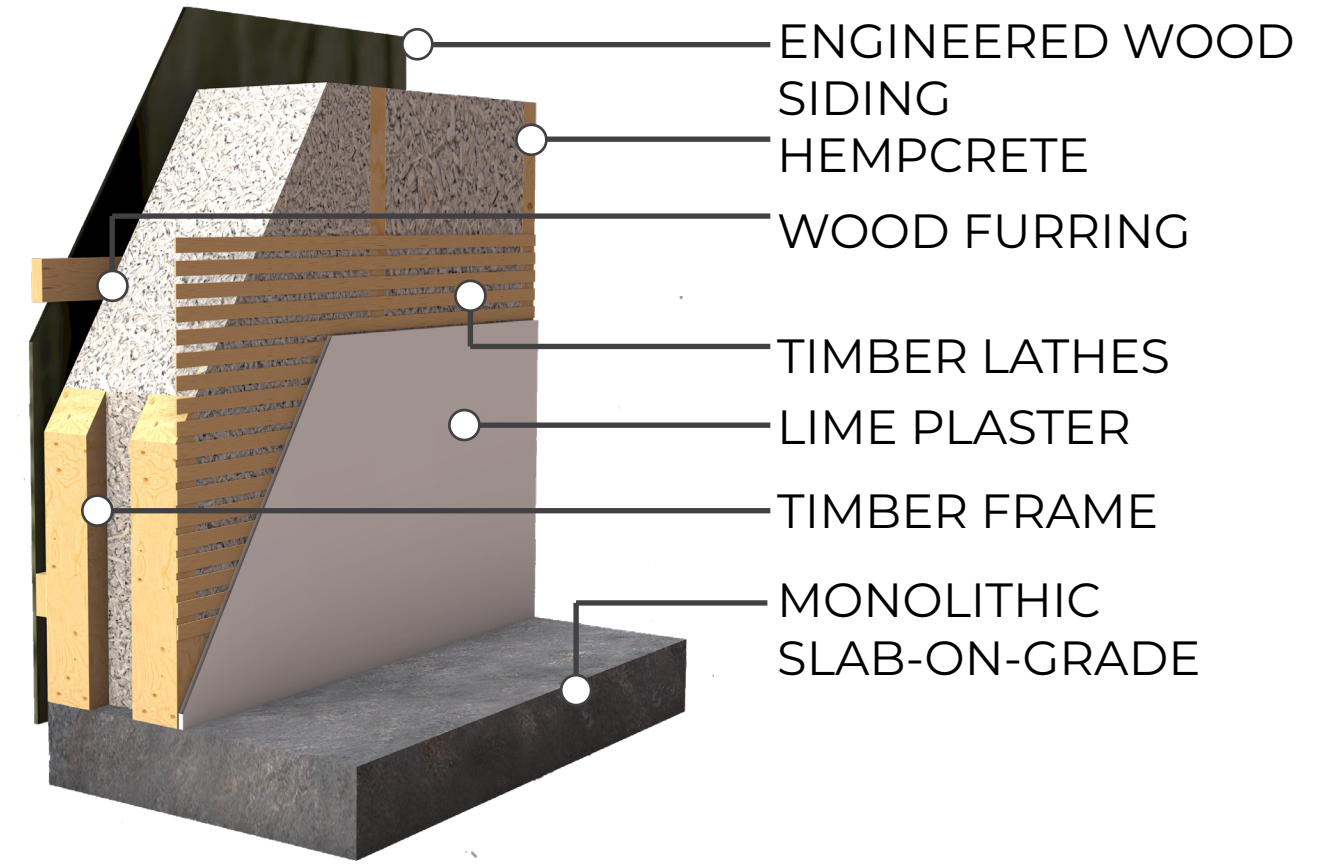




① GREEN ROOF SYSTEM



② PREFAB MODULAR WALL WITH NATURAL MATERIALS



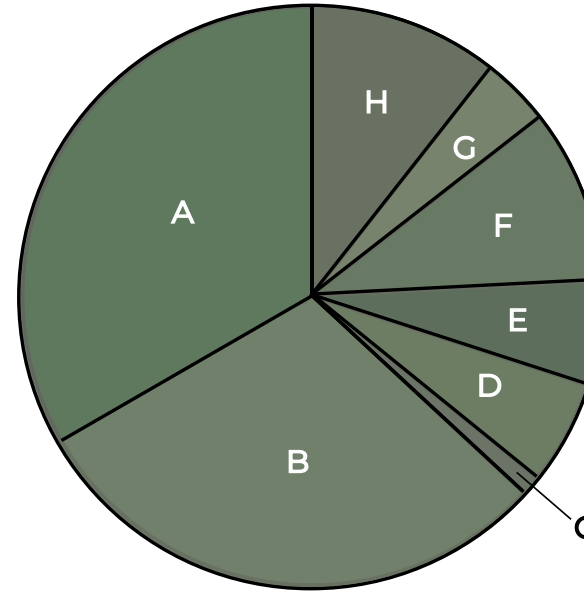
THERMAL MASS



WINTER SOLSTICE

SUMMER SOLSTICE

- A** GREEN ROOF SYSTEM
\$108,495.00
- B** GLAZING (DOUBLE PANE, LOW-E)
\$97,440.00
- C** DOUBLE STUD WALL (2X4)
\$2,920.20
- D** HEMPCRETE INSULATION
\$18,930.00
- E** ENGINEERED WOOD SIDING
\$19,354.59
- F** LIME PLASTER WALL
\$31,833.20
- G** GYPSUM WALL BOARD
\$12,458.52
- H** MONOLITHIC SLAB-ON-GRADE FOUNDATION
\$35,199.00



ROUGH
ESTIMATE TOTAL:
\$326,631.51
or
\$163,315.75 / family unit

BUILDING COMPONENT TYPE	EST. AMOUNT OF MATERIALS			EST. COST MATERIALS		
	AREA (SF)	VOLUME (CF)	NUMBER	PER/SQFT	PER/CF	PER/#
Monolithic Slab on Grade Foundation	3911			\$5.00		
Gypsum Wall Board on Interiors	5537.12					
Plaster Wall	3183.32			\$10.00		
Engineered Wood Siding	3183.32			\$6.08		
Hempcrete Insulation		3155			\$6	
Double Stud Wall (2x4 Wood Studs)			872			\$3.35
Fenestration (Double Pane, Low-E, Glazing)	1220		92	\$12		
Green Roof	4822			\$15		
BUILDING COMPONENT TYPE	EST. COST INSTALLATION			TOTAL MATERIAL	ROUGH EST. TOTAL	ROUGH EST. TOTAL
	PER/SQFT	PER/CF	PER/#			
Monolithic Slab on Grade Foundation	\$4			\$19,555.00	\$15,644.00	\$35,199.00
