

Mt. Baker Base Camp and Research Facility:
An American Typology Standard for the European Mountain Hut

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A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Architecture

University of Washington
2015

Committee:
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Program Authorized to Offer Degree:
Architecture

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Abstract

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This thesis explores a design strategy to adapt the European system of mountain huts to the US in a way that is sensitive to American culture and their attitudes towards nature. Using the well-developed mountain hut network in the European Alps as a framework, this thesis focuses on bringing that typology to the US with minimal environmental impact. The Mt. Baker Base Camp and Avalanche Research Facility develops a net-zero building typology that will serve as a model for various high alpine base camps across the US. The year-round function will be primarily research, and based on the location, it would serve to advance avalanche research, snow research, weather data, seismic, and volcano research. During the hiking and mountaineering seasons, the base camp will provide lodging to a select number of people, but will be open to the public as a dining hall and further serve as an emergency shelter in the event of extreme weather conditions.

MOUNT BAKER BASE CAMP AND RESEARCH FACILITY: An American Typology Standard for the European Mountain Hut

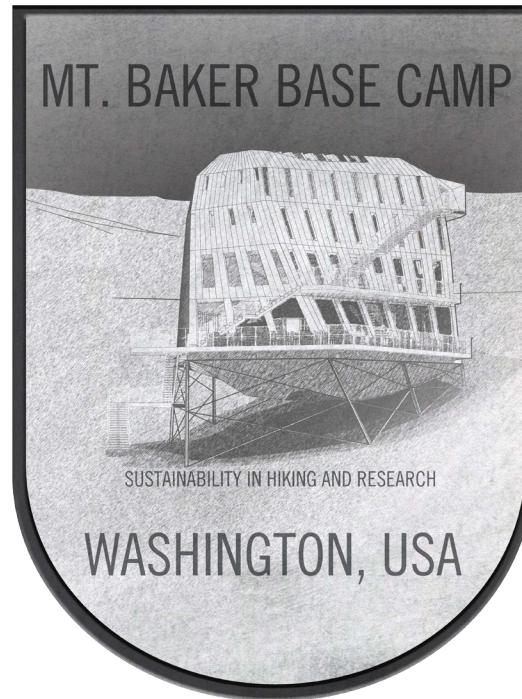














Figure - 1 The Mt. Baker Base Camp and Research Facility Patch

Figure - 2 The north face of Mt. Baker



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ACKNOWLEDGEMENTS

First and foremost, I would like to thank my thesis committee, Chris and Judith. Through your dedication, expertise, and constant availability, this thesis became a true team effort. Thank you for your guidance through this process and for urging me to constantly push the development of this project from the research preparation to the final presentation, especially within the short 10-week design window.

I would also like to thank all of my hiking buddies: Kelly, Tim, Giselle, Janelle, Monica, and Peter. Struggling to find a site by hiking all over Washington wouldn't have been the same without all your smiles.

Lastly, I would like to thank all of my family members who have supported me and my dreams through all the sleepless nights and missed holidays. You have been my constant cheerleading squad and I've been so lucky to have you in my corner.

My sincerest gratitude,
Marisol



Figure - 3 Hikers on the west ridge of the Sandy Campsite

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INTRODUCTION



Figure - 4 Snow layer test for avalanche prevention

This thesis explores a design strategy to adapt the European system of mountain huts to the US in a way that is sensitive to American culture and their attitudes towards nature. Using the well-developed mountain hut network in the European Alps as a framework, this thesis focuses on bringing that typology to the U.S. with minimal environmental impact. The Mt. Baker Base Camp and Avalanche Research Facility develops a near-zero energy and water building typology that will serve as a model for various high alpine base camps across the U.S. The year-round function will be primarily research, and based on the location, it would serve to advance avalanche research, snow research, weather data, seismic, and volcano research. During the hiking and mountaineering seasons, the base camp will provide lodging to a select number of people, but will be open to the public as a dining hall and further serve as an emergency shelter in the event of extreme weather conditions.

Mountains such as Mount Baker hold a visceral allure, bringing hundreds of hikers, backpackers, and skiers to its base to brave the elements in the hopes of gaining the summit. For as long as outdoor enthusiasts have been spellbound by the beauty and quiet power of Washington's peaks, there is a surprising lack of research and information available to them. The base camp will serve as a research facility gathering a wide range of snow, avalanche, glacier and volcanic information, similar to the Northwest Avalanche Center (NWAC), which is located in Seattle. NWAC provides avalanche warnings throughout Washington and Oregon during the fall and winter months. Due to lack of resources are unable to provide avalanche reports during the late spring and summer months when wet slab avalanches are very prevalent and hikers abound. Not only is there an insufficient amount of information available, but also Washington has also been very slow to adopt a European approach towards mountain huts and base camps for hikers to find respite in inclement weather. This is further compounded by the minimal development in the immediate vicinity of the base of the mountain.

In addition to the research and training conducted on site, lodging will be available for mountaineering enthusiasts on their quest to summit Mount Baker. Currently, experienced hikers and guided

groups going up the Easton Glacier on the south side can make the summit in two days, with one night at a predetermined base camp. Several guided groups will take three days to summit, with two nights at a base camp, using the second day for mountain training before taking on the summit. The facility will be located at this altitude, providing travelers with indoor lodging and dining, as well as providing utilities to those choosing to set up camp in the vicinity. Most backcountry accidents occur during extreme weather conditions when exhaustion sets in, so the base camp will provide a safe respite for weary travelers to wait out a storm.

With growing technology, scientists are able to better understand and predict snow conditions, volcanic activity, and glacial movement, however there is still much to be learned. Providing a center for research and education focused organizations will allow scientists to live directly in the environment they are studying and collect accurate, up-to date information for mountaineers while contributing research to the snow and avalanche sciences.

Every year, around 150 fatalities are attributed to avalanche accidents in the U.S., and of those, 93% were human caused, and 94% were on unpatrolled, backcountry terrain.¹ Avalanche training and education is the best way to mitigate mistakes and equip

backcountry explorers with the necessary information to recognize potentially hazardous zones. The educational component of the research facility will provide outdoor enthusiasts with the best training, from the industry's leading researchers, directly on location. The building itself will also serve as a teaching tool and educate its users on proper backcountry etiquette, as well as sustainable building techniques.



Figure - 5 Hikers going off trail on a snowy spring slope

Endnotes:

1. Tremper, Bruce. "THE HUMAN FACTOR - LESSONS FOR AVALANCHE EDUCATION." Backcountry Access. BackcountryAccess.com, n.d. Web. 10 May 2015. <<http://www.backcountryaccess.com/wp-content/uploads/2013/02/issw-1994-473-487.pdf>>.

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HISTORY OF MOUNTAIN HUTS



Figure - 6 :Indigenous Hut

A mountain hut is commonly acknowledged as a building in a mountainous area, accessible by foot, servicing hikers, climbers, and mountaineers. This definition has evolved from primitive shelters to the highly complex, sustainable buildings that modern technology has made possible. The earliest presence of humans in North America was found in Alaska approximately 15,000 years ago. The extreme conditions necessitated shelters be made from found materials, primarily, snow, ice, wood, sod, and animal hides¹. These structures were designed from a purely functional and performative approach and most were made as temporary structures. The well-known Inuit snow structures were based on the premise that warm air rises and would locate the entrance on

a subterranean level to keep warm air from escaping. Ventilation was simply a small hole in the roof, and burning seal oil could keep the room at a constant comfortable temperature, even during extreme conditions.¹ Some 500 years before Columbus, North America received its first European visitors who brought with them a strange new construction technique. The post-and-beam construction was brought from their temperate climates and unsuitable for the harsh conditions found in the north. Buildings in extreme climates need to account for increased thermal loss, little to no sun in the winter, snowdrifts, weight and movement, extreme wind speeds, and difficult accessibility. As William Cronon in his book, *Modern North*, warns, “The farther north you go, the longer and colder the winters get and the more skill and experience it takes for people to survive.”² This thesis will attempt to combine efficient design strategies employed by the first primitive shelters with the newest envelope, HVAC, and sustainable energy technologies.



Figure - 7 : Igloo Shelters

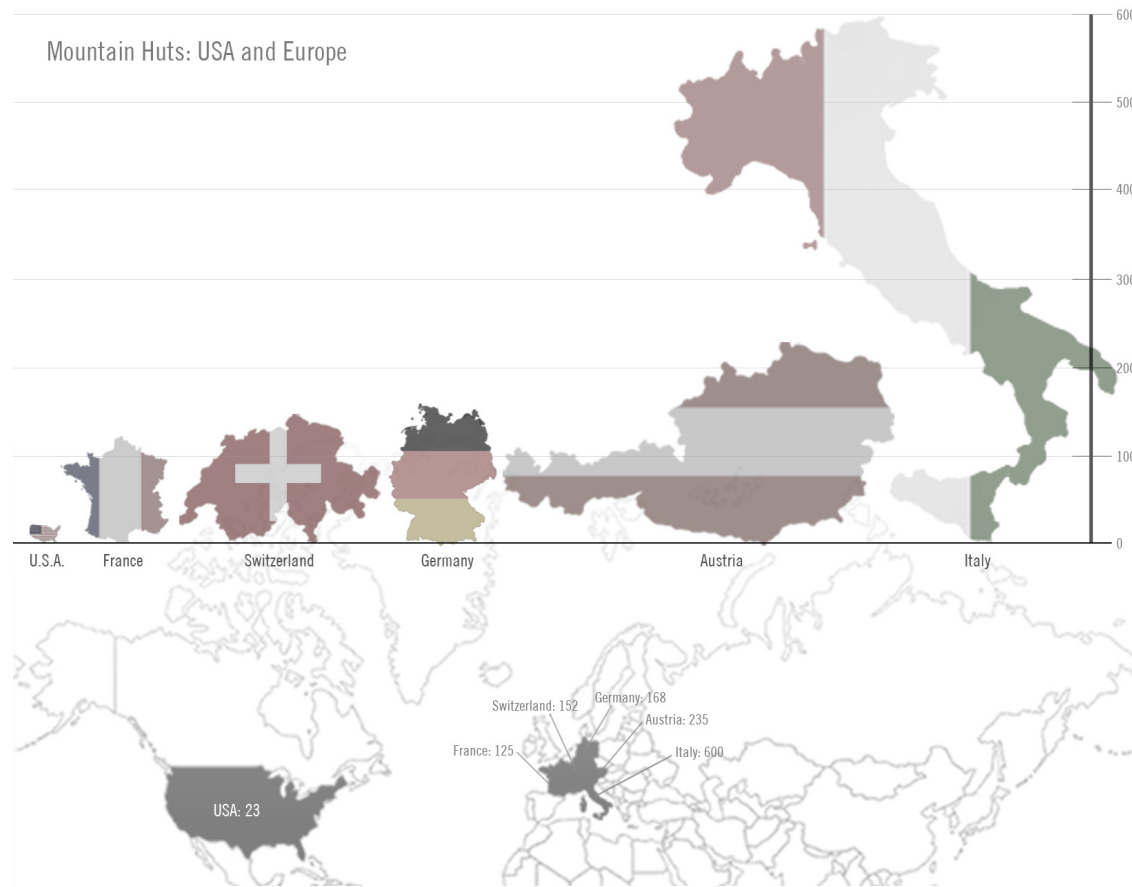


Figure - 8 : Number of Mountain Huts comparison between Europe and the U.S.

MOUNTAIN HUTS IN EUROPE

The diagram above highlights the lack of mountain huts located in the U.S. compared to those across the European Alps, particularly in France, Switzerland, Germany, Austria, and Italy. For the sake of consistency, these statistics were taken from each country's Alpine Club, while in reality, there are many more mountain huts in each country that are not registered and a part of the Alpine Club organizations. The map in the lower half further indicates the potential for the U.S. to grow given the area of the U.S. compared to that of the much smaller European countries. Next step analysis would be to take a closer look at the U.S., and specifically the mountain ranges that could support a system of mountain huts. This could be determined by the lack of development in an area, the amount of visitors to a location, or in an area providing optimal resources for research. ³⁻⁸

Austrian Mountain Huts: Österreichischer Alpenverein (ÖAV)

Number of Huts: 235
Categories: I, II, III

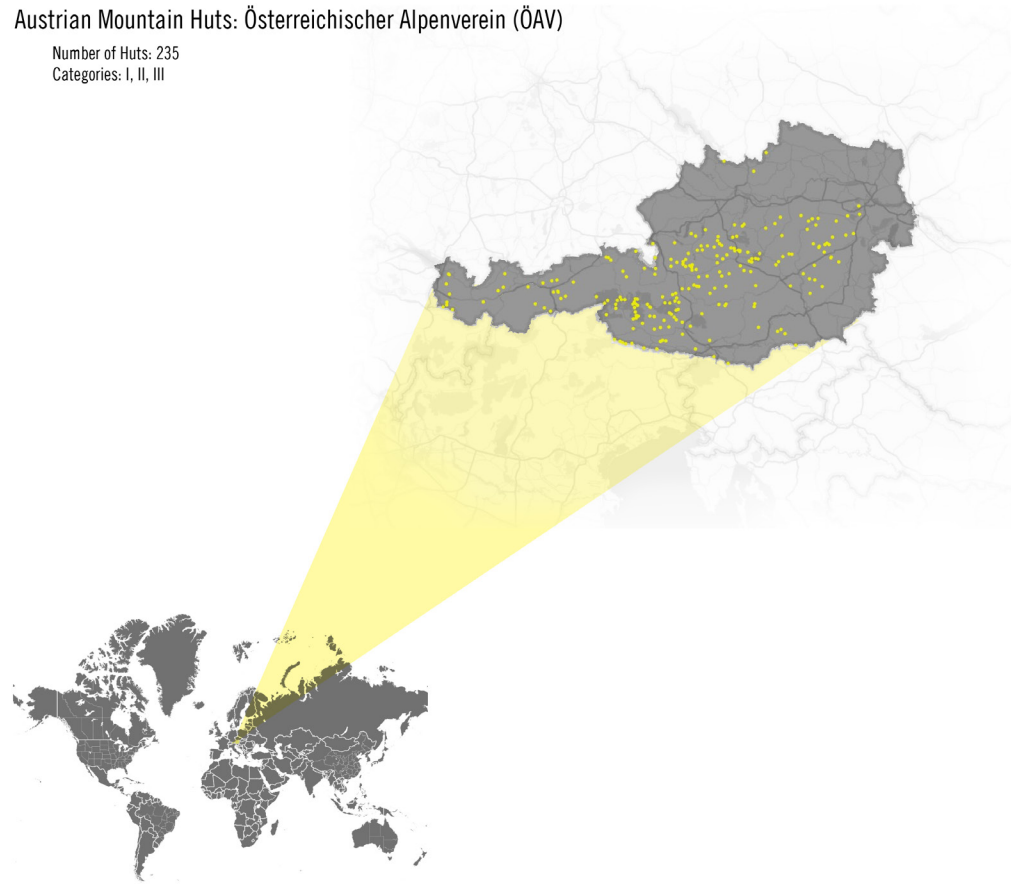
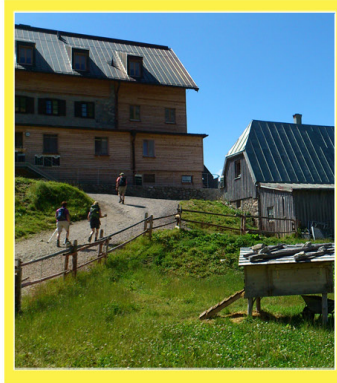


Figure - 9 : Mountain Hut Network in Austria

AUSTRIAN MOUNTAIN HUTS

Taking a closer look at Austria specifically, there are 235 registered mountain huts in the Österreichischer Alpenverein. These huts are organized into three categories according to certain criteria detailed in the next few pages. It is clear in the above map of the mountain huts across Austria that most of the huts are within close proximity to one another, creating a network of huts across different regions. These are accessible by Austria's vast trails, and in most cases connect one hut to another. ⁶



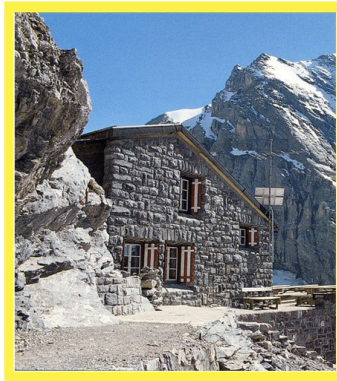
Rotwandhaus, Germany



Tegernseer Huette, Germany



Snowbird Hut, USA



Gspaltenhorn, Switzerland



Buehne Hut, Switzerland

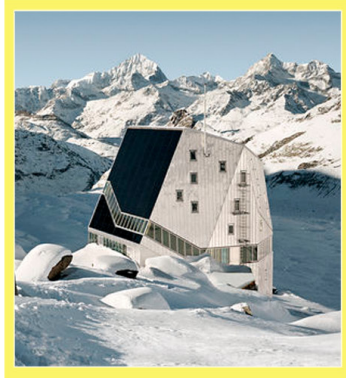


Camp Muir, USA

Figure - 10 : Compilation of Traditional Mountain Huts

TRADITIONAL MOUNTAIN HUTS

The above images are examples of mountains huts constructed with traditional materials, following the traditional vernacular of a mountain hut for each respective region. Common construction materials include wood frame construction or masonry, with each structure containing minimal apertures to minimize thermal loss in the winter. There is also a clear distinction between the mountain huts on the left (located in the European Alps), and the structures on the right (located in the U.S.). The European examples resemble the amenities of a hotel, whereas the American examples have minimal amenities and are similar to that of a rustic shelter.



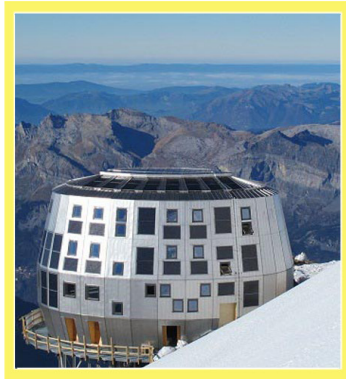
Monte Rosa Hut, Switzerland



Tracuit Hut, Switzerland



Mt. Pilatus, Switzerland



Refuge du Gouter, France



Tete Rousse, France



Zugspitze, Germany

Figure - 11 : Compilation of Contemporary Mountain Huts

CONTEMPORARY MOUNTAIN HUTS

This selection of mountain huts was chosen as examples of contemporary modern huts across the European Alps. Some examples such as the Monte Rosa Hut, the Refuge du Gouter, and the Tete Rousse show the integration of solar panels into the façade of the building. The examples also demonstrate the recent trend of using metal cladding, specifically zinc, because of the predictability of the thermal expansion, as well as the ability to work with the material at very cold temperatures.

Category I:

Simple huts for walkers and climbers; basic facilities and food; not manned all year; could be a bivouac; more than an hours' walking time from land-based mechanical transport.



Figure - 12 Tegernseer Huette

CATEGORY I

Category I can be defined as a simple huts for walkers and climbers; basic facilities and food; not manned all year; could be a bivouac; more than an hours' walking time from land-based mechanical transport. The Tegernseer Hütte shown above is an example of a Category I mountain hut. (See the Precedents section for a detailed examination of the Tegernseer Hütte.) The Mt. Baker Base Camp and Research Facility would be placed into this category. ⁶

Category II:

Alpenverein hut in popular area; may be open all year; can be provisioned from road.



Figure - 13 Madrisa Alm Huette

CATEGORY II

Category II huts are typically found in the lower mountains and often accessible by road transport. The Madrisa Alm Hütte is an example of a Category II mountain hut. This particular hut is road accessible, however the roads are not cleared in the winter, when visitors are required to hike in with the necessary supplies for their stay. Simple amenities are provided such as bunks with pillows and blankets, but visitors are required to bring their own food as there is no one living on site.⁶





Figure - 14 Rotwandhaus

CATEGORY III

Category III is defined as an Alpenverein (alpine club) hut in popular area, which may be open all year and can be provisioned from road. The Rotwandhaus near Spitzingsee en route to the Rotwand summit is an example of the final category, Category III. This hut provides lodging, dining, and a modest Bier Garten (beer garden). The hut is located at a low elevation, is road accessible, and accessible by foot via a gentle trail, suitable for most.⁶

Endnotes:

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3. "Lodging Network." American Alpine Club. AAC, n.d. Web. 15 Oct. 2015. <<http://www.americanalpineclub.org/p/lodging-network#national>>.
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PRECEDENTS

Monte Rosa Hut

Architect: ETH Studio Monte Rosa

Typology: Mountain Hut

Size: 12,420 sf

Location: Switzerland

Completion Date: 2009

The Monte Rosa Hut was built as one of 50 projects to celebrate the 150th anniversary of the ETH Zurich University in Switzerland. This project began as a design studio through the ETH department of architecture, producing four semesters worth of student



Figure - 15

work and designs. From the beginning, ETH had chosen the Swiss Alpine Club (SAC) as their client and proposed to construct a new Monte Rosa Hut instead of renovating the existing hut. Students were very involved with the final designs and even the construction of the new hut.

As this was a university project, a lot of research went into the design and systems of the hut to make it 90% self sufficient in its operations. This created a new standard for sustainability in alpine architecture. The fully automated hut sends a constant flow of information back to researchers at the university. They are using this knowledge to better understand the operating efficiency of the building and decide how to better implement these systems in the future. Students at ETH Zurich designed the software for its operations. It will take into account the expected occupancy and local weather forecast to program the energy management software for the most efficient use of resources.

The timber construction of the hut had to be carefully planned for the extreme weather conditions and snow loads that are inherent problems when designing in an alpine location. Other factors such as bringing the materials to site via helicopter and the short construction time frame were instrumental in the design decisions. The timber elements of the hut were designed as a kit of parts that could be pre-fabricated off site and then “snap” together

for quick construction on site.

As previously stated, the building operations function at 90% self-sufficiency, this is possible through the collaborative integration of several systems. The solar panels on the building can contribute to 90% of the required energy during peak operating seasons, with 10% coming from a rapeseed oil powered co-generation plant. The use of rapeseed oil is important because it can be stored inside, whereas storage of propane or other fuel sources have to follow a very strict policy and be stored outside. Heating and ventilation is also partially supported by the co-generation plant, with a large percentage of the heating coming from a series of thermal solar collectors. Due to the location and the possibility of extreme weather, the building is mechanically ventilated. Additionally, in an effort to save energy, rooms are given ventilation priority based on their use times throughout the day.

As there are no water sources in the vicinity of the hut, water collection and waste-water management systems were also specially designed for the hut. A large 200 cubic meter cistern was dug out 40 meters above the hut to store summer glacial melt water for use throughout the year. The water is cleaned and purified before being used for showers and cooking. The grey and black water is treated in a biological waste-water treatment plant and recycled through the building to service toilets and washing

machines.

All of the design and system components of the Monte Rosa Hut were carefully planned with a focus on economy, efficiency, and sustainability. “The important thing in implementing this autonomous services concept was not concentrating on individual components and optimizing them, it was far more essential to combine the elements – from the building envelope to the services and the production of energy – to create an optimal and efficiently functioning overall system.”¹



Figure - 16 Monte Rosa Hut and Thermal Solar Collectors

MONTE ROSA HUT

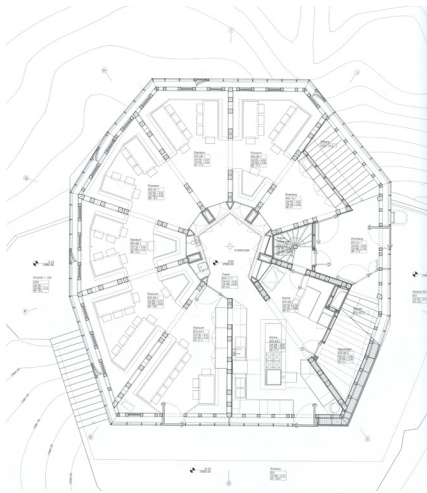


Figure - 17 Dining Plan

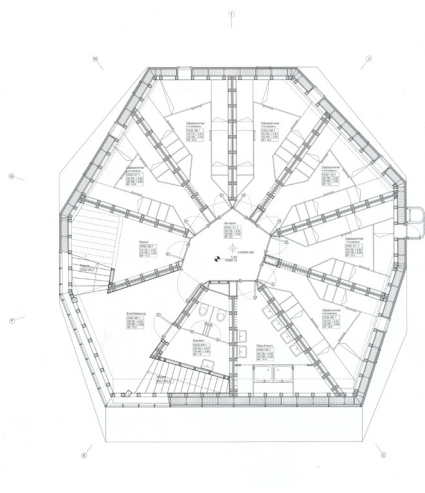


Figure - 18 Lodging Plan

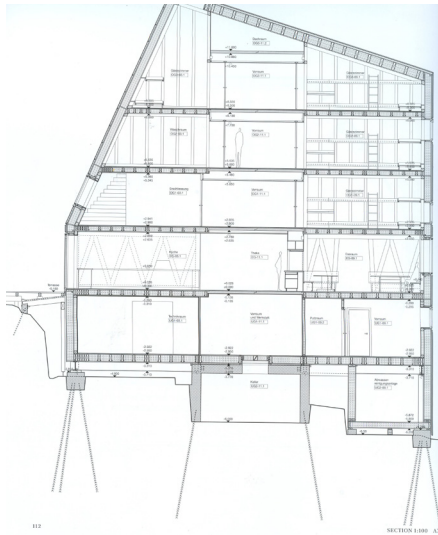


Figure - 19 Section through building



Figure - 20 Window and Cladding Detail



Figure - 21 South Facade with PV Panels



Figure - 22 Exterior View



Figure - 23 Bunk room



Figure - 24 Dining Room

PRECEDENTS

Camp Muir

Architect: Carl F. Gould

Typology: Mountain Hut

Location: Mt. Rainier, Washington

Completion Date: 1936

Camp Muir Hut sits at 10,080', 700' below the summit of Mt. Baker, and serves as the base camp to climbers summiting Mt. Rainier, but also serves as a popular destination itself. This site is particularly important to this thesis as it was built in response to the growing number of hikers making the ascent to Mt. Rainier, the tallest peak in Washington. The hut was originally named Cloud Camp, but was renamed after the famous naturalist, John Muir, after his successful summit of Mt. Rainier in 1888. The present-day facilities include a Ranger station, solar toilets, and a 25-person public shelter that functions on a first come – first served basis. John Muir advocated to turn Mt. Rainier into a national forest, but also chose this location as an ideal spot for a base camp.²



Figure - 25 Camp Muir

PRECEDENTS

Tegernseer Hütte

Architect: owners

Typology: Mountain Hut

Location: Germany

Completion Date: 2001

The first Tegernsee Hut was constructed in 1903 on the precipice of a cliff along one of the many hiking paths that wind through the German Alps, overlooking the beautiful Tegernsee Lake. All materials had to be carried up by hand along the hiking path using local stone and wood for the simple construction. An addition was added in 1913 to accommodate the rising number of visitors, and it operated successfully until May 1965 when it was struck by lightning and burned down.

The owners quickly set to constructing a new hut, this time installing a cable lift to help bring materials to the site. The cable lift is still used today to transport food and essentials up to the hut's remote location. In 2005/2006, the owners started raising money to modernize the hut's operations. Solar panels were added to the roof, and motion sensitive light fixtures and water taps were installed. The grey water comes from a 10,000 liter capacity rain water collection tank. The water goes through four different filters

and a UV treatment before being used. Drinking water is delivered to the site. The urinals and toilets are all dry compostable toilets that need to be emptied every three years via the cable lift. Similar to the Monte Rosa Hut, warm water is heated by thermal solar collectors.

