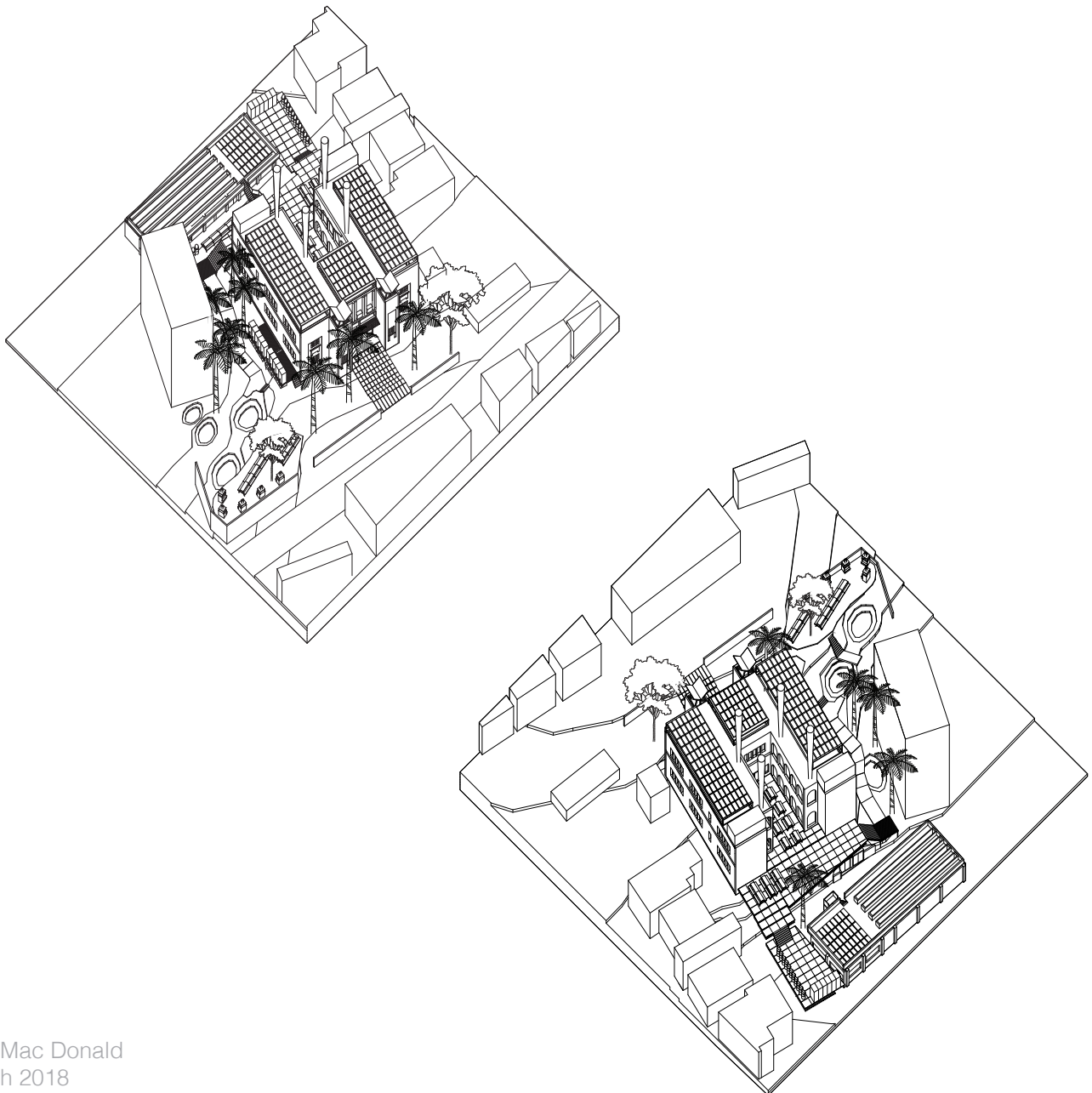


Designing for Disaster Resilience in Puerto Rico

a graduate thesis



Aislin Mac Donald
M.Arch 2018
Rhode Island School of Design

Copyright © 2018 Aislin Mac Donald

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without written permission from the author.

This book was set in Helvetica and was printed and bound in the United States of America.

Designing for Disaster Resilience in Puerto Rico

A thesis presented in partial fulfillment of the requirements for the degree Master of Architecture in the Department of Architecture at the Rhode Island School of Design, Providence, Rhode Island.

by

Aislin Mac Donald

2018

Approved by Master's Examination Committee:

Signature



Hansy Better, Professor of Architecture, Thesis Chair

Signature



Anne Tate, Professor of Architecture, Thesis Advisor

Signature



Jonathan Knowles, Professor of Architecture, Secondary Thesis Advisor

For my family, friends, peers, and instructors who have always supported and encouraged me to do my best work. This thesis would not be possible without these people who have made me who I am today. I am thankful for you.

Sincerely,

Aislin Mac Donald

Table of Contents

Abstract.....	8
Hurricane Maria.....	10
Thesis Project.....	17
Preliminary Design Research.....	37
Architectural Precedents.....	54
Acknowledgments.....	56
References.....	58



A protester wearing a Puerto Rican Flag. Reuters

Abstract

Being hit by both Hurricane Irma and Hurricane Maria in September 2017, Puerto Rico was left devastated economically, psychologically, and infrastructurally. After Hurricane Maria, Puerto Rico entered into what would become the longest blackout in US history, and the second longest blackout in global history. Forty-eight per cent of the island was left without access to clean water and the death toll has risen to over 1000 people. The lack of federal support and Puerto Rico's depleted economy has become a dire human rights issue. Federal relief efforts were delayed, disorganized and underfunded. Many people did not know where or how to access support even when it was available. It is clear that there is an urgent need for Puerto Ricans to have the resources to be able to help themselves at the community level. This design problem has been the guiding force behind this thesis project.

This proposal is a redesign of Escuela Dr. Pedro Goyco, a vacant elementary school located in the Santurce district of San Juan, Puerto Rico, that is centered around disaster resilience and renewable energy. The project has a dual program of being both a center for hurricane relief and a community space. After a natural disaster, people often gather in public spaces such as community centers, schools, and sports stadiums for their basic needs, although these places aren't normally designed for these dire situations. The rate of natural disasters occurring is increasing every year and we need to accept this harsh reality and design solutions to address it.

Escuela Dr. Pedro Goyco is one of 300,000 vacant buildings on the island, and its central location provides the opportunity for it to become an area of refuge during a hurricane. The site is located in the Parque neighborhood and is part of the most densely populated

area in San Juan. Being waterside and primarily low income, the area is highly vulnerable to hurricanes and its aftermath. After a hurricane, the site would be able to function as a shelter, provide clean water, electricity, cooking, and workspaces for those whose lives have been disrupted. With a landscape designed to resist flooding and a roof that gathers renewable energy, the project follows a cohesive vision of resilience and sustainability.

This architectural intervention will not only address issues of damage, but also fits into the broader issue of departing from colonial attitudes on the island. Although there is a sharp political divide between being pro-state and pro-independence, Puerto Ricans are unified by their incredible generosity and resourcefulness. This thesis aims to empower Puerto Ricans to be able to support themselves in the aftermath of a hurricane, and highlight their defining qualities and sustain independence.

Hurricane Maria: Sept. 20th, 2017

On September 20th, 2017, a category five hurricane swept across Puerto Rico, leaving the island devastated. With limited options and a severe lack of government support, Puerto Ricans were left with a difficult choice: to flee the island or stay and try to make it work, with many unable to afford the first option.



People trying to drive through a flooded road in the aftermath of Hurricane Maria in San Juan, Puerto Rico, on Sept. 21st, 2017. Ricardo Arduengo—AFP/Getty Images



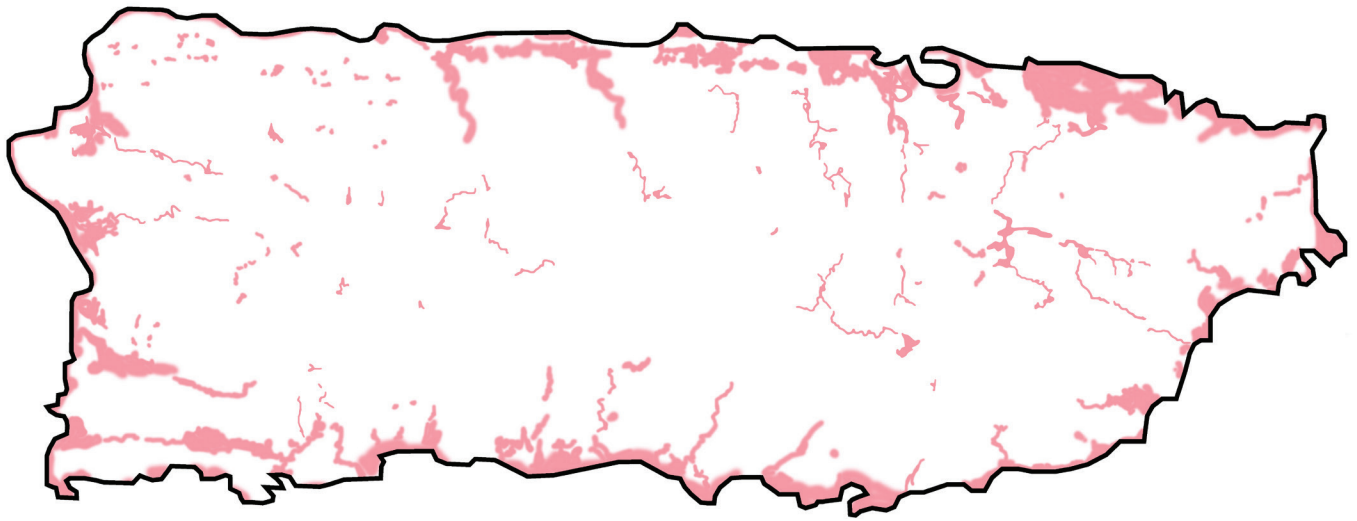
A man riding his bike on a damaged road in Toa Alta, west of San Juan, Puerto Rico, on Sept. 24th. Ricardo Arduengo—AFP/Getty Images



A woman holds her baby at their makeshift home, that was mostly destroyed by Hurricane Maria. Getty Images / Mario Tama



Many homes had their roofs torn off during the hurricane and are now covered with blue tarps. M. Scott Mahaskey/
POLITICO



Flooding from Hurricane Mara in Puerto Rico.

Thesis Project

A redesign of Escuela Pedro Goyco into a hurricane relief center and community center. The site operates primarily on renewable energy and water is sourced from rainwater collection.

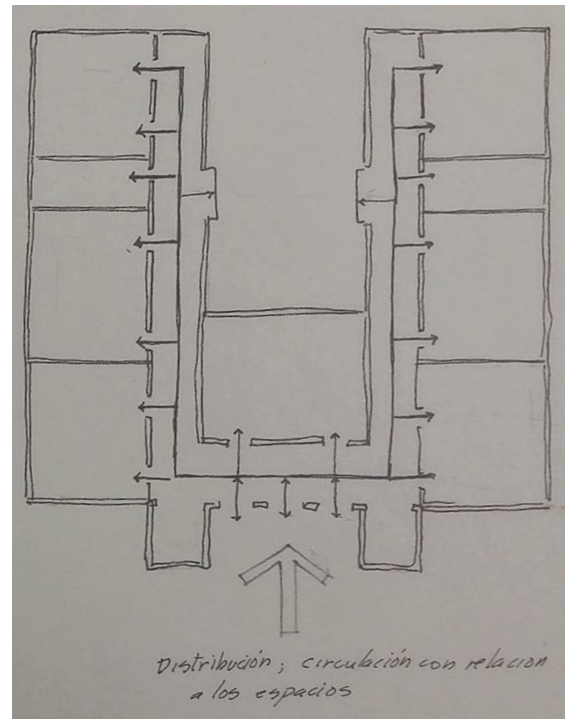
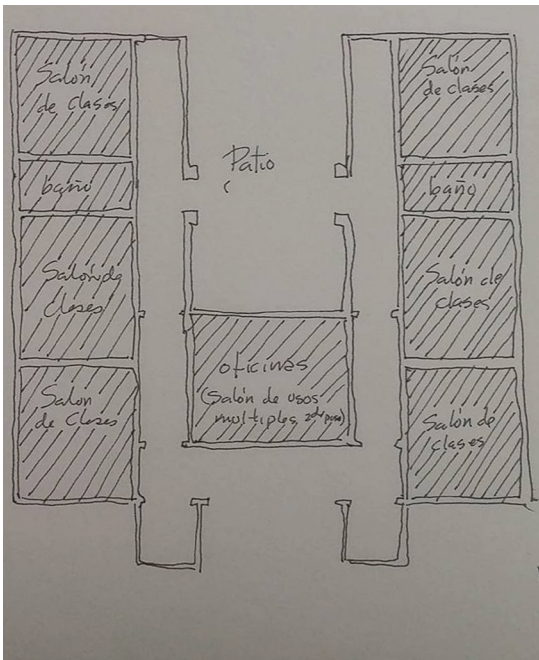
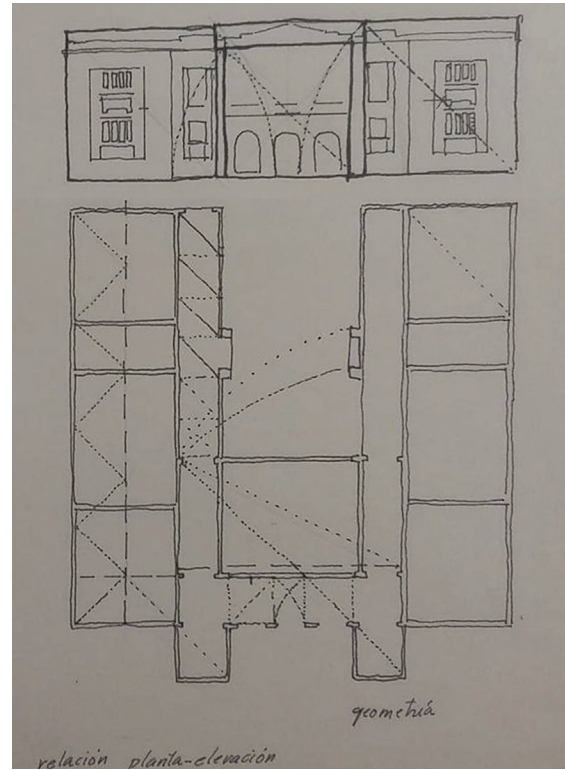
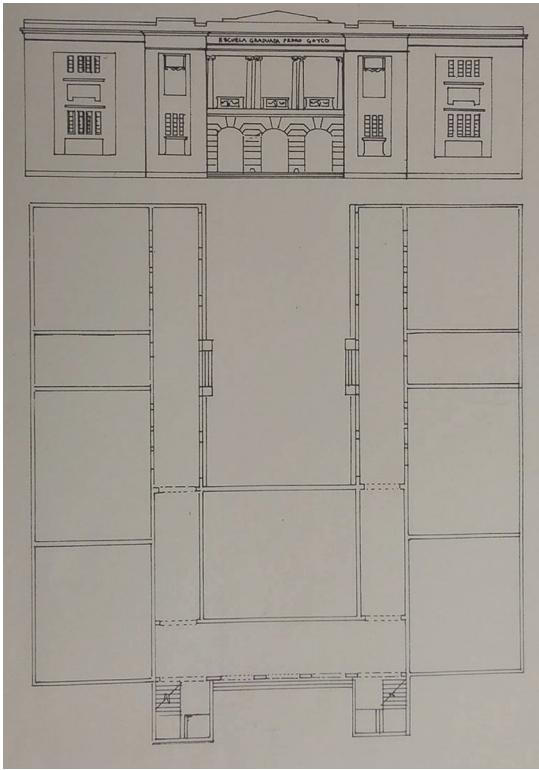


Site photos of Escuela Dr. Pedro Goyco.

