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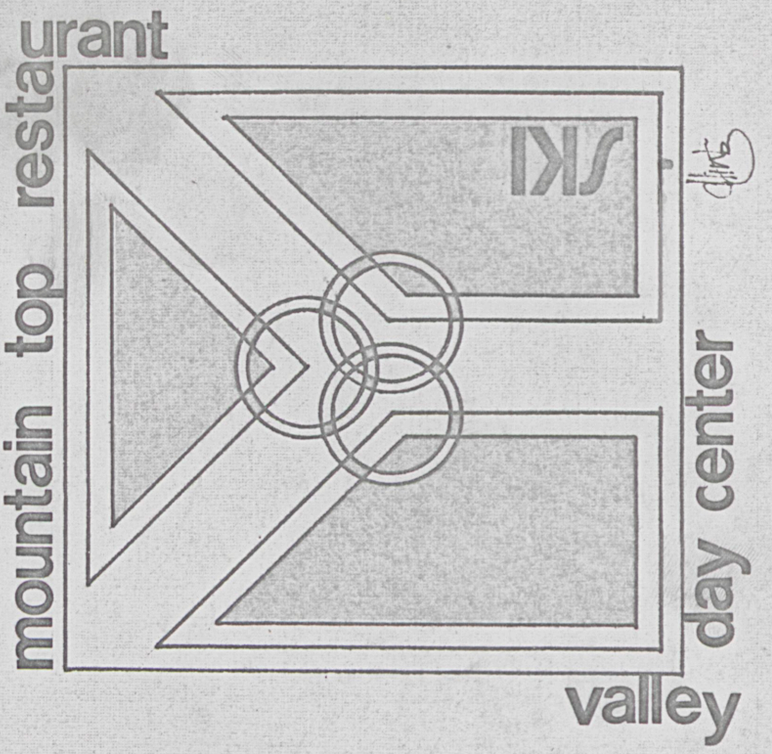

mountain top restaurant
SKI
day center
valley

Bound By AMERICAN BINDERY, TOPEKA, KS. – Date_____

A

Mountain Top Restaurant

and

Valley Commercial Day Center

Submitted to the School of Architecture

As Partial Fulfillment of the Requirements

For the Degree of

Bachelor of Architecture

at

Montana State University

Bozeman, Montana

Undergraduate Thesis in Architecture

by

David R. Lintz

June 1975

TABLE OF CONTENTS

DEDICATION iii

ACKNOWLEDGEMENTS iv

SPECIAL THANKS iv

ABSTRACT vi

THESIS STATEMENT vii

INTRODUCTION xii

PROJECT xv

RESEARCH . . . . .

CULTURAL FORCES 1

ENVIRONMENTAL FORCES 5

TOWARDS A NEW BUILDING ECONOMY 10

ANALYSIS AND SYNTHESIS . . . . .

ANALYSIS AND SYNTHESIS 15

WEATHER 34

PRODUCT SYNTHESIS 63

PROGRAM 80

DESIGN 116

. . . . .

BIBLIOGRAPHY 137

Oversize
P378
.L6588

This thesis is dedicated to

Sandra Thiesen Lintz

and

Muri

a symbol of something we

didn't really ever have.

ACKNOWLEDGEMENTS

Dr. Ifan Payne my advisor, for his patience and invaluable guidance.

Mr. Dave Wessel, for unexpected support.

Mr. Walt Nixon, for economic consultation.

The faculty of the School of Architecture.

My friends and colleagues.

Mr. James Barnes.

Mr. Mark Gelernter.

SPECIAL THANKS

Miss Gail Schultz, whose affection helped me maintain a measure of sanity.

ABSTRACT

ABSTRACT

Thesis Statement:

Architecture should satisfy its users' needs through the designer's special consideration of the unique character of micro environmental variables using energy conserving principles.

Conclusions:

The relationship between architectural variables and micro environmental variables led to the key point that energy conserving principles are a result of the interaction between the two variables.

Project Description:

The project consisted of a mountain top restaurant and a commercial day center in the valley of the ski development, Ski Yellowstone at Hebgen Lake. The two buildings were used to show how architectural variables will respond according to micro environmental changes.

THESIS STATEMENT

THESIS STATEMENT:

Architecture should satisfy its users needs through the designer's special consideration of the unique character of micro-environmental variables using energy conserving principles.

Inception:

At the outset of the thesis programming quarter, my principle interests in architecture lay with the ideas of methodology and indigeneous architecture (that which man built for himself with his own hands and ideas using native materials and technology). Having previously completed a quarter concerning itself primarily with methodology with special emphasis on a method for conceptualizing,my thesis thrust began moving toward an understanding of the relationship between indigeneous (vernacular) architecture and current technology.

Two examples of this interaction that come to mind are: 1. Some indigeneous architecture used steeply sloping roofs to shed precipitation while also using the structural characteristics of the triangle for support of the roof structure. However, today's technology allows us the use of prefabricated steel trusses which similarly use the triangles inherent structural capabilities but in such a manner so as to give us flat roofs and as a result yield a more efficient use of building space.

2. Again some vernacular architecture used sod on the roof to provide insulation for the structure as well as weight to the walls to help seal cracks in the log connections, yet today's technology provides us with the opportunity to use commercial fiber blanket insulation which can provide the same insulative qualities using much much less quantity.

One of the major considerations that must be made is the fact that the production of steel for trusses and fiberglass for batt insulation have a cost to society that previously sloping wood trusses and sod insulation did not have. The question arises, then, "How does one decide which material or structural system to use?" (To name only two of the myriad of choices to be made in an architectural solution to a building problem)

Going beyond functional or aesthetic reasons for the choice of materials the subject of economics always seems to have some voice in the decision. A discussion of the economics of choice in this context is found in the portion of this thesis entitled "Towards a New Building Economy."

Original Inclination:

My original inclination for a thesis statement came about as a result of a compromise between vernacular architecture and current technology and is as follows:

"How can we use technology to
our indigeneous advantage?"

At this point the idea of regionality had an influence on my first thesis inclination and modified it as follows:

"Architecture must find a compromise
between technology and vernacular to
develop a regional architecture for Montana today."

It seemed the reason architecture should develop regionality was so that its buildings fit and operate efficiently with its surroundings, climatologically, environmentally, visually, and for conservation of energy.

First Statement:

The above discussion led me to my first statement which follows:

"Architecture should seek regional
character. . .in its use of materials,
building configuration and orientation
in order that its building may operate
harmoniously with its environment."

An examination of "harmoniously with its environment" leads to the following seven points:

1. So that the building or by-products do not adversely affect its environment.
2. So that environment may be used to the building's advantage.
3. So that its users may reach their full potential and its nonusers are unimposed.
4. So that construction observes rules of natural preservation.
5. So that materials consumed can be replenished and not merely stolen from the earth (conservation).
6. So that production or preparation of materials used produces little or no effluents.
7. So that transportation of materials does not unnecessarily expend energy.

Two Points:

This point in my research led me to House Form and Culture by Amos Rapoport. This work and others eventually pointed to two key turning points in my evolution of my thesis statement as it remains. These two points are as follows:

1. Two different cultures, given the same physical parameters and characteristics will produce two different forms.

2. Indigeneous architecture is a result of the consideration of the immediate situation and the physical and cultural principles involved at that time and place.

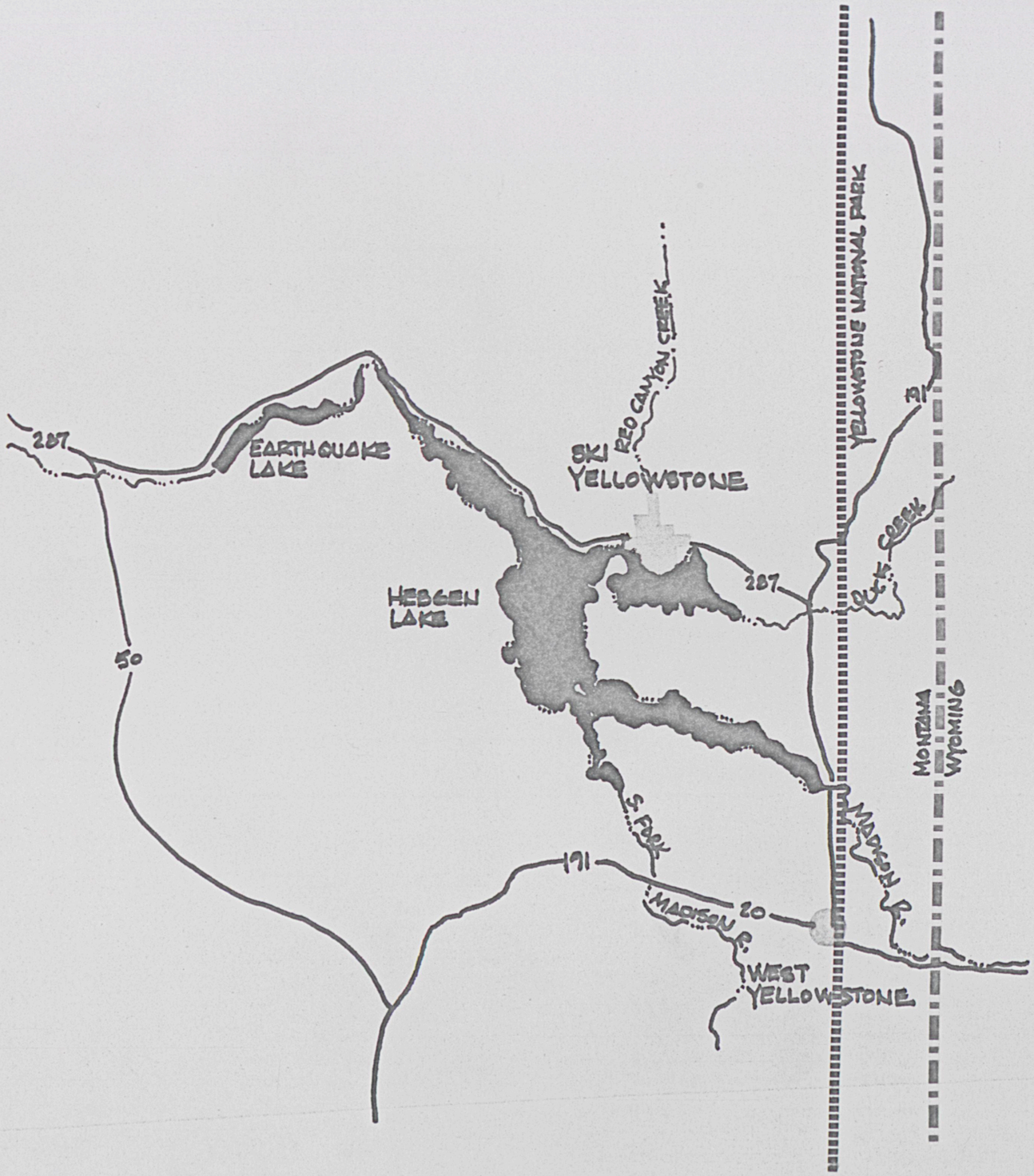
Definition:

Architecture (as it should be known) should satisfy its user's needs (cultural, economic, utilitarian, psychological, social) through the designer's special consideration (an in-depth study, far removed from a fashionable tokenism glance) of the unique character (each site and circumstance of construction) of the micro (at a scale of the immediate site, the context of macro meaning a much larger pattern) environmental variables (climate: air movement, precipitation, solar radiation, etc.; topography: geology, limnology, vegetation, wildlife, etc.; amenities: view, access, etc.) using energy conserving principles (transportation costs, building configuration, natural lighting and ventilation, comfort tolerances, etc.).

