

# **Sustainability of Time**

**Nicholas Peake**



# THE SUSTAINABILITY OF TIME

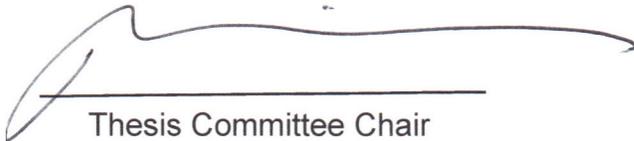
A Design Thesis Submitted to the  
Department of Architecture and Landscape Architecture  
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By

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In Partial Fulfillment of the Requirements  
for the Degree of  
Masters of Architecture

Primary Thesis Advisor



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*Mark M. Bamhorne 4/19/2010*

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# **Table of Contents**

<b>1. Abstract</b>	<b>__ 6</b>
<b>2. Problem Statement</b>	<b>__ 7</b>
<b>3. Statement of Intent</b>	<b>__ 8</b>
<b>4. Proposal</b>	<b>__ 12</b>
<b>5. Program Document</b>	<b>__ 20</b>
<b>Theoretical Research</b>	<b>__ 22</b>
<b>Case Studies</b>	<b>__ 32</b>
<b>Historical Context</b>	<b>__ 42</b>
<b>Goals of Thesis</b>	<b>__ 50</b>
<b>Site Analysis</b>	<b>__ 54</b>
<b>Programatic Requirements</b>	<b>__ 70</b>
<b>6. Design Proposal</b>	<b>__ 75</b>
<b>7. Reference List</b>	<b>__ 97</b>

## **Abstract**

The Government is building a storage facility at Yucca Mountain in the Nevada desert, which is where the dormitory complex would need to be as well. This is as structure that will have a program and life span of at least 1000 years. The structure needs to last 1000 years because it takes less money and fewer resources to build one building that lasts 1000 years, then to build 35 buildings that will last as long. This is important because the sustainability of buildings is going to greatly effect how long mankind has left on Earth. The type of building that could support a life span this long is rare, and that is why the typology for this thesis is a military dormitory complex. The typology determines the site location for this project. The case studies used are dormitory type buildings but also include a medieval cathedral. The historical context of the project contains a discussion of Nuclear materials and how we handle them. This project is composed of three buildings along with a monument.

## **The Problem Statement:**

Is a structure that lasts 1000 years, instead of the normal 20 years we build for, more sustainable?



# Statement Of Intent

## **Typology:**

Military dormitory complex

## **The Theoretical Premise:**

Claim:

Building structures to have a life span of 1000 or more years is both more cost effective and has a less of a negative effect on the environment.

Supporting Premises:

- It is the designer's/client's/builder's responsibility to have less of an impact on the environment
- Designing buildings to survive 1000 or more years will help achieve the desired effect on the environment
- The environment will be sustained if our buildings are provided with greater survivability.

Theoretical Premise:

This thesis will explore how the longevity of a structure is directly related to influence it has on the environment.

## **The Project Justification:**

In our world that we seem to be ever poisoning, there are two ways to proceed. The first is to continue on the same path that we have been traveling which is to further the poisoning until we can no longer survive. The second is to conserve the resources we have while continuing to prosper. Sustainable architecture can definitely help the latter outcome I hope we all would like to see.





# Proposal

All most Architects care about lately is if you are Leed certified or if you have Photovoltaic panels and all the other “green” additions to your building. But is this really what we should be focusing our energy on? Leed is all well and good for now, and at least we are doing something to change our wasteful habits. Is less bad actually good enough? People think that by attaching some solar panels on their buildings they are making them more sustainable. It seems like what Leed accomplishes is to put a fake “green” facade on the same old wasteful modern buildings we have been building for the last half a century!

We need to break this way of thinking by thinking outside the box. There are many ways this can be done, but it must be done. Completely changing what a building or structure does or can be is a good place to start. Looking back to the past is another good exercise.

Looking at the past is beneficial, considering that the most sustainable periods of human existence occurred then. This is where I found the inspiration for this project. In the times that the great churches of Europe were built humans were building more sustainable buildings than we are now. Those churches are still standing and being used today. So which is more sustainable: the apartment complex being built down the street with photovoltaic panels that with luck will be used for the next 40 years, or the catholic cathedral made from solid stone that has been standing for the better part of the last millennium?

## **Client and User Descriptions**

### **Client**

The list of potential clients is a very small one. Very few clients have the need for a structure that will last 200 plus years. Only clients such as governments of countries and religious institutions have the stability to continually use a structure for a 200 year period of time. This is why I am going to design for a government installation. The end client becomes the government.

### **User**

The user would be administrators of the US government. They would obviously change as the building continues to be used throughout the generations of users, because the lifespan of the building would be longer than the lifespan of a human.

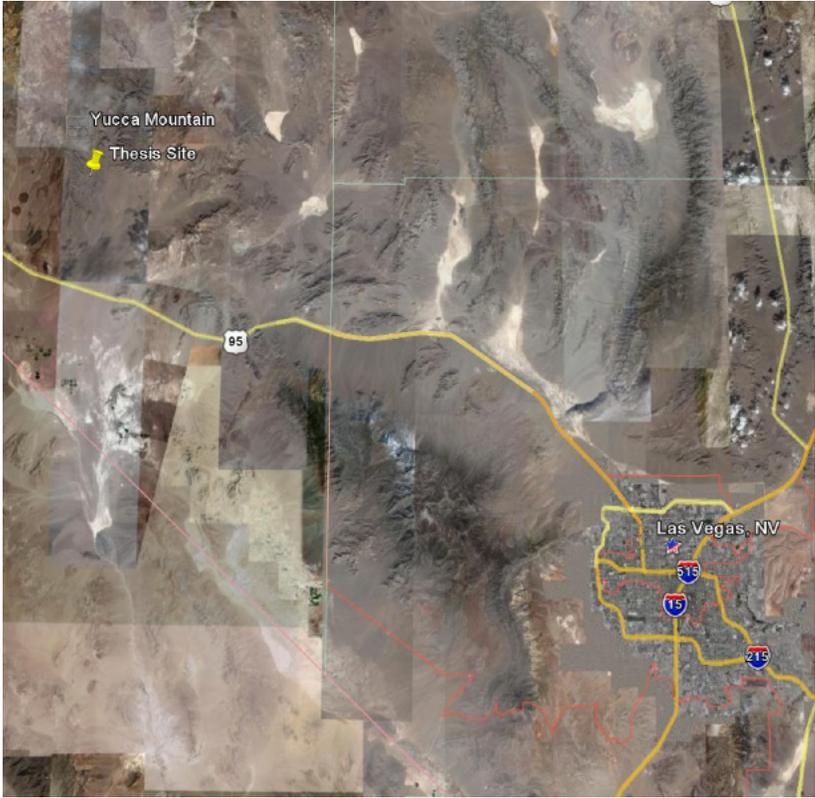
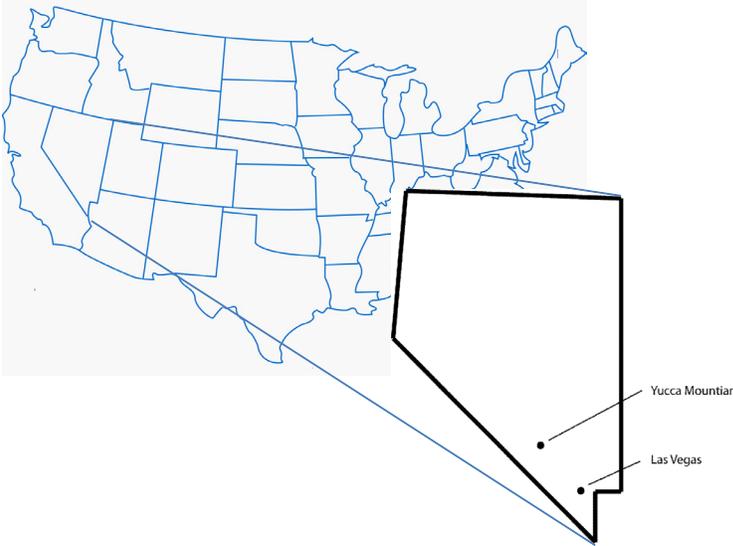
## Major Project Elements

The major elements will consist of support structures for the Nuclear waste storage facility. These would consist of:

- Dorms for the workers
- Kitchen and other living facilities
- Entertainment facilities for workers
- Storage facilities external to the mountain

# Site Information

The site is in southwest America, particularly the state of Nevada. The facilities would be adjacent the entrance to the Nuclear Storage Facility in the Yucca mountain complex on the Armed forces base in central Nevada. This part of the country has a dry, arid climate and as such has very little vegetation. It is on the side of a mountain which used to be a volcano, but has been dormant for a long time. The site sees very little precipitation, and has a water table far below the ground. This is the reason it was chosen for a good nuclear waste storage site. It is about an hour drive from Las Vegas, NV, off Highway 95, and the closest town is about 15 to 20 miles away.



## **Project Emphasis**

This project will focus on the way we as Architects can be sustainable by designing structures to be used for at least 200 years. More specifically, I will focus on the integration of materials into the design because this is what will make the time period of this building possible but also the type of client that could benefit from this way of thinking of building is also needed.

## **Plan for Proceeding**

Much research will be done in the following areas:

Theoretical premise

Project typology

Site

Materials

Research will mostly be in the form of sketch book drawings and writings, but also has the potential to be images that are either scanned out of books or found elsewhere. Much research also needs to be done in material studies, including the lifespan of materials, as this will be key to this project.

## Previous Design Studio Experience

2nd year fall: Stephen Wischer  
Primitive Place  
Art Gallery  
Center for Temporarily Blind  
Tea House

2nd year spring: Mark Barnhouse  
House/Conference Center  
Library  
C.I.D.I

3rd year fall: Mohammed Diab  
Volvo Showroom  
Art Museum

3rd year spring: Mike Christenson  
Skyway Addition

4th year fall: Mark Lindquist  
Urban Studies

4th year spring: Phil Stahl  
Design Build Housing

5th year fall: Regin Schwaen  
Hotel/Motel



# Program Document

## Theoretical Premise Research 1

My theoretical research for this project started with the idea of being sustainable by designing the fourth dimension, time, while still creating a sense of place that, flexible, longer lasting buildings that are designed now, lack. Research continued in the area of embodied energy of built structures and ended with materials that can last the full 1000 years.

There are a few reasons why I want to work with the idea of buildings that last more than 1000 years. The first reason is that this way of thinking can and has added much to the fight for sustainable buildings. I will expand on this idea later. The main reason that this is such an interesting idea for me is a History Channel documentary called "Life After People." The documentary is about what would happen if the human race suddenly vanished from earth. This intrigued me because the main reason I became an Architect was to make my mark on the world in the form of a built structure. I think this is shared by most other Architects. How long will that mark really last? Will the building that I designed be standing after I pass on, or even before that? Considering the way we design, build, and use buildings in our society now, that building will most likely not be around even thirty years after we as Architects put all that hard work into designing them.

The documentary talked about how the environment would heal itself,

quite quickly and how our cities would deteriorate and crumble back to that from which it came. Now, all these are estimates on how long things will last if there wasn't anyone to keep up on maintenance, but they are still interesting. They project that within 40 years most if not all the wooden structures would either be burned or deteriorated. The steel framed buildings wouldn't be far behind the wood at around 80 to 100 years. The stone buildings would be standing after them, around 200 years after people. The building material that would last the longest is concrete. These projections are all subject to the climate in which these materials are left. In a warm, dry climate there is no ice or water to freeze and thaw, and there is no sea salt and harsh wet wind to rust metal. The reason why the Pyramids at Giza have lasted 5000 years is because the only thing attacking them is the wind and desert sand. Another contributing factor is that there is no salt in environment, as salt is what deteriorates stone structures.

So if I want my building to last long past me, the only choice of material is concrete. Out of all the main materials to choose from: wood, steel, glass, and concrete, the last is not only more sustainable by being longer lasting, but it is also a very green material even if used in the traditional ways. In fact, according to the documentary one of the last structures to fall would be the

### Theoretical Premise Research 3

Hoover dam because of its unbelievably thick concrete. It is so thick that it is believed that the concrete at the center of the wall is still curing from when it was originally built.

In order to understand concrete better, I did some more research on the composition of concrete and the history of the material. Concrete is usually a mixture of cement, coarse aggregate, fine aggregate and water. The percentages of each of the parts depend on where the concrete comes from or how it is mixed. People use the words concrete and cement interchangeably, but in fact cement is only one ingredient in concrete. This is a very common mistake. In fact I had to go through what I had written to make sure I had the right words in the right places.

Cement is produced in 115 factories in 36 states around the US. This means a factory is most likely located within the 500 mile radius that Leed calls for. Even with all those factories there was still a shortage of cement in the US so about 33.7 million metric tons of cement was imported in 2005 from China, Canada, Thailand, and Greece. (Portland Cement Association, 2006)

Another sustainable aspect of concrete is the fact that manufacturers use the waste products of other industries to create concrete. These byproducts include fly ash from coal power

plants and slag from blast furnaces. Concrete is also made from recycled aggregate from concrete buildings that are torn down. If done right, buildings can be almost totally recycled, including the steel reinforcements inside the concrete. Precast concrete uses little waste when pouring and curing the specific pieces. Site cast concrete is also very efficient with little leftover waste compared to other building materials. (Portland Cement Association, 2006)

In general, therefore concrete is sustainable because of its longevity, heat capture abilities, and general chemically neutral nature. It is ideal for buildings in the arid Nevada climate, as it prevents solar heat from reaching the inside of the building during the day and provides thermal heat during cool nights. In comparison to all the other building materials, it requires one of the most energy intensive production processes. This is not ideal if you are designing for the short term, but this aspect is not as much of a concern when designing for the long term. This is because even though the structure has more embodied energy, it will last a longer period of time to make up for the initial energy needs.

This embodied energy is equal to about six million BTUs per ton of cement. This figure makes cement seem like the wrong choice in terms of total energy used but if the figure for concrete and not just cement is used, the figure looks alot better with a lot less BTUs per

## Theoretical Premise Research 5

ton of concrete. Water, sand and aggregate require little energy to process. Cement usually accounts for 12% of the whole concrete mix and 92% of its total embodied energy. The one thing that makes cement so costly in energy is the fact that in order to make cement they have to fire parts of the cement mix in a kiln that requires extreme heat to operate. (Woodbury, 1993) This can become more sustainable with the use of more waste fuel. The kilns are fired at such a high temperature that burning things like used automotive oil and tires burn in a relatively clean manner. One million tires could power one kiln for a year, and compared to burning coal tires have a better fuel per weight ratio. (Woodbury, 1993)

When considering concrete in terms of its green aspects concerning off gassing and VOC, it is one of the industry leaders. Concrete itself gives off little to no chemical gases. Although, as concrete has become more high tech the chemicals added to it to make it work faster, slower, or more fluid have compounds in them that could off gas harmful chemicals. If things like superplasticizers and other like additives are not used there is no worry as to what they off gas. Also, the releasing agents and sealers used on the forms can be potentially hazardous to the health of workers and occupants. If there is any worry as to the potential of the concrete to off gas it can always be sealed to lock in all

of those harmful chemicals.

Another green concern with concrete is the mold and mildew problems of slabs that are not adequately sealed and insulated from the ground and the outdoors. This is a bigger issue in a wet or cold climate and not as big a problem in the American southwest, where the climate is much more arid. If there is good sealer on the in ground fixtures and insulation on all slabs there is very little risk of mold or mildew.

The other reason I was interested in the 1000 year mark was the sustainability aspect. As we build today, the average lifespan of a building is between 20 and 30 years. If we take the time period of 1000 years, it would mean that building would have to be torn down and rebuilt 50 separate times, whereas if a building were to last 1000 years, it would only be built once. This is alarming, considering most of the energy a building uses is embodied energy. The material it takes to build a structure has to be grown or mined. Then it has to be processed in to materials that can be used, and most of the time this takes place at another location from where it was mined. In between mining and processing it has to be transported to the refineries. Then it has to be transported to the construction site where it will be erected. This would be the simplest path it can take, as many times there are more steps that require even more energy.

## Theoretical Premise Research 7

We can understand that energy is used, and therefore added to the embodied energy of a material when it is mined and refined, but it is also added when that material is transported. This is the reason Leed restricts the procurement of materials from less than 500 miles. Is this enough? The embodied energy in a building that is rebuilt 10 times is 10 times greater than a building that is built only once. Even if the building you build only once requires more energy the first time it is still way less than building 10 times.

The other difficulty with designing a building to last 1000 years is the fact that it will inevitably stand for multiple generations to use. This tends to be a problem because different people do different things in the same space. For example, if I were to design a rental property to last 1000 years, I would have to allow for very flexible space because the tenants over the years would be doing different things and would require very different special arrangements. This type of design tends to lack the sense of place that is instilled in a building when it is designed for certain programs and for certain client. It ends up being a shell with movable interior walls that change for the occupant. I want to stay away from that kind of designing, even though I know it has its time and place. I still want to design for one client and one program that will last the entire

lifespan of the building. Finding a client that needs a building for that amount of time is difficult. The only two clients that really can support a facility for that amount of time are the church and the state, as they have proven in the past to withstand time the longest. I decided to design a government facility rather than a religious one. I didn't choose just any facility. I chose the one that would need to have the longest lifespan, a nuclear waste repository.