Escuela Dr. Pedro Goyco

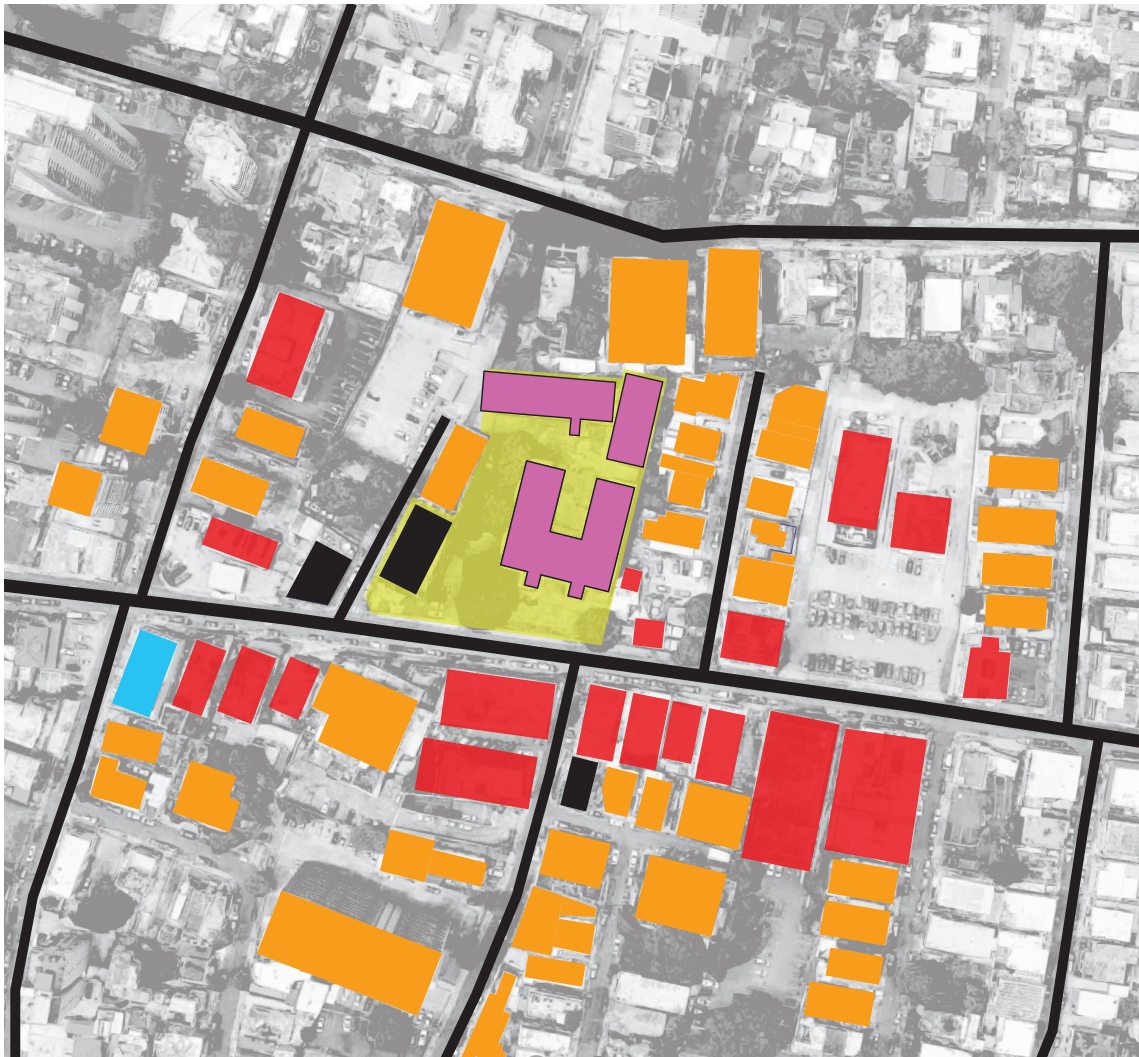
Escuela Dr. Pedro Goyco was founded in 1923 and designed by the architect Carlos del Valle Zeno, who was also known for designing the Casino of Puerto Rico. Combining a mixture of architectural styles, there is a large entrance hall that divides into two wide corridors that are lined with classrooms and entrances to the courtyard. The gate that faces the street has a mural which is reminiscent of the artistic culture of the area. The school once had over 500 students but has now been closed for nearly a decade as a result of population decline.

Existing Drawings



Existing architectural drawings. Architecture and Construction Archive of the University of Puerto Rico (AACUPR)

Urban Plan



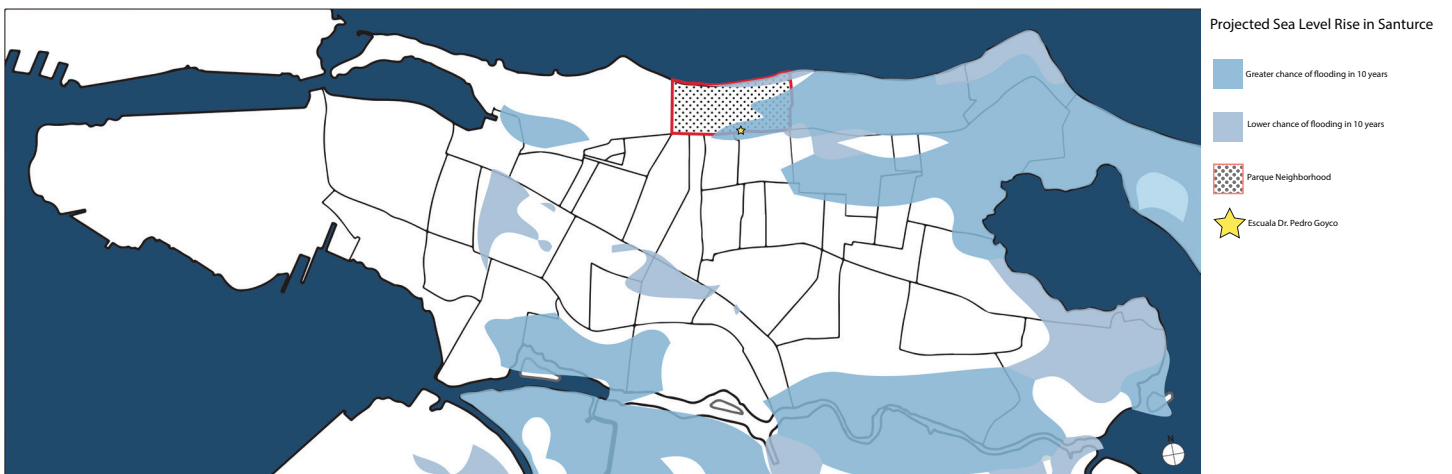
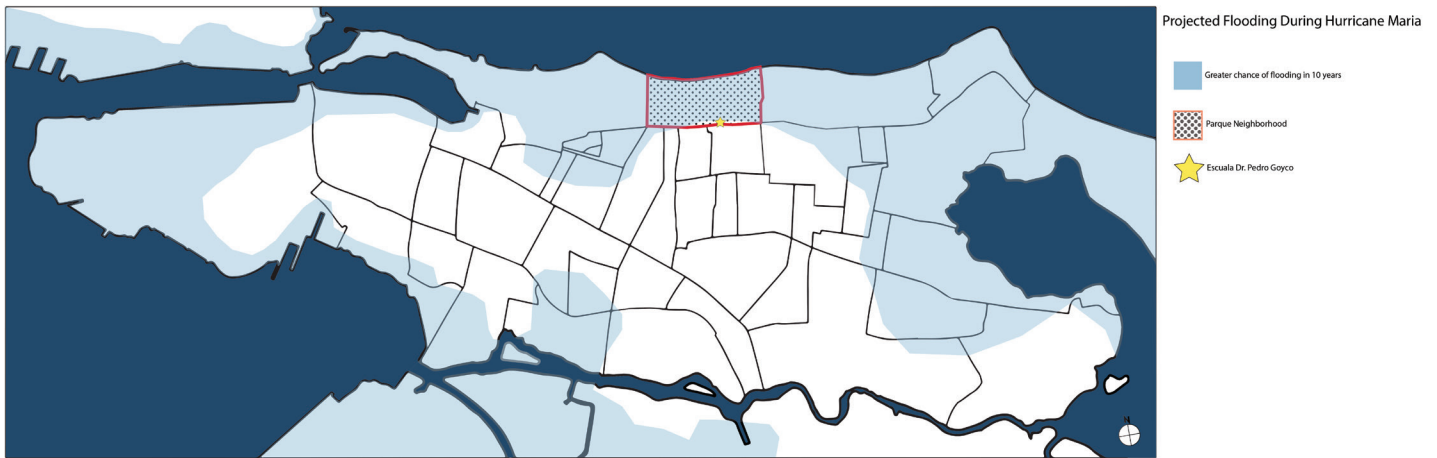
- Residential
- Commercial
- Vacant
- Educational

Escuela Dr. Pedro Goyco is located on Calle Loíza in Santurce, a district of San Juan. The surrounding Parque neighborhood has a population of about 3200 people, according to the 2000 United States Census. It is unknown as to why there is not a more recent census of the area available. The vacant elementary school is one of three abandoned buildings in a row on this street. Calle Loíza is an up and coming neighborhood in Santurce, known for its vibrant art scene and urban renewal.

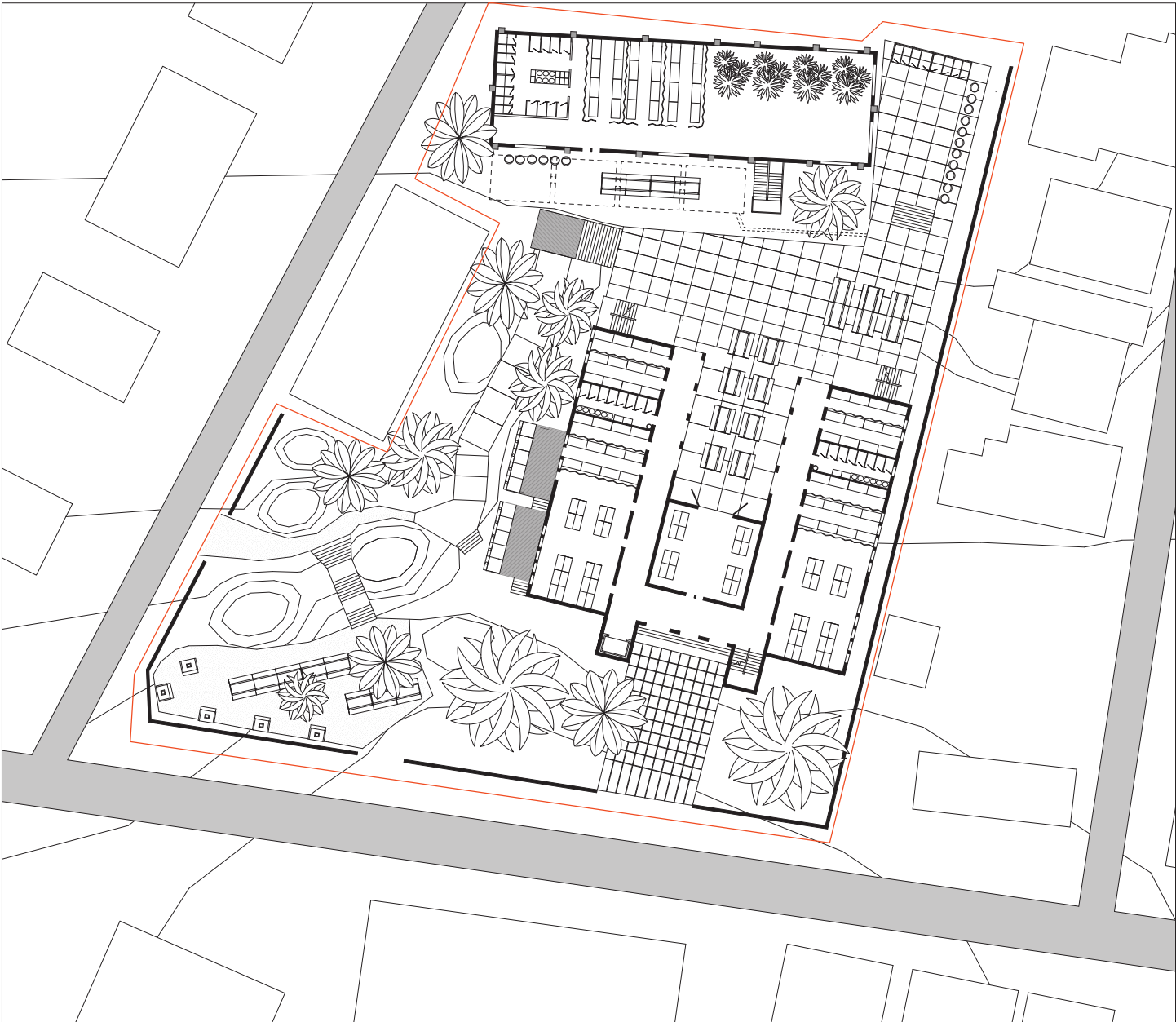


Top: Café Tresbé, a restaurant and outdoor eatery which is located next door to Escuela Dr. Pedro Goyco, part of the urban renewal project on Calle Loíza. Spoon Food Tours
Bottom Left: Libros Libres: An outdoor free library on Calle Loíza. Descubre Puerto Rico Ahora
Bottom Right: Street view of Calle Loíza. Discover Puerto Rico

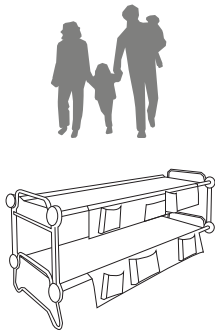
Mapping



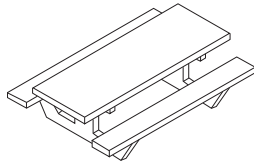
According to the projected hurricane flood map and personal accounts from locals, the section of Calle Loíza that Escuela Dr. Pedro Goyco is located did not flood during Hurricane Maria. The street above it, Calle McLeary, did flood. Even though the site did not flood, it still experienced a heavy sixteen inches of rainfall during the hurricane. The higher elevation of the site and local familiarity make it an ideal location for people to seek refuge during and after a hurricane. The site is still has a high chance of flooding in the next ten years, so this design incorporates how to utilize the landscape and architectural intervention to make the site habitable during sea level rise.



