POTABLE THOUGHTS :

Architecture Towards Stewardship

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Texas A&M University

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Potable Thoughts: Architecture Towards Stewardship

Was published upon completion of the Texas A&M University Master of Architecture program to chronical the development of the thesis project requried for degree consideration. Project completed for

the ARCH 607 & 608 courses in the 2022-2023 academic year and submitted for graduation in May 2023.

DEDICATION

To my family and friends that supported me,

The School of Architecture, instructors, advisors, and staff

that lit the path,

My fellow classmates and colleagues that

challenged and encouraged me,

Thank you,

I will forever be grateful.

In Memory of Bruce Alan Rath.

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1 | *PREFACE*

Topic Introduction

“In many ways, the environmental crisis is a design crisis. It is a consequence of how things are made, buildings are constructed, and landscapes are used. Design manifests culture, and culture rests firmly on the foundation of what we believe to be true about the world.”

-Sym Van Der Ryn (McLennan, 2004)

The depletion of natural sources of potable water is a global issue that requires immediate attention. With the growing population and increased urbanization, the demand for clean water is becoming higher than ever before. As architects, we have a responsibility to address this issue and influence people to value stewardship. Stewardship refers to the responsible use and management of natural resources for the benefit of present and future generations. This thesis aims to answer the question, how architecture can influence people to value stewardship, by designing a modern research and education facility, showcasing sustainable materials, biophilia, and displaying the value of new concepts and traditional insights.

Relevance

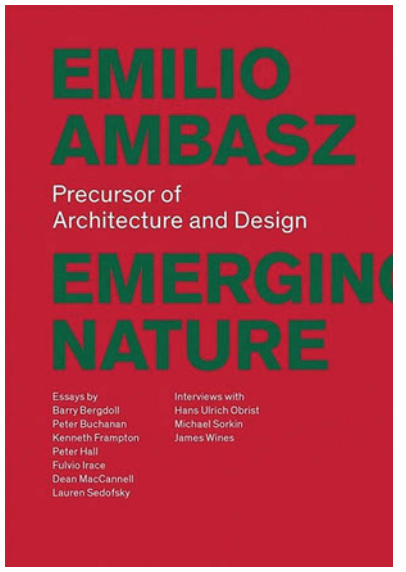
To answer the architectural question, the project explores the longstanding relationship between stewardship and architecture by asking where is the line between the built environment and the natural environment? Logically, architecture and the landscape cannot exist separately from one another, therefore stewardship of the natural environment is a necessity of architecture. Frank Lloyd Wright says, “If a house is to be architecture, it must become a natural part of the landscape. The land is the simplest form of architecture.” (Wright, 1953). Due to our profound power to impact our natural environment, for better or worse, we have a great responsibility to not only design in a sustainable manner, but to ensure our architecture prompts people to engage in sustainable practices.

2 | *PHILOSOPHIES & PRECEDENTS*

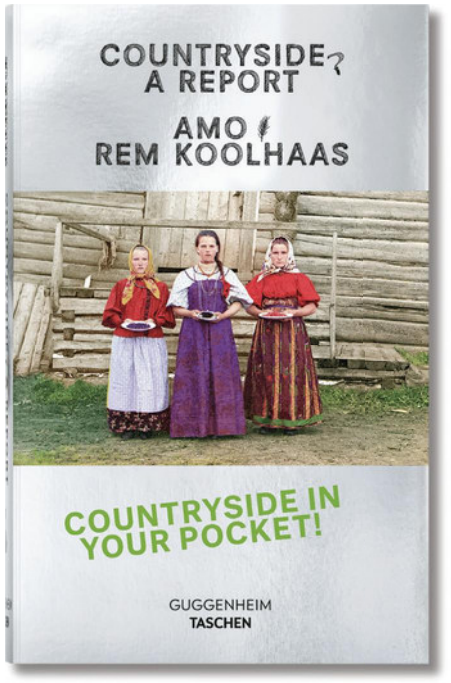
The project developed through a philosophical lens with several questions and statements. The decision to begin with a philosophical approach began with Chase Williams paper which speculates on how philosophy and theory allow us to shape the world around us (Williams, 2019). I began by posing the questions, what is the nature of place? What is the place of nature? Adler poses a similar question, “Does Nature consist of a hierarchy of natures or distinct kinds; or is it a continuum of things all having the same nature and differing from each other only individually or accidentally, but not essentially?” (Adler, 1952). Looking at architecture as existing on a gradient of allowing the most amount of nature to the least, e.g., a gazebo in a forest compared to a windowless warehouse in the middle of a city, I developed a core design value for the project, the line between nature and the built spaces should be blurred as much as possible. This design value works in tandem with increasing the use of biophilia in a space, as biophilia can be seen as a range as well, e.g. having a plant on a desk to being immersed in a forest.

Foundational Works

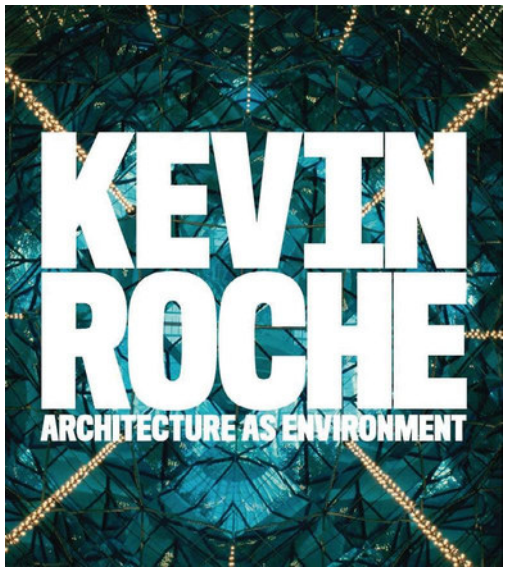
To establish precedents, a dedicated language defining biophilic architecture, and reinforce and define my design guidelines I looked primarily to Emilio Ambasz, Rem Koolhaas, and Kevin Roche.



In his book Emerging Nature, Ambasz explores the integration of nature in architecture and design. The author argues that the integration of nature in architecture can promote sustainability and influence people to value stewardship.“The most beautiful and functional designs emerge when we work with nature, rather than against it.” (Bergdoll & Obrist, 2017). This translates to a core design value of utilizing traditional/ colloquial architectural designs which decrease energy use via passive means. “The goal of architecture should be to create environments that are in harmony with nature, that allow us to reconnect with the natural world and restore our sense of wonder and awe.” (Bergdoll & Obrist, 2017). This statement reinforces the need for biophilia as a transformative tool.



The book, Countryside, reinforces Koolhaas’ assertion of biophilia as an agent of transformation “The countryside is no longer a refuge for a simpler, authentic way of life. It is now, more than ever, a laboratory for change.” (Koolhaas, 2020).



In Architecture As Environment: The Grand Picture, Roche states, “The power of architecture lies in its ability to shape our perceptions and emotions, to create a sense of place.” (Roche, 2004). This established another core design guideline for me, to create unique spaces that inspire awe of nature and one’s perspective. My research covered many other sources that did not make it into this paper, they are listed in the Appendix.

3 | RESEARCH & REASONING

Books

1. Elements of sustainable architecture / Rosa Urbano Gutiérrez and Laura de la Plaza Hidalgo.

2. Environmental stewardship : critical perspectives, past and present / edited by R.J. Berry

3. Regenerative urban design and ecosystem biomimicry / Maibritt Pedersen Zari.

4. Stewardship ; the land, the landowner, the metropolis / Prepared for landowners in the New York Metropolitan Region by the Open Space Action Committee. [Text by Charles E. Little and Robert L. Burnap].

5. The philosophy of sustainable design : the future of architecture / Jason F. McLennan.

6. The Routledge companion to architecture and social engagement / edited by Farhan Karim.

7. The vertical garden : from nature to the city / Patrick Blanc ; preface by Jean Nouvel ; photography by the author and Véronique Lalot ; translation by Gregory P. Bruhn.

8. Ecological buildings : new strategies for sustainable architecture / Dorian Lucas.

Books

9. Emilio Ambasz : emerging nature : precursor of architecture and design / essays by Barry Bergdoll, Peter Buchanan, Kenneth Frampton, Peter Hall, Fulvio Irace, Dean MacCannell, Lauren Sedofsky ; interviews with Hans Ulrich Obrist, Michael Sorkin, James Wines.

10. Ecology and the architectural imagination / Muller, Brook

11. Challenge of the Land. Open Space Preservation at the Local Level

12. Basics Landscape Architecture 02 Ecological Design

13. Strategies for Sustainable Architecture, Paola Sassi

14. Groundwater Allan Freeze and John Cherry (1979)

15. Blue Architecture_ Water, Design, and Environmental Futures- Brook Muller

16. Poetics of Architecture

17. Kevin Roche Architecture as Environment

Case Studies

1. Biosciences Research Building (BRB)

2. Chu Hall - Solar Energy Research Center (SERC)
Lawrence Berkeley National Laboratory
Berkeley, California

3. TAMU Agrilife Extension Dallas Center

4. Seoul National University South Forest Research & Education Center / TAAL Architects

5. Albert Einstein Education and Research Center SAFDIE

6. The Bertschi School, Living Building Challenge Building for Educating Kids

7. Hawaii Preparatory Academy Energy Lab

4 | *AIMS & ANALYSIS*

ESTABLISHMENT

Design Aims:

- Express the Architectural Issue of fresh water being depleted faster than it can be replenished.

- Optimize the building performance to adhere to modern and future energy and environmental standards.

- Explore the line between nature and the built spaces.

- Utilize traditional/colloquial architectural designs which decrease energy use via passive means.

- Create unique spaces that inspire awe of nature and one’s perspective through biophilia.

In this section, I will identify the design challenges and opportunities presented by the project, establish the design criteria that guided the decision-making process, and develop a set of design aims and objectives that reflect the project's goals and values.

Functionality, Sustainability, Design, Context, User Experience, and Social Impact.

The Design Option Analysis component involved exploring various design options that could meet the project's aims and objectives.

Methods to generate and evaluate design options were initially based on generative design techniques centered on evolutionary algorithms that prioritized certain energy efficiency markers. I then evaluated these design options against the established design criteria and selected the most promising option to move forward with.

AIMS

Goal 1: Maximize exposure to nature

Object: Incorporating large windows and skylights to provide natural light and views of nature, as well as outdoor spaces like courtyards and green roofs. Additionally, designing spaces with direct access to nature, such as outdoor classrooms or research stations, can help create a connection to the natural environment.

Goal 10: Promote social interaction and collaboration

Object: Designing spaces that promote social interaction and collaboration, such as shared workspaces and community gardens. Additionally, incorporating educational programs and events that promote sustainability and environmental stewardship can help foster a sense of community and encourage sustainable behavior among building occupants and visitors.

Goal 11: Create opportunities for physical activity

Object: Incorporating opportunities for physical activity, such as walking paths. and incorporating staircases that are visually appealing and well-lit can encourage physical activity over taking the elevator, promoting a healthier and more active lifestyle.

Goal 14: Incorporate water features

Object: Incorporating water features, such as fountains or ponds, that promote relaxation and provide a calming atmosphere. Additionally, incorporating educational displays that highlight the importance of water conservation and the role of water in the local ecosystem can promote stewardship.

Goal 4: Create a sense of refuge

Object: Designing spaces that provide a sense of refuge and retreat, such as quiet spaces or private outdoor spaces. Additionally, incorporating acoustic design principles that reduce noise and promote soundscapes of nature can improve occupant well-being and reduce stress.

AIMS

Inspired by Terrapin Bright Green's Research and Materials, I utilized the information provided in their 14 Patterns of Biophilic Design publication.

This source was used to provide information and support for the idea of incorporating biophilic design into sustainable planning and design.

TABLE 1. BIOPHILIC DESIGN PATTERNS & BIOLOGICAL RESPONSES

Table 1 illustrates the functions of each of the 14 Patterns in supporting stress reduction, cognitive performance, emotion and mood enhancement and the human body. Patterns that are supported by more rigourous emphirical data are marked with up to three asterisks (***), indicating that the quantity and quality of available peer-reviewed evidence is robust and the potential for impact is great, and no asterisk indicates that there is minimal research to support the biological relationship between health and design, but the anecdotal information is compelling and adequate for hypothesizing its potential impact and importance as a unique pattern.

	14 PATTERNS	*	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	**Visual Connection with Nature**	* * *	**Lowered blood pressure and heart rate** (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	**Improved mental engagement/ attentiveness** (Biederman & Vessel, 2006)	**Positively impacted attitude and overall happiness** (Barton & Pretty, 2010)
	Non-Visual Connection with Nature	* *	**Reduced systolic blood pressure and stress hormones** (Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991)	**Positively impacted on cognitive performance** (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundström, 2004)	**Perceived improvements in mental health and tranquility** (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003)
	Non-Rhythmic Sensory Stimuli	* *	**Positively impacted on heart rate, systolic blood pressure and sympathetic nervous system activity** (Li, 2009; Park et al, 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)	**Observed and quantified behavioral measures of attention and exploration** (Windhager et al., 2011)	
	Thermal & Airflow Variability	* *	**Positively impacted comfort, well-being and productivity** (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005)	**Positively impacted concentration** (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	**Improved perception of temporal and spatial pleasure (alliesthesia)** (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
	Presence of Water	* *	**Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure** (Alvarsson, Wiens, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006)	**Improved concentration and memory restoration** (Alvarsson et al., 2010; Biederman & Vessel, 2006) **Enhanced perception and psychological responsiveness** (Alvarsson et al., 2010; Hunter et al., 2010)	**Observed preferences and positive emotional responses** (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphryes et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983)
	Dynamic & Diffuse Light	* *	**Positively impacted circadian system functioning** (Figueiro, Brons, Plitnick et al., 2011; Beckett & Roden, 2009) **Increased visual comfort** (Elyezadi, 2012; Kim & Kim, 2007)		
	Connection with Natural Systems				**Enhanced positive health responses; Shifted perception of environment** (Kellert et al., 2008)
NATURAL ANALOGUES	**Biomorphic Forms & Patterns**	*			**Observed view preference** (Vessel, 2012; Joye, 2007)
	Material Connection with Nature			**Decreased diastolic blood pressure** (Tsunetsugu, Miyazaki & Sato, 2007) **Improved creative performance** (Lichtenfeld et al., 2012)	**Improved comfort** (Tsunetsugu, Miyazaki & Sato 2007)
	Complexity & Order	* *	**Positively impacted perceptual and physiological stress responses** (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)		**Observed view preference** (Salingaros, 2012; Hägerhäll, Laike, Taylor et al., 2008; Hägerhäll, Purcella, & Taylor, 2004; Taylor, 2006)
NATURE OF THE SPACE	**Prospect**	* * *	**Reduced stress** (Grahn & Stigsdotter, 2010)	**Reduced boredom, irritation, fatigue** (Clearwater & Coss, 1991)	**Improved comfort and perceived safety** (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)
	Refuge	* * *		**Improved concentration, attention and perception of safety** (Grahn & Stigsdotter, 2010; Wang & Taylor, 2006; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)	
	Mystery	* *			**Induced strong pleasure response** (Biederman, 2011; Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001)
	Risk/Peril	*			**Resulted in strong dopamine or pleasure responses** (Kohno et al., 2013; Wang & Tsien, 2011; Zald et al., 2008)

NATURE IN THE SPACE

Biophilic Design Pattern	No Budget	Low Budget	Medium Budget	High Budget
1. Visual Connection with Nature View to elements of nature, living systems and natural processes	Plants in view outdoors: Changing layout of furniture to take advantage of views outside if building situated in natural landscape/ next to park/body of water	Cut flowers on tables & desks; Hanging plants: kokodema, macramé, baskets; Cut Flowers subscriptions; Window planters; Trellis wall plant screens; Potted plants on desks & shelves	Plant services –hire of plants with monthly subscription for maintenance; Interior and exterior planting scheme	Green roof; Landscaped gardens with seating areas; Living green walls; Internal courtyards; Lightwell Atrium
2. Non-Visual Connection with Nature Sounds, touch, smells, or tastes that engender a positive reference to nature	Natural soundtracks to create acoustic backdrop	Scent atomisers and diffusers; Sound masking: natural sounds/ water lapping; Cleaning products: low VOC, good quality and nice smelling hand soaps/ moisturisers; Citrus or coffee smells (stimulate taste buds)	Furniture materials: chairs, tables, stair cases, use soft/ contrasting materials for relaxation vs. focus spaces; Include kitchen with healthy food options	Green walls that release scent and are touch resilient; Zoning: floor textures – carpet/ timber/ stone/ biometric; Refurbished operable windows
3. Non-Rhythmic Sensory Stimuli Objects or materials in consistent yet unpredictable motion as found in nature (e.g: grass swaying/ripples on water/leaves in a breeze)	Opening windows to allow breezes to create gentle movement in plant leaves, blinds or curtains	Blinds: cut outs to project shadows and light; Lighting that projects dappled light (gobo/ moving lights); Kinetic artwork: mobiles; Bird boxes and squirrel houses in sight	Handmade/ glazed reflective tiles; Lights in trees; Kinetic sculptures; Digital: moving screens, projections of patterns; Indoor willow tree	Fans blowing onto green walls to create movement; Light reflecting off water features/ fish tanks to create rippling movements
4. Thermal & Airflow Variability Changes in air temperature, humidity, airflow across the skin and surface temperatures that mimic natural environments	Enable opening and closing of windows throughout the day according to comfort levels	Clay paints and surfaces: absorb heat/ moisture imbalances; Visible mechanical ventilation; Seasonal winter considerations: fire pits, blankets, hot water bottles; Covered outdoor spaces: eating areas, canopy in winter, covered outdoor exercise spaces, weather proof; Kinetic water features: cools the air and increases humidity, zones areas by making them feel different, trickling water/ fountains	Green walls: absorb heat, humidity & moisture imbalances; HVAC (heating, ventilation and air conditioning) delivery combined with natural plant strategy	Installing windows that can open individually & skylights
5. Presence of Water Seeing, hearing or touching of water	Positioning of furniture to face water features	Sight: Imagery with water in the composition, instances of the colour blue, LED screens, projection of water flowing/ waterfall, ripples, bouncing light; Contrast/ use of tonal variation of blues – depth for different feels (ecological valence theory): fabric, carpet tiles, curtains, wall paint, lighting (use for changing times of day – circadian rhythms)	Pools of water in or outdoors; Seating by non-fixed water features	Full height glass walls/ windows to see water flow down – rain or water feature; Fountains, flowing water (sound masking) and zoning of spaces; Offices/ hotels: showers, pools, steam rooms, waterfalls, bath in the bedroom
6. Dynamic and Diffuse Light Varying intensities of light and shadow that change over time to mimic natural patterns and cycles	Position desks close to windows/skylights	Fairylights; Colour changing LED lights or lampshades projecting colour & pattern; Adjustable blinds to control light	Sheltered space outside; Planting to create shadows (deciduous windows); Materials: light reflecting floors, tables, walls and surfaces, mirrors, light reflective paint, tile glazes, white surfaces, sequin/mirrored surfaces	Glass roof – skylight; External fins (archi-tectural); Glass doors/ walls; Circadian lighting
7. Connection with Natural Systems Awareness of natural processes such as seasons and temporal changes	Position furniture to enable views of sky/ weather outside	Rain catchers, wind chimes, rainbow maker (prism); Inside/outside: cloud maps, tide charts, temperature/ humidity/ air pressure measurements, moon cycles	Exterior: water features/ ponds (ripples from raindrops, freeze in winter); Plant deciduous trees outside; Planters – Boston ivy facades; Patio/ rooftops with seasonal plants	Position building surrounded by nature