Gypsum Wall Board on Interiors	\$2.25			\$0.00	\$12,458.52	\$12,458.52
Plaster Wall	Installation cost included in material cost			\$31,833.20		\$31,833.20
Engineered Wood Siding	Installation cost included in material cost			\$19,354.59		\$19,354.59
Hempcrete Insulation	Installation cost included in material cost			\$18,930.00		\$18,930.00
Double Stud Wall (2x4 Wood Studs)	Prefabricated Framed Wall			\$2,921.20		\$2,921.20
Fenestration (Double Pane, Low-E, Glazing)			\$900	\$14,640.00	\$82,800.00	\$97,440.00
Green Roof	\$7.50			\$72,330.00	\$36,165.00	\$108,495.00
						\$326,631.51











CONCLUSION

HEALTHIER HOMES

INTEGRATING EMERGING DESIGN STRATEGIES INTO AFFORDABLE HOUSING



SITE LOCATION



The different kinds of materials used within homes can have a significant impact on a person's health. At least half of a person's life is spent inside their house, meaning the materials used to construct housing should be healthy. It is especially important to note the types of materials being used when designing affordable housing. Many users of affordable housing belong to vulnerable groups such as children, people with disabilities, and the elderly. It is important that healthy and sustainable housing is accessible to people of all income levels.

