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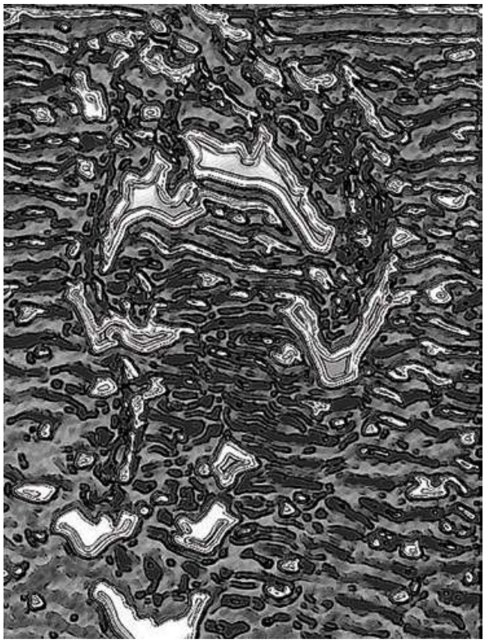
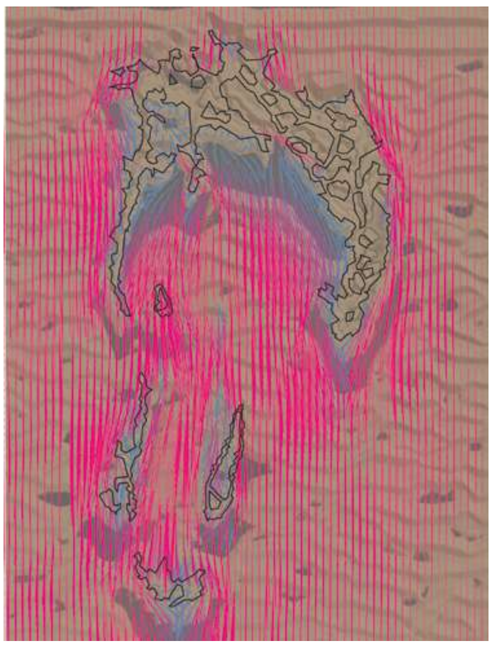
CONTENTS





Tactical Sedimentation of Architectural Reef System

Hanauma Bay, Honolulu, HI

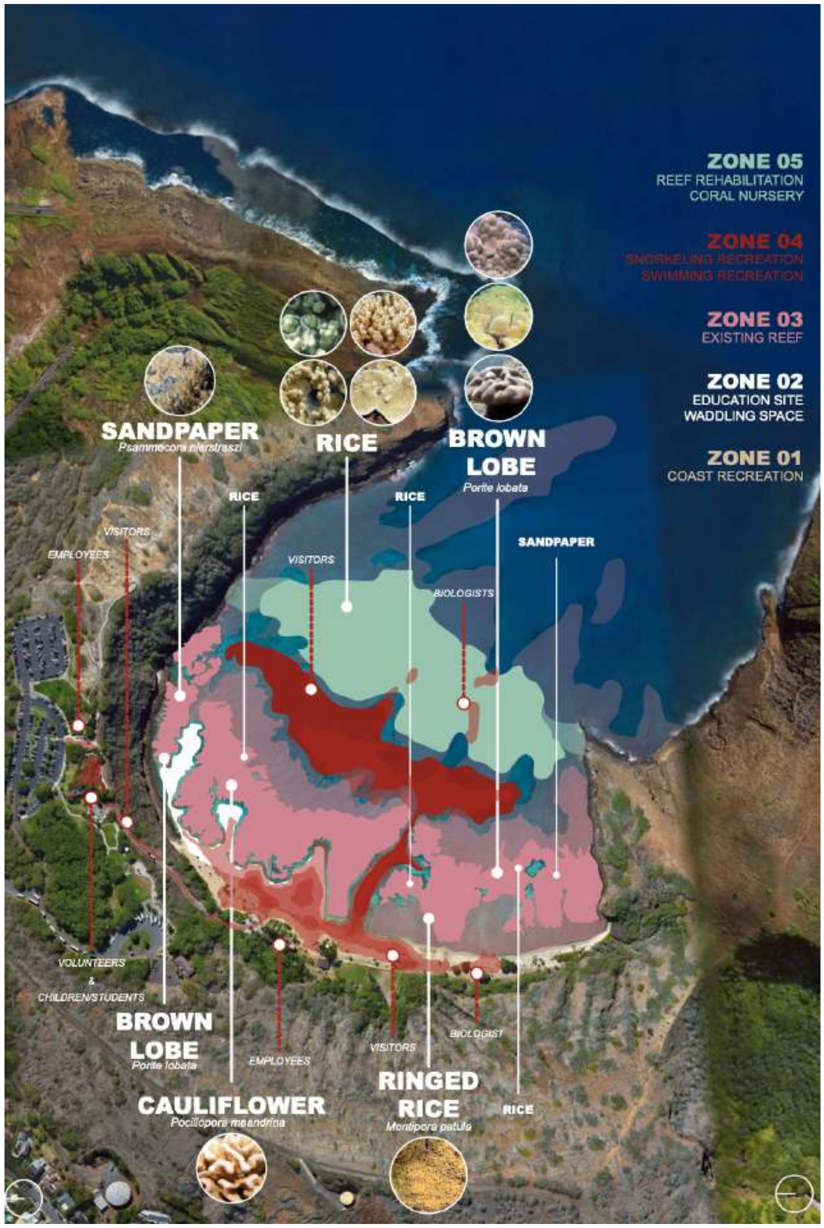
Coral reefs are rapidly dying due to climate change and anthropogenic activities. Because these sensitive ecosystems are critical to ocean health, new approaches for designing synthetic reef systems have emerged in the last 50 years to sustain and promote coral diversity. However, despite their success, these studies lack the larger-scale and higher-level ecological analysis that accounts for anthropogenic threats to these ecosystems. Without considering how contemporary near-shore environments are hybrid, novel landscapes, artificial reefs are not designed for shared ecologies.

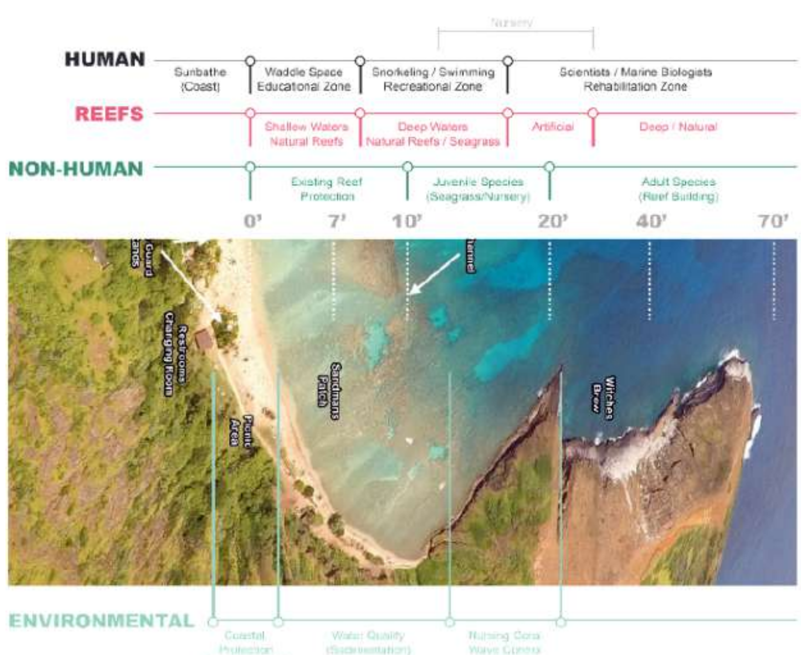
This study proposes a novel simulation framework that expands the existing analytical modeling methods, allowing us to visualize and test underwater eco-spatial phenomena within dynamic systems to better identify a design space for intervention with the goal of mitigating the conventional human-reef relationship through tactically choreographing sedimentation.