NATURAL ANALOGUES

Biophilic Design Pattern	No Budget	Low Budget	Medium Budget	High Budget
8. Biomorphic Forms & Patterns Contoured, patterned, textured or numerical arrangements that mimic nature	Display occupants' pictures of natural forms/patterns on screensavers or social media	Artwork (mimic shapes and patterns); Light fittings e.g: petals, mushrooms, pineapple shapes; Fibonacci series, photos of natural forms	Patterns: undulating glass (underwater feel), tiles, floor tiles, wallpaper (colour/ texture), screens of etched glass/ partitions; Organic shaped furniture; Mathematical: fractals (3's), patterns within patterns, repeated forms at different scales	Columns like trees, spirals (stairs, corridors, Gaudi-esque), cell like facades; Layout of interior/ exterior spaces: curved paths and zones; Freedom to be experimental, pavilions installations, structures
9. Material Connection with Nature Materials and elements from nature that reflect local ecology/ geology to create sense of place	Display objects occupants have found in local natural environments e.g. stones, shells, seedpods, branches	Materials: natural colours, textures and patterns; Wallpaper that mimics natural material surface; Use of nature inspired colour – ecological valence theory	Wood: handles/ hand rails, timber wall panels, veneer; Clay/ ceramics furnishings and fittings; Bark tiles, cork, leather, wood, stone; Biomimetic tiles, wallpapers, flooring	Materials: colour, texture, pattern; Timber cladding; Structural timber beams
10. Complexity and Order Rich sensory information that adheres to a spatial hierarchy similar to nature	Move existing furniture and plants to organise spaces into zones	Layer light; Wallpaper	Zoning spaces using pattern, texture, light, sound, colour and touch; Partitions (glass textures, etched film on glass)	Exposed structure and mechanical systems (exoskeletal); Mimic natural hierarchy in structure and key architectural elements

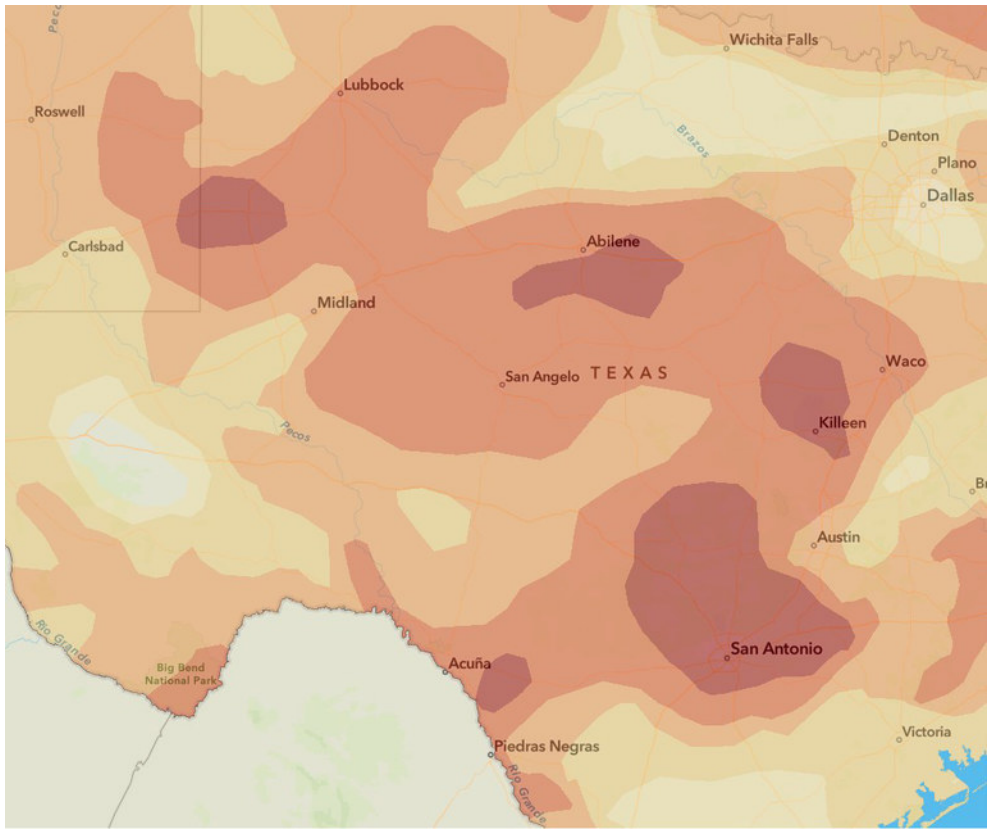
NATURE OF THE SPACE

Biophilic Design Pattern	No Budget	Low Budget	Medium Budget	High Budget
11. Prospect Unimpeded view over a distance for surveillance and planning	Consider seating orientation and positioning by windows	Wayfinding through signpost; Low partitions	Seating (low back), tiered communal seating; Window seats; Transparent materials: glass/ polycarbonate walls/ doors/ partitions	Wayfinding through structure; Choice of site for building (in nature); Balconies – sense of space, mezzanine, elevated platforms (interior and exterior)
12. Refuge Place for withdrawal with protection from behind and overhead	Move existing furniture and plants to create private spaces for retreating & restoring energy	Headphones; Curtains/ partitioning; Set up quiet corners (seat, lamp, carpet); Outdoor seating - benches	Raised platforms; Refuge pods; Outdoor mezzanine or gazebo	Pavilion arcades & walkways; Indoor winter garden
13. Mystery The promise of more information using partially obscured views to entice an individual to go further into the environment	Move existing furniture and plants to create partial views through the interior space to enhance sense of intrigue	Leafy/ planted screens; Trompe D'oueil Mural; Mirrors – disorientate; Slowly revealed view or artwork (so you have to keep walking to reveal more of it)	Screen/ curtain/ frosted glass creates shadow movement and implied activity that you want to see; Obscured views: plants hanging, glass, partitions (or semi obscured with frosted glass); A pull towards a space: sounds, smells, light, wonder; Labyrinths	Winding paths through spaces, gentle curving (slightly disorientating); Digital mapping projection
14. Risk/Peril Identifiable threat to create tension paired with reliable safeguard	Create a supportive culture that encourages everyone to step outside their comfort zone e.g. learning new skills	Images: view down from mountain top, murals (Trompe D'oeuil); Ham-mocks, hanging chairs/ swing seats, hanging shelves	Seating over drops; Uneven flooring; Water: digital LED	Glass elevator/ escalator/ floor/ railing: height (walkway, double height atriums, tree houses, gazebos); Hanging walkways; Bouldering walls

The facility is able to accomplish it's tasks of providing education, outreach, and influence through unique and creative spatial experiences.

ANALYSIS:
SITE

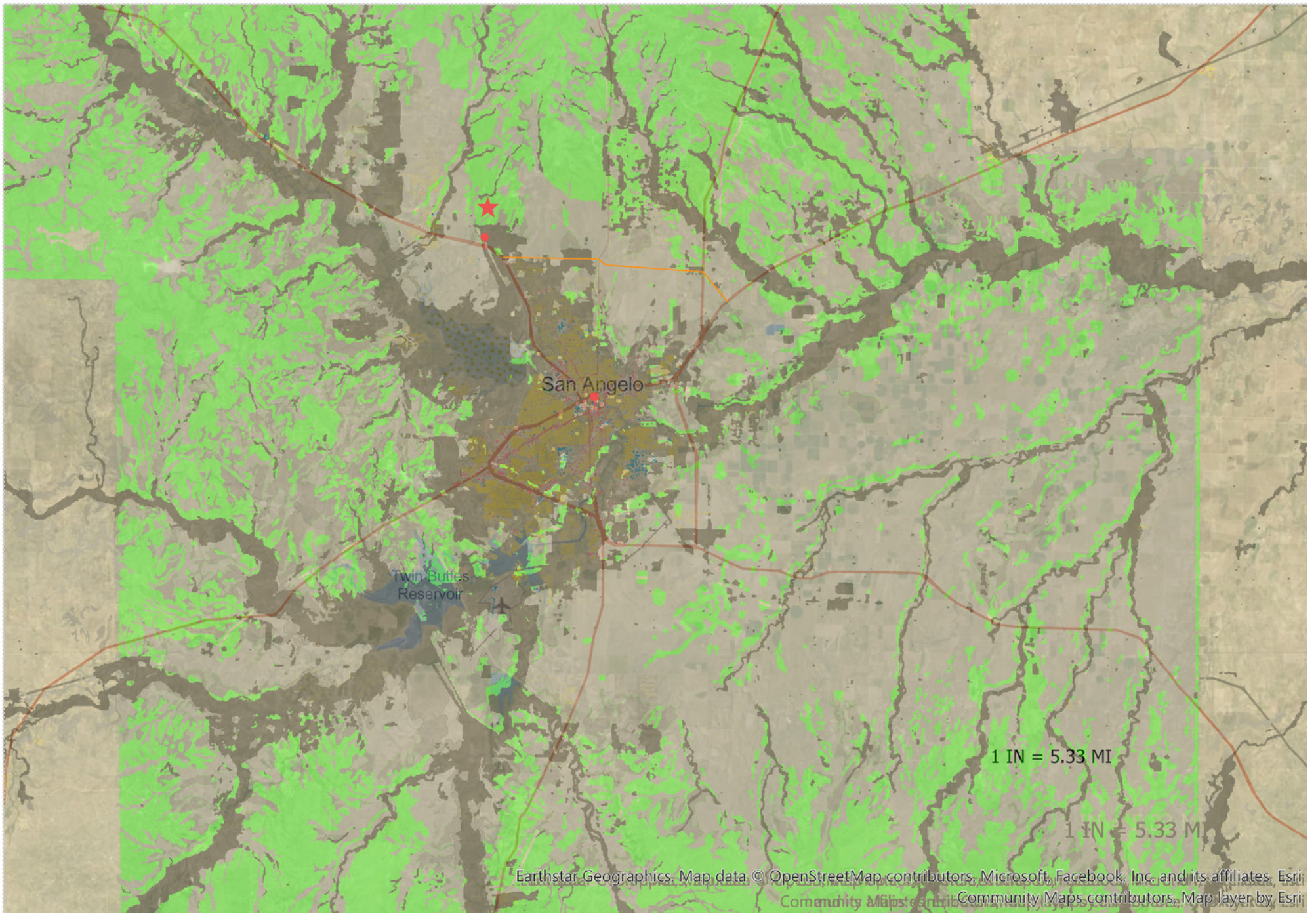
With drought maps of Texas I was able to identify the places most vulnerable to drought in Texas.



Of this area, I researched the connected aquifers, then analyzed and compared their water inflow, outflow, and recharge rates, to determine the most endangered areas.

Utilizing ArcGIS, I was able to narrow my search down to a specific area, the region surrounding San Angelo, Tx. I further overlaid several other maps pertaining to land usage,flood plain risk, important local sites and features, agricultural land, and public vs private land.

From these combined maps, the lime green regions identified viable sites. I chose the site indicated by the red star due to it's proximity flood area, giving it a potential for horticultural studies, and for it's proximity to the red dot below it, an existing TAMU facility.

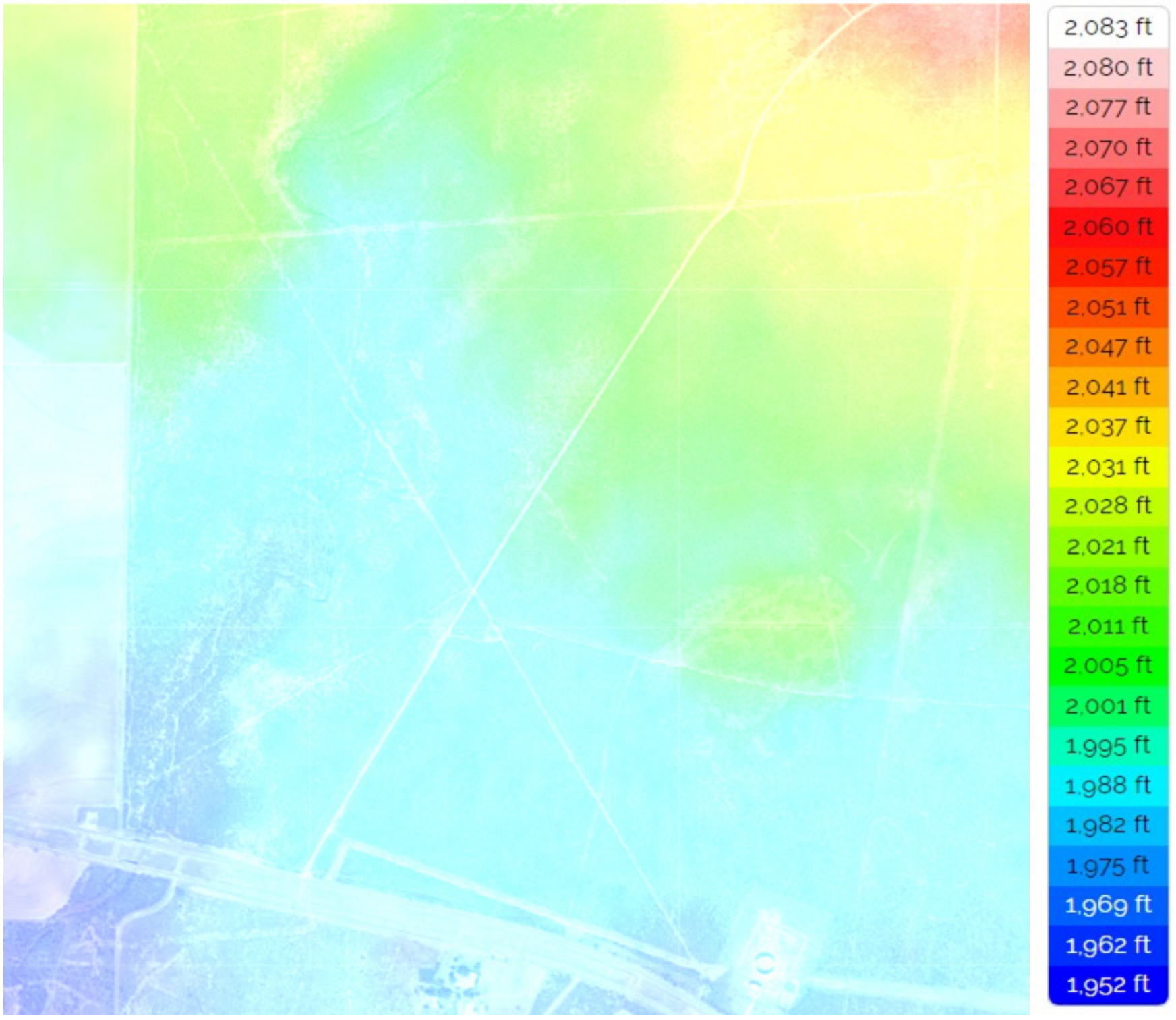


ANALYSIS:
SITE

The site went through a standard analysis, locating major civil infrastructure, flood plains, nearby buildings, and land usage.

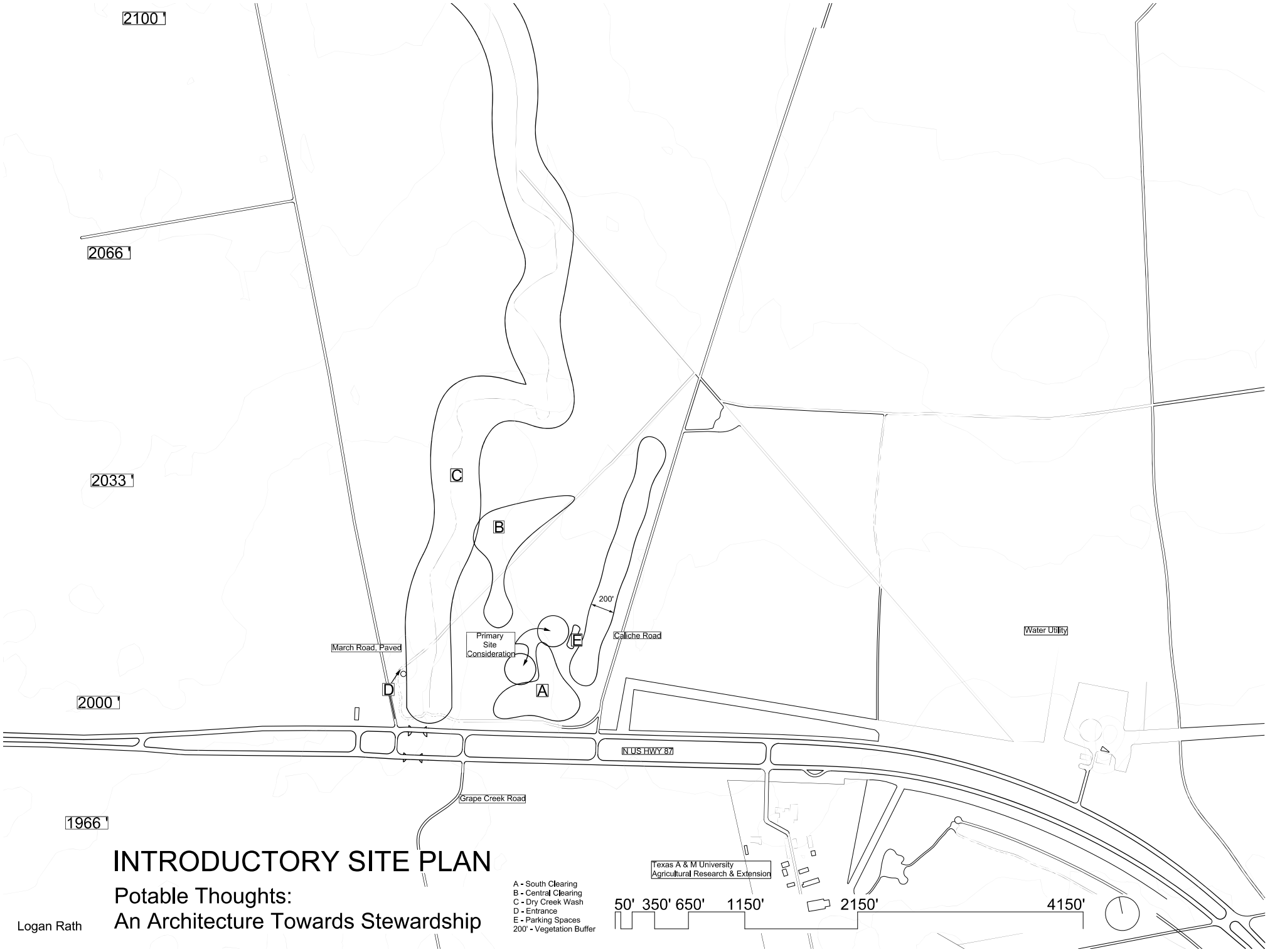
Sun orientation in the summer and winter seasons was taken into account for window placement and shading design.

This image is a topographial representation of the site.



This preliminary site plan outlines the existing civil infrastructure, such as the electrical lines, water treatment facility, major highway to the south of the site, the paved country road to west, and the unpaved caliche road to the east of the site.

The predominant feature on the site is the semi-dry creekbed running nearly straight through the middle and will figure into being a prominent focus for my design.