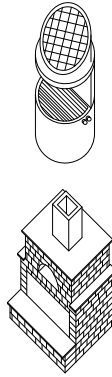
Beds for 248 people



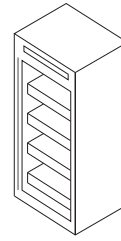
Seating



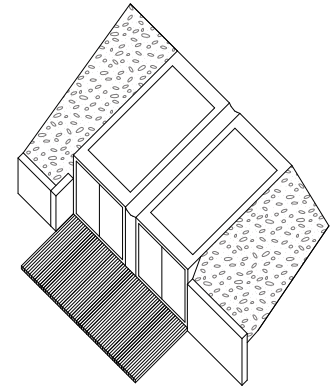
Outdoor Cooking



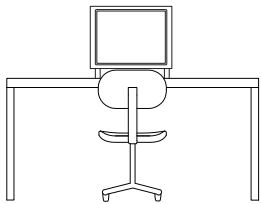
Medicine Storage



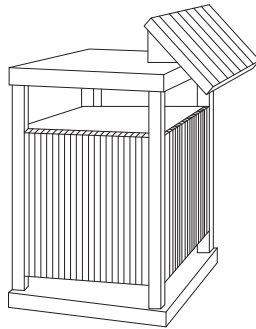
Food Storage



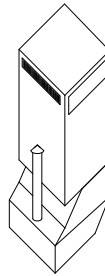
Work Spaces



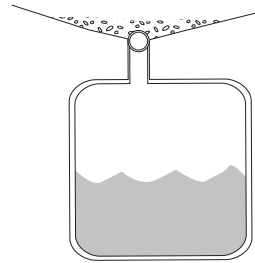
Outdoor Showers



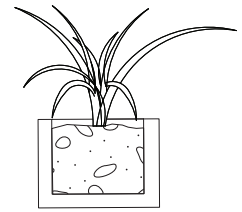
Compost Toilets



Water Collection

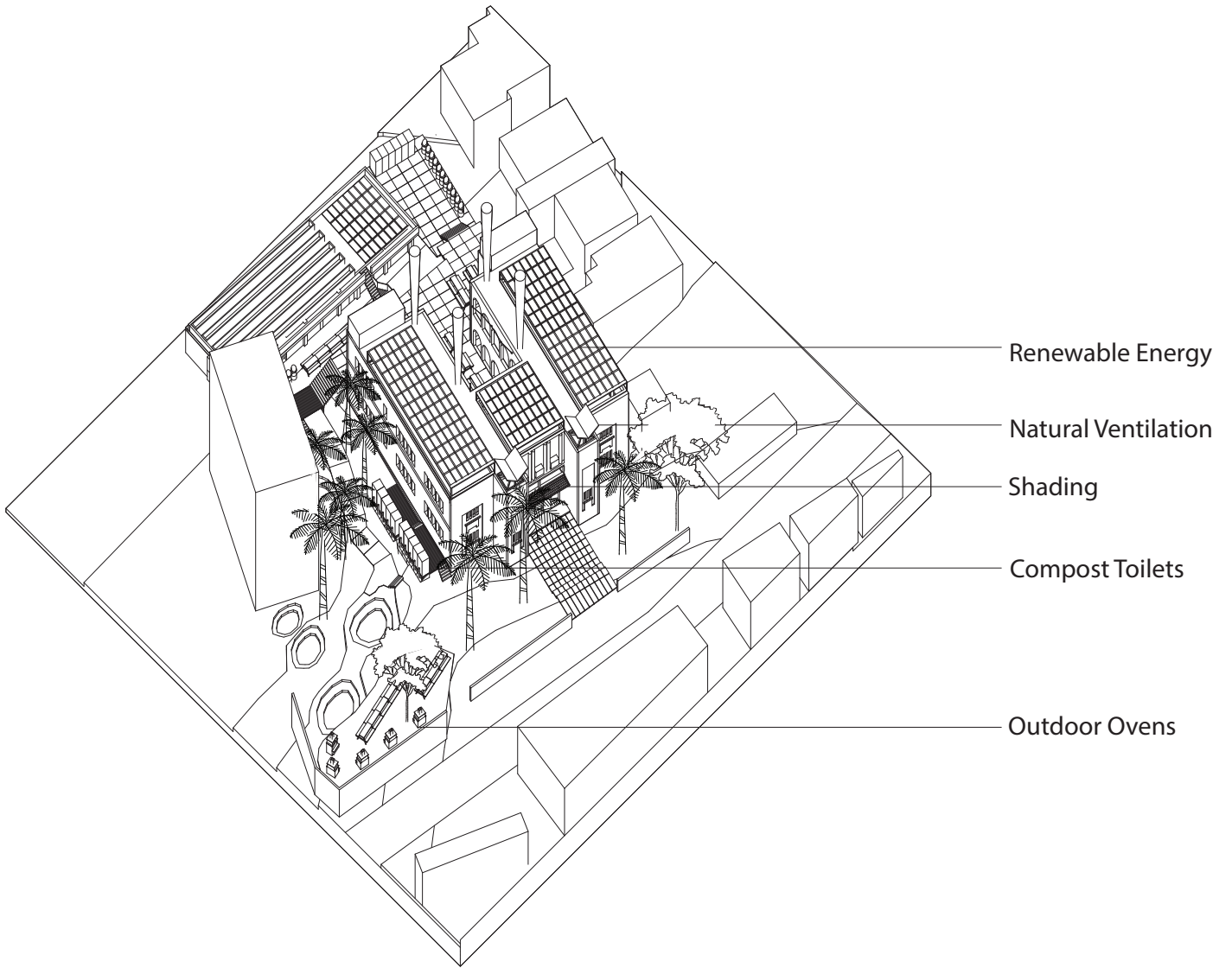


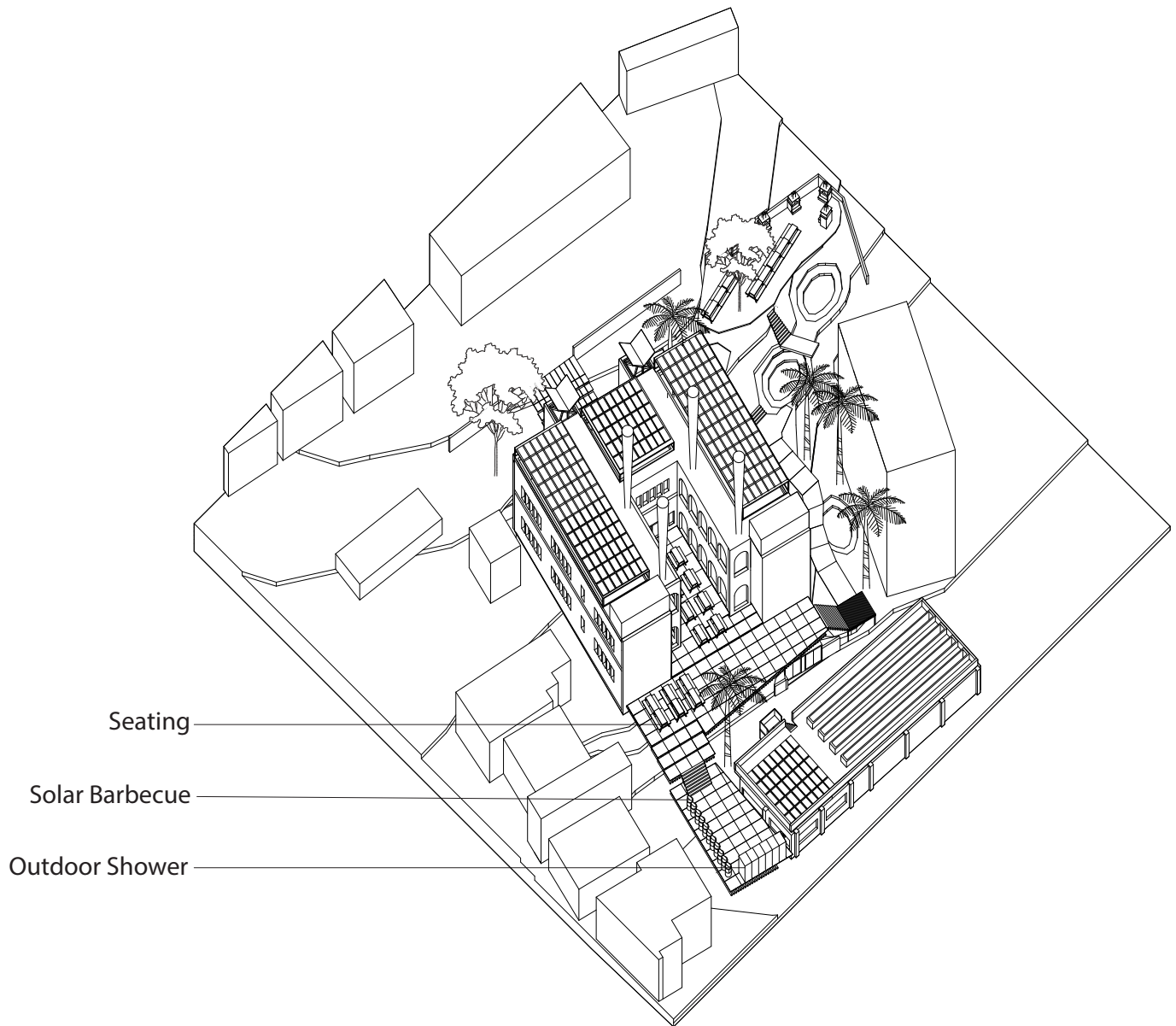
Urban Gardening



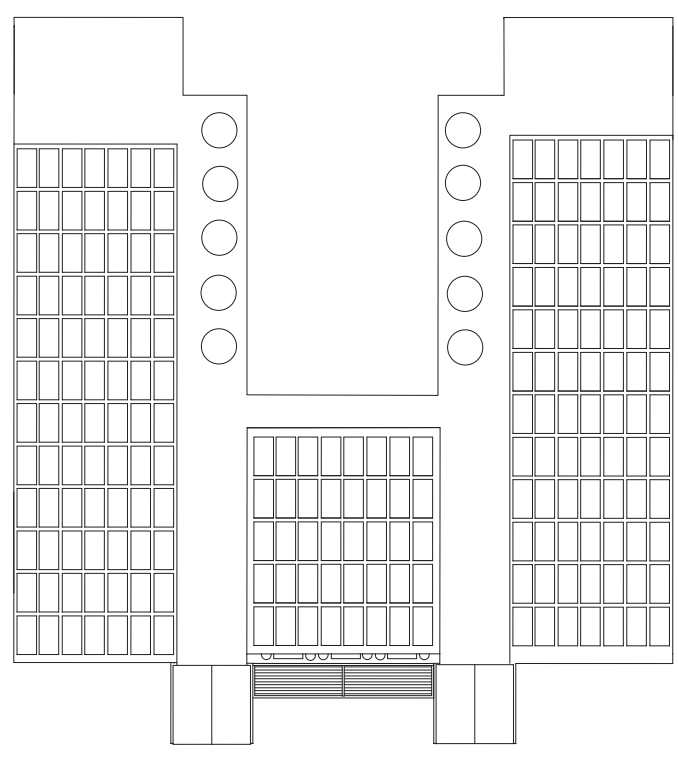
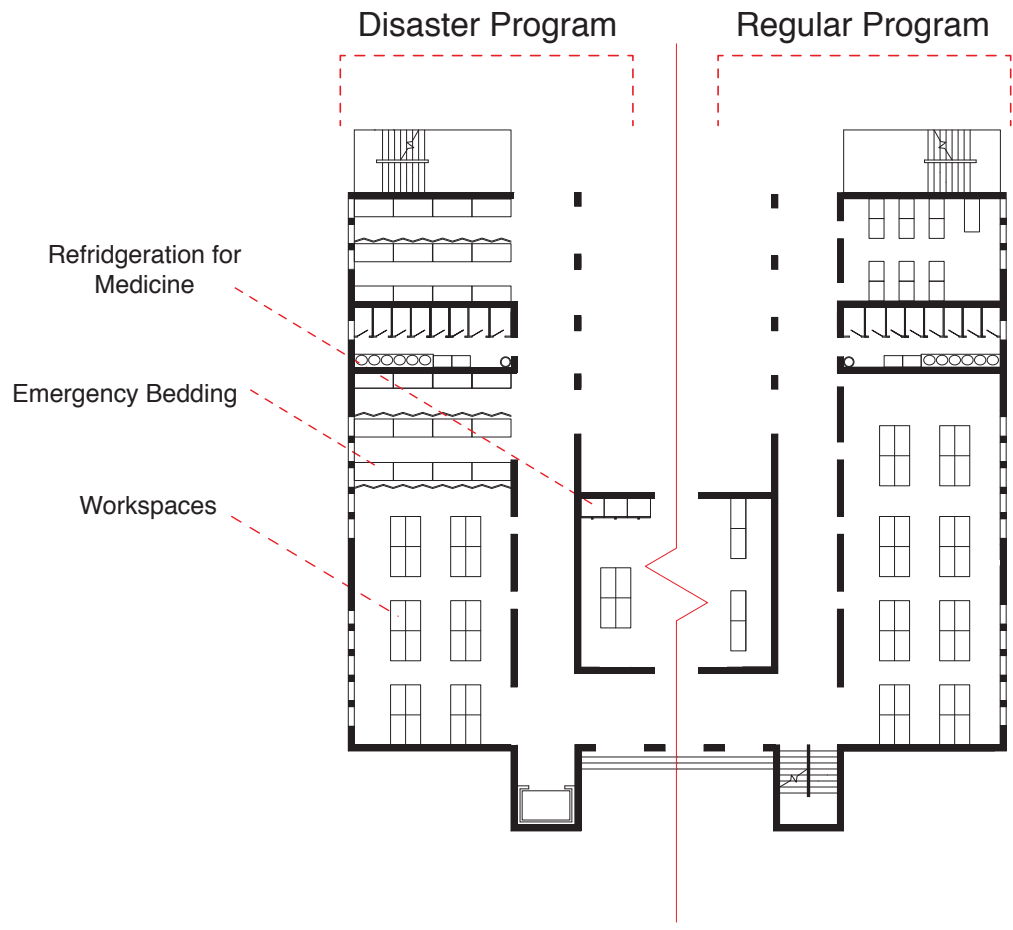
This graphic describes the variety of uses on the site that are utilized in the time of a hurricane. There is a focus on renewable energy, water collection and conservation, and versatility. After Hurricane Maria hit, many people lost their livelihood, being unable to return to work or run their businesses because of the power outage. The workspaces are a way for people to continue working and contact loved ones, as well as allow children to continue their schooling. The food storage utilizes the topography of the site to keep food refrigerated without the use of electricity. There are also refrigeration units located inside for storing medications.