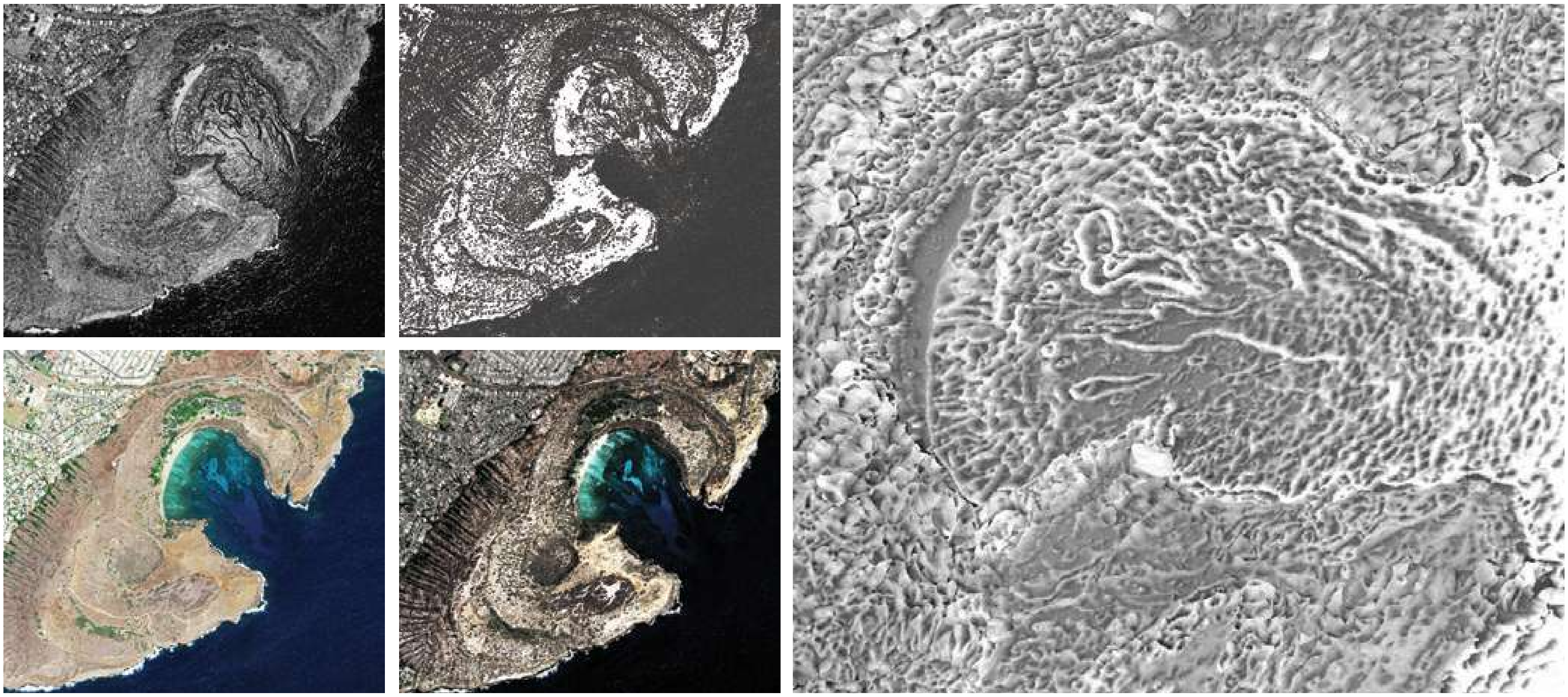
The simulation sequence proposes an overlay of (a) CFD analysis with (b) computational sand dune formation and (c) physical experimentation using a simulated sand and water table to study the sediment response to morphological intervention. The goal is to identify zones of intervention within the dynamic underwater landscape that encourage strategic increase or decrease of sediment build-up, nurturing coral health.

The images to the left display the analysis workflow of overlaying digital CFD and sediment movement simulations to evaluate potential areas for safe sediment accumulation to enhance coral growth.

Existing Site Conditions





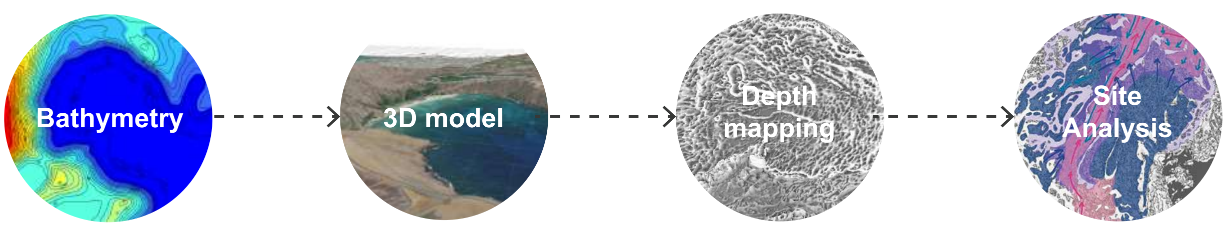


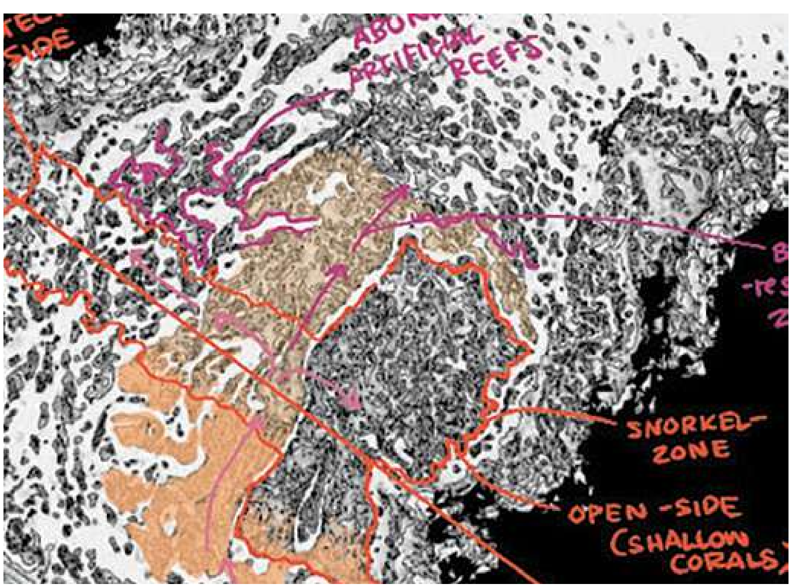
Modeling the Site & Underwater Habitats

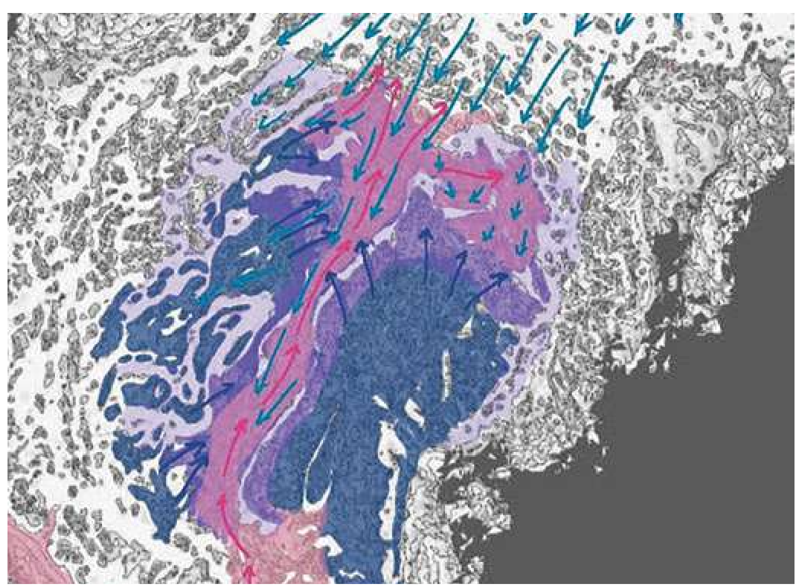
Many small islands that house coral reefs, like Hawai'i, lack digital databases due to their small size and secluded locations. Additionally, there is no standard method for modeling dynamic over-time relationships between coral reefs and recreational landscapes. To respond to this gap, a method developed using the scarce online resources was used to create a digital model for this reef typology.

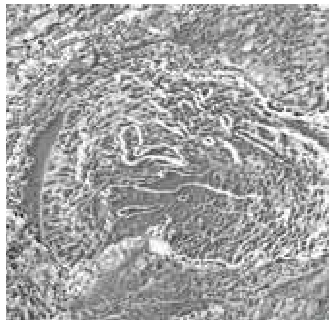
The images above display a 3D model of the coral reef in Hanauma Bay developed with depth mapping techniques utilizing google satellite and arcgis bathymetry data.

The images below is an analysis of site conditions based on existing research on current coral formations and forms created from the digital model produced.