INTRODUCTORY SITE PLAN

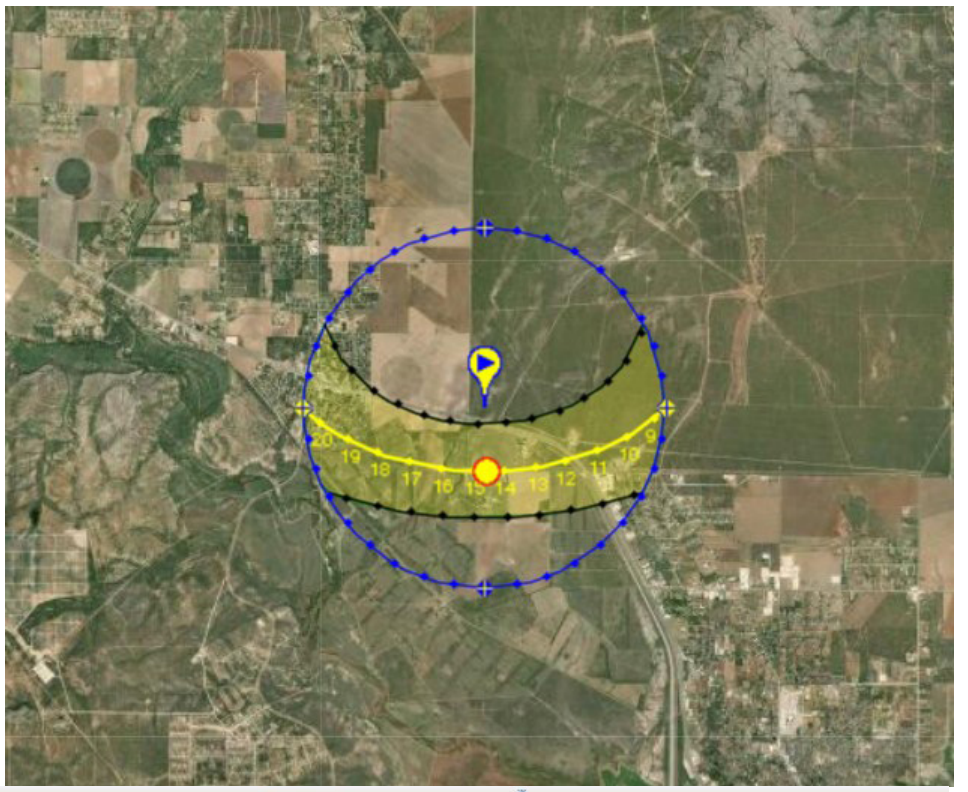
Potable Thoughts:
An Architecture Towards Stewardship

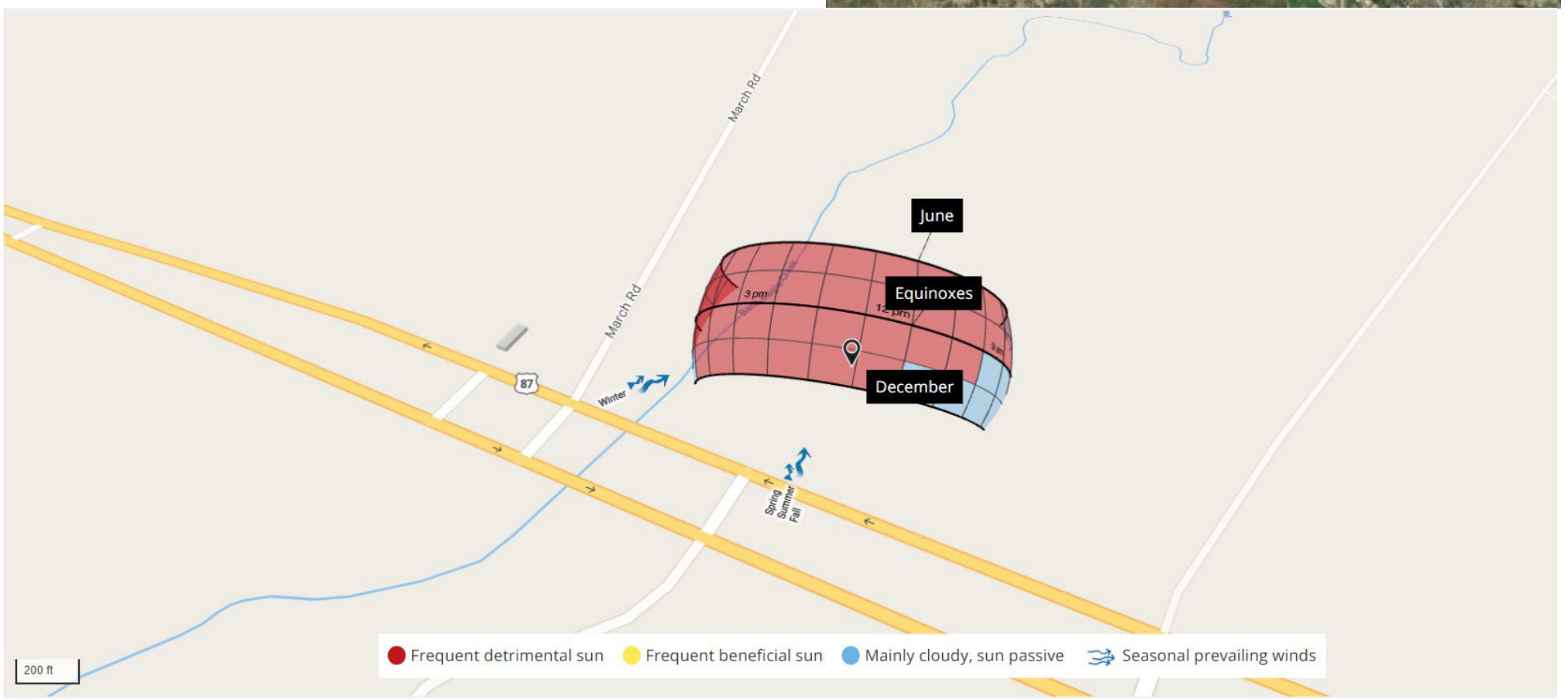
Logan Rath

ANALYSIS:
SITE

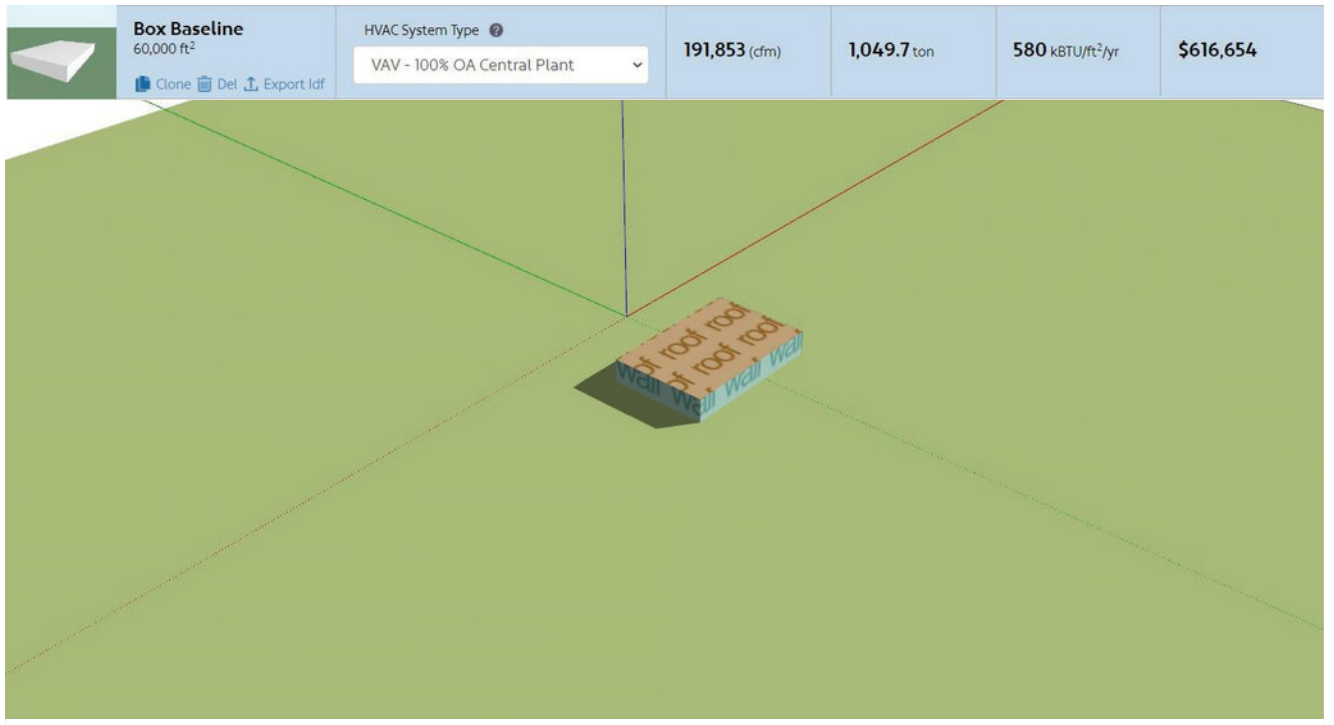
This sun study illustrates the altitude of the sun in the summer and winter months.

This allows for an informed design when placing windows and shading devices, and for configuring patio overhangs and internal daylighting effectiveness.



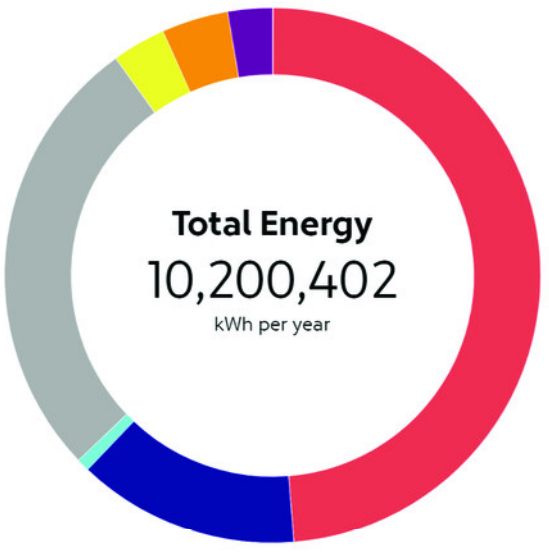


ANALYSIS:
MASSING OPTIMIZATION



A bare rectangular prism was placed on the site, at the approximate location for the building, to establish a baseline for potential energy consumption of a building.

This shape was filled with three floors, and approximately 30% window to wall ratio of exterior glazing.



Segment	kWh per year	% of total use
Heating	**4,971,056**	**49 %**
AHU	3,820	0 %
Zones	4,967,236	49 %
Humidification	0	0 %
Cooling	**1,443,209**	**14 %**
AHU	1,364,083	13 %
Heat Rejection	79,126	1 %
Zones	0	0 %
Fans	**2,773,192**	**27 %**
AHU	2,773,192	27 %
Zones	0	0 %
Interior	**739,220**	**7 %**
Lighting	328,542	3 %
Equipment	410,678	4 %
Pumps	**273,725**	**3 %**

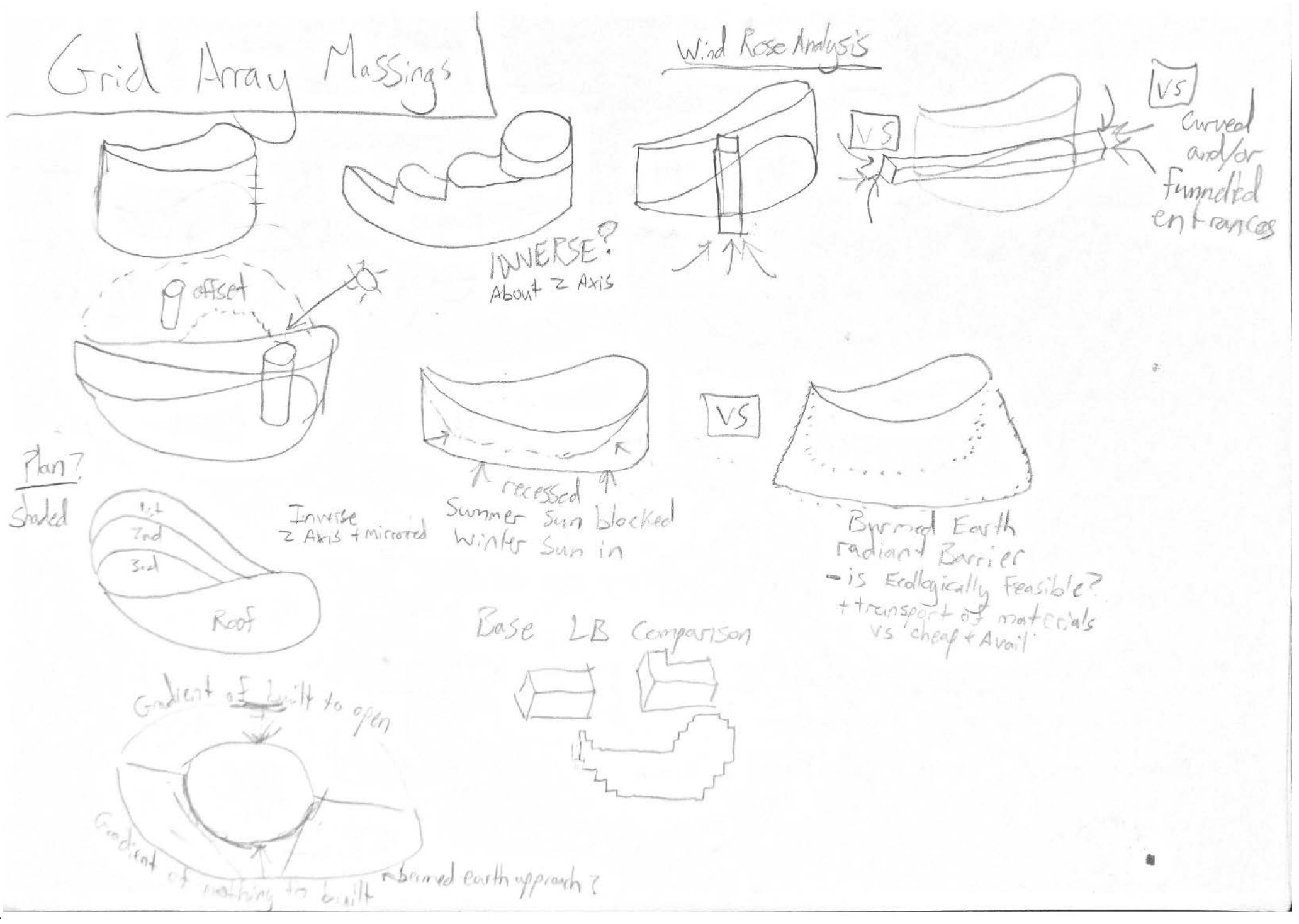
FS Mass 1 - Box Baseline. Produced by Logan Rath from LRATH89@TAMU.EDU, 21 Oct 2022 @ 11:22:27

From this basic model, ran in Sketchup with Sefairra, I was able to establish a rough estimation of what a building could expect to expend in kilowatt per hour annually.

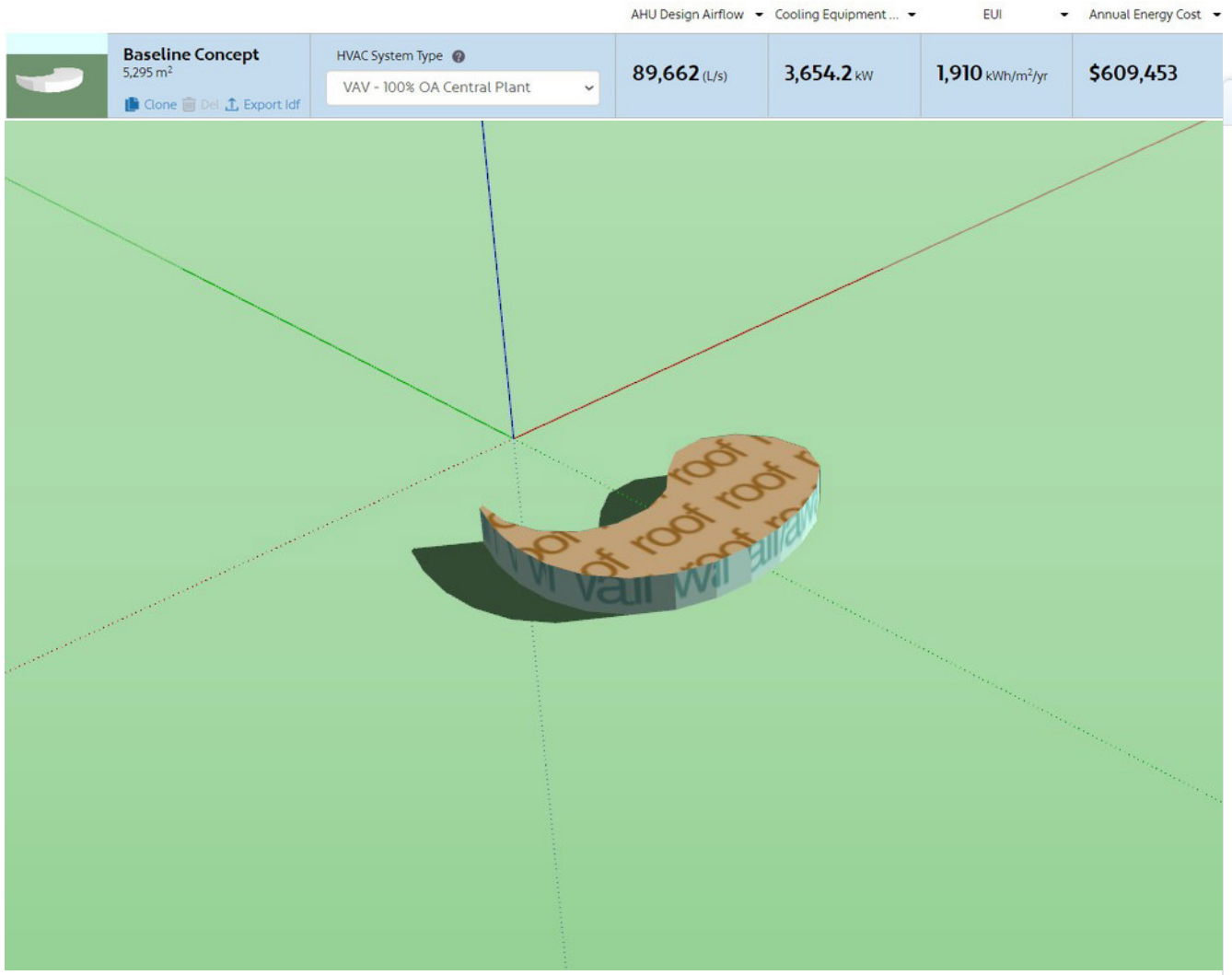
ANALYSIS:

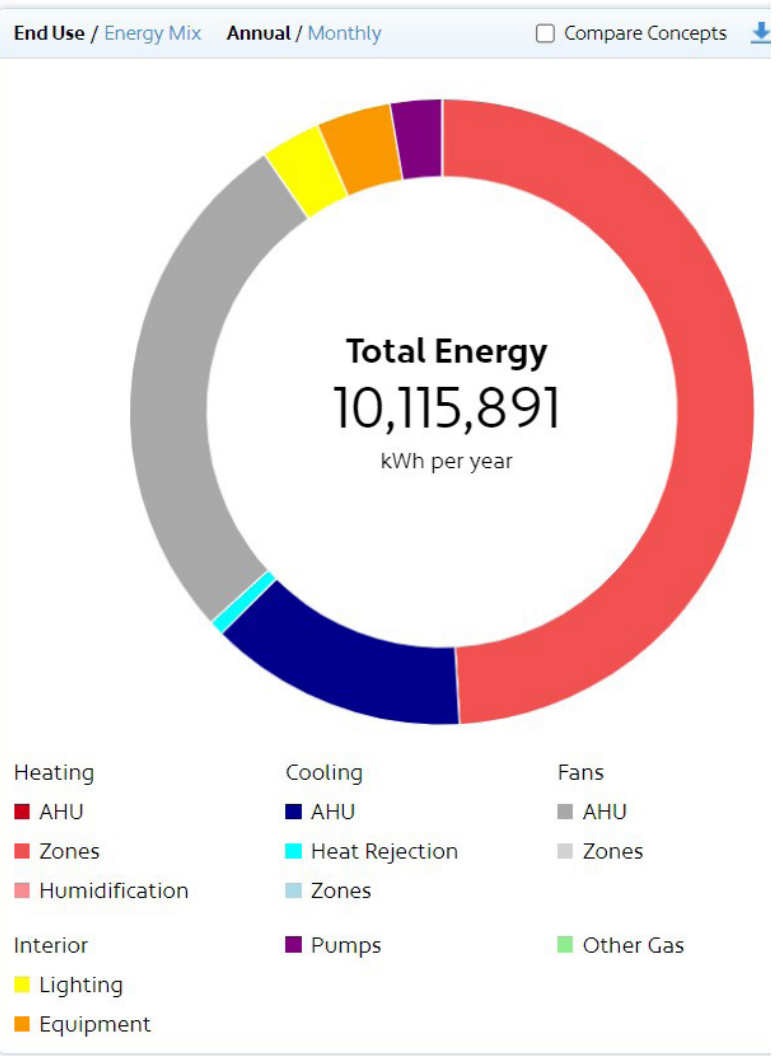
MASSING OPTIMIZATION

In the early stages of the project I made some rough sketches of potential massings based on the concept of flowing water and symbols for balance, wich I took to the perfect representation of Humans, Stewardship, and Nature.