The purpose of the program is to house people who need shelter as well as provide cooking, food storage, sanitation facilities and workspaces to the people of the community. The compost toilets form fertilizer for the gardens and raised beds that are located on the roof of the accessory building.

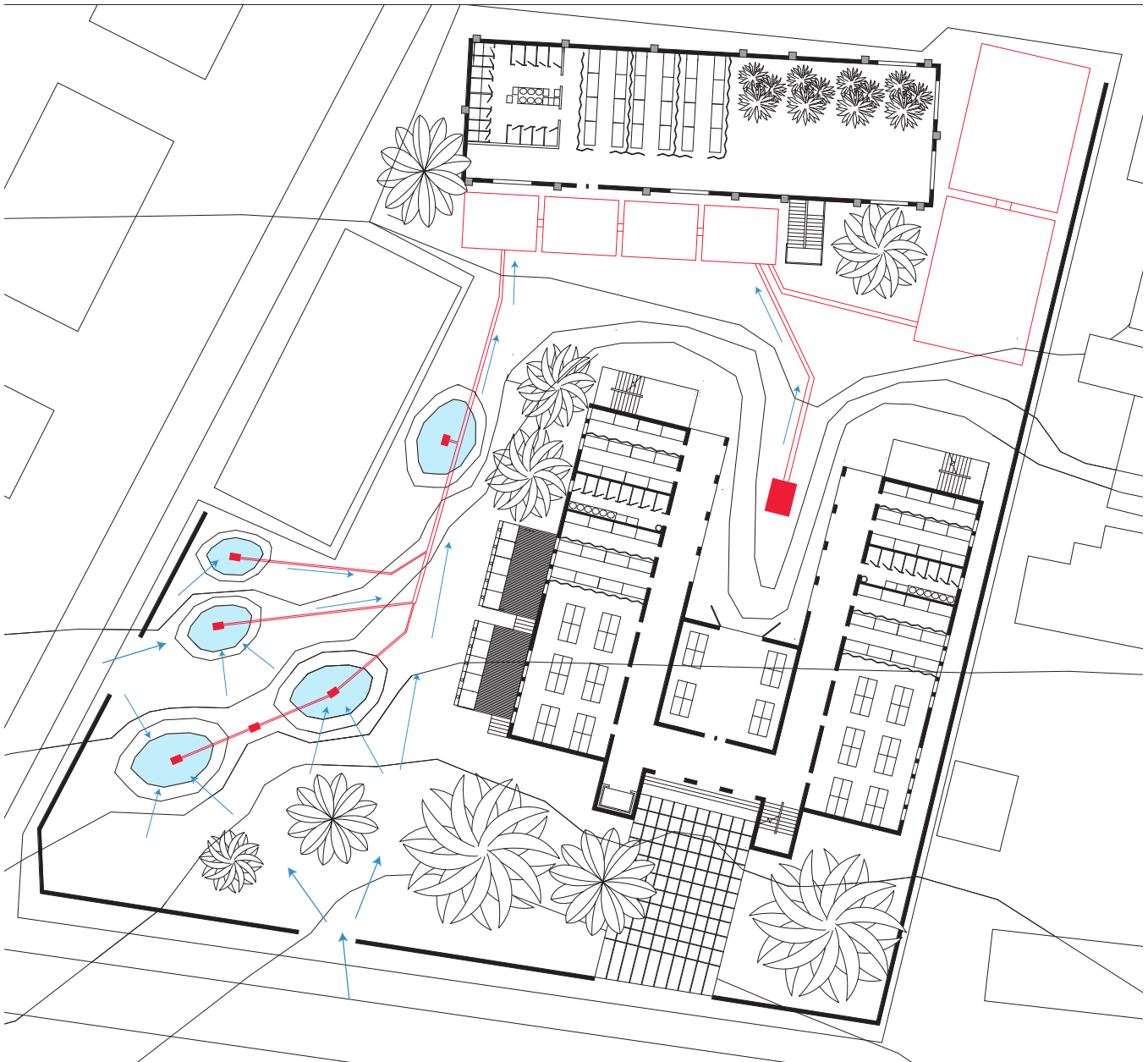




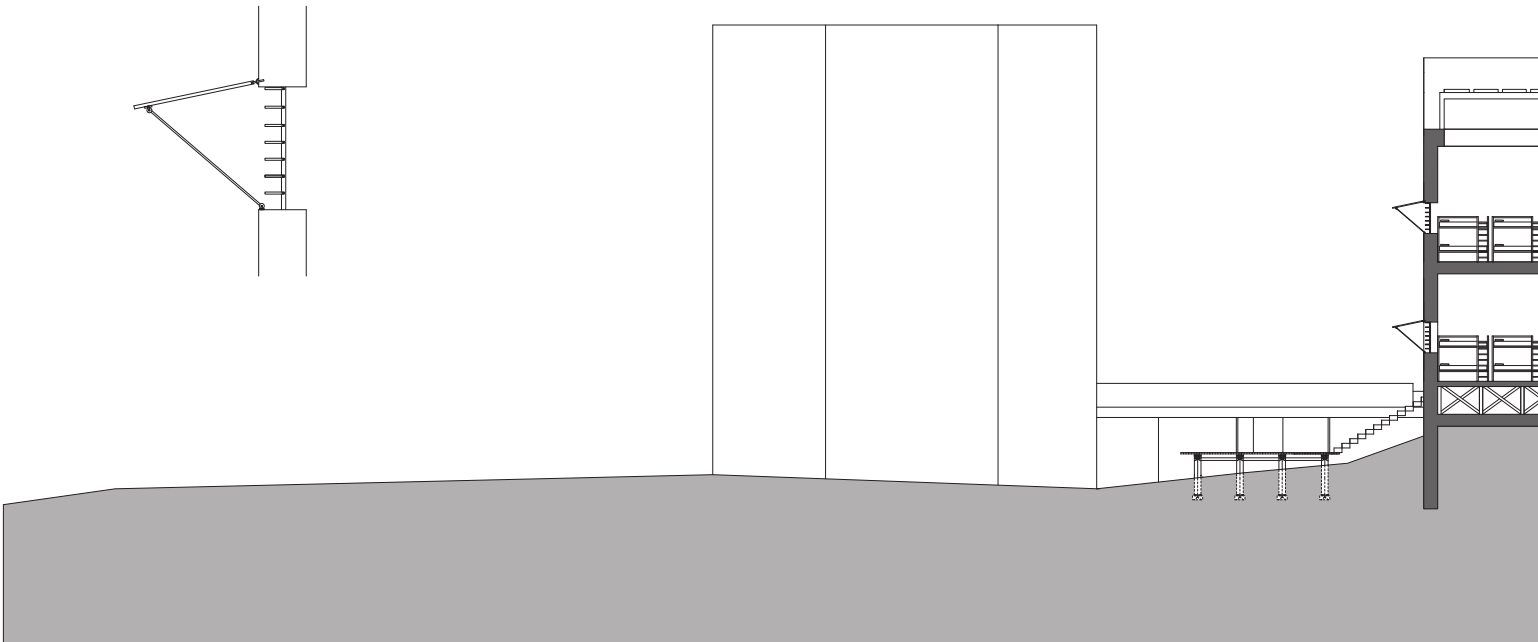
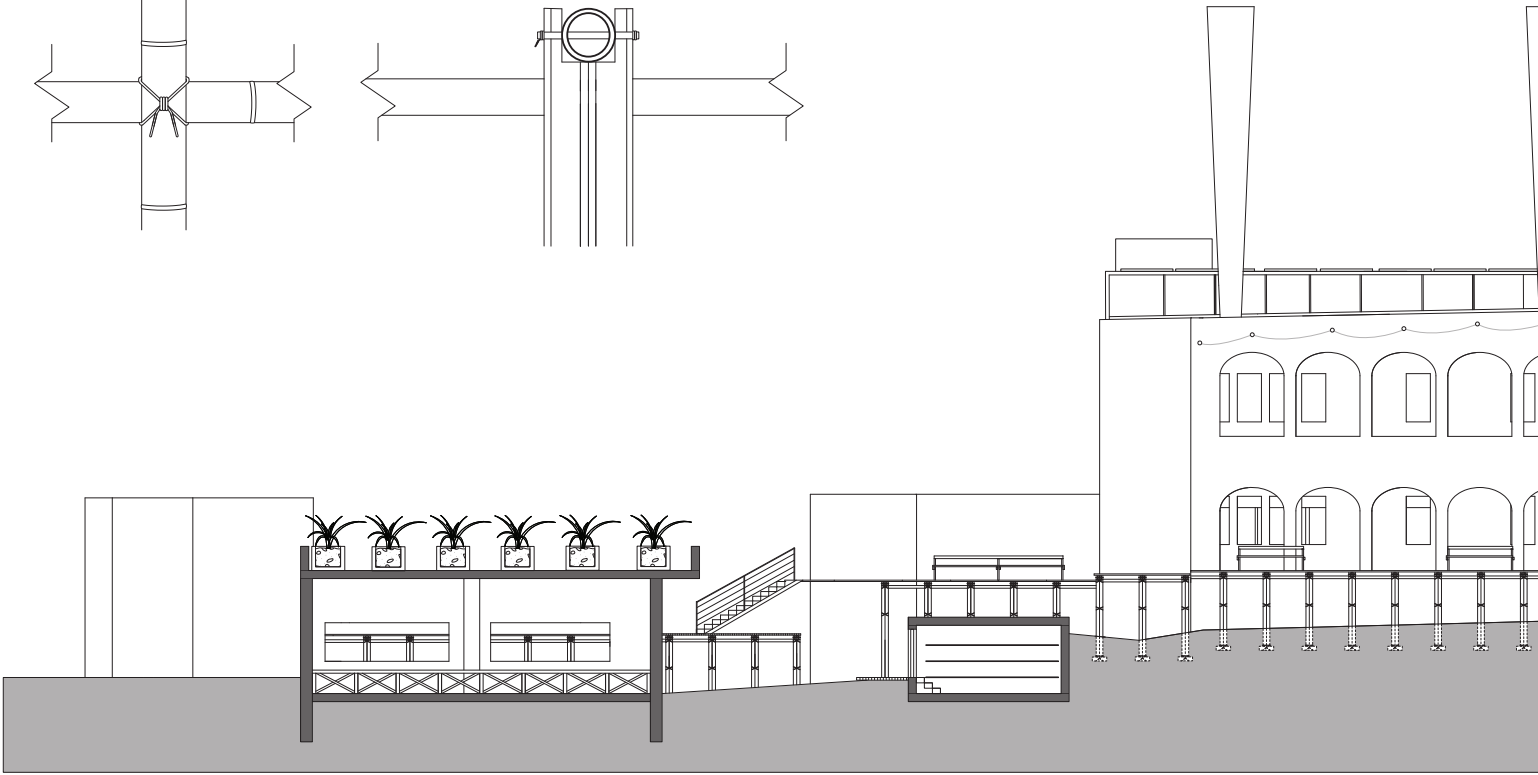
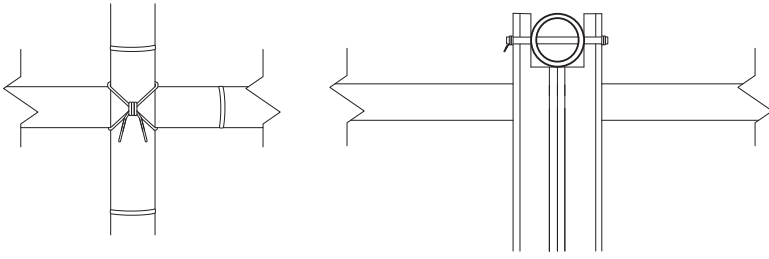
The platform in the back of the site is the center of amenities. It is constructed out of bamboo, an abundant natural material in Puerto Rico. Its structure does not require complex machinery.