This thesis explores different sustainable materials and practices and how to integrate those practices into an affordable housing development in Duluth, Minnesota. As the need for affordable housing grows, integrating healthier building materials and sustainable design into affordable housing must become a more common practice. It is important that sustainable design be inclusive to people of all income levels, as it is the architect's responsibility to help protect the health, safety, and welfare of the public regardless of socioeconomic status.



FLOOR PLAN

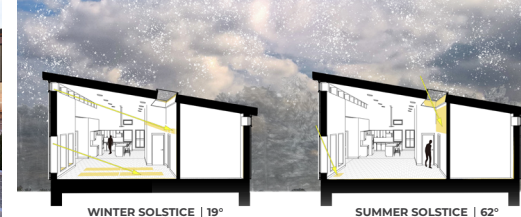
Each dwelling shares the same floor plan and has access to the same amount of southern sunlight. The sharing of walls saves costs on plumbing, heating/cooling, and materials.



AFFORDABLE STRATEGIES

- 1 PREFABRICATED CONSTRUCTION** is when parts of a building are manufactured in advanced off site, and brought to the site afterwards to be assembled into a building. Using prefabricated construction helps make home building more efficient and affordable, reduces waste, and is environment-friendly.
 - PREFABRICATED HEMPCRETE WALL PROCESS
- 2 THE MASS CONSTRUCTION** of the same dwelling type helps lower costs and increase efficiency. Since a large amount of dwellings will be constructed, buying materials in bulk will help lower material cost.
- 3 THE REUSE** of wood from the excavated trees will create pathways and garden beds out of mulch. The wood from these trees is also used to construct the fencing surrounding each of the dwellings.
- 4 SLAB-ON-GRADE FOUNDATION** is a type of foundation in which the concrete is poured directly into a mold in the ground. This foundation type reduces the amount of CO2 produced during production and delivery of materials, as well as provides good insulation.
- 5 THERMAL MASS** is the ability of a material to absorb, store, and release heat. Thermal mass is used within the floors and the walls of the dwellings. Hempcrete walls will store energy and release it slowly for hours afterwards, making it an excellent product for thermal mass.

SECTION PERSPECTIVES



HEALTHY BUILDING MATERIALS

- CARBON NEGATIVE
- NATURAL MATERIAL
- RECYCLABLE
- AFFORDABLE

HEMPCRETE - INSULATION

Hempcrete is created by mixing hemp, water, and lime. This material is a good insulator, fire proof, and absorbs a large amount of carbon from the atmosphere during its growth, production, and even while it is sitting in the wall.

Since this insulation breathes, it is not necessary to include a vapor barrier as long as the finishes on the interior and exterior are breathable as well to allow water to evaporate.

LIME PLASTER - INTERIOR FINISH

Lime plaster is a natural and breathable finish material that is lightweight, flexible, and crack resistant. Lime plaster is also carbon-neutral as lime absorbs carbon dioxide as it sets. This material can be recycled to create new lime plasters and mortars.

ENGINEERED WOOD - SIDING

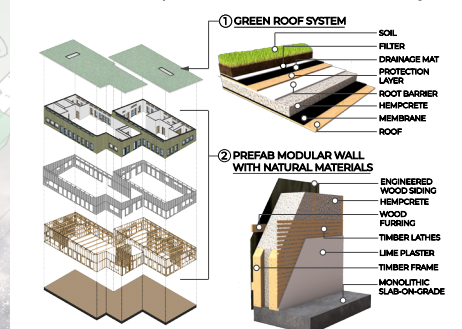
Engineered wood is made from sustainable, biodegradable scrap wood. While it is not as sustainable as 100% wood, it is more sustainable than siding made from 100% plastic. This material choice is a good balance between sustainable and affordable.