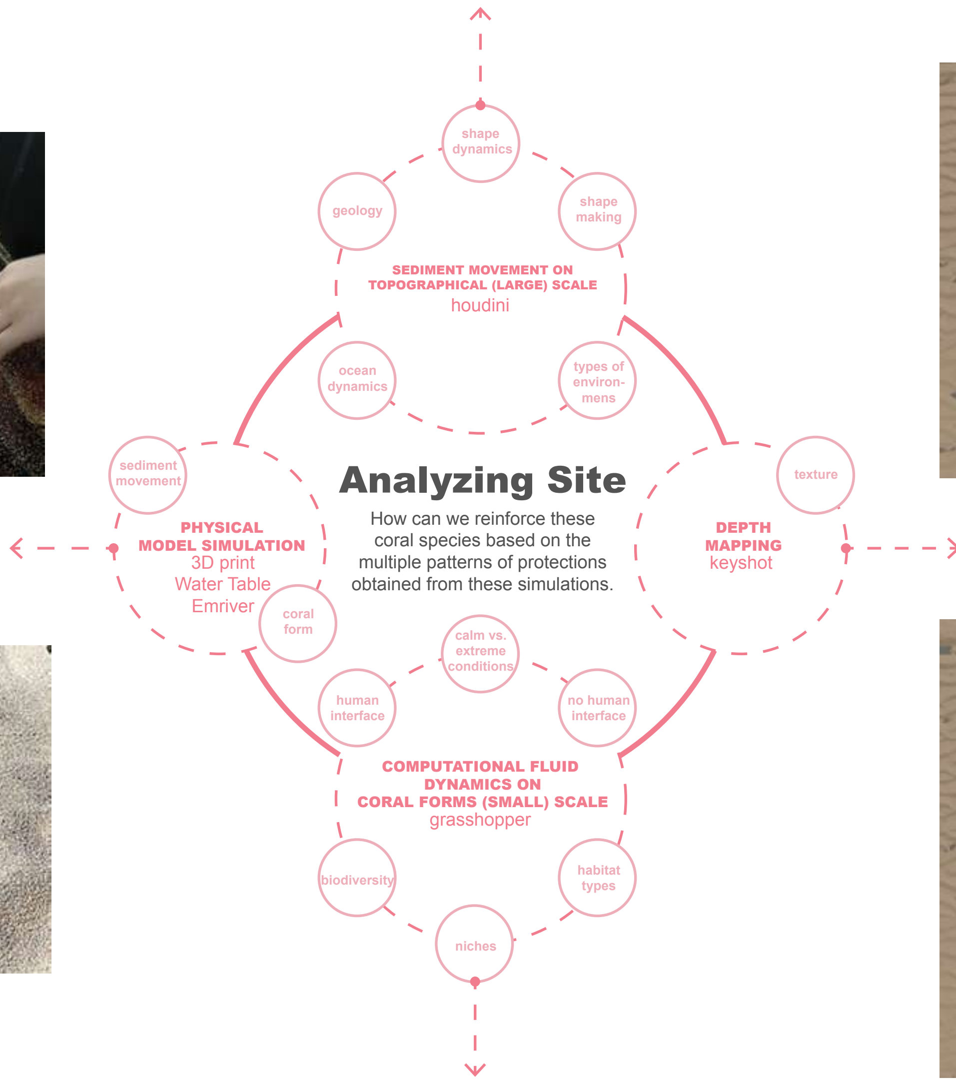






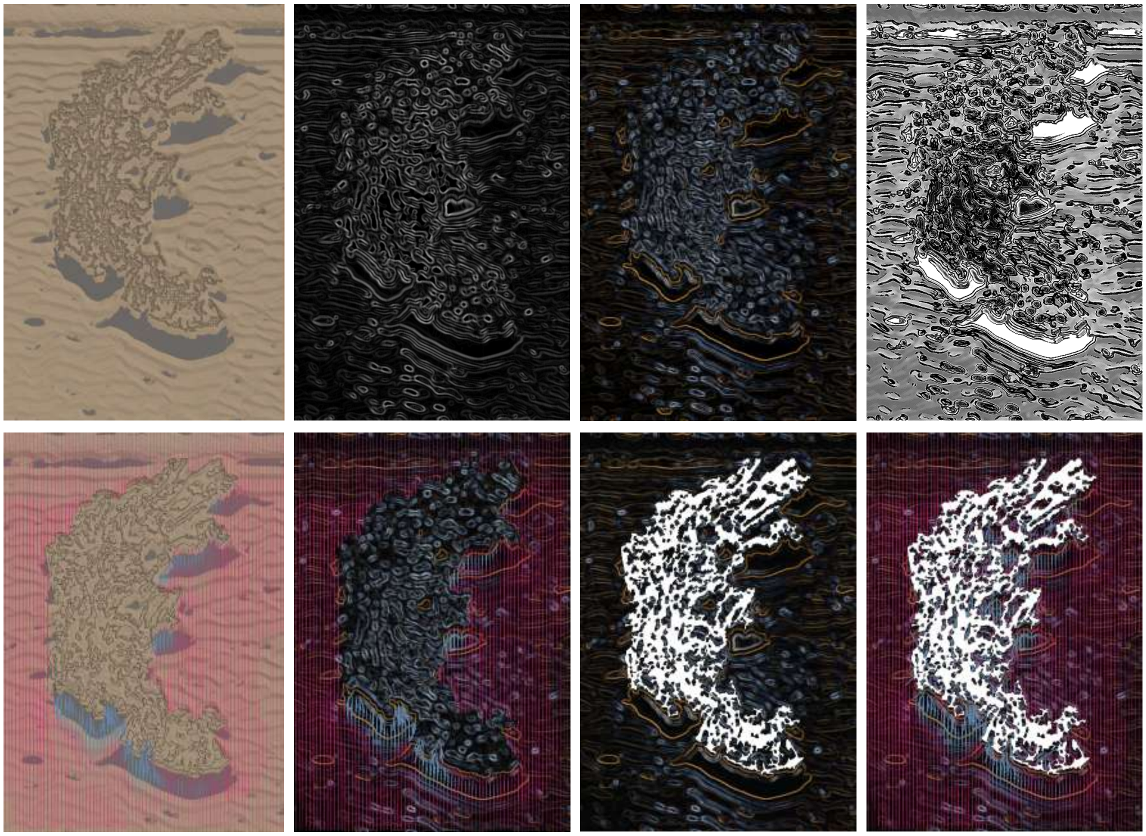
distinguishing relationships between
coral form, resilient coral forms,
and ocean dynamics for design.

beginning to build concept and
creating a way of thinking about
design morphologies through
water and sediment to
inform design.

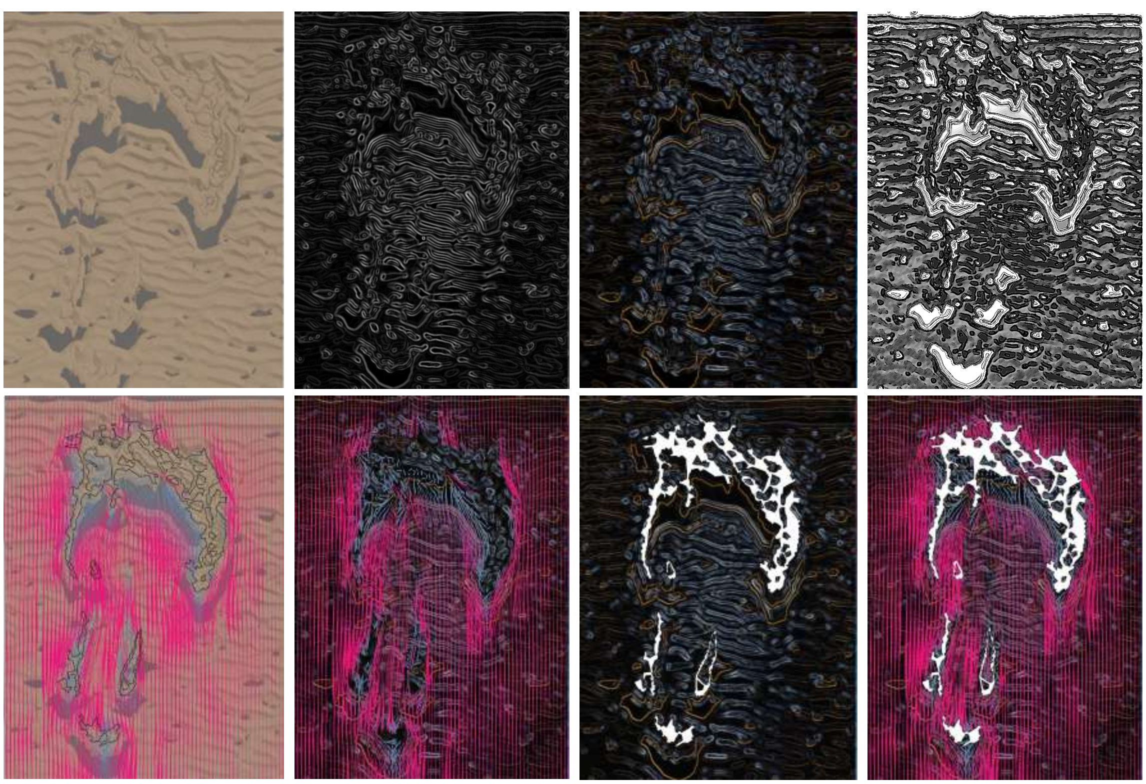


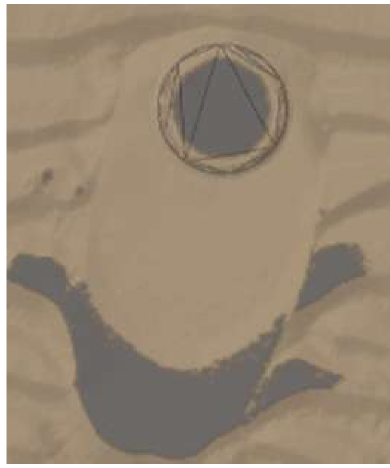
identifying existing
coral forms
on site

identifying real coral forms,
their environment typologies and
conditions, and understanding the
varying coral species potentials on site.



The images show the workflow of conducting CFD simulations and sediment movement simulations then overlaying the two results on top of one another to locate potential areas for safe sediment accumulation to encourage vertical coral growth.