The most current hut has two rooms with 19 beds in each, and a maximum capacity of 38 guests per night. Hiking to the remote hut location is no easy feat, but the 17 euros per night fee (~\$18.50) rivals even the cheapest city hostels. German food and beer are served in the restaurant, which more than doubled its seating capacity with the construction of an outdoor patio. The hut is open each year to visitors from the second weekend in May to the first weekend in November.³



Figure - 26 Tegernseer Huetette as seen from above

PRECEDENTS

Bharati Research Station

Architect: bof Architekten + IMS

Typology: Research/Technology

Size: 27,000 sf

Location: Antarctica

Completion Date: 2012

India was granted permission to build their third research facility in Antarctica and subsequently held an international competition. According to the Antarctic Treaty, the building needs to function self-sufficiently, not break the permafrost-soil, and have the capacity for easy disassembly and relocation. BOF Architekten in association with IMS won the competition in 2006 and planning started in 2009. The designers approached this design problem with 134 shipping containers. The containers created a module within the building and could be prefabricated offsite for quick assembly on site during the short construction window. Like many buildings in the arctic, the designers utilized light colored materials and used color where possible to raise morale during the dark winter months. The shipping containers double as part of the structural system and are all clad in an aerodynamic metal panel system to withstand extreme weather conditions. The station is also lifted off



Figure - 27 Concept Render



Figure - 28 Final exterior image

PRECEDENTS

the ground to allow snowdrifts to move underneath. The building is able to generate its own electricity, run a water purification system, and contains a self-sufficient heating and cooling system.⁴

The research station has three levels with the ventilation systems on the third; the living spaces, conference rooms, kitchen, dining, a library, medical facilities, sauna, fitness room, prayer room, and lounge on the second floor; and the first floor houses the laboratories, garage, storage, and workshop. The facility can maintain 24 researches during the winter, and 47 during the summer months when energy demands aren't as high and solar energy is abundant. A mock-up of the building assembly, and consequently the building parts, were constructed in Germany before construction began. Each shipping container module was shipped from Germany to Cape Town, on to Antarctica, and then flown onto site via helicopter from the shipping vessel.⁵

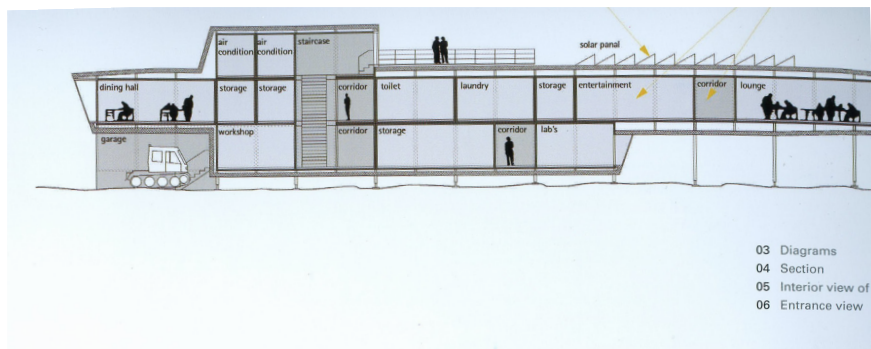


Figure - 29 Section Diagram

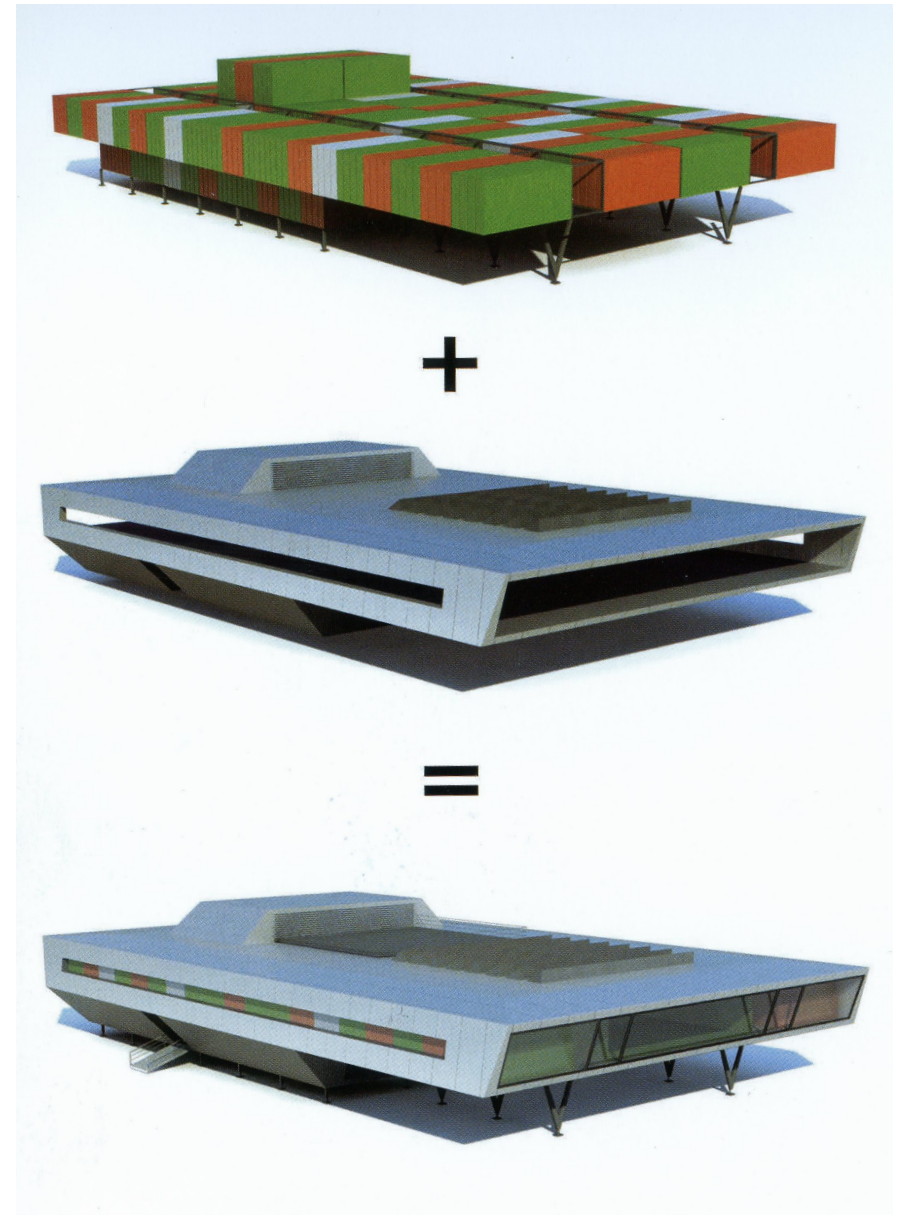


Figure - 30 Shipping container core and shell diagram

PRECEDENTS

Longyearbyen Research Center, Svalbard University

Architect: Jarmund / Vignæs Architects

Typology: Education

Size: 91,500 sf

Location: Norway

Completion Date: 2005

This large research center, university, and museum is located in the northernmost town with a population of more than 1,000 residents. Designing in this arctic environment necessitated special design considerations, and climactic BIM modeling was used to optimize the design. The structure itself is raised on 390 steel poles to allow the movement of snow underneath the building, optimized with the analysis of snowdrift simulations. As is the case with many arctic buildings, the designers did not want to penetrate the fragile permafrost-sealed soil, so the steel poles are resting on top of the soil. The exterior copper cladding was chosen because it retains its workability even in low temperatures, allowing for a longer construction window. The angular and undulating roof and façade were designed according to the wind and snow flows through the site to minimize snow build up at crucial points of entry.

Due to the lack of sunlight during the winter months, the architects chose to clad the interior in a light pine, using color as wayfinding, but also as a morale booster. The circulation was also strategically planned to facilitate nodes of human interaction and contact. Heavily used areas such as the atrium and dining halls were allowed generous windows to maximize sunlight, and ribbon windows were used throughout the building to bring in the summer light.⁶



Figure - 31 Exterior view showing zinc cladding

PRECEDENTS



Figure - 32 Exterior view



Figure - 33 Exterior view showing the raised foundation



Figure - 34 Exterior view of the center during winter



Figure - 35 Main Desk



Figure - 36 Circulation and Hallway

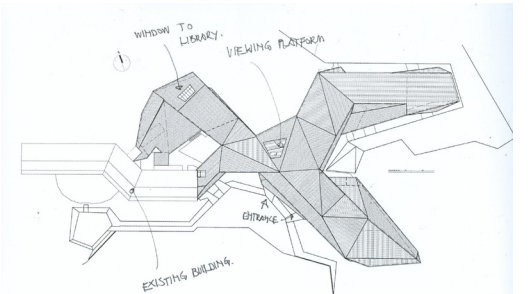


Figure - 37 Site Plan

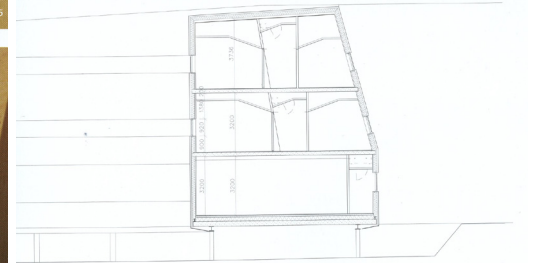


Figure - 38 Building section

PRECEDENTS

Pulpit Rock Mountain Lodge

Architect: Helen and Hard

Typology: Lodging

Size: 13,600 sf

Location: Norway

Completion Date: 2008

The competition for the new Pulpit Rock Mountain Lodge called for a modest lodge for 28 people, a restaurant for 100 people, conference room, updated bathroom facilities, and environmentally friendly construction. Helen and Hard's winning design is made from "pure" construction elements, wood, steel, stone, glass, and concrete. All of which were tested to be emission free and non-toxic. The main structural elements are made from Holz100,



Figure - 39 Dining Room

a massive timber system that doesn't contain glue or nails. The elements are held together with wooden dowels that swell after injection, holding the panels tightly together. The exterior walls are insulated with recycled newspaper and the exterior is covered in a wood fiber plate with pine-core wood cladding. The building is also constructed to PassivHaus standards with 24" thick walls and triple glazed windows. The heating is a radiant floor system from a heat exchanger that acquires energy from the lake.

The building itself is at the trailhead to the Pulpit Rock



Figure - 40 Exterior view

PRECEDENTS

lookout, a sheer cliff cantilevering over the Lysefjord. In this pristine mountain environment, the undulating roof shape was designed to emulate the surrounding mountain peaks. In addition, the building faces southwest and the structural ribs were oriented to open up to the southern sun to allow the building to take advantage of passive heating over the summer.^{6, 7, 8}



Figure - 41 Dining room



Figure - 42 Sitting and lodging spaces



Figure - 43 Hallway showing Holz100

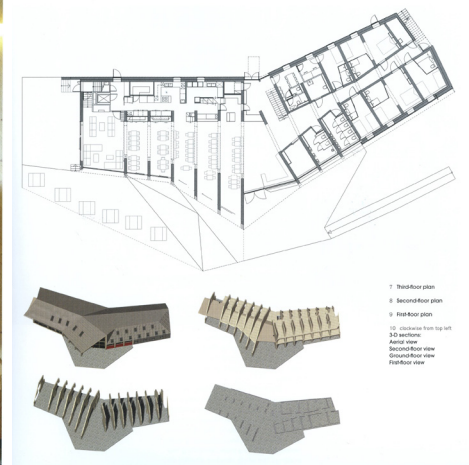


Figure - 44 Plan and Tectonic Diagram

PRECEDENTS

Weissfluhjoch

Architect: N/A

Typology: Research / Technology

Location: Switzerland

Completion Date: 1995

Weissfluhjoch is a snow research center located at 8,300' elevation near Davos in the Eastern Swiss Alps. The research and equipment is funded by the Swiss Federal Institute for Forest, Snow, and Landscape Research WSL, and can be accessed by the public via a written request. The site sits adjacent to an active ski resort, also by the same name, providing easy access to the site and research hut. When the center was started in 1936, it was the first high alpine snow research facility to provide daily snowfall, overall



Figure - 45 Exterior view of shed and research equipment

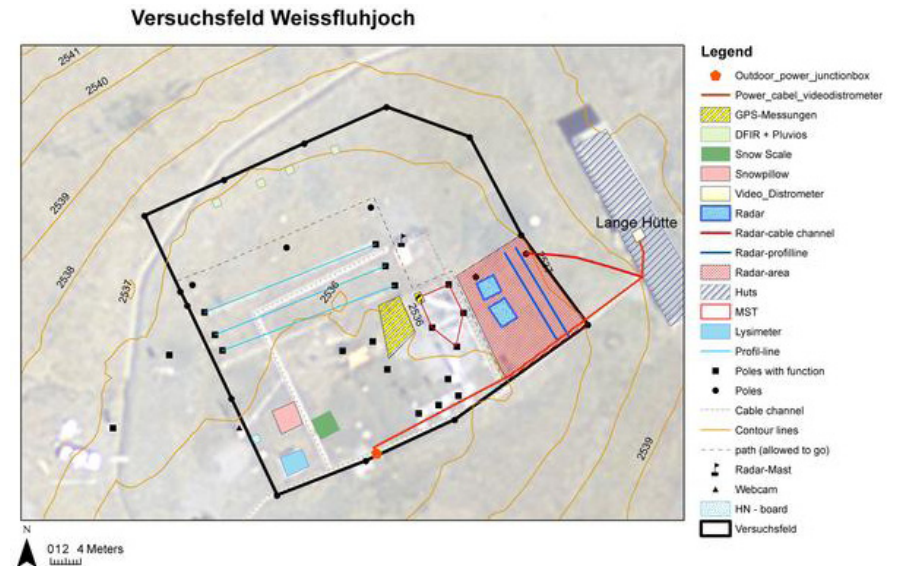






Figure - 46 Plan of research equipment and shed

snow depth, and water equivalents. Since the 1970's, the equipment has been continually updated to provide automated reports, but manual snow profiling is still conducted only twice per month. The Swiss Avalanche Warning Services, the Swiss equivalent of the Northwest Avalanche Center, uses these automated and manual readings to provide mountaineers accurate and up-to-date snow conditions. This equips travelers with the knowledge to make informed backcountry decisions. The equipment, implementation, size, and maintenance at Weissfluhjoch is comparable to what will be installed on Mt. Baker, and will help inform design considerations for snow research.⁹

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“Theodore Roosevelt wrote with much the same nostalgic fervor about the ‘fine, manly qualities’ of the ‘wild rough-rider of the plains.’ No one could be more heroically masculine...or more at home in the western wilderness.”

Figure - 47

NATURE AND THE AMERICAN

The Merriam-Webster dictionary defines nature as “the physical world and everything in it (such as plants, animals, mountains, oceans, stars, etc.) that is not made by people.”¹ In this definition, nature is everything outside of what humans create. This may seem all encompassing, but it doesn’t even begin to describe the complex understanding Americans have of nature, and its role in our culture, society, and everyday lives. Humans cannot escape that the definition of nature has arisen out of a cultural understanding of the word, and therefore varies from culture to culture. In a world of vastly different cultures, nature is widely understood to be a common thread, something that is beyond cultural influence because it lies in the realm of subjects beyond human creation. This

chapter will examine the many definitions of nature to the American people by pulling from three exemplary texts on the subject, *Uncommon Ground*, compiled by William Cronon², *Nature, Aesthetics, and Environmentalism: from Beauty to Duty*, edited by Allen Carlson and Sheila Lintott³, and *Nature and the American: Three Centuries of Changing Attitudes*, by Hans Huth⁴.

Through a better understanding of the meaning of nature in current American society, architects, planners, builders, and designers can work within this framework towards a more responsible architecture, sensitive to its users. This is a lofty goal, and it must be said from the beginning that there will be no way to please everyone when designing in an untouched, pristine environment. This chapter will explore the broad, perhaps abstract, definition of nature as understood by Americans, synthesized into eight themes. This information will then be used to inform the design portion of this thesis. Particularly, how to design a research center and mountain hut typology, which is similar to that seen in the European Alps and sensitive to the ways Americans view nature.

When developing in urban settings, there are certain measures that can be taken to make the building more sustainable and environmentally friendly, however the new development isn't contested

if the land was already stripped of its original, natural state. Once the "nature" is taken from a place, humans don't contest to the creation of more artifice on top of artifice. The issue arises when humans intend to develop on virgin land, especially on national forests and parks that 'belong to the people'. This chapter will also analyze the varying ways Americans view nature to reduce the opposition towards building in a pristine environment, while also responding to the ways Americans live in nature.

The American 'nature' cannot be defined with one or two over-generalized statements about the embodiment of everything outside the human-made. As William Cronon aptly states, "Ideas of nature never exist outside a cultural context, and the meanings we assign to nature cannot help reflecting that context."⁵ To understand nature in today's American cultural construct, one must go back to the first American colonists and trace the evolution of American attitudes towards nature to unwrap the many different meanings of the word. In doing so, several themes start to emerge. Through an analysis of the leading experts on this topic, the American attitude towards nature can be synthesized into eight categories: Nature as Savage, Nature as Frontier, Nature as Commodity, Nature as Aesthetic, Nature as God, Nature as Justification, Nature as Natural, and Nature as Virtual Reality. The first three follow each other

successively in chronological order, but the rest spans over centuries and isn't particular to a certain era.

The goal of understanding the American attitude towards nature is to design a system of modest mountain huts and research facilities in high alpine locations along difficult hiking routes. The necessity of this building typology will be explored later, but it should be made clear from the beginning that this chapter is not searching for justification, or a loophole for development in virgin forests. The argument in question is how to bring a well-accepted building typology from one culture to another in a way that is sensitive to an American public.

The European model of mountain huts along well-defined hiking routes has been a long-standing tradition, however institutions such as the Swiss Alpine Center (SAC) have been pressured to begin massive efforts to retrofit the existing huts for a more sustainable and environmentally friendly operation. As this system of mountain huts has not been effectively established in the U.S., Americans have the opportunity to learn from the European model, adapt it, and create a new model for the American outdoors. In order to design this new model, the nature that must be explored is not of a natural sense, but a cultural perception.

Nature as Savage

In understanding the American attitude towards nature, it is prudent to start at the beginning. As the first settlers arrived on the east coast, they came from a society where traveling through the untamed wilderness was where one came face to face with danger. A traveler might have to deal with bandits or gypsies, as well as "meet a variety of disasters caused by inclement weather, precipices, wolves, washed-out roads, or sudden torrents...and give him the feeling of being in a 'howling wilderness.'"⁶ This mindset was brought to the U.S., where Native Americans replaced the bandits and gypsies, and the wilderness that had only confronted them during travels was now surrounding them. Michael Wigglesworth described this space outside the settlements as "A waste and howling wilderness, where none inhabited but hellish fiends, and brutish men that Devils worshipped."⁷ This view through their experience with wilderness was further perpetuated by strong Christian beliefs.

The Christian bible repeatedly refers to the wilderness as the savage home to the devil. The place where Moses and Jesus both traveled to endure the temptation of the devil, "And immediately the Spirit driveth him into the wilderness. And he was there in the wilderness for forty days tempted of Satan; and was with the wild

beasts; and the angels ministered unto him.”⁸ Temptation was first mentioned in the biblical story of creation where Eve was tempted by the devil, succumbed to temptation, and lost the Garden of Eden for all humanity, who were banished to the desert. Nature and the wilderness were used synonymously and thought of as something to be tamed. Early American pioneers were tasked with the job of taming the savage native inhabitants and the savage land. Little by little, the colonists moved out west, taming the savage as they went.

Nature as Frontier

Fast-forward to the 1890’s and the nature that had been so feared before was now regarded as an American Identity, and was slipping away. The Americans had been so successful in their attempt to tame the savage lands that they were now choking with their own civility. The times of the cowboys and Indians was becoming romanticized as simpler times, and a wild nature was a part of that picture, “Theodore Roosevelt wrote with much the same nostalgic fervor about the ‘fine, manly qualities’ of the ‘wild rough-rider of the plains.’ No one could be more heroically masculine...or more at home in the western wilderness.”⁹ Through this romanticism of nature and its associations to a lost era, the savage became the

sublime. “Thus, in the myth of the vanishing frontier lay the seeds of wilderness preservation in the United States...as an insurance policy to protect its future.”¹⁰ A new charge for the preservation of nature prompted scientists into nature to understand how to best save what was remaining.

Through the works of Muir, Wordsworth, and other well-known naturalists of this time, nature was perceived through poetry, painting, and later, photography. Scientists called on artists to assist in documenting nature, “the resulting interplay between naturalists, geologists, and artists led to a common perception of the natural world shared by both groups which placed emphasis on both fact and value.”¹¹ The beauty of nature, documented by artists, became the way the urban American public came to view nature as well. In one of Muir’s articles, he writes, “none of the Nature’s landscapes are ugly so long as they are wild.”¹² This evolution towards an attitude of biophilia, or the need for a connection to nature in one’s life, arose out of the awareness of nature’s beauty, but also from Americans rejecting the civilized world they were a part of. America had grown to the extent that the all-consuming nature became much too rare in the eyes of a city dweller. The urban American believed “that the best antidote to the ills of an overly refined and civilized modern world was a return to simpler, more primitive living.”¹³ It became very popular to spend time outdoors



“Thus, in the myth of the vanishing frontier lay the seeds of wilderness preservation in the United States... as an insurance policy to protect its future.” - William Cronon

Figure - 48

and Americans eagerly pursued activities in nature. Like all fads, some saw this as an opportunity to capitalize on the excitement, which leads to the next category of nature.

Nature as Commodity

In true Marxist fashion, the fashionable great outdoors began down the slippery slope of commodification. An escape from the perils of society was being packaged as a trip into nature, conveniently accessible through a growing railroad system across the

country. "These new types of conveyance found people ready and willing to avail themselves of the splendid opportunities to explore the country side and visit the little-known lakes and mountain valleys, the beauty and sublimity of which had been extolled by poets, writers, and painters for many years."¹⁴

Nature was offered to the urban public as more of a spectacle sport, then the actual interaction between human and nature. Trips were sold as packages from the train, to the lodge, to the promenade through nature, and back home again. Providing the illusion of the outdoors in its 'natural' state through a carefully contrived experience. One example of this was the opening of Seaworld, a place where the animal trainers were selling the 'inherent nature' of aquatic animals, and charging the beguiled public for bringing this nature to them.

There is an important distinction that must be made between the city dweller escaping civilization through nature, and the Americans who lived and worked with the land. As Cronon states, "the dream of an unworked natural landscape is very much the fantasy of people who have never themselves had to work the land to make a living."¹⁵ There were Americans who did not understand this commodification of nature because their livelihood existed through their connection with nature. Others however, decided to

capitalize on nature's growing prestige,

"Foresters began to have confidence in the public and, realizing that the forest had educational and inspirations values in addition to their utilitarian worth, decided to admit large numbers of tourists who were trying to escape the 'abominations of mechanized life'"¹⁶ The city tourists brought with them a very urban way of looking at nature, as if through a window, seen but not quite a part of.

Those who loved and lived off the land began take notice of the neglect and destruction of previously untouched forests by tourists who were ignorant of the proper way to treat this landscape.

"Wilderness suddenly emerged as the landscape of choice for elite tourists, who brought with them strikingly urban ideas of the countryside through which they traveled."¹⁷

Pollution and the destruction of pristine landscapes was happening on two fronts, from industrial waste in urban areas, and through the massive influx of people into nature who were uneducated about a responsible way to interact with nature. This was the beginning of the conservation crusade by naturalists, scientists, and those witnessing the destruction first hand.

Nature as Aesthetic

As beautiful as nature can be, there is a strange phenomenon in American culture to conserve and preserve the aesthetic nature,

what people refer to as the 'sublime'. The dramatic Niagara Falls, and the terrifyingly beautiful volcanic hot spots at Yellowstone were seen as treasures to preserve. However, "to this day there is no national park in the grasslands"¹⁸ as this is not viewed by Americans as aesthetically pleasing and original. In the 19th century, the prairie was described by an American as "picturesquely beautiful when it presented itself to the eye for the first time, but loses much of its interest, for its monotony wearies the senses."¹⁹ In general, it seems that the Americans living and/or working in environments such as these appreciated them for the beauty they possessed. It was very difficult for scientists and environmentalists to convince the American public that a portion of these lands were worth setting aside for conservation because "less sublime landscapes simply did not appear worthy of such protection."²⁰

When Americans enter the landscape, they are searching for the emotions that these sights evoke. Even Muir, a well known naturalist bought into this idea of nature as aesthetic stating, "'reserved places of great natural beauty were as important in everybody's daily life as those utilized areas that took care of physical needs,' because 'natural scenery... makes better men and women, physically, and mentally and spiritually.'"²¹ Growing up, Americans are often told of the health and rejuvenation benefits of nature, as if

nature could provide a spiritual cleansing from the lives we lead.

Nature as God

In continuation of the line of thought labeling nature as aesthetic, is the notion that one can find god within nature. Romantics often wrote, "sublime landscapes were those rare places on earth where one had more chance than elsewhere to glimpse the face of God."²² Both the beautiful and the destructive characteristics of nature were attributed to God, as "there is a wonderfully attractive clarity in this way of thinking about nature, for it turns the nonhuman world into a moral universe whose parables and teachings are strikingly similar to those of a religion."²³ In this way, natural events (or even disasters) were attributed to acts of god, either through love or retribution of a bad deed. Americans came to view nature as the spokesperson for whichever God they worshipped.

In addition to discovering God in nature, the American culture is saturated with monotheistic religions, and this idea of finding God in nature, evolved into nature as God. In the history of mankind, this wasn't a new idea. The many deities of the ancient Greeks were created to explain natural phenomena; from Icarus rising the sun in the morning, to Poseidon creating the waves on the shores. Science and religion have since molded each other, with the

mainstream religion in the U.S. being monotheistic, and focusing on moral imperatives and a spiritual connection. In this way, nature has become an unspoken God, where religion “would most often be found in those vast, powerful landscapes where one could not help feeling insignificant and being reminded of one’s own mortality.”²⁴ In an attempt to emulate this, power was transcribed into religious architecture through their size and height, lending the worshipper this feeling of insignificance in the presence of something so holy.

Nature as Justification

The first several themes exploring nature in an American context were applying nature to something concrete, or widely understood and accepted in American culture. The next few themes will explore a more abstract, linguistic comprehension of nature. In American culture, there also began a shift towards citing nature instead of God as a moral authority, and as Cronon aptly states, “It would have been far more common in the past for people in Western traditions to cite God as the authority for their beliefs. The fact that so many now cite Nature instead (implicitly capitalizing it as they once might have capitalized God) suggests the extent to which Nature has become a secular deity in this post-romantic age.”²⁵

Americans currently use nature to justify their actions in a way that would have been outlined in a religious framework previously. Americans commonly say something is ‘in their nature’ as a way to defend or justify an aspect that is inherently part of their being, such as a temper. “When we speak of ‘the natural way of doing things,’ we implicitly suggest that there can be no other way, and that all alternatives, being unnatural, should have no claim on our sympathies.”²⁶

Nature as Natural

There has been a shift from the assurance that something grown from the earth is natural. This is again another shift in how Americans view nature. Through modern science and technologies, the naturalness of elements that were never before questioned have created entire markets in which Americans are all too eager to take advantage of. Similar to the commodification of the natural landscape, raw food products have been capitalized on due to the willingness of Americans to pay more for nature. Food companies are able to price their products directly related to the food’s level of ‘naturalness’, described as either organic or genetically altered. This begs the question of what it means to be natural – if nature is defined as everything that is not human made, does this include changing the genetic structure of something natural?

Similarly, if a plant from a different part of the world were grown by human hands and planted in a foreign land, how natural is the plant? It is not 'native' to the region, it would not 'naturally' grow there, but is it separate from nature? One stark example of this is the picture of Eden that has been cultivated in "the southern California landscape...[which] has been transformed into a vision of nature utterly different from the ecosystems that once characterized the region."²⁷ When looking at biophilic architecture, no matter the location of the building, there is almost certainly an incredible amount of greenery that may or may not be native to the region. The point is that it doesn't matter, "once we believe we know what nature ought to look like... we can remake it so completely that we become altogether indifferent or even hospitable toward its prior condition."²⁸ Americans want to recreate the nature of their urban environments in the image of the Garden of Eden.

Nature as Virtual Reality

The last and perhaps most abstract comprehension of nature is perhaps not a singularly American concept, but is important to explore nonetheless. The idea of nature as a virtual reality stems from a nature beyond our visual capabilities. Modern technologies have allowed us deeper access into the building blocks of our genetic makeup, and we use these findings to justify actions, heal and di-

agnose ailments, all elements we cannot see, but modern science tells us exist. This extends from the smallest atom to the makeup of our universe, "some of the most dramatic environmental problems we appear to be facing as we enter the twenty-first century exist mainly as simulated representations in complex computer models of natural systems."²⁹ Countless laws concerning nature preservation, conservation, and sustainability are enforced by the American government because modern science has forecasted the negative effects of proceeding on the current wasteful trajectory. The justifications of these actions are based on computer models that attempt to forecast an uncertain natural projection. When scientists used the available information from 100 years ago in their computer simulations of nature, the predictions were not even close to where our current environmental situation lies. This is not a critique of current scientific technologies, but more so an observation of the huge influence digital models of nature through simulated processes has on the American government, and its voting population.

From the abstract virtual reality to the memory of an American frontier, American culture has shaped the unique way its citizens view, treat, respect, interact, and understand nature. The United States is not a closed circuit free from outside influence, and this must

also be accounted for. This investigation began to best understand how to implement a European system of mountain huts within the American framework of nature. The eight themes outlined in this chapter show the evolution of American attitudes towards nature, which are significantly different today than they were when settlers first arrived. Attempting to predict the direction these trends will continue is a difficult challenge. Americans are still heavily influenced by the romanticized image of the wild frontier when land was plenty and unmarred by the forces of industry.

Similarly, Europeans have their own romance with mountain life, however their system of mountain huts allows them access into the wilderness while creating a protective infrastructure for their users. The Mt. Baker Base Camp and Research Facility will be the beginning of this infrastructure in the U.S. and address the issue of the loss of the frontier by creating a light touch on the environment. One strategy for accomplishing this is through lifting the building off the ground by a system of screw piles. The screw piles would be drilled into the ground, however were the building to be removed, the only remaining evidence would be a series of small holes the diameter of the screw core. The main entrance to the building would act as a bridge between the landscape and the built environment with one contact point on the ground itself.