CONCRETE - MONOLITHIC SLAB-ON-GRADE

A monolithic slab-on-grade foundation is simple, quick, and cost-effective for construction. This concrete slab will also act as a thermal mass floor which will help to heat/cool the dwelling.

BUILDING SYSTEMS

These are two sustainable systems used within the construction of the dwellings.



COST ESTIMATE

Estimate includes materials and installation. The median price of each product was taken and multiplied by the amount of that material in the project

A	GREEN ROOF SYSTEM	108,495.00
B	GLAZING (DOUBLE PANE, LOW-E)	177,440.00
C	DOUBLE STUD WALL (2X4)	15,920.20
D	HEMPCRETE INSULATION	18,930.00
E	ENGINEERED WOOD SIDING	19,354.59
F	LIME PLASTER WALL	11,833.20
G	GYPSUM WALL BOARD	12,448.32
H	MONOLITHIC SLAB-ON-GRADE FOUNDATION	233,199.00

ROUGH ESTIMATE TOTAL: \$508,620.31 or \$163,376.76 / family unit

Thank you!

FIGURES

Figure 1: Prints of Duluth Minnesota US City Street Map. (n.d.). Media Storehouse Photo Prints. Retrieved March 23, 2024, from <https://www.mediastorehouse.com.au/fine-art-storehouse/map/street-maps/duluth-minnesota-city-street-map-15215812.html>

Figure 2: The City of Duluth Minnesota. (2023). Housing Indicator Report 2022. https://duluthmn.gov/media/15127/final_2022-hir-report_042723.pdf

Figure 3: The City of Duluth Minnesota. (2023). Housing Indicator Report 2022. https://duluthmn.gov/media/15127/final_2022-hir-report_042723.pdf

Figure 4: The City of Duluth Minnesota. (2023). Housing Indicator Report 2022. https://duluthmn.gov/media/15127/final_2022-hir-report_042723.pdf

Figure 5: The City of Duluth Minnesota. (2023). Housing Indicator Report 2022. https://duluthmn.gov/media/15127/final_2022-hir-report_042723.pdf

Figure 6: The City of Duluth Minnesota. (2023). Housing Indicator Report 2022. https://duluthmn.gov/media/15127/final_2022-hir-report_042723.pdf

Figure 7: The City of Duluth Minnesota. (2023). Housing Indicator Report 2022. https://duluthmn.gov/media/15127/final_2022-hir-report_042723.pdf

Figure 8: Inc, Z. (n.d.). Duluth MN Real Estate—Duluth MN Homes For Sale. Zillow. Retrieved March 27, 2024, from <https://www.zillow.com/duluth-mn/>

Figure 9: Anderson, P. (2020, November 5). Homeless in Duluth. <https://duluthreader.com/articles/2020/11/04/116201-homeless-in-duluth>

Figure 10: Local View: Duluth's focus on homelessness snubs locals, shortchanges economic development—Duluth News Tribune | News, weather, and sports from Duluth, Minnesota. (n.d.). Retrieved March 17, 2024, from <https://www.duluthnewstribune.com/opinion/columns/local-view-duluths-focus-on-homelessness-snubs-locals-shortchanges-economic-development>

Figure 11: Tribune, J. H. S. (n.d.). Duluth's homeless shelter set to expand with \$2 million earmark. Star Tribune. Retrieved March 17, 2024, from <https://www.startribune.com/duluths-homeless-shelter-set-to-expand-with-2-million-earmark/600240509/>

Figure 12: About Hempcrete. (n.d.). Homeland Hempcrete. Retrieved January 04, 2024, from <https://www.homelandhempcrete.com/about-hempcrete>

Figure 13: ModularConstruction_TheGrahpci_Jan2017_Header1.jpg (JPEG Image, 1500 × 1000 pixels)—Scaled (91%). (n.d.). Retrieved November 29, 2023, from https://www.tocci.com/wp-content/uploads/2017/01/ModularConstruction_TheGrahpci_Jan2017_Header1.jpg