The Yucca Mountain website talks about building a monument on top of the storage tunnels, warning future generations and even other forms of life of what is under the ground in that spot. I thought this was a very important part of the facility because even though the state is a long-lasting entity, it could at some time collapse. That would probably leave this facility abandoned. That is where I got the idea to design the building for this facility, because the monument would have to last thousands of years, why couldn't the facility itself? (US Department of Energy, 2008)

## Theoretical Premise Research Summary

In conclusion, I have learned a lot of things that can and will help me in my design for this thesis but they are on very different wavelengths and therefore difficult to summarize. I will summarize in three separate parts, as this is how I structured the research itself.

In the beginning of my research I explored why it is that we as humans build and design structures in the twenty first century. I offered up the idea that we become Architects to leave something behind after we have passed on that can be appreciated by generations to come. I think this is something that my theoretical premise tries to address. By designing a building to last 1000 years, I think we as designers can be fulfilled with the fact that our creations will live long after us. These ideas were inspired by a documentary on the History Channel.

The next aspect of my theoretical premise is the building material out of which to make this structure. It needs not only to stand for 1000 years but also be sustainable in the process. In some of my research before I began writing my theoretical research document I narrowed the material of choice down to concrete. Because of its wonderful ability to hold up over a long expanse of time while not needing very much maintenance, concrete sprung to the top of choices.

After I had narrowed it down to concrete, I realized I didn't know enough about it to be able to design with it properly. I decided to research the topic more in depth. I found out that it is a very good material to use in a hot, arid climate like the one I was using for my site. The passive solar heating and cooling was a very good

reason to use the material, not to mention the green attributes it has. I learned concrete has little to no VOC off gassing which makes it very green and not just green wash.

Concrete also has negative attributes. It has the most embodied energy of all the general materials including glass, wood and metal. I learned that most of this energy is in the cement itself. I pitted this against the reason I decided to design with the material in the first place, which is its durability. This is a concept that brought me to the third aspect of my theoretical research.

The last thing I explored was the sustainability in general of designing buildings to last 1000 years rather than the time period we build for today. I posed the question: of Which is more sustainable, building 50 buildings, each lasting 20 years or building one building that lasts 1000 years? The obvious answer is building only one building because of the embodied energy of all buildings is immense. The truth is that it isn't as simple as that scenario. This is because the embodied energy of one building that would last 1000 years is most likely far greater than the embodied energy of a 20 year building. But when added up the 50 buildings surpass the embodied energy of the one 1000 year building So the idea that a longer lasting building is more sustainable is a true one.



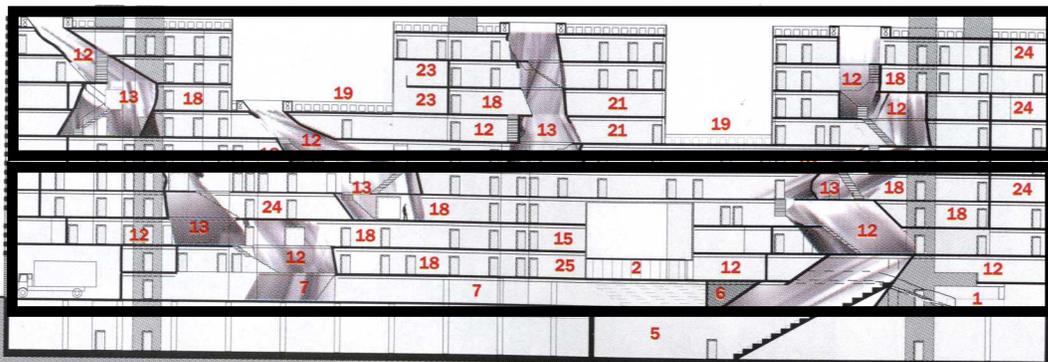
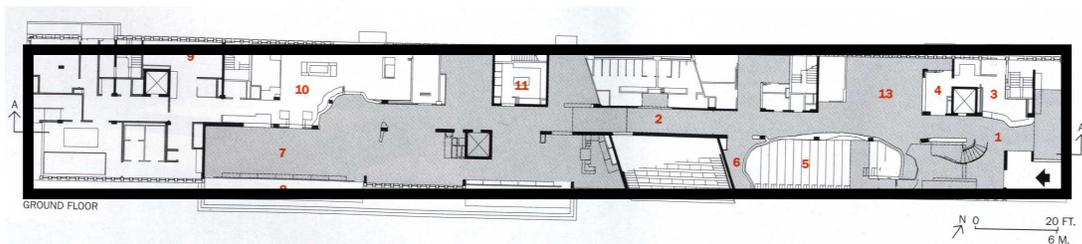
# Case Studies

# MIT Dormitories - Boston, Massachusetts

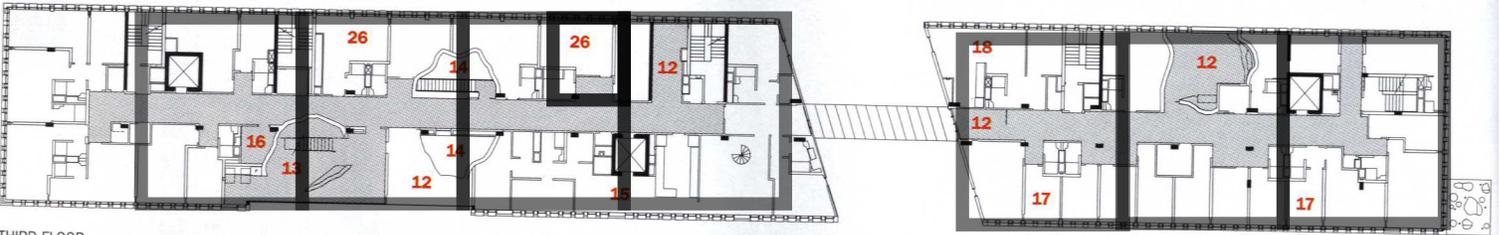


This building, Simmons Hall, was designed by Steven Holl as a dormitory for students attending Massachusetts Institute of Technology. It houses 350 students, and is made of concrete with a metal facade. It has dorm rooms in various configuration, broken up into three towers. It also has lounges and a dining center housed inside. The building is massive and very close to the roadway, and so it feels massive. It almost seems like a wall into which the fields across the street run.

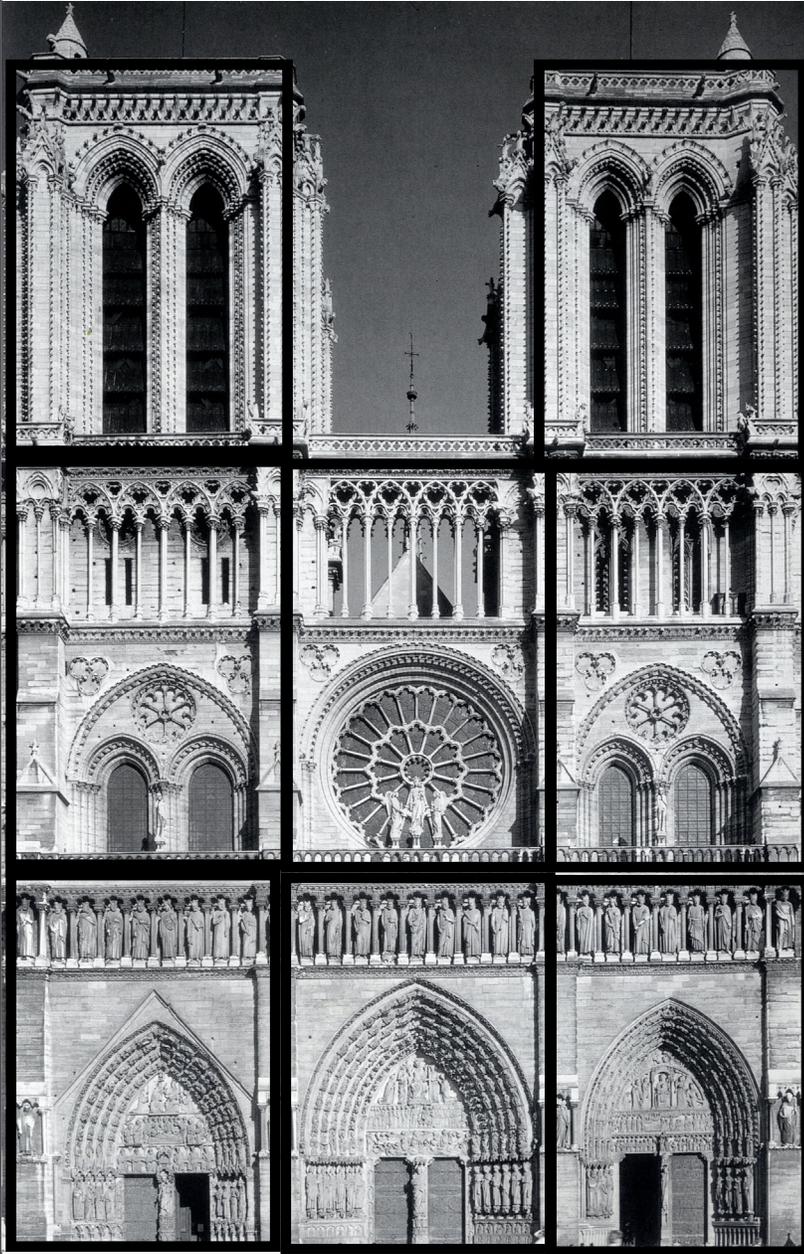
The elevation is roughly twice the plan in terms of square footage as shown below. The building uses the ideas of units put together to make a whole, except the units are fit inside the container that is the exterior. For how geometrical the exterior looks, there is a lot of organic spaces happening in the interior.



The natural light comes from the permeated openings in the concrete. The windows were designed to let air and light throughout all the space. There is a central hallway that runs the length of the building and allows circulation. The exterior of the building has a subtractive feel to it because the walls are 18" thick, making the window opening very deep. There are also bigger pieces taken out of the building as a whole. (Amclar, 2003)

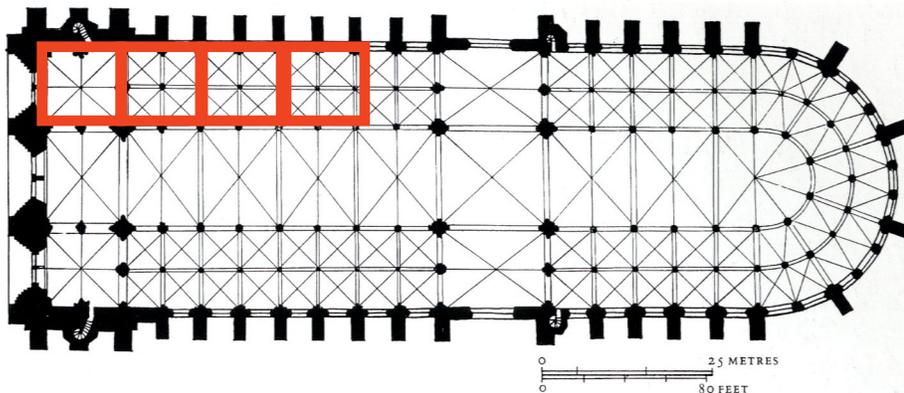


## Notre-Dame - Paris, France



This building is a cathedral in Paris, France. Notre Dame means “our lady” in french. It is designed like most of the churches from the Gothic era with apse, nave, and side isles, along with being one of the first churches to use flying buttresses. Their use was only by accident, to keep the thin Gothic walls from collapsing. This church is close to 1000 years old, as it was started in 1163. This is my reasoning for analyzing it as a case study since this is the unit of time I am studying.

The way this church was built allowed it to survive the last almost 1000 years. Its construction uses bays to break down its massive size to a much more manageable scale to build.



(Frankl, 1962)

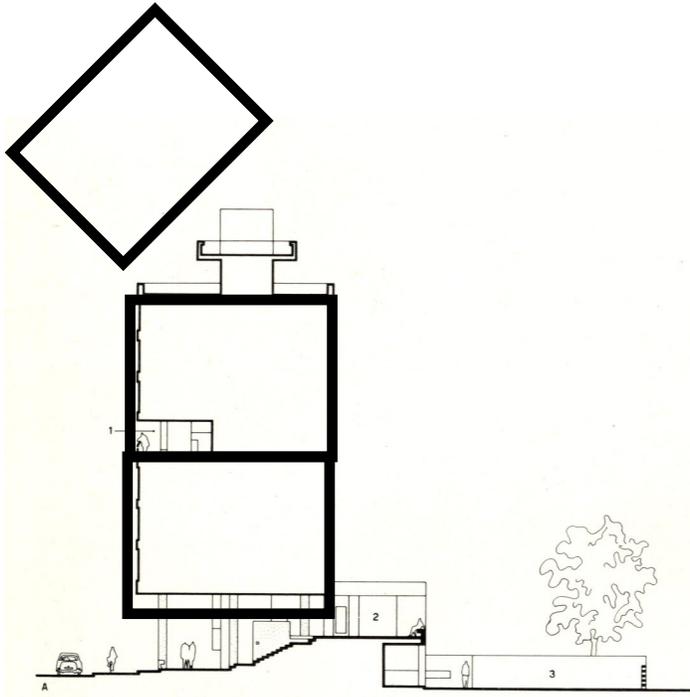
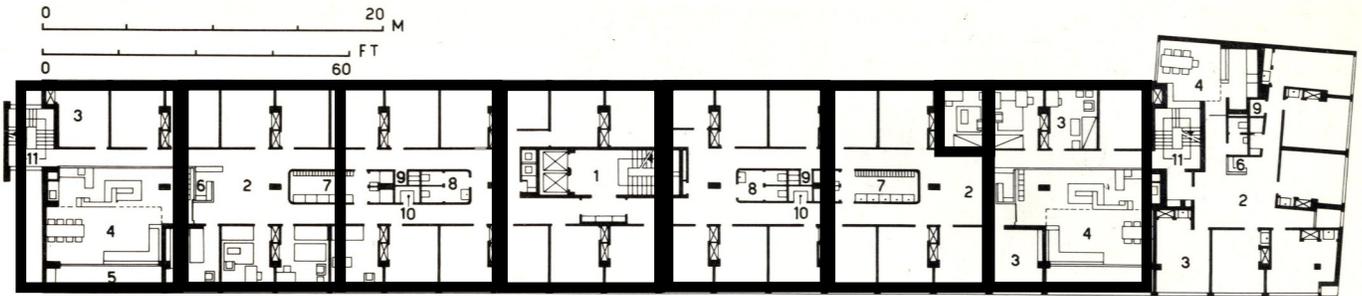
This repetition of bays is what makes it unique. It is very symmetrical which gives it balance and that is carried through into its elevation. The elevation also has bay like qualities, divided up into different sections that are also symmetrical.

This case study is really dissimilar from the other two because they do not share the same typologies. Yet is strangely similar in the use of units that make a whole. This seems to be key in creating a building that can be used for this long of a period. It allows interior elements to be moved around, yet still fit because the units are very similar. (Frankl, 1962)



(Frankl, 1962)

## Studenthouse Amsterdam, Holland



(Aloi, 1970)

This Building was designed by Herman Hertzberger and is a dormitory that holds about 250 students. This case study, like the previous two, uses units to build a whole but in a much more structured way than the first case study. Herman was a Dutch structuralist. Along with dorm rooms of varying sizes there is a restaurant on the main floor along with offices for student organizations.

The plan takes the individual rooms as one unit and six of them make a bay. The section is two of these bays high. Along with these very structural elements, there is a slight variation on one side of the building where there is a portion of the building at a 5 degree angle from the rest of the building. This

variation really offsets the structure and complements it well. This Plan also utilizes the double loaded hallway down the center of the building. The public bathrooms are in the center of this hallway, however, which serves to break it up.

This case study is a good example of a concrete dormitory that uses structure very well. The massing of the whole building is very nice no matter if you are looking at the plans or the section. (Aloi, 1970)



(Aloi, 1970)

## Case Study Summary

My goal for the case studies was to find a few buildings that were the type of institutional/residential buildings I plan to design for my final thesis. I ended up also looking at buildings that have survived the lifespan for which I plan to design. The reason for this is to try to understand what is needed to make a building last that long. Analyzing these case studies along with other research, got me to make a few changes to earlier portions of the thesis.

The MIT dormitories and the Studenthouse both gave me ideas on spatial planning and different ways of resolving circulation in a dormitory type building. The MIT building showed an interesting way of filtering light and a passive way of cooling into one type of fenestration. It is also built from concrete, and it was interesting to see how they use that material. There is also a curious shift in the way people view the building. When asked if they liked living in the building residents stated many problems with the functionality of the building. On the other hand the building has won numerous architectural design awards. It reminds me that architecture is art, but it also has to be functional

because people use it everyday. If users are not happy with it, then it fails as a design.

The Studenthouse case study is a good example of structuring units and how that helps the design of the whole building. The building also shows how a little variation can make the building much more dynamic.

Notre Dame cathedral is a building that has stood the test of time, as it is almost a thousand years old. This figure moved me to change my length of time from 200 to 1000 years as a more lofty goal. The building has a totally different function than the other two case studies yet the way they use units to create a whole is apparent in all of them. This is a very interesting finding because it is possible that this is a big key to designing a great building instead of just a mediocre building.

All three are in urban sites, yet all are very different in the way they address the site. This leads me to believe the sites for these buildings were not that considered as much as the design of the spaces inside the buildings.

These case studies helped me to gain insight on my project as a whole.