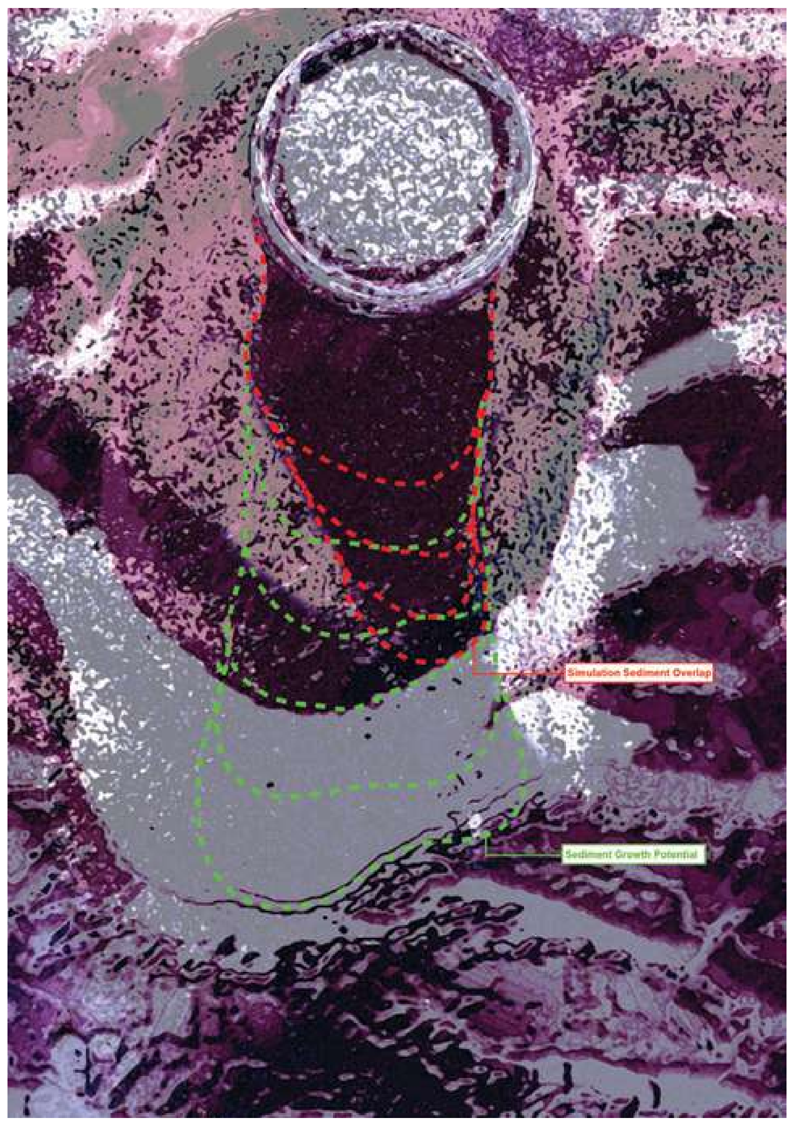


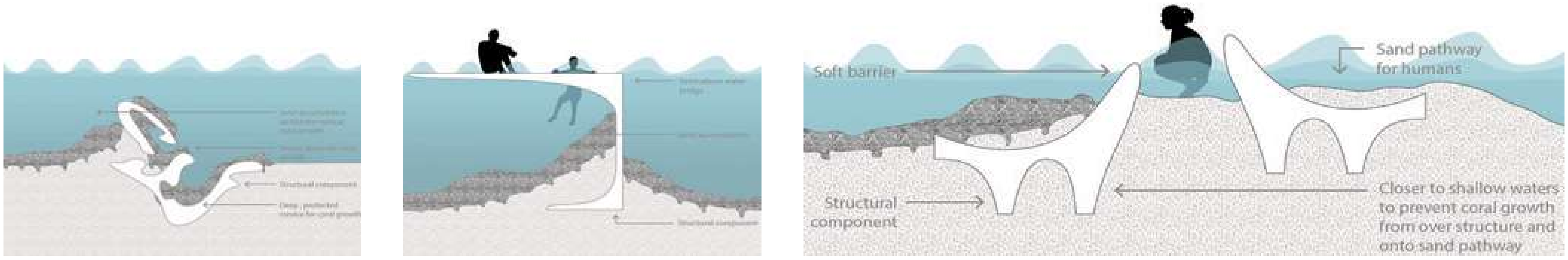
Physical Simulations with Mixed-media Sediments

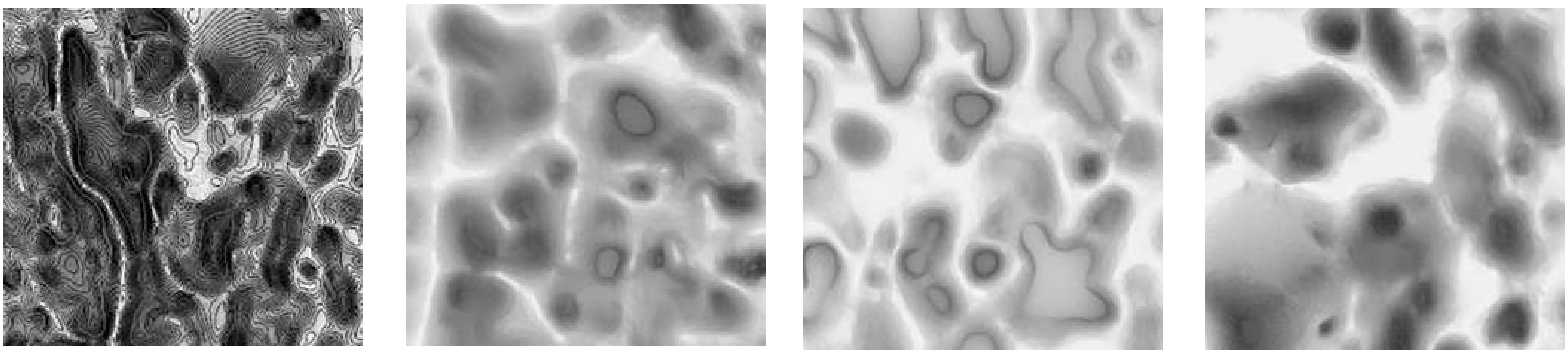
The physical simulations with the water table and engineered sand focused on sediment movement by comparing the results of the digital and the physical simulations. Overlaps between the two sets of simulations contributed to identifying more nuanced sedimentation phenomena and aided in the process of designing artificial reefs that can accumulate differing amounts and forms of sediment.

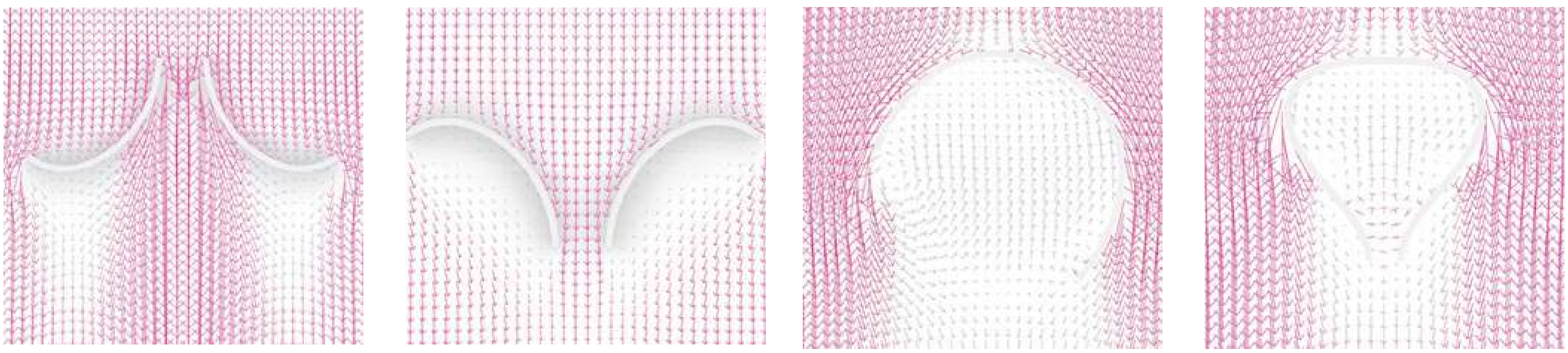
Overlaps of information show the shadow of sediment accumulation. The darkest areas shown in the simulation (outlined in red) show the locations with the largest potentials for sediment accumulation.

The images showcase the physical simulation setup and engineered sand (Emriver) and the results of the simulation and overlap studies.









RE-SITUATING SIMULATION RESULTS ON SITE
Designing New Lands

The results of the various simulations (digital fluid dynamics, digital sediment movement, and physical sediment movement) were combined and superimposed onto the Hanauma Bay coral reef model to study the potential for the formation of new land.

The design moves away from the traditional idea of mixed-use programming used in architecture, and begins to create hybrid dynamic fuzzy zones for multi-species engagement. Moving away from the typological segregation of public and private spaces in terms of marine creatures and coral reef ecologies for humans, this project prioritizes creating safe spaces for multiple species to interact without entirely separating them. The idea of 'private' is centered around creating specific areas that are directed towards rehabilitation and research rather than exclusion.

This creates 'safe public spaces' for humans, coral, and marine species to interact. These proposed strategies inspire us to rethink how these artificial reefs could construct self-maintaining, regenerative architectures for sensitive landscapes.

The series of images above show:

(1) proposed designs of artificial reef barriers and bridges focused towards developing new lands and creating safe pathways for humans and non-humans,

(2) 3D depth mapping rugosity models of coral species that reside in Hanauma Bay,

(3) additional studies on forms that create water tunnels with increased water speeds, water barriers with slower moving water, and water vortexes to trap and clean out sediments.