Project Choice:

The four seasons destination resort, Ski Yellowstone, was chosen as a vehicle to test this thesis because of its proximity, its nature, a year around ski resort with a variety of building types, and the environmental information available. Ski Yellowstone, having an environmental impact study and preliminary development plan previously completed, allowed me to address my problem with a minimum of extraneous site information and history gathering.

My thesis does not, therefore, question Ski Yellowstone or the topic of new Montana ski developments nor does it question the building types, number, size, or location of such buildings involved with Ski Yellowstone, but merely uses the mountain top restaurant and valley commercial center as a vehicle to test my thesis statement.



vicinity map n

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HEBGEN DAM QUADRANGLE
MONTANA–IDAHO
15 MINUTE SERIES (TOPOGRAPHIC)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEPEE CREEK QUADRANGLE
MONTANA–WYOMING
15 MINUTE SERIES (TOPOGRAPHIC)

Stereo compilation by Fairchild Aerial Surveys, Inc
for the Bureau of Reclamation
Field examination and publication by the Geological Survey
as part of the Department of the Interior program
for the development of the Missouri River Basin

Control by USGS and USC&GS

Topography from aerial photographs by stereoplanigraph methods 1948. Aerial photographs taken 1947. Field check 1950

Polyconic projection. 1927 North American datum.
10,000-foot grid based on Montana coordinate system, south zone and Idaho coordinate system, east zone

Dashed land lines indicate approximate locations

Unchecked elevations are shown in brown

1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

TARGHEE PEAK (24 000)
3773 III NW

SCALE 1:62500

CONTOUR INTERVAL 80 FEET
DATUM IS MEAN SEA LEVEL

ROAD CLASSIFICATION
Medium duty — Light duty
Unimproved dirt
State Route

HEBGEN DAM, MONT.–IDAHO
N4445—W11115/15
1950
AMS 3773 IV SERIES V794

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography from aerial photographs by photogrammetric methods for the Bureau of Reclamation 1948, and by the Geological Survey 1958
Aerial photographs taken 1947 and 1954. Field checked 1958

Polyconic projection. 1927 North American datum
10,000 foot grid based on Montana coordinate, system,
south zone Wyoming coordinate system, west zone
1000 meter Universal Transverse Mercator grid ticks,
zone 12, shown in blue

Dashed land lines indicate approximate locations

Land lines unsurveyed in T. 9 S., R. 4 E. and T. 10 S., Rs. 4 and 5 E.

This map portrays ground conditions prior to the earthquake of August 17, 1959

TARGHEE PASS (24 000)
3773 III NE

SCALE 1:62500

CONTOUR INTERVAL 80 FEET
DOTTED LINES REPRESENT 40 FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

ROAD CLASSIFICATION
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Unimproved dirt
U.S. Route — State Route

TEPEE CREEK, MONT.–WYO.
N4445—W11100/15
1958

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INTRODUCTION

The research for this thesis set out to investigate the forces that shaped indigeneous architecture. Through this type of investigation, it was hoped a knowledge of specific indigeneous shapes and building techniques would be gained. This new understanding was to be applied in the traditional high style manner to a building of today. As the research progressed, this attitude was modified by two ideas and as a result, shifted direction to what this thesis eventually became. These two modifiers were: 1. the book, House Form and Culture. In it Amos Rapoport builds the case that the major forces that have shpaed man's building can be categorized into two main headings: a) cultural forces. b) environmental forces.

This indicated that the built environment has not been and is not now controlled by the designers. It is a result of "vernacular" (folk, popular) architecture and has largely been ignored in architectural history and theory.

2. The concept that indigeneous shapes were derived from logical "principles" of materials and shapes, and adapted to local conditions using native materials. I became aware of the idea that a knowledge of older primitive or indigeneous methods of building and uses of materials was useless without an understanding of the principles with which they built.

The thrust of the thesis, therefore, is to understand those principles, the micro environmental variables unique to my sites, and combine the two with the materials available today to form what could be called an indigeneous architecture.

The first portion of my research deals with the cultural forces that have shaped our built environment, the second deals with the environmental forces and the third points to a new value system with which to base future decisions involved with a built environment.

The contrast between anonymous, vernacular "primitive" type architecture and what Mr. Rapoport calls "high style design" has placed an important-unimportant value system on our building. The so called primitive architecture has been placed on the unimportant value list, while, because of our culture, high style design has been placed on the important side.

The point here is that even though "primitive" indigeneous architecture has generally been ignored, we must acknowledge that there is a great deal to learn from the built

environment of these conditions. He points to the ideas that if two different and unique cultures were given the same environmental variables, they would inevitably arrive at two unique solutions. In other words, although natural environmental forces greatly affect the built environment, it is the cultural forces that ultimately provide the guidelines for what is built.

PROJECT HISTORY

Ski Yellowstone was conceived as a recreation community proposed for the Mount Hebgen area near Grayling, Montana, off Hebgen Lake. The resort is to be located adjacent to U.S. Highway 287 approximately 12 miles northwest of West Yellowstone, Montana (the west entrance to Yellowstone National Park).

The 4 seasons destination resort will include a major ski area on the slopes of Mt. Hebgen as well as a lake village on Hebgen Lake providing both winter and summer recreation for several thousand persons. Trails and lifts for skiing, as well as a mountain restaurant, are planned for Mt. Hebgen with the gondola lift facilities being used in summer for sightseeing. The base area village will provide accomodations, shops, restaurants, recreation facilities including a marina on Hebgen Lake, and an environmental education facility. A total ultimate development with 5,500 beds for visitors and employees residing in the area, and for 1,000 additional day skiers, is planned.

The site for the proposed development was chosen on the basis of a number of locational factors and favorable existing conditions, as outlined below:

1. The site is located in close proximity to Yellowstone National Park. Yellowstone attracted 2,246,428 visitors in 1972, with 692,901 of these entering the Park at its west entrance, which is twelve miles from the Ski Yellowstone site.

2. Ski Yellowstone is located in the Madison River Canyon, which is traveled by 200,000 to 300,000 visitors in the summer months.

3. Mt. Hebgen is a very good skiing mountain, with a total verticle rise of 2,000 feet, trails for all abilities, and the potential for excellent cross-country skiing and summer recreational activities.

4. Mt. Hebgen possesses excellent snow, wind, and weather conditions for skiing.

5. Hebgen Lake which borders on the Ski Yellowstone development site, provides the potential for water-related summer recreation activities.

6. The ownership characteristics of land in the vicinity of the proposed development -- largely Gallatin National Forest lands -- guarantee relatively limited future urbanization in the area surrounding the project site.

7. The National Park Service has initiated a policy which encourages future development of overnight visitor accommodations outside, and within one hours driving distance, of Yellowstone National Park.

RESEARCH

CULTURAL FORCES

The cultural forces that continually shape our environment have a greater overall influence on building than the physical environment especially where criticality of climate, topography, etc. is low. This chapter discusses some of the cultural forces and their influences.

Primitive as a Relative Term:

The term primitive actually refers to technological and economic development. By our "technological" standards primitive buildings appear to be elementary. However, they were built by people using their intellegence and resources to their fullest extent within their limited means while we, with almost unlimited means, work well below ours.

Depending on the context, another cultural group may appear to be "primitive" compared to our society but this does not refer to the group abilities or intentions. In time, our society will appear primitive to future cultural groups.

Tradition as a Regulator:

Tradition has been a cultural form modifier in the past but because of our rapid and expanding communication and loss of hierchies within society, tradition as a regulator has disappeared. This breakdown can also be attributed to the following:

1. A greater number of building types that are too complex for tradition construction methods and because of specialization.
2. Loss of a common shared value system and image of the world.
3. Today's culture put such a high premium on originality that society becomes dissatisfied with traditional forms and methods many traditional cultures place novelty on the undesirable list in order to maintain. Our culture still holds to some of this tendency as it shuns new ideas until they are widely accepted.

The American Dream:

The American Dream of owning one's own home has had an immense affect on the form in our culture. It has in fact forced us into the system of standardization. Standardization as a system in terms of efficiency of production is not undesireable. It could conceivable be used if the system could gear to varying climatic variables.

Symbolic Nature and Basic Needs:

It can be shown that many immigrants tend to take their architecture with and it is only natural to expect since we would not believe that a group in transient would suddenly drop all they had known prior to the point of moving. The Log Cabin Myth

shows this to be true. It would take incredible ingenuity to land on the shores of North America and, because of the need for shelter, immediately construct a log cabin, a system of construction altogether unknown to you previously. The colonists of New England brought with them forms and construction methods of their own from their native land. This was gradually modified because of material availability into forms of the log cabins as we know them.

The tendency to bring the symbols of previous climates and locations is typical and often creates difficulty since the persistance of use is often unsuitable in the new area.

Basic human needs such as the need for sustenance (to eat) indirectly affect our built environment but the specific manner of how and where to eat directly affects form.

The relation of various components to one another symbolically has a great influence as a cultural form modifier. The site and its choices has affects on two levles: 1. physical, and 2. symbolic, cultural, religious.