# Historical Context

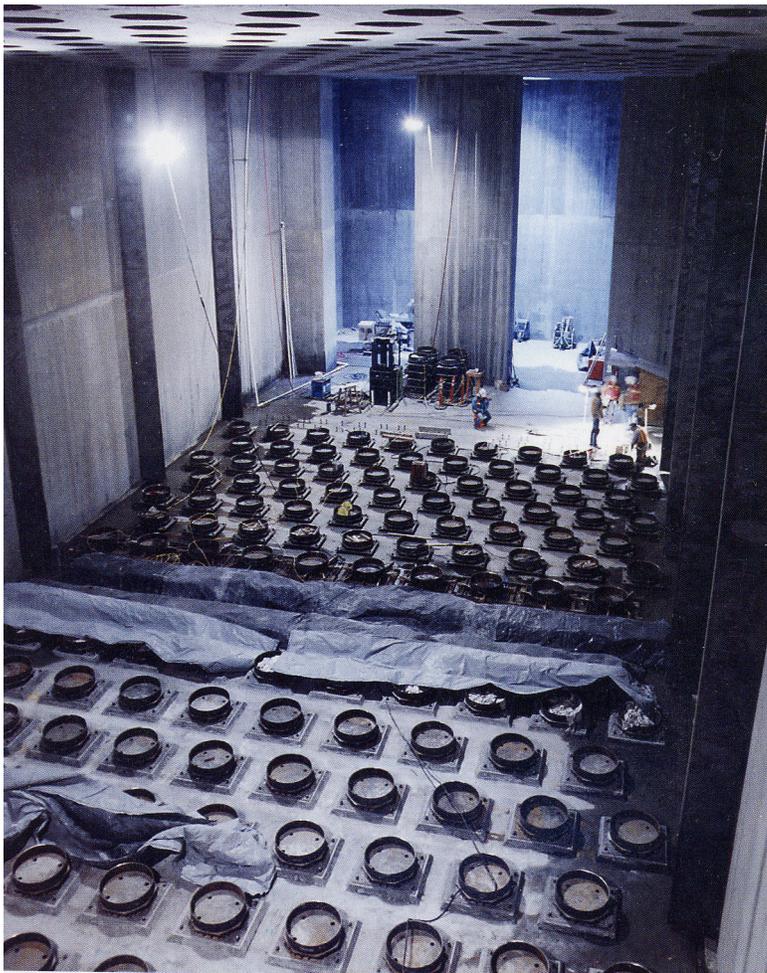
## Historical Context 1

There are two parts of historical context on which I wanted to focus: the history of what the facility will function to do, store nuclear waste; and the history of government facilities in general. This will give some insight on what has been done and what still needs to be designed for this particular facility.

There are two types of nuclear waste that are produced: low level and high level waste. There is much more low level nuclear waste in the country than the other. The good part about this is that low level nuclear waste has a half life of 500 to 1000 years. This means that it will deteriorate to safe levels of radiation within that time. Low level waste mainly comes from medical uses of radioactive materials. So, therefore the items inside these containers of waste can include medical gloves and instruments.

Although this type of waste will not be stored in the type of facility I am designing, it is still interesting. The fact that low level waste is stored in steel barrels and buried in shallow trenches is something to be alarmed about. These barrels tend to rust and leak the radioactive contents into the ground contaminating the ground water of that area. This is not a long term storage solution. If we do not





find a long term storage solution, the last remaining temporary storage facility in Barnwell County, South Carolina may close. It has been slated to close since 1993, and there will be nowhere else to put the waste. Imagine going to the hospital because you have a tumor, and hearing the doctor tell you that they can't locate it because they have nowhere to put the materials after the test. We rely on these radioactive materials everyday and we take it for granted. That is only one way we use it, there are over 20,000 licensed users of radioactive materials. (Daley, 1997)

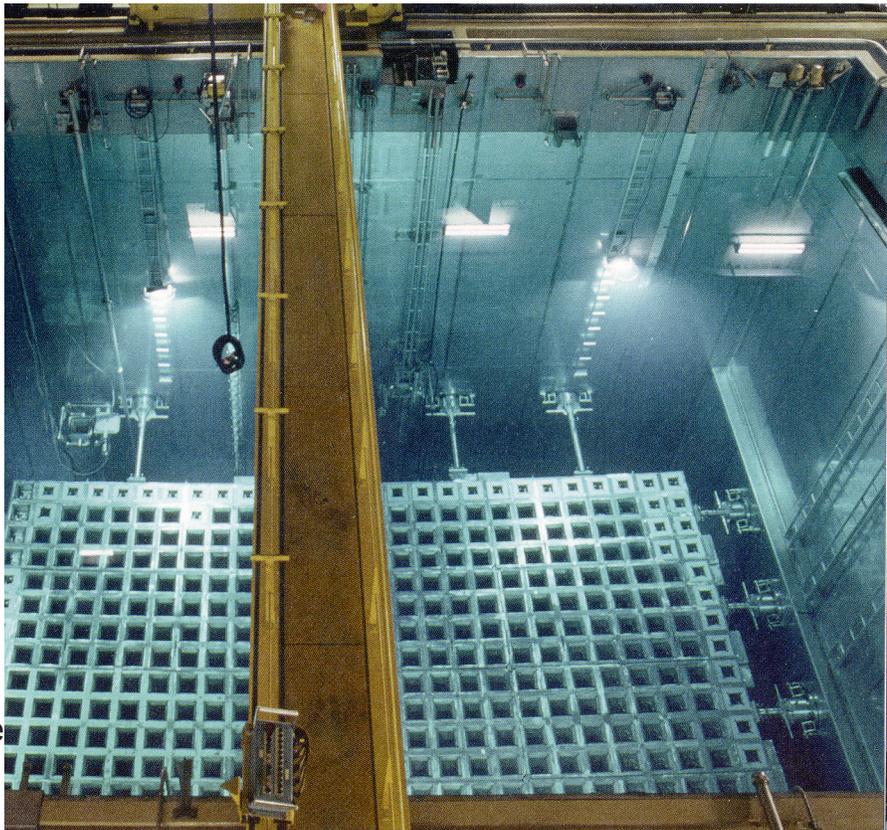
The other storage solution they have come up with is sealing it in heavy concrete casks and dropping it in the deepest parts of the ocean. The idea behind this is that they know it will leak but when it does the massive amount of water will dilute it enough to render it safe. Others say that if fish swim by while this is happening they will become affected by the radiation. Then other fish will eat them and eventually human will eat the fish and it will eventually affect us.

The second type of nuclear waste is high level. This type of waste will not be at safe levels of radiation for tens of thousands of years, or for the human race, forever. This is the type of waste that will be stored at the Yucca Mountain complex.

### Historical Context 3

Currently, it is stored at the power plants where it is produced at and at government facilities. The problem with this is that these power plants were only meant to store a limited amount of waste and are at capacity. This is true even though the amount of high level waste that has been produced would only fill up a football field at about 9 feet high. This means that the amount of waste the average American produces in their lifetime, if using only nuclear energy is about the size of 100 Aspirin pills. (Daley, 1997) The amount of energy produced by one ounce of Uranium is equal to one ton of coal.(Daley, 1997) To me Nuclear Energy is relatively safe, provided we keep the same standards of safety. It is a clean alternative to the coal and oil power that we have been using. Yet there has not been another nuclear power plant built since the 1980s because of the accidents at Three Mile Island.

The US government is under contracts to have provided a facility to store this type of waste by 1998, but has not done so. This is because no one wants a nuclear storage facility in their state. The Yucca Mountain facility was supposed to start accepting waste in 1998, then 2003, and now 2010. Because of lawsuits and other bureaucratic red tape, the date will probably



be pushed back again. Unlike the low level waste, this waste is stored in a much better way. This is probably because just one storage container full of waste is speculated to be enough to poison the world population if spread out evenly. In 2004 there were 540 of these containers in use around the US. This is because power plants need to change out their fuel rods every 18 to 24 months. Even though the rods are solid and compact in size, they add up quickly.

These containers are another influence to the design of the facility. The containers are made from concrete with a steel liner or just reinforced concrete. These containers sit on a concrete slab that is three feet thick. If concrete is good enough to shield people from the waste itself, then it should be safe enough to shield people living in the facilities surrounding the storage tunnels. There is also the fact that concrete is one of the most long-lasting building materials in use today. All these containers at power plants are a big target for terrorists. While the manufacturers of the containers test them under the most extreme conditions, and even say that they can withstand a direct hit with a commercial airliner, they still should be moved to an alternate site that can be more closely guarded.



## Historical Context 5

This is also a concern when they start to move these containers across the country. The government is concerned about terrorists, and have a detailed plan to transport all the containers to the Yucca Mountain complex. The citizens of Nevada will continue to fight the storage of nuclear waste in their state, citing that they have no nuclear reactors of their own, Why should they be forced to house the waste of other states?

The other Historical context is that of institutional government facilities, as this is the typology that will be designed. It is interesting to study the buildings that are already planned to be built on the site for this thesis. There are the major buildings which house the transfer of nuclear waste to different containers for storage inside the mountain. These are subject to heavy scrutinizing and are very heavily regulated because they are used for nuclear material. The other proposed structures are similar to government and military style buildings that are more common. They include dormitories, cafeteria, and other support structures for the workers.

To get an idea of what has been designed in this context all I have to do is look at any military base across the country. They are all very similar

in programmatic requirements and so tend to look very similar.

I interviewed, Dan Mickelson, a man who lived on an air force base for the last year, about the facilities and dorms. He said his dorm is one of the newest on the base, and is set up with a room for two to share, and each two rooms shared one bathroom. He said the dining building is about a half mile away, and is quite large as it is used by the whole base. Because the base he was on, Eglin Air Force Base, Florida, is one of the biggest in the country, everything was spread out. According to Mickelson, the recreation area was equally far away from his dorm and he would go there every day as did his peers. When asked if he liked his living arrangements he said yes, mostly because he was the one that had been there the longest and so made the other three suitemates clean the bathroom and he made his roommate clean the room. (personal communication, November 20, 2008)

The historical context I found during my research helped me learn more about the typography of the government facility and the increasing need for storage facilities for spent nuclear waste. It reaffirmed the need for the facility I will design at Yucca Mountain, Nevada.



# Goals of Thesis

## Goals of Thesis

This thesis will explore the trials and tribulations of designing a building to survive for hundreds of years instead of continually building and tearing down buildings. The building that results will hopefully be not only more sustainable but better suited to the clients' needs. I considered that the building will have to be either tailored to the clients' needs or very open to host many needs of the many clients that would inhabit the space. The design will be suited for one client, the US government. By doing this and all research connected to it, I hope to get a better understanding of the country's nuclear power, and nuclear waste needs. This, I believe, is sustainable, in comparison to the sources of energy being used in the US now. I also hope to learn more about designing and using concrete as a building material and a barrier against radiation. Along with these end goals, there is a list of goals that should keep the project on track through out the design process. These goals are as follows:

## List of Goals

1. Continue research throughout
2. Experiment with materials
3. Investigate multiple forms
4. Stay on track
5. Continue to push the design
6. Create a clear program
7. Document process throughout
8. Create interesting outcomes
9. Respect the site
10. Provide places to continue



# Site Analysis



## Site Analysis: Qualitative

I went to the site on the 6th of January, 2009. The experience began as I drove out of Las Vegas, Nevada, going northwest along Highway 95. As I left the city limits the sites became more and more desolate. There is no wildlife; there are no trees, only sand, rock and a few bushes. The most interesting feature I thought was the mountains on all sides of the Las Vegas valley. No matter which direction I turned there was a mountain in the distance. Additionally, in comparison to the last valley city I saw in Germany, this valley is huge.

As the road wound through a hole in the seeming impenetrable mountains, I saw that the mountains went on and on. More and more of the same desolate mountain views continued until I came upon the town of Indian Springs, Nevada. The town appeared out of nowhere. I turned along a curve in the road and there it was, almost like an improbable mirage. The town was home to an Air Force landing strip and a casino. The next town was Armargosa Valley, which had even less to make it a town. It is here where I took most of my pictures as it is straight south of my site and the closes point to it where I was allowed to take pictures.

During a tour of the site I,

unfortunately was not allowed to take pictures as it was a military facility. I am able to describe it, however the views of the surrounding landscape were quite amazing. When I looked to the northwest, Yucca Mountain encompassed my entire view. But when looking southeast, you could see for miles and miles when atop a ridge next to the site. The tunnels themselves were amazing themselves. As we went through them, they seemed to go on and on forever.

When I visited it was obviously winter, but the high for that day was 63 degrees and the sun was shining. The plants on the actual site had mostly been plowed under so that they could level out the area. The surrounding plants consisted of mostly low-growing bushes. The existing building consisted of mostly tent-like structures that I was told were temporary.

This site I was told by the tour guide, was perfect for the storage of high level nuclear waste both in the remoteness of the location and the history of the site. Nearby are the proving grounds for the first nuclear tests in this country. This area is considered the reason we won the cold war, because it allowed us to develop nuclear weapons.

# Site Analysis: Quantitative

As stated before, there are few functions that would support a structure for hundreds of years. This list does include government facilities as the government is a stable enough institution to ensure the continued use of buildings. Also, the fact that nuclear waste will take thousands and thousands of years to become inert also guarantees that the buildings that are built for its storage would be used for even longer than the previous goal of 200 years. That is why I picked the Yucca Mountain nuclear waste repository to test out my thesis project.

## FEDERAL LANDS IN SOUTHERN NEVADA

### Land use:



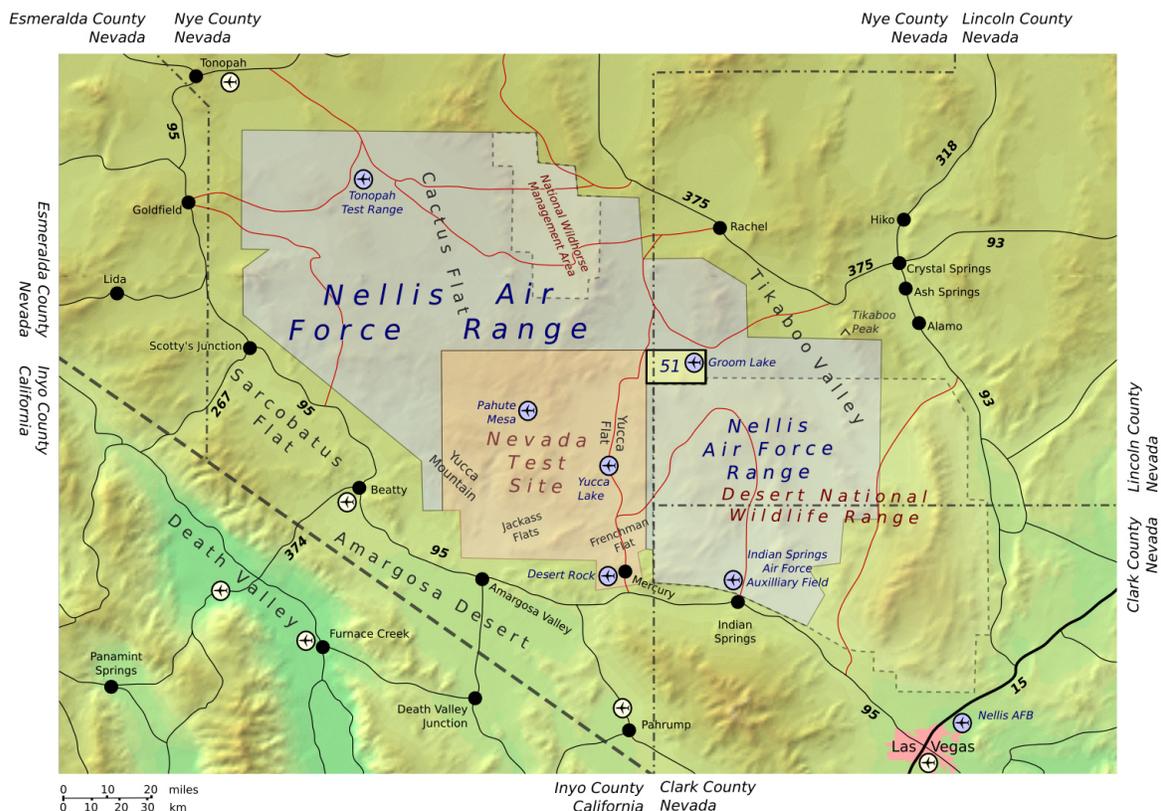
### Legend:



### Location:



Location of main map



**The site** is about a one hour drive from Las Vegas, Nevada. It is located on a military base next to Yucca Mountain, which is where the complex gets its name. The actual storage of nuclear waste is underground in the side of the mountain. The support buildings for the people who run this facility would then be adjacent to the entrance to the storage facility.