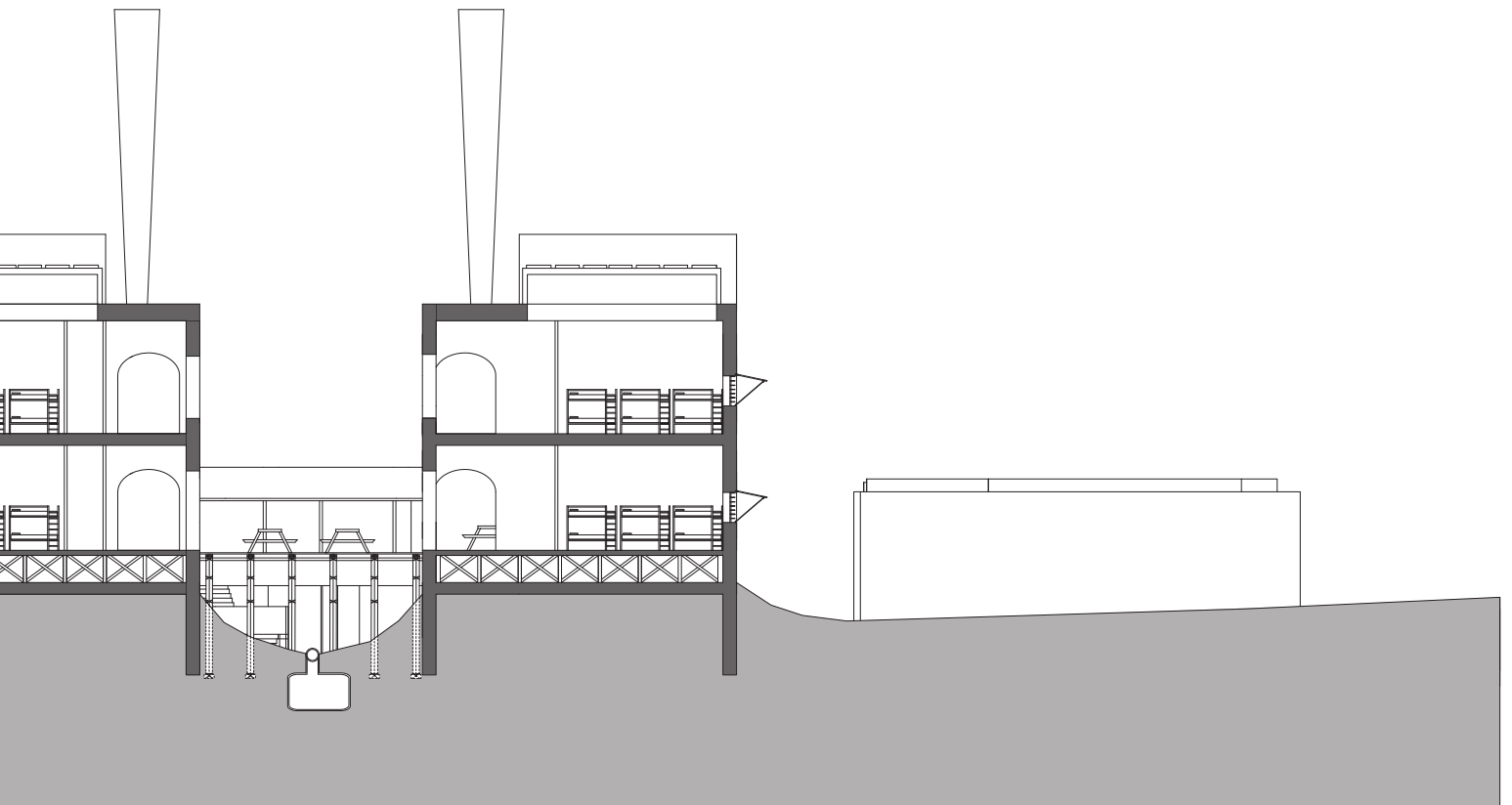
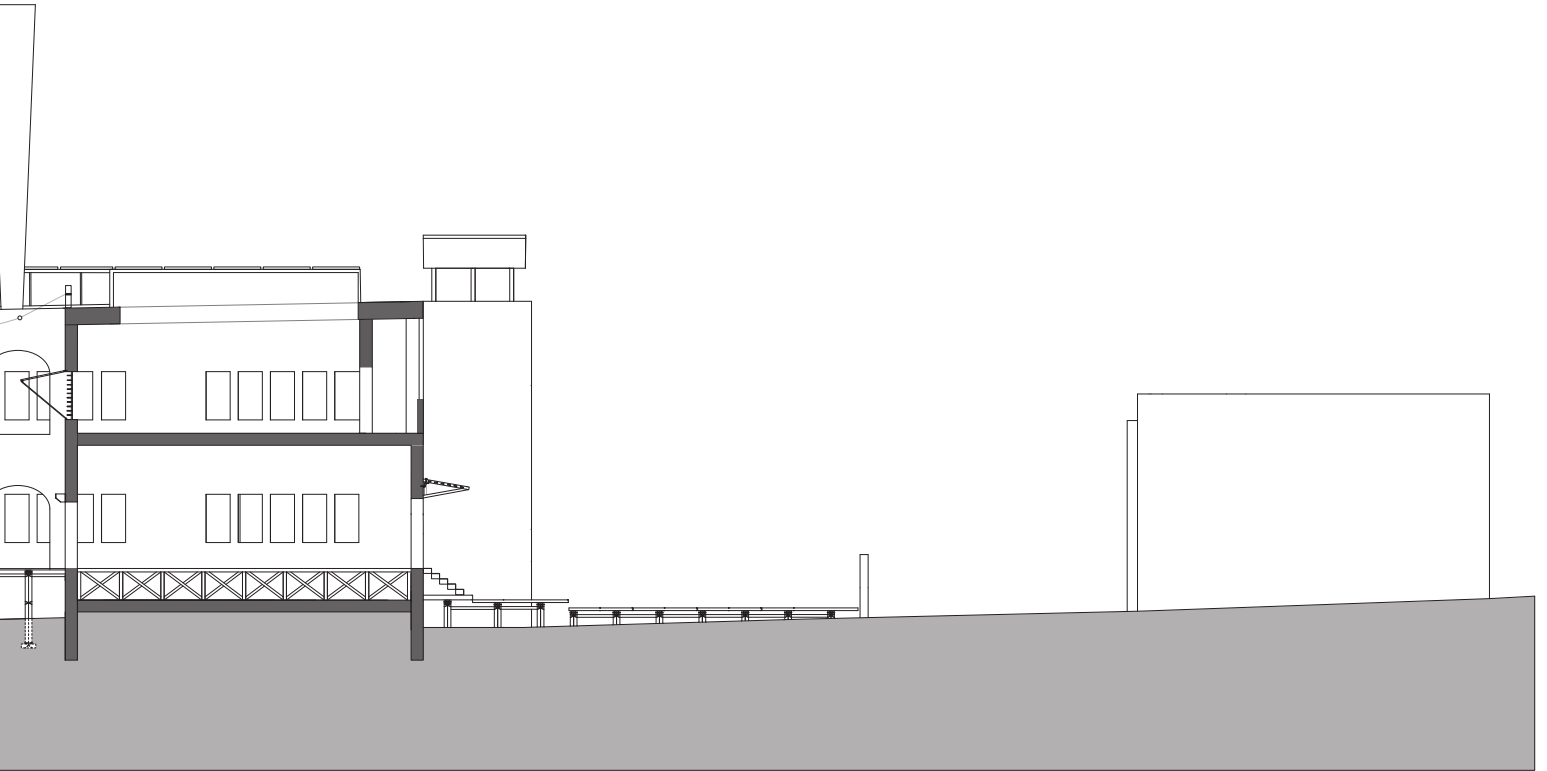


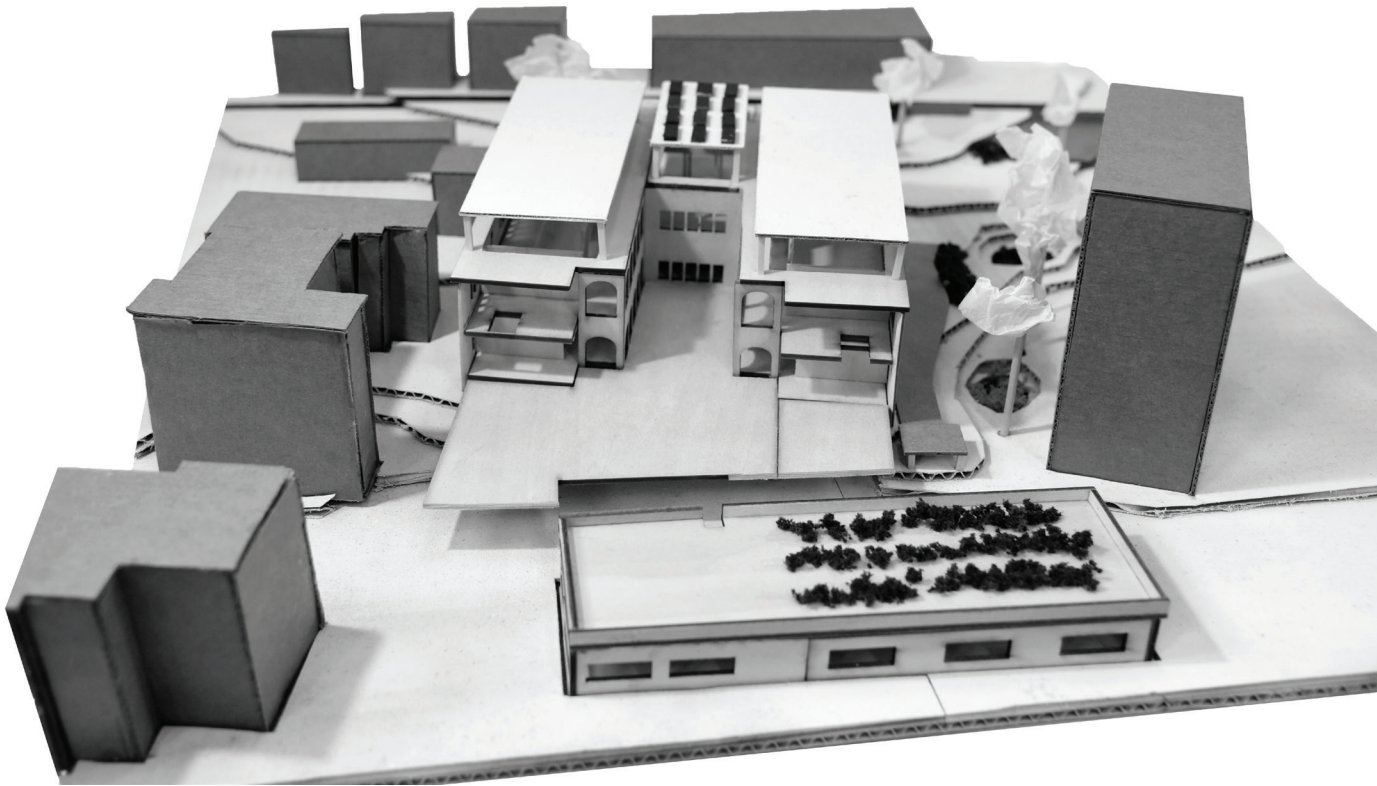
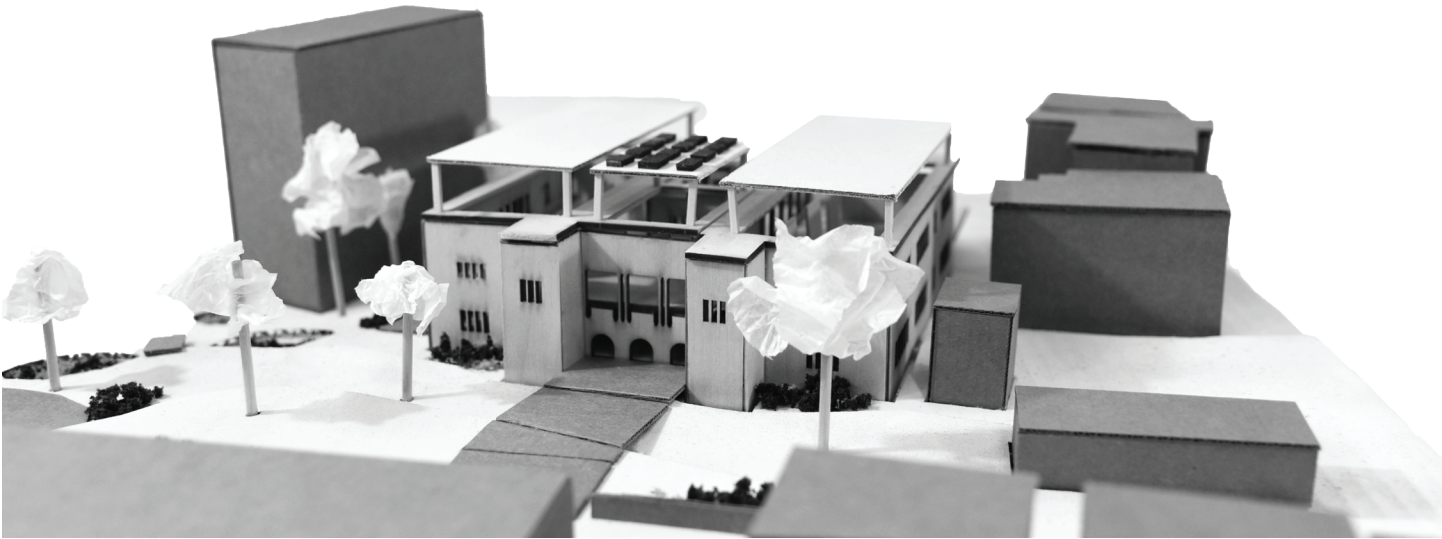
Top: First floor plan highlighting the dual program
 Bottom: Roof plan