The reluctance to change and the acceptance of older forms due to prestige value rather than continued validity or utility has long provided modifying effect.

Religion:

The symbolism involved with religion has traditionally been one of the greatest determinants throughout time. The symbol of the mandale, a cross within a circle, has been a traditional design element. At the center of the cross lies the church. The church being the center of the community both physically, spiritually, and symbolically. In the case of the cathedral chartres, the catherdral is the center of the city with all roads leading to it, in the church on the floor lies a maze and symbolically the center of the maze was the center of the universe.

The Present:

Man has lost the mythological and cosmological orientation so important to primitive man. These ideas have been replaced with institutionalization and specialization, the assembly line process, the concept of Laissez-Faire to name a few not to exclude the bureaucratic method. These new value structures tend to destroy many dominant vernacular characteristics.

Health and recreation have become new religion in effect. The religious and symbolic orientation of previous societies have been replaced with sun and sport as ideas. Our modern houses orient "picture windows" to views, the beach, the sun, etc. We are status oriented in such a way that we demand our residences provide space to display our material possessions, i.e. boats, second cars, trailers, snow mobiles, etc.

Territoriality has great significance with our modern society as it places a need to fence your land in such a way as to give the owners "privacy" as a symbol.

The American Dream home surrounded with a manicured carpet of rich green lush grass must be "owned," yet "owners" rarely stay more than five years.

Many people join a subdivision of dream homes in enclosed communities. The communities are symbols of security and prestige.

Our commercialization has created the problem of excessive choice.

Mobility has changed so many items that everything becomes similar. People do not go camping to "rough it" any longer in their trailers equiped with everything their ~~everything their~~ home has.

Our culture is in severe trouble. We seem to be acquiring the shared image of no image. Our cultural form determinants seem shallow. We need to collectively reexamine our goals and aspirations if we are to continue civilization. In my fresh naive country boy way, I believe as a young graduate should, that hopefully, architecture as a profession can become involved at the "decision-making level" and help to bring about meaningful change and direction to society through the built environment.

ENVIRONMENTAL FORCES

This chapter deals with the environmental forces that have shaped our built environment and because of the "nature" of the topic, the items mentioned are not conclusive, they are merely indicative.

"Climate ranks with racial inheritance and cultural development as one of the three factors that determine the condition of civilization."

Ellsworth Huntington

Mankinds physical inflexibility and capacity for adaption are relatively feeble compared to those of animals who possess a wide range of defenses for inclement weather. For cold weather some animals grow more feathers, while others reduce metabolism through hybernation. For excessive heat, some animals shed fur, others utilize heighten transportation, still others use nature to cool their homes that they so strategically build.

While at one time in man's evolution ne may have had some of these animal characteristics such as growing more hair (our natural body processes still show some resemblence, e.g. when chilled, the hair on our body stands on end), general development has followed more of an intellectual course. As a result we are the only animal with a capacity to reason.

As man has developed his power to think and reason, he has also learned to take more and more control of the environmental rigors in which he is surrounded. He has been able to cope with his environment at many different levels. He has "progressed" from the discovery of fire for warmth and fur for clothing to the point where his own ingenuity has produced buildings that have become prisoners of extensive mechanical repair and preventative maintenance, since the complex equipment systems do not work unless windows are fixed and sealed. This "progressive condition" provides uninhabitable spaces because of minor equipment failure.

Man's clever discovery of reflective glass has helped immeasurably to reduce heat in the building it is used on. However, in some cases the improper use has caused older buildings without the new glass to become ovens as a result of reflection. Our physical and psychological reactions are a direct result of the struggle for biological equilibrium.

The range at which man achieves a minimum expenditure of energy to maintain a steady state of balance is called the comfort zone. Our shelter is our main means of fulfillment of this comfort zone. We have learned to modify the natural environment by using our buildings as filters, to absorb some elements and to repel others.

Ideally we will be able to satisfy our own biological needs without dominating the natural environment. This will come to pass simply because nature will not stand for anything else.

Nature's Morphology:

The forces of nature are of immense complexity and any organism living in harmony with nature has a great deal of information to teach us. Orientation can be discussed in relation to the direction flowers grow, the growth of moss. The force of gravity commands the subject of structure at one level while many other environmental variables control structure and shape at another level.

Consider leaf formation. In the cool zone, pine needles are slightly flattened and the form is compact so they may withstand extremes of conditions. The leaves of the temperate zone have a transparent upper side that permits light through its surface. The temperature allows the leaf to broaden. The hot arid zone causes severe strain and therefore forms are massive for protection. The warm wet conditions of the hot humid zone allow freedom of growth with liberal large shapes.

Hopefully this natural morphology provides an analogy for building morphology in similar situations.

"The conception of a form is ultimately the understanding of the forces that give rise to it, as a representation of a form is a diagram of forces in equilibrium."

Victor Olgyay

Natural Advantage:

Nature's characteristics provide us the opportunity to use them to our architectural advantage, i f we understand the principle involved with each characteristic.

The customary use of trees to surround a home arises from roots that are deeper than the aethetic harmony and variety they provide. The thermal performance of vegetation can be especially beneficial when properly used.

The two main elements of consideration for the use of trees are: the shape and character of the tree itself during all seasons and its shadow shape. An understanding of the forces involved with the movement of free air, i.e. wind, can provide many architectural advantages. It can show proper location of building with topography in order that we do not built in cold air pockets caused by land forms. We also can use the effect of placing buildings near large expanses of water since air movement surrounding these bodies moves toward the water at night and away during the day.

There are many implications involved with an understanding of the laws of nature that control structure.

Perhaps the most obvious advantage that nature provides us in this climate is the use of the sun.

Two Main Influences:

Early man was bound to the sun as a symbol and many civilizations oriented their building to the rising and setting of the sun's glorious rays. Today our cultural demands turn our interest in the sun to the psychological and therapeutic value. The use of the sun to satisfy these values gives rise to a need for orientation. The problems involved with orientation, however, are composed or many factors such as topography, privacy, view, noise reduction, heat gain from the sun's radiation, and wind. Today the two main influences on physical orientation are sun and wind with view following close behind.

Climatic Differences and Similarities:

The design for climate and necessity to respond to the variables unique to various regions can be readily shown by examination of the civilization's response to climatic differences.

Climatic differences change the principles of design that are involved with the changing characteristics. As a result of similar climates, various cultures develop unique methods of applications of the same principles. This is caused by cultural and/or religious differences plus the materials unique to the region.

The point here is that although different cultures may produce diverse physical forms with the same climate variable, the principle involved does not change. This concept gives rise to the proposition that Regionality is possible and to some extent and in some location exists. This regionality is one of principles though and not of form.

The commonality of material, so typically associated with regional character, does not exist in our culture today and will not as long as our economic system allows for the transportation of a material unique to one area to a region without that material.

We seem to look at older cultures without the mobility we have and attempt to associate to two cultures. We could reasonably expect that, if the Navajo could import steel, marble, and plastic, for example, their physical form would be different. Therefore, a regionality characteristic can exist in our own culture.

Another difficulty that regionalism faces in the United States is that we are composed of many cultural backgrounds and as previously discussed by Amos Rapoport in the introduction, two different cultures using the same physical restraints would arrive at different forms.

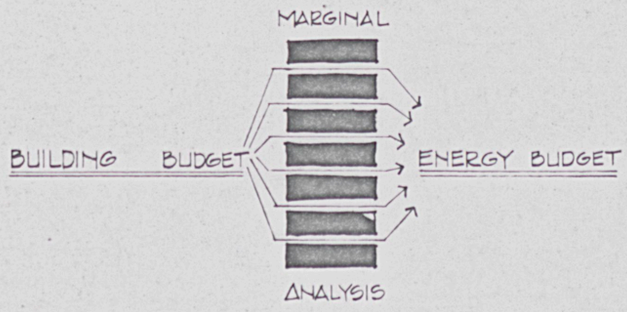
Therefore, a regional character can exist in the United States but it will be on a level of the principles used in the varying climatic areas. That is if design will acknowledge these principles (and stop trying to grow large expanses of green lush carpet called lawns in areas where they would not otherwise survive.).

TOWARDS A NEW BUILDING ECONOMY

The following chapter discusses the relation of energy conservation and economic choice and hopefully points toward a new direction in future building economy.

concepts

1 filter

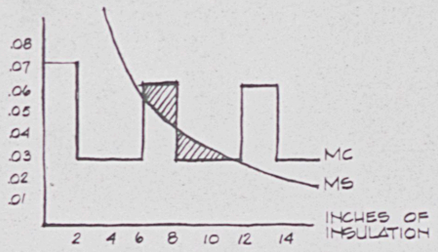


2 marginal analysis

$$\frac{M_{S_1}}{M_{C_1}} = \frac{M_{S_2}}{M_{C_2}}$$

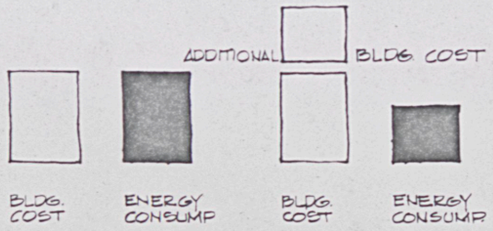
M_S = MARGINAL SAVINGS
M_C = MARGINAL COST





NET SAVINGS GENERATED BY 9TH THRU 12TH INCHES GREATER THAN NET LOSS GENERATED BY THE 7TH THRU 8TH INCHES.