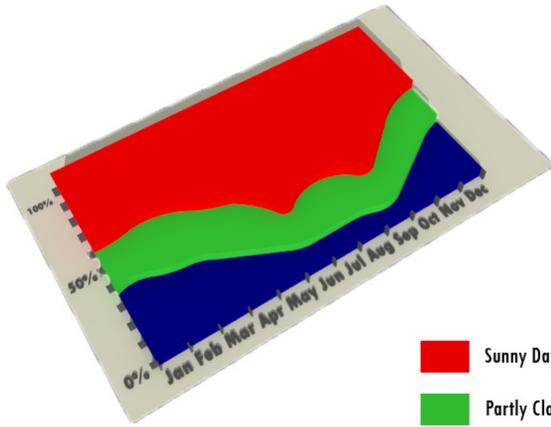






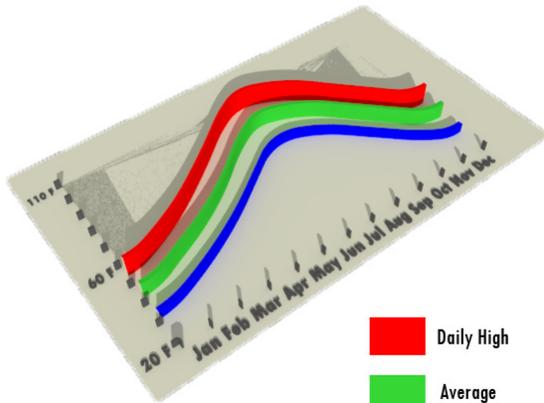
**Entrance to Storage Area**

**- Existing Structures**



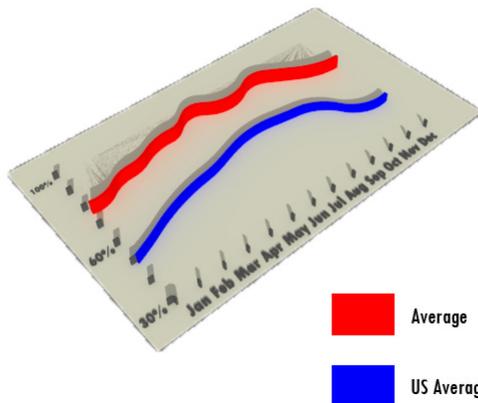
## Cloudy Days

- Sunny Days
- Partly Cloudy Days
- Cloudy Days



## Average Temperature

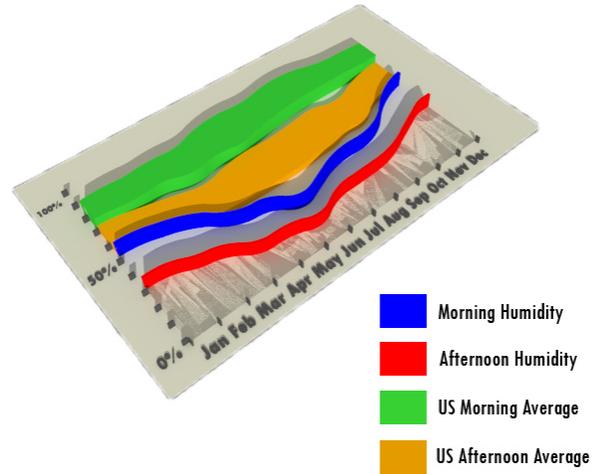
- Daily High
- Average
- Daily Low



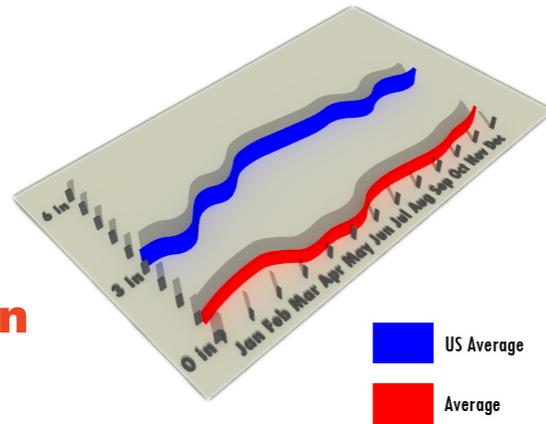
## Sunny Days

- Average
- US Average

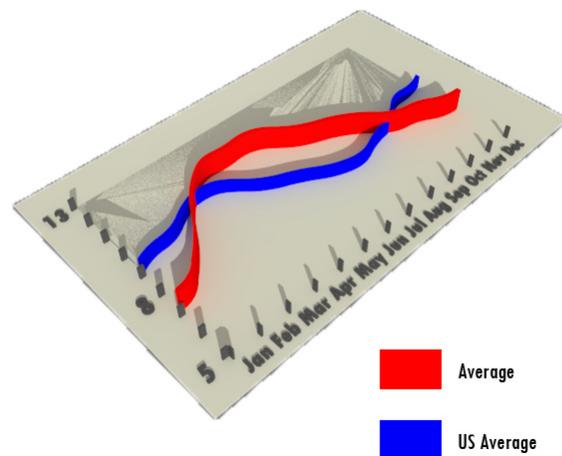
## Average Humidity



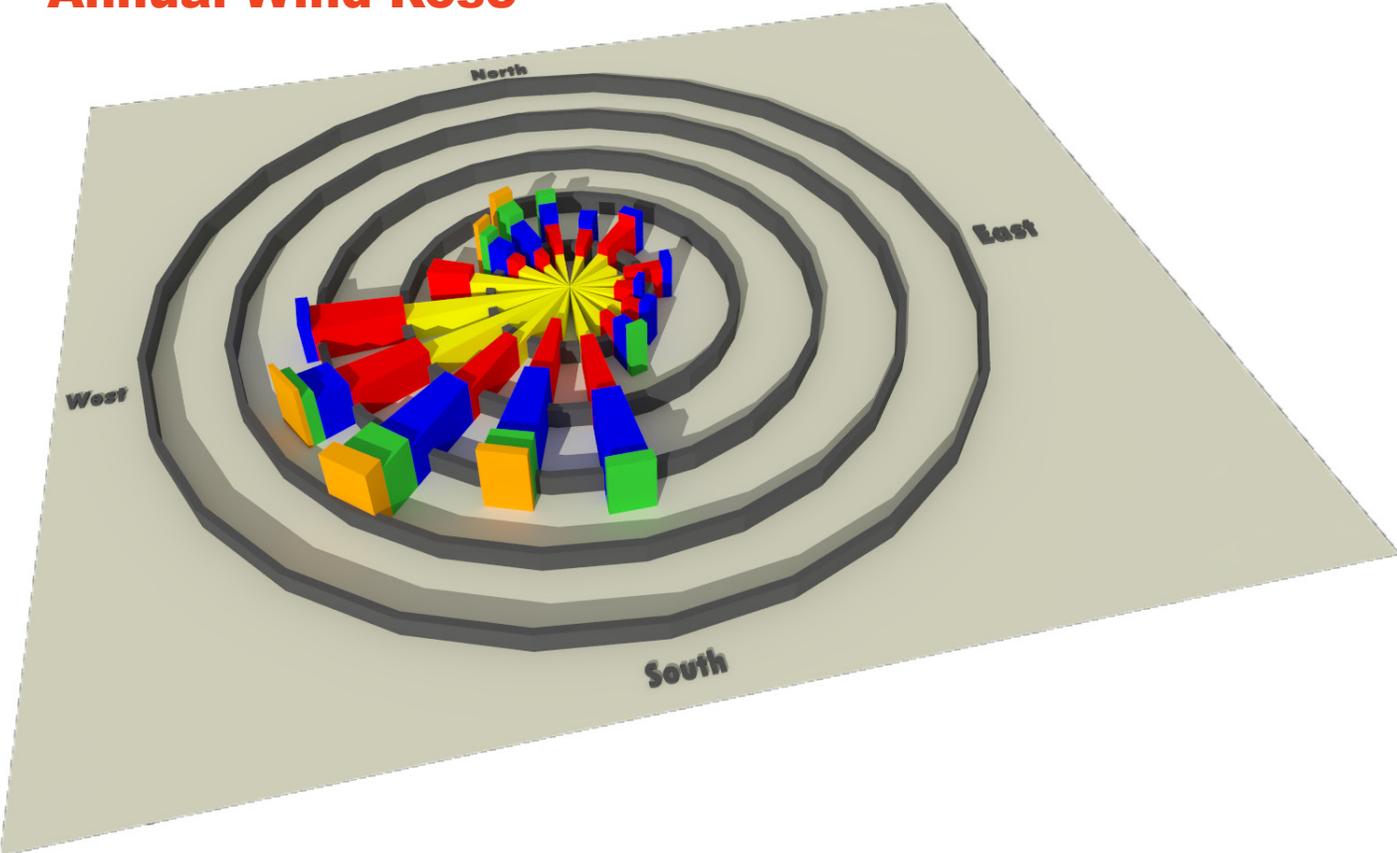
## Average Precipitation



## Average Wind Speed



# Annual Wind Rose

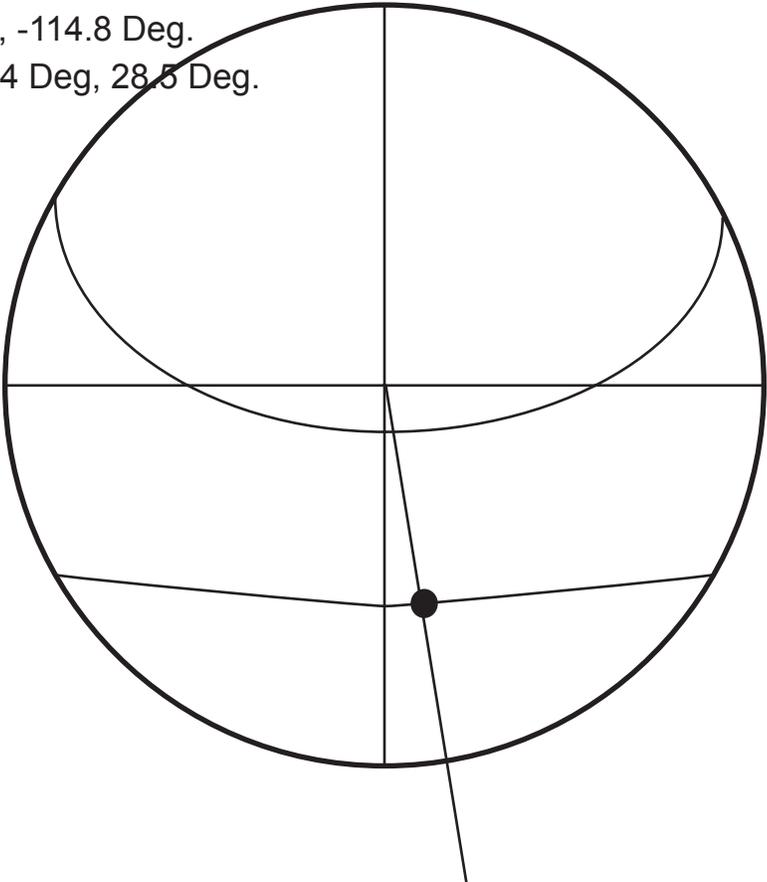


- 0 - 3.8 m/s
- 3.8 - 5.8 m/s
- 5.8 - 8.7 m/s
- 8.7 - 10.7 m/s
- > 10.7 m/s

# Sun Angles

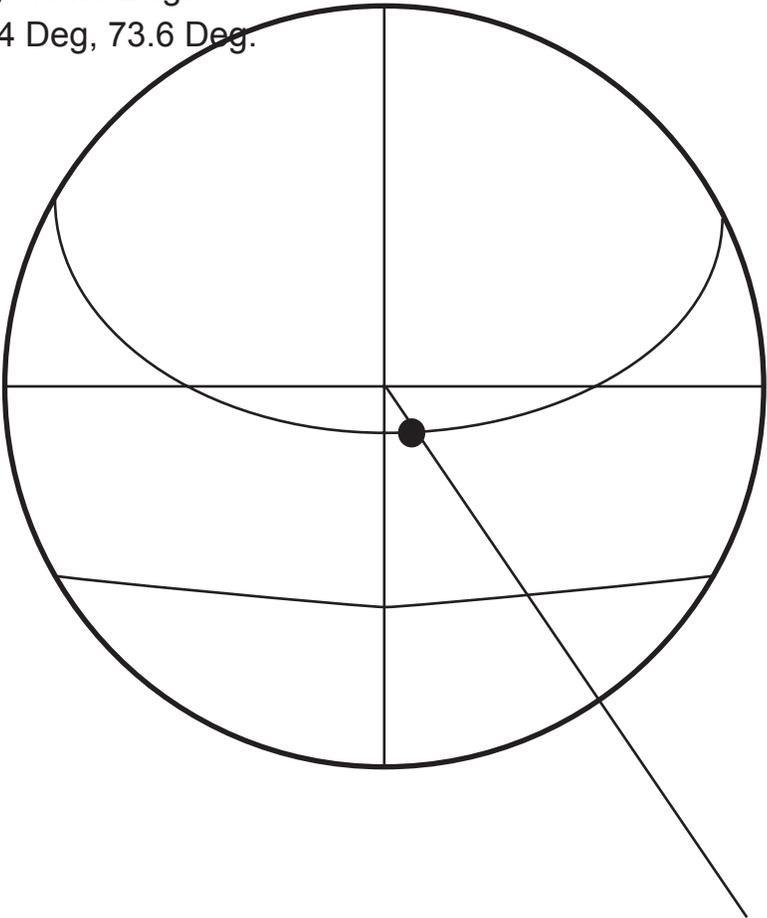
## December 21

location 37.4 Deg, -114.8 Deg.  
Sun Position 170.4 Deg, 28.5 Deg.  
HSA 170.4 Deg  
VSA 151.1 Deg



## June 21

location 37.4 Deg, -114.8 Deg.  
Sun Position 145.4 Deg, 73.6 Deg.  
HSA 145.4 Deg  
VSA 103.6 Deg



## Climate Analysis

The climate of the site is very desert like. It has precipitation totals far below the national average and an average temp that is above average. The high temperature is partly due to the amount of sunny days, which is also far above the national average. The humidity levels through out the year are far below average making it very dry in terms of air quality. I would classify it as high dessert climate, as it is technically in the mountains and meets all the rules for this classification.

This type of climate is ideal for the passive heating and cooling of a concrete structure. During the day when it is hot and the sun is shining, concrete absorbs the heat and if thick enough, prevents it from reaching the interior of the enclosure. Then at night when the sun is no longer heating the surface and the temperature drops, the heat that is stored in the concrete finally makes its way into the interior of the space and warms it. This delayed heating effect is something that the people of the area have used for hundreds of years with adobe structures.

The site has wind that blows mostly from the south-southwest and is quite strong. This is also something I need to consider when orientating the building to take advantage of the passive cooling effect of the wind through the structure. It is also relevant to the transfer buildings as the wind should not be allowed to enter during the transfer process, as not to disturb the nuclear material.

## Soil Survey Analysis

The majority of the soil on the site consists of what the US department of Agriculture calls Wieser. It is a very gravelly sandy loam for the first 6 inches. The rest of the area down to 60 inches the soil is a stratified, extremely gravelly sandy loam, to very gravelly fine sandy loam soil. This type of soil has a low risk of concrete corrosion.

The water table is at about 180 feet below the surface. This is why the storage tunnels are about 100 feet under ground, so that they can split the difference between the surface and the water table, as to not contaminate either if a spill occurred. (US Department of Agriculture)



## Site Analysis

This site is ideal for this thesis project. Not only is the program of the site a perfect platform for testing my thesis, but the climate is perfect for the type of structure that I plan to use.

In terms of utilities available on the site, there are none. All would have to be dug and drilled. The nearest town is about 14 miles away, so there is no way to get utilities from there. There would have to be a small power plant on site to power all the operations, wells would have to be drilled for water, and a septic system or small sewer system would be built to service the facility.

The only vehicular traffic would be the workers coming and going on leave and shipments of supplies to keep the facility running. Most movement in the facility itself would likely be pedestrian, with a few motorized vehicles. The shipments of waste would come by way of a railroad track that would also have to be added.

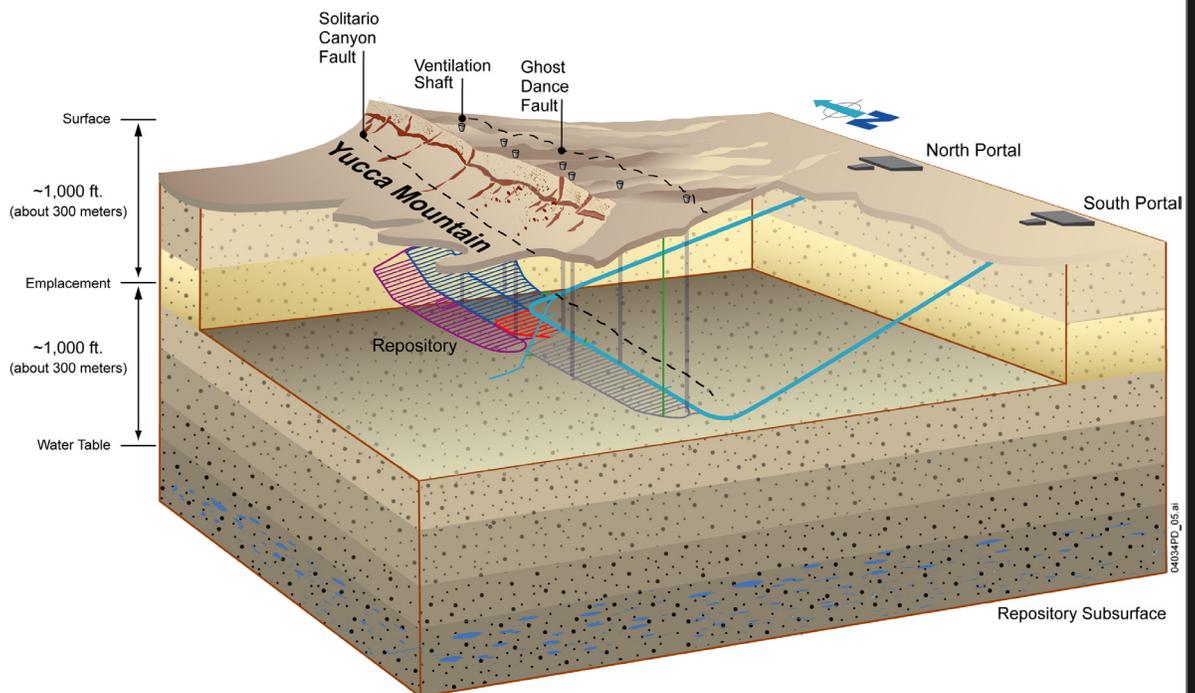
The vegetation the site has to offer is very little. There are no medium to large plants that can survive here, so they are not able to be introduced here. There is, however, a few varieties of cacti and smaller shrub-type plants. As the site is on the lower portion of a mountain, the bed rock is very close to the surface. There is also the occasional outcropping of rock to con-

sider.