In addition to creating a light touch on the environment, the building would effectively aggregate use on the mountain by creating a focal point along the trail. The base camp would be located in an area already used by hikers as a campsite, and by aggregating use, keep hikers on the trail. Furthermore, Mt. Baker encourages hikers to pack out all human waste, even though there is currently evidence of human waste along the trail. Providing a facility with composting toilets will serve to mitigate this issue. To conclude, the Mt. Baker Base Camp and Research Facility will be encroaching on a pristine environment, but will do so with minimal impact while also solving trail issues such as aggregating use and mitigating waste.



Figure - 49 Morning clouds on the Railroad Grade



Leave No Trace 7 Principles:

- Plan Ahead and Prepare
- Travel and Camp on Durable Surfaces
- Dispose of Waste Properly
- Leave What You Find
- Minimize Campfire Impacts
- Respect Wildlife
- Be Considerate of Other Visitors

Figure - 50

LEAVE NO TRACE

American hikers are no strangers to the Leave No Trace campaign³⁰, which promotes responsible interaction with the outdoors by urging hikers to leave an environment as it was found. American mountain guides are required to memorize, teach, and abide by the seven principles listed above. As such, it is important for new construction along trails to follow these principles to the furthest extent possible. This could be translated into the way the building touches the ground by designing the structure to leave as minimal trace as possible were the building to be removed.

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Figure - 51 Hikers descending on the Railroad Grade

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Figure - 52 The south side of Mt. Baker in the sunset

THE SITE

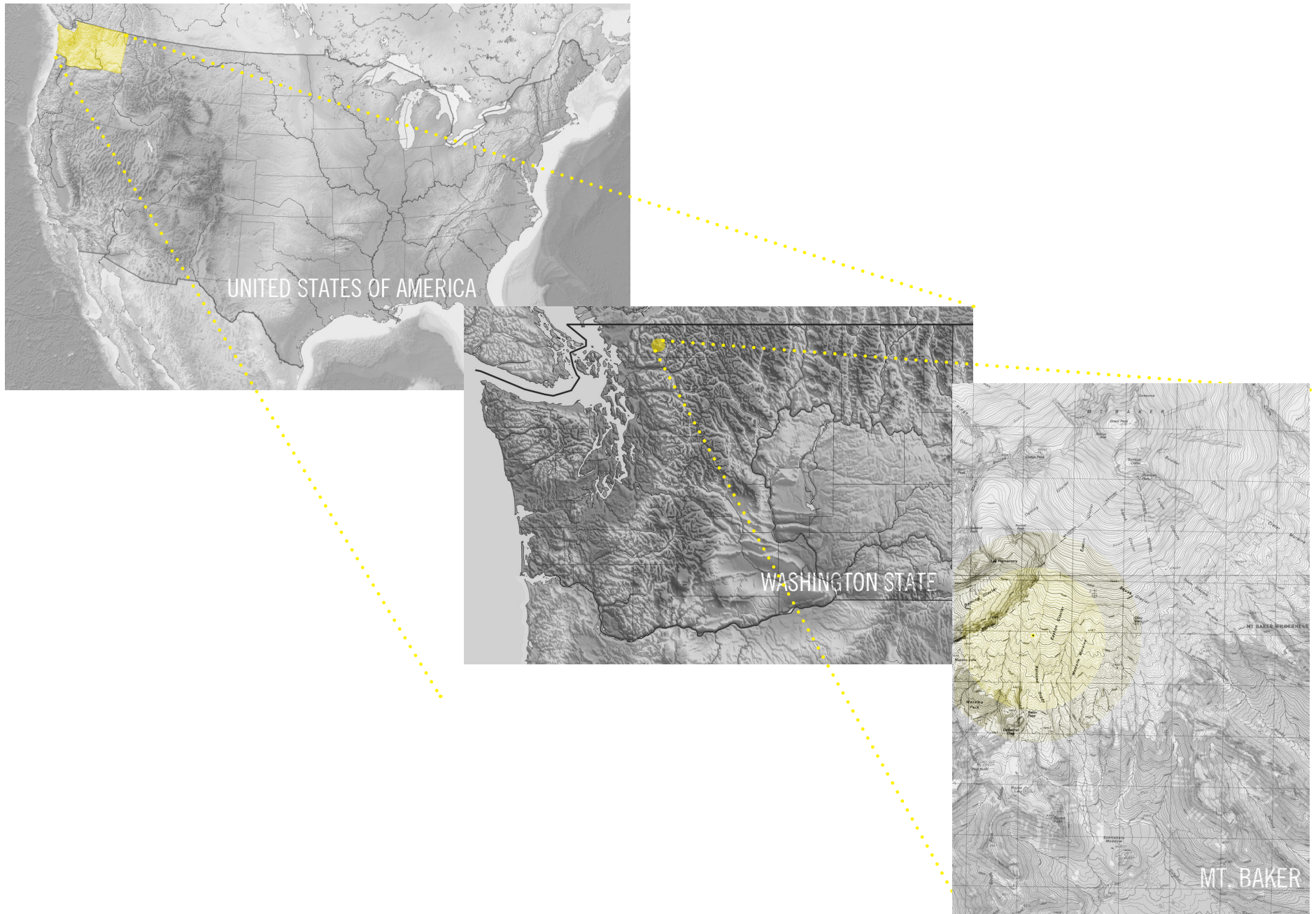


Figure - 53 Mt. Baker location diagram

HISTORY OF MOUNT BAKER



Figure - 54 Sketch by Gonzalo Lopez de Haro

The local Native American Lummi Tribe first knew Mt. Baker as “Koma Kulshan”. The first known sighting was in 1790 by Spanish explorer, Gonzalo Lopez de Haro, who charted the great mountain as “La gran montaña del Carmelo” while on an exploratory mission from Vancouver Island. His sketch however wasn’t published until 1872. In 1792, two years after de Haro, an English Navy Lieutenant, Joseph Baker, reported the mountain to the naval base in Vancouver giving the mountain its official name. Mt. Baker is a part of the Mt. Baker National Forest, which was established as part of the Washington Forest Reserve in 1897.

The very first summit of Mt. Baker was made on August 7, 1868 by Edmund Thomas Coleman after two unsuccessful attempts. By the early 1900’s, the climbing fever had struck the Pacific Northwest. Climbing groups such as Seattle’s Mountaineers, Portland’s Mazamas, and Bellingham’s Mount Baker club were adding notoriety to the mountain. The first big national attention came with the first race from Bellingham to the summit and back in 1911. After this point, tourism and alpine expeditions skyrocketed on Mt. Baker and the surrounding forest. In 1926, the Mt. Baker Lodge was constructed on a nearby peak, which eventually became the Mt. Baker ski area. Today around 5,000 people summit, or attempt to summit, Mt. Baker every year.¹

Its notoriety is well deserved as Mt. Baker is the second most glaciated peak in the contiguous U.S. (Mt. Rainier being the first) with 15 named glaciers and 124 perennial snow/ice features. The glaciers and features cover approximately 19 square miles. According to the National Oceanic and Atmospheric Administration (NOAA)², Mt. Baker holds the record for the most snowfall in the U.S. over a single year. During the 1998/99 season, Mt. Baker received a record breaking 1,140 inches of snowfall, beating Mt. Rainier’s previous record by a mere 18 inches. In addition to the

anticipated snow loads, Mt. Baker, like many peaks in the Cascade Range, is an active stratovolcano with a long history of eruptions and activity.



Figure - 55 Easton Glacier via 1912



Figure - 57 Easton Glacier



Figure - 56 Present-day Easton Glacier

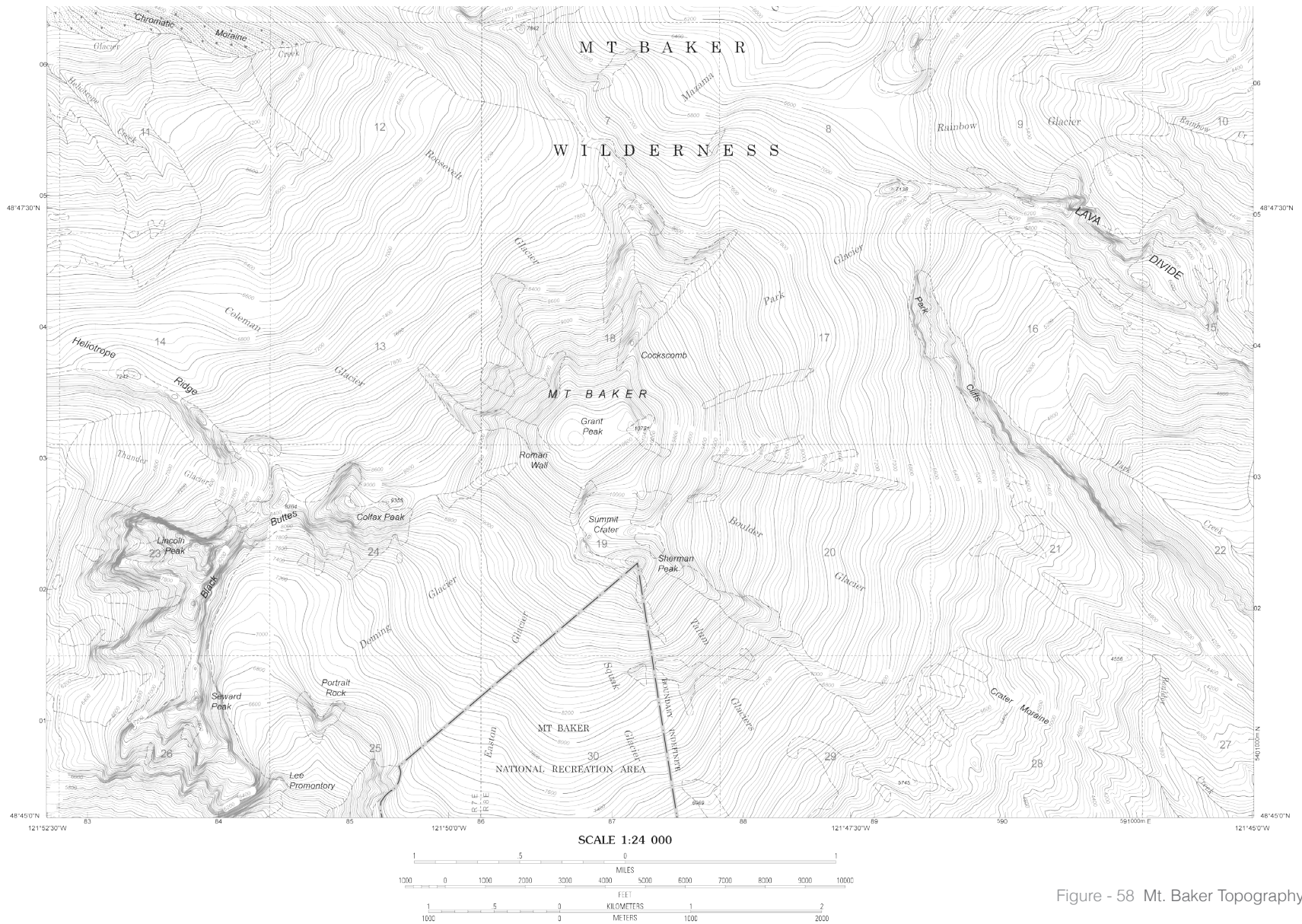


Figure - 58 Mt. Baker Topography

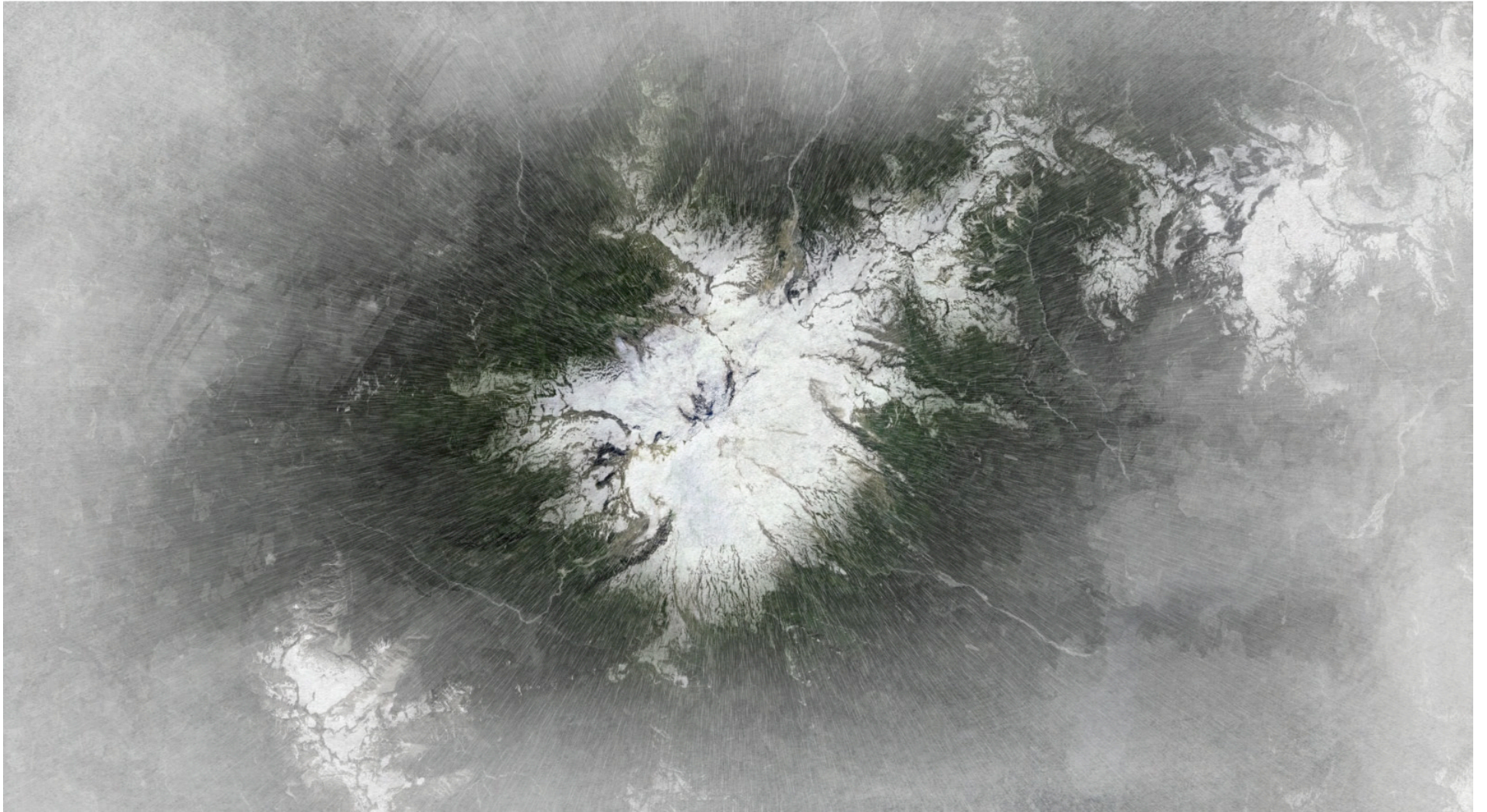


Figure - 59 Aerial view of Mt. Baker

GLACIERS

After Alaska, Washington is the second most glaciated state in the U.S. with glaciers covering all of its tallest peaks. Glaciers are ice masses that are made when fallen snow compresses over time into ice. These ice masses move slowly over time and can vary greatly in size from several hundred yards, to several miles long. There are 15 named glaciers on Mt. Baker and 124 perennial snow and ice features. Mt. Baker is unique in that it is the only mountain in the Cascade mountain range to experience both alpine and continental glaciers. During the last ice age, the Cordilleran Ice Sheet covered Mt. Baker and carved the mountain and surrounding lakes as it retreated into Canada.³

As a glacier moves, it erodes the earth and leaves deposits called moraines in its path, several of which are visible from the Easton/ Deming Route. During the winter, the cold temperatures and heavy snowfall enable the glaciers to grow in size and they become almost indistinguishable from one another. However, during the summer months, they shrink and create large crevasses between them, making the ascent a very technical climb.

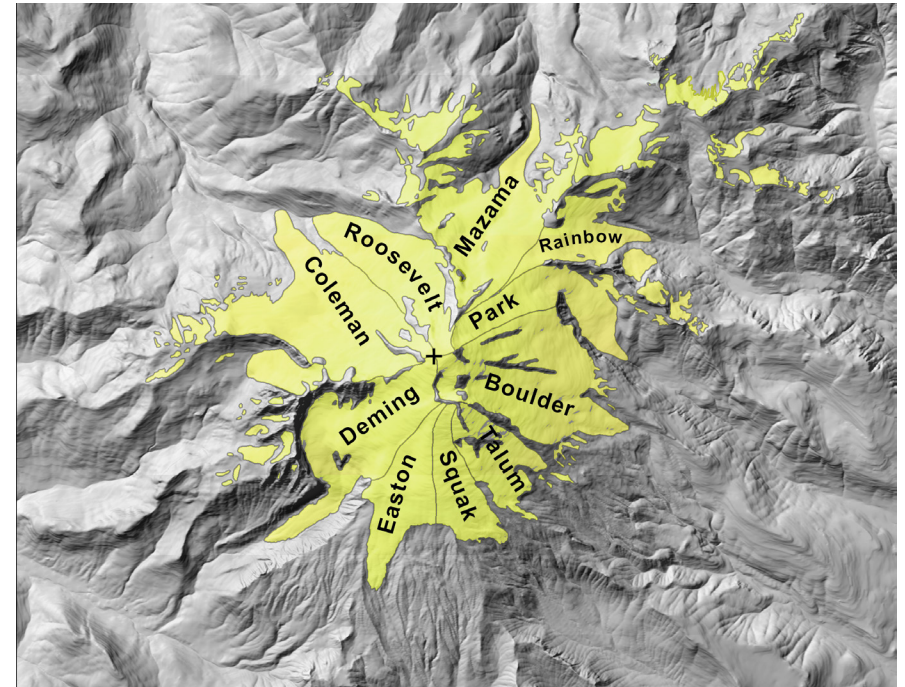


Figure - 61 Glaciers on Mt. Baker

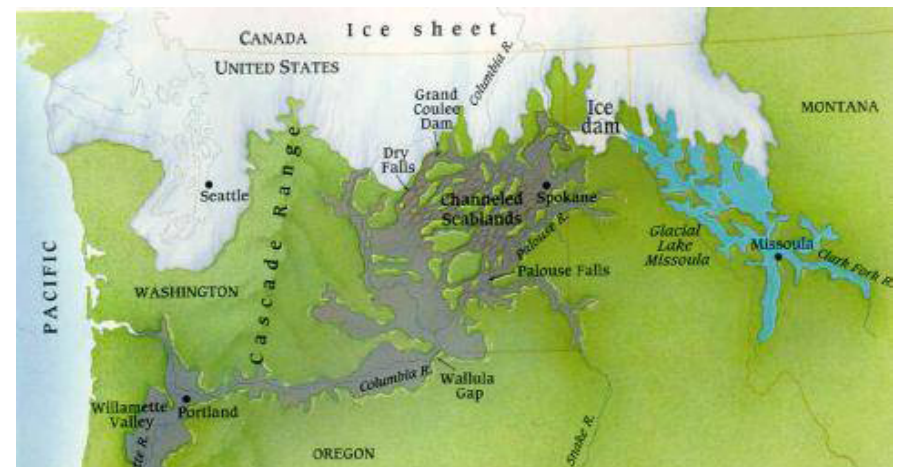


Figure - 60 Continental Glacier

NATIVE AMERICAN LORE : Koma Kulshan

The meaning of the Native American name for Mt. Baker, “Koma Kulshan,” has been heavily debated. In 1913, Dr. Charles Milton Buchanan, the superintendent of the Tulalip Indian Reservation, provided a clear definition based on the Native American Lummi tribe:

“‘Kulshan’ is a Lummi word indicating that the summit of the peak has been damaged, or blown off by an explosion (‘just as if shot at the end,’ as one Indian explained it). This word is used if other things are damaged or supposed to be damaged in a similar manner, and it is not limited at all in its use to Mt. Baker. The term does not mean ‘The Great White Watcher/ or ‘The Shining One,’ as commonly interpreted.”¹

The Lummi legend tells a story about a handsome young man, Kulshan, who has two wives. His favorite wife of the two, named Duh-hwähk, is very pretty and has given him three sons. The second wife, Whüht-kway, is not as beautiful as the first, but is very kind. Over time, Whüht-kway’s kindness won Kulshan’s heart, making Duh-hwähk very jealous. In an attempt to win his heart back and prove that she was still his favorite, Duh-hwähk decided to leave Kulshan expecting him to call her back and proclaim his love. Duh-hwähk had to stretch higher and higher to keep Kulshan

in sight as she moved over the hills and valleys. Eventually, she made camp at the highest point around so that she could still keep an eye on Kulshan. Over time, Kulshan became Mt. Baker, and Duh-hwähk transformed into Mt. Rainier, and still keeps an eye on Kulshan.¹



Figure - 62 Members of the Lummi Tribe

EASTON/DEMMING ROUTE

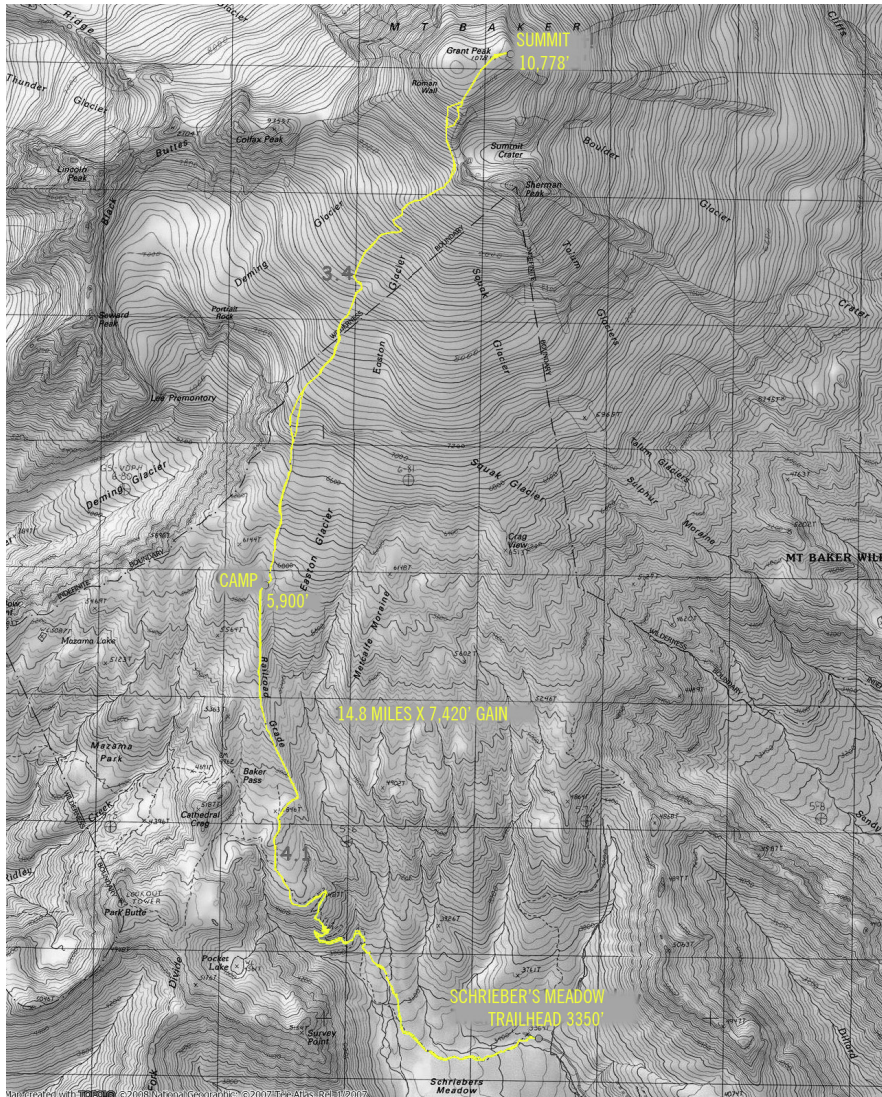


Figure - 63 A GPS tracking of the Easton Demming Route

Mt. Baker sees over 5,000 hikers who attempt to summit the mountain each year via a series of routes. The recommended time frame for hikers is between September to mid-October, and for skiers, the recommended window is January until June. One of the most common routes, known for its gentler ascent and technical crevasses is the Easton/Deming route, which winds up the south side of the mountain. The shorter, but more demanding, Coleman/Deming Route is the other more frequently traveled ascent and is located on the northwestern side of the mountain. The Easton/Deming ascent is a total of 14.8 miles roundtrip from the trailhead with a 7,420' elevation gain. The hike begins with a gentle climb through Schrieber's Meadow passing over several creeks, which vary in size depending on the season. The trailhead services several trails so hikers of all levels and preparedness are seen until the



Figure - 64 Creek Crossing near the trailhead

turn off onto the Railroad Grade. The Railroad Grade section of trail follows a ridge with a steep drop off on both sides. The east side of the ridge is a moraine, which has been carved into the mountain by the Easton Glacier. Camping begins at around 5,000' elevation and can go as high as 6,700' for hikers wishing to camp directly on the Easton Glacier. At 6,700' hikers will reach the Easton Glacier and rope up for the remainder of the hike. For summer hikers, the path is clear enough to follow, however, care must be taken to avoid crevasses.

As hikers approach the Sherman Crater, a sulfur smell will become apparent. This is from the volcanic gases emanating from the crater. Just beyond the crater is Sherman Peak, Mt. Baker's false summit. Beyond the Sherman Crater, hikers will face the steepest portion of the hike on the 35-degree Roman Wall. This steep, south-facing aspect is a prime set up for a wet slab avalanche during the warmer summer months, and prior avalanche training is necessary for the safety of the hiking party, and others on the trail.

After a successful climb up the Roman Wall, hikers will come to a flat top, which is roughly the size of several football fields. Hikers will then head northwest towards Grant Peak, the true summit of Mt. Baker at 10,778'.



Figure - 65 Hikers on the Railroad Grade

There are several companies who offer guided hiking and skiing expeditions to the summit of Mt. Baker. While Mt. Baker can be summited in one day on skis, most hiking and skiing guided groups offer a three-day summit expedition. The first day's objective is to reach a base camp location and set up camp. The second day is spent around the base camp and on the Easton glacier, instructing hikers on proper climbing techniques and familiarizing hikers with the climbing equipment. The third day begins well before dawn as the group packs up and starts towards the summit. This can usually be done in 4-6 hours from the base camp location, and then hikers begin the long descent back to the trailhead, stopping again at the base camp to pack up.



Figure - 66 Hikers near the Sherman Crater



Figure - 67 Hikers navigating crevasses



Figure - 68



Figure - 69

THE SITE: WEST

The above image, looking west, shows the Sandy Campsite at around 5,900' elevation on the south side of Mt. Baker. As is visible in the image, this site features a large ridge along the west side, which will block direct beam sunlight onto the site at around 4pm during the spring and fall equinox, earlier during the winter solstice, and later during the summer solstice.



Figure - 70

THE SITE: NORTH

This image shows the Sandy campsite looking north towards the summit of Mt. Baker. This site is commonly used for hikers, climbers, and mountaineering groups who attempt to gain the summit. When there is no snow present, campers will move the rocks to create a half moon wall around the tent to protect their site from the strong winds coming from the southwest. During the snowy winter months, campers will create the same wall out of snow pack.



Figure - 71

THE SITE: EAST

This image shows the Sandy Campsite looking east. This image clearly shows the site in the shadow of the large ridge on the west side of the site. This is very important to consider when designing a building that intends to be powered primarily by photovoltaic panels, especially for the winter months when the daylight hours are very short.