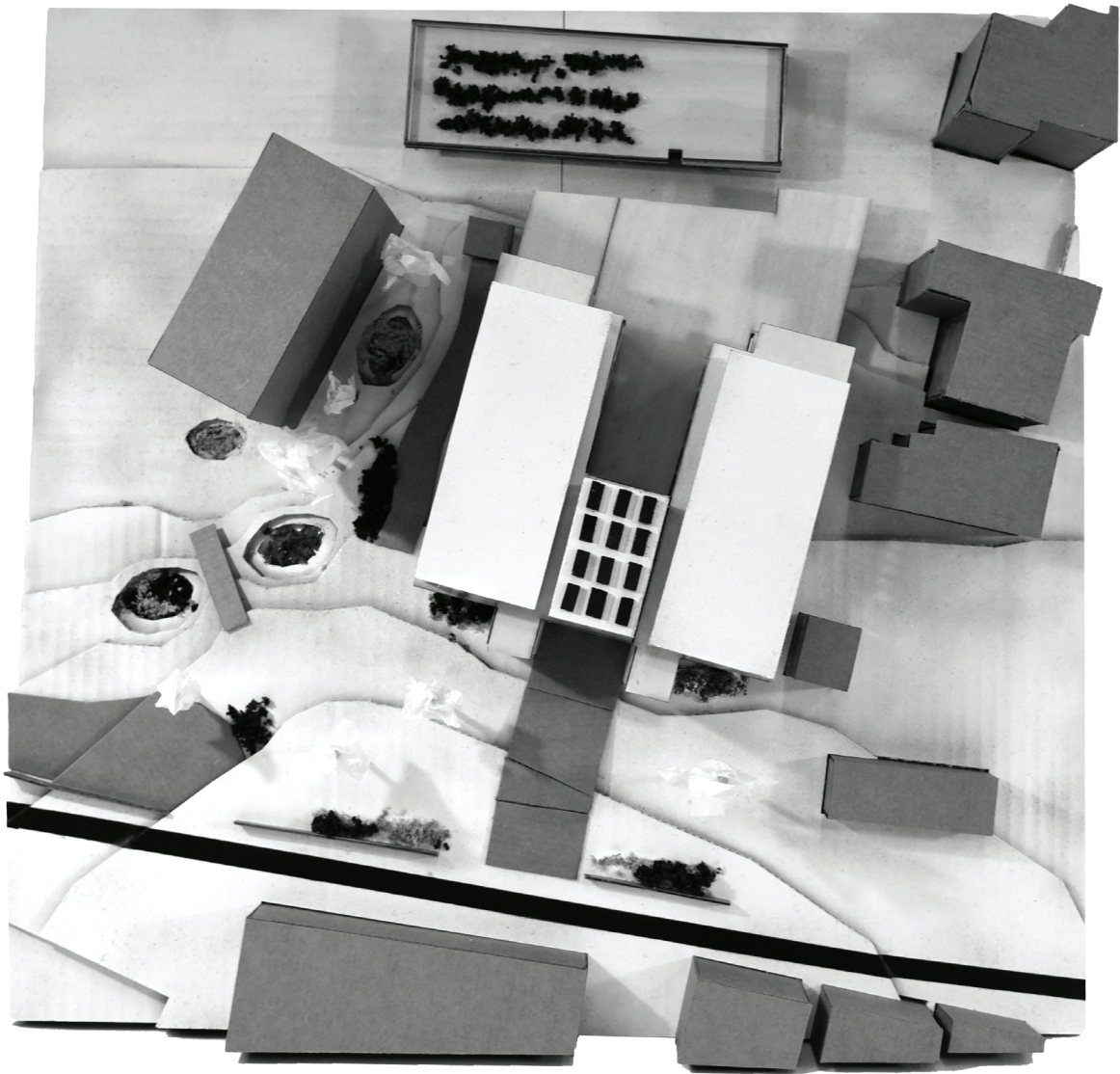


This water collection diagram shows how water drains into swales and is taken to rain cisterns through a French drain system. These six rain cisterns have the capacity to hold enough water to sustain the community of 3200 people for two months. This is a dire need because 48% of the island was left without access to water after the hurricane. The water is filtered by a living machine that is located in the accessory unit behind the main building.











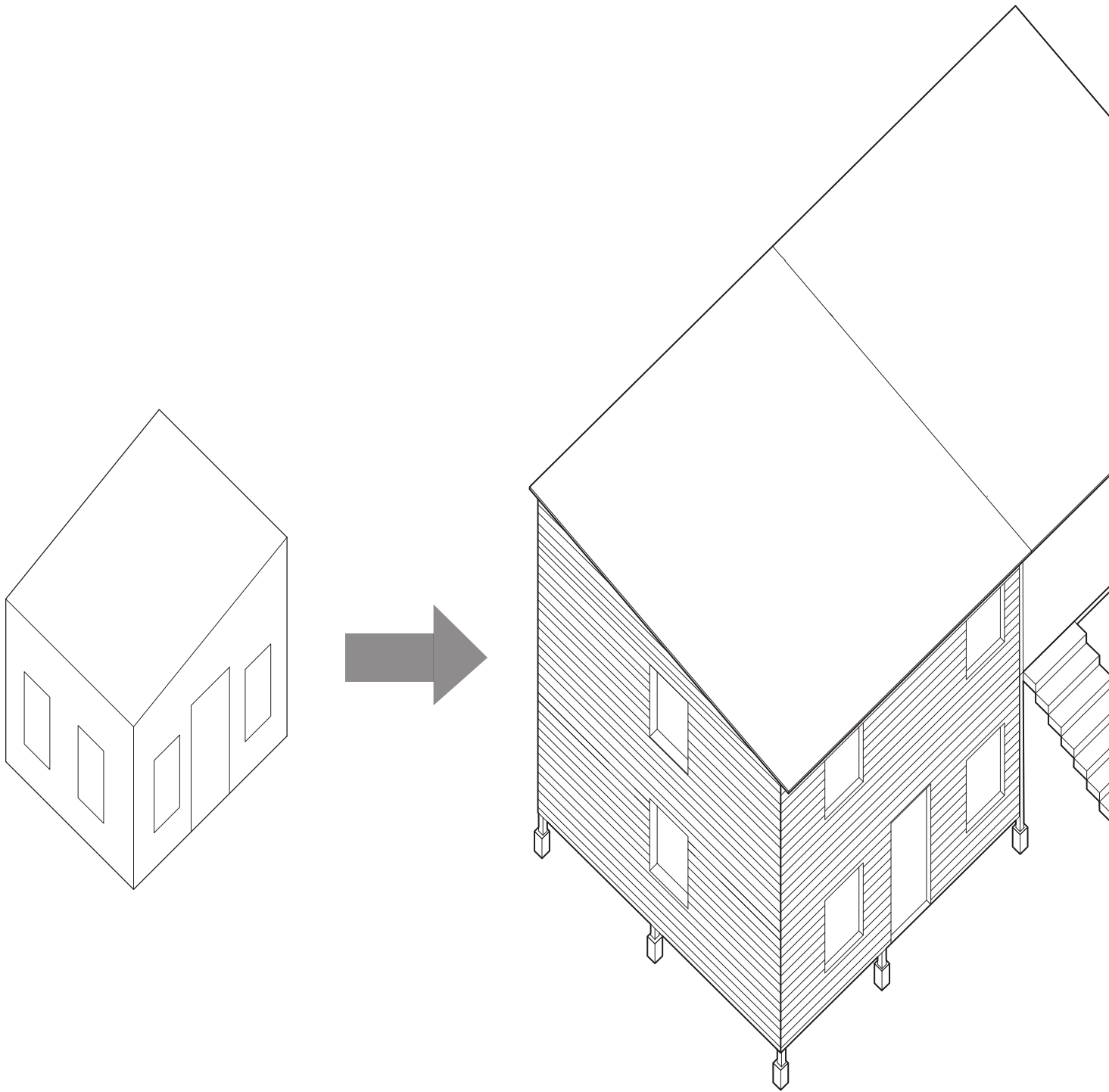


Preliminary Design Research

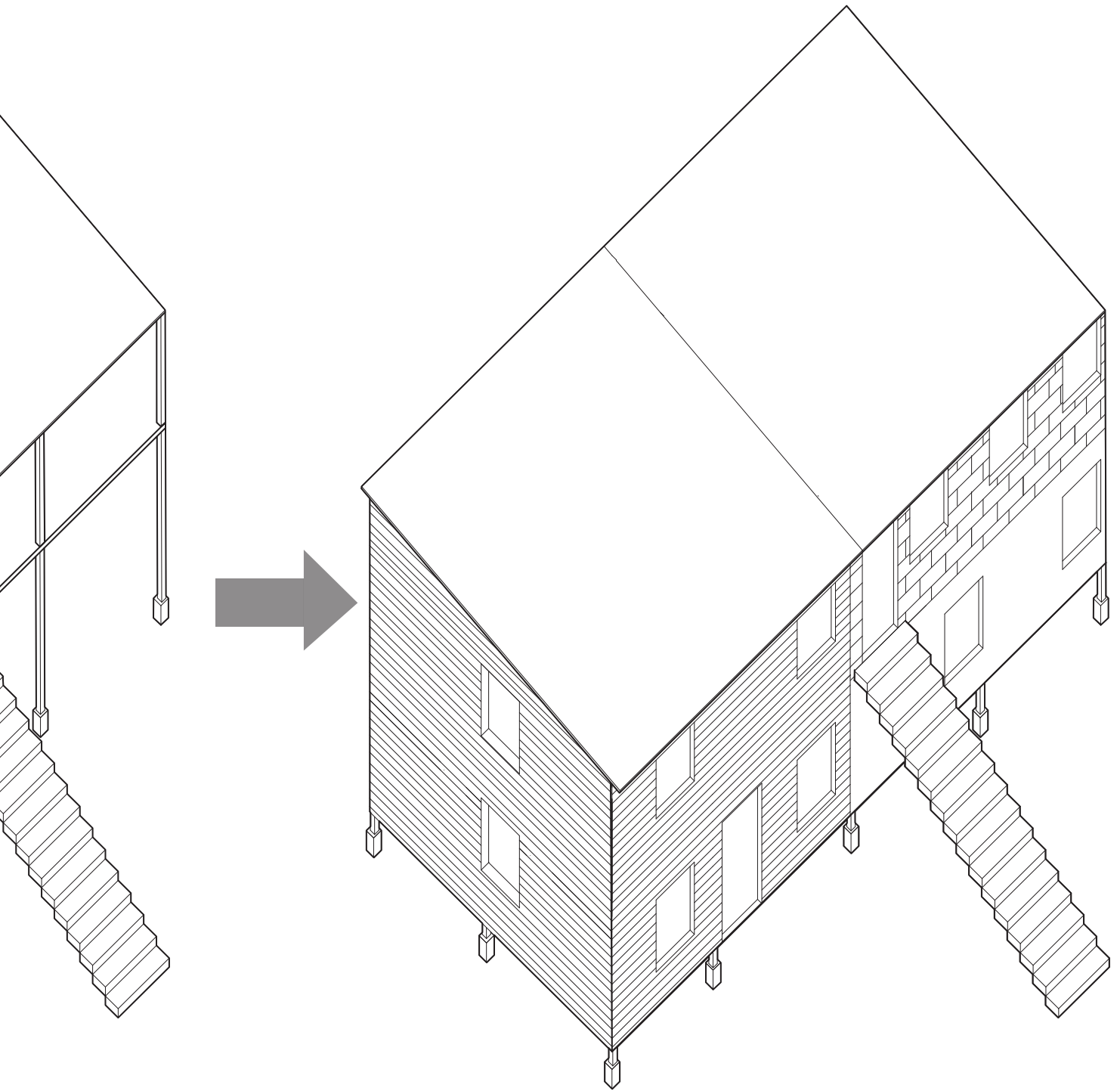
The following are designs that did not make it into the final project but are important explorations for reaching the final solution.

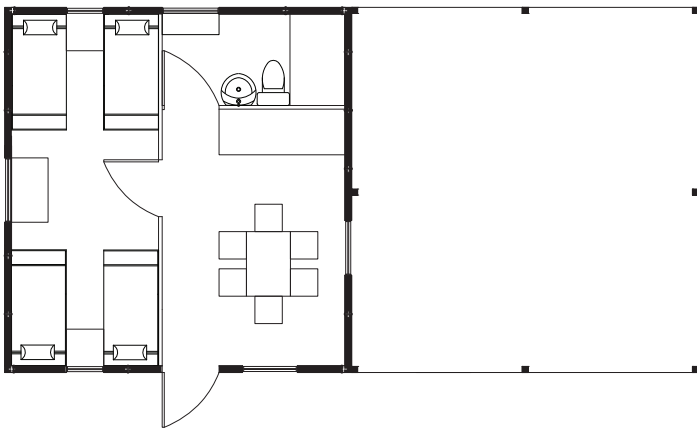
Thesis Probe: Research through Design

In Fall 2017, thesis students were asked to construct a work about their proposed thesis topics that could fit into a 17" x 92" space. The following is a one week design charrette exploring how to construct an easy to build, deployable home that can be built using unskilled labor. The entire kit can fit into a 8' x 8.5' x 40' shipping container. The home is an occupiable structure with room to expand upon it over time, following an incremental housing model that was first proposed by 2016 Pritzker Prize winner Alejandro Aravena.

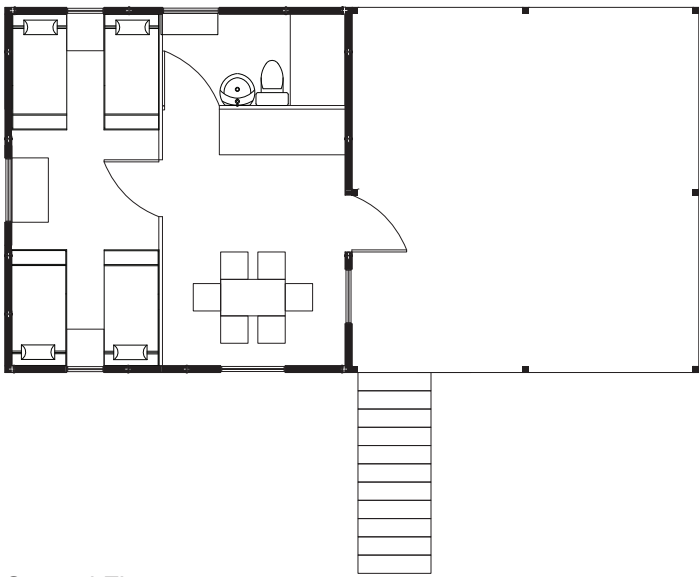


A proposed three phase housing plan, this probe is focused on phase 2. Phase 1 would be deploying a temporary shelter, phase 2 is this easy to build home that can fit in a shipping container, and phase 3 is building the rest of the home using local materials.