REHABILITATIVE ZONE
Users:
Coral Reefs (Juvenile, Adult)
Marine Creatures (Juvenile, Adult)
Marine Biologists
Researchers
Scientists
RECREATION ZONE
Users:
Coral Reefs (Adult)
Marine Creatures (Adult)
Snorkelers (Instructors, Adults, Children, etc.)
Tourists / Visitors (Adults, Children, etc.)
Locals (Adults, Children, etc.)
EDUCATION ZONE
Users:
Coral Reefs (Adult)
Marine Creatures (Adult)
Tourists / Visitors (Adults, Children, etc.)
Locals (Adults, Children, etc.)
Hanauma Bay Education Program
Marine Biologists / Researchers
Visiting Schools / Orgs
Volunteers
Employees
etc.
Water Valley
Snorkeling Area
Sand Pathways
Sediment Traps
Research Niche
Floating Bridge Potential Space
Learning Niche
Coral Free Pathway
Shore
Deep Waters
Deep ocean separated by sand lands to prevent snorkelers from going too deep into the ocean for safety as well as an area with a large, open space for undisturbed coral growth.
Sediment Lands Breakwaters
Protected area from high-intensity environmental elements, like strong waves, for more fragile coral species.
Nursery Niches
Elevated Sand Lands
Shallow Sand Lands
Wadding Area
Seagrass Homes
HANAUMA BAY

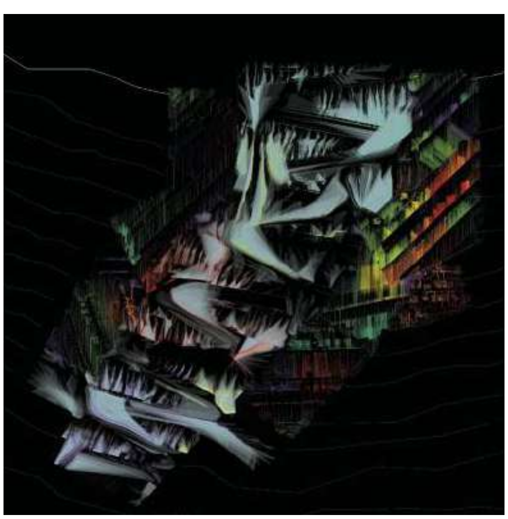
Split House
Co-Housing

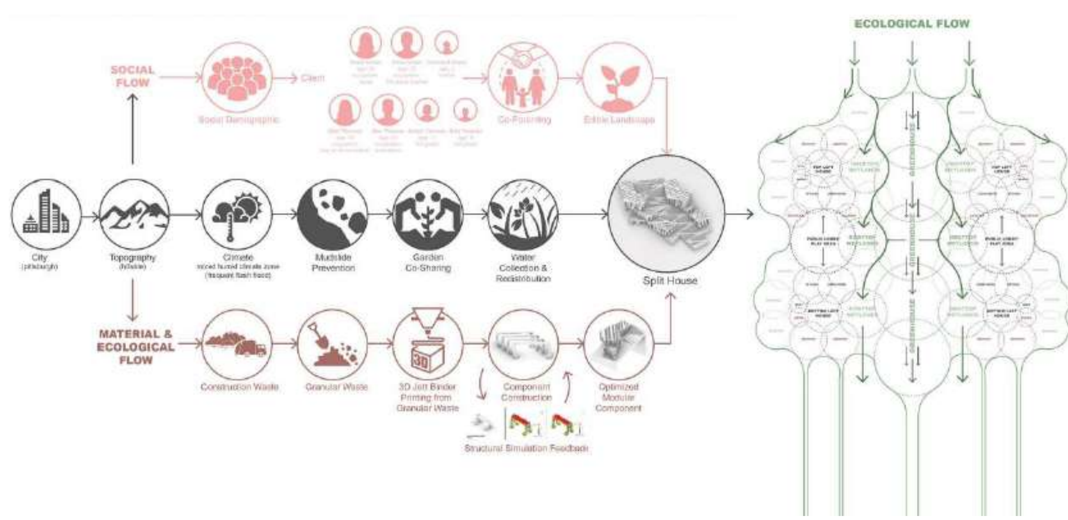
Hazelwood, Pittsburgh, PA

Embedded in an ecological hillside, the co-house focuses on taking advantage of landslides that occur in Pittsburgh due to heavy rain. The central greenhouse and co-housing rooftops collect mud and water and redirects it over, through, and around the architecture, allowing occupants to directly interact with the environment around them.

The images to the left display (1) an analysis of waterflow and water collection on a terrain, (2) the housing typology context, (3) the hillside topographical condition, (4) water flow simulation over new house-landform.

The image below is a flow chart that shows the different properties of each flow category (social, natural, material, and ecological) and how they all interweave with one another in the Split House.