Figure - 72 A hiker looks south over the site

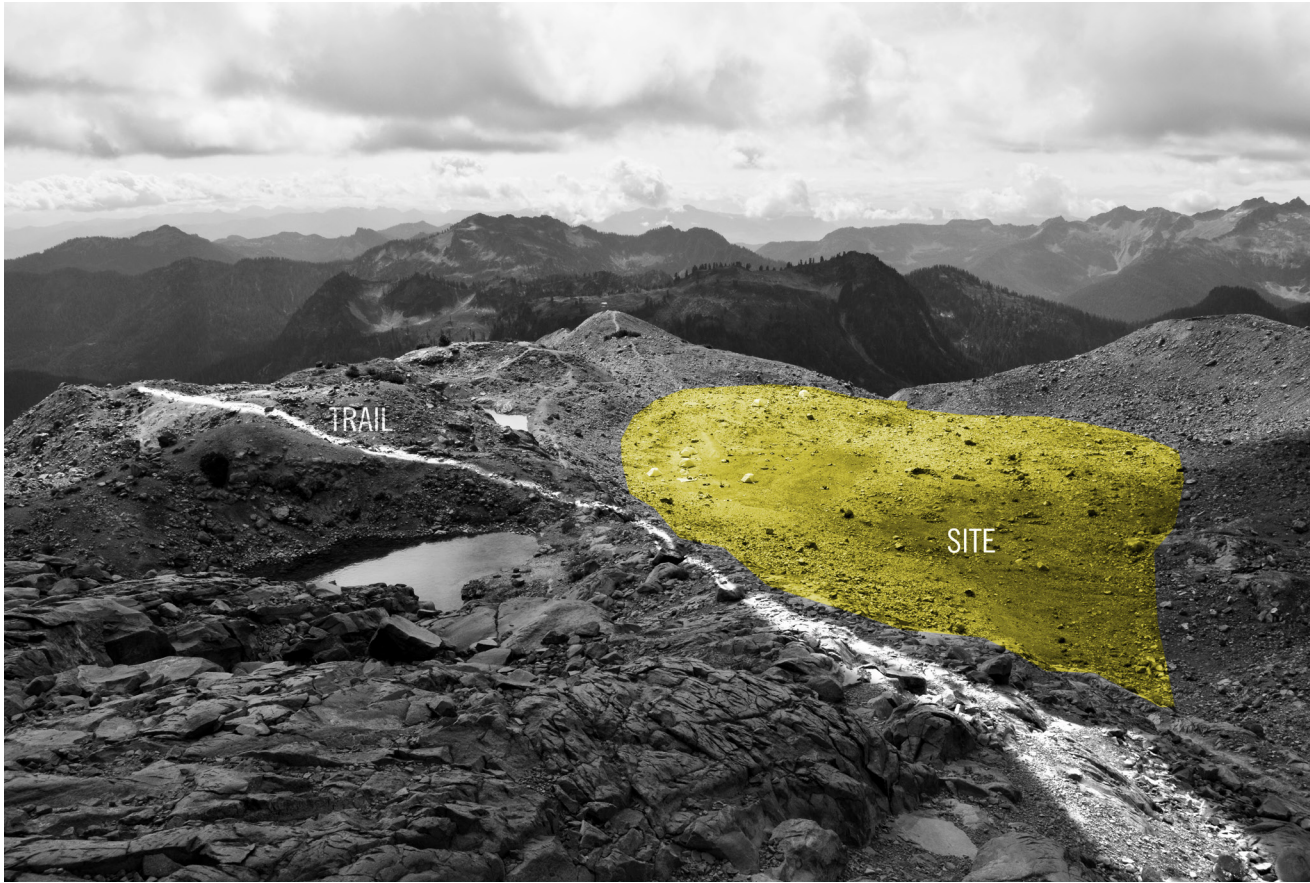


Figure - 73

THE SITE

This diagram shows the site looking south above the site (marked here in yellow). The trail is clearly marked to indicate its proximity to the site. Also evident, are the seemingly endless mountain ranges visible from the site. Desirable views from the site are of the summit, looking north, and of the mountain ranges to the south.

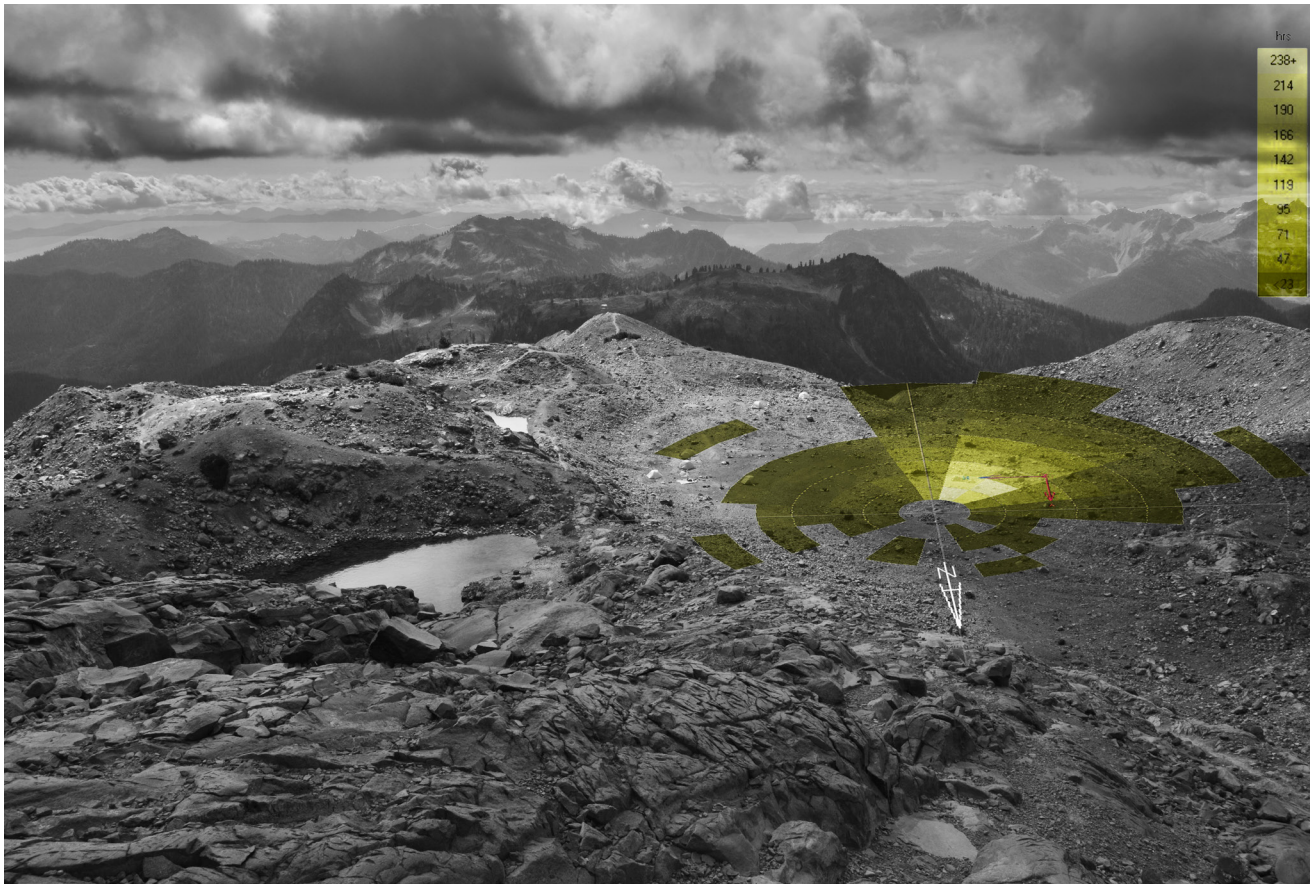


Figure - 74

THE SITE: WIND

The wind hours chart for the month of January was indicative of the average wind direction and wind hours and was thus chosen to represent wind patterns in this diagram. On average, the wind blows consistently from the southwest and can reach very high speeds as is common in high alpine environments. Understanding the wind patterns is important in the overall design, especially with the intention of lifting the building off the ground. The building design should respond appropriately to work with the wind, instead of against it.

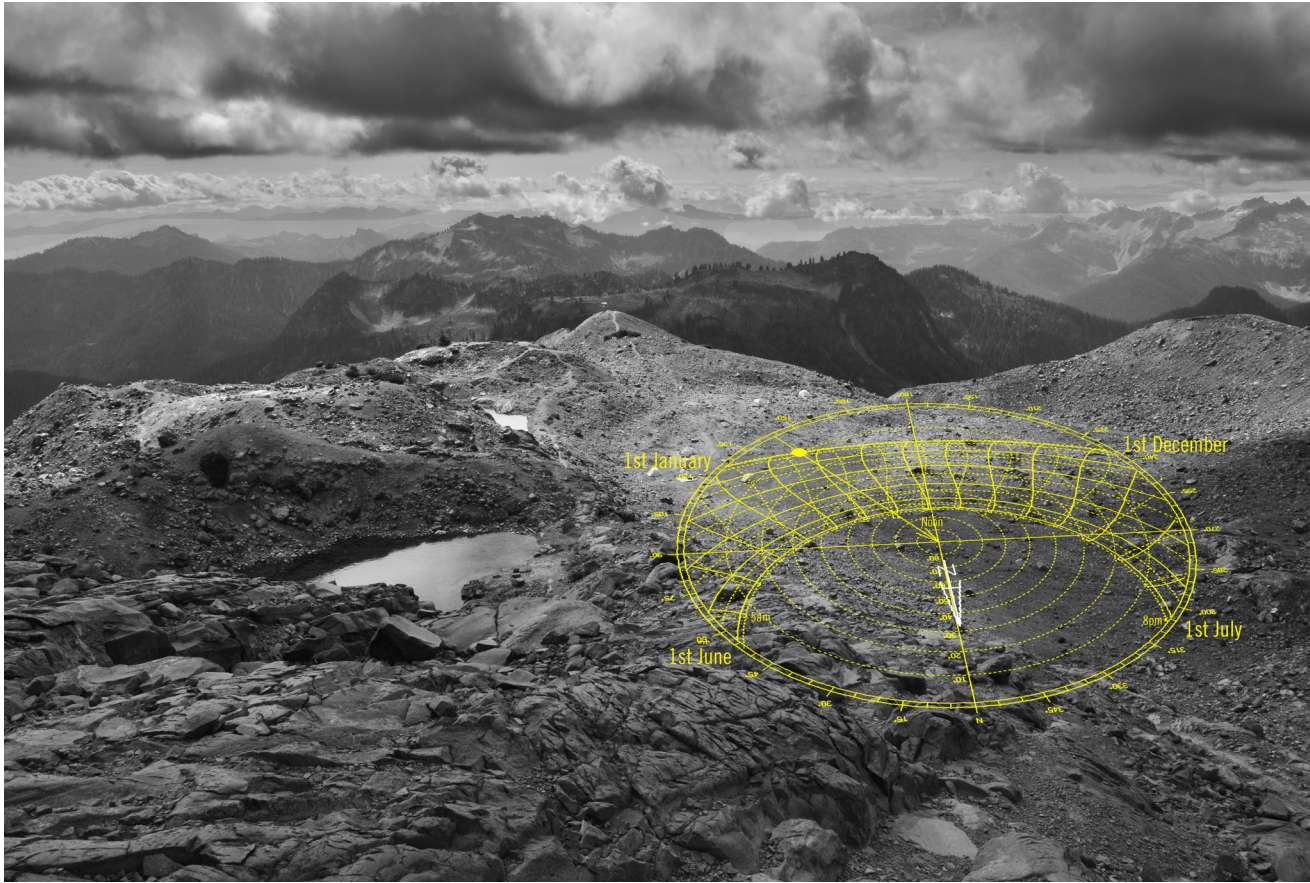


Figure - 75

THE SITE: SOLAR

This image displays the stereographic chart for Mt. Baker overlaid on the site. The building intends to be powered primarily through photovoltaic panels, so understanding the sun patterns is important for efficient design as well as maximizing potential solar thermal gain in the winter. The long summer months will provide more direct solar gain than will be necessary to power the building. The opposite is the case for the short daylight hours in the winter. This, coupled with the high snow pack, will be insufficient to power the building through solar radiation alone.

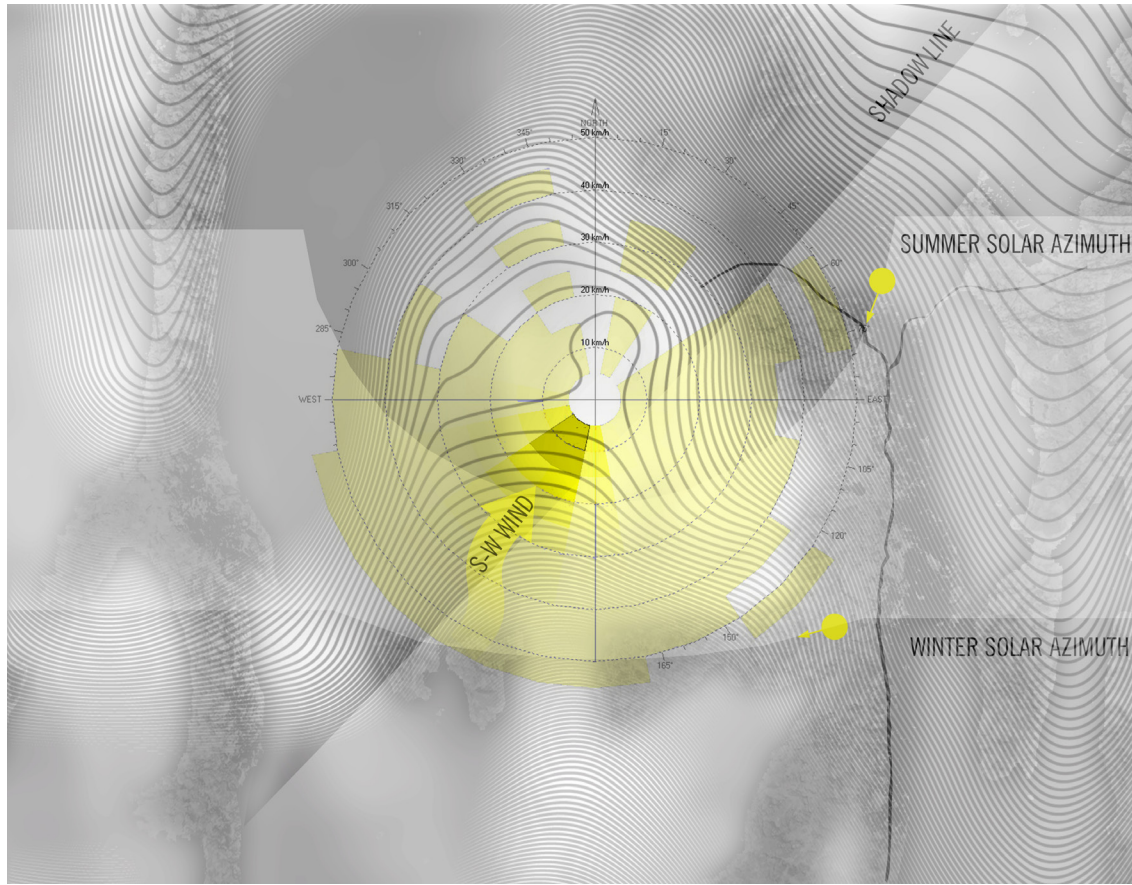


Figure - 76

THE SITE: ANALYSIS

This diagram combines the solar and wind patterns for the site. In addition, a shadow line shows where the building itself will begin to fall into the shadow of the west ridge meaning a loss of direct solar gain for the PV panels. This of course would vary over the course of the year.



Figure - 77 A hiker looks northwest over the site

THE SITE: WEATHER AND SAFETY

As previously stated, the Easton Demming route to the summit of Mt. Baker is typically climbed in either two or three days with one or two nights at a base camp location. This base camp allows for hikers to rest for an evening to start the summit ascent fresh the next morning. Currently, there are no facilities at the base camp location at the Sandy Camp, with the closest winter medical facilities at the Mt. Baker Ski Area on the northeast base of the mountain. Building a base camp at this location would provide vital shelter in the instance of a white out or injury. The base camp would be supplied with a medical facility to provide first response care to any injured hikers.



Figure - 78 The site as it would appear in a blizzard

The image above displays the sudden weather changes that can transform a high visibility day into a white out. Choosing a building material that contrasts with the white of the snow could help hikers find their way to safety. Additionally, providing a facility where hikers could rest, be well fed, and wait out a storm would help to prevent mountaineering accidents caused from exhaustion or lack of resources.

THE SITE: SNOW, TEMPERATURE, AND OCCUPANCY

When designing in a high alpine location, it is important to understand the local climate, and how this correlates to the hiking and mountaineering seasons when the building would be running at full capacity. Figure 79 shows the 10-year average snowfall for the Mt. Baker Ski Area.⁴ This information was gathered at the ski area's Panorama Dome at an elevation of 5,000'. This is 900 feet below the elevation of the base camp, as well as further inland. Unfortunately, this is the closest weather station to the site. Scott Shell, the one of the directors for the Northwest Avalanche Center, has stated that the average snowpack (not to be confused with snowfall, snowpack is the amount of accumulated snow) at the Sandy campsite can reach heights of 30-40 feet during the winter season⁵. This has been accounted for in the building design and will be discussed further in the next chapter.

Figure 80 shows the average temperatures as an overlay on the snowfall chart. As would be expected, the amount of snowfall is correlated to the cold and warm temperatures. This data was retrieved from a special weather data file created by the Swiss company, Meteonorm⁶, specifically for the coordinates of the Mt. Baker Base Camp and Research Facility site.

Furthermore, Figure 81 shows how the temperature and snowfall

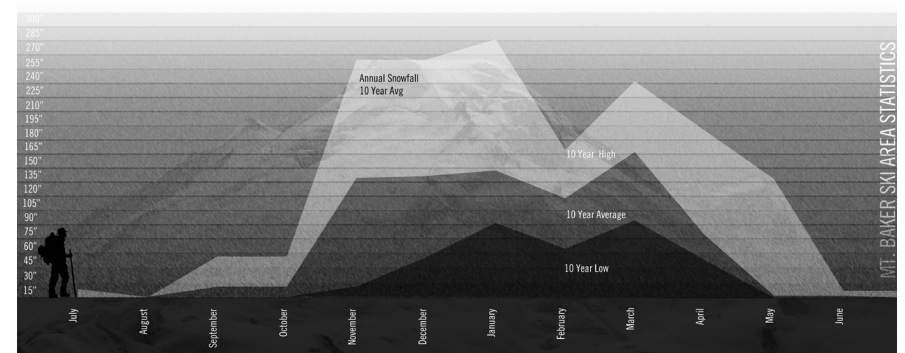


Figure - 79

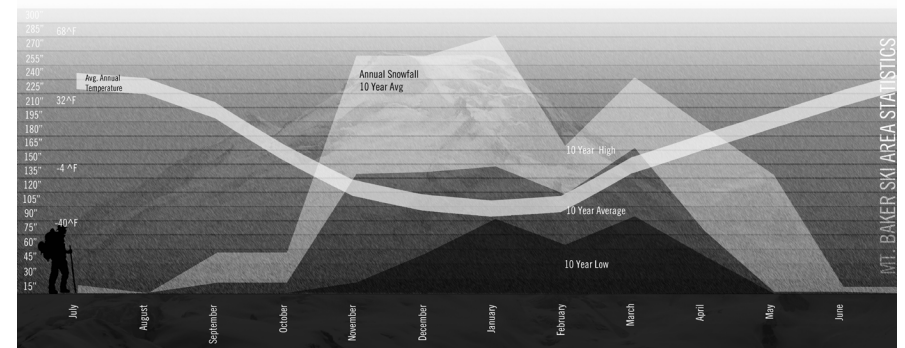


Figure - 80

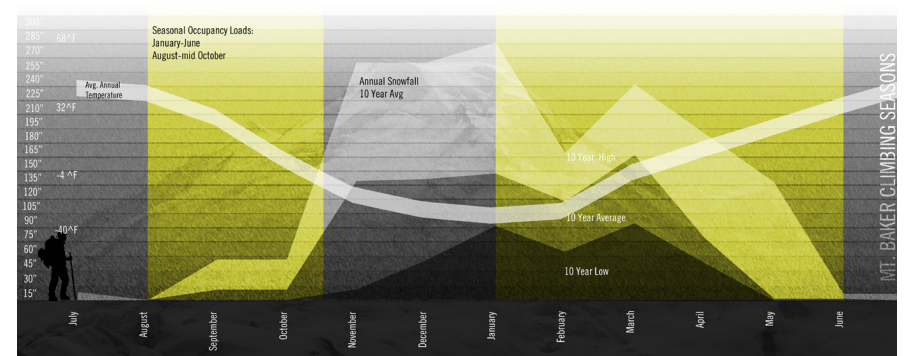


Figure - 81

data correlate to the peak occupancy time. These are the Mt. Baker hiking seasons according to Pacific Alpine Guides in Port Angeles, WA⁷. The mountaineering season, meaning guided groups making their way to the summit, is from January to early June. This is the time when the crevasses have filled and the glaciers have grown enough to support a trail over the glaciers to the summit, but before warm temperatures bring the return of the crevasses. The season from August to mid-October is for summer hikers and climbers who are not trying to gain the summit as the field of crevasses renders it nearly impossible. This diagram illustrates that the peak occupancy months for the base camp will be during the coldest months with the most snow, as well as the warmest months with minimal snow, so the building needs to perform at an optimal level at both ends of the seasonal weather condition spectrum.

Endnotes:

1. Lloyd, T. Abe. "Wild Harvests." : Koma Kulshan: Origins of the Mysterious Mountain Moniker. Arcadianabe, 18 Nov. 2012. Web. 15 May 2015. <<http://arcadianabe.blogspot.com/2012/12/koma-kulshan-mysterious-mountain-moniker.html>>.
2. "MT. BAKER HOLDS SNOWFALL RECORD, NOAA REPORTS." NOAA. NOAA, 2 Aug. 1999. Web. 4 Feb. 2015. <<http://www.publicaffairs.noaa.gov/releases99/aug99/noaa99056.html>>.
3. Hekkers, Mike, and Kristina Thorneycroft. "Glaciers of Washington."Glaciers of the American West. Portland State University, 7 Sept. 2011. Web. 31 May 2015. <<http://glaciers.us/glaciers-washington#History>>.
4. "Snowfall Statistics." Mt. Baker Ski Area:: Mt. Baker Ski Area, n.d. Web. 21 Apr. 2015. <<http://mtbaker.us/ski-area-info/snowfall-statistics/>>.
5. Shell, Scott. Personal Interview. November 4, 2015.
6. "Meteonorm Software." Meteonorm. Meteotest, n.d. Web. 3 Feb. 2015. <<http://meteonorm.com/>>.



Figure - 82 View of the Easton Glacier in September with several deep crevasses

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Program Element

ENTRY

Wind Break
Shoe Room

LODGING

Guests
Staff
Research

BATHROOMS

Guest WC -
Guest Shower -
Staff -
Research -

DINING

Kitchen/Preparation
Food Storage (dry and cold)
Dining Room
Dining Room Bathrooms

STORAGE

Guest Equipment
General Facilities Storage
Laundry and Cleaning

RESEARCH FACILITIES

Offices / Data Processing / Lab
Data Collection (exterior)

SYSTEMS

Sustainable Building Systems

OTHER

Medical Facilities

THE PROGRAM

The program for the Mt. Baker Base Camp and Research Facility was developed to combine research and education with dining and lodging. This building is not meant to make camping in the area obsolete so only 40 beds are available for guests. Typical guided groups to Mt. Baker consist of 8-12 people, so the base camp will accommodate around four guided groups, but will also be available for booking to the general public. The building itself will be split into two parts, one which is meant to be fully conditioned and operational year-round, and the other which will be shut off and kept at a minimal temperature during the off season. The dining, kitchen, research, classrooms, and staff/research lodging will be located in the year-round portion of the building, whereas the guest lodging and their showers/bathrooms will be located in the seasonal section. This split will be discussed in further detail in the Building Performance Chapter.

During peak mountaineering seasons, the base camp is expected to operate at full capacity, as well as serve food and drink to hikers, climbers, and mountaineers who are either camping nearby or making a day hike to the base camp. There are five individual rooms for the staff, which would include a chef, server, housekeeper, medical professional, and manager. During the off season, less staff will be needed for the running of the base camp, but all

five rooms are located on the south side of the building which is operational year-round. Additional researchers, whose bedrooms are indistinguishable from the staff's, and also located in the year-round portion of the building, are able to utilize these extra rooms. The staff and researchers share a bathroom and showers.

The decision to provide the staff and researchers with individual rooms rather than guest lodging bunk plan, was based on an article by David Hill regarding the OZ Architecture master plan of the McMurdo research station in Antarctica. In the article, the architecture firm determined that "morale is definitely an issue at McMurdo, and the need for privacy in such close quarters remains a major concern. It makes a huge difference to people when they're in a remote situation to have some private space that they can go to."²³ Since the researchers and staff will be living on site for long periods of time, providing them with individual rooms was an important design decision. This is especially significant when the building would be subject to 30' of snowpack. Researchers and staff will also have a lounge and game room on the fourth level, adjacent to the winter entrance.

The bathrooms are designed with fully enclosed cabins for each toilet so that the bathrooms can function for both male and female

users. Given that this building is a base camp, and not a hotel, users will be more willing to adapt to tighter quarters and a mixed gender bathroom.

There are also fairly large storage and utilities rooms located in the basement, as well as on the second floor. This will house the storage of necessary items, such as food and water that will be transported to the base camp via snow cat. Since the base camp will be producing the necessary energy to function, these spaces will store the HVAC and electrical systems, as well as the biomass pellets necessary to fuel the co-generator (see the diagrams in the Building Performance Chapter).

Mountaineering can be a very dangerous sport, especially on a mountain with glaciers where deep crevasses form. Therefore, the Base Camp will serve as a first response medical facility. There is very little development on Mt. Baker with the closest hospital located approximately 40 miles away. This on-site medical facility would provide basic operations that could be the difference between life and death for a critical patient while waiting for an airlift to the nearest hospital.

Lastly, an exterior stair and fourth level entry is necessary for ac-

cess into the building during the months when there is the anticipated 30-40 feet of snowpack. The exterior stair will connect the fourth level entry to the first level exterior dining, and further to the ground stair for camper access. As the snow accumulates around the building, hikers will have access to the stair at any level to gain entry into the building. From there, the whole building will be internally accessible, even the basement storage through a hatch on the first floor. In the event that the first and second floors are covered with snow, the lodging will be above snow level and still have access to daylight. While the light well in the center of the building will help to illuminate the internal spaces, daylight will still need to be supplemented with electric lighting on the first two levels during these snowed-in months.



Figure - 83 Campers on the ridge above the site with Mt. Shuksan in the distance

THE NORTHWEST AVALANCHE CENTER AND RESEARCH POTENTIAL

Mission: “The mission of NWAC is to save lives and reduce the impacts of avalanches on recreation, industry and transportation in the Cascade and Olympic Mountains of Washington and northern Oregon through mountain weather and avalanche forecasting, data collection and education.”¹

The research facilities of the Mt. Baker Base Camp and Research Facility were designed with a flexible floor plan to allow for several disciplines of snow, avalanche, glacial, and volcanic sciences to utilize the space for their own needs. The chosen location for the facilities, directly adjacent to the Demming and Easton Glaciers, and below the Sherman Crater, makes it possible for researchers to live on site year-round with direct access to the focus of their studies. The Northwest Avalanche Center (NWAC) was chosen as one such research organizations in an attempt to take a deeper look at the real-life applications for this site and type of facility.

Typically, when hikers, skiers, and snowshoers in Washington and Oregon embark on a backcountry trip, they check the weather forecasts and observations, read recent trip reports, and check the Northwest Avalanche Center website for the most recent condi-



Figure - 84

tions. Without this valuable information, mountaineers who aren't trained to recognize hazardous conditions could find themselves in a life-threatening situation. The information that NWAC provides is an invaluable resource to the Pacific Northwest. NWAC is a partnership between the U.S. Forest Service Northwest Avalanche Center and the Northwest Avalanche Center non-profit organization. They have an extensive network throughout Oregon and Washington with on-duty forecasters posting the most up-to-date information during the winter months. Their resource network is one of the most comprehensive in the US and consists of 25 remote automated weather stations, some of which are directly tied to the NWAC website to instantly report weather and snowpack data.¹

The education aspect of the NWAC mission consists of hundreds of avalanche awareness classes, youth education programs, and their most in-depth workshops, the Going Deep series. The NWAC offices are located in Seattle, with many of their education classes and workshops occurring in various locations throughout Portland and Seattle. The website notifies users of upcoming Level 1-3 avalanche training courses hosted by third party educators. Currently, without proper facilities, NWAC cannot offer these courses themselves.

NWAC has several resources, but in order to provide introductory avalanche training and Level 1-3 avalanche training, they need a facility located on one of the many mountains in Washington. This thesis proposes to provide organizations such as NWAC with a snow and avalanche research facility on Mount Baker to further knowledge of avalanche prone areas, as well as lodging for on-site education classes. By providing NWAC with an education center on a high alpine location, they would have the opportunity to host Level 1-3 avalanche training courses with instructors who are experts in the field as well as provide a series of avalanche education courses to the general visiting public.



Figure - 85

THE EXPERIENCE

This early conceptual collage shows the inspiration for the program layout and the sequence of experiences for the user. Starting from left to right, as the hikers crest the final ridge before the site, the building starts to come into view as their safety and shelter, a hopeful symbol that they have made it half way to the summit. As they move into the building, the hikers enter an intimate, internally focused entryway where it is safe to shed their layers, store their equipment, and change out of their hiking boots and into house shoes. Visible from the warmth of the entry is the externally focused dining hall with large south-facing windows acting as a frame for the beautiful mountain ranges beyond. Additionally, the main stair to the research, classrooms, and lodging is visible from the entrance.

The building changes vertically from public to private, so moving up from the dining hall is the classrooms and research facilities. These are adjacent to a light well, around which the vertical circulation is centered. As the researchers are expected to live in the base camp year-round, they will have a line of sight from their offices to the entry in the case that an unexpected visitor arrives.

Continuing up the light well and vertical circulation, the user finds themselves in the more compact space of their lodging quar-

ters. These are located on the top floors where the bunks in each room, in combination with the windows, create personal views of the summit of Mt. Baker, which visible from the north side of the building, a reminder of the target and ultimate goal of gaining the summit.