ANALYSIS:
MASSING OPTIMIZATION



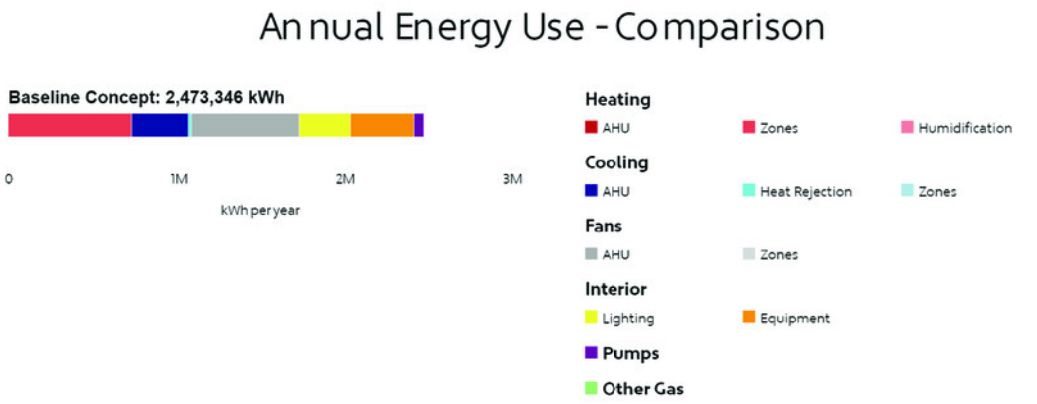


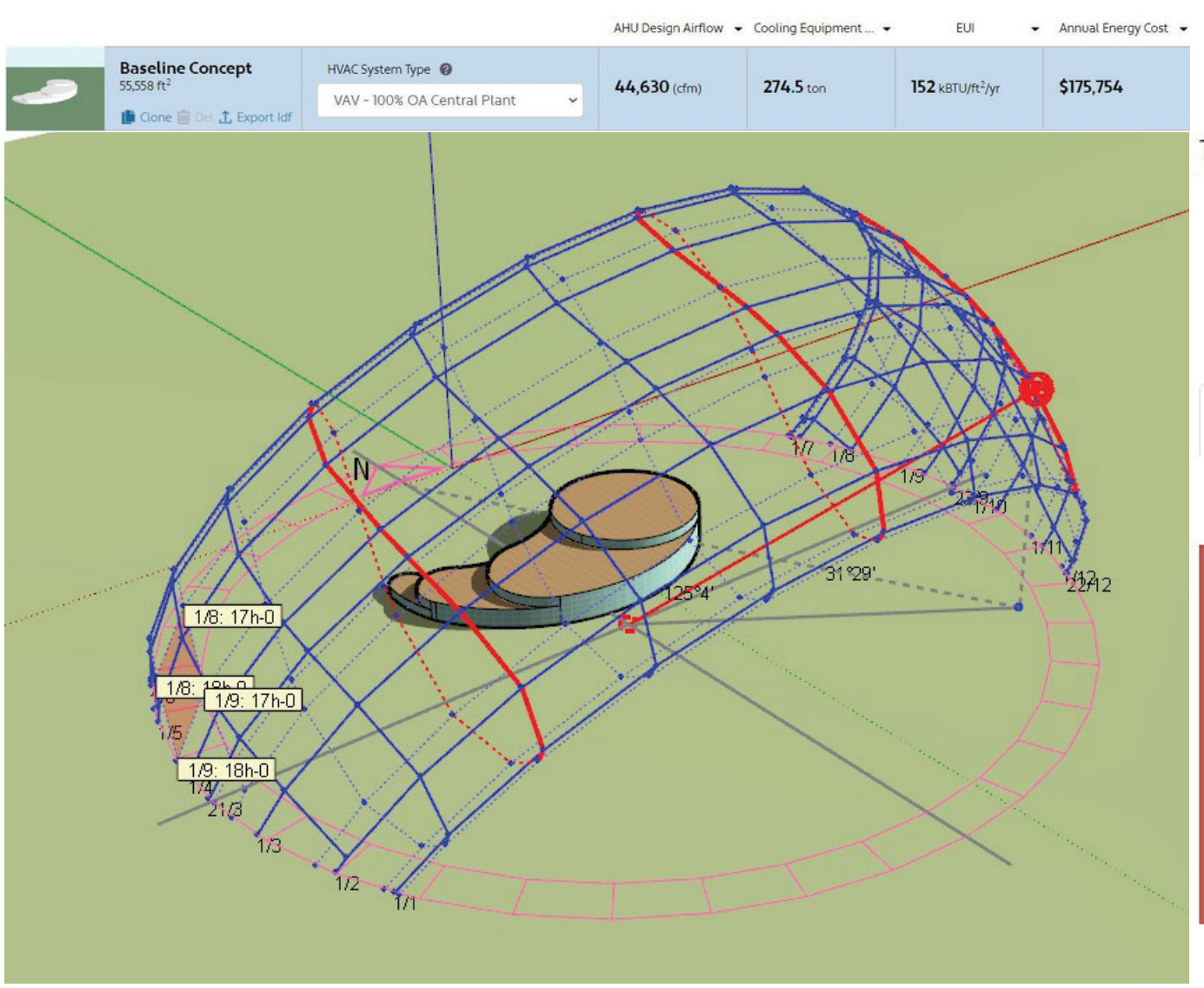
This model is the first of my inspired forms that I started comparing to see how they would measure up against the control model.

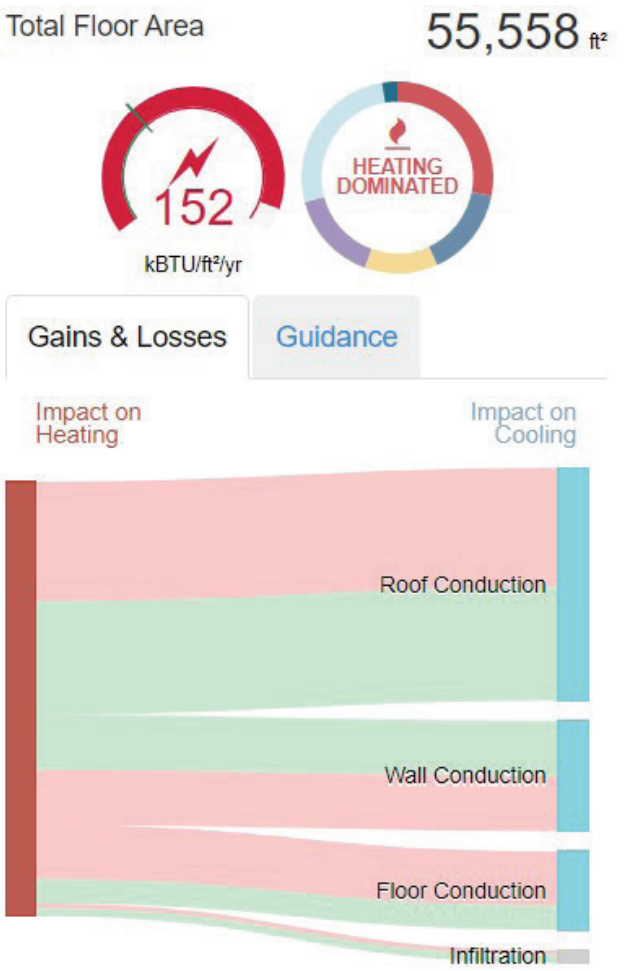
The thought processing being, if one shape in particular was most successful, I would then use that form to guide the parameters of the generative design algorithms, and adjust the form as needed.