The facility itself is located on the east site of one of the legs of Yucca Mountain, and so slopes range from near flat farther to the east to over 20 to 30 percent slope on the west side of the site where the waste would enter the storage tunnels. All the structures would be on the near flat slopes of the site as to provide easy access, or have easy access to the flat surfaces.

The only type of erosion occurs with the wind that invades the region. There is very little precipitation so almost no water erosion occurs. If it were to rain heavily, care would have to be taken to prevent flash floods.

The presence of the mountain leg to the west of the site would provide partial shading in the early evenings when the sun is setting.





# Programmatic Requirements

## Program

The programmatic requirements of this project are quite extensive, as the typology of the project is not just limited to one. These spaces are also broken down in outline form to the right. From the list of required buildings used to run an operation like this are first the buildings that will actually house the spent fuel for a short period of time. From a limited understanding of what the process is for the spent nuclear fuel to be transported and stored in this site, there would have to be at least five different types of structures. The buildings that are necessary are structures that would house the facilities to change from the different types of containers used to store spent fuel to the type of container used at Yucca Mountain. These buildings would not have any human occupants in them for fear of an accident. The buildings would be all run by robots which would have to be controlled remotely. This would necessitate another command central type of building. It would be where all the robot operators would run the machines with cameras. The machines inside the storage tunnels would also be run from this remote spot, so there would have to be ample space for the equipment to do this and for the climate systems to keep said equipment cool.

As stated before, there would be workers that control the equipment who would need a place to stay in between their shifts. There would have to be multiple shifts of workers, as the facility would run 24 hours a day, and due to the nature of the work, the workers would have shorter shifts to combat tiredness. This means the personnel required to run the facility would be more than was originally thought. The support facilities would consist of a dormitory area where the workers would sleep, a dining services area that would have a kitchen and eating area, and a recreational area for workers to go when not working or sleeping. These support buildings would be far from the rest of the facility as not to endanger the workers, but close enough to walk to.