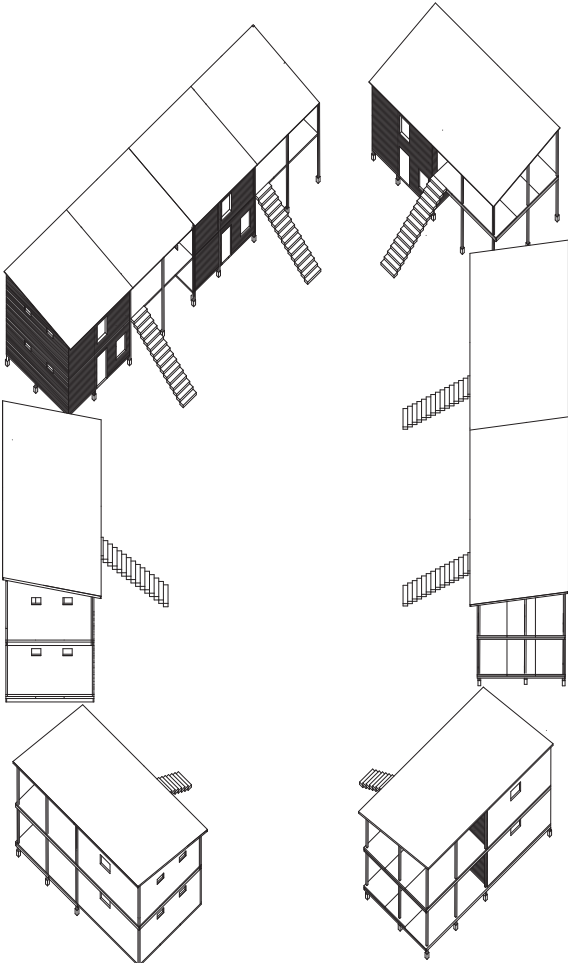




First Floor

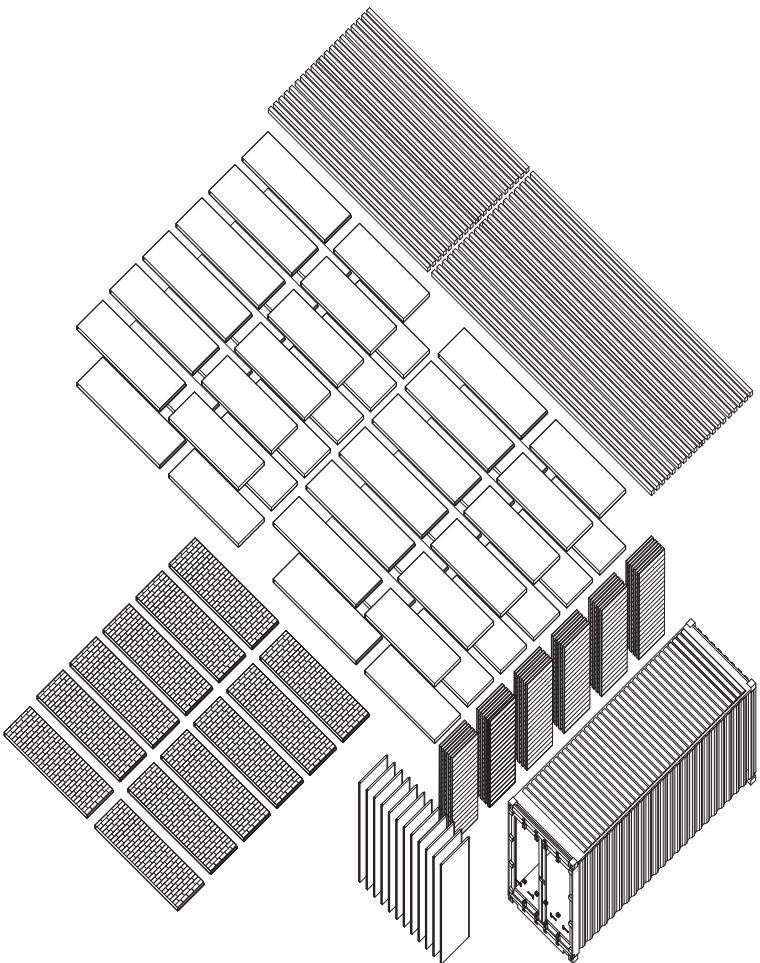


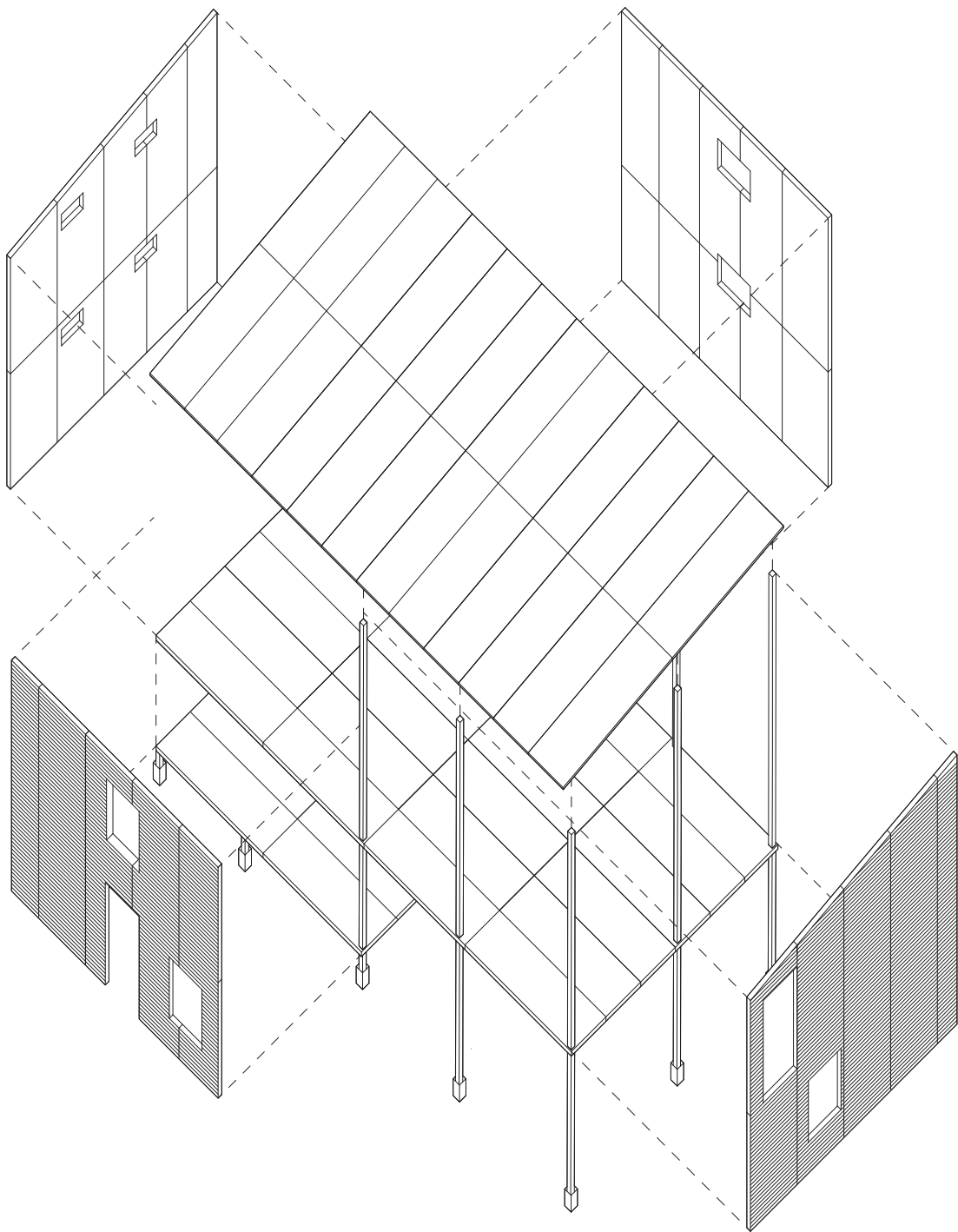
Second Floor



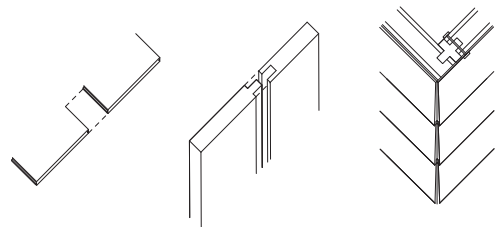
Left: Potential Configuration of houses.

Right: Showing all the parts needed to construct this house.

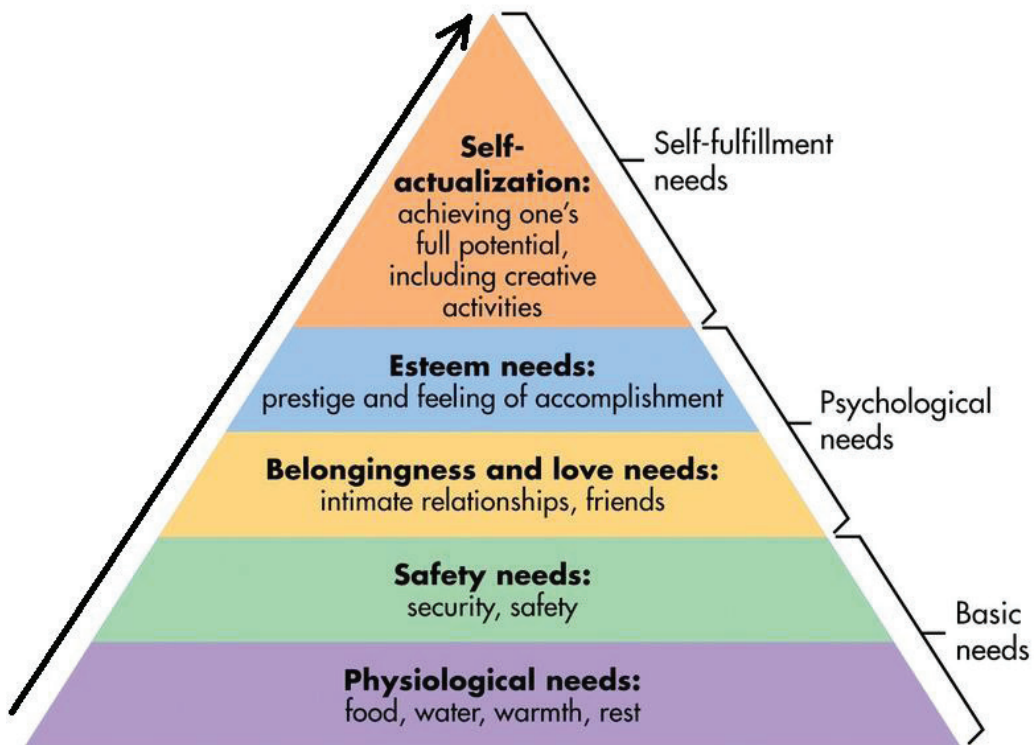




An exploded axon drawing showing the structural components of the house and the simplicity of its parts. It would be primarily constructed using SIPs panels that can be attached by slotting into each other and attaching with bolts.





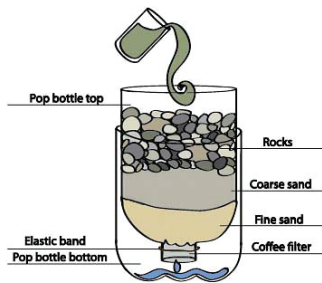


Wintersession and Spring 2018: Continued Exploration

Continuing to design in hopes of finding innovative solutions. These are tectonic exercises centered around the disaster relief process and components that treat disaster relief as a design problem.

Water

Emergency DIY water filter



Emergency water filter



By Survivor
Four stage water filtering system that can filter water from lakes and ponds

Sanitation

Electricity-free Washing Machine



Drummi By Yirego
Uses no electricity and very little water, washes clothes like a salad spinner

Solar Shower



By Coleman
\$14.00 per unit
Is hung from a tree and uses the sun to heat up the water

Foot-pump Handwashing Station



DIY Foot-pump handwashing
Sanitary handwashing made of buckets, a foot pump, and scrap wood

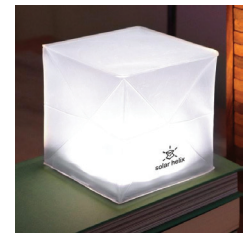
Shelter

Bunk Bed with Storage



by Disco-O-Bed
Portable, comes in a small bag the size of a laptop bag

Solar Powered Portable Light



SolarPuff
By Solight Design
Inflatable solar powered light

Hatchett/Shovel/Saw Multi-tool

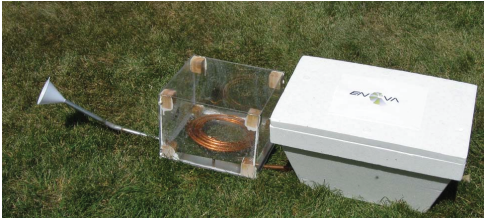


By M48
\$60 per unit
A tool that is able to perform as an axe, shovel or saw

A community kit that would make it possible for a population to fulfill their basic needs without using electricity and conserving water.

Food

Refrigerator: Food Preservation Unit



By University of Calgary Students

A cooling unit for food that does not use electricity, is stored underground and uses vents and evaporation

Cooking: Clean Cookstoves



By Envirolift

Portable stove that limits fuel cost and reduces exposure to pollution and can boil water

Cooking: Earthen Oven



An oven that can be made from sand, bricks and straw

Power

Solar powered phone charger



By EC Technology

\$18 per unit

A waterproof charger connected by USB

Satellite phone + satellite wifi



By Hughes

Runs on a rechargeable battery and you can connect your phone to it to make it a satellite phone