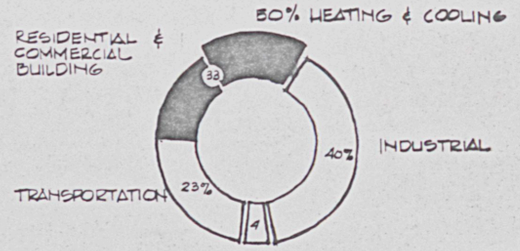
3 consumption savings

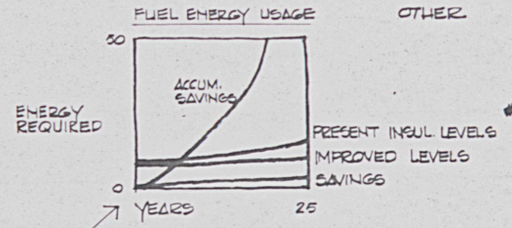


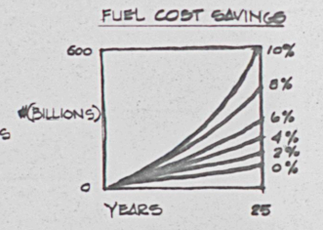
COST
PRIVATE
SOCIAL

BENEFIT
SOCIAL
PRIVATE

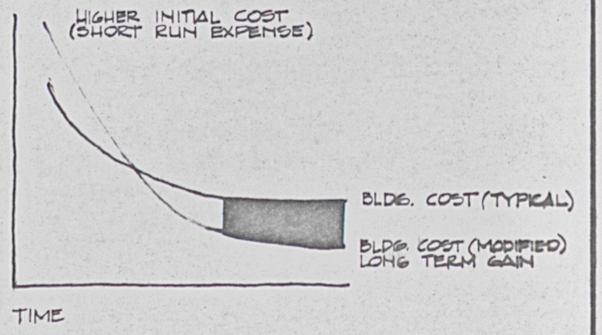
4 33% consumption







5 short run vs. long term



6 equation

- **t** TOTAL COST OF BLDG. OPERATION FOR (**n**) PERIOD OF YEARS
- **x** BLDG. BUDGET EXPENSE (CONSTRUCTION, MAINTENANCE, ETC.)
- **y** ENERGY CONSUMPTION EXPENSE
- **z** EXPENSE OF ADDITIONAL CONSTRUCTION DETERMINED BY MARGINAL ANALYSIS
- **s** ENERGY SAVINGS RESULTING FROM ADDITIONAL CONSTRUCTION

$$x+n(y)=t \quad \text{(TYPICAL)}$$

$$(x+z)+n(y-s)=T$$

WHERE **T** EQUALS REDUCED TOTAL OPERATIONAL BUILDING EXPENSE

MARGINAL ANALYSIS

ENERGY BUDGET

SOCIAL MOTIVATION THRU PROFIT MOTIVATION CHANGES

CONSUMPTION AFFECTED BY DESIGN DECISIONS

LONG TERM SAVINGS (HIGHER RESALE)

energy equation

Market-Place Prices:

In an attempt to discover which materials, available to man at this time and place would be the most energy efficient, it became necessary to determine which of those materials would have the least effect on the immediate site and society in general.

Material choice for this project, in terms of the least energy use, to society was to be considered. The following items: the processing of raw material, the production of finished goods, and the transportation of the finished item to the construction site were considered. However, because of the scope of this thesis another method of material determination was needed since processing, production, and transportation costs change as fast as information becomes available.

With the aid of the expertise of Mr. Walt Nixon and Mr. Richard Stroup, it seemed the most feasible "method" for material choice was simply"at the marketplace," since all costs to society are actually reflected in the price consumers pay.

If a material gradually becomes less accessible then processing costs go up and these prices affect the rest of the economic chain.

All externalized costs, processing, production, transportation, installation of new pollution reducing equipment, etc, become internalized to the company. The company as a result is forced to raise the price to the consumers. The economic system we deal with every day then, is the method by which architecture can determine the most energy efficient materials, that is if society and government keep placing restrictions on industry that serve to protect the environment. There is a low likelihood of devising a better system than that of the "marketplace price."

Benefit and Cost:

The concepts of benefit and cost are a result of today's economic system and therefore provide additional credence to the previous discussion of "marketplace price."

Benefit and cost have an affect at two levels, private and social. Private costs include financing, risk, construction, additional maintenance, to name a few. Social costs could be considered as externalities from industry such as possible from production or automobiles or noise in cities.

Society actually absorbs private benefit in some cases such as an individual who feels the need to operate a heated outdoor swimming pool in a cold climate. Although the individual pays the direct cost to heat the pool, society as a whole ends up paying because of the increased energy consumption of the individual.

Benefit can be viewed as expense avoided. Therefore, private benefit can result in many ways, but one way in terms of energy that the private individual can benefit for the use of added insulation for instance is lower fuel bills. As this additional insulation reduces fuel costs, the resale value of the structure will go up. Social benefits in the case of the private benefit mentioned above could be measured in many ways, such as reduced fuel consumption, less pollution, lower marketplace prices.

Marginal Analysis:

A difficulty exists in determining the balance between cost and benefit in economic terms. Economics makes use of the concept of marginal analysis to determine this balance. It has been applied in a publication concerned with retrofitting existing housing with such energy-conserving techniques as storm windows, shutters, insulation thickness, etc. in order to measure savings (2).

The basis for this marginal analysis is that additional investments in Energy-conserving Techniques (ECT) beyond certain limits generates increasingly smaller energy savings. The optimal combination being:

$$\frac{Ms_1}{Mc_1} = \frac{Ms_2}{Mc_2}$$

where Ms = marginal savings and
Mc = marginal costs

Building Budget vs. Energy Budget:

At this point it would be instructive to introduce the ever increasing need to consider an energy budget along with the building budget. If we can discuss the building budget as the cost of land, financing, construction, materials and operation of the building, then we should consider an energy budget which includes the cost of energy consumption for the life or use of the building (the portion of the energy budget that involves material choice and societies costs can be considered to be included in the building budget, in this way the two budgets overlap).

These two budgets, as you can see, can not clearly be separated and actually are a result of one another. Therefore, the use of marginal analysis can act as a two-way filter (1) placing restrictions on both sides of the total budget. The result being one that is a benefit to the individual and society.

Energy Consumption:

Energy consumption is greatly affected by initial design decisions such as size, shape, orientation, height, proportion, design and number of windows, insulation levels, solar shading and use, etc. Of the energy consumption in the U.S., 33% is consumed by residential and commercial buildings, 50% of that 33% is consumed by heating and cooling. 20% to 30% of energy needed for heating and cooling has been consumed by over design of large expanses of glass (4).

A portion of this overuse of energy can be attributed to relying on standardization as the most efficient way to build. This has resulted in a uniform physical environment, one of low differentiation for the entire U.S. The condition further requires a high level of energy to maintain a "steady state between homogeneous physical form and diverse physical environments." This creates the obvious need to understand the unique character of each physical environment to be designed for especially where environmental criticalty is high.

Consider (3) building cost and energy consumption at an even level. If marginal analysis is used to aid initial design decisions and determine exactly how much additional construction or building costs would result in maximized savings, then energy consumption would be cut much below the original level. The result is that private benefit goes up, social benefit goes up, in the long run (although private costs are higher initially), private cost goes down, and social cost goes down.

Towards a New Economy:

Hopefully our new and arising social consciousness to the ever-increasing problem of energy consumption will bring about a better tommorrow through more long range thinking and less impatience about short-run expense (5). Using marginal analysis as a tool, perhaps society can be shown that higher initial costs will result in long-term gain both to individuals and society (each man helping each other).

The following equation can possibly show how this would work (6)

> Consider the variable "t," allow it to represent the total cost to build and operate a building for a period of "n" number of years. Assign "x" to be the value of the building budget (real estate costs, construction, materials, etc.), assign "y" to be the cost of energy consumption of the building for the same period of "n" years.

The variable "z" will represent the cost of additional construction to maximize savings, this being determined by marginal analysis. "s" will represent the savings realized as a result of the additional construction as determined by marginal analysis.

We can show that:

$$x + n(y) = t$$

(as y changes with time, its cost rises accordingly and hence "n(y).)

if z is added to x:

$$(x + z)$$

then s must be subtracted from y:

$$n(y-s)$$

by substitution, we have:

$$(x + z) + n(y-s) = T$$

the value of our new total "T" therefore is much smaller than the original "t" since each year the savings will increase as a result of rising energy prices. The investment in "z" (the additional construction at the outset of the project) can be shown to be quickly regained.

Because of these new pressures our new building economy could be established because of social motivation through a change in profit motivation.

ANALYSIS & SYNTHESIS

ANALYSIS AND SYNTHESIS

The importance of the research in this thesis was the realization that primitives built an environment that although modified by culture, materials, construction and technology, their solution demonstrates the use of environmental principles. It is the intent of the following section to discuss a way to arrive at and understand those principles.

The Matrix:

The primary inclination for this portion of research was to be based on an understanding of "energy conserving principles" with an emphasis placed on applying the resulting "energy conserving techniques" to the project's architectural solution. Some of the principles of consideration were:

thermal lag
natural lighting
natural ventilation
space efficiency
compactness of geometry
comfort zone limits
earth insulation
solar power
wind power
production and use of methane gas
task lighting

The next step required an understanding of "micro environmental variables" under the heating of micro climate were the following:

wind
precipitation
humidity
radiation
temperature

Under micro topography the following items were to be considered:

soil structure
orientation
elevation
slope
vegetation

Upon careful consideration and many discussions, the above topics appeared to be at a secondary level of understanding to the fundamental issues. Each topic discussed above appeared to have its own unique relationship to various different elements of architecture also has its effect on each item.

Therefore it appeared that some sort of cross-reference should be accomplished relating each micro environmental variable to each architectural variable. This study

also served to breakdown the headings mentioned above into their primary components, e.g. under the major heading "micro climate" we see a minor heading, "solar radiation," and under that we have the subheadings, "light and heat," below each of these occur sub-subheadings, "incoming and outgoing." By cross referencing each of these items with the architectural variables (in the case of incoming solar radiation in the form of light) and windows, a building component we arrive at an energy conserving principle. . . "natural lighting" or in the cross of windows with incoming solar radiation in the form of heat. . ."radiation control."