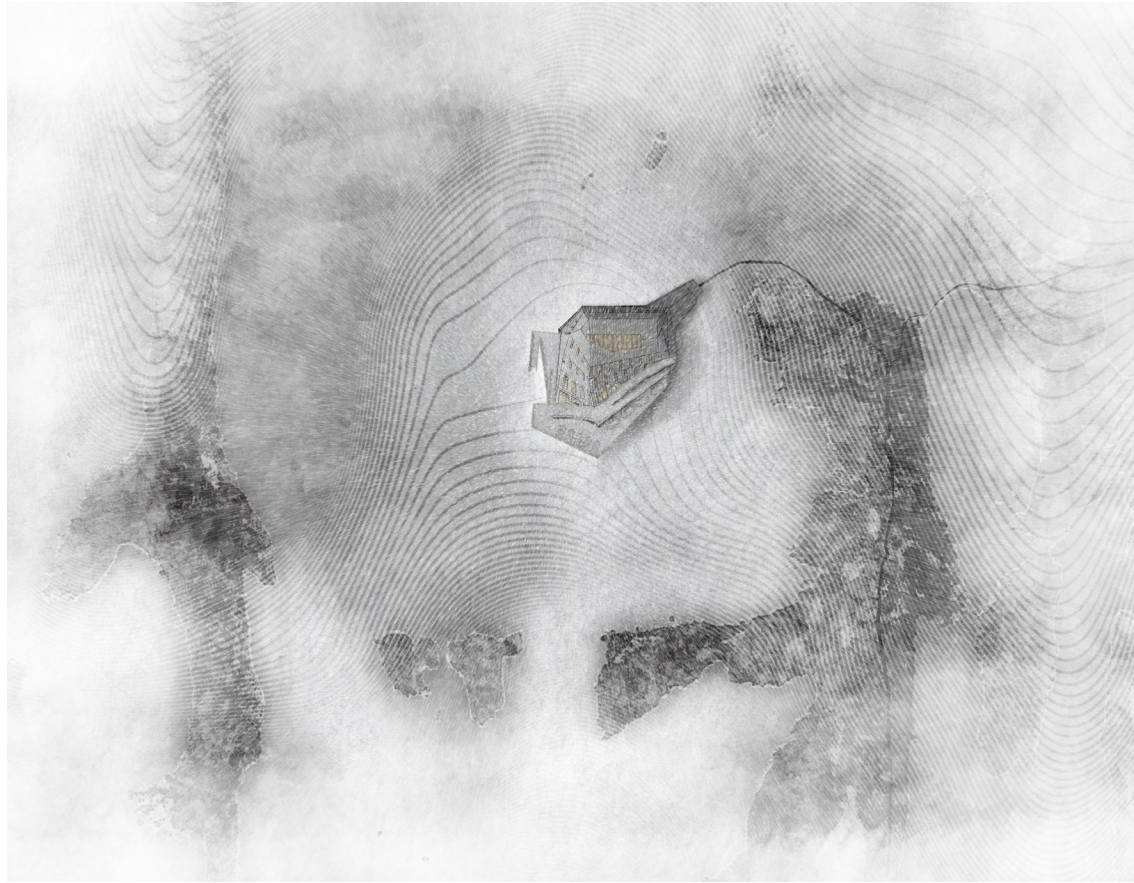
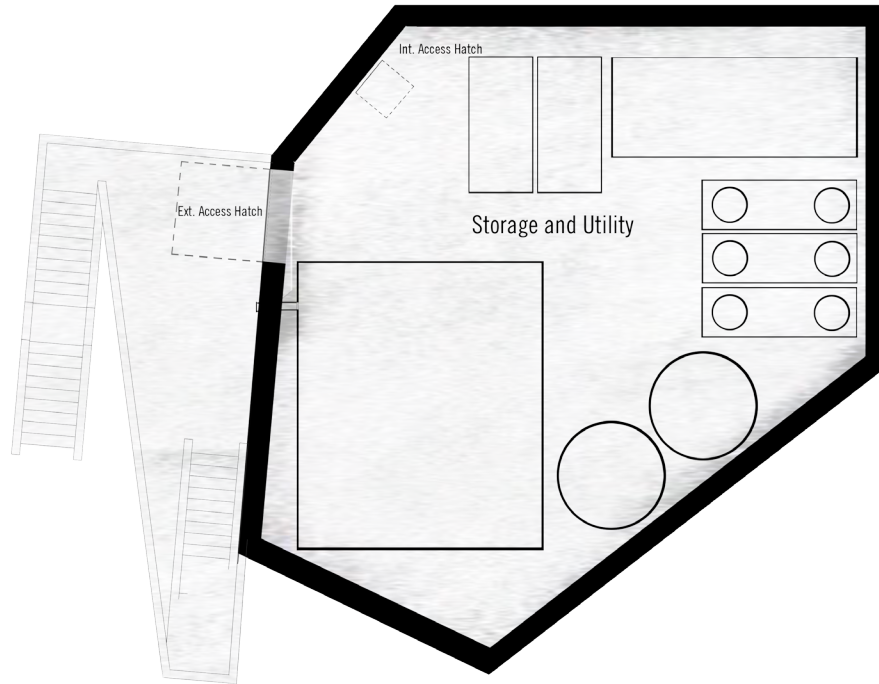
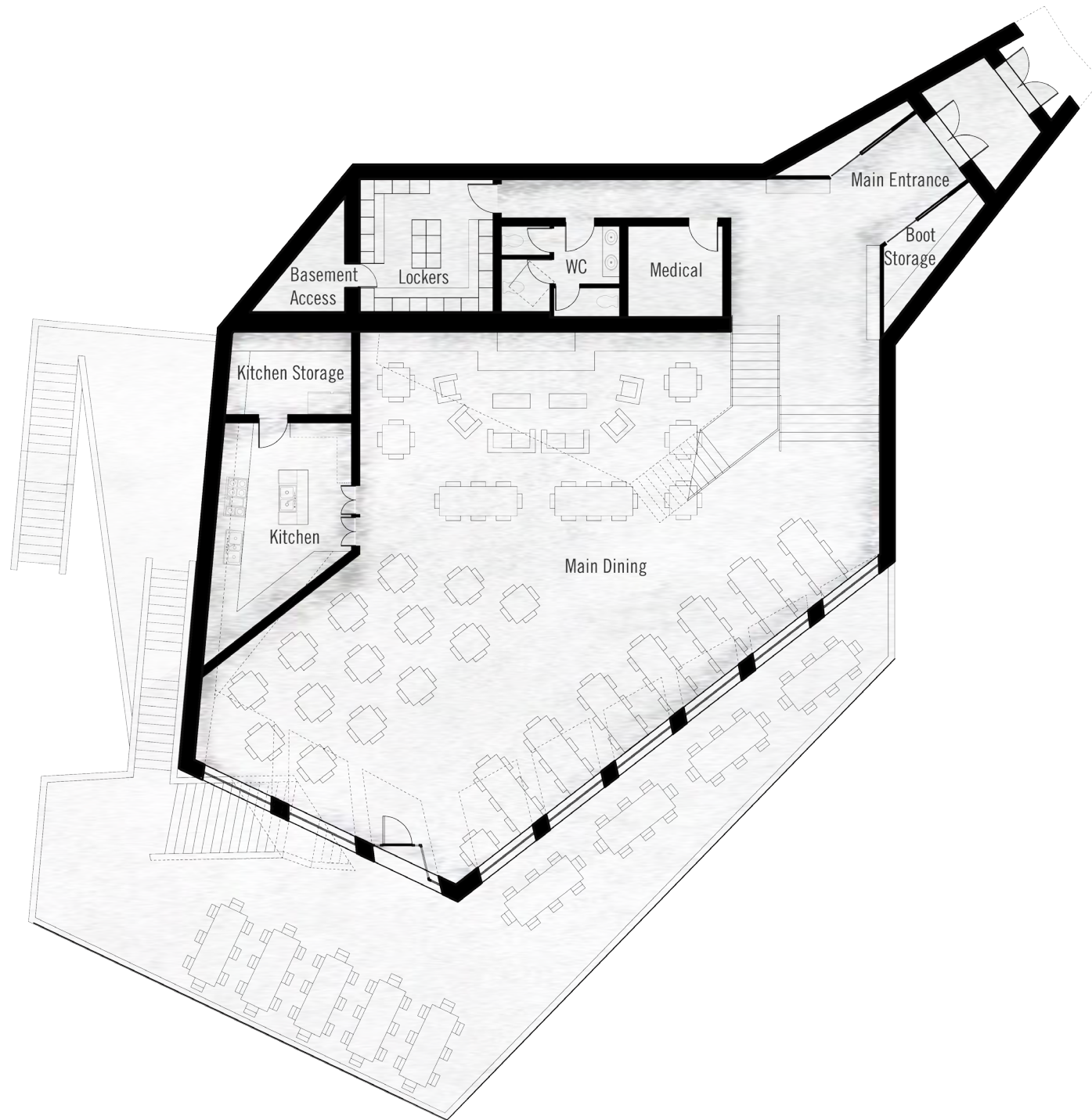


Figure - 86 Aerial View of The Mt. Baker Base Camp and Research Facility

THE SITE

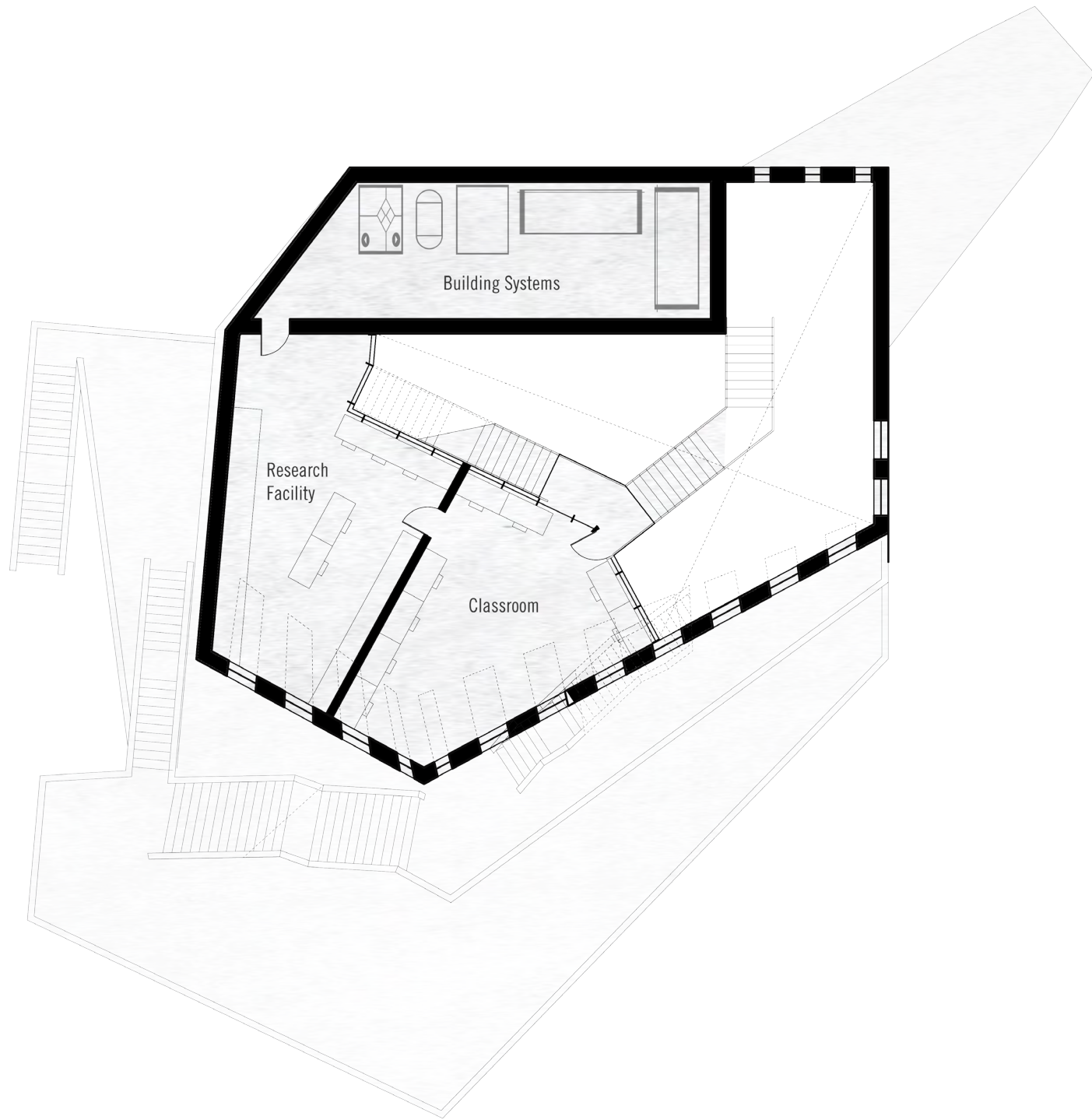
The decision to design the Mt. Baker Base Camp and Research Facility in the relatively flat bowl of the Sandy campsite arises out of several factors. First and foremost, hikers visiting Mt. Baker are there to enjoy the great outdoors and escape the built environment. Because of this, the decision was made to keep the building out of the line of sight of the trail until just before the building is reached. Furthermore, a design goal for the building was to keep as light of a touch on the environment as possible so placing the building in a protected area, instead of on a wind-blasted ridge, would decrease the scale of the structure.

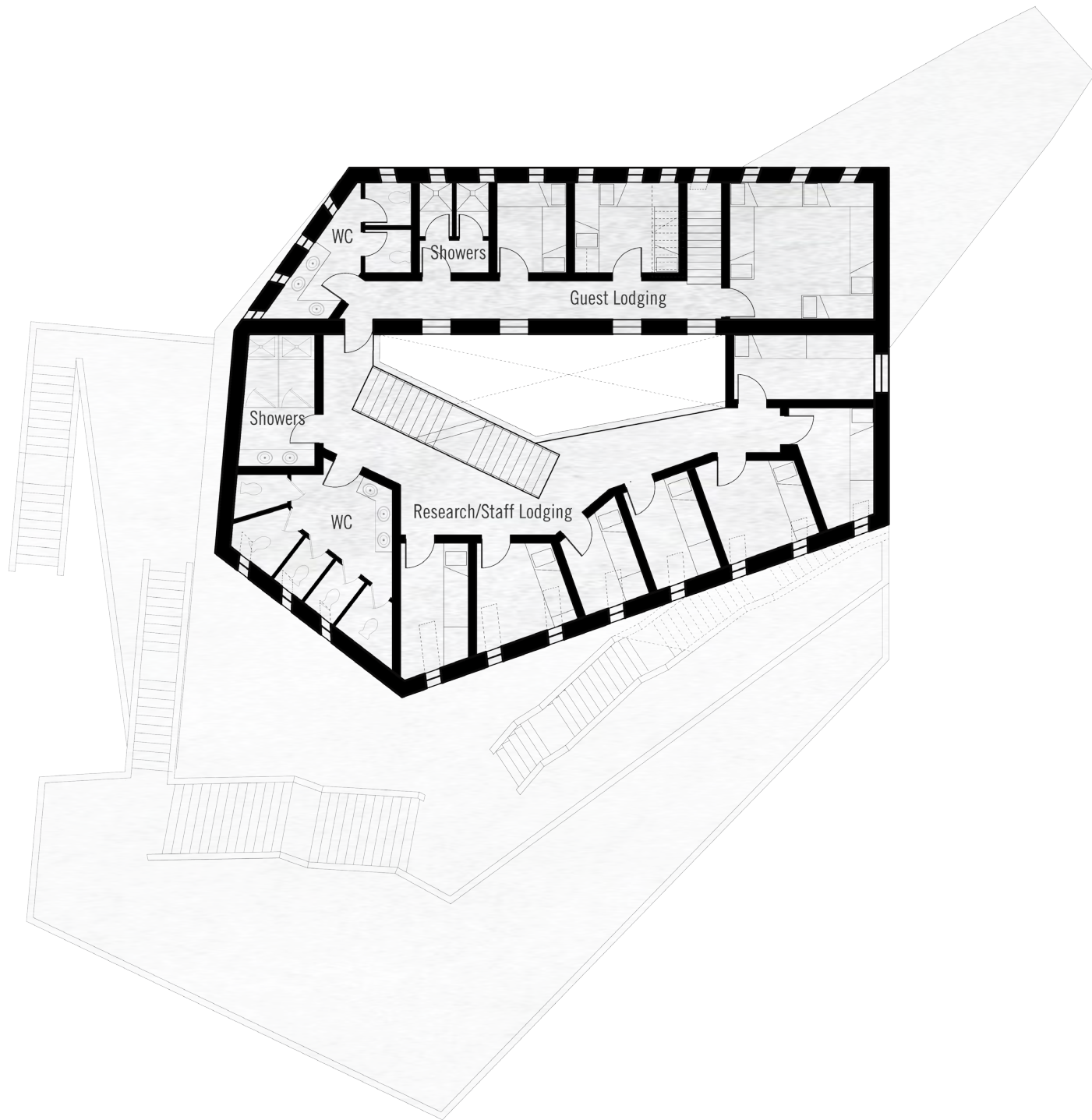




Level 1: Dining

Figure - 88





Level 3: Lodging

Figure - 90

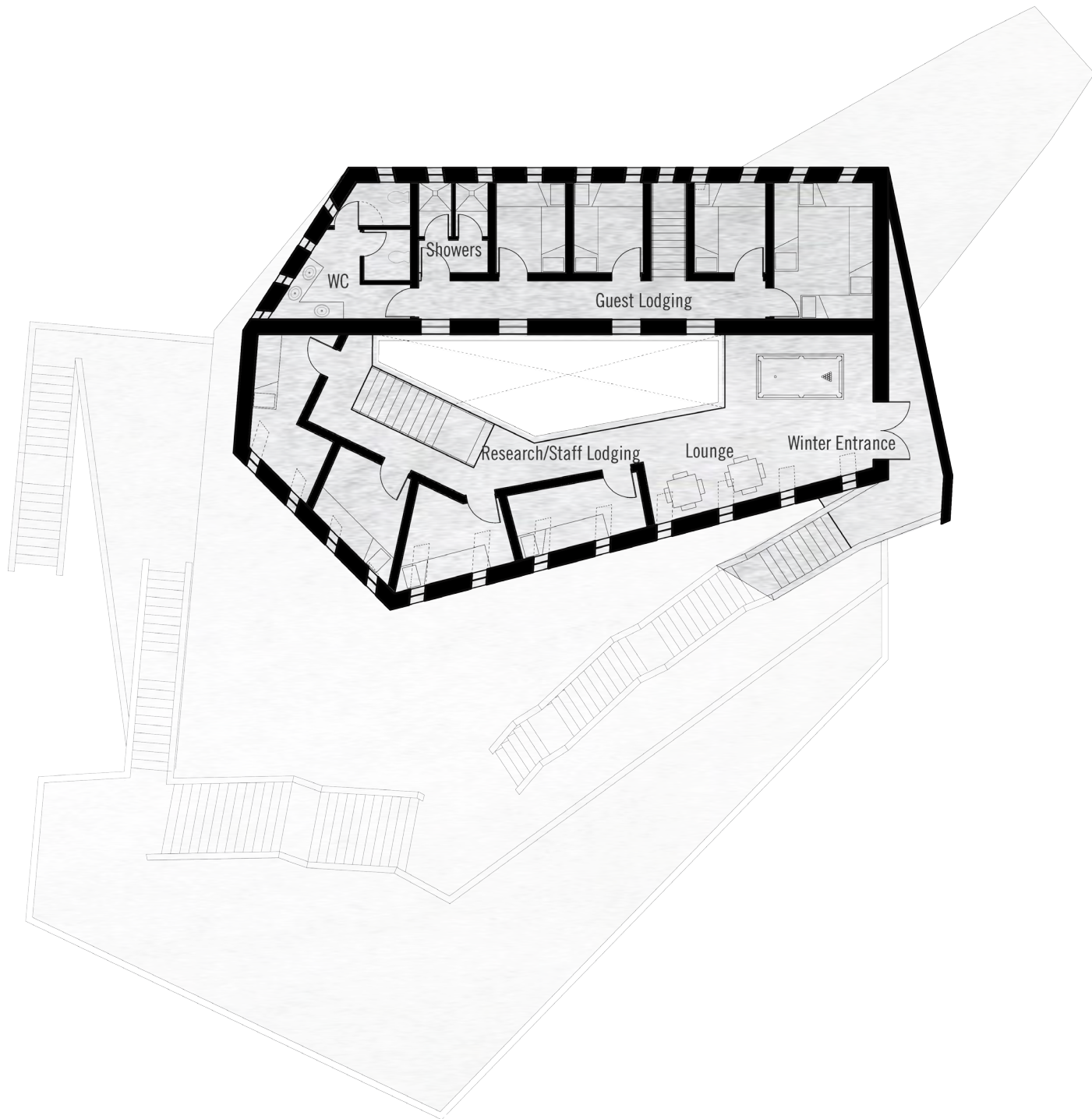


Figure - 91

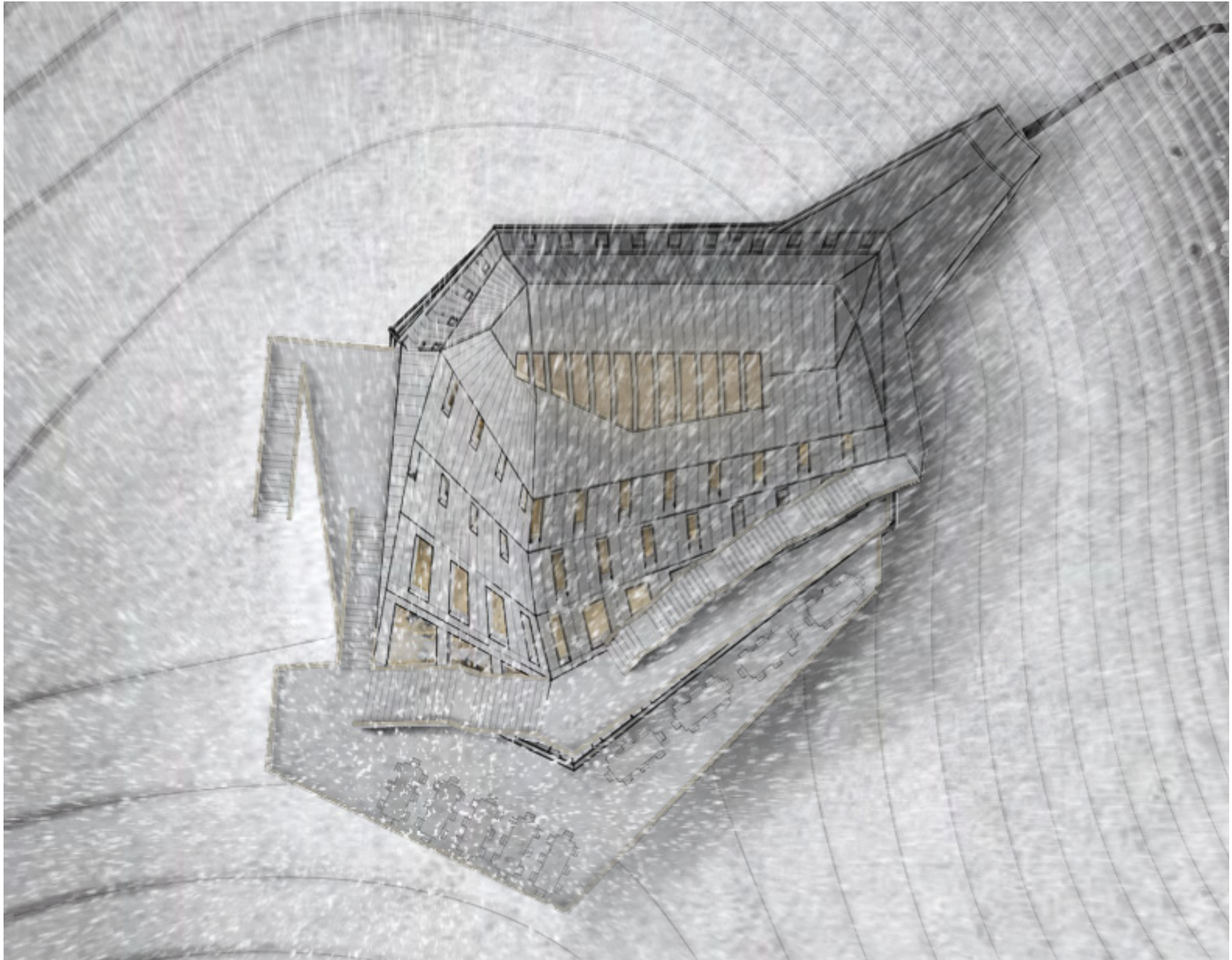


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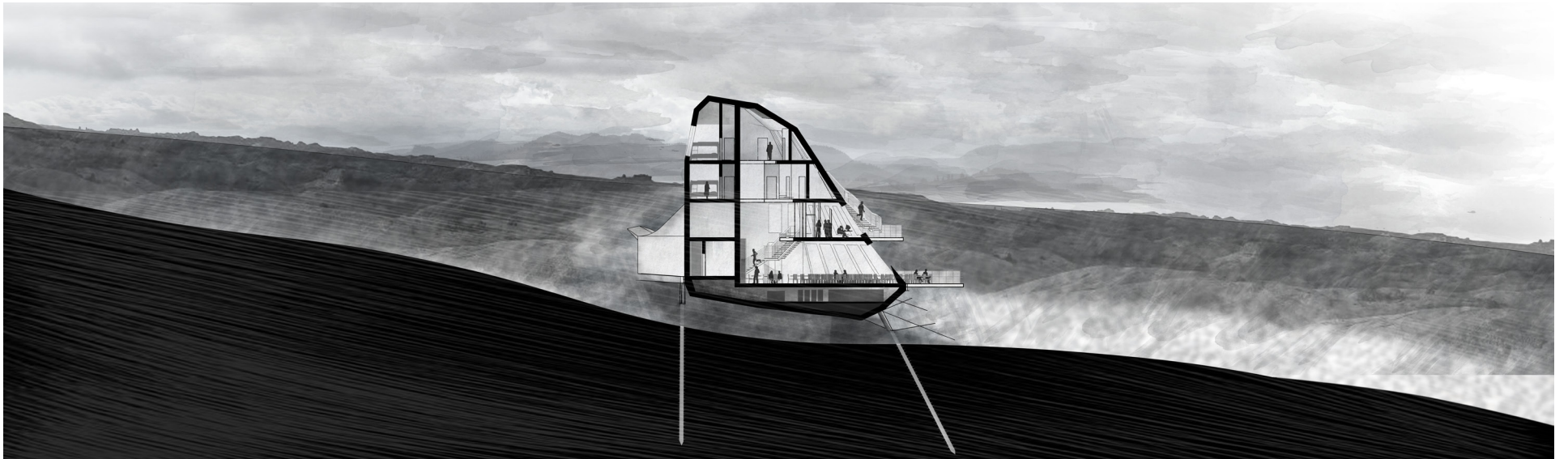