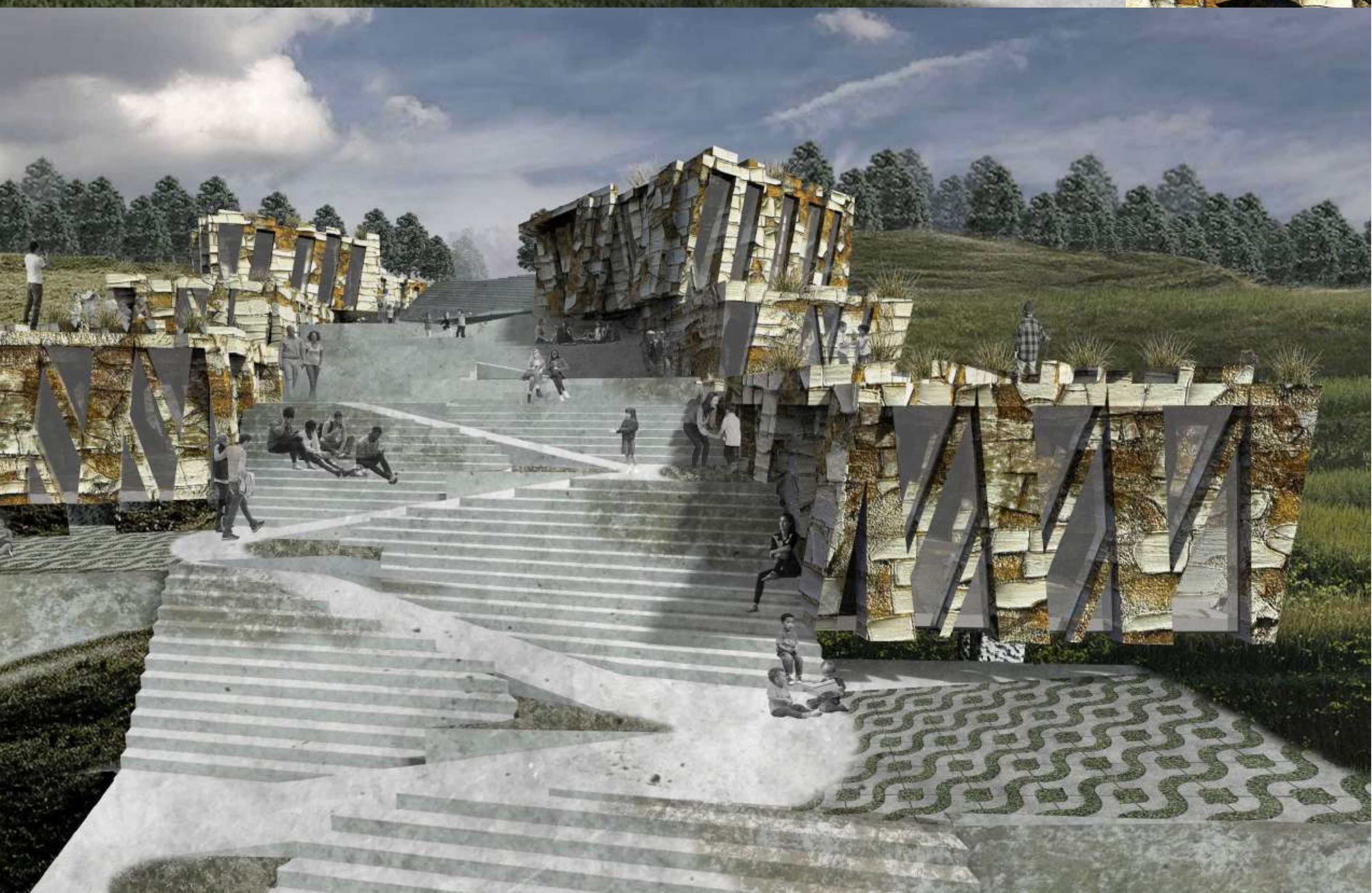


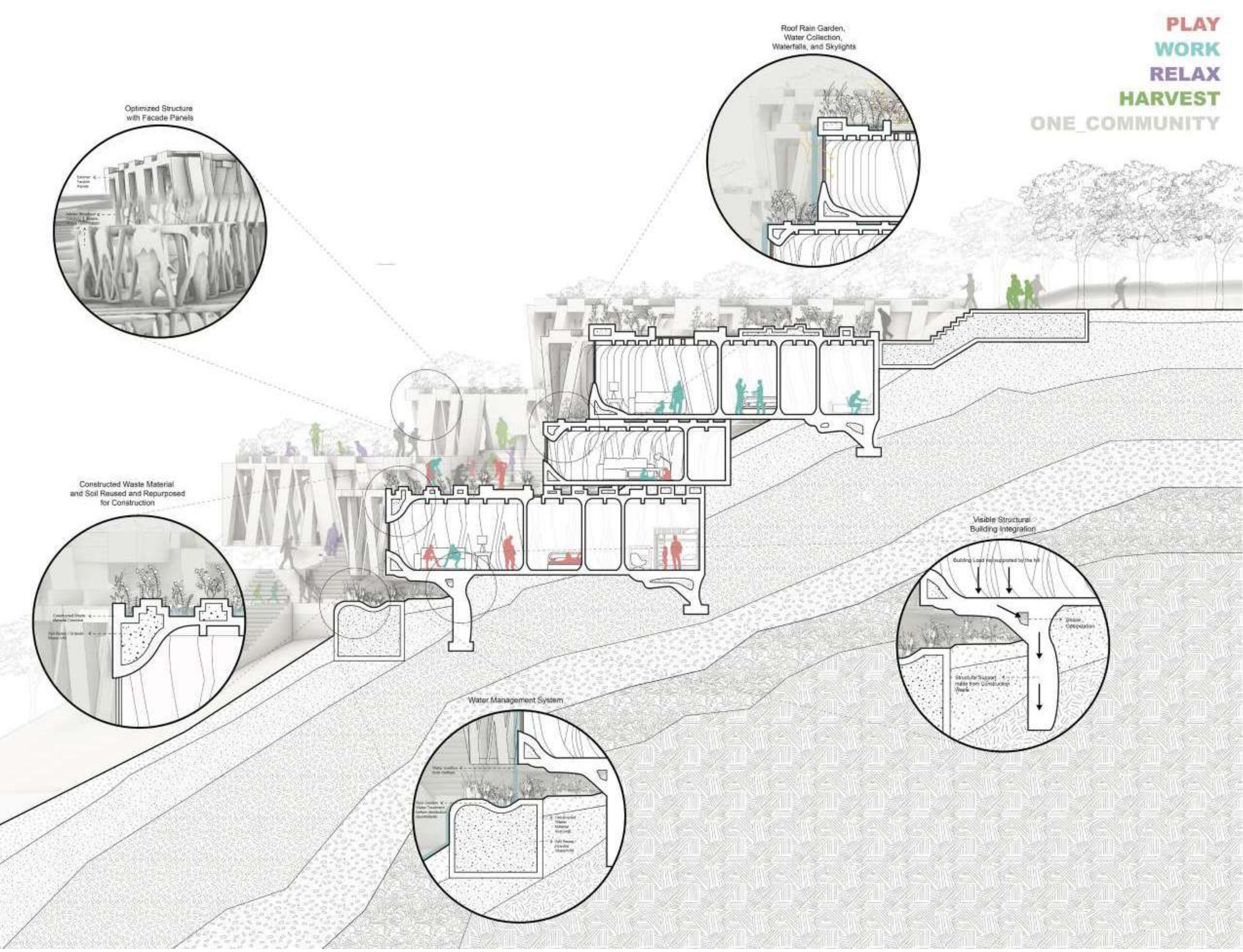


Design Process Workflow

Using artificial intelligence to identify ecological patterns that would support plant growth integrated into the material form of the house.

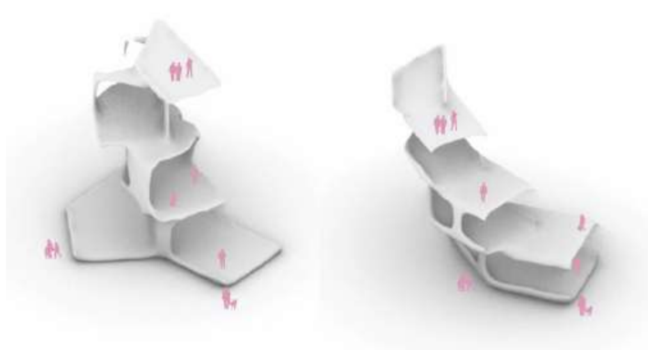
The images above show GAN (Generative Adversial Networks) images that study how ecological textures affects the landscape and can be integrated onto building structures to begin to shift the building's relationship with the natural environment it sits within.





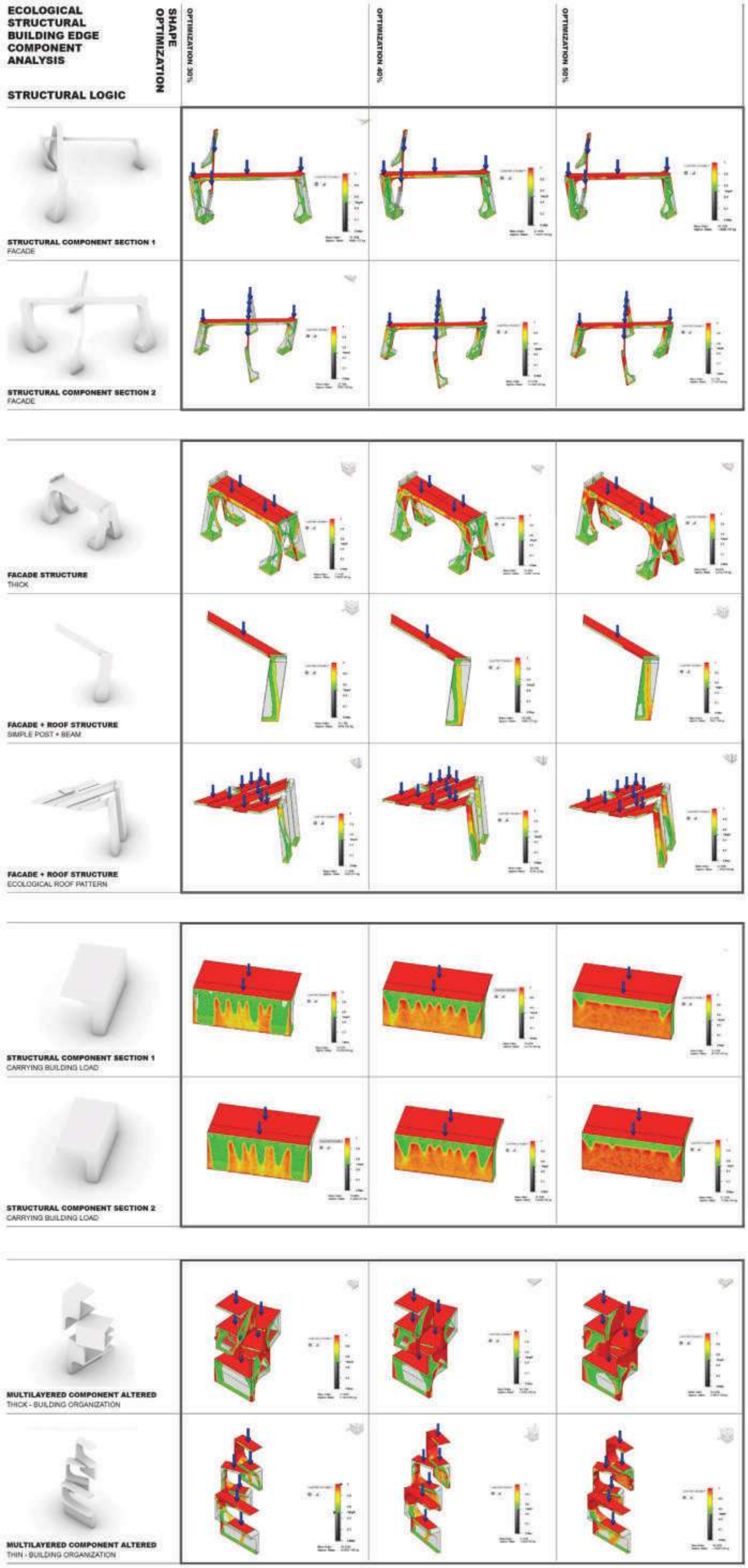
Hillside Condition

Split House is a garden embedded into a hillside. It creates a form that allows flows of mud, water, and debris to be moved through, around, and over the entire structure, capturing the sediments into a new landform. Enforced by a central split that holds a stair-ramp circulatory greenhouse, this playscape manages natural flows as well as acting as a shared public space for families and for the community of Hazelwood.



The image above describes the different components that make up the Split House.

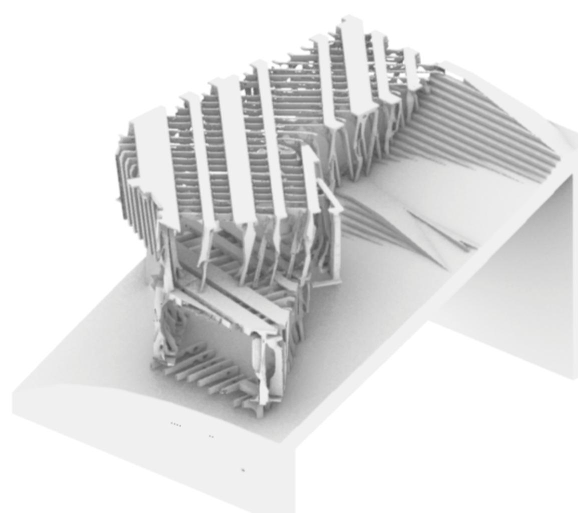
The image to the right displays a short series of form-finding studies to determine how spaces would be shared amongst various families.