## **Program Outline**

Storage Tunnels

Container Transfer Buildings

Unloading Area

Transfer Area

Loading Area

Command Central

Restrooms

Workrooms

Equipment Rooms

Dormitories

Bedrooms

Bathrooms

Laundry Rooms

Dining Services

Kitchen

Loading Dock

Storage

Freezer

Recreation Building

Gym

Track

Restrooms

Pool

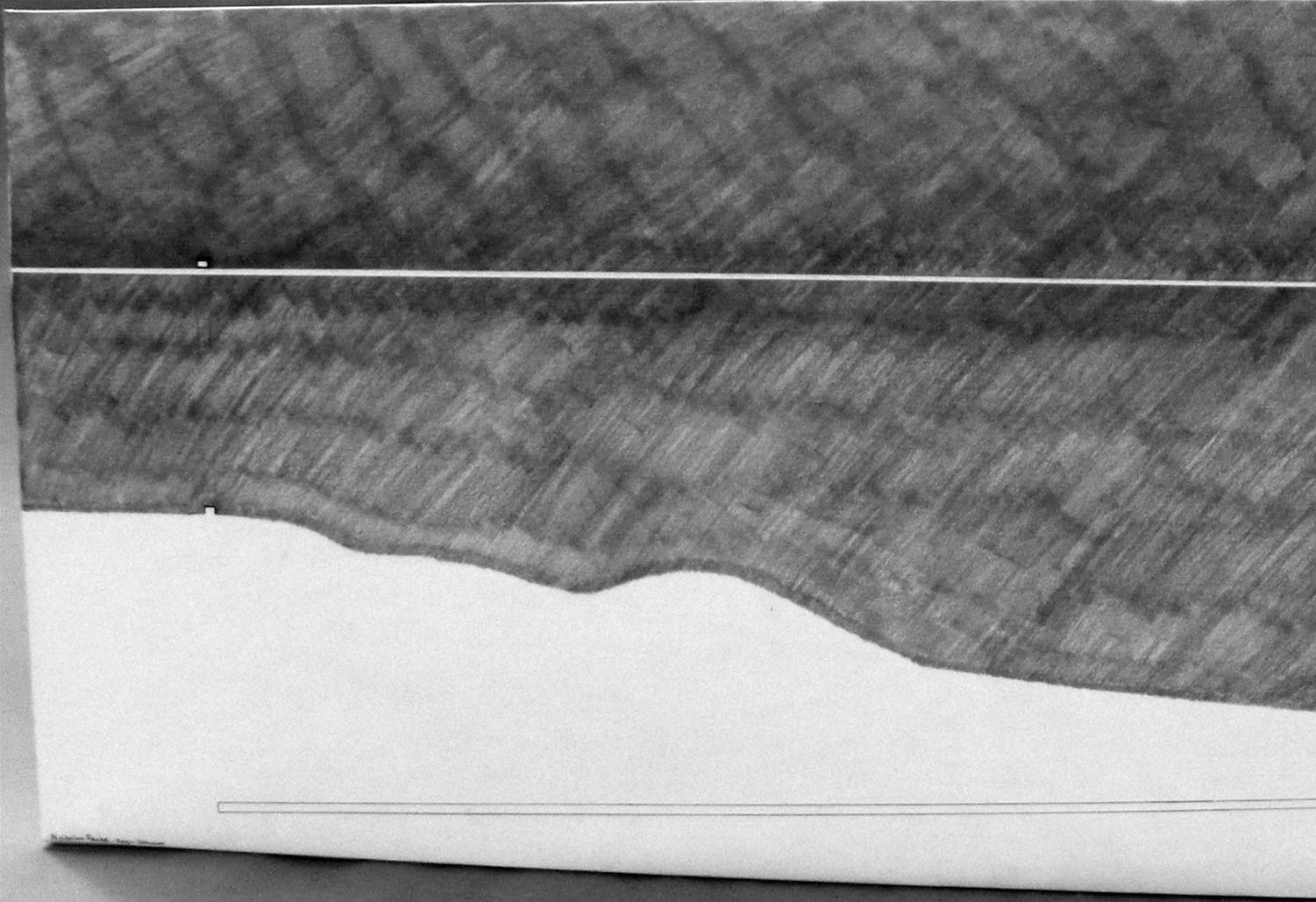
Locker Rooms

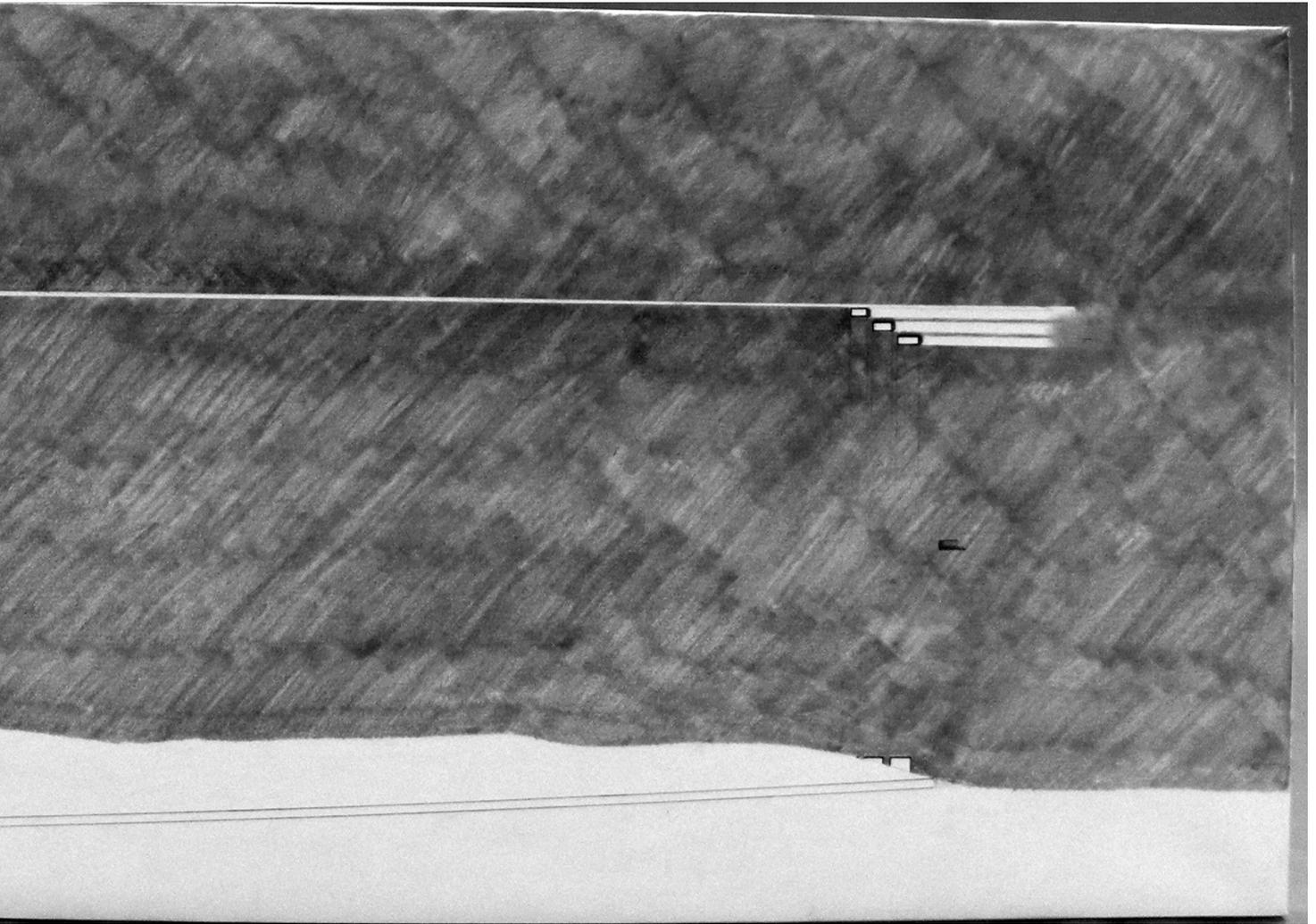
Equipment Storage

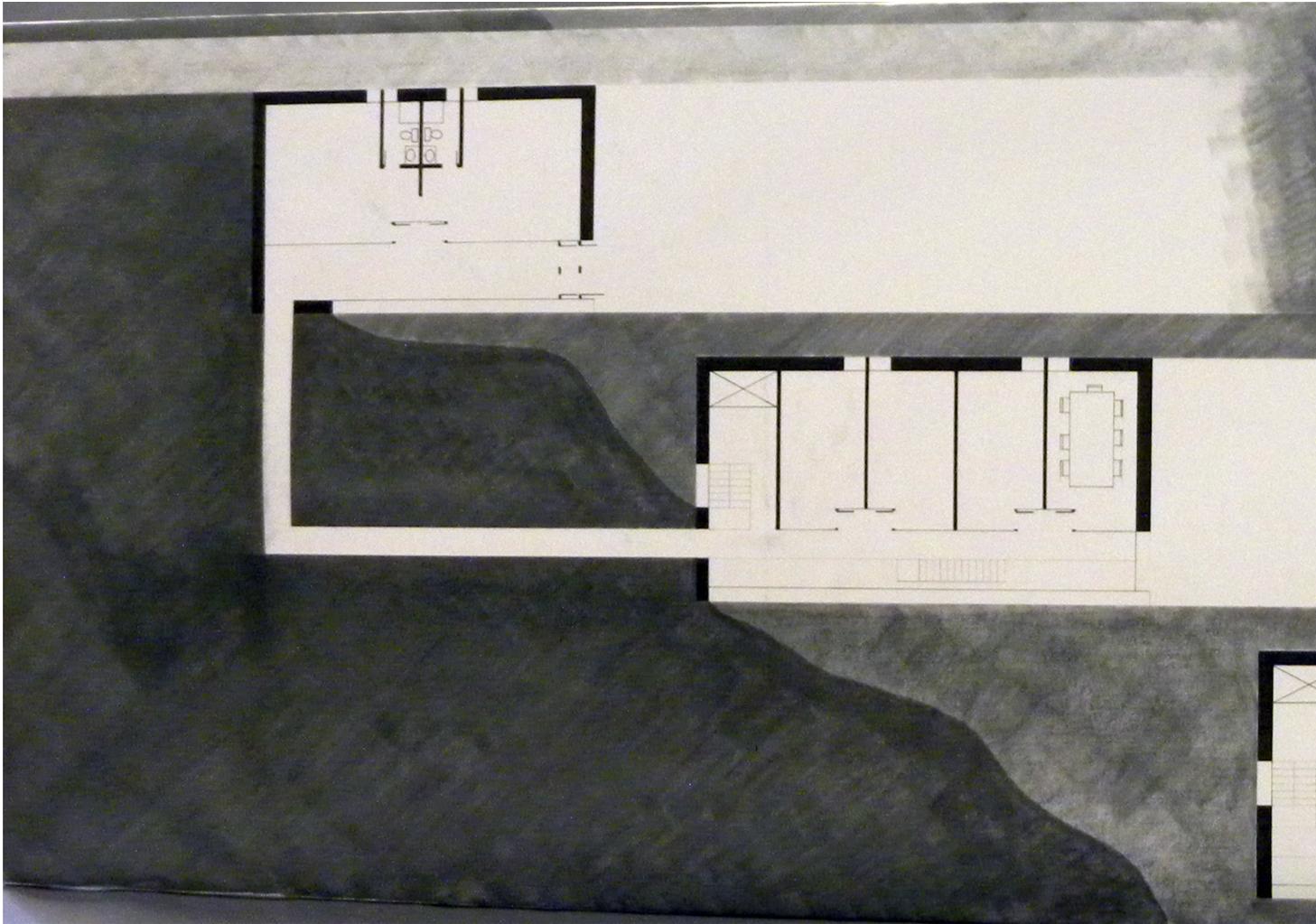


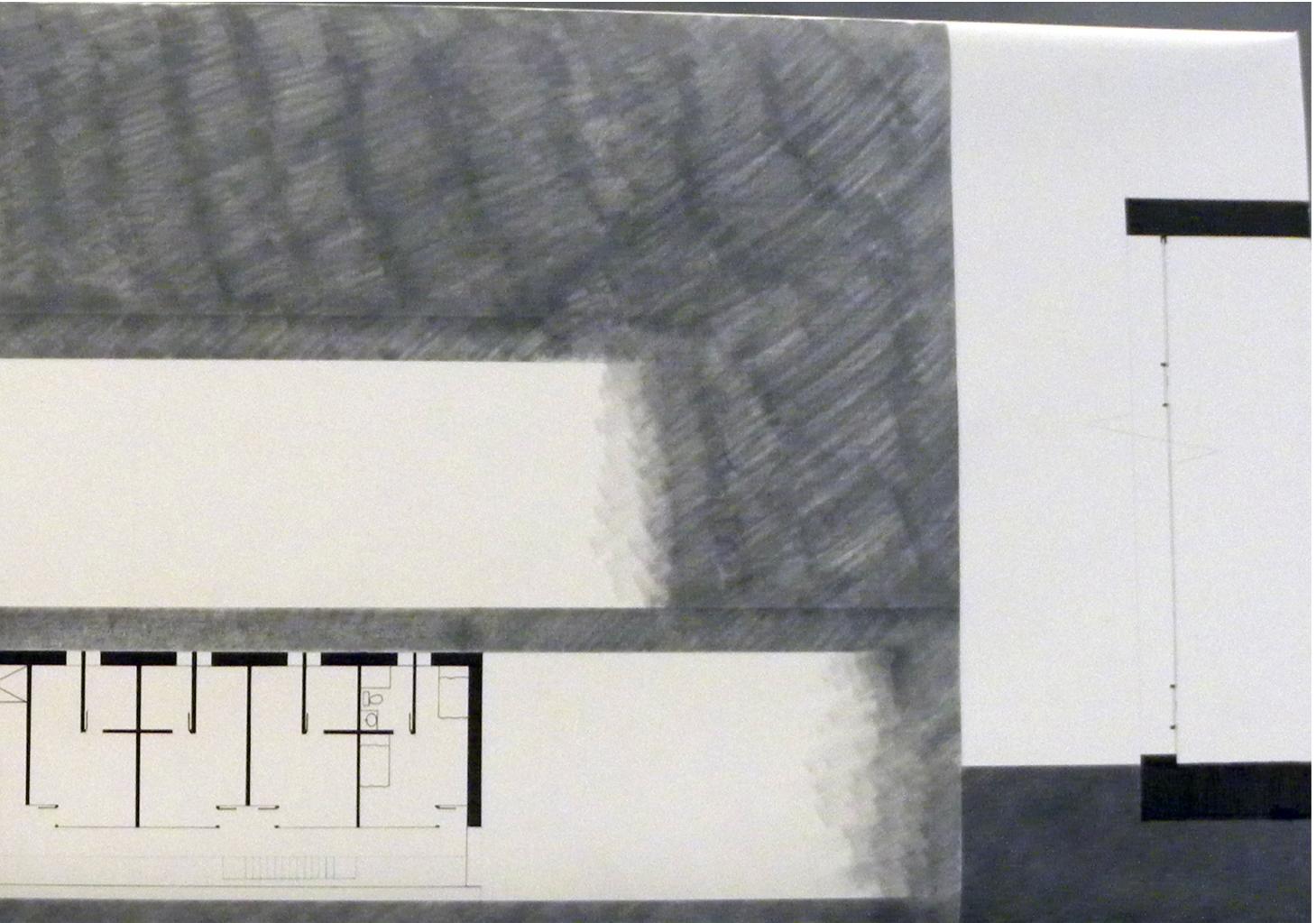