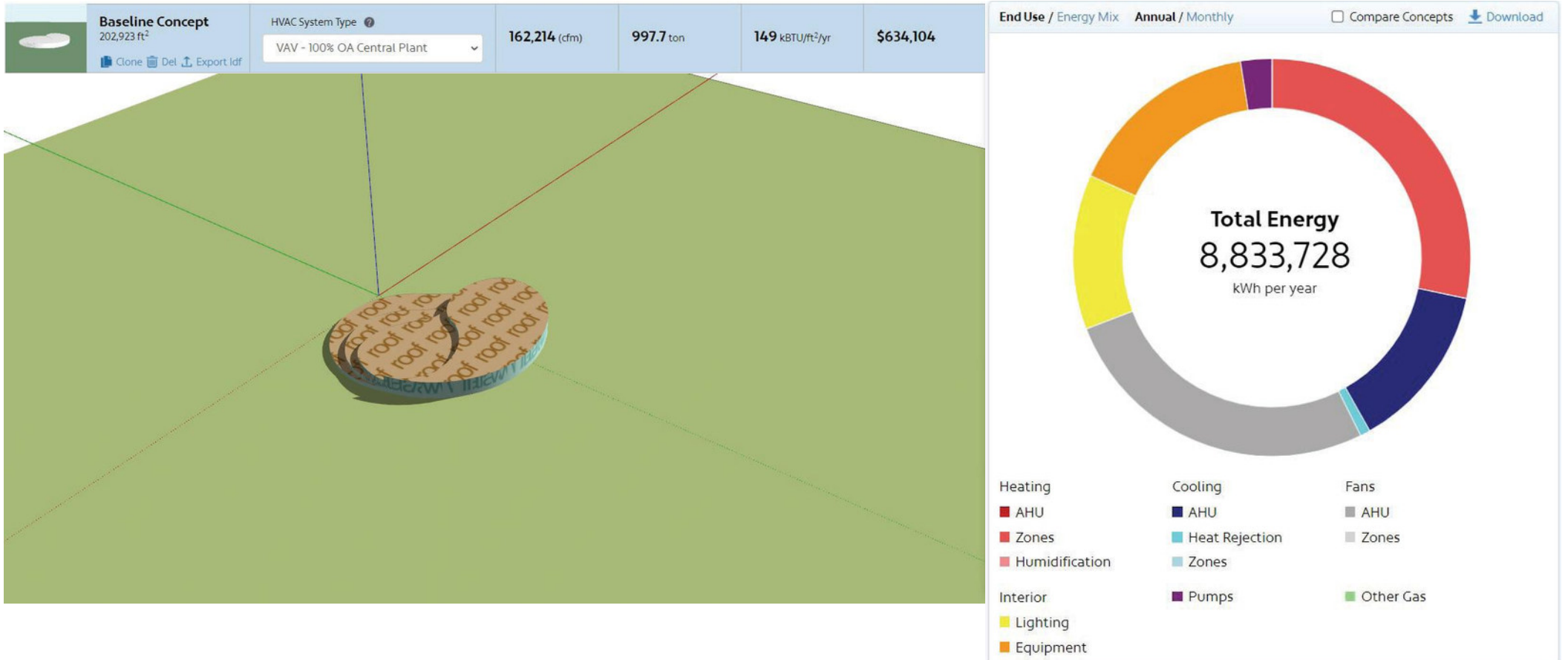
5 | PART I - PRIMARY PROCEDURE

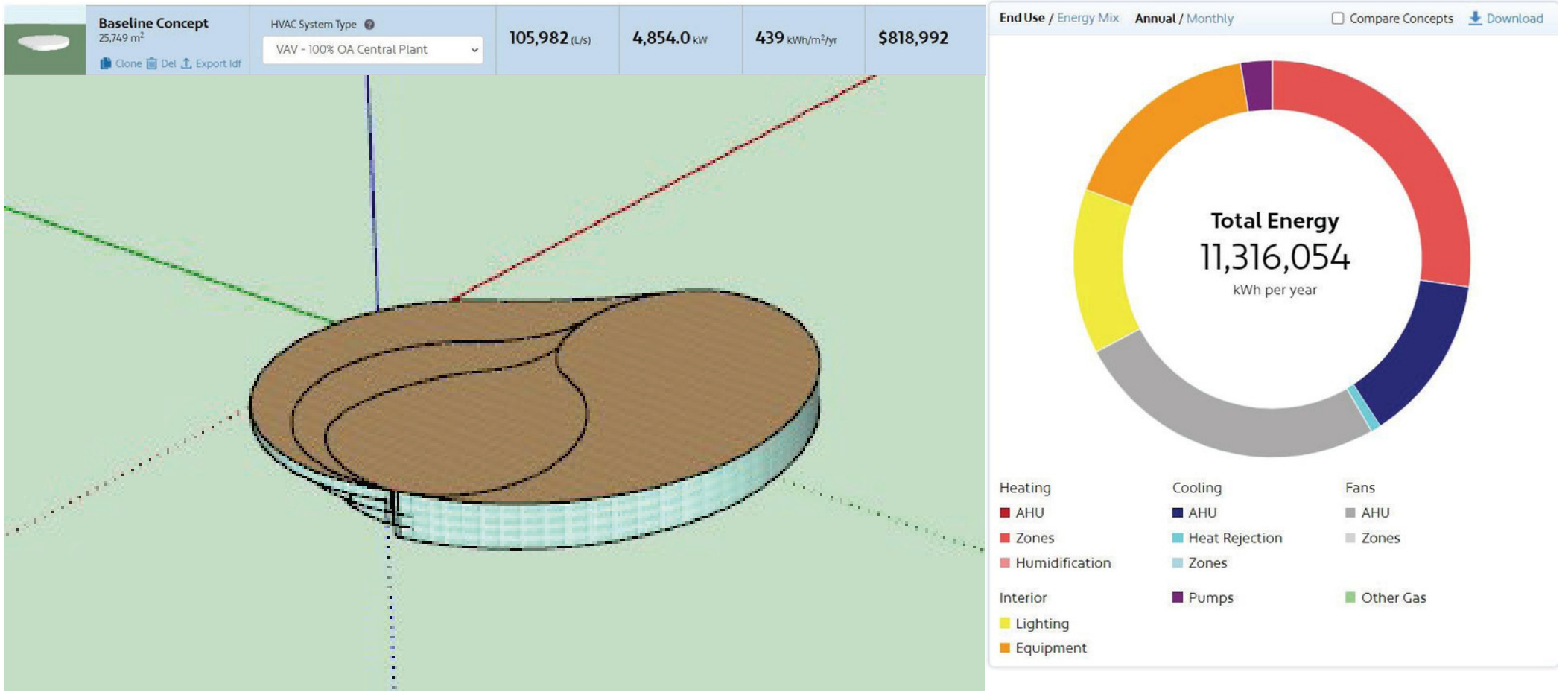
EXPLORATION

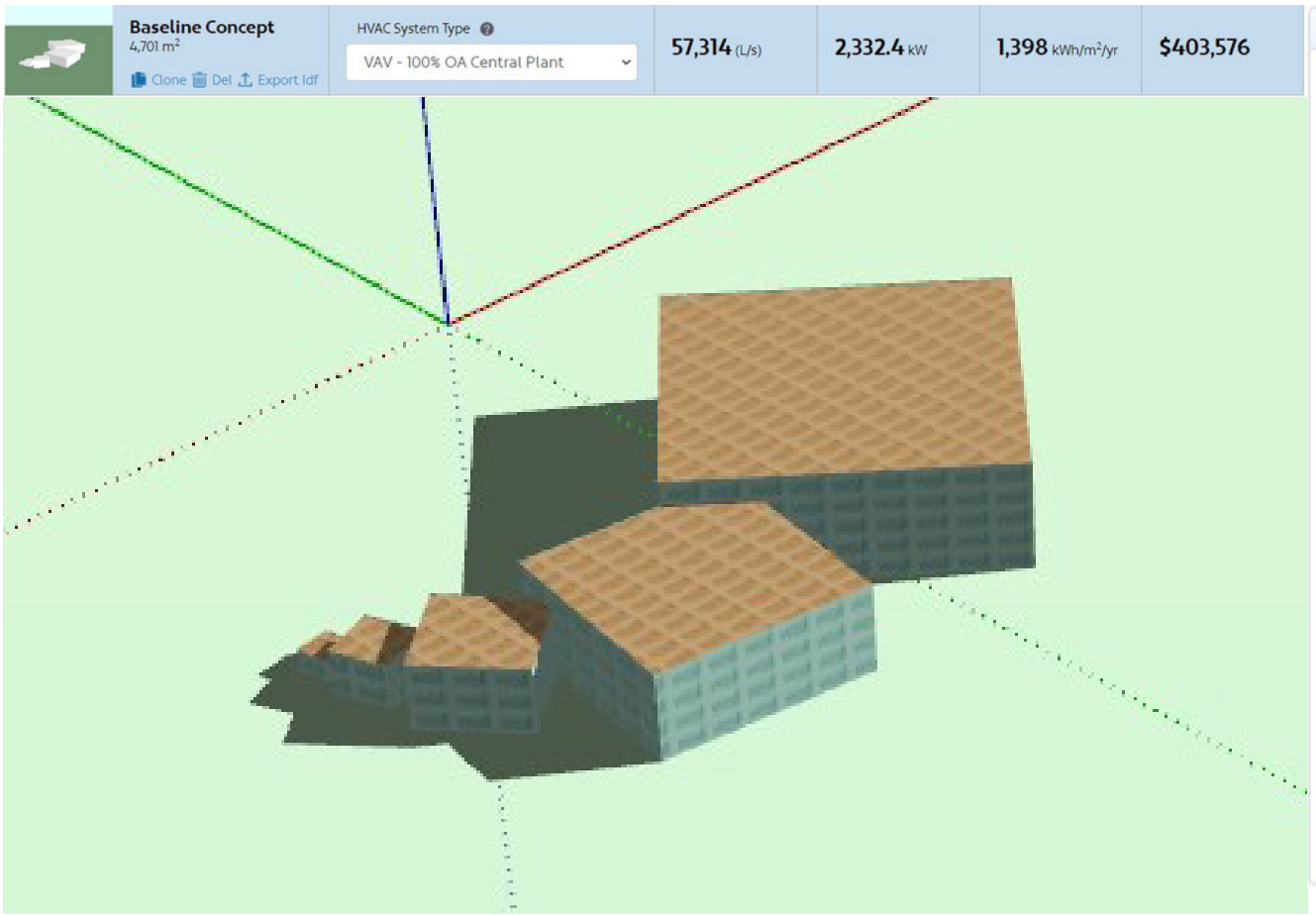


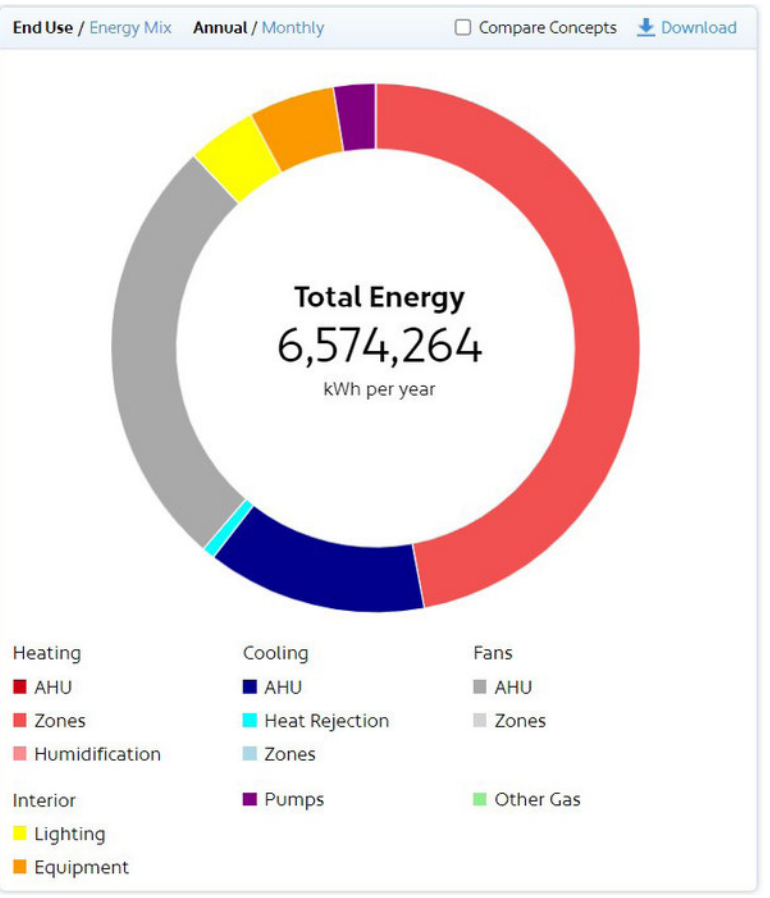


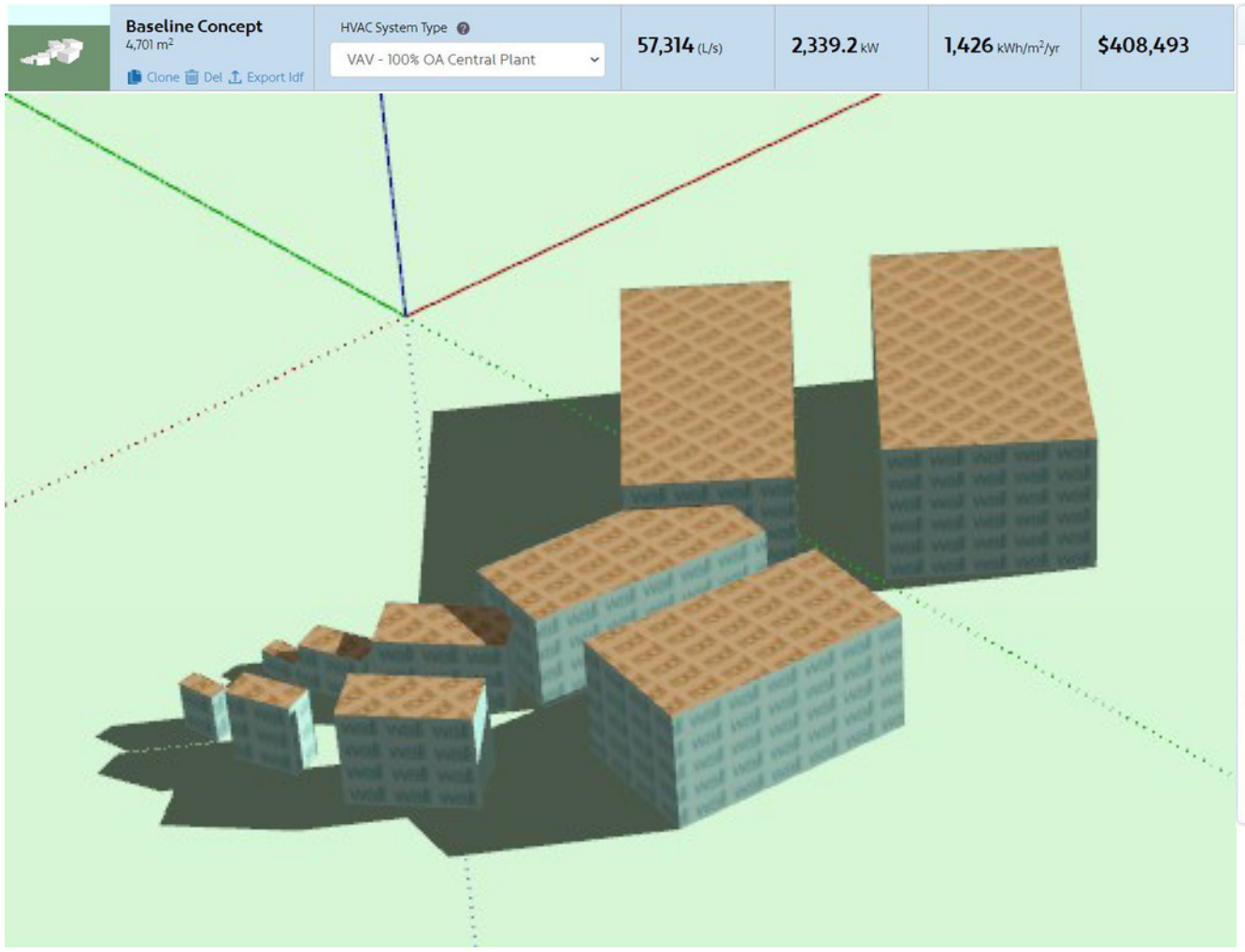


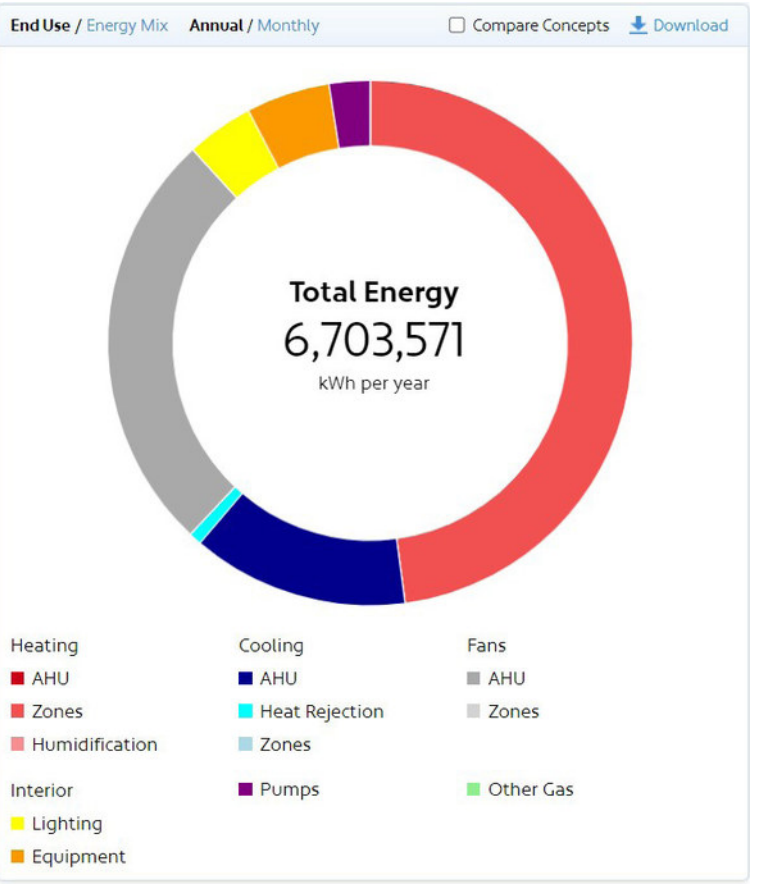

Baseline Concept
202,923 ft²
Clone Del Export Idf
HVAC System Type
VAV - 100% OA Central Plant
162,214 (cfm)
997.7 ton
149 kBTU/ft²/yr
$634,104
End Use / Energy Mix
Annual / Monthly
Compare Concepts
Download
Total Energy
8,833,728
kWh per year
Heating
AHU
Zones
Humidification
Cooling
AHU
Heat Rejection
Zones
Fans
AHU
Zones
Interior
Lighting
Equipment
Pumps
Other Gas


Baseline Concept
25,749 m²
Clone Del Export Idf
HVAC System Type
VAV - 100% OA Central Plant
105,982 (L/s)
4,854.0 kW
439 kWh/m²/yr
$818,992
End Use / Energy Mix
Annual / Monthly
Compare Concepts
Download
Total Energy
11,316,054
kWh per year
Heating
AHU
Zones
Humidification
Cooling
AHU
Heat Rejection
Zones
Fans
AHU
Zones
Interior
Lighting
Equipment
Pumps
Other Gas

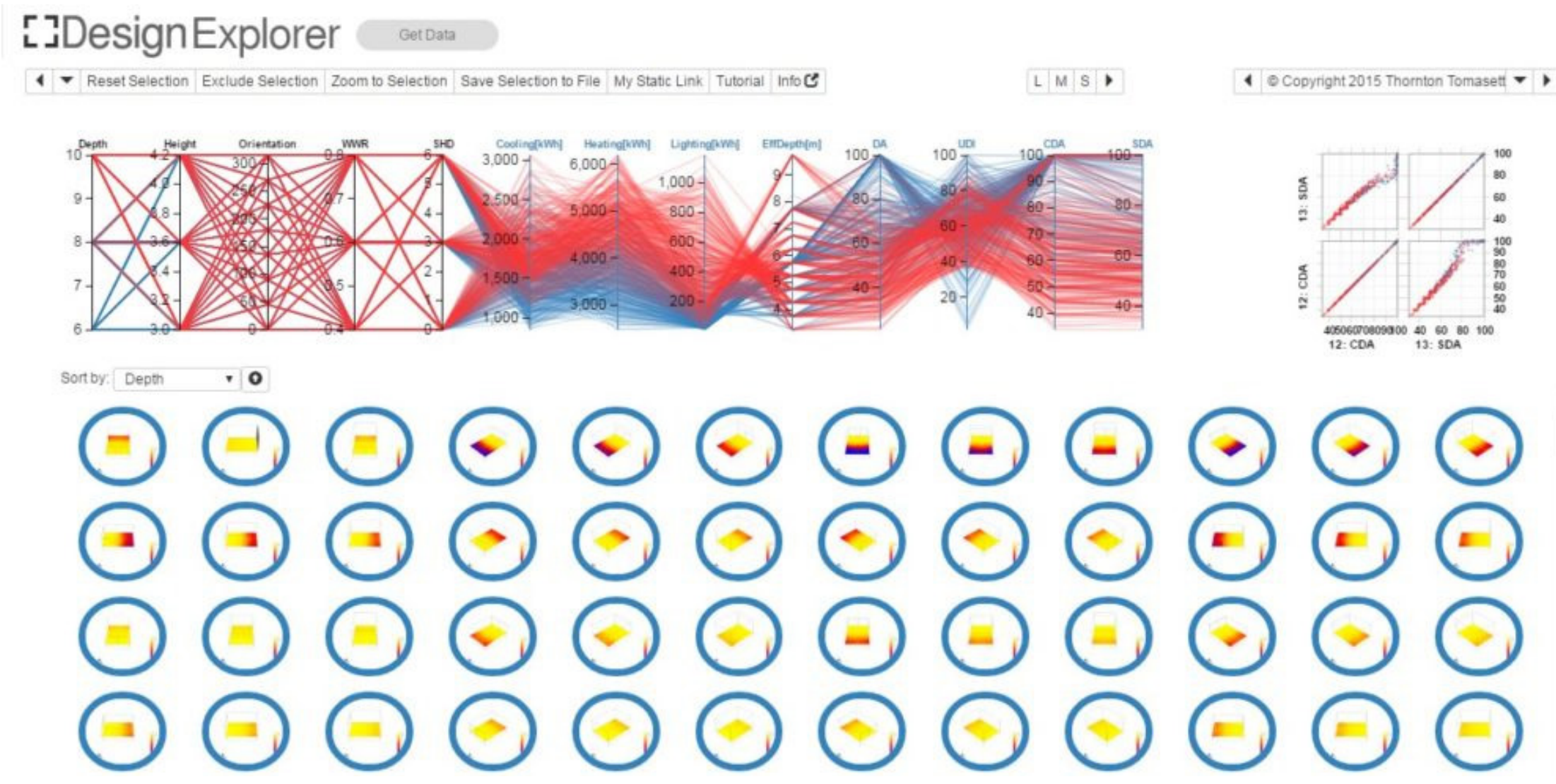

Baseline Concept
4,701 m²
Clone Del Export Idf
HVAC System Type
VAV - 100% OA Central Plant
57,314 (L/s)
2,332.4 kW
1,398 kWh/m²/yr
$403,576


End Use / Energy Mix
Annual / Monthly
Compare Concepts
Download
Total Energy
6,574,264
kWh per year
Heating
AHU
Zones
Humidification
Cooling
AHU
Heat Rejection
Zones
Fans
AHU
Zones
Interior
Lighting
Equipment
Pumps
Other Gas


Baseline Concept
4,701 m²
Clone Del Export Idf
HVAC System Type
VAV - 100% OA Central Plant
57,314 (L/s)
2,339.2 kW
1,426 kWh/m²/yr
$408,493


End Use / Energy Mix
Annual / Monthly
Compare Concepts
Download
Total Energy
6,703,571
kWh per year
Heating
AHU
Zones
Humidification
Cooling
AHU
Heat Rejection
Zones
Fans
AHU
Zones
Interior
Lighting
Equipment
Pumps
Other Gas

GENERATION:
OPTIMIZATION



Design Explorer, hosted at https://tt-acm.github.io/DesignExplorer/, is an open-source tool used for exploring multi-dimensional parametric studies.

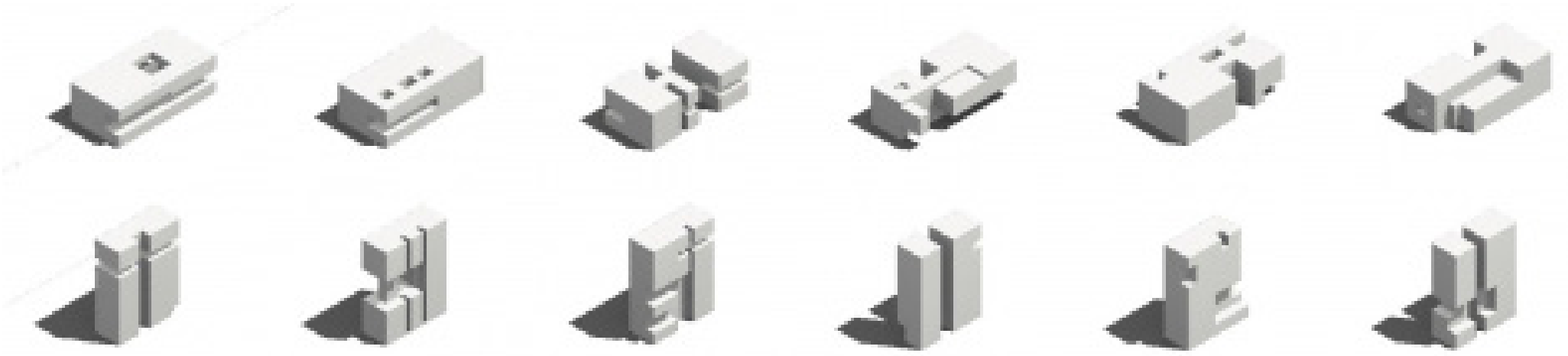
A parametric study is a type of analysis where you change the parameters of a system to see how those changes affect the output or behavior of the system.

Multi-dimensional means the tool can handle multiple parameters at once. In the building example, this means you could change, e.g., the material, shape, and insulation, all at the same time, and see how all three changes together affect the cost, energy efficiency, and aesthetics.

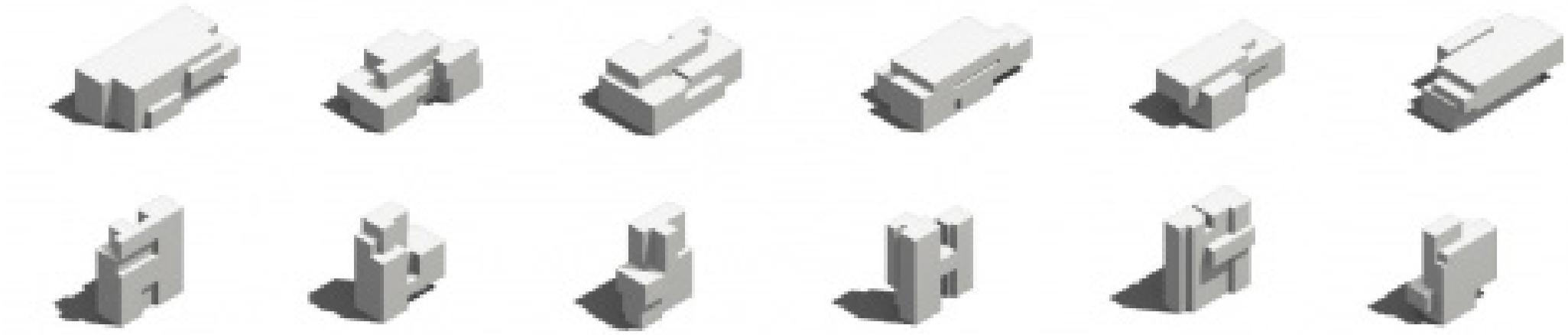
The chart on the left is a Parallel Coordinates Plot, which is a common type of visualization used in multi-dimensional parametric studies, This type of chart allows for the visualization of multi-dimensional data.

In a parallel coordinates plot, each line represents one configuration of parameters, and each vertical axis represents one parameter of the system. The position of the line along an axis represents the value of that parameter for that data point.

Design Explorer imports the data in an excel format, places all of the various generations onto the chart, then allows users to change the criteria and isolate specific iterations.



Building massing generation model based on the subtractive form generation principle



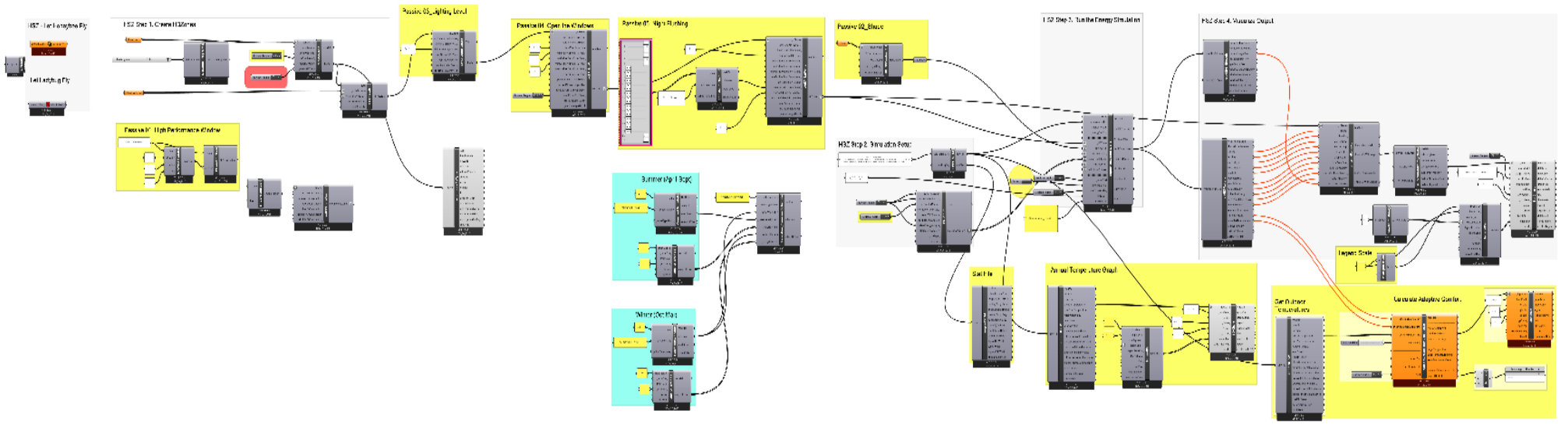
Building massing generation model based on the additive form generation principle

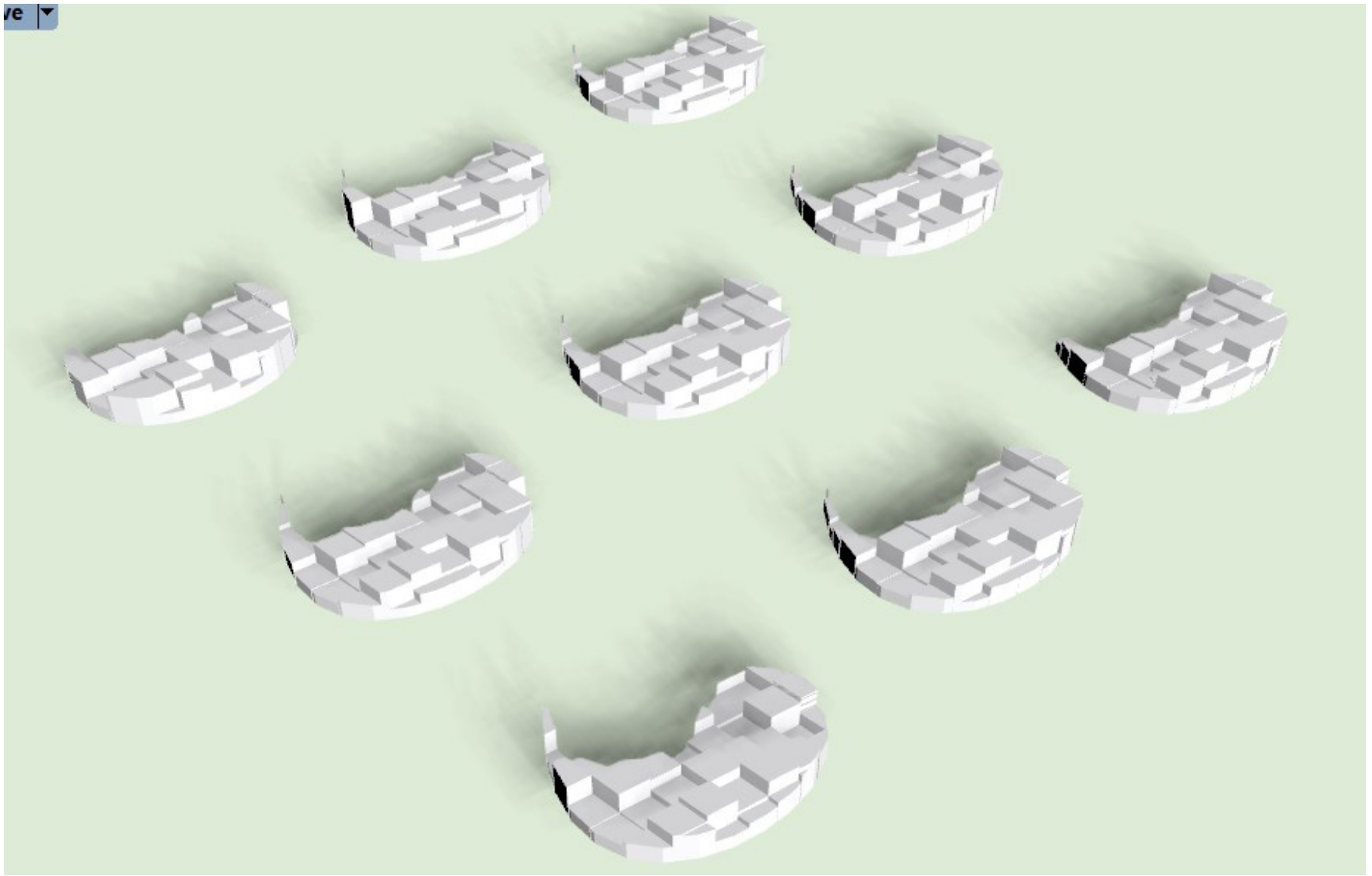
The software also displays the physical models that correlate to each iteration below the chart.