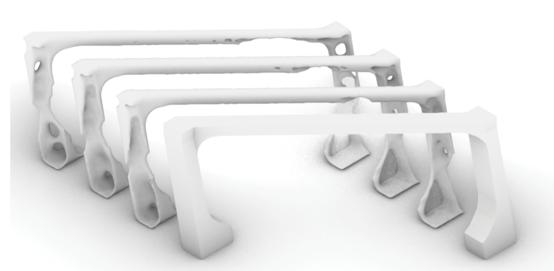


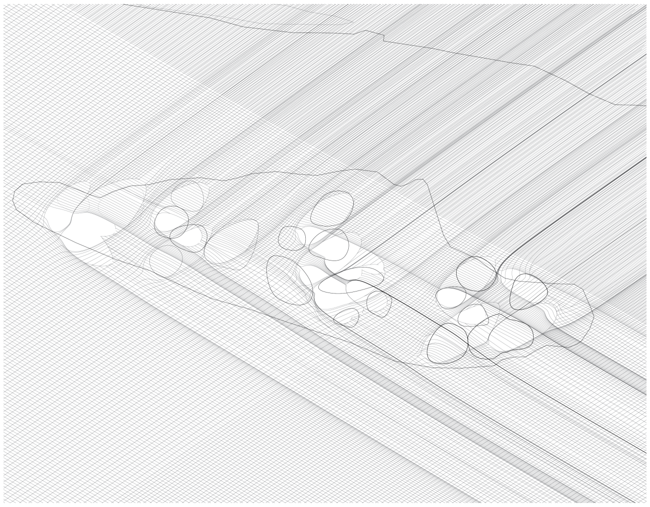
Material Optimization

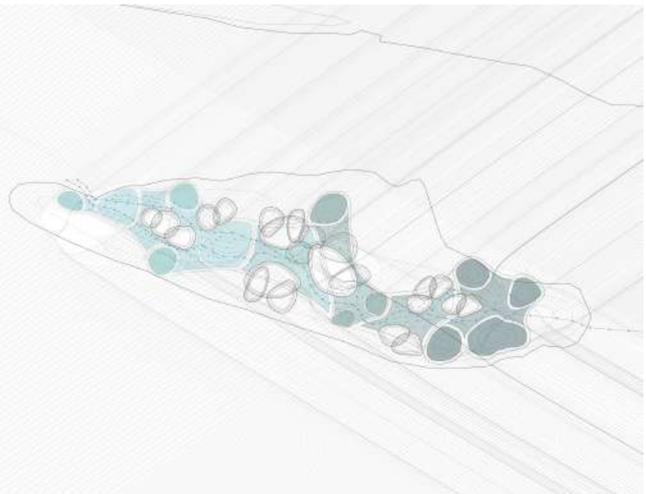
The images to the left are component studies that focus on understanding how much material can be optimized in the overall component's form to save material and reduce weight and waste.

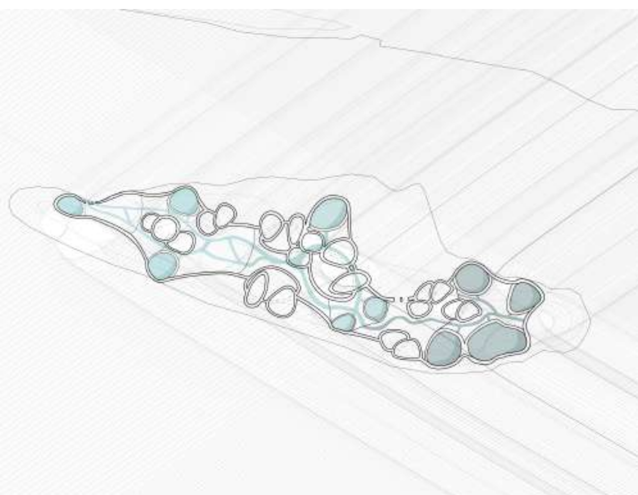
The images below combine the optimized building components together into a building structure.











ECO-MACHINE Co-Housing

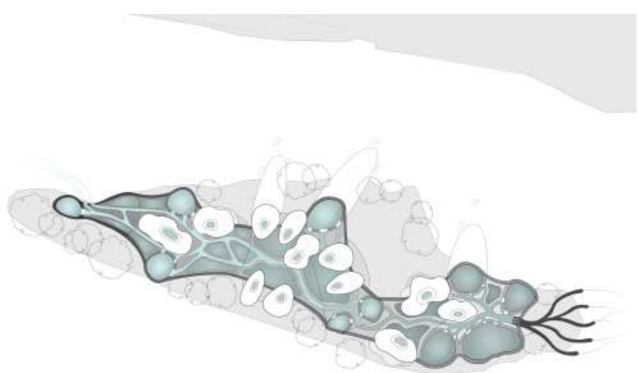
Six Mile Island, Pittsburgh, PA

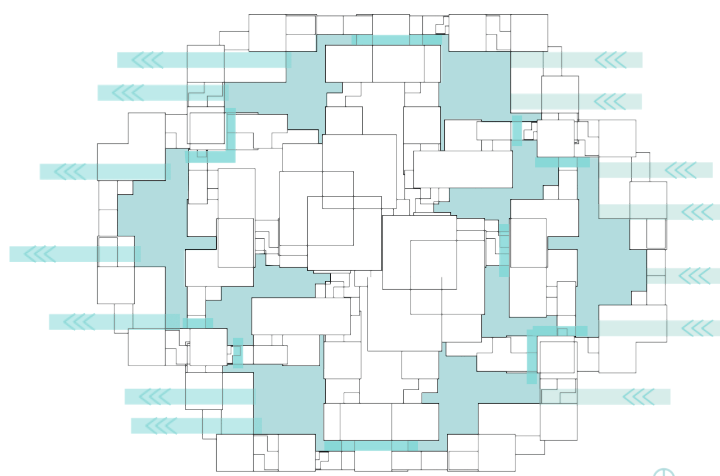
Utilizing urbanization strategies, a co-housing and eco-machine prototype was developed that began to utilize an understanding and focused knowledge on a specific system's behavior and logic and integrating it into both the site and the lives of those living there.

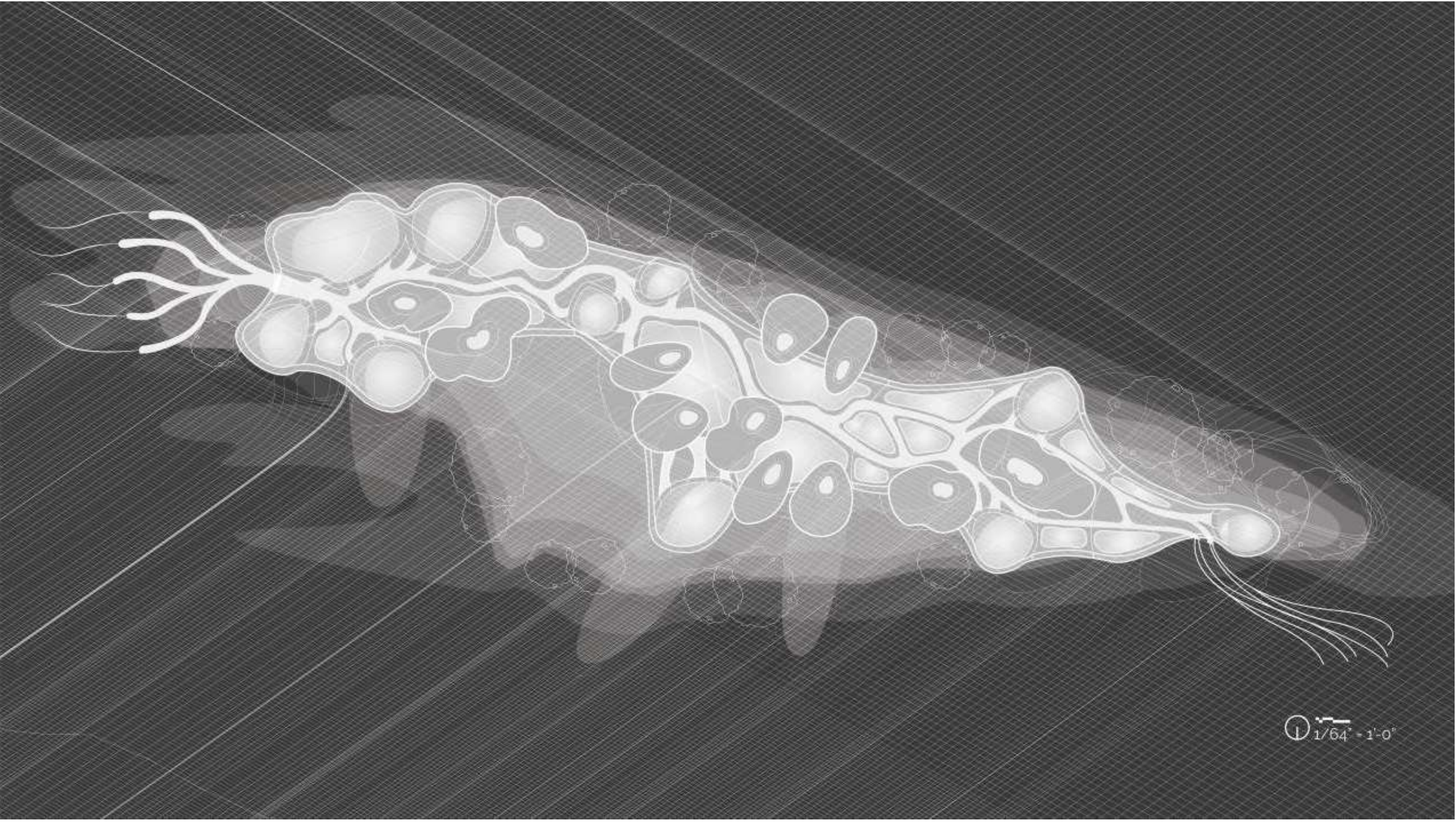
The goal of this design was to design a large biofiltration system that would take water from the Allegheny River, clean it, and return it back to the river. The biofiltration system aims to use streams, waterfalls, and greenwalls to treat the water.