The following chart was derived in order to comprehend the micro environmental variables and their relationship to architectural variables. The cross of any two variables represents an energy conserving principle. The primary principles that this thesis has dealt with are represented with a dot. The two tones in each square represent primary and secondary relations of variables.

environmental design principles

ARCHITECTURAL VARIABLES

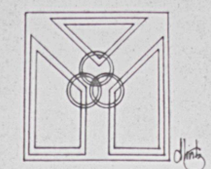
MICRO ENVIRONMENTAL VARIABLES

MICROCLIMATE | MICROTOPOGRAPHY | AMENITIES

AIR | MOISTURE | RADIATION | SLOPE | GEO | WATER | VEGETATION | AMENITIES

TEMP. | MOVEMENT | POLLUTION | HUMIDITY | MIST | FOG | CLOUDS | PRECIPITATION: RAIN, SNOW, SLEET, HAIL | IN: HEAT, LIGHT, U.V. | OUT: HEAT | ALTITUDE | GRADIENT | NEG. RELIEF | SOIL | SUB SOIL | SURFACE | SUB SURF. | GD. COVER | TREES | VINES | SUB SURF. | VIEW | PRIVACY

- SITE LAYOUT: ORIENTATION, ELEVATION, LOCATION
- BUILDING LAYOUT: RM. ORIENT., EX. WALL AREA, PROFILE, FORM, INT. SUB.
- MATERIAL: WOOD, STONE, METAL, CONCRETE, PLASTIC, GLASS
- CONSTRUCTION: WOOD (LOGS, FRAME, PANEL, LAMELA); STONE (FIELD, BRICK, BLOCK); METAL (SPACEFRAME, PRESTRESS, SUSPENSION, TRUSSES); CONC. (POUR IN PL., SHELL, PRECAST); PLAS.
- BUILDING COMPONS.: DOORS, WINDOWS, VENTS, CHIMNEY, FLOOR, WALLS, ROOF, OVERHANG



The Principles:

At this point, by the use of the convenient cross reference variable chart, I was not only able to comprehend the variable but obviously the principles involved that have been unique to each micro environment. These are the principles for which indigeneous builders built. The next step was to name each principle, diagram its meaning schematically, and represent the various methods of solution to each principle.

The following sheets list and describe the principles considered for this project.

topic:

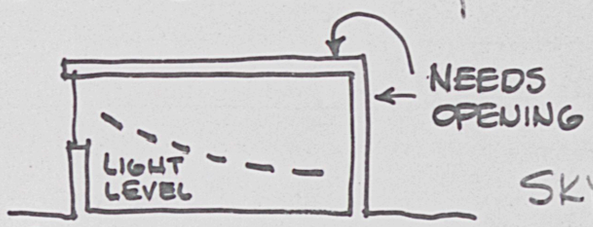
NATURAL LIGHTING

RADIATION (LIGHT) vs ARTIFICIAL

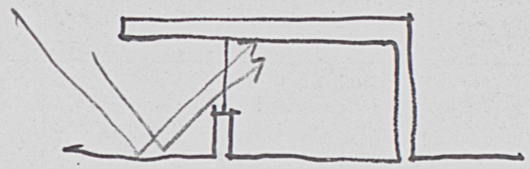
methods of solution:



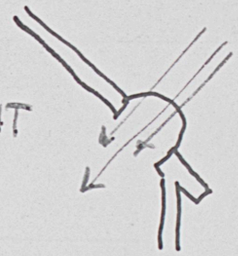
LIGHT BILATERALLY



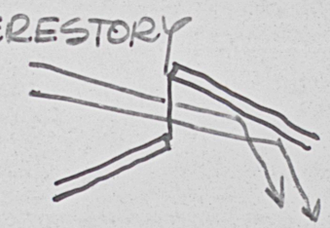
USE OF GROUND REFLECTION



SKYLIGHT



CLERESTORY

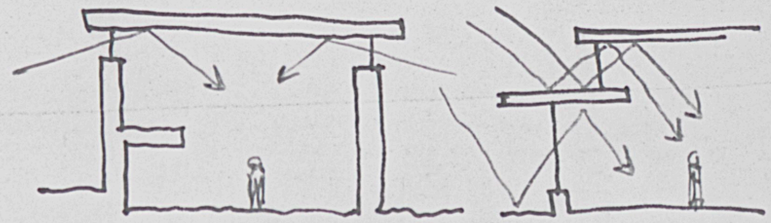


LIGHTER COLORS
REFLECT LIGHT

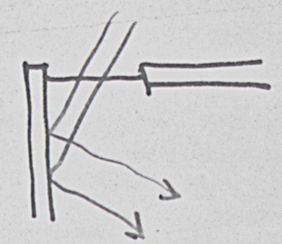
LIGHT SPECIFIC TASKS



BRING LIGHT IN HIGH
PREF. AT CEILING
USE CEILING REFLEC.



USE WALLS NEAR WINDOWS



LIGHT IS DYNAMIC
NEED TO CONTROL

IN GENERAL
ASSOC. LIGHT
OPENINGS W/
BLDG SURFACES

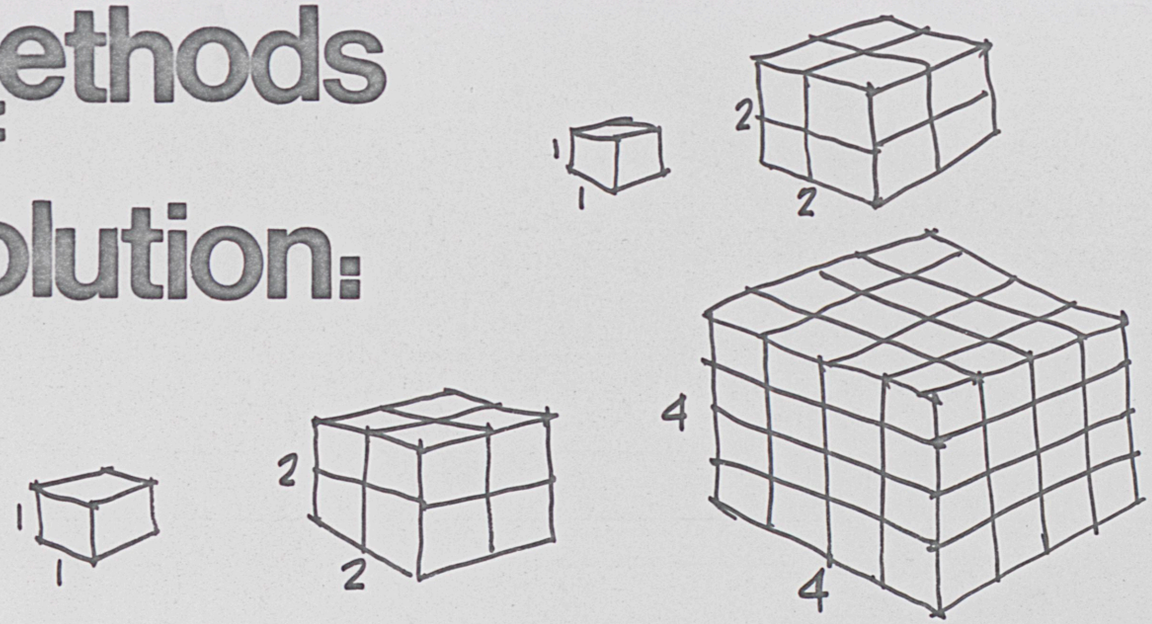


topic:

VOLUME EFFECT

ASPECT RATIO AND ORIENTATION

methods of solution:



CONTENT	1	8	64	LOWER RATIO = MORE EFFICIENT COLDER CLIMATE
SURFACE	6	24	96	
RATIO	1:6	1:3	1:1:5	HIGHER RATIO = MORE EFFICIENT WARMER CLIMATE

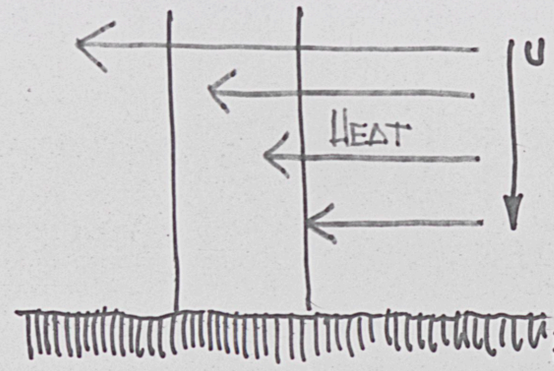
AS RATIO INCREASES:

SOLAR HEAT & LIGHT GAIN INCREASE
WIND HAS GREATER EFFECT ON BLDG.
BLDG. HAS GREATER EFFECT ON WIND.

topic: HEAT TRANSFER

SOLAR RADIATION VS. MATERIALS

methods of solution:



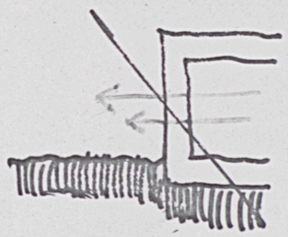
K = CONDUCTIVITY
C = CONDUCTION

$R = \frac{1}{C} = \frac{x''}{K}$

$U = \frac{K}{x''}$

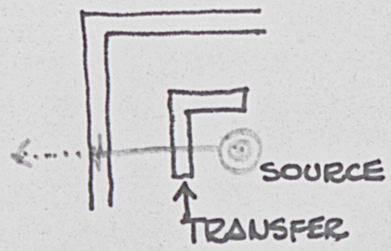
AS U-VALUE DECREASES
RESISTANCE INSULATION INCREASES

TRANSMISSION UNDESIRABLE ON NORTH WALL

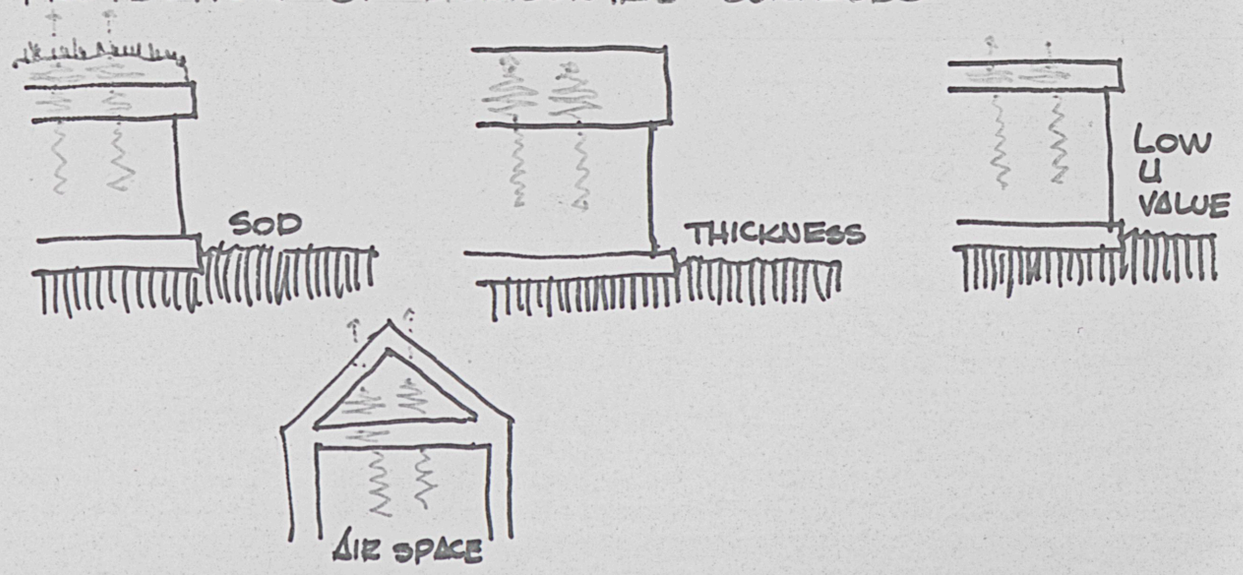


USE TRANSFER AS ADVANTAGE

AS INTERIOR WALLS



PROTECTION OF HORIZONTAL SURFACES



HEAT TRANSFER IS DESIRABLE W/IN BLDG.