Figure - 93 East-Facing Building Section

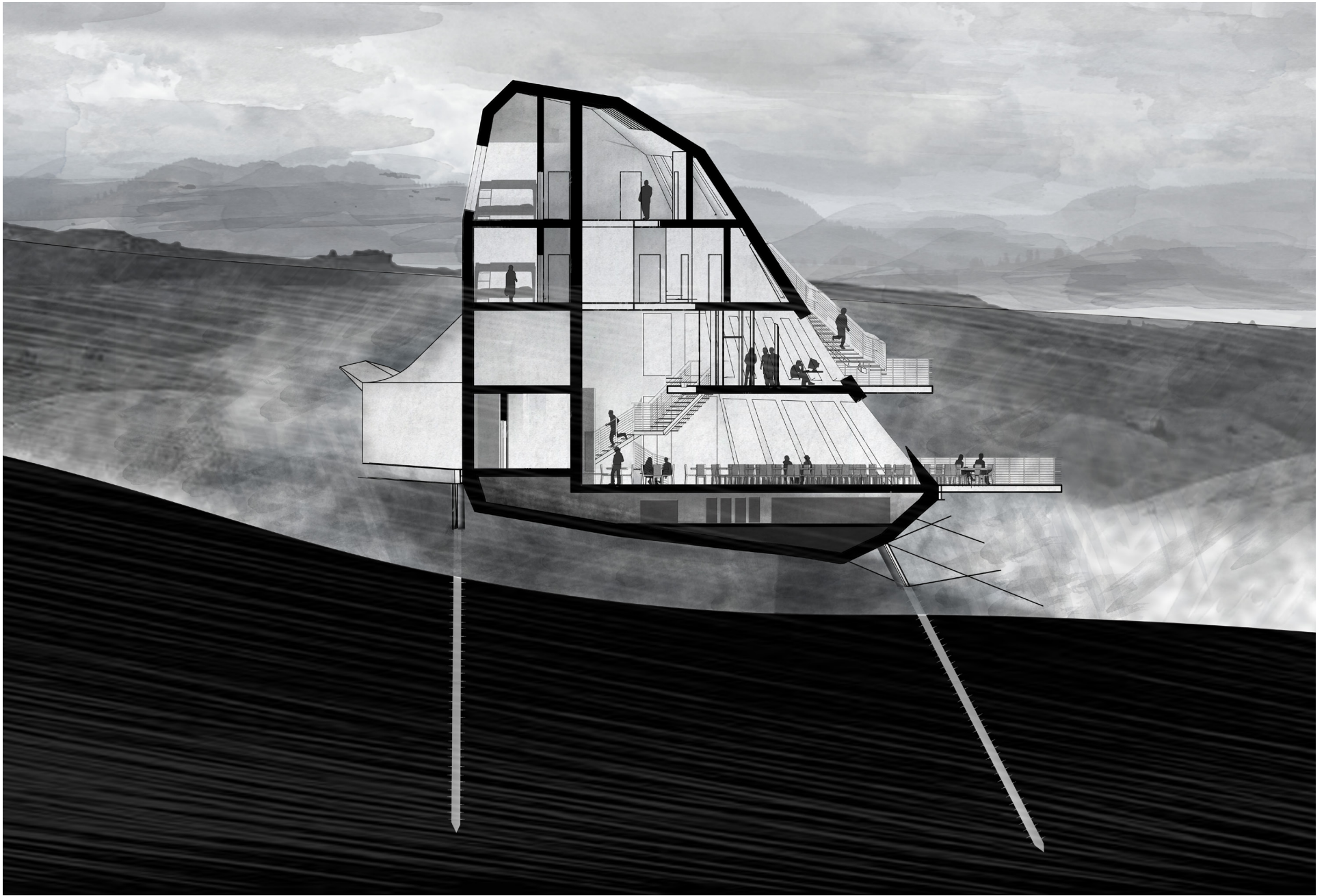


Figure - 94 Close-up of the east-facing Building Section

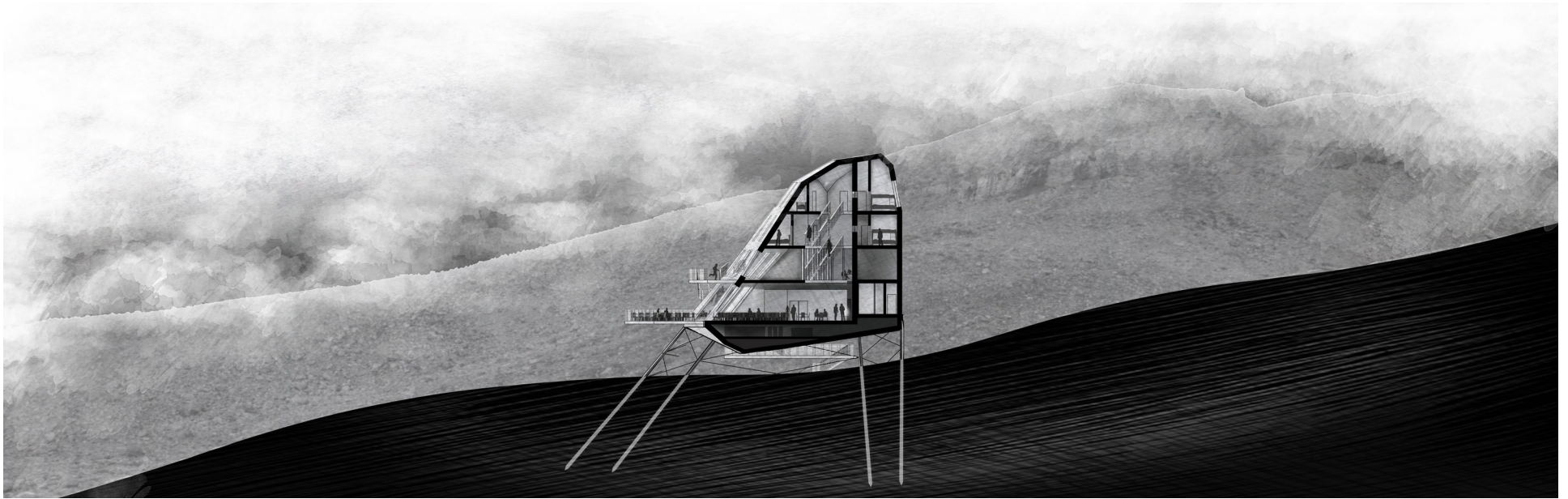


Figure - 95 West-Facing Building Section

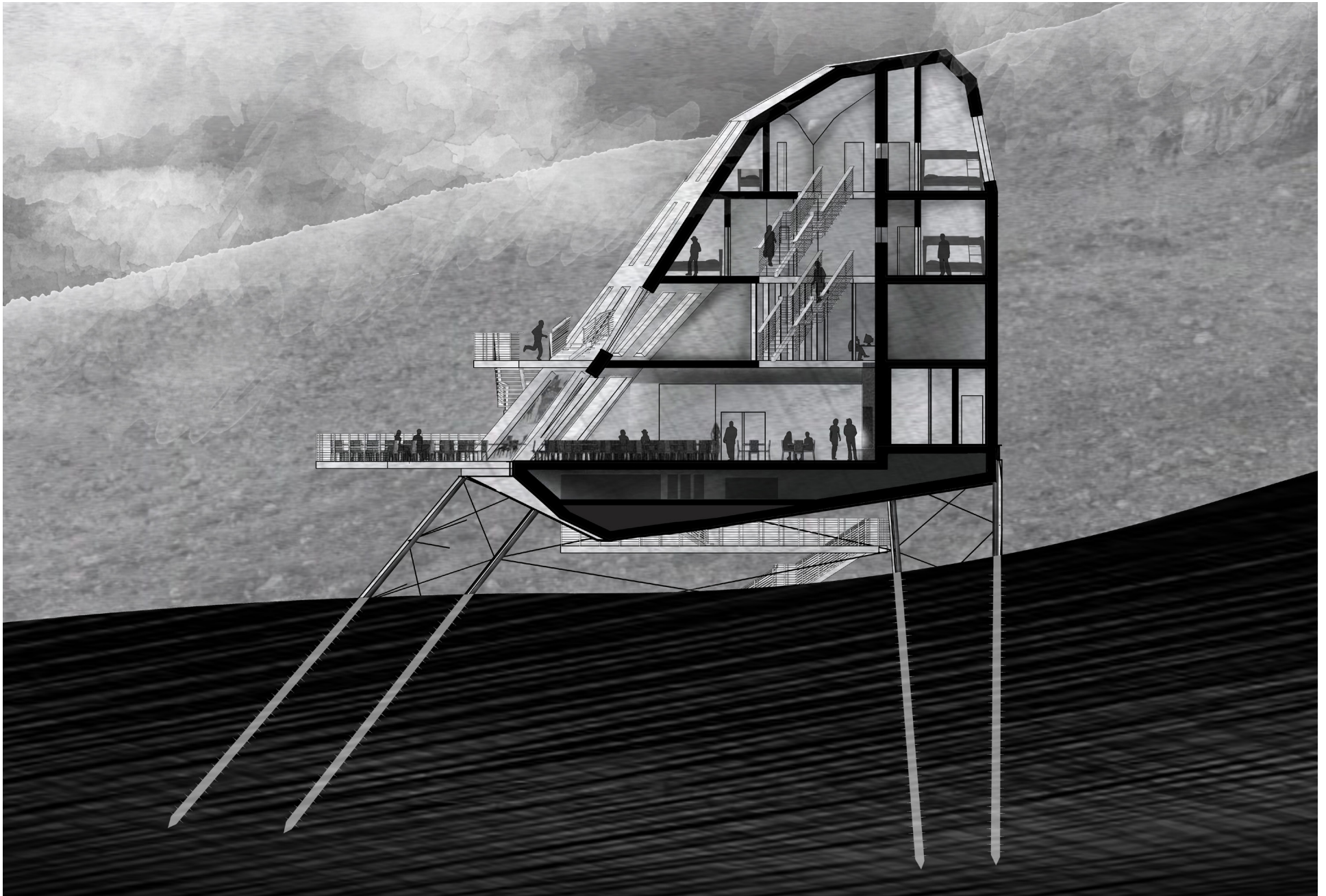


Figure - 96 Close-up of the west-facing Building Section



Figure - 97 South-facing Building Section

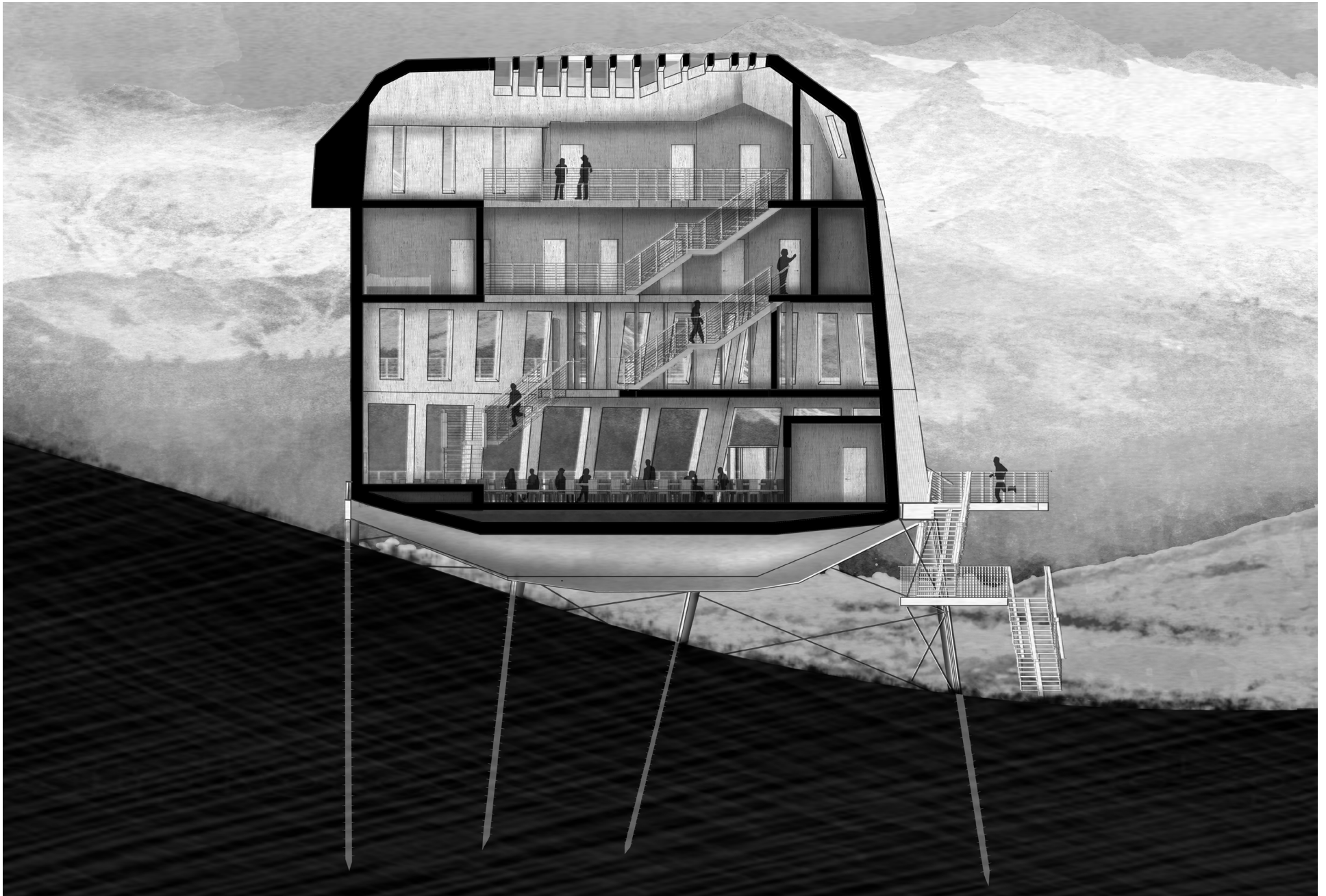
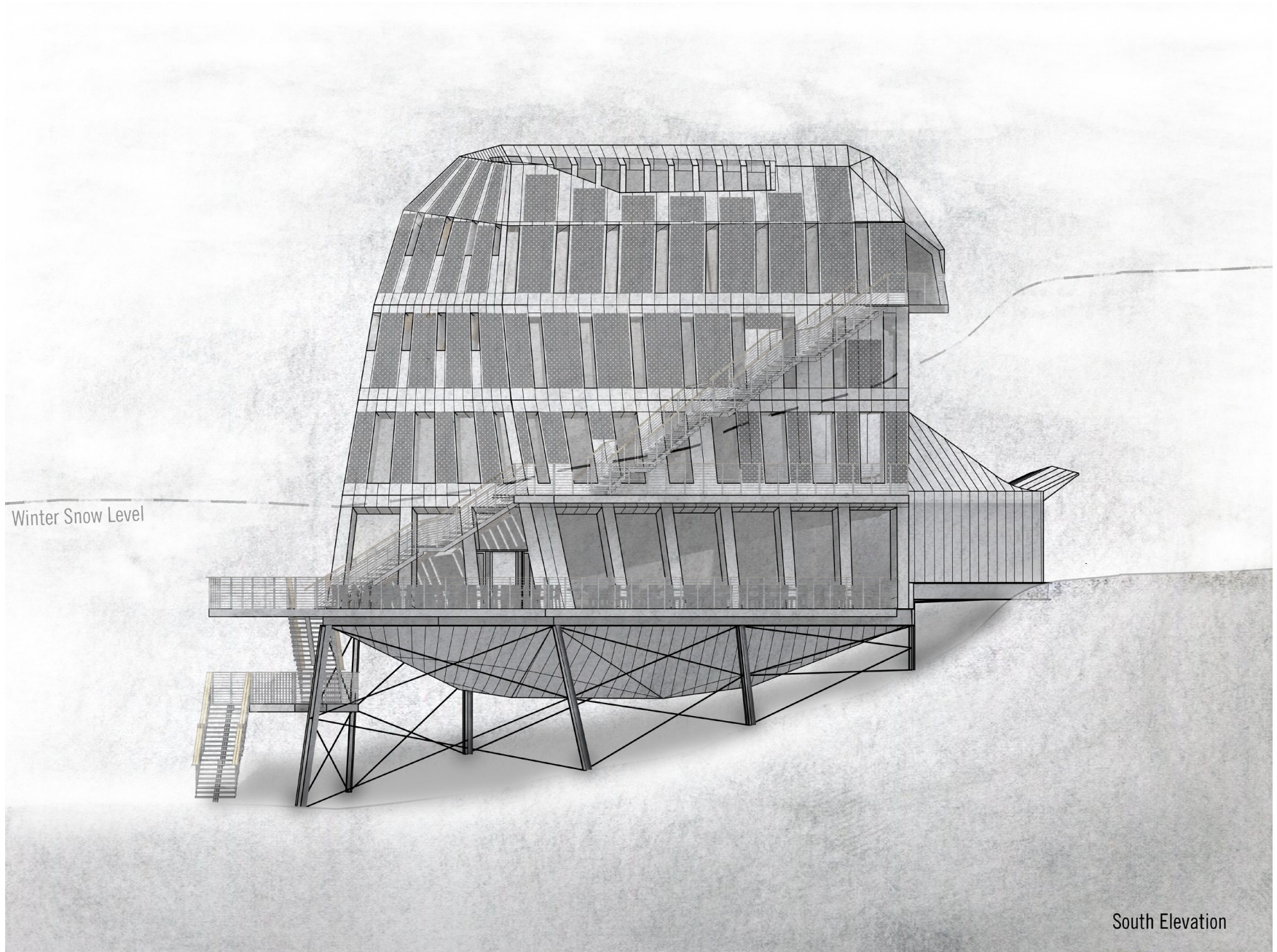
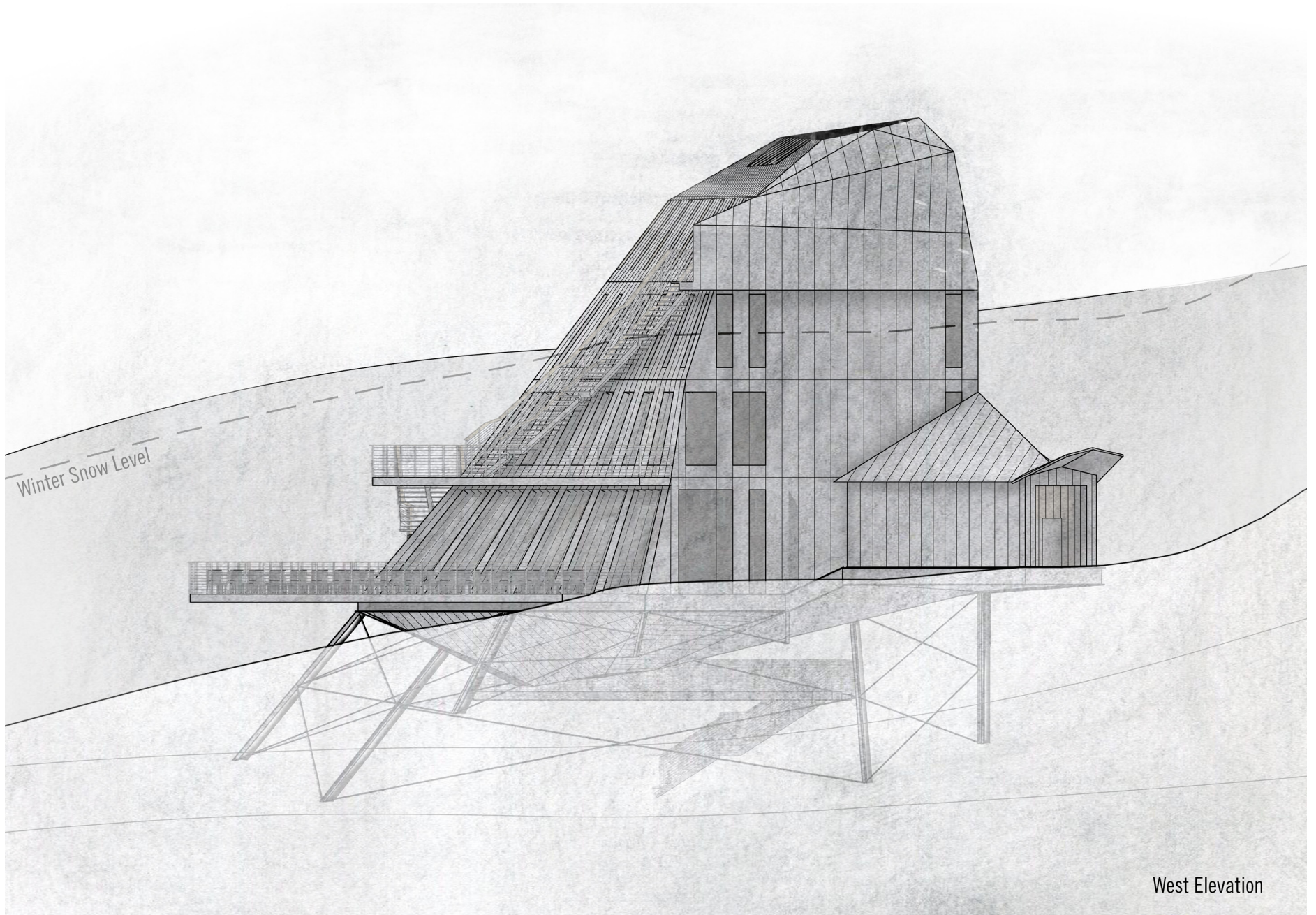