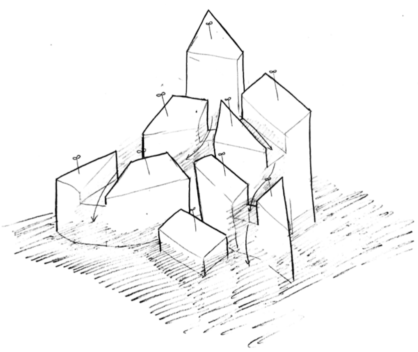
The images to the left display (1) a wind analysis on the existing site conditions, (2) using the wind data to begin to carve architecture out of the landscape, (3) studying potential stream flow and collection, (4) the project site plan.

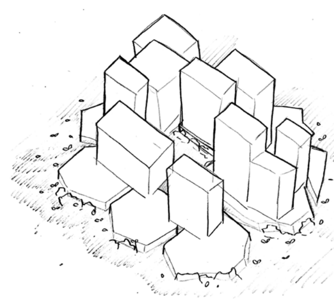
The image below displays an initial study of a water system that goes into a structure, flows through a series of systems to filter it out, and sends it back out of the system.

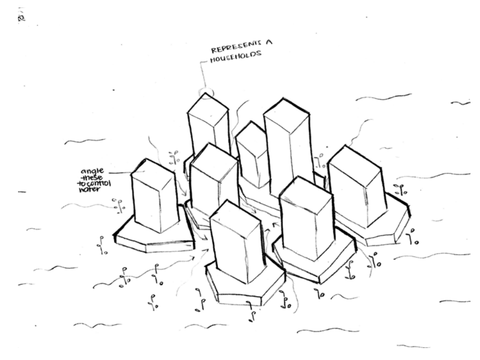


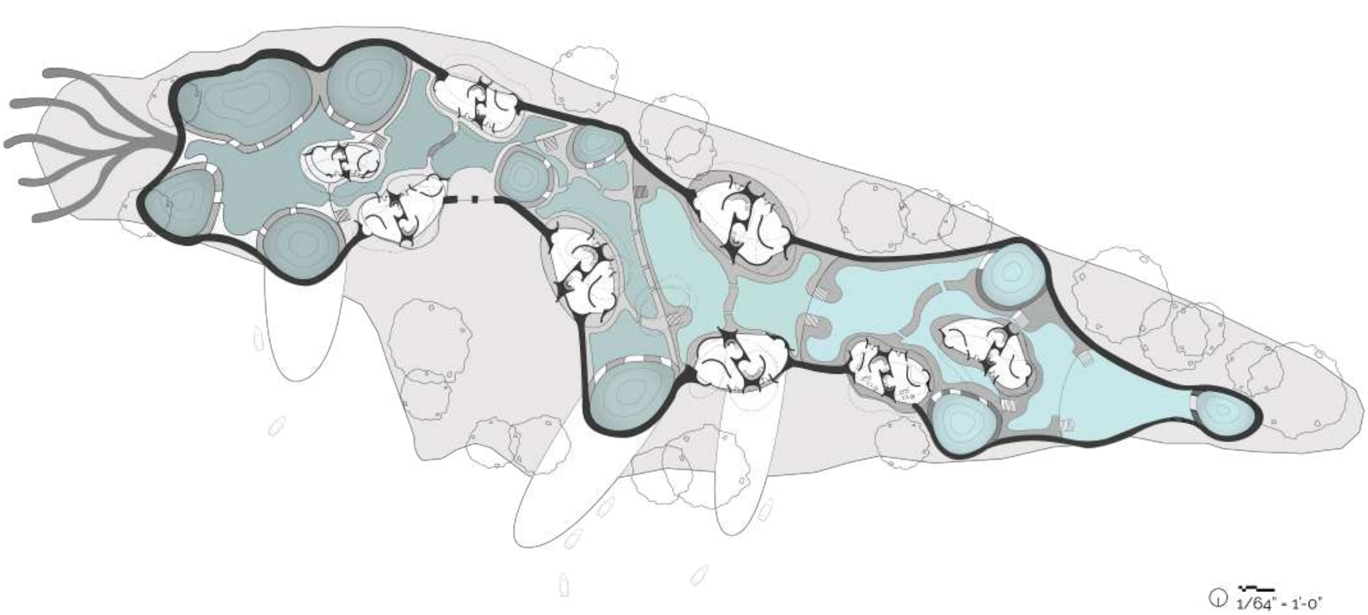



1/64" = 1'-0"






REPRESENTS A
HOUSEHOLDS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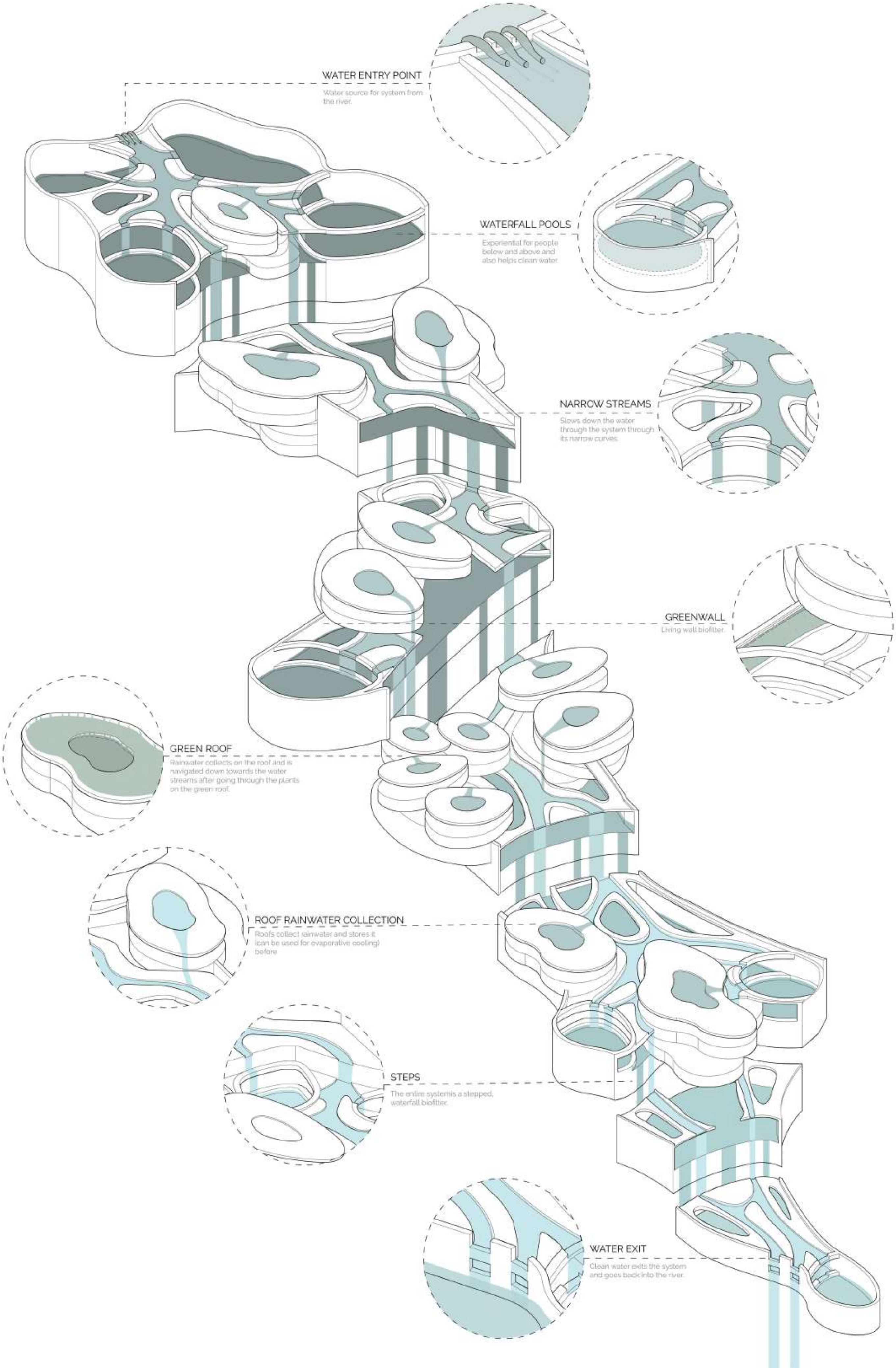
WATER ENTRY POINT
Water source for system from the river.
WATERFALL POOLS
Experiential for people below and above and also helps clean water.
NARROW STREAMS
Slows down the water through the system through its narrow curves.
GREENWALL
Living wall biofilter.
GREEN ROOF
Rainwater collects on the roof and is navigated down towards the water streams after going through the plants on the green roof.
ROOF RAINWATER COLLECTION
Roofs collect rainwater and stores it (can be used for evaporative cooling) before
STEPS
The entire systemis a stepped, waterfall biofilter.
WATER EXIT
Clean water exits the system and goes back into the river.