For example, the massings above were provided with the Grasshopper Plugin Evomass, which allows the designer to specify a set of parameters to add cubes through tens of thousands of iterations, then run all of those massings through a Design Explorer program to isolate the designs that best match the criteria that we prioritize.

GENERATION:
PARAMETRICISM

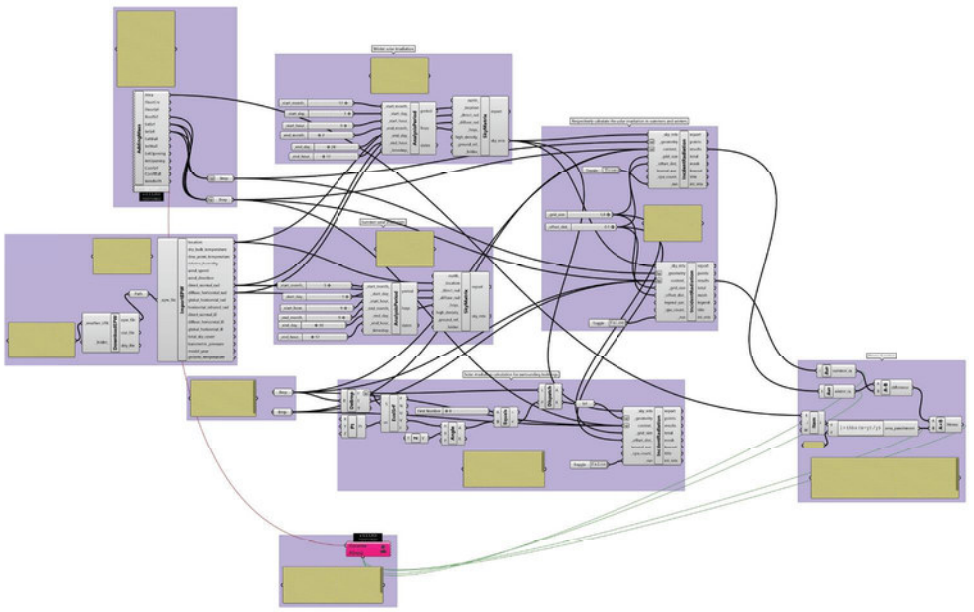
The following represents my initial attempt at assigning parametric massing generations within a field of shape constraints utilizing the Grasshopper Plug-in Galapagos, another evolutionary algorithm solver that shuffles through the may thousands of permutations dependent on the designer assigned variables.

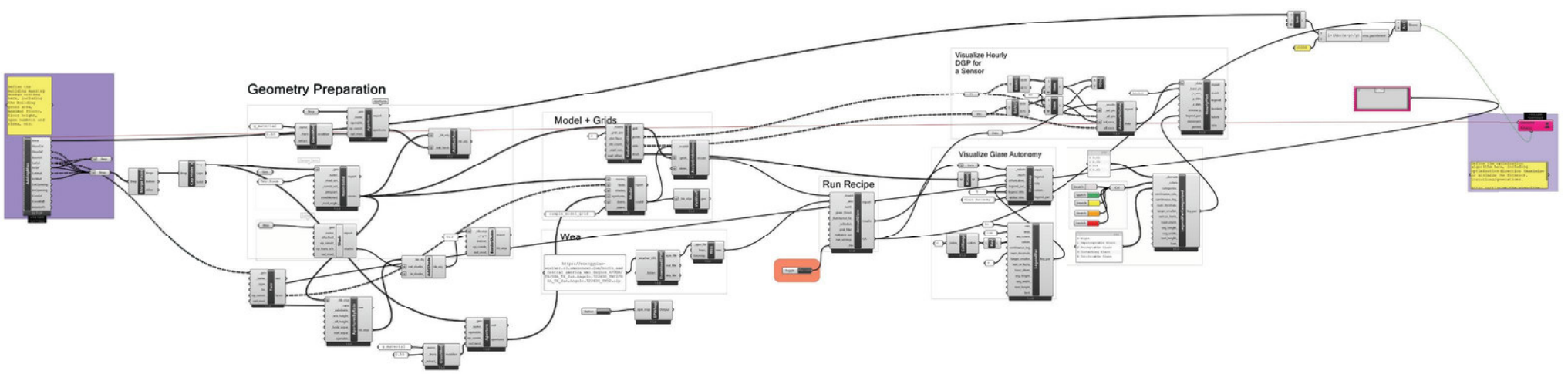




GENERATION:
PARAMETRICISM

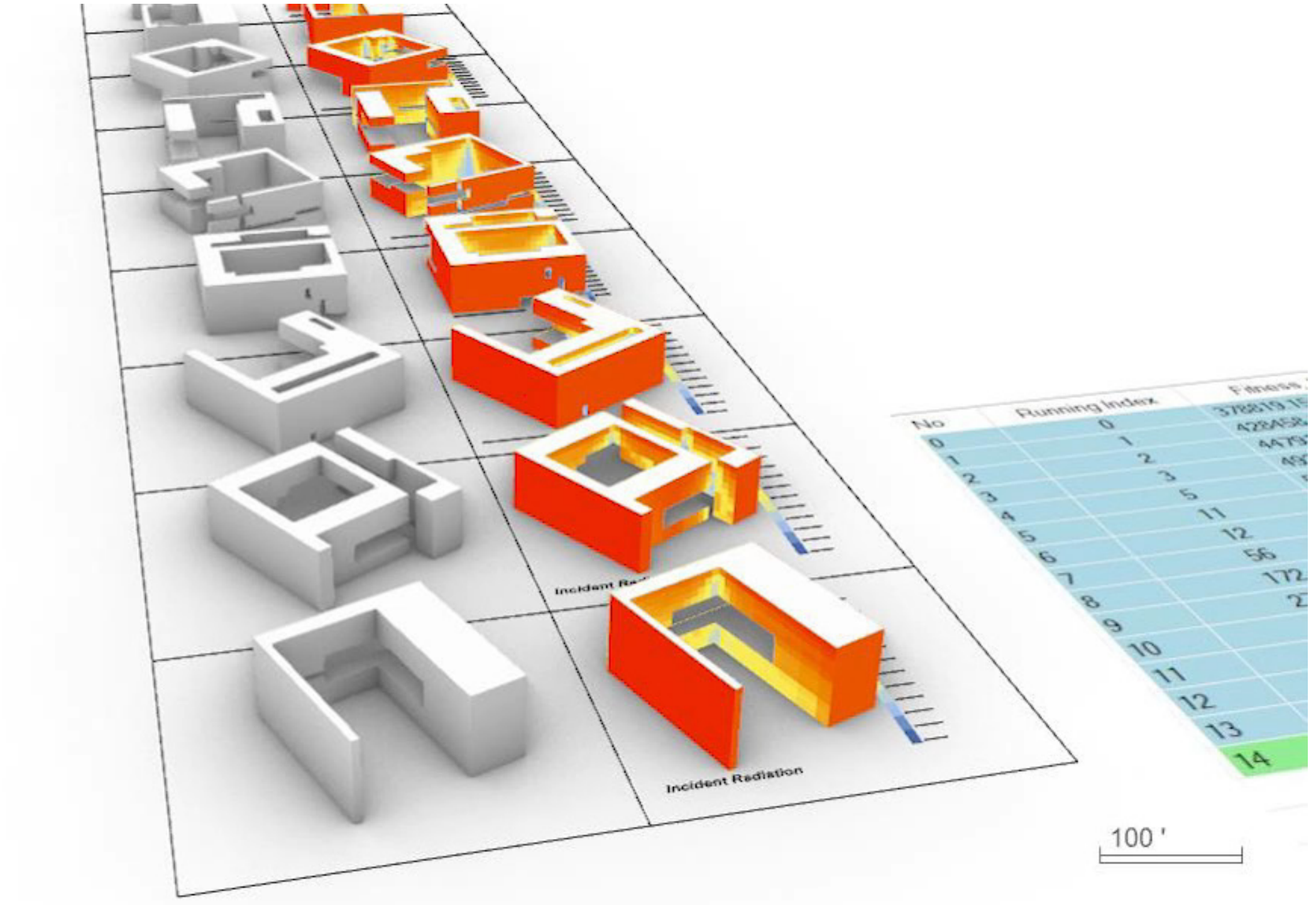
To provide the criteria/data points against which to evaluate the generated massings, I linked a Grasshopper - Ladybug Plugin script that analyzes the positive solar radiation gained by a building in the winter months against the negative solar radiation it gains in the summer months, with a constant negative value assigned to glare throughout all months.





The generated massings with the most optimal scores within the first 5,000 generations were physically created in Rhino, with an overlay corresponding to the solar radiation received in total.

For the initial 5,000 generations it took my laptop 12 hours to compute, and even then it was nowhere near the most optimal design, but it did lead to some interesting design conclusions and inferences that could be drawn from the simulations.



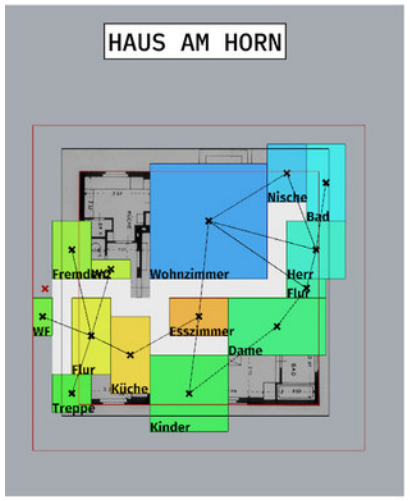
GENERATION:
PARAMETRICISM

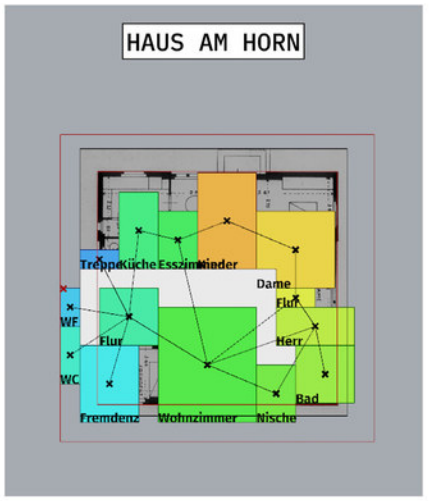
Other plug-ins available during my research were PlanBee, Termite Nest, and Space Chase. The aim of these plug-ins is to take data provided from a designer and placing blocks with corresponding square footage, in relation to other blocks which represent program.

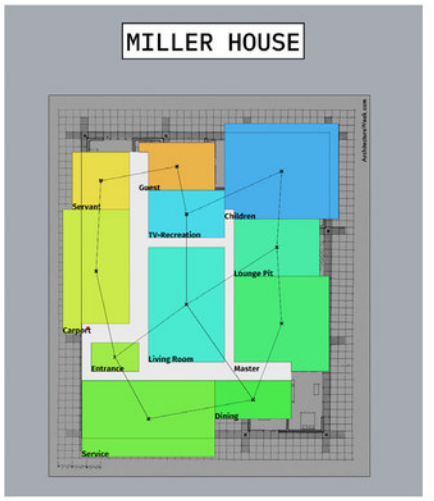
The designer inputs into an excel spreadsheet which rooms relate to which other rooms, making it as intricate as needed, then defining potential building envelopes as preferred, or leaving an open space.

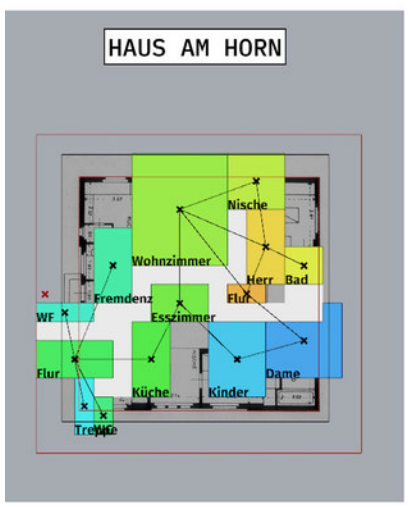
These plug-ins rely on another physics based Plug-in, Kangaroo, which applies “springs”, “attractors”, and repellers to each of the objects.

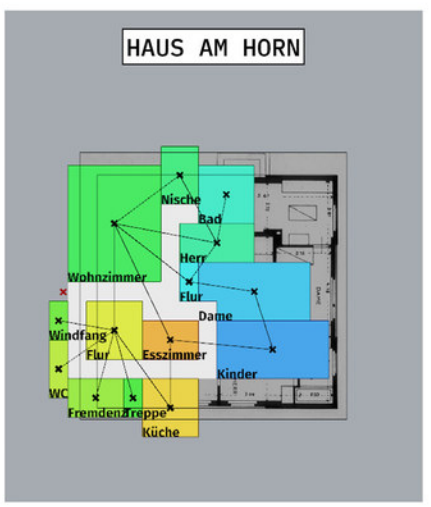
Some prominent examples of how the programs can run is provided by the creators below.