Figure - 98 Close-up of the South-facing Building Section



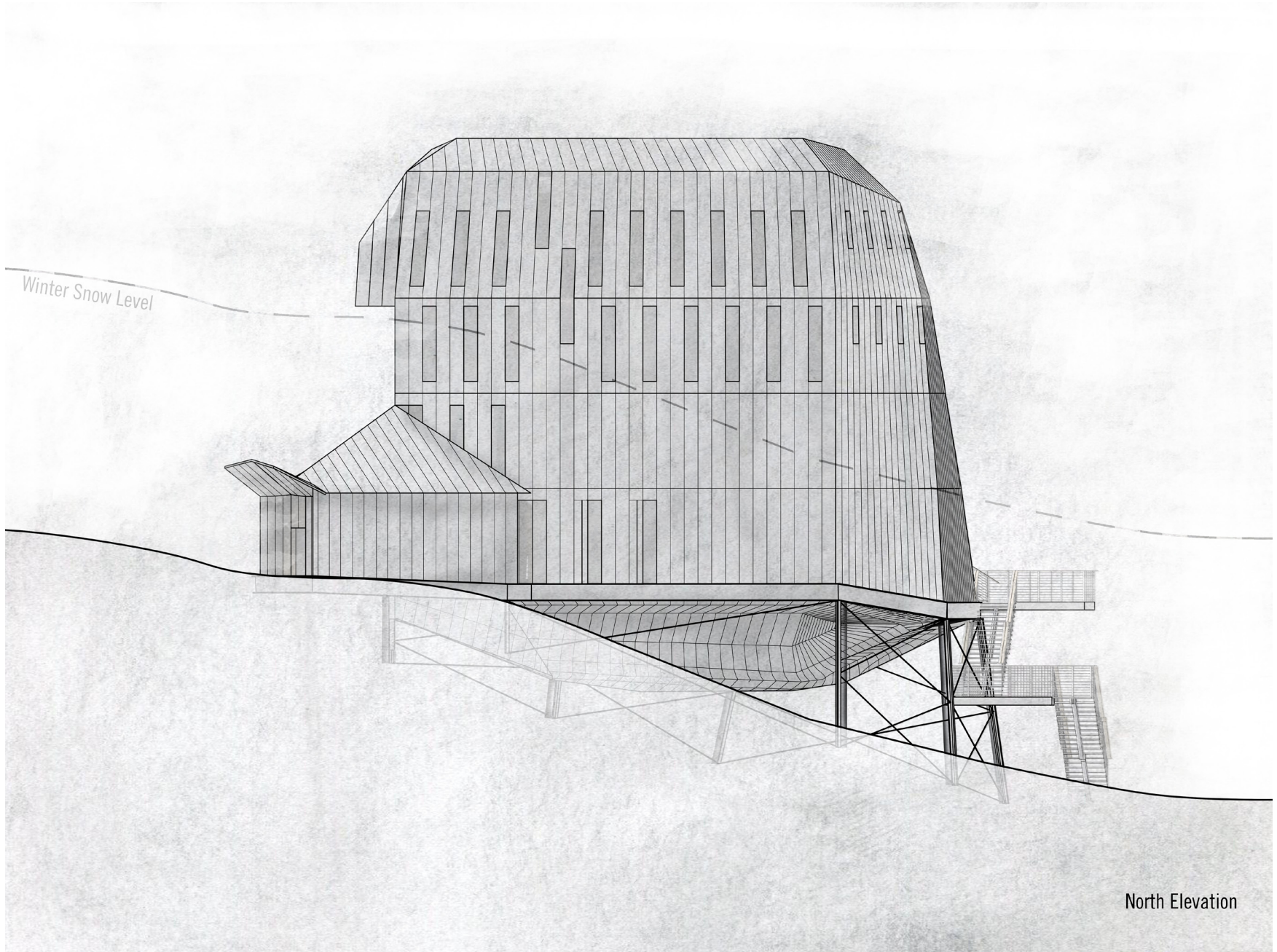
South Elevation

Figure - 99



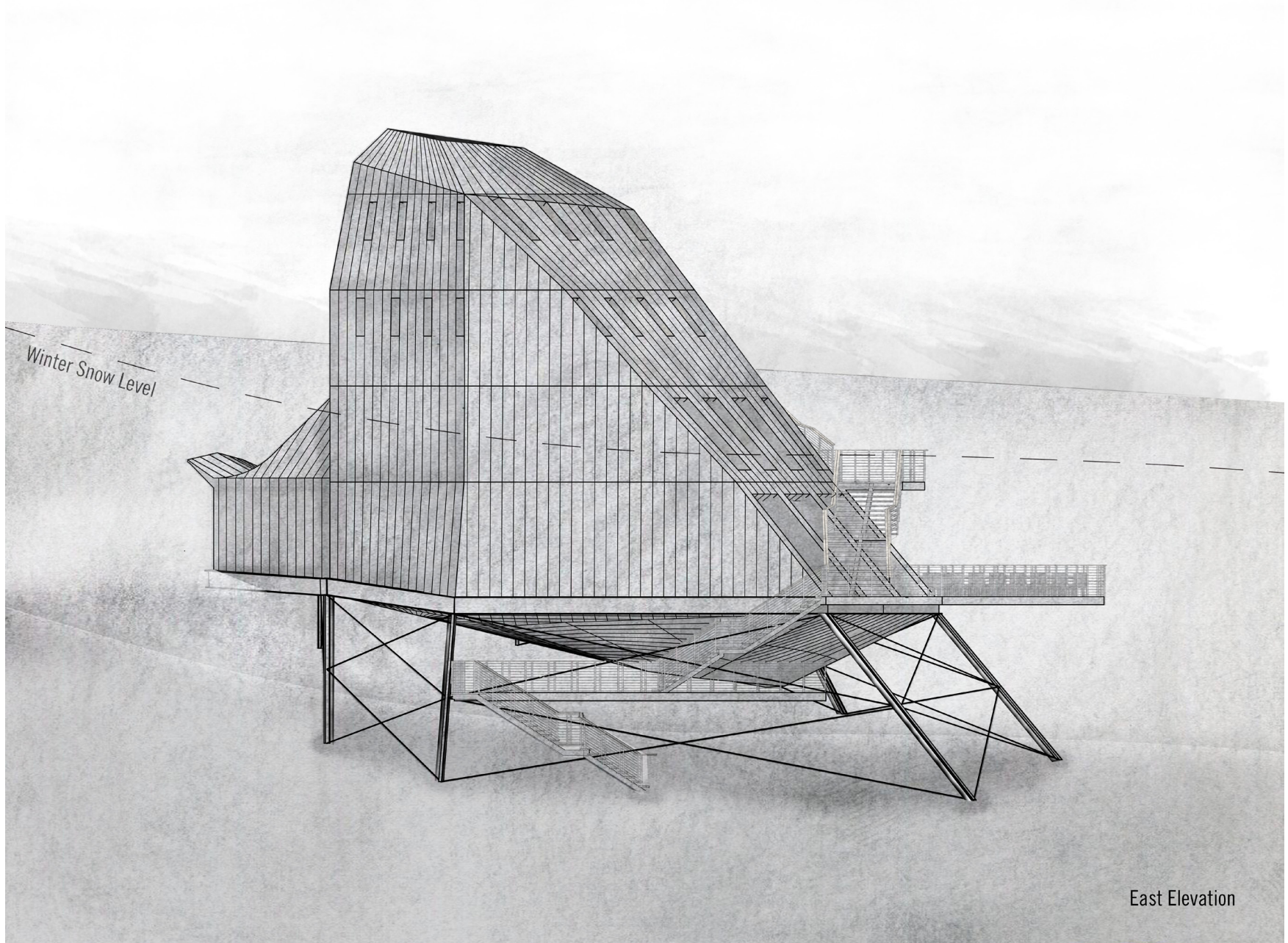
West Elevation

Figure - 100



North Elevation

Figure - 101



East Elevation

Figure - 102



Figure - 103 The view of the Base Camp as it comes into view



Figure - 104 The Base Camp under the anticipated 30-40 feet of snowpack



Figure - 105 The main dining space

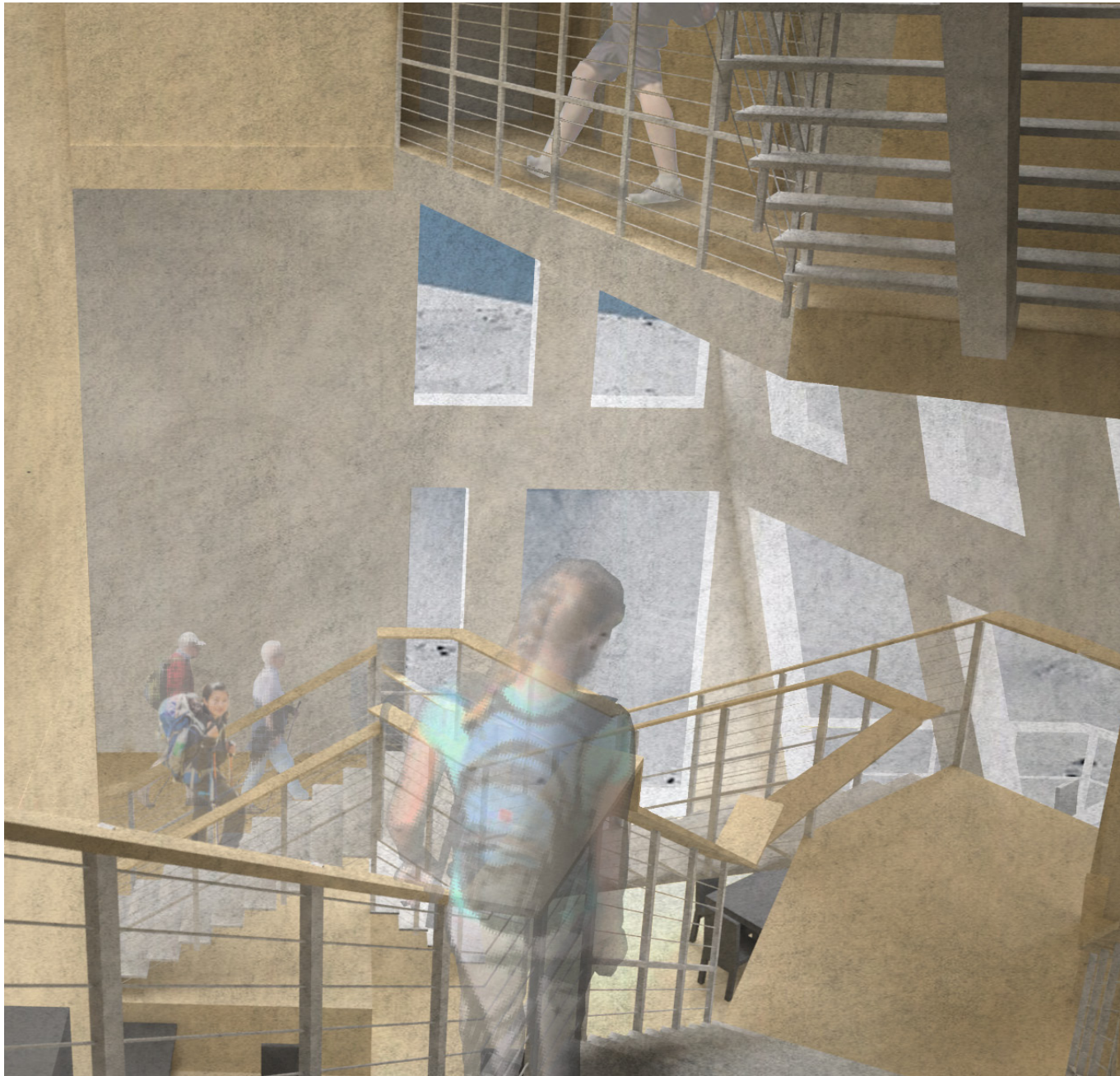


Figure - 106 Looking down the vertical circulation around the light well



Figure - 107 The hallway of the guest lodging

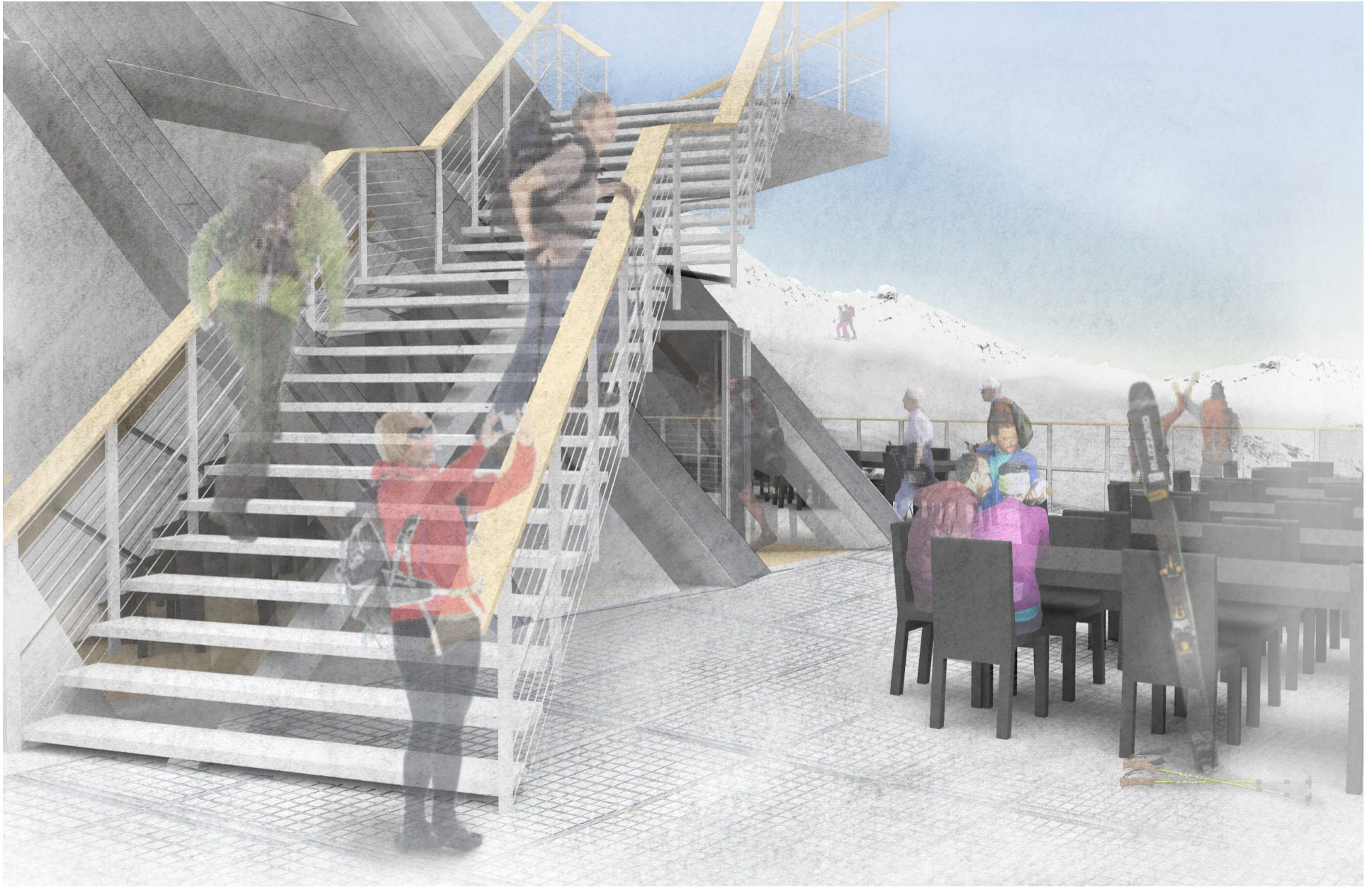


Figure - 108 A view of the outdoor dining and exterior stair

Endnotes:

1. "Northwest Avalanche Center." Northwest Avalanche Center. N.p., n.d. Web. 09 May 2015. <<http://www.nwac.us/about/about-us/>>.



Figure - 109 Exterior rendering looking north towards the summit of Mt. Baker

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BUILDING PERFORMANCE

The design for the Mt. Baker Base Camp came about through the desire to deliver a high quality experience, while maximizing the efficiency of the building performance given its location, climate, and site factors. The experiential elements of the building were discussed in the previous chapter, where as this chapter will take those experiential moments and marry those features to the function of a highly efficient building through aerodynamics, solar, daylighting, tectonics, and building systems.

When considering thermal loss, the optimal building mass is one with the lowest surface area to volume ratio, essentially a sphere. This correlates well with the need for the building form to be high enough for access into the building above the snowpack. Additionally, the building should be aerodynamically shaped to respond to the strong wind loads and the fact that the building is held up off the ground entirely. Next, the south slope of the building façade will be covered in solar panels as the main source of electric energy. The aim of the design for the south façade is to maximize solar gain in the late fall, winter, and early spring months when there aren't as many sun hours in a day, especially at this location's northern latitude. Incident solar radiation on the photovoltaic panels is not the only way to utilize the power of the sun. Thermal gains through south facing windows also help heat the building

in the winter and will need to be avoided in the summer months. Designing to maximize daylight, while minimizing thermal loss through an aperture, helps to decrease the lighting energy loads in the building. This is an important feature for a building that generates it's own electricity.

Furthermore, the tectonics and building envelope should be developed in a way that is consistent with Passive House standards,¹ a common building construction used across Europe and one that is becoming more popular in the United States. The Passive House envelope works in tandem with the HVAC system by warming a space, decreasing the air change rate through the building envelope, and re-utilizing the warm air to heat air supply. All of these systems will be discussed and diagrammed in more detail throughout this chapter.

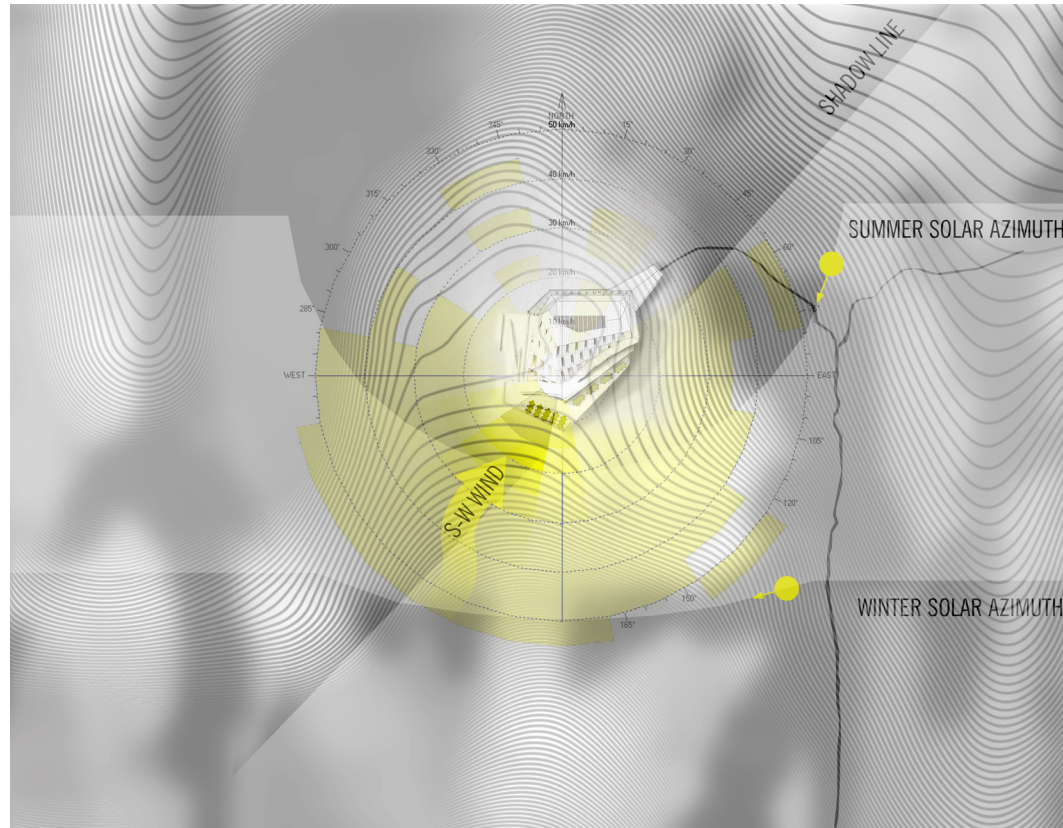


Figure - 110

BUILDING ON SITE

The figure above shows the site analysis diagram with the base camp. It is evident that the form of the building is responding to several unique site patterns, which will be described in further detail throughout this chapter

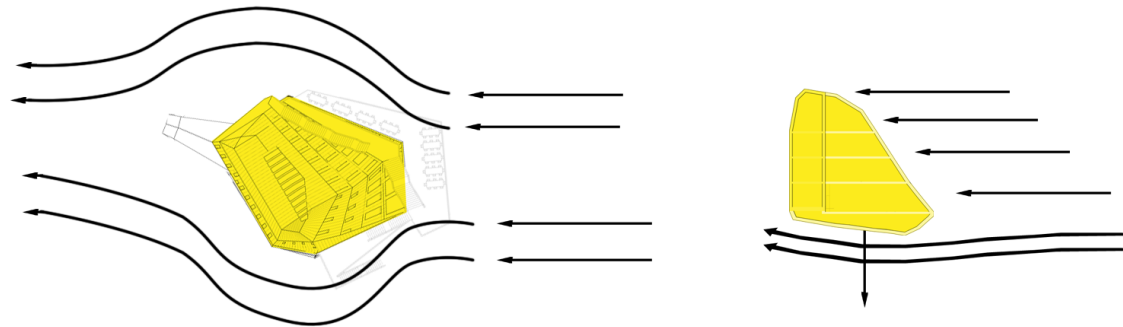
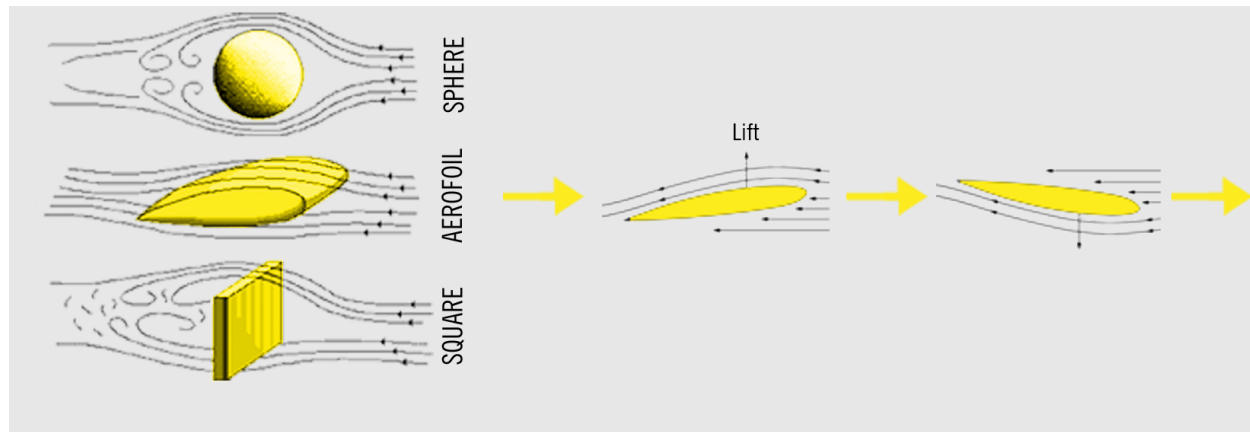


Figure - 111

BUILDING AERODYNAMICS

The decision to lift the building up off the ground has several environmental benefits as was previously detailed in chapter 6. Given the strength of the wind and the consistency of the direction throughout the year (see Figure 70), the building form should respond to the wind patterns in a way that utilizes the force of the wind, instead of reacting against it. This was accomplished by relating the building form to an airplane wing, or aerofoil. An aerofoil's shape creates the least resistance, while also influencing lift. By shaping the nose of the building downward the wind forces will work to push the building into the ground, instead of lifting it off the ground. The building's shape was also streamlined in plan to minimize snowdrift build up and drag.

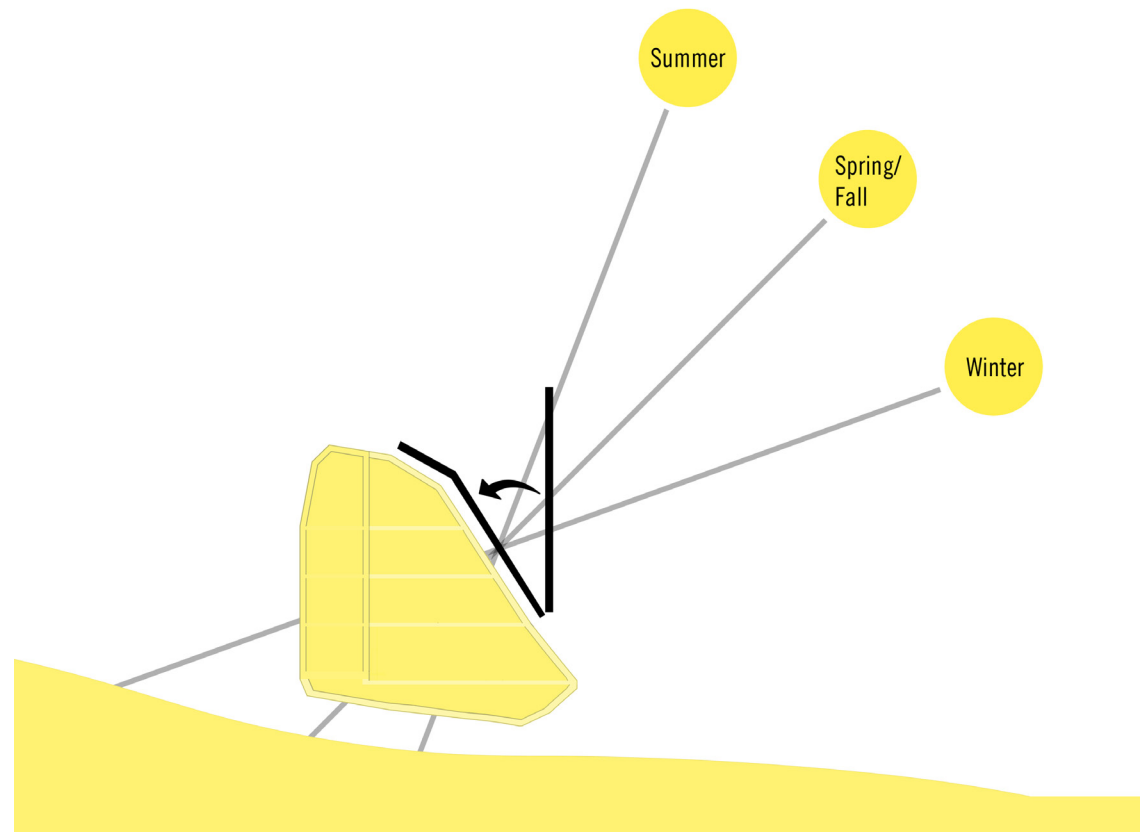


Figure - 112

DESIGNING WITH SOLAR

With the base camp producing its own energy primarily from solar power, there was an opportunity to maximize the efficiency of the panel angles by utilizing the large surface area of the south facing façade for photovoltaic panel placement. Since “the power density will always be at its maximum when the PV module is perpendicular to the sun,”²⁷ the façade of the building was tilted back to maximize the solar gain during the late fall, winter, and early spring months when there is less daylight available, especially in the Pacific Northwest. The panel density is such that there is more energy produced during the summer than would be needed by the base camp, so the designed angle of incidence focused on the rest of the year. This design decision worked in collaboration with the aerodynamics of the building described on the previous page.

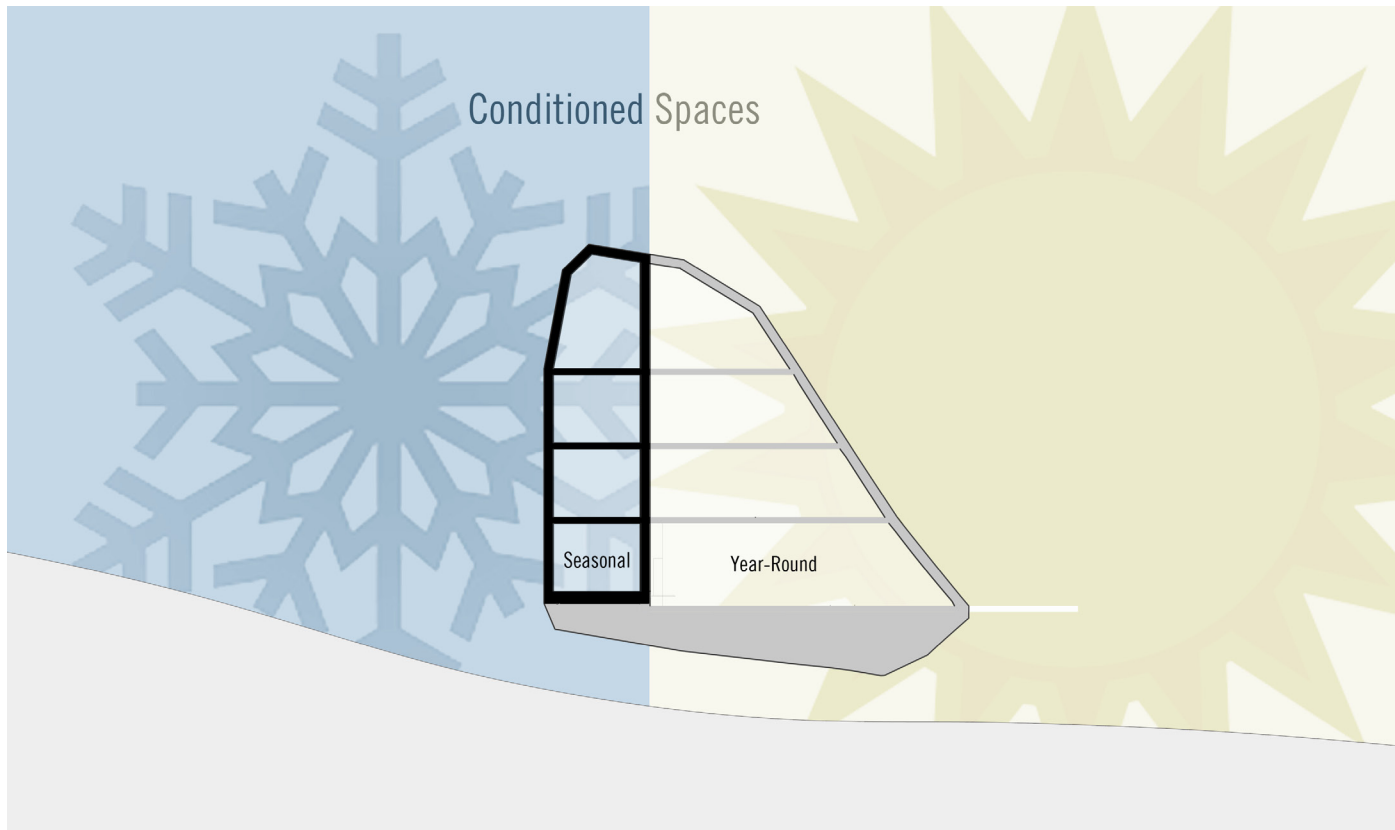


Figure - 113

CONDITIONED SPACES

The figure above illustrates the division in the building between the year-round and seasonal programs. During the off-season, the guest lodging, guest bathrooms, and the second floor services room will be kept at a minimum temperature, but would otherwise be completely shut down, saving energy for the running of the building. This space would also act as additional insulation for the rest of the building. The year-round portion was strategically placed on the south-facing side of the building to take advantage of the solar thermal access and daylighting gains.

DAYLIGHT ANALYSIS

The following pages illustrate a series of daylighting analyses for the base camp. Each view was taken during three different times of the year, July 21st (summer solstice), September 21st (fall equinox), and December 21st (winter solstice), at 12:00pm. The goal of this analysis was to understand the success of the daylighting scheme within the building, and these three dates exemplify the brightest, darkest, and middle-range in terms of available sunlight. To accomplish this, the summer solstice was captured under a sunny sky, the fall equinox under an intermediate sky, and the winter solstice under a cloudy sky. The false color images show the luminance values, measured in candela/m², on a scale of 0-2000 cd/m² (see scale). Figures 114-116 show the dining space looking south from the main entrance. Figures 117-119 views the dining space from the south looking north towards the main entrance. Figures 120-122 show the lightwell taken from the 4th level hallway looking down to the dining space. These are all interior perspective views of various places where the daylighting design was carefully considered to maximize daylight and minimize the need for electric lighting. The following page shows a more holistic view of the daylighting throughout the building by analyzing a transverse (Figures 123-125) and longitudinal (Figures 126-128) section through the building.

The dining hall and circulation areas were the primary areas of focus for the daylighting design analysis because they will have the most frequent use. The dining spaces require enough light for simple tasks such as eating, and light reading (target: 100cd/m² minimum, 2000 cd/m² maximum), where as the circulation areas around the lightwell require even less light, as the primary function is navigation (target: 50 cd/m² minimum, 2000 cd/m² maximum). The summer solstice and fall equinox images show plenty of light for these functions throughout the building, where electric light would not be necessary during this time of the day. In fact, sun shades could possibly be utilized in the summer to minimize solar thermal gain and direct beam light in the dining space. In contrast, the winter solstice images show much lower light levels, however there is still enough light available for simple tasks in each space.

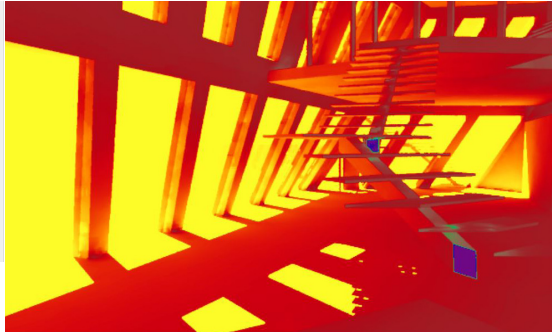
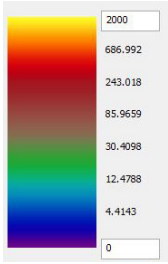


Figure - 114 Summer Solstice, clear, 12:00 pm

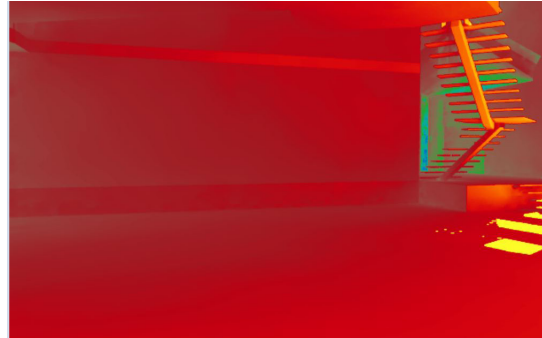


Figure - 117 Summer Solstice, clear, 12:00 pm

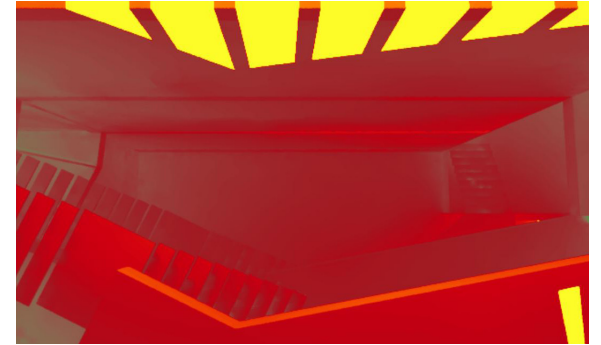


Figure - 120 Summer Solstice, clear, 12:00 pm

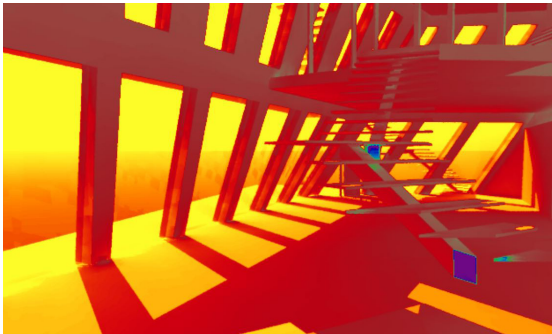


Figure - 115 Fall Equinox, intermediate sky,

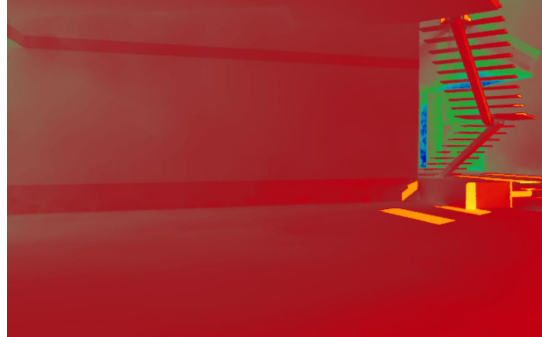


Figure - 118 Fall Equinox, intermediate sky, 12:00pm

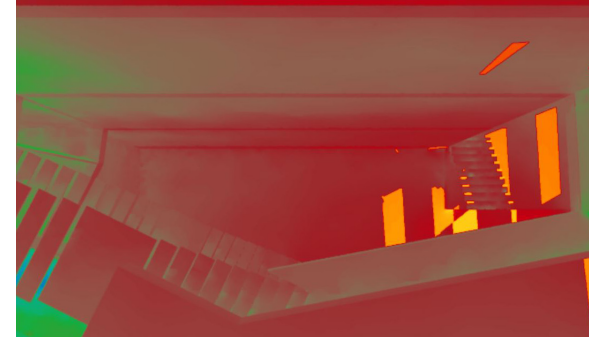


Figure - 121 Fall Equinox, intermediate sky, 12:00pm

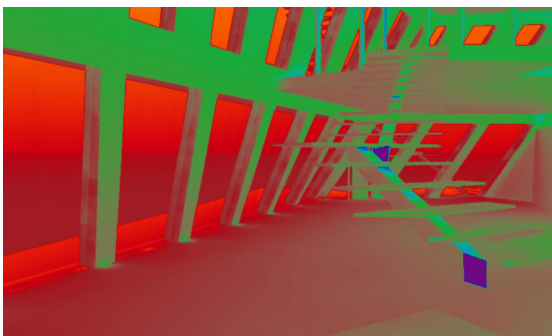


Figure - 116 Winter Solstice, cloudy sky, 12:00

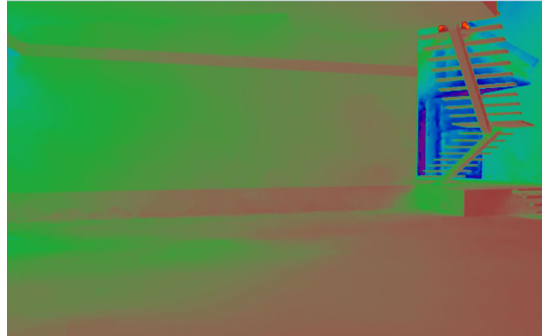


Figure - 119 Winter Solstice, cloudy sky, 12:00 pm

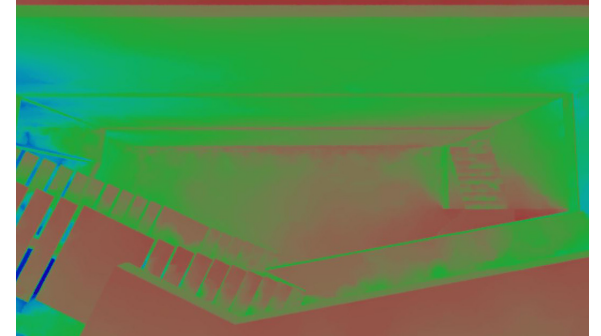


Figure - 122 Winter Solstice, cloudy sky, 12:00 pm

DAYLIGHT ANALYSIS

The minimum target light levels describe the least amount of light necessary to perform the defined tasks successfully, however the maximum range is more difficult to describe. Several factors play into how the human eye interprets light and brightness. For instance, on a sunny summer day, the outside levels would be so high, that even though the inside reaches the target minimum, the contrast is so strong, that the space feels too dark. For this reason, the summer solstice images may appear much brighter than the winter solstice, and possibly too bright, but the contrast to the environmental light is intended to make the user perceive the light as appropriate. To conclude, the daylighting scheme was a success and met its target goals even in the low light of the winter.