# Design Proposal

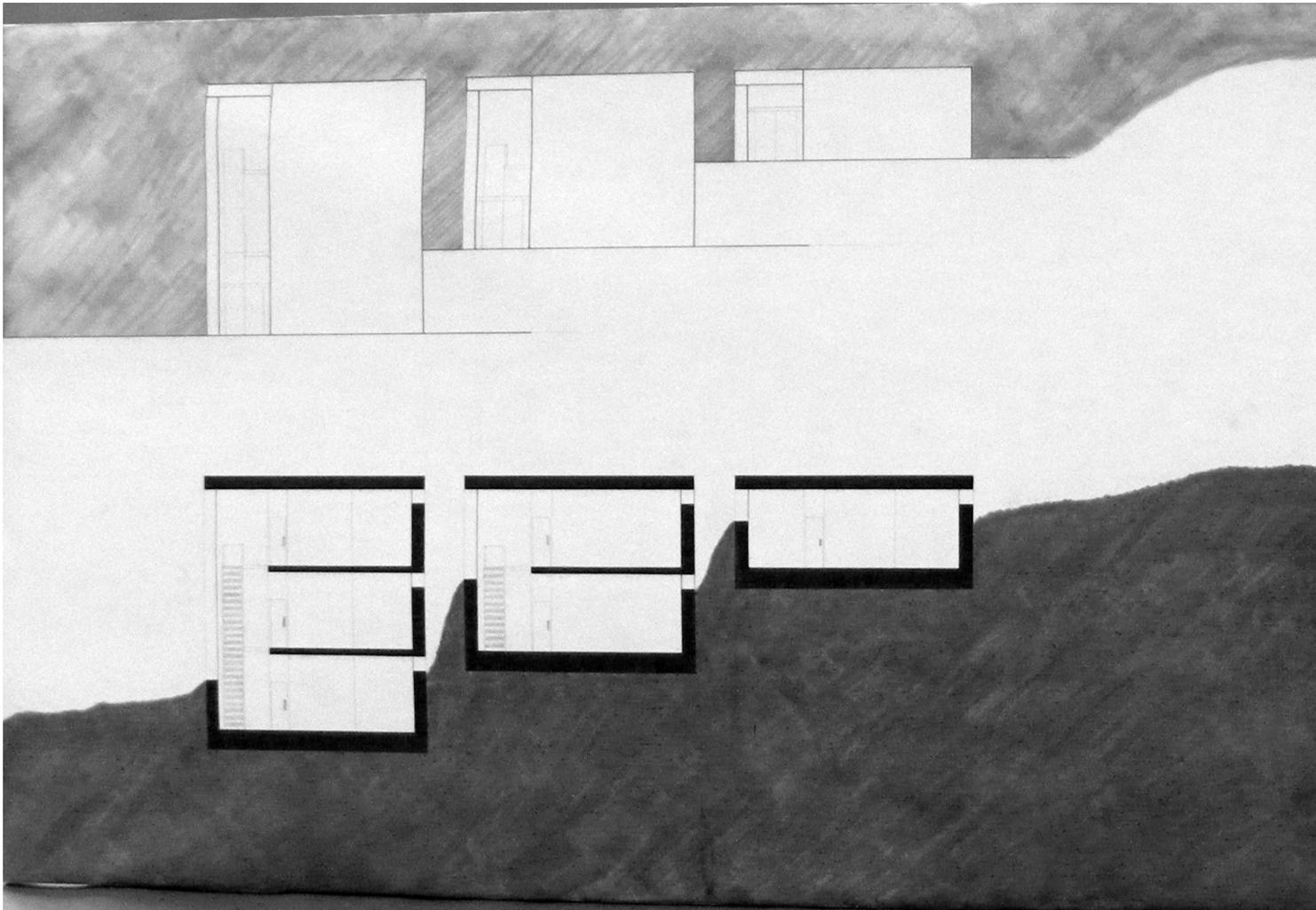
## Final Boards

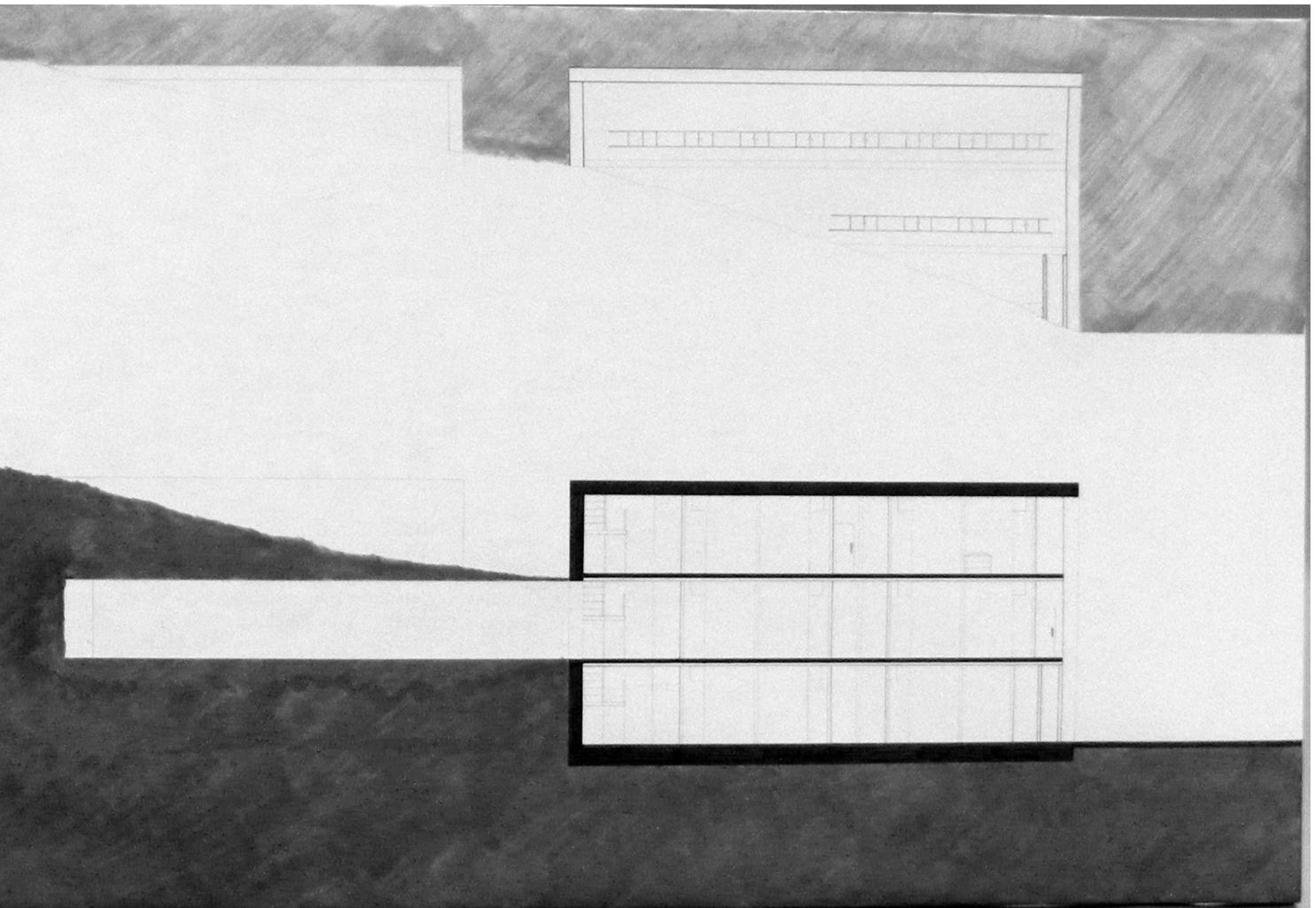






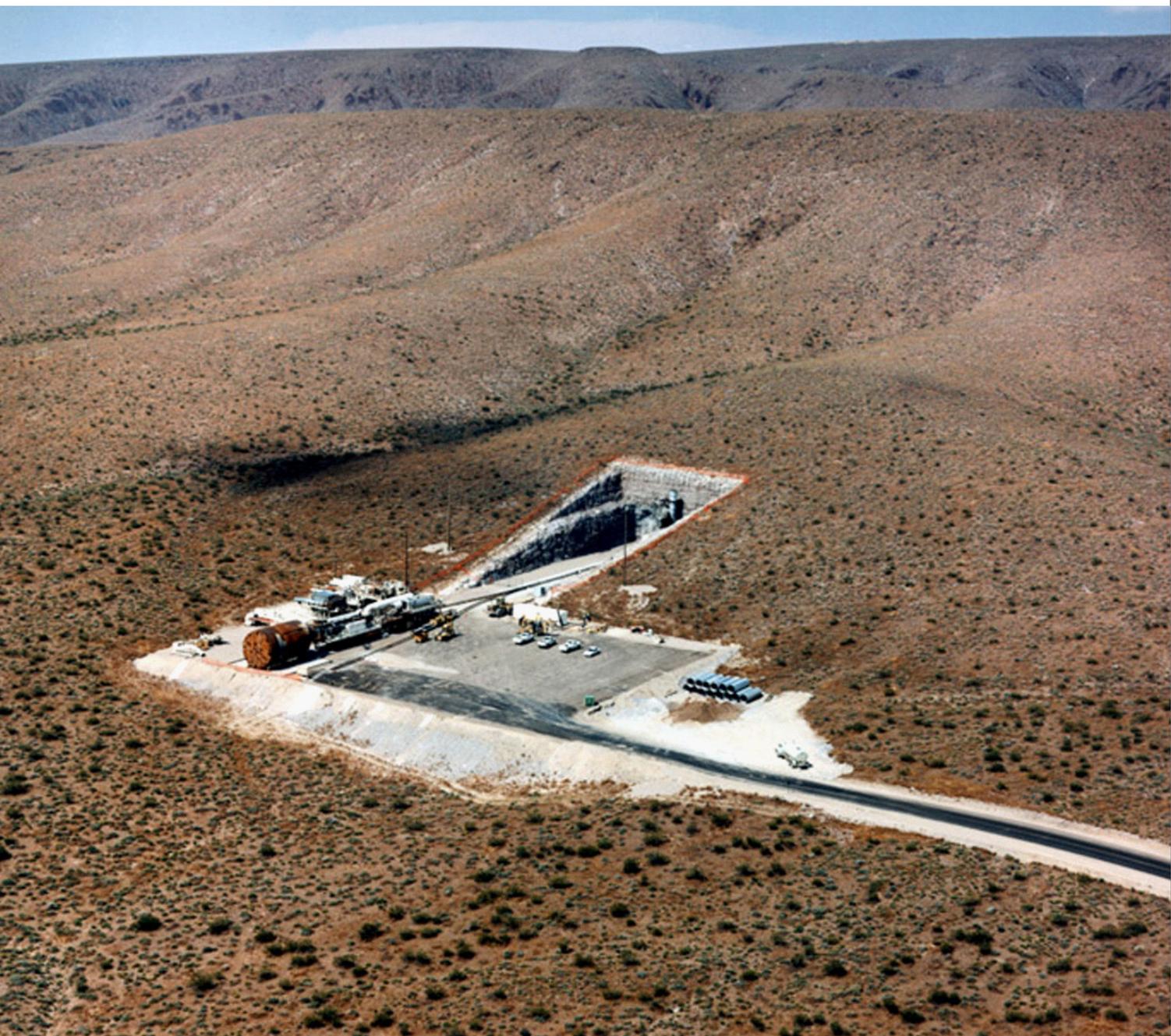


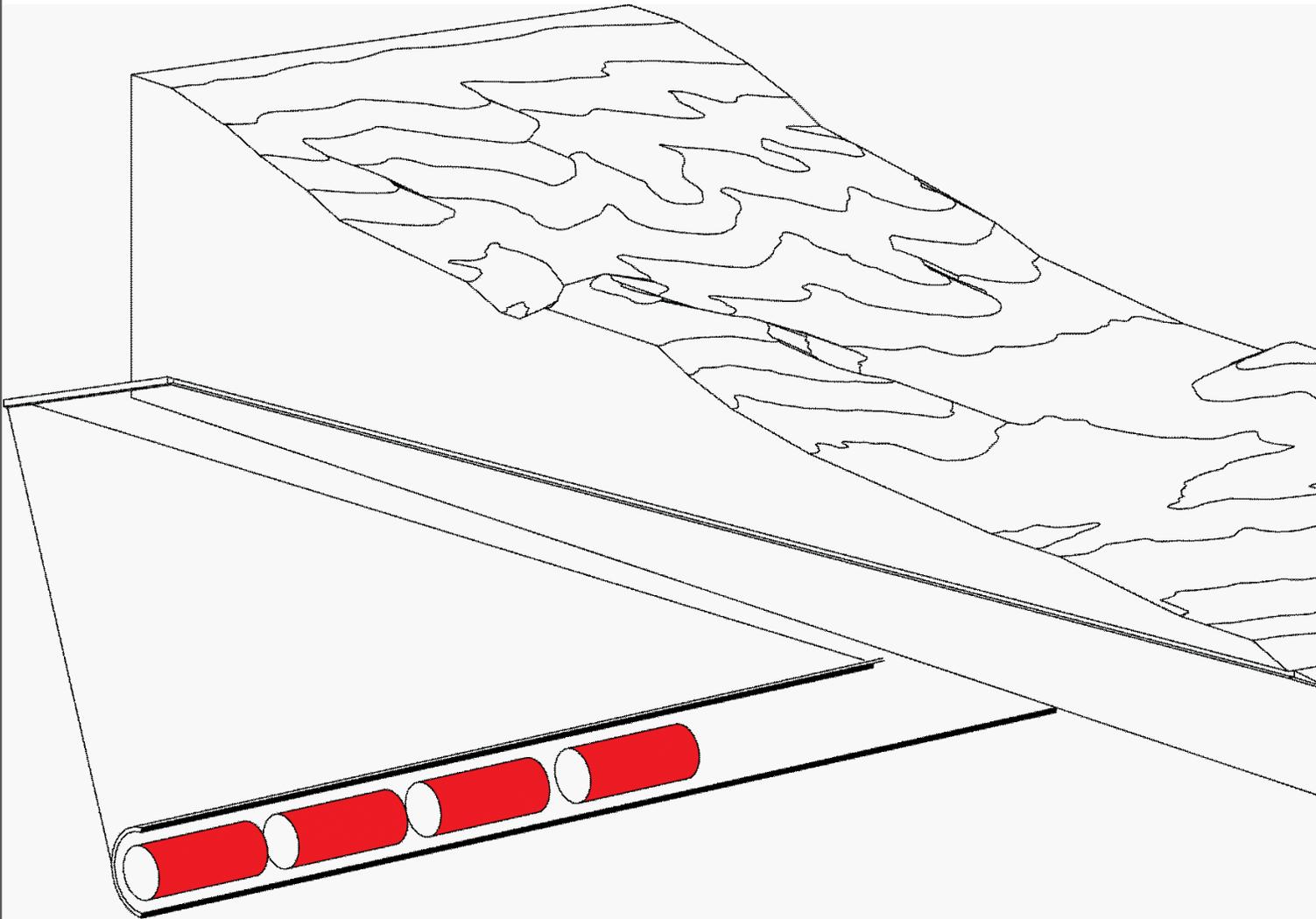




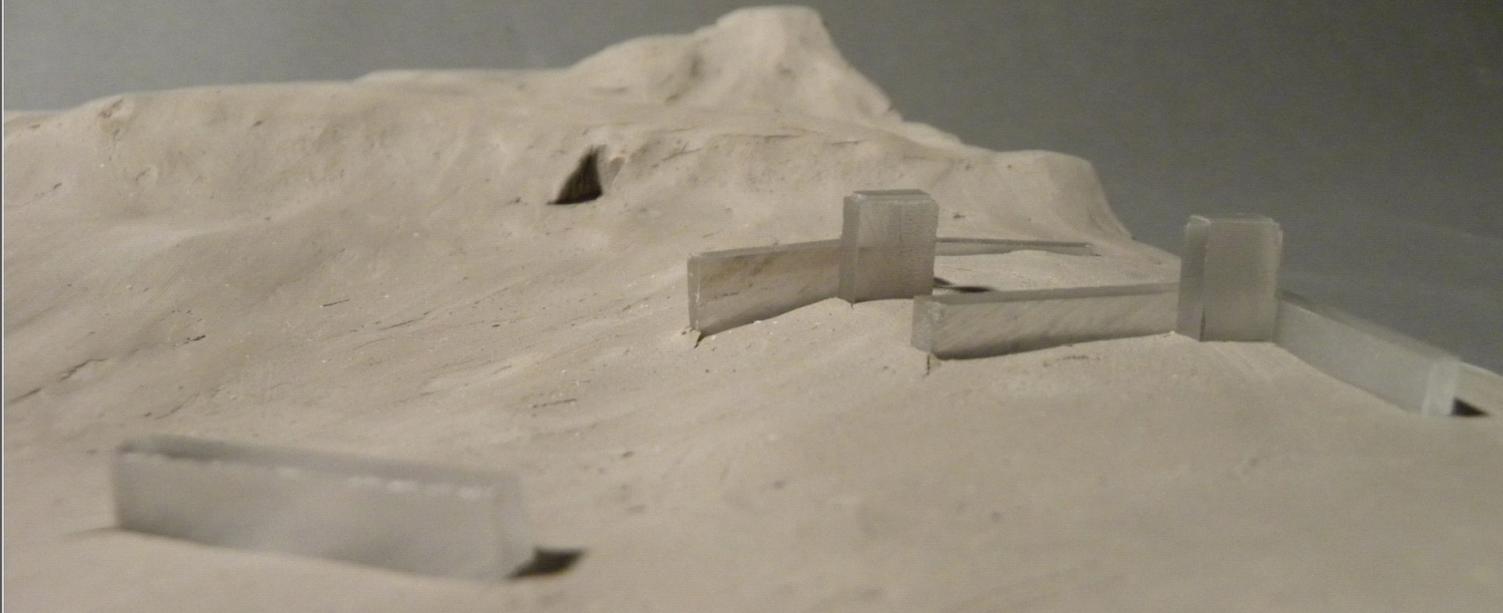
## Final Presentation





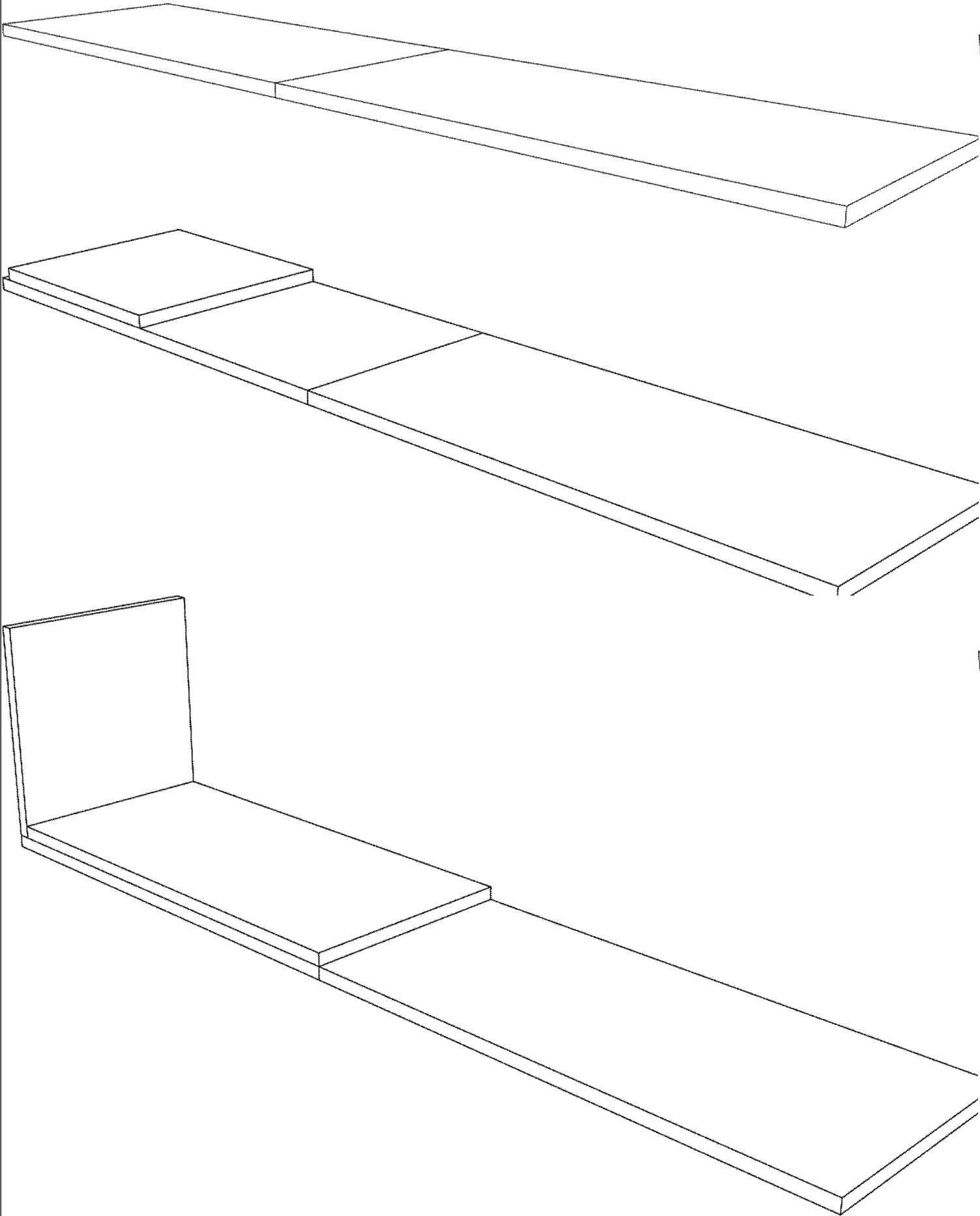


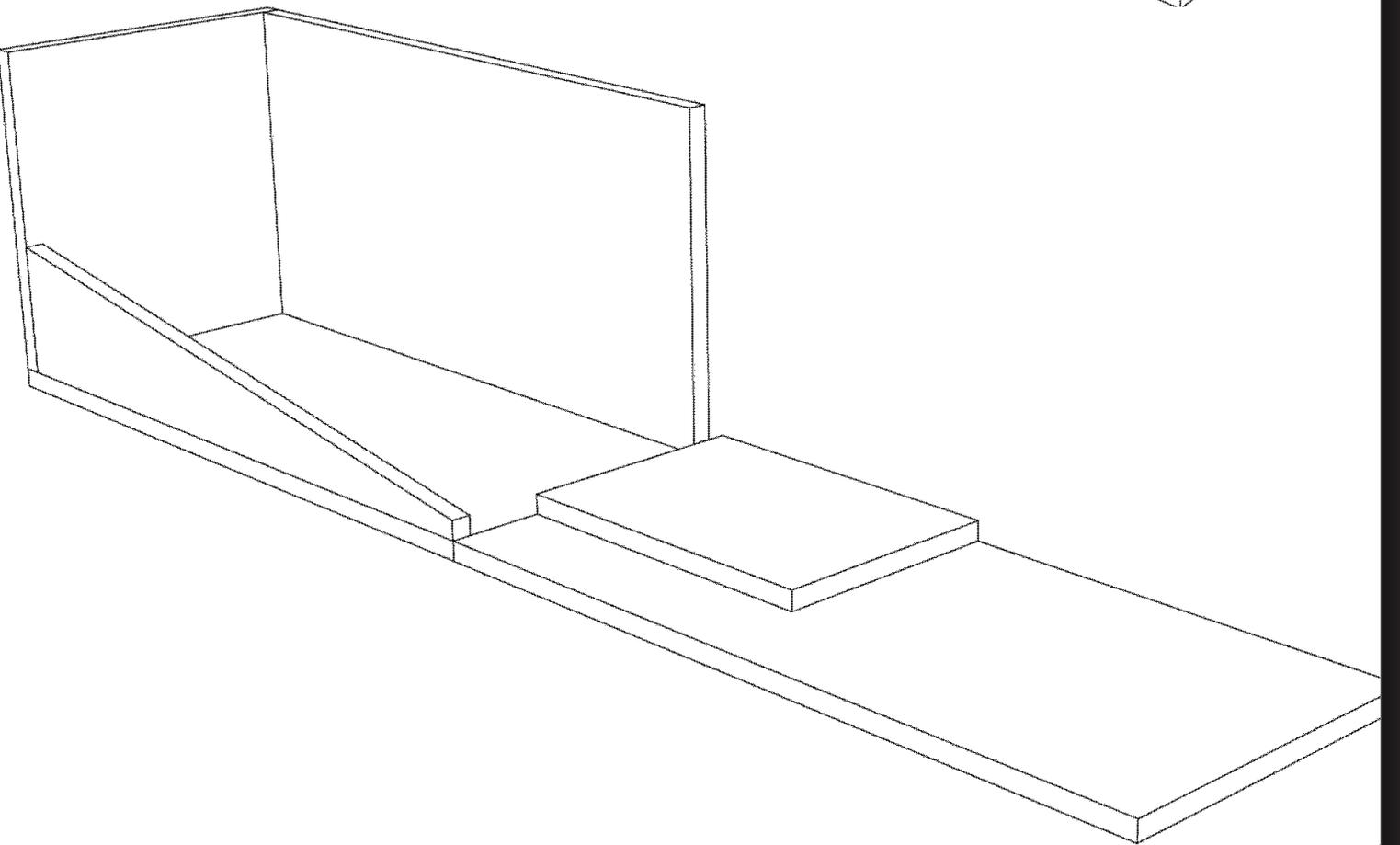
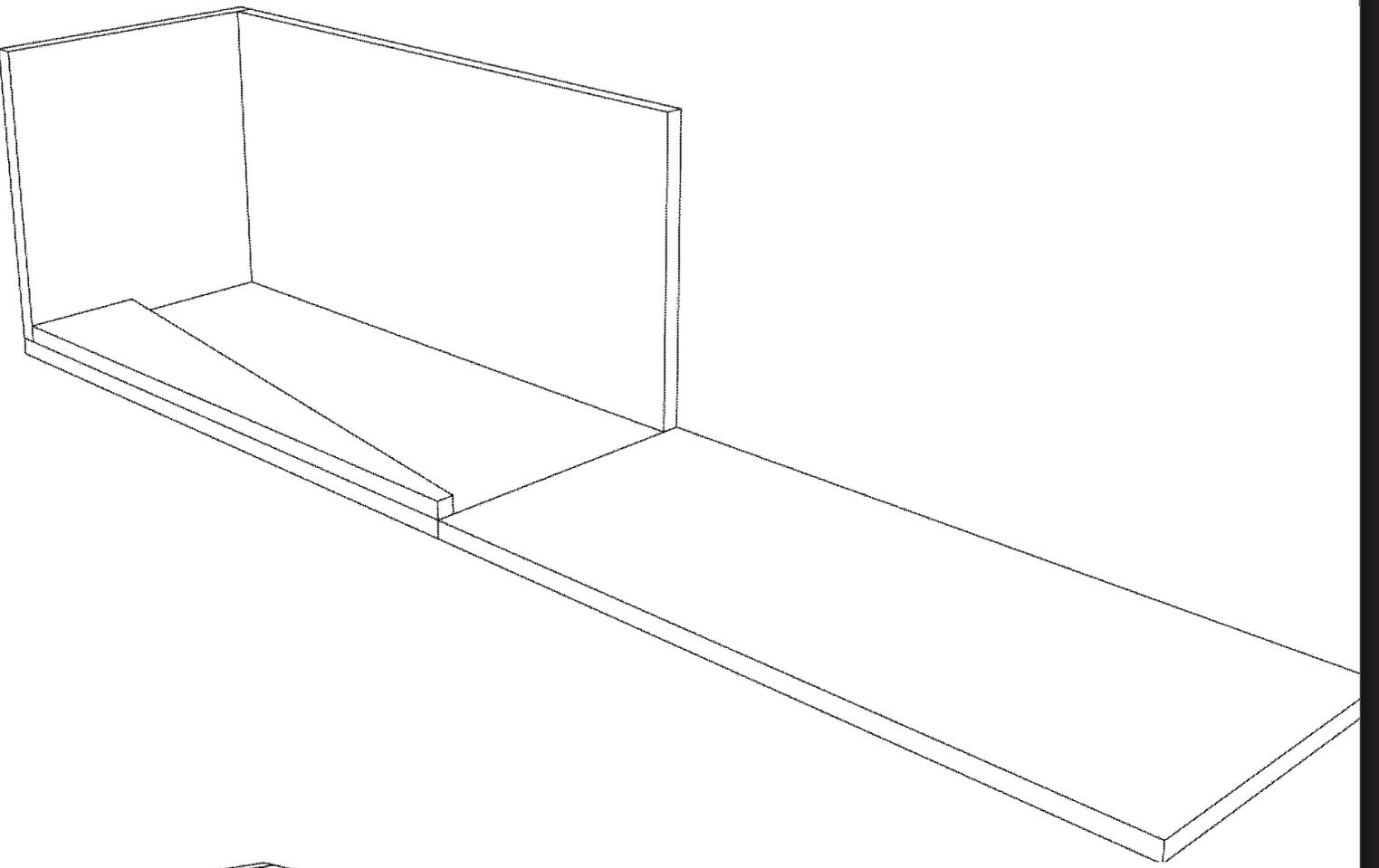


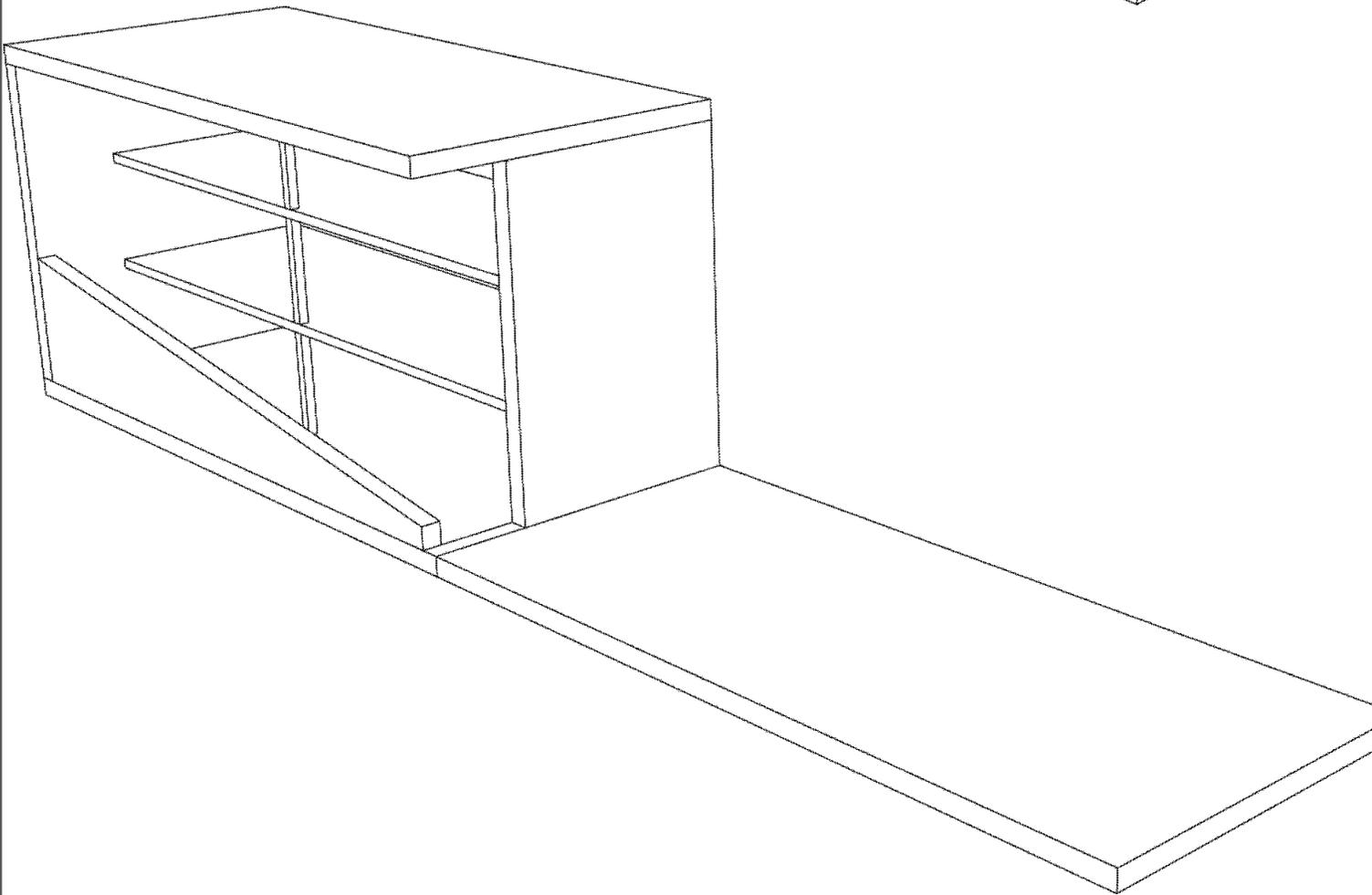
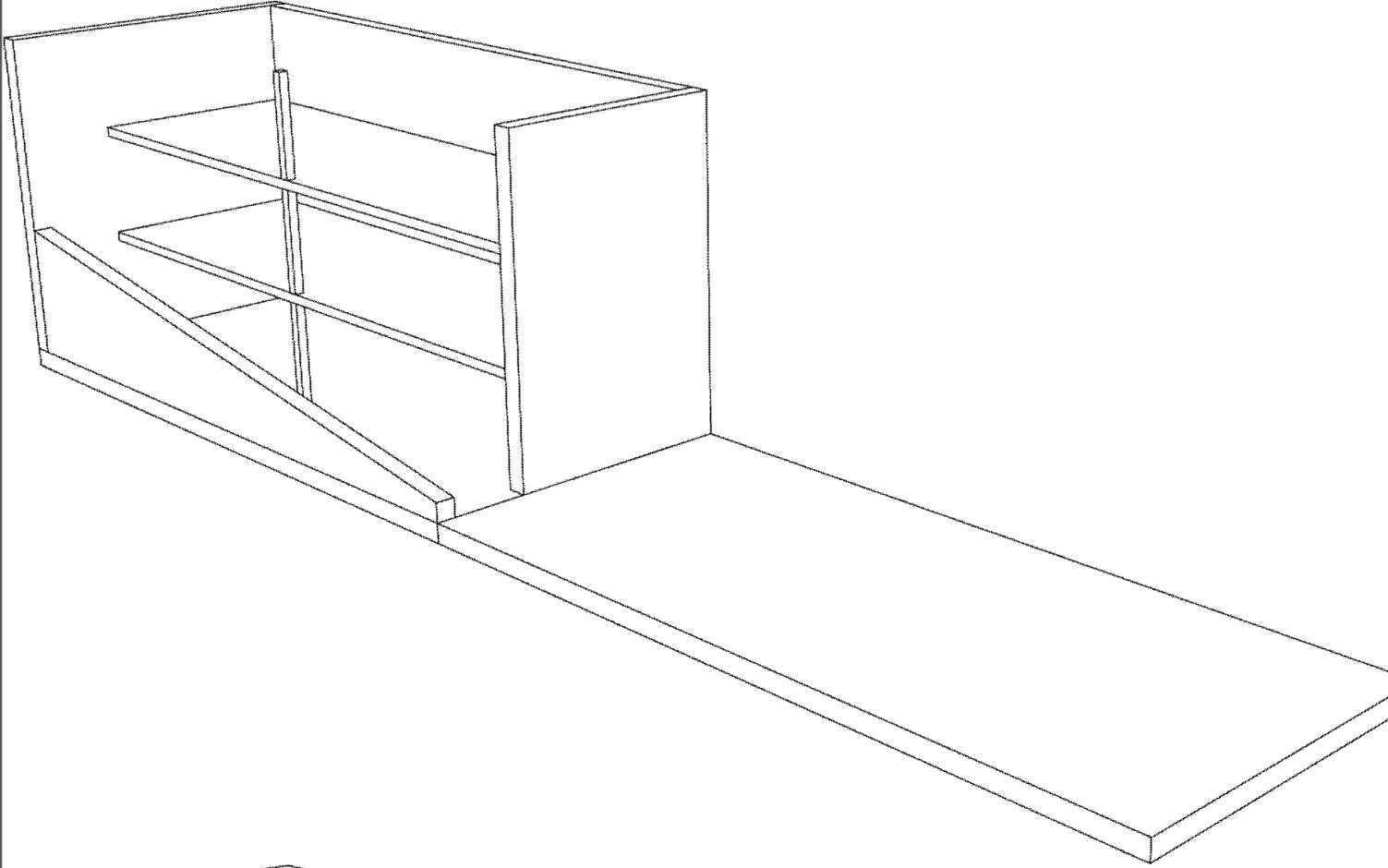