Figure 14: Orentas, G. (2024, March 19). Learn The Pros And Cons Of Fiberglass Insulation. Forbes Home. <https://www.forbes.com/home-improvement/insulation/what-is-fiberglass-insulation/>

Figure 15: Spray Foam in Baltimore, MD. (n.d.). Devere Insulation. Retrieved April 2, 2024, from <https://devereinsulation.com/insulation-products/spray-foam/>

Figure 16: Rigid Foam in Baltimore, MD. (n.d.). Devere Insulation. Retrieved April 2, 2024, from <https://devereinsulation.com/insulation-products/rigid-foam-insulation/>

Figure 17: What Are Sips. (n.d.). Retrieved February 11, 2024, from <https://www.sips.org/what-are-sips>

Figure 18: Heckstall, A. (2020, January 2). Hempcrete, sustainable, lightweight and insulating construction material. IBIZALIVING Natural Lifestyle Architects Firm in IBIZA Spain. <https://www.ibizaliving.net/topic/architecture-design/hempcrete-sustainable-insulating-construction-material/>

Figure 19: New-drywall.jpg (JPEG Image, 1000 × 563 pixels). (n.d.). Retrieved April 01, 2024, from <https://toddtomashomeimprovements.com/wp-content/uploads/2020/06/new-drywall.jpg>

Figure 20: Lime Render for Your Property | Professional Advice. (n.d.). Retrieved April 01, 2024, from <https://www.artisanplastercraft.com/artisan-tips-and-advice/a-professional-guide-to-lime-render-for-your-property/>

Figure 21: Alan. (2022, May 29). How To Use Grey Venetian Plaster Throughout Your Home. <https://Signature-Walls.Co.Uk/> <https://signature-walls.co.uk/uncategorised/how-to-use-grey-venetian-plaster-throughout-your-home/>

Figure 22: Gypsum-Plaster-Plaster-Of-Paris-Advantages-Disadvantages.jpg (WEBP Image, 820 × 507 pixels). (n.d.). Retrieved April 01, 2024, from <https://housing.com/news/wp-content/uploads/2023/02/Gypsum-Plaster-Plaster-Of-Paris-Advantages-Disadvantages.jpg>

Figure 23: 2-3.jpg (JPEG Image, 1000 × 667 pixels)—Scaled (95%). (n.d.). Retrieved April 01, 2024, from <https://legacyusa.com/wp-content/uploads/2022/05/2-3.jpg>

Figure 24: can-you-pain-vinyl-siding-a2d8b31c60b541c69c1aa4a0ddff501f.jpg (JPEG Image, 2000 × 1333 pixels)—Scaled (47%). (n.d.). Retrieved April 01, 2024, from [https://www.bhg.com/thmb/pf4bs1C7zyKujYA0q0jU7wiMgyA=/2000x0/filters:no_upscale\(\)/strip_icc\(\)/can-you-pain-vinyl-siding-a2d8b31c60b541c69c1aa4a0ddff501f.jpg](https://www.bhg.com/thmb/pf4bs1C7zyKujYA0q0jU7wiMgyA=/2000x0/filters:no_upscale()/strip_icc()/can-you-pain-vinyl-siding-a2d8b31c60b541c69c1aa4a0ddff501f.jpg)

Figure 25: Rs=w:388,h:517.3333333333334,cg:true (WEBP Image, 388 × 517 pixels). (n.d.). Retrieved April 01, 2024, from https://img1.wsimg.com/isteam/ip/2b81bce6-bb31-4c73-8a98-b76637f3fa95/facebook_1660159146291_6963212147925395833.jpg/:cr=t:19.99%25,l:0%25,w:100%25,h:60.03%25/rs=w:388,h:517.3333333333334,cg:true

Figure 26: top-reasons-to-choose-green-siding-01.jpg (WEBP Image, 1920 × 1182 pixels)—Scaled (49%). (n.d.). Retrieved April 01, 2024, from <https://jdhosetter.com/wp-content/uploads/2023/01/top-reasons-to-choose-green-siding-01.jpg>

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