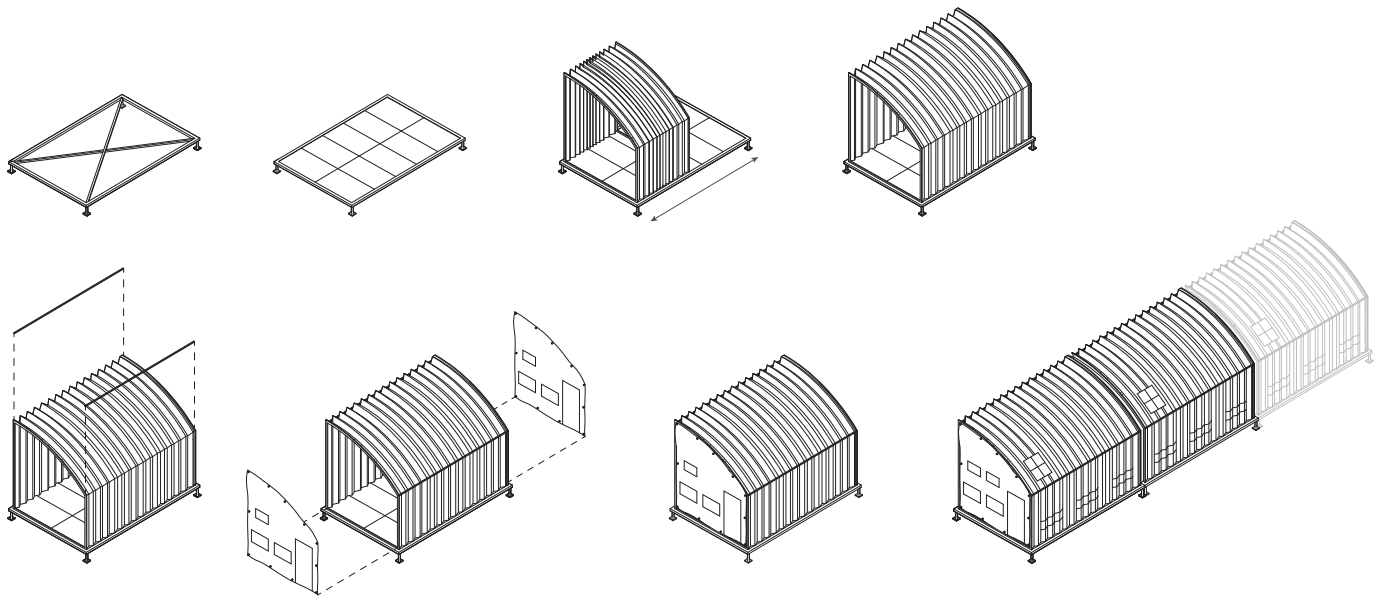
Hand-crank radio/phone charger



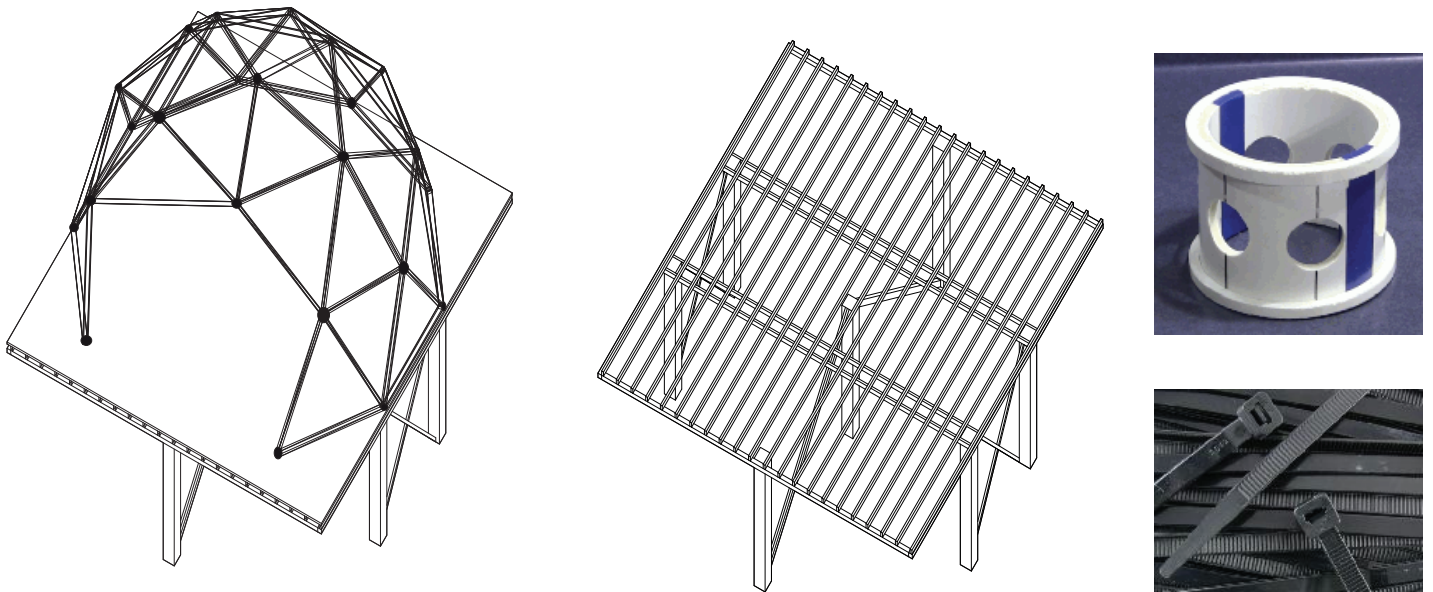
By NOAA

\$60 per unit

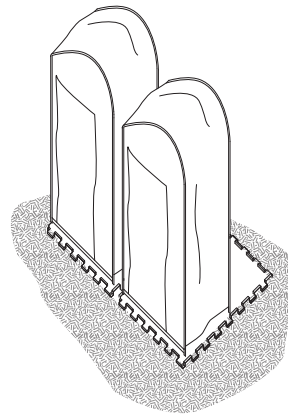
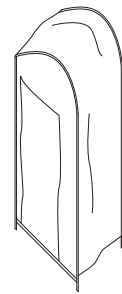
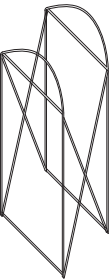
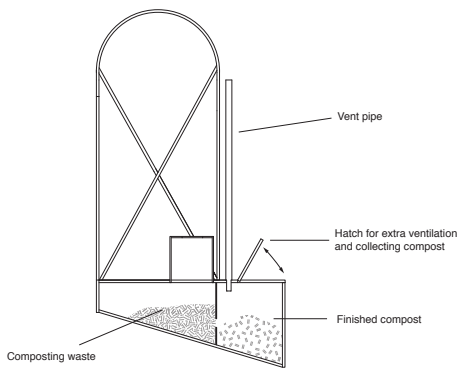
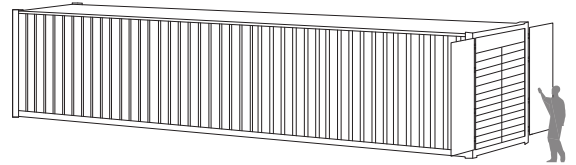
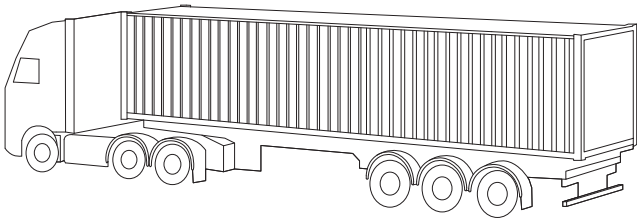
Can be set to automatically broadcast weather alerts



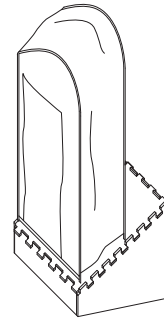
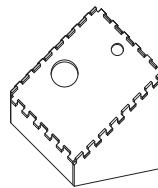
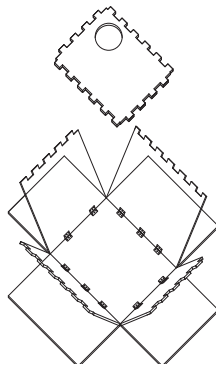
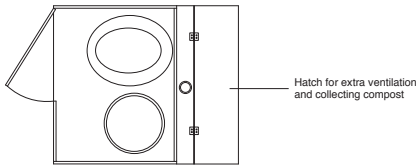
Deployable disaster shelter design charrette



Deployable geodesic dome structure, using zip ties as a form of attachment



Base



Deployable compost toilet design

Architectural Precedents



Schools for refugee camp in Jordan - Cameron Sinclair and Pouya Khazaeli



IKEA flat-pack refugee shelter



Paper log houses - Shigeru Ban



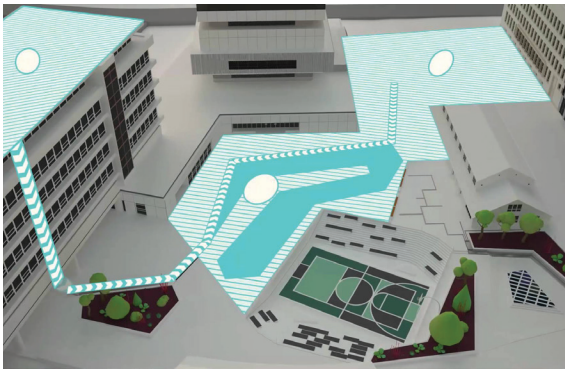
Hex house - Architects for Society



Incremental Housing - Elemental/Alejandro Aravena



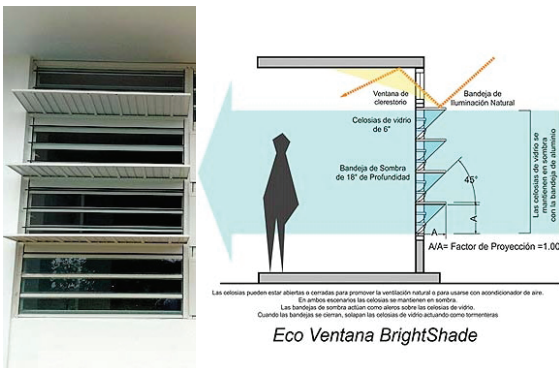
Relief Shelter for earthquake victims - Designnobis



Water plaza Benthemplein Rotterdam - De Urbanisten



LVMH Community Center - Shigeru Ban



Brightshade - A&M Architects



The Aceh Tsunami Museum - Ridwan Kamil

Acknowledgments

To me, one of the most rewarding things about doing an architectural thesis on disaster relief is the enriching conversations I have on a daily basis. Some of the most important critiques I had about my thesis were with people outside of my discipline. Below are a list of individuals that I would like to thank, for this thesis would not be possible without you.

My Academic Advisors & Mentors

Anne Tate, Professor of Architecture at Rhode Island School of Design

Jonathan Knowles, Professor of Architecture at Rhode Island School of Design

Dr. Bonnie Epstein, Part time Lecturer at the Rhode Island School of Design and Director of the Rhode Island Museum of Art and Science

Dr. Anna Geores, Professor of Architecture at University of Puerto Rico

Manuel Cordero-Alvarado, Professor of Architecture at Rhode Island School of Design

My trusted colleagues:

Andrea Kelly, M.Arch Graduate at the Rhode Island School of Design

Emily Svenningsen, B.Arch Graduate at the Rhode Island School of Design

Danielle Cara Sy, B.Arch Graduate at the Rhode Island School of Design

Adelaide Mackintosh, M.Arch Graduate at the Rhode Island School of Design

Iris King, M.Arch Graduate at the Rhode Island School of Design

Kyuyeon Park, M.Arch Graduate at the Rhode Island School of Design

Others:

Jesus Manuel Melendez, M.Arch student at Rhode Island School of Design, from Puerto Rico and studied at Pontifical Catholic University of Puerto Rico

Jesus Alfonso, Graduate of Pontificia Universidad Católica de Puerto Rico

Thank you to every Puerto Rican who took the time to tell me about their experiences during and after Hurricane Maria.

Thank you to my dear family who has always supported me in my architectural journey: Alvin Mac Donald, Raylene Mac Donald, Kaitlin Mac Donald, Devin Mac Donald.

Image Credits

Creator's Last name, First name. "Title of the digital image." Title of the website, First name Last name of any contributors, Version (if applicable), Number (if applicable), Publisher, Publication date, URL.

"Protester wrapped in Puerto Rican Flag." Telesur, July 27, 2017 <https://www.telesurtv.net/english/opinion/Independence-Not-Negotiable-Venezuela-Envoy-on-Puerto-Rico-20170727-0020.html>

"Cars drive through a flooded road in the aftermath of Hurricane Maria." TIME, Lisa Marie Segarra and Kim Bubello, TIME Magazine, 2018. <http://time.com/hurricane-maria-destruction-photos/>

"A man rides his bicycle through a damaged road in Toa Alta, west of San Juan, Puerto Rico" TIME, Lisa Marie Segarra and Kim Bubello, TIME Magazine, 2018. <http://time.com/hurricane-maria-destruction-photos/>

"Mother and child." TIME, Lisa Marie Segarra and Kim Bubello, TIME Magazine, 2018. <http://time.com/hurricane-maria-destruction-photos/>

"Nabal Guzman Solis, who has yet to hear from FEMA, lost nearly everything in Hurricane Maria." Politico, M. Scott Mahaskey, Politico, December 31, 2017.

"Escuela Dr. Pedro Goyco Drawings." Architecture and Construction Archive of the University of Puerto Rico (AACUPR)

"Café Tresbé" Spoon Food Tours, July 16, 2015, <https://www.xtremefoodies.tv/features/essential-eats/san-juan-puerto-rico>

"Libros Libres" Discover Puerto Rico, July 19, 2016, http://descubrepuertoricoahora.blogspot.com/2016/07/resurgimiento-en-la-calle-loiza_75.html

"Street View of Calle Loiza" Discover Puerto Rico, July 19, 2016, http://descubrepuertoricoahora.blogspot.com/2016/07/resurgimiento-en-la-calle-loiza_75.html

"Maslow's Hierarchy of Needs." Simply Psychology, May 21, 2018, <https://www.simplypsychology.org/maslow.html>

References

Angleró, Mariana Reyes. “Pedro Gerónimo Goyco.” Calle Loiza, www.lacalleloiza.com/pedro-geronimo-goyco/.

“Eco Ventana Brightshade.” Projects Abruña and Musgrave, A&M Architects, www.abrunaandmusgrave.com/projects/.

Hernández, Arelis R. “In Puerto Rico’s ‘Last Mile,’ Power Is Still Elusive as next Hurricane Season Looms.” *The Washington Post*, WP Company, 4 Apr. 2018, www.washingtonpost.com/national/in-puerto-ricos-last-mile-power-is-stillelusive-as-next-hurricane-season-looms/2018/04/04/00dc0cb4-1e69-11e8-b2d9-08e748f892c0_story.html?utm_term=.1d60f0f4b92b.

Mazzei, Patricia. “What Puerto Rico Is, and Isn’t, Getting in Disaster Relief.” *The New York Times*, The New York Times, 8 Feb. 2018, www.nytimes.com/2018/02/08/us/puerto-rico-disaster-relief.html.

Mori, Alejandro Aravena, and Andrei’s Iacobelli. *Elemental: Incremental Housing and Participatory Design Manual*. Hatje Cantz Verlag, 2016.

“Recent Events.” KatRisk, KatRisk, 2017, www.katrisk.com/recent-events/

Sinclair, Cameron. *Design like You Give a Damn*. Abrams, 2012. Print.

“Sistema Solar Fotovoltaico Para Diálisis.” Casa Pueblo • Puerto Rico, casapueblo.org/index.php/sistema-solar-para-dialisis/.

Sutter, John D., and Sergio Hernandez. “‘Exodus’ from Puerto Rico: A Visual Guide.” CNN, Cable News Network, 21 Feb. 2018, www.cnn.com/2018/02/21/us/puerto-rico-migration-data-invs/index.html.

Thomas, Vinod. *Climate Change and Natural Disasters: Transforming Economies and Policies for a Sustainable Future*. Routledge 2017. Print.

To be continued,
for the design process
is a lifelong journey.