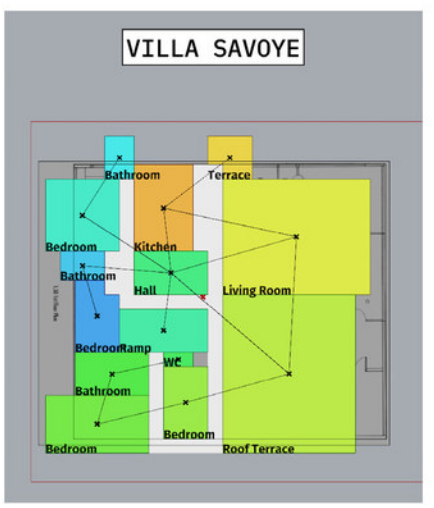


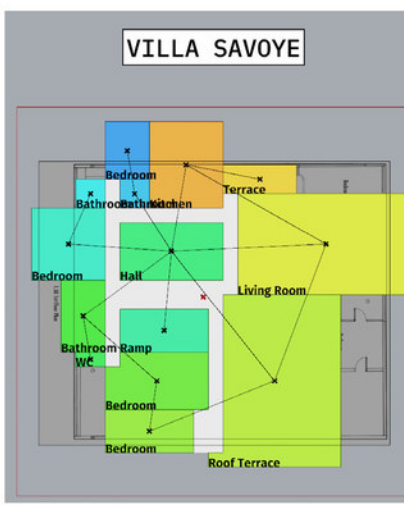




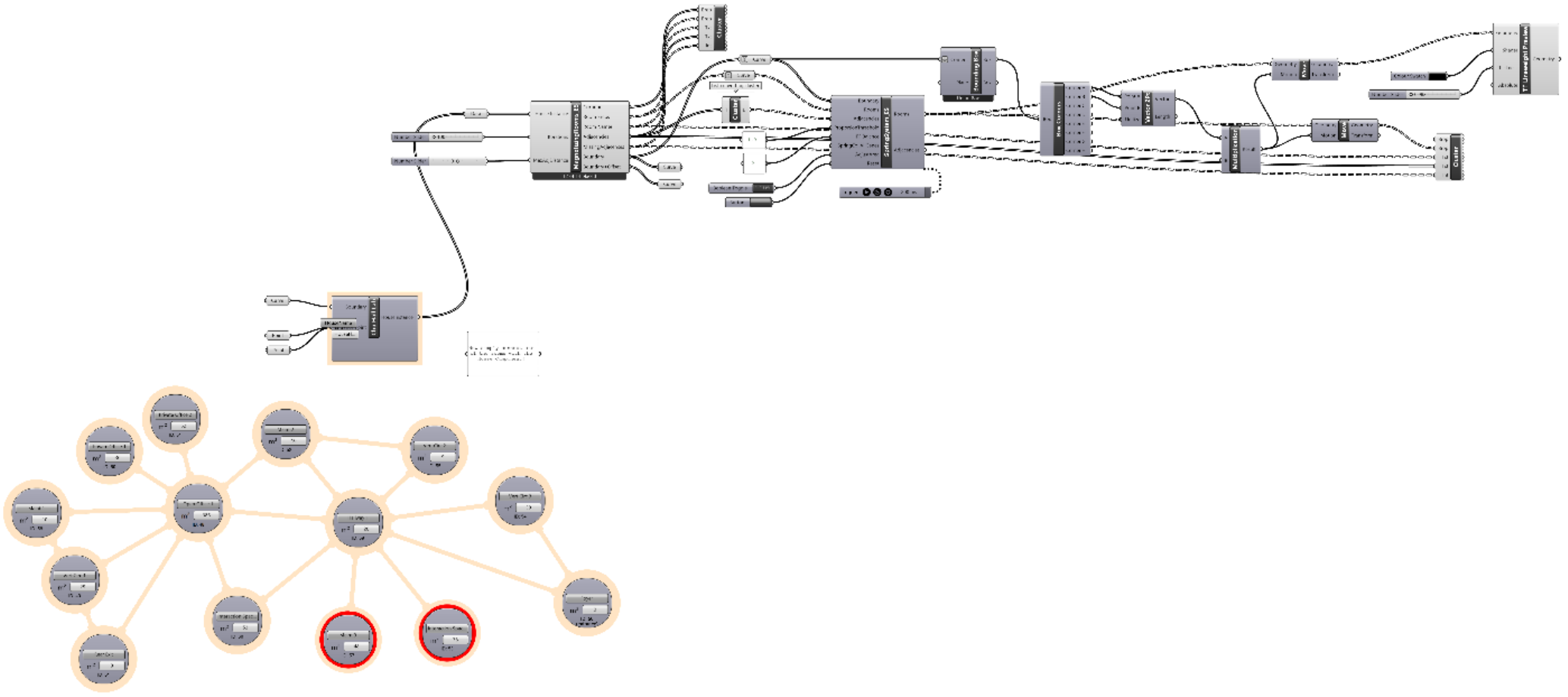




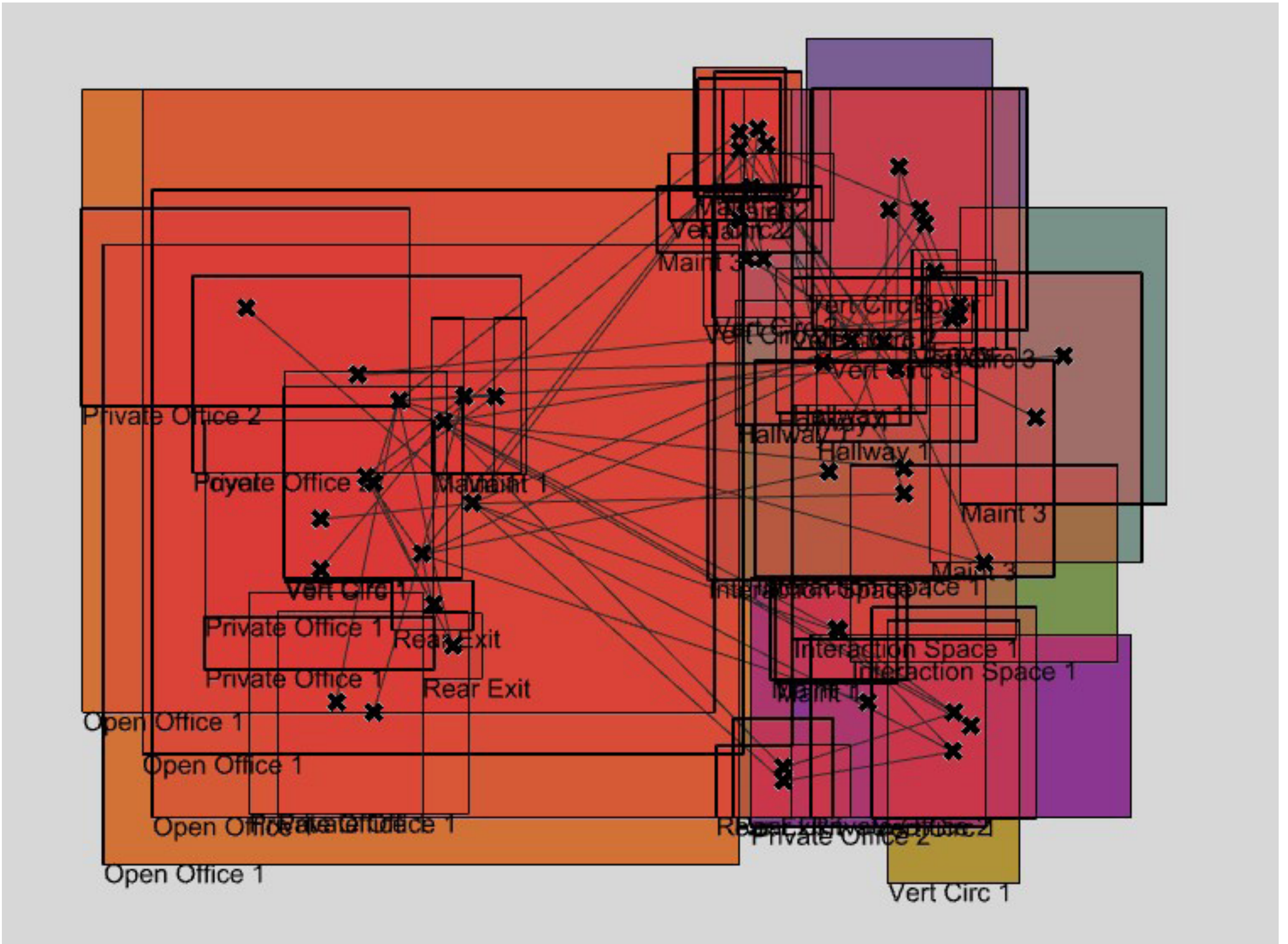


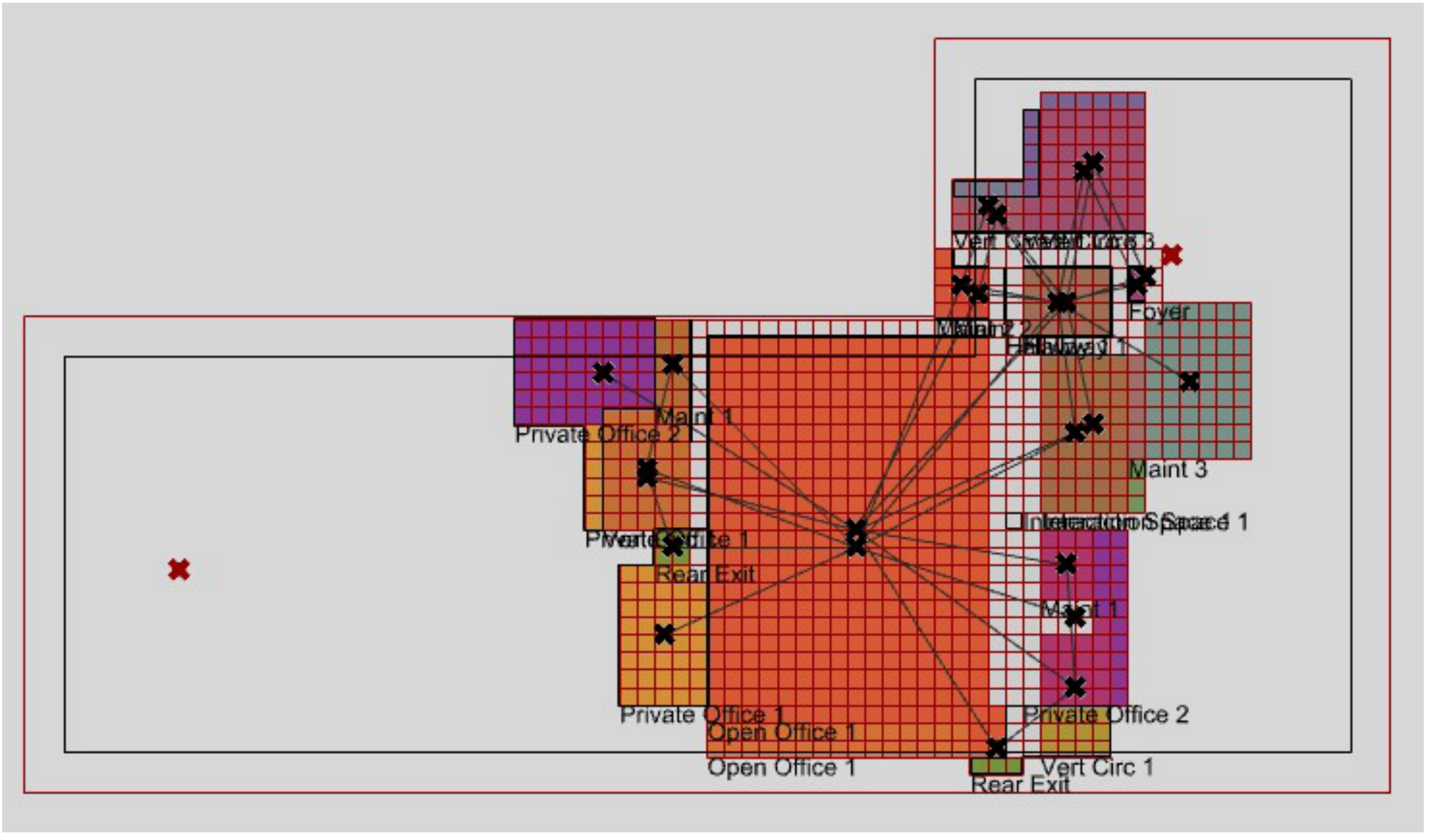


My own explorations with these programs led to rough definitions of what the spaces could look like, what the overall building shape could be, and how the program could potentially be situated within a prescribed shape.



GENERATION:
PARAMETRICISM




Foyer
Maint 1
Private Office 2
Maint 3
Rear Exit
Private Office 1
Open Office 1
Open Office 1
Private Office 2
Vert Circ 1
Rear Exit

6 | PART II - PROGRESSION PHASE

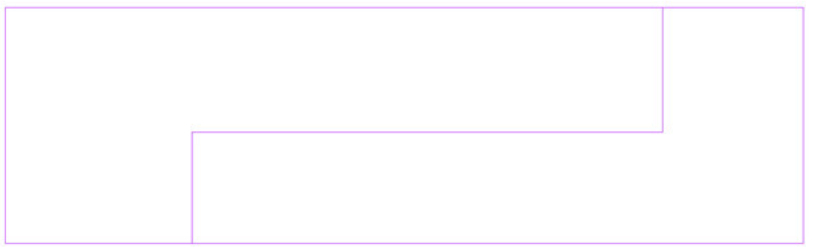
FUNDAMENTALS

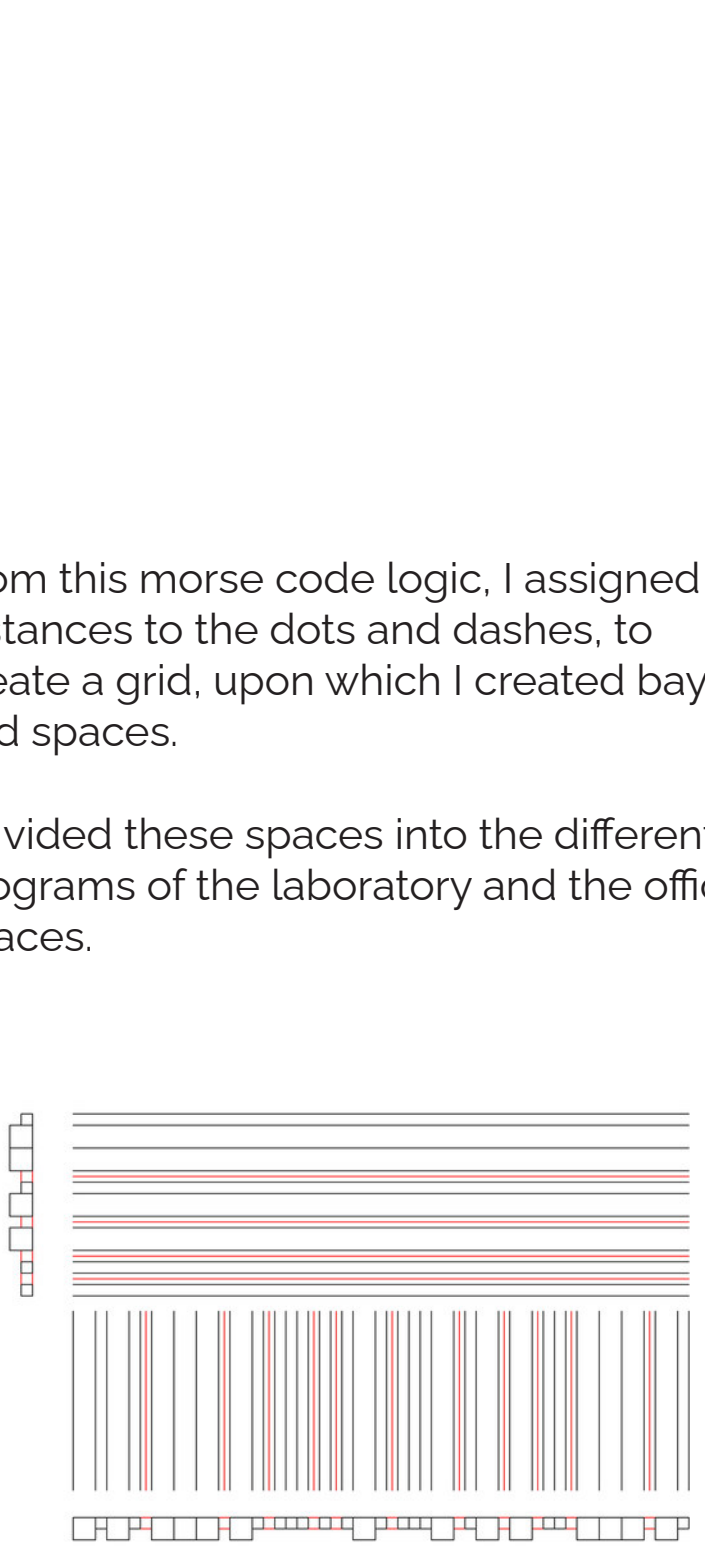
Six months into the project I took a return to the fundamentals of deriving more inspiration of the building from the site.

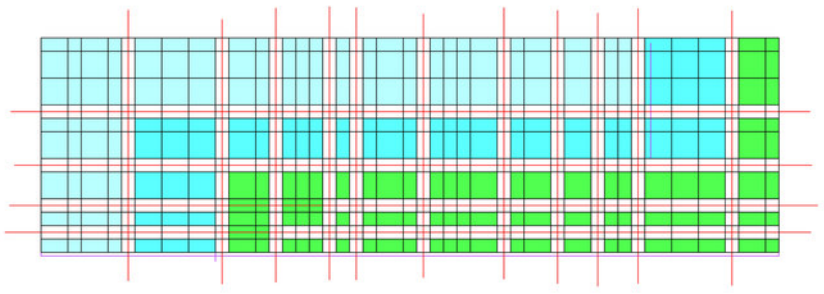
I saw from the site, the most prominent feature of the semi-dry creek bed, flowing south, jutting abruptly to the west, and then diverting south again. I interpreted this motion to the start, stop, start motion of morse code. A technological invention that brought communication and innovation to the world, much as the research laboratory and education outreach center would.

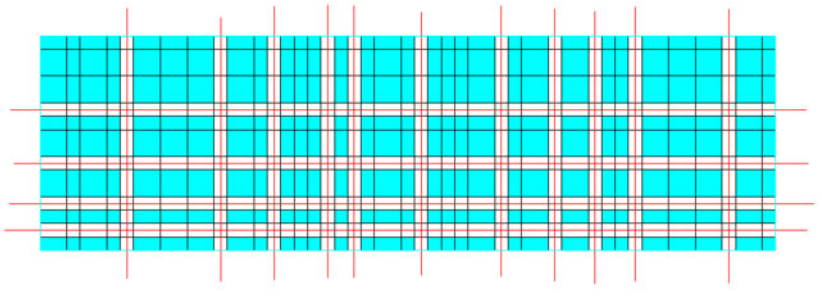
From this morse code logic, I assigned distances to the dots and dashes, to create a grid, upon which I created bays, and spaces.

I divided these spaces into the different programs of the laboratory and the office spaces.







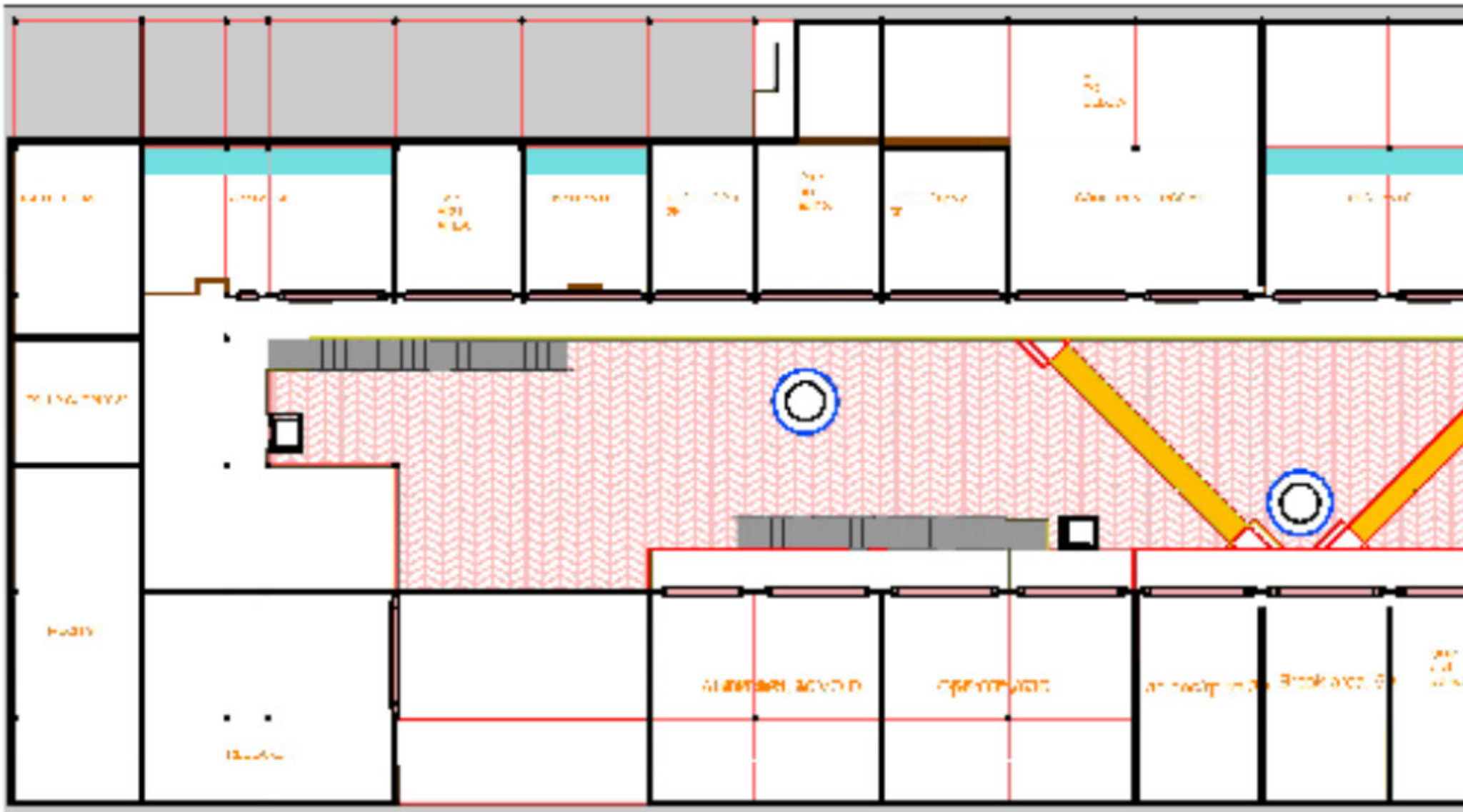


PROGRESSION

SPACE LAYOUT

I divided the two separate spaces with an open atrium to be filled with plants, rest and reflection areas, collaboration areas, fountains and evaporative cooling towers.