PROTECTION AGAINST TRANSFER SHOULD OCCUR AT BLDG. PERIMETER.

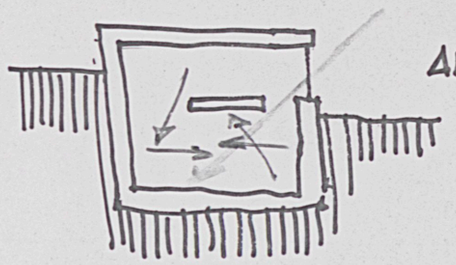
topic:

UNDERGROUND

SITE ELEVATION VS. EARTH INSULATION

methods of solution:

BURY INWARD DIRECTED ACTIVITIES

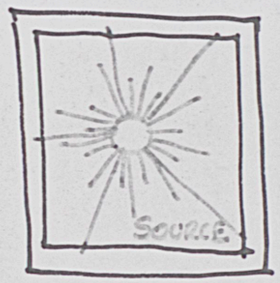


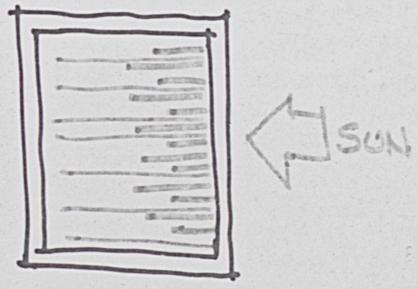
ADMIT NATURAL LIGHT A.M.A.P.

topic: INTERIOR HEAT STORAGE

INTERIOR SUBDIVISION

methods of solution:





PARTITIONING

IF SOURCE TO EVERY ROOM EACH CONTAINS ITS OWN HEAT

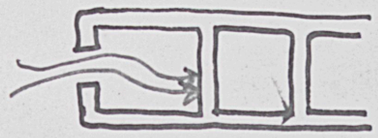


LIMITS VIEW

COLOR

- DARKER COLORS AID I.H.S.
- HAVE PSYCHO. IMPACT.

INHIBITS VENTILATION



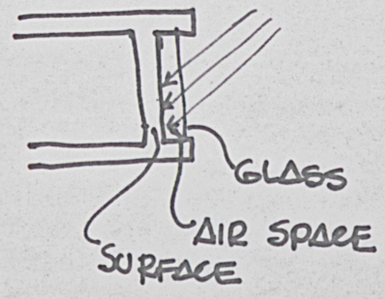
OPEN SPACE

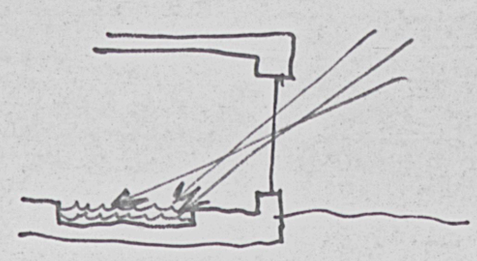
PERMITS HEAT SHARE



SURFACE CONDITIONING

INTERIOR PROTECTED SURFACE

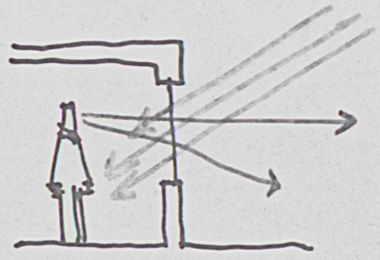




topic: VIEW

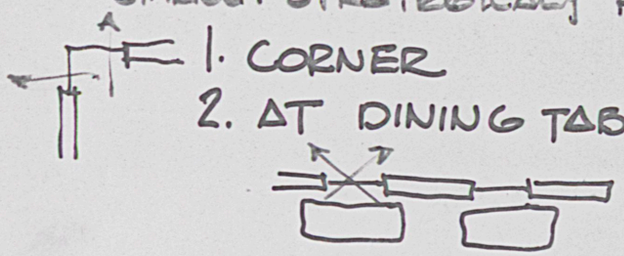
AMENITY vs. THERMAL CONTROL

methods of solution:



SMALL: STRATEGICALY PLACED

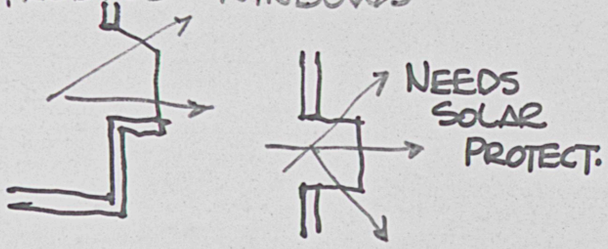
1. CORNER
2. AT DINING TABLES



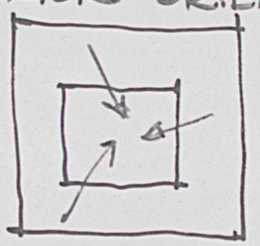
USE OF "LOOK-OUT" AREA TO REPLACE BLDG. AS LOOKOUT



PROTRUDING WINDOWS



INTERIOR ORIENTED



TINTED GLASS
REFLEC. GLASS

VIEW FOR REFERENCE & RELIEF

FEW WINDOWS

— USE SHORT PROTECTED VIEWS FROM BLDG.
— GO OUTSIDE FOR LONG VIEWS



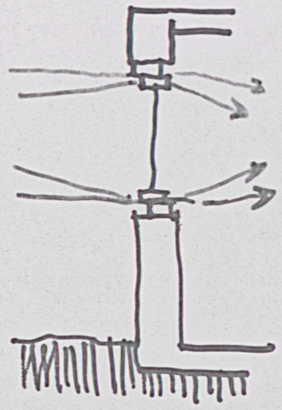
PURPOSE:

— STIMULATE
— OUTSIDE CONTACT
— RELAX FROM TASK

topic: INFILTRATION

AIR MOVEMENT vs. OPENINGS

methods of solution:



REDUCTION OF OPENING PERIMETER



SIMPLIFIED DETAILING



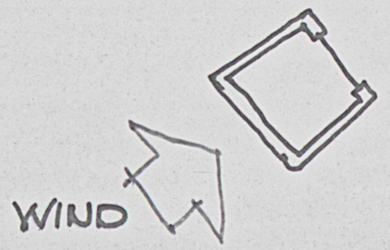
WEATHER STRIPPING



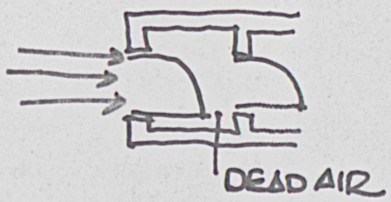
SHIELD OPENING FROM AIR MOVEMENT



ORIENTATION AWAY FROM AIR MOVEMENT



DOUBLE OPENINGS



HIGH HEAT STORAGE FRAMES

WOOD MUCH MORE EFFICIENT THAN METAL

DOUBLE GLAZING



SIMPLE CONFIGURATION

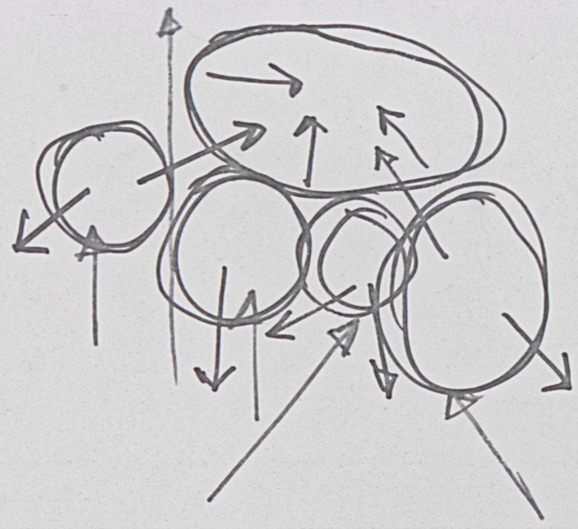
REFER REDUCTION OPENINGS

topic:

ROOM ORIENTATION

SOLAR RADIATION vs. ROOM ORIENTATION

methods of solution:



RELIGIOUS

CULTURAL

COMPROMISE
- VIEW
- CIRCULATION
- SUN
- SERVICES.