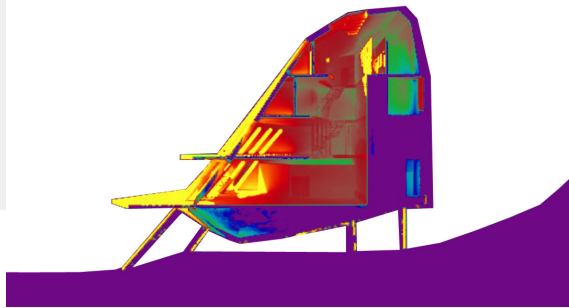
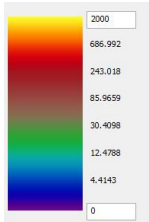


Figure - 123 Summer Solstice, clear, 12:00 pm

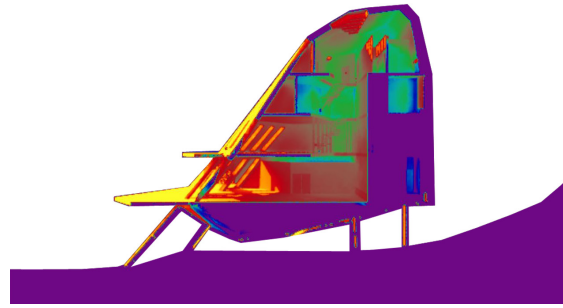


Figure - 124 Fall Equinox, intermediate sky, 12:00pm

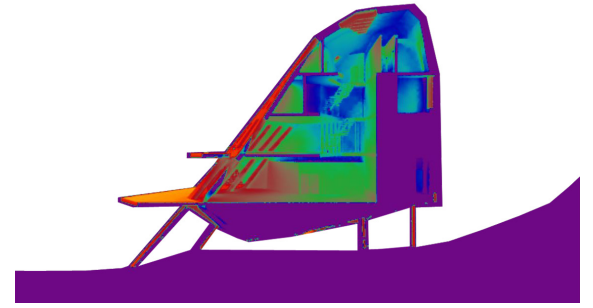


Figure - 125 Winter Solstice, cloudy sky, 12:00 pm



Figure - 126 Summer Solstice, clear, 12:00 pm

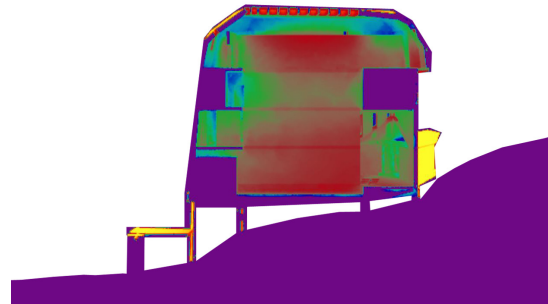


Figure - 127 Fall Equinox, intermediate sky, 12:00pm

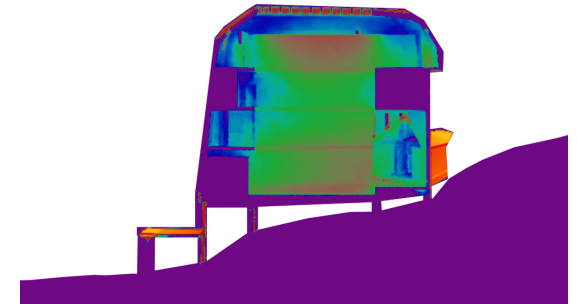


Figure - 128 Winter Solstice, cloudy sky, 12:00 pm

BUILDING TECTONICS

The figure to the right details the building tectonics for the base camp. The building envelope would be constructed to passive house standards with an insulation value of R-80 in the exterior walls and R-85 in the roof and floors. The main structural elements of the building would be comprised of several Cross Laminated Timber (CLT) Panels, manufactured regionally in the Pacific Northwest. The unique manufacturing of CLT allows each panel to be cut at a specific angle allowing for the unique shape of the building. Where possible, the warm color of the pine CLT would be left exposed on the interior. The external cladding system would be comprised of a standing seam zinc metal cladding. Zinc is a prime material for high alpine construction due to its workability at cold temperatures. Additionally, the standing seam panels would allow the metal panels to shrink and expand independently of one another as temperatures fluctuate.

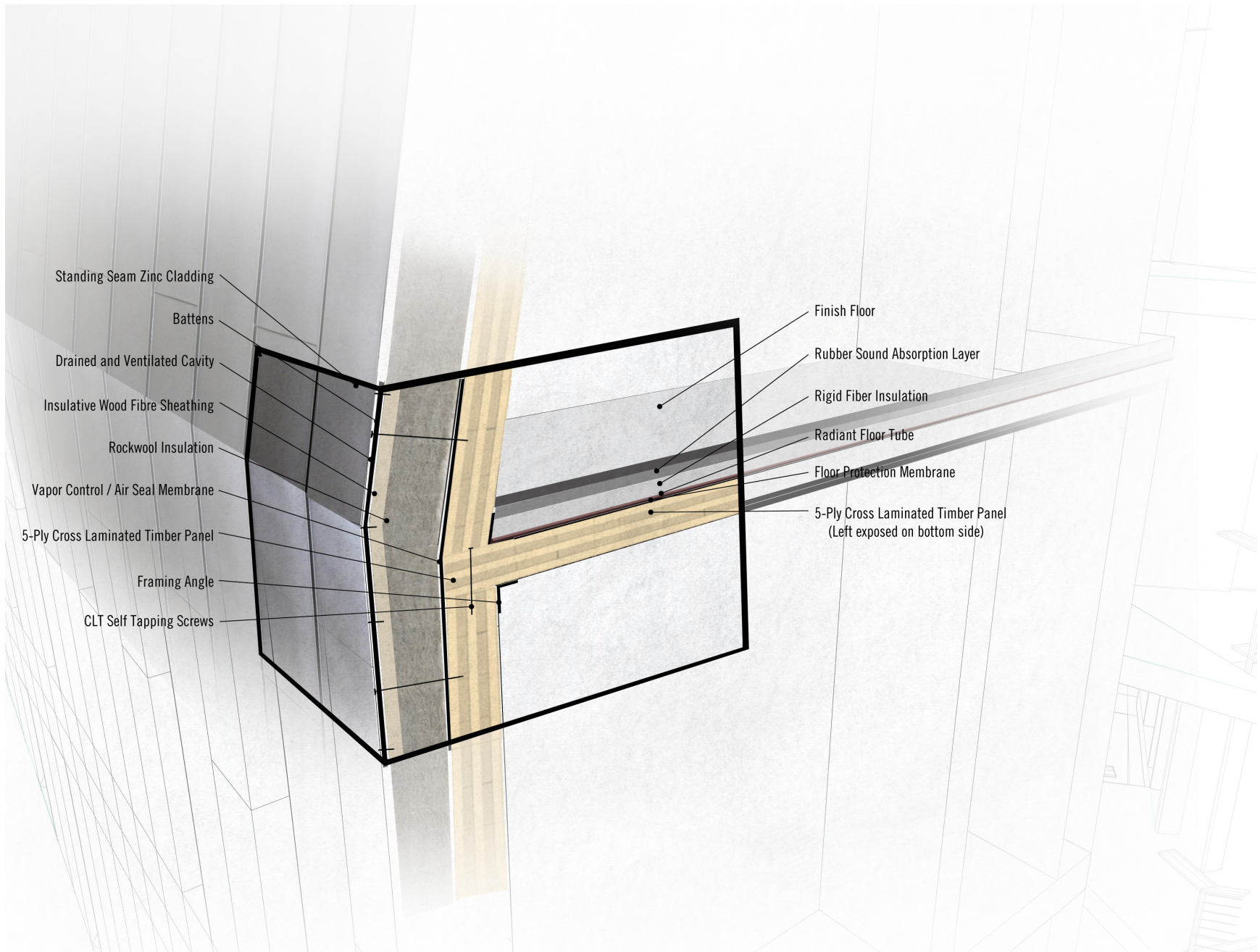


Figure - 129 Tectonic Section

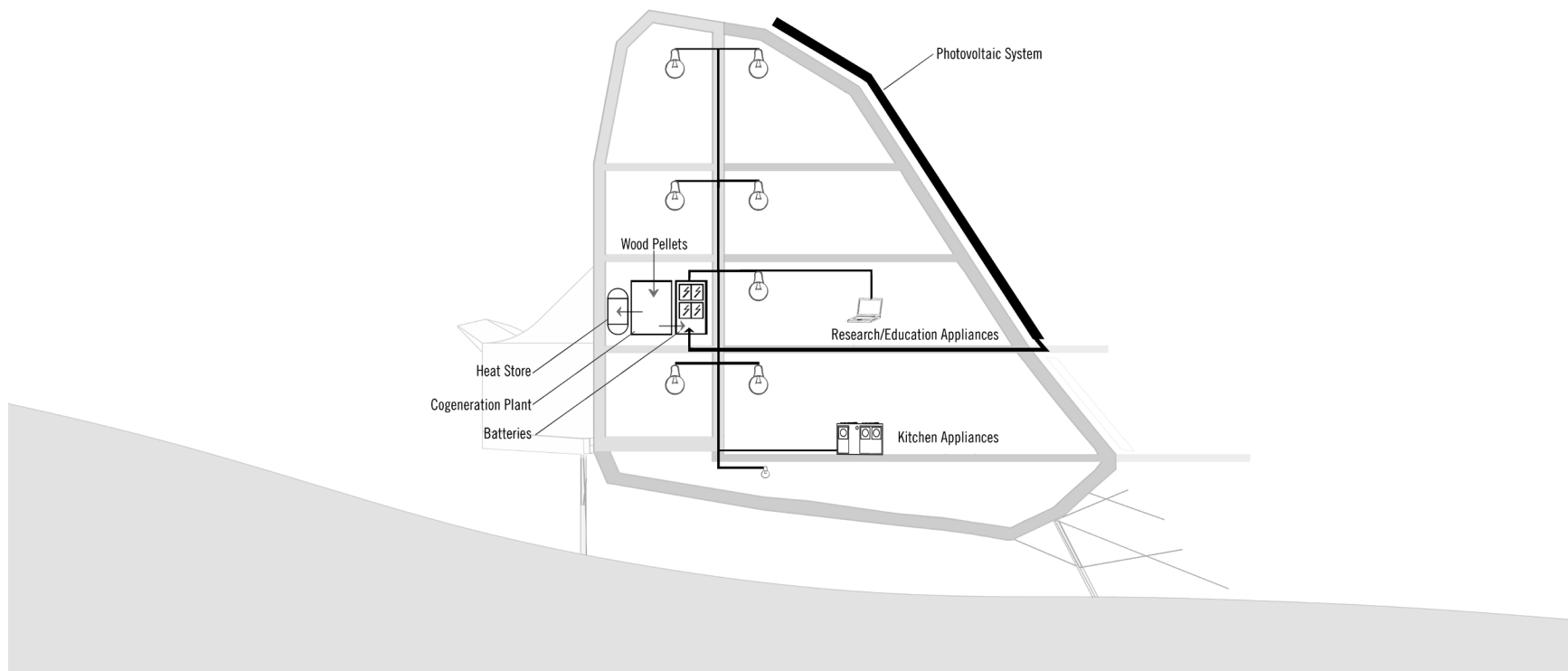


Figure - 130

ELECTRICAL SYSTEMS

The electrical diagram illustrates a fairly straightforward electrical system. The photovoltaic panels on the south façade will generate the bulk of the necessary electricity. This energy will be brought into the systems room on the second level and into batteries that will feed the building's electric currents. When the PV panels are not sufficient, there is a cogenerator run by wood pellets, which would be utilized only to supplement the PV system. The main electric loads for the building are the plug loads, kitchen appliances, and lighting.

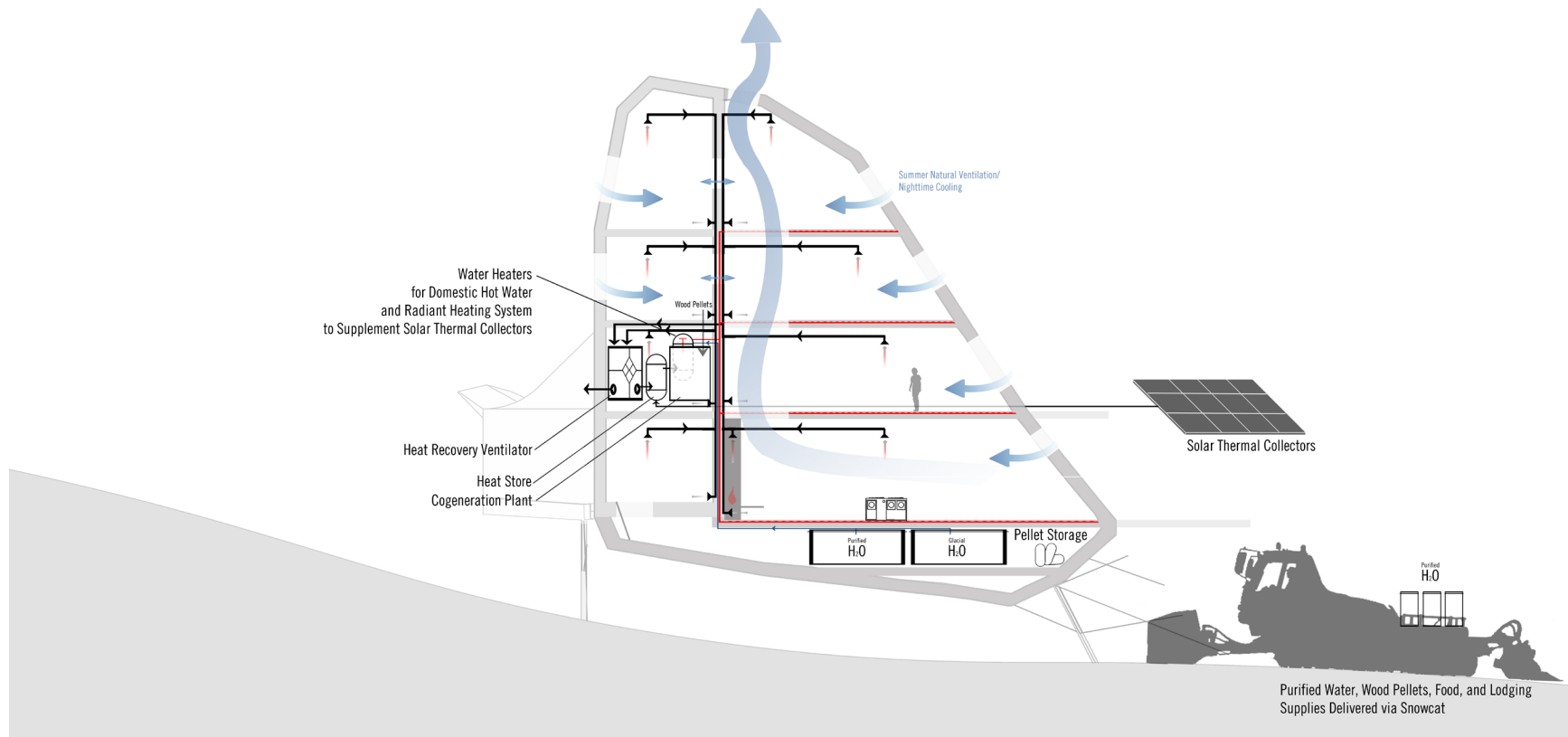


Figure - 131

HVAC SYSTEMS

The primary energy consumption in the hut is space heating during the cold winter months. Heating is delivered using an in-floor radiant heating system, with hot water heated by a biomass co-generation (combined heat and power) plant. This is supplemented by a solar thermal hot water system, which is also tied into the HVAC system. The HVAC system as diagrammed above delivers 100% fresh air while achieving low energy consumption by using a heat recovery ventilation system. This system recycles the warm air in the building and uses the recycled heat to warm the incoming air, effectively reducing the amount of energy needed to warm the freezing outdoor air temperatures. The building utilizes passive cooling via operable windows and a central atrium when necessary, enabling the elimination of mechanical cooling which further minimizes the electric needs. Each window is fully operable and can be opened to allow fresh air in. Opening the skylights in the roof, which helps to passively ventilate the space, creates a stack effect. Additionally, each window will be equipped with a insulating sun shade, which would be deployed at night and when a space isn't in use to prevent thermal loss through the windows.

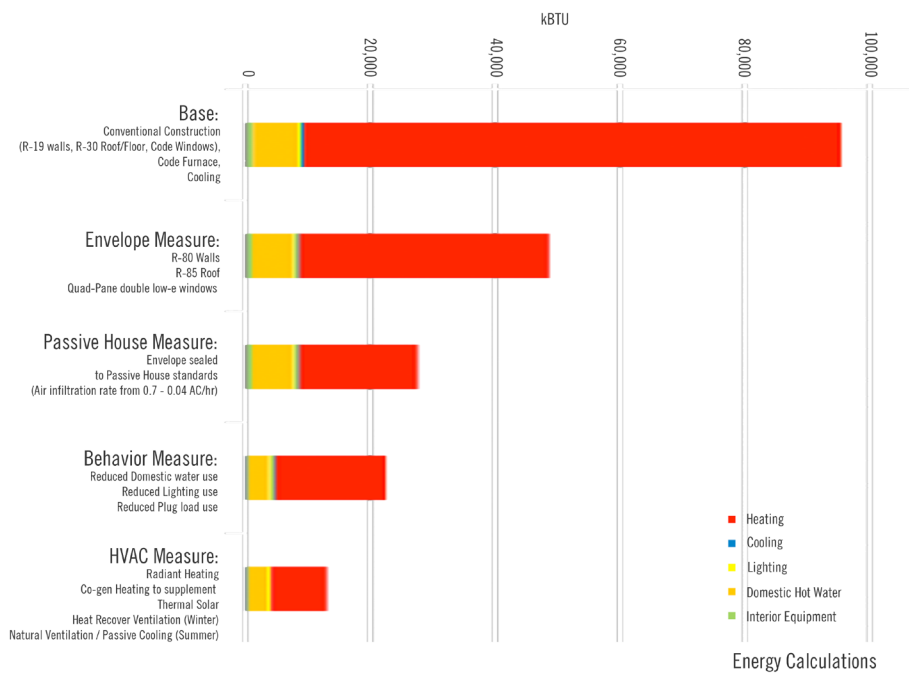
MAXIMIZING ENERGY EFFICIENCY

Table 1 and 2 display the culmination of the system design decisions and how it affects the energy needs and loads for the base camp. A program called Design Builder was used to run several energy efficiency measures starting with a base model, and adding on 4 successive measures to get to the final energy needs and energy use intensity. As was stated previously in the document, there isn't a weather station on Mt. Baker, so a different location with a similar climate, elevation, and proximity to the ocean was chosen. This location was Talkeetna, Alaska. Table 1 charts the energy end uses in kBTU and is divided between heating, cooling, lighting, domestic hot water, and interior equipment. Table 2 shows the Energy Use Intensity (EUI) for the building in kBTU/sf-yr.

The five energy efficiency models are as follows: The base model consisted of conventional wood-frame construction with R-19 walls, R-30 Roof, code windows, code furnace, and a cooling system as the only source of cooling (ie, no passive cooling). The next measure was to improve the envelope by increasing the insulation of the exterior walls to R-80, roof to R-85, and changing the code windows to quad-pane double low-e windows. This first measure created the most dramatic drop of energy needs in both charts, particularly the heating load in Table 1. The third measure was to seal the building to meet Passive House standards, meaning

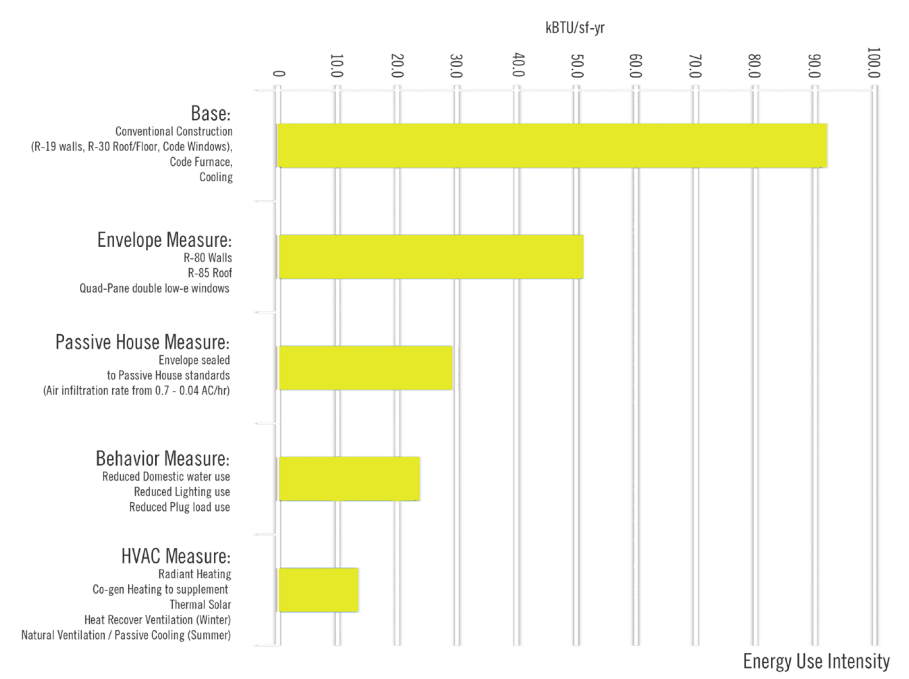
changing the air change per hour (ac/h), or infiltration rate, from 0.7 ac/h to .04 ac/h. Again, this heavily influenced the heating loads in Table 1. The fourth measure was the behavior measure. Since this is a base camp and research facility, its users will be expected to take shorter showers requiring less domestic hot water, reduce lighting uses with more efficient lighting and an effective daylighting design, and lastly reduce the plug load for personal electronics. In this measure, the heating load changed minimally, but the lighting, domestic hot water, and interior equipment were all decreased. The final measure was the HVAC measure. This measure included the use of radiant heating, a heat recovery ventilator (for the winter), and also eliminated a cooling load by utilizing natural ventilation and passive cooling (for the summer months). This final step shows another drastic decrease in the heating load, with the cooling load entirely eliminated. It is important to remember that each of these measures are building on top of each other, not a reflection of the individual measure over the base. Overall, the EUI decreased from 91.7 kBTU/sf-yr to 13.4 kBTU/sf-yr, a total of 15% of the base model's energy needs.

Table 1



Energy Calculations

Table 2



Energy Use Intensity

Endnotes:

1. "What Is Passive Building?: Passive House Institute U.S." What Is Passive Building?: Passive House Institute U.S. N.p., n.d. Web. 1 Oct. 2015. <<http://www.phius.org/what-is-passive-building->>.

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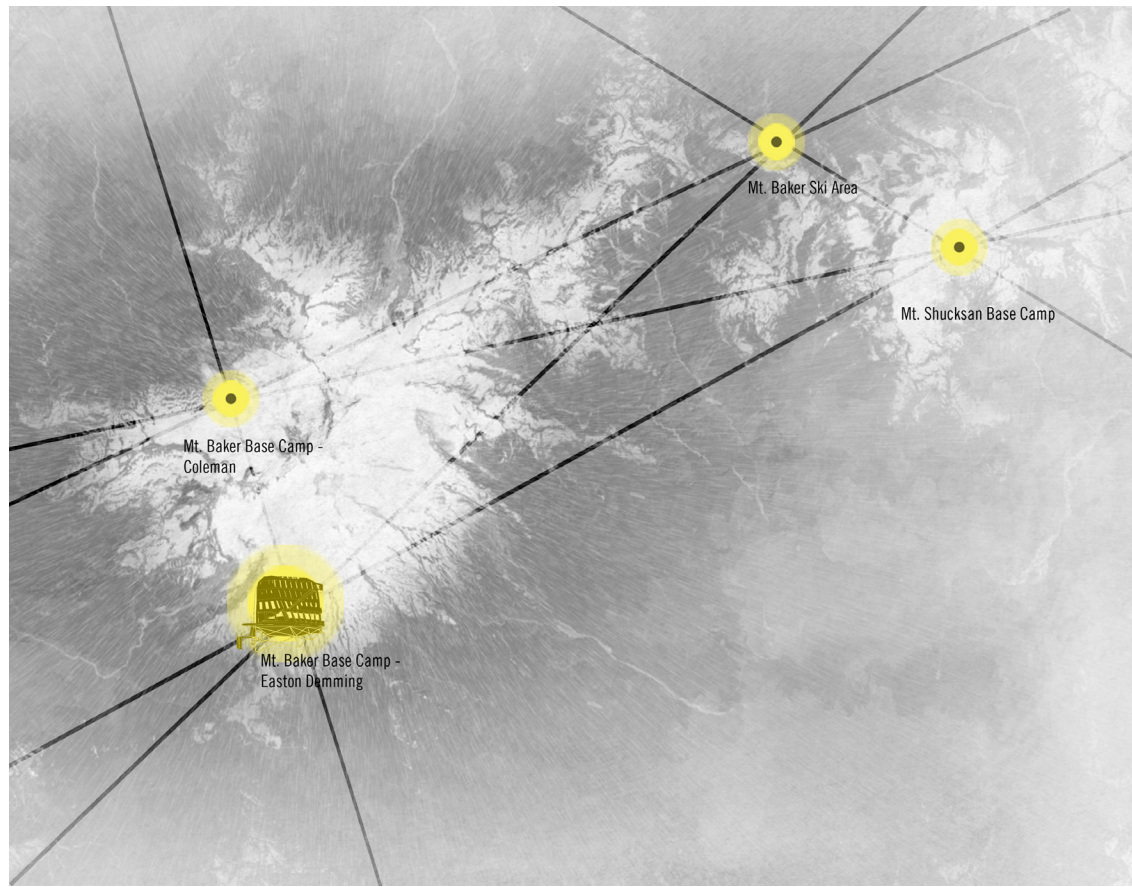


Figure - 132

REGIONAL NETWORKS

One of the reasons the mountain hut philosophy works so well in Europe is because of the established network throughout the Alps. Granted some are in remote locations, but several of the European mountain huts are arranged as a network where hikers can travel from one hut to the next. What would this network look like in the U.S.? Washington State for instance, does not have the same level of mountain development found in Colorado, so a mountain hut network could begin to connect these isolated nodes. The Mt. Baker Base Camp on the Easton Damming route, would easily connect to the Mt. Baker Ski Area, which could in turn create a connection to the nearby Mt. Shuksan.



Figure - 133

NATIONAL NETWORKS

Expanding the scope further to the entire U.S., the mountain hut networks could be implemented in the Cascade Range, Sierra Nevada, Rocky Mountains, Appalachians, and up into Canada and Alaska. Given the size of the U.S., each range could develop its own alpine club to strategically place mountain huts where they would be the most effective, without overdeveloping



Figure - 134 Hikers watching the sunset from the west ridge above the site

CONCLUSION

This thesis addressed the design of a very specific building typology and its adaptation from a European standard to one appropriate for the United States. Starting with the definition of a mountain hut and precedent examples across the European Alps, a building program was developed to create a similar experience on Mt. Baker. The implementation of the building typology into its environment was fulfilled based on the combination of an understanding of the American attitude towards nature with a thorough site analysis. Determined to be a nearly self-sufficient building, this thesis also focused heavily on sustainable systems and design to discern how the building would function, as well as how effectively these goals were met.

This thesis utilized an examination of the American attitude towards nature for the design of the Mt. Baker Base Camp and Research Facility as the first of its kind in its region. Further development of this thesis would formulate a strategy for creating a network across the United States. This would include an examination of the potential environmental drawbacks and opposition in order to develop a network with the same sensitivity to the American people as was considered for the single building typology.

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