RESEARCH to the North

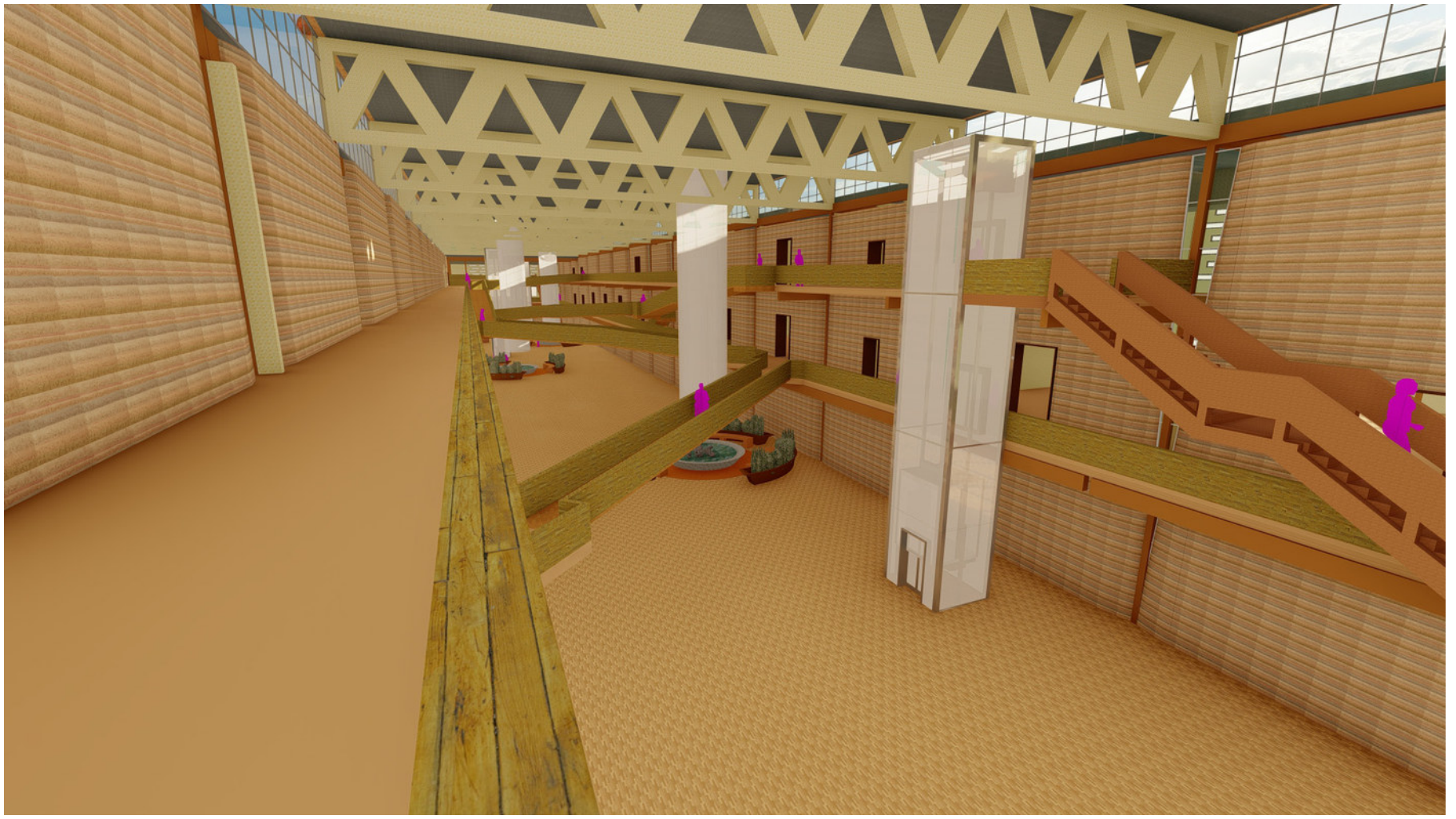


OFFICES to the South

The labs were placed to the north to protect research projects from excessive sunlight, and the offices were placed to the south to take advantage of the natural light. The spaces between the two programs are activated by the crossing ramps that provide unique vantage points throughout the space.

Early Ramp Layout and Organization

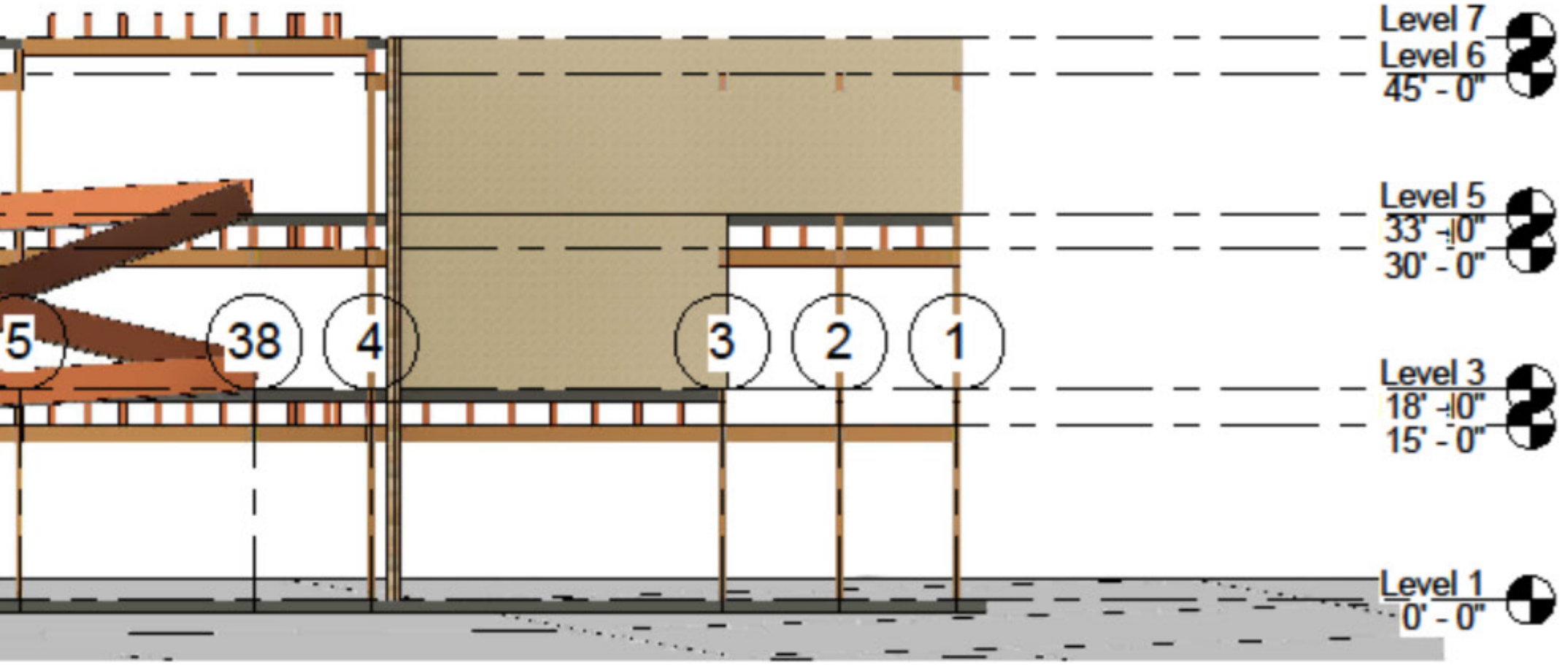
PROGRESSION
UNIQUE VIEW POINTS

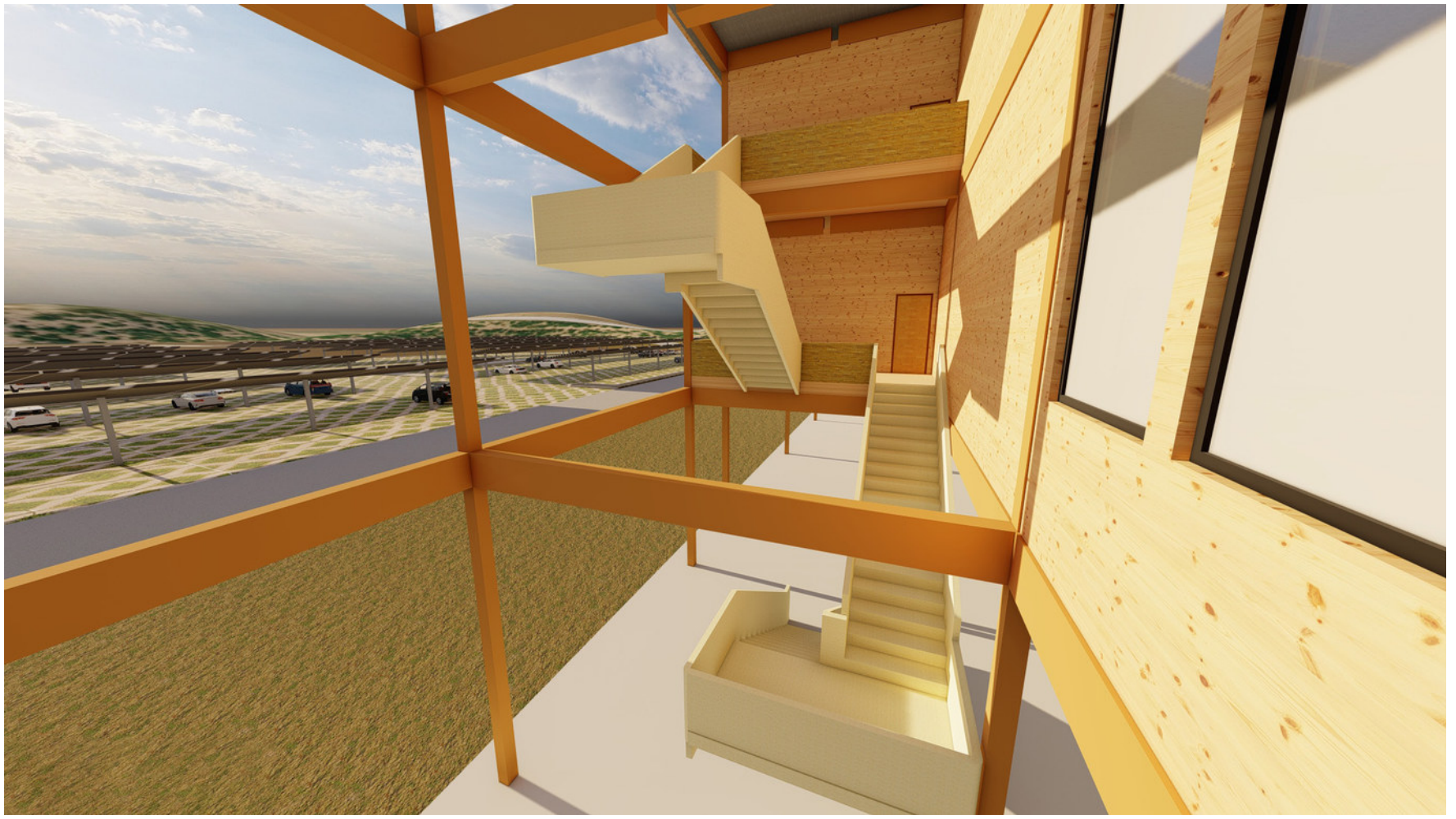


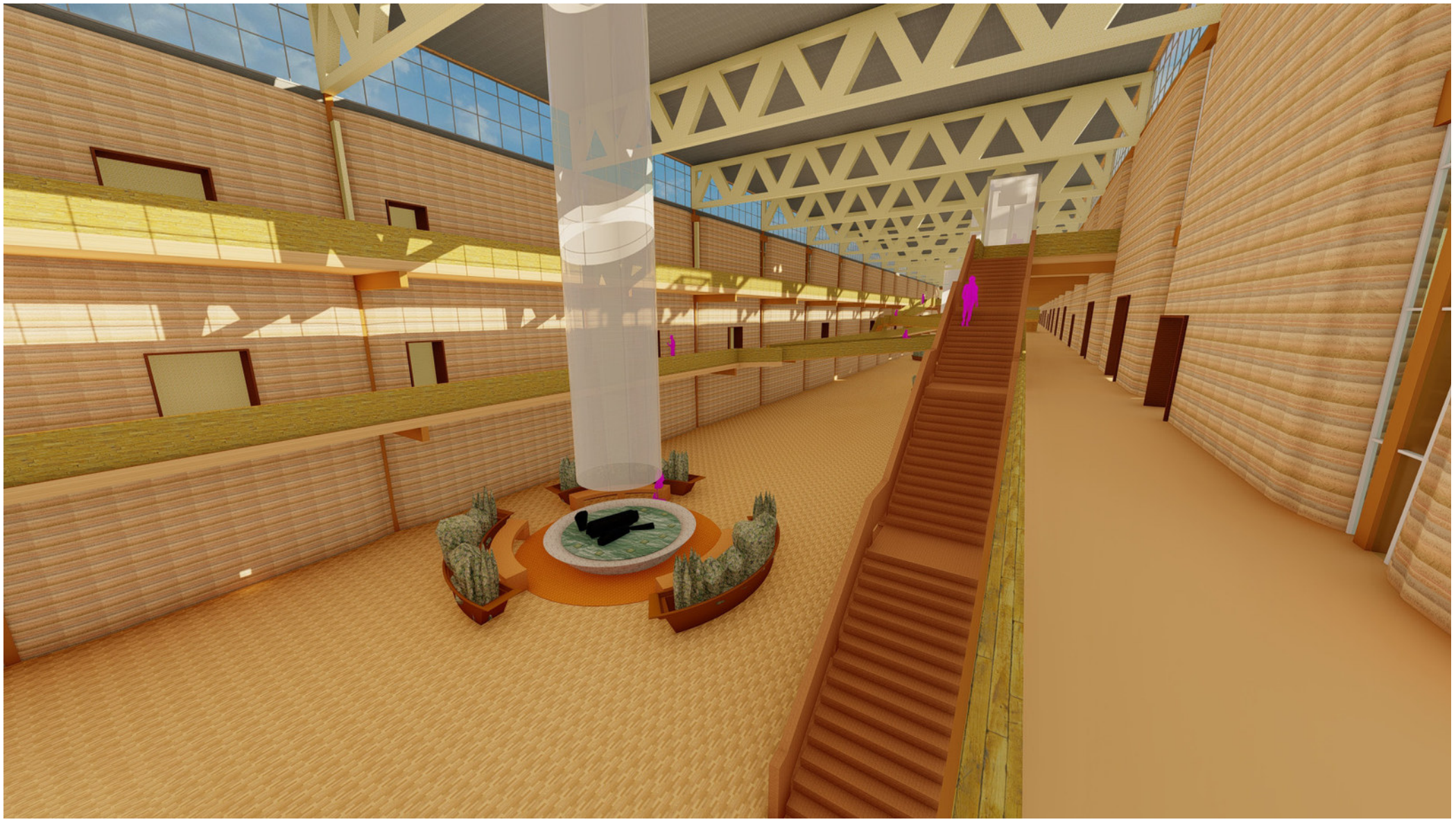
PROGRESSION
UNIQUE VIEW POINTS

The north levels are 3 feet higher than the south levels, created a 1st, 2nd, 3rd, 4th, and 5th floors. This allows a greater spatial generation, allows more ambient light to enter the north side, and provides more overhang and shade on the south side.

Rammed earth walls create the bulk of the walls, and carve out unique habitable pavilion like spaces under the upper floors.







PROGRESSION
BIOPHILIC TOOLS

Material Connection with Nature

- Decreased diastolic blood pressure

- Improved creative performance

- Improved comfort (Tsunetsugu)

Presence of Water

- Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure

- Improved concentration and memory restoration

- Enhanced perception and psychological responsiveness

- Observed preferences and positive emotional responses (Alvarsson)

Prospect, Refuge, Mystery, Risk, Peril

- Reduced stress, boredome, fatigue

- Improved comfort, perceived safety, and concentration

- Strong dopamine and pleasure response
(Terrapin)

Complexity and Order

- Positively impacted physiological and perceptual stress responses

- Observed view preference
(Terrapin)

Dynamic and Diffuse Light

- Positively impacted circadian system functioning

- Increased visual comfort

- Enhanced positive health responses; shifted perspectives of environment
(Terrapin)

7 | *IMPRESSIONS & INSIGHTS*

This thesis presents a compelling exploration of the role of architectural design in fostering environmental stewardship and biophilia. The incorporation of biophilic design elements and the adoption of sustainable materials underline the pivotal role of biophilia in architecture, aiming to promote a sense of wellbeing and environmental awareness. The use of generative design techniques and tools like Design Space Exploration, Grasshopper plugins, and other design tools have all been instrumental in creating an environmentally-responsive building. Energy efficiency markers, daylighting considerations, and sun orientation considerations demonstrate the importance of adapting to the site's unique environmental conditions.

The meticulous process, from initial energy consumption estimates to the evolution of the design through algorithms, showcases the iterative nature of sustainable design. It highlights how different parameters can influence the building's energy efficiency, aesthetics, and functionality.

Due to the parametric design and optimization software, I was able to make informed decisions on material, shape, insulation, and more, understanding how these factors affected cost, energy efficiency, and aesthetics.

The project emphasizes the pivotal role of architecture as a medium to promote environmental stewardship. It showcases how thoughtful design, informed by the principles of sustainability and biophilia, can result in buildings that not only minimize their impact on the environment but also inspire users to adopt sustainable practices. It underlines the importance of a multidisciplinary approach in sustainable design, blending traditional insights, modern technology, and innovative design methodologies.

8 | BIBLIOGRAPHY

Adler, M. &. (1952). Nature. In R. M. (Ed.), The Great Ideas: A Syntopicon of Great Books of the Western World (Vol. 3, pp. 456-511). Encyclopedia Britannica.

Alexander, C. I. (1977). A Pattern Language: Towns, Buildings, Construction. Oxford University Press.

Alvarsson, J. J., Wiens, S., & Nilsson, M. E. (2010). Stress recovery during exposure to nature sound and environmental noise. International Journal of Environmental Research and Public Health, 7(3), 1036-1046. https://doi.org/10.3390/ijerph7031036

Bergdoll, B. A., & Obrist, H. U. (2017). Emilio Ambasz: Emerging Nature. Lars Müller Publishers.

Broad Institute of MIT and Harvard. (2022, September). Campus Facilities. Retrieved from Broad Institute of MIT and Harvard: https://www.broadinstitute.org/about-us/facilities-and-operations/campus-facilities/

Koolhaas, R. (2020). Countryside: A Report. Taschen.

Living Future Institute. (2019, June). Living Building Challenge 4.0: A Visionary Path to a Regenerative Future. Retrieved from https://living-future.org/lbc/

McLennan, J. F. (2004). The philosophy of sustainable design the future of Architecture. Ecotone.

National Renewable Energy Laboratory. (2022, September). About the Research Support Facility. Retrieved from National Renewable Energy Laboratory: https://www.nrel.gov/rsf/about-rsf.html

Simon, S. (2o22, July 16). A water crisis restricts usage to 6 hours a day in one of Mexico's largest cities. Retrieved from npr.org: https://www.npr.org/2022/07/16/1111868458/a-water-crisis-restricts-usage-to-6-hours-a-day-in-one-of-mexicos-largest-cities

Terrapin Bright Green. (2014). 14 patterns of biophilic design. Retrieved from Terrapin Bright Green: https://www.terrapinbrightgreen.com/wp-content/uploads/2014/04/14-Patterns-of-Biophilic-Design-Terrapin-Bright-Green-2014.pdf

Tsunetsugu, Y., Miyazaki, Y., & Sato, H. (2007). Physiological effects in humans induced by the visual stimulation of room interiors with different wood quantities. Journal of Wood Science, 53, 11-16. https://doi.org/10.1007/s10086-006-0812-5

The Nature Conservancy. (n.d.). Texas Water Program. Retrieved from Nature.org: https://www.nature.org/en-us/about-us/where-we-work/united-states/texas/stories-in-texas/tx-water-program/

USGS. (2013). Water Availability and Use Science Program: High Plains Aquifer Groundwater Availability Study. Retrieved from usgs.gov: https://www.usgs.gov/news/technical-announcement/usgs-high-plains-aquifer-groundwater-levels-continue-decline

Wright, F. L. (1953). “The Future of Architecture.”. New American Library, Horizon Press.

9 | APPENDIX

SOFTWARE RESOURCES

1. MIT Design Space Exploration
    a. food4rhino.com/en/app/design-space-exploration
    b. https://github.com/Digital-Structures/gh-design-space-exploration
    c. digitalstructures.mit.edu/page/tools#design-space-exploration-tool-suite-for-grasshopper

2. EvoMass
    a. food4rhino.com/en/app/evomass

3. Space Syntax
    a. https://www.food4rhino.com/en/app/syntactic
    b. https://genesis-lab.dev/products/syntactic/

4. Termite Nest
    a. https://www.food4rhino.com/en/app/termite-nest
    b. https://sites.google.com/view/termite-nest/home

5. Wallacei
    a. https://www.food4rhino.com/en/app/wallacei
    b. https://www.wallacei.com/

6. Grasshopper - Ladybug Suite
    a. https://www.food4rhino.com/en/app/ladybug-tools
    b. https://www.ladybug.tools/
    c. https://github.com/ladybug-tools/ladybug-grasshopper

7. Sefaira
    a. https://www.sketchup.com/products/sefaira
    b. https://www.youtube.com/c/Sefaira

8. Climate Studio
    a. https://www.solemma.com/climatestudio
    b. https://climatestudiodocs.com/
    c. https://www.youtube.com/@solemma

9. Cove.Tool
    a. https://cove.tools/
    b. https://cove.tools/rhinoceros-plugin
    c. https://www.youtube.com/@covetool/