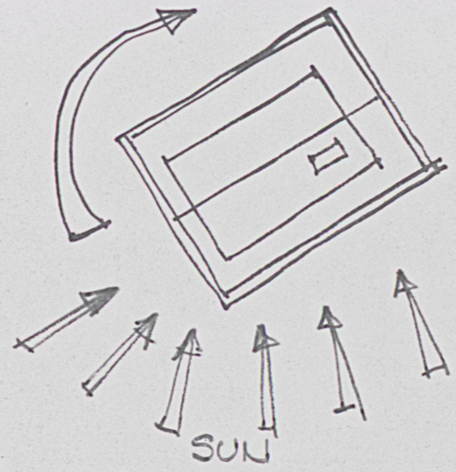
SEE CHART

topic:

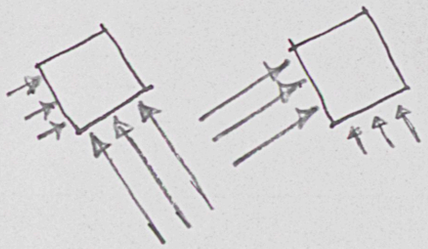
ORIENTATION

SOLAR RADIATION VS. ORIENTATION

methods of solution:



SOLAR GAIN IN WINTER
SOLAR PROTECTION IN SUMMER



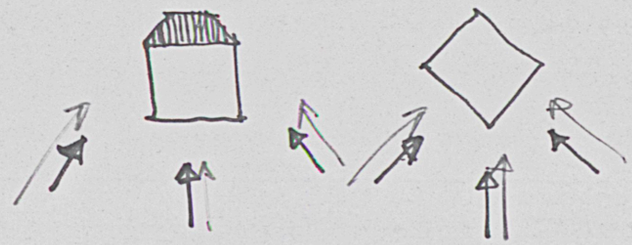
WINTER SUMMER

N

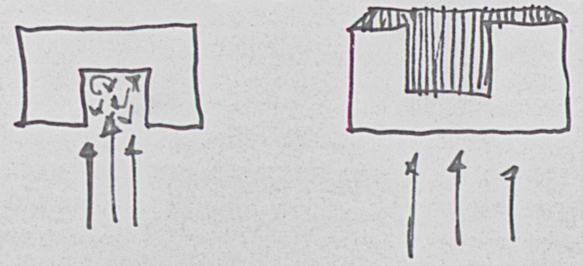
ORIENT SHORT LOW SIDES IN WESTERLY DIRECTION (SUMMER PROTECTION)

ORIENT LONG TALLER SIDES IN EASTERLY DIRECTION (WINTER GAIN)

MINIMIZE SHADE IN WINTER



BUILDING SHAPE AS SUN TRAP

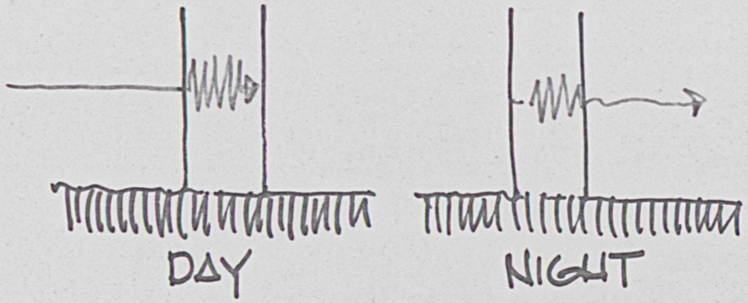


topic:

HEAT STORAGE

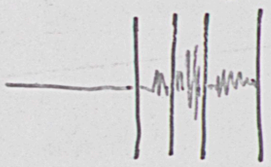
SOLAR RADIATION VS. MATERIALS

methods of solution:



VOLUMETRIC SPECIFIC HEAT
DENSITY x SPECIFIC HEAT
ρ x C

DEAD AIR SPACE



COLOR

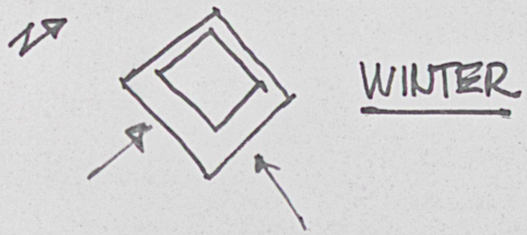
DARK ⟶ LIGHT

⟵ HEAT STORAGE

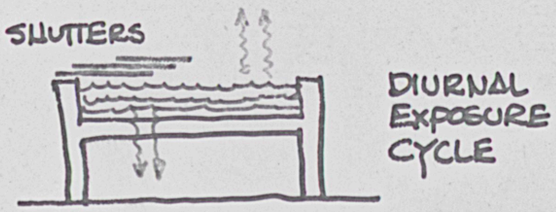
ABSORBTIVE WATER POOLS
PROVIDE HEAT STORAGE
HUMIDITY.



HEAT STORAGE WALLS
OPTIMUM
EAST & SOUTH

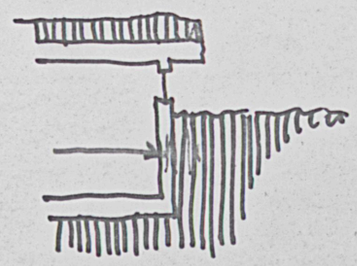


WATER ON ROOF



FIBER BLANKET INSUL.

EARTH AS INSULATION

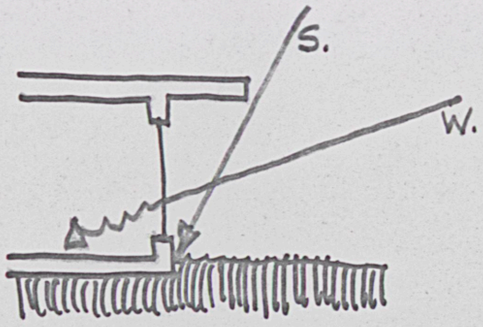


topic:

RADIATION CONTROL

SOLAR RADIATION vs. WINDOWS

methods of solution:



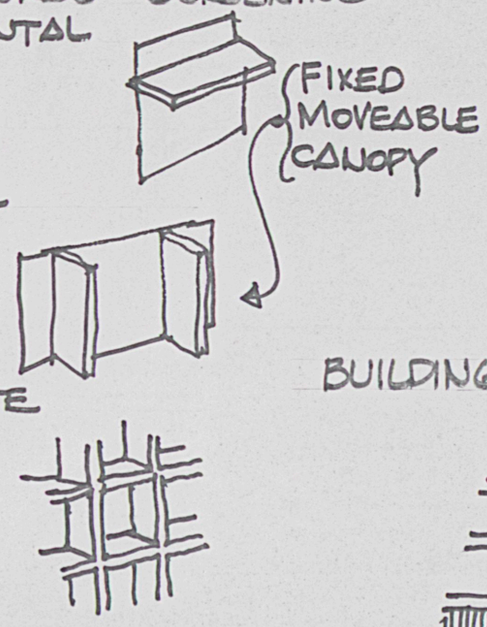
ARCHITECTURAL SCREENING

HORIZONTAL

FIXED
MOVEABLE
CANOPY

VERTICAL

EGGCRATE



VEGETATIVE

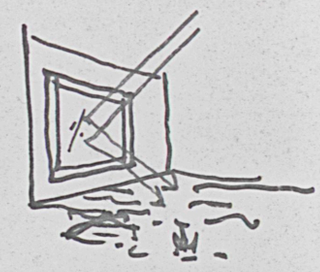


GLASS TYPE

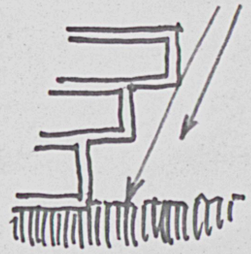
REFLECTIVE

SINGLE vs. DOUBLE

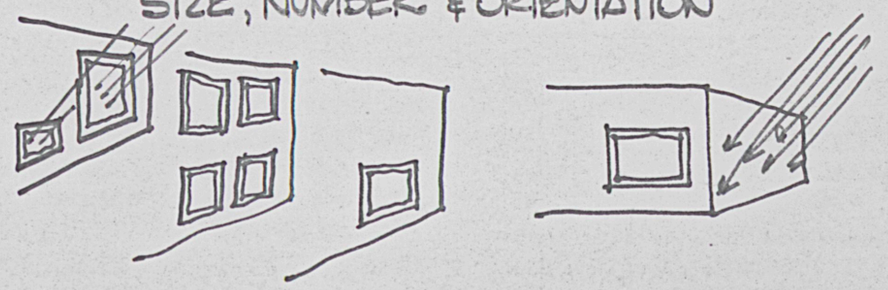
TINTED



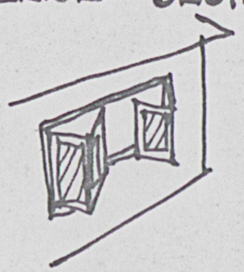
BUILDING AS OVERHANG



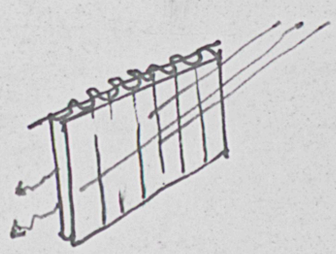
SIZE, NUMBER & ORIENTATION



EXTERIOR SHUTTERS



CURTAINS

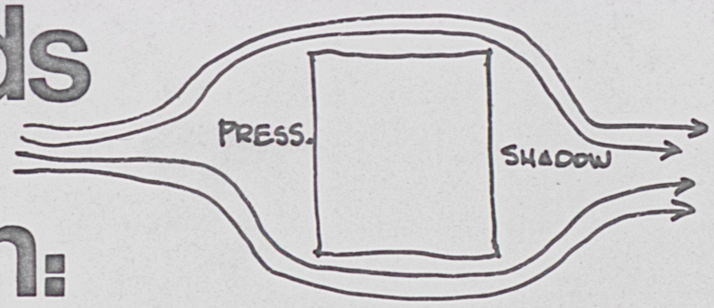


topic:

AIR MOVEMENT

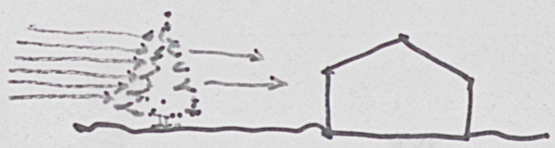
WIND VS. ORIENTATION

methods of solution:



1. AFFECT OF FREE MOVEMENT ON BLDG.
2. AFFECT OF DISTURBED MOVEMENT BY BARRIERS
3. AFFECT CAUSED BY BLDG.

VEGETATIVE

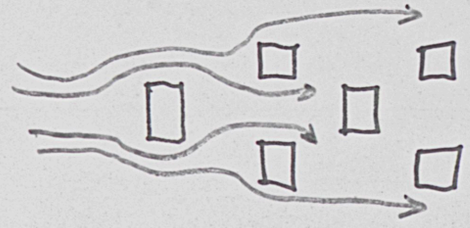


BARRIERS (ARCH)

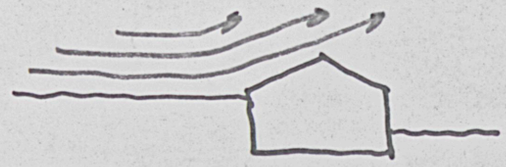


BUILDING LAYOUT

USE OF WIND SHADOWS
HIGH & LOW PRESS.