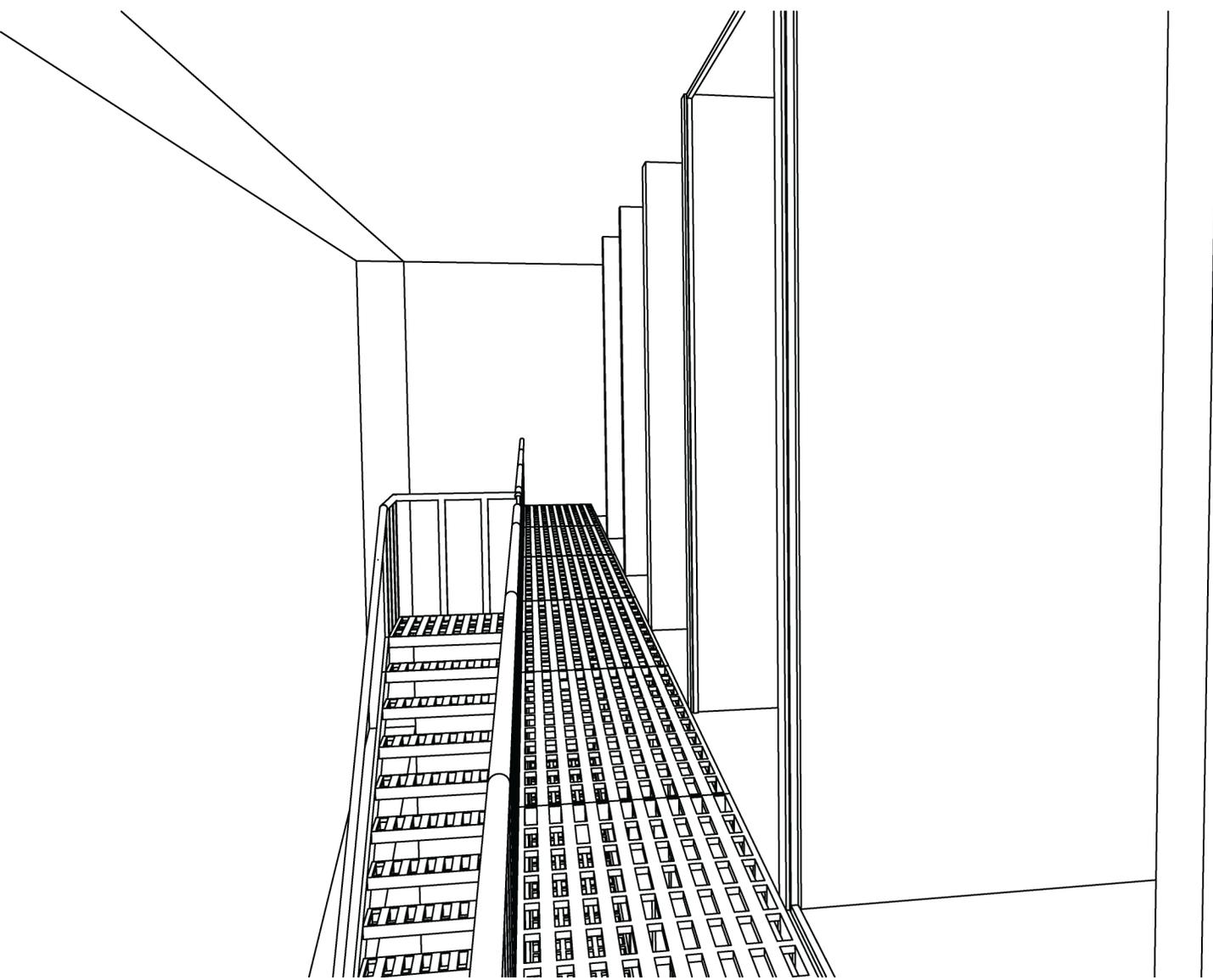
## Process Models

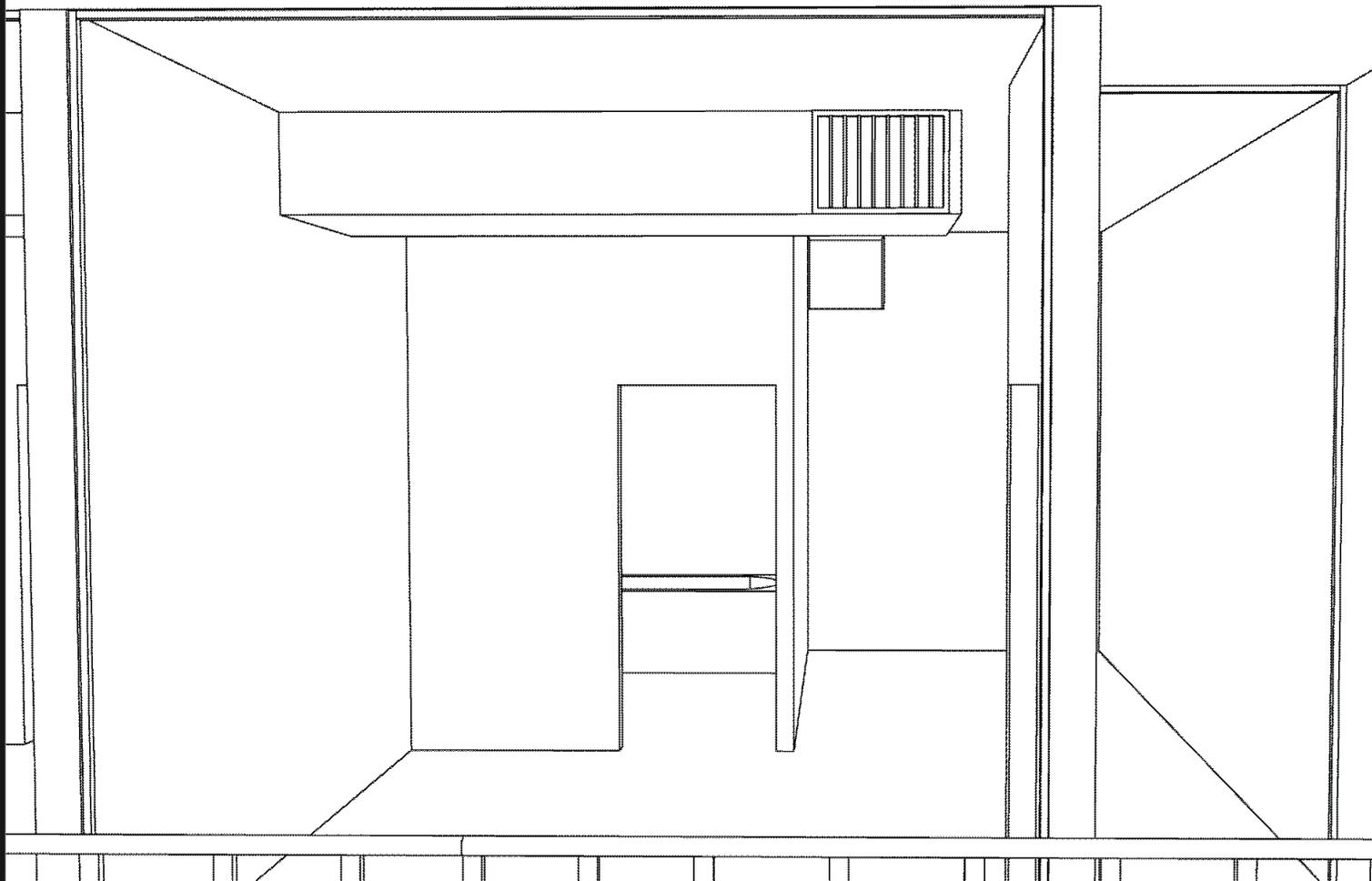
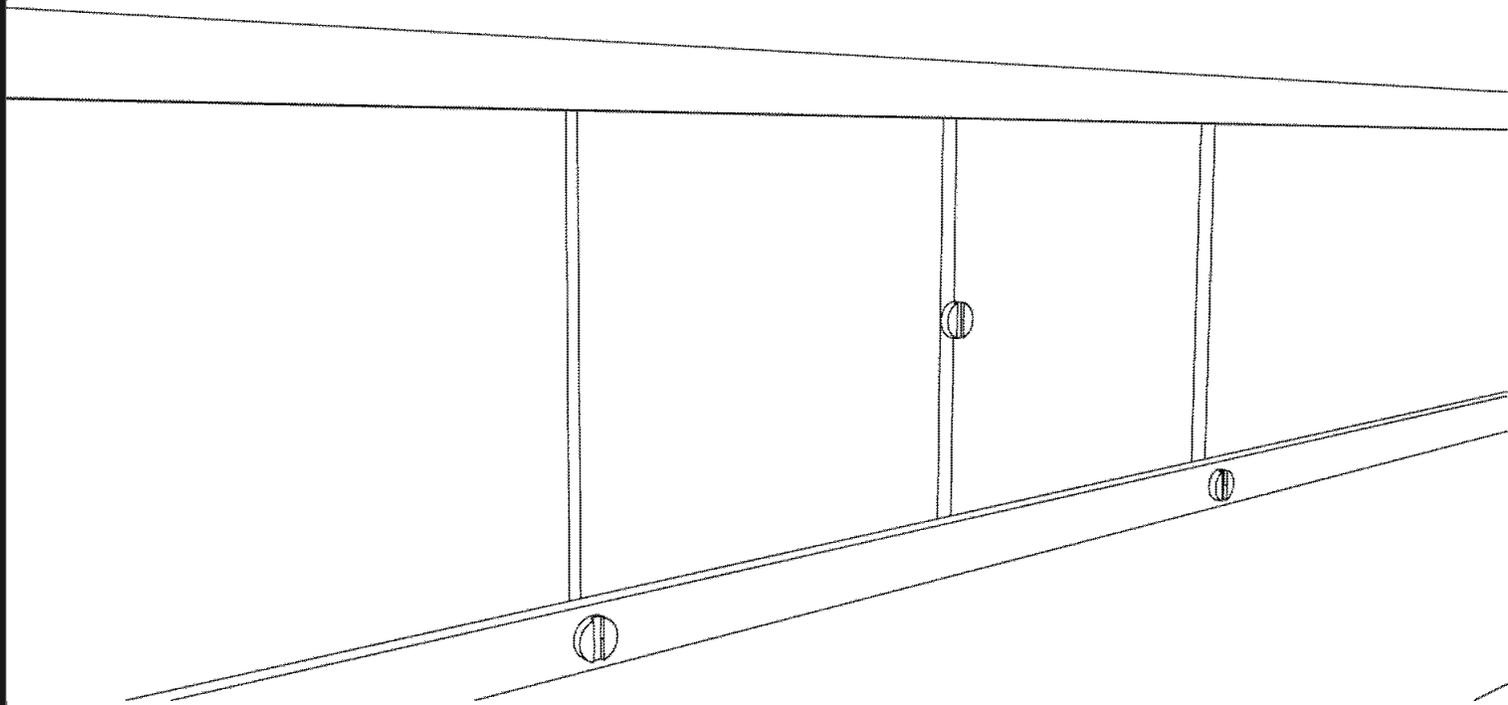








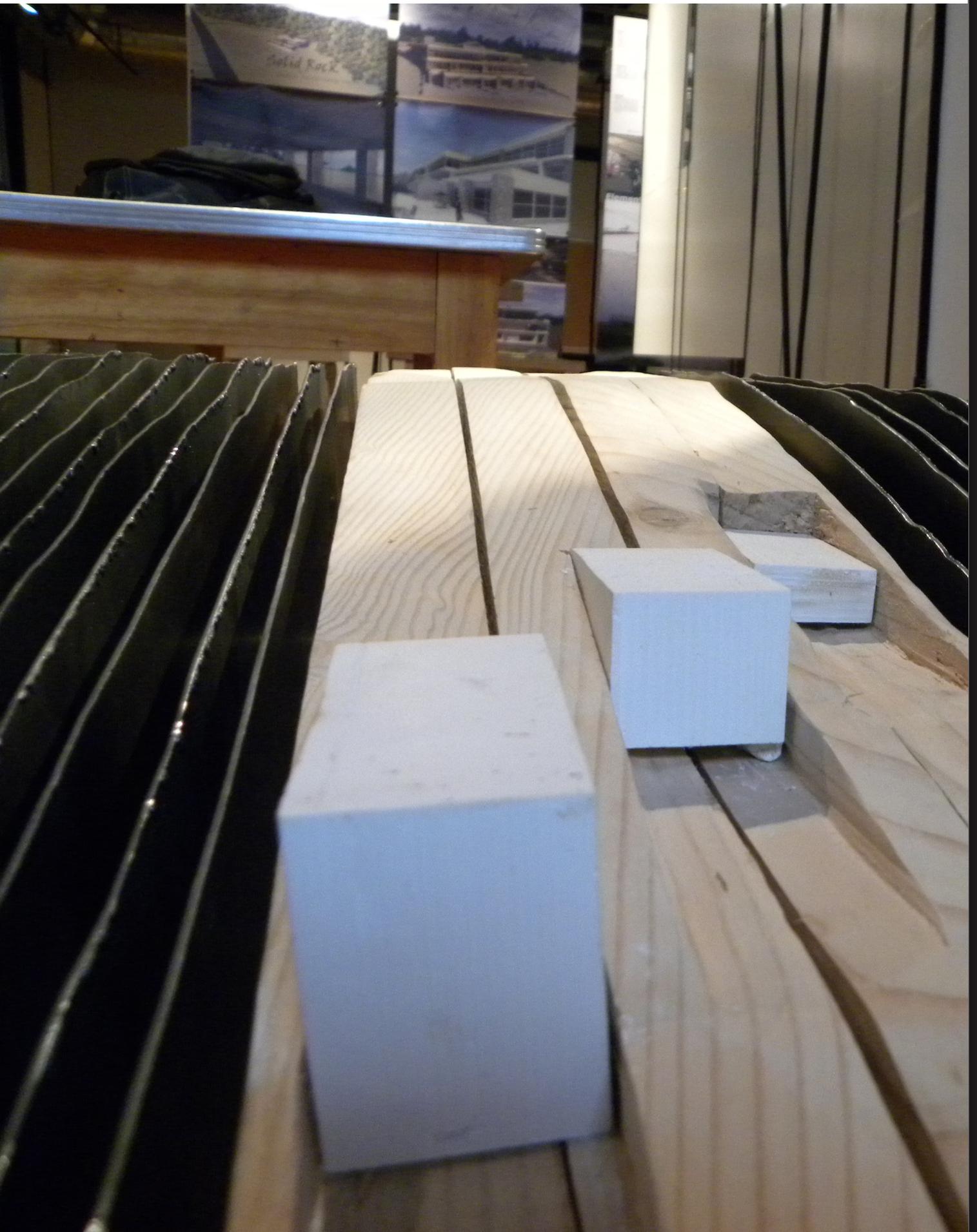




**Final Models**









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