ELEVATION



SOLAR WALLS

PROTECT
INSULATIVE
LAYER

topic:

PRECIPITATION

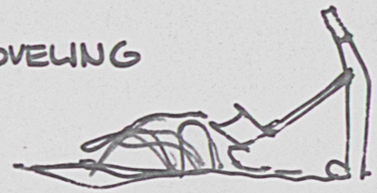
BUILD-UP vs. ROOF AND OVERHANG

methods of solution:



SNOW

SHOVELING



STRONG ROOF

LONG OVERHANGS

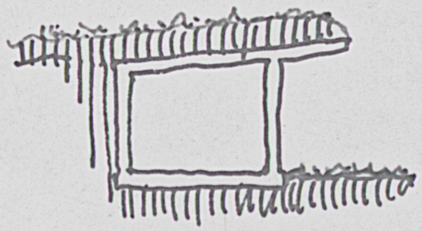


INSULATE OVERHANGS

PROTECTION FROM ICE BUILD UP & BACK CREEP

PROTECT FROM PILE UP & BACK DRAIN

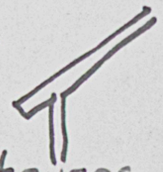
BURY IT



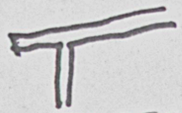
STANT

AMOUNT

WIND ASSIT. REMOVAL



SHEDS PRECIP.



UTILIZES AS INSULATION

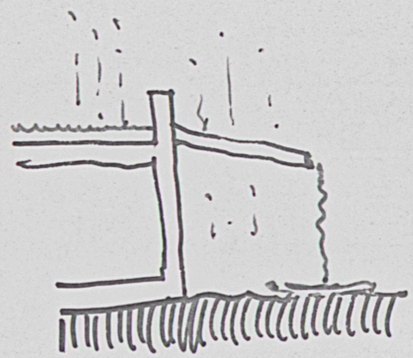
ORIENTATION

SUN ASSIT. REMOVAL

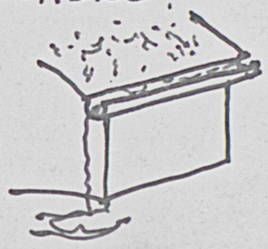
CAPTURE FOR USE !!!

RAIN

SCUPPERS



GUTTERS



PROTECT AGAINST SPLASH



ORIENTATION

TO PROTECT PED. BUILDING ENVIRONMENT

The next consideration was that of the understanding of the unique character of micro environmental variables. The principles previously mentioned become modified by the site information.

This site information has acted as a filter to the energy conserving principles, describing how each unique site requires varying architectural solutions.

The following is an excerpt of weather and climate in the Mt. Hebgen area by Mr. Val Mitchell. Following the text are site diagrams that summarize the primary influences acting on each location, the mountain top and the valley below.

WEATHER

The following information was extracted from the Ski Yellowstone environmental study.

Introduction:

The weather and climate of the Red Canyon area contribute significantly to make the area desirable as a year round recreational area. Summers are usually very pleasant for outdoor recreation with warm days and cool nights and little precipitation. The area is cold in winter, but not as cool as the reputation of the area might have it. Winter temperatures are cold enough that the substantial snowfall remains on the ground throughout the winter.

Weather data in the Red Canyon area are very limited, hence the data that follows are estimates for the area of interest based on a knowledge of mountain meteorology and the weather records of West Yellowstone, Hebgen Dam, and to a much lesser degree, Horse Butte lookout.

Temperature:

The only temperature records available in Red Canyon are those taken from a thermograph network set up on the east slope of Mt. Hebgen in late January, 1973. However, a good long term temperature record is available for Hebgen Dam, eight miles west-northwest of the mouth of Red Canyon. The Hebgen Dam record provides the basis of the following discussion of temperature in the Red Canyon-Mt. Hebgen area. The thermograph network data have been used for guidance whenever they were helpful.

As stated previously summers in the Red Canyon area are mild and winters are cold. This is borne out by the estimates of mean monthly maximun, minimum, and mean temperatures for the proposed village site at the mouth of Red Canyon presented in Table 1.

January is the coldest month with a mean maximum temperature of 22° F and a mean minimum temperature of 5° F. Although the West Yellowstone-Hebgen Lake area has the reputation of being very cold in winter, these figures suggest that there are periods even during January that are pleasant and mild for winter.

The mean maximum for July is 78° F and the mean minimum is 46° F. Summer days tend to be very pleasant but the nights are usually distinctly cool. There are some days during the summer when the diurnal range (the difference between the maximum temperature and the minimum temperature) is about 50 degrees. This large temperature change from day to night should be considered when planning evening or nighttime outdoor recreation activities.

Typical of most places in the middle latitudes, the Red Canyon area experiences temperature fluctuations resulting from the movement of fronts and pressure systems through the area. Tables 2 and 3 have been prepared in an effort to show both the variability of temperature and the proportion of time extreme temperatures occur. Table 2 presents the percent of days of each month that the maximum temperatures can be expected to be lower than the selected values indicated. For example, the maximum temperature on 86% of the days in January will probably be 32° F. or colder, while maximum temperatures are below 0° F on 6% of the days in January.

Table 2 shows that, while it does get cold in the Red Canyon area, the percent of the time that it is very cold is small. Maximum temperatures below 0° F can be expected only 6% of the time in January, 1% of the time in February, and 4% of the time in December. On the other hand, maximum temperatures above 32° F can be expected 14% of the time. (The percent of days that maximum or minimum temperatures are above a certain level can be obtained from Tables 2 and 3 by subtracting the percent figure in the body of the table from 100.)

Maximum temperatures in summer rarely exceed 90° F, but cool days when the maximum does not exceed 70° F are not uncommon, especially in August.

Winter minimum temperatures (Table 3) can be very cold, with the temperature occasionally reaching -40° F. However, the percent of days when these very cold temperatures occur is small. During December and January, and February, minimum temperatures below zero can be expected about one third of the time. This will usually not be a problem for outdoor recreation since maximum temperatures on these days will usually be at least 10° F. Also, temperature inversions are quite likely when the minimum temperatures at the village site are below zero, with the result that it will usually be warmer in the morning on the slopes of Mt. Hebgen than at the village.

As suggested before, summer minimum temperatures can be quite cool. For example, in July and August the minimum temperatures on about one half the days can be expected to be 45° F or cooler.

It should be noted that Tables 2 and 3 are based on a number of years and that the percent frequency of temperature for any one month may depart from the estimates in the tables.

The duration of very cold weather is often as important as the temperature itself. While it does get very cold in the Red Canyon area from time to time, the cold periods are usually of short (1-3 days) duration. In the 36 year period from January 1938 to February 1973, maximum temperatures at Hebgen Dam remained at or below 0° F for 4 or

more days on only five occasions. The longest period of cold weather was in December, 1972 when the maximum temperature remained at or below zero for eight days. This was the result of an unusually large and severe artic outbreak that covered most of the western United States.

The temperature estimates just given are for the proposed village area at the mouth of Red Canyon. These estimates cannot be realistically applied to Mt. Hebgen. Although temperature information would be desirable, especially for the top of Mt. Hebgen, such information is not available and reasonable estimates cannot be made with currently existing data. The best that can be done at the present time is to present, in a very broad manner, some general relationships between a mountain ridge or peak and the adjacent valley floor using the short term thermograph records from Mt. Hebgen and the weather records from the Horse Butte lookout, which are for summers only, as guidance.

The temperatures on top of Mt. Hebgen should be more than those at the mouth of Red Canyon. Daytime temperatures should be from 3 to 10 degrees cooler than the valley and nighttime temperatures should vary between a few degrees cooler to perhaps as much as 30 degrees warmer than the valley floor. The large positive difference at night results from the formation of temperature inversions which form frequently at night. During the winter, the top of Mt. Hebgen should be considerably warmer than the valley floor during periods of intensely cold weather. Temperatures on the top of Mt. Hebgen probably rarely drop much below 0° F.

Another situation when Mt. Hebgen will usually be warmer than the valley below is on clear summer nights, when cooling by radiation is usually at a maximum. The temperature difference here, however, will not be as great at that during the very cold periods of winter and is not of the practical significance of the wintertime situation. More will be said about temperature inversions in the discussion of air pollution.

Precipitation:

The best estimate of the monthly and annual precipitation at the proposed village site at the mouth of Red Canyon is the precipitation data from Hebgen dam. Although the precipitation at the Dam is not representative of the precipitation on the ski areas of Mt. Hebgen, it is probably quite representative of the village site. Hence, the following estimates for the village site are based on the Hebgen Dam precipitation records.

The mean precipitation for each month is presented in Table 4. The average annual precipitation for the 1931-1970 period is 27.41 inches. There are two rather distinct

wet seasons, winter and late spring. The wettest month is June, with an average of 3.11 inches but January precipitation is nearly as high with an average of 3.05 inches. Of the total precipitation, 48.9% falls during the winter (November through March) and 20.6% falls during May and June. The driest season of the year runs from July through September.

An important characteristic of the precipitation in the Hebgen Lake area is variability. In addition to mean precipitation, Table 4 also presents the standard deviation of precipitation, greatest amount, and least amount for each month for the 40 year period considered. As can be seen, any month of the year can be very wet or very dry. Nine of the twelve months of the year have received more than five inches of precipitation, with the greatest total going over seven inches in June and December. On the other hand, each month has had at least one occurrence of precipitation less than one inch, with the least precipitation in August, October, and November being less than 0.1 inches.

The driest year during the period considered was 1931 when only 19.44 inches of precipitation fell. The wettest year was 1964 with just over 38 inches of precipitation. It should be noted that the decade from 1961 to 1970 was considerably wetter than the preceding thirty years. Each year in the decade was wetter than the average for the preceding thirty years. During three years, 1964, 1967, and 1970, over 35 inches of precipitation fell. Both 1971 and 1972 were also above the long term average. There is no way of determining whether or not this trend of increased precipitation will continue.

From a recreational viewpoint, one pertinent factor relating to precipitation is the number of days in a given month when precipitation occurs. For skiing, frequent precipitation has distinct benefits as well as a few disadvantages. However, from the viewpoint of summer outdoor recreation, frequent rainy weather is a distinct disadvantage. Estimates of hte average number of days with measurable (.01 inches or more) precipitation to be expected are given in Table 5 for each month. These estimates may be slightly high since they are based on the period from 1960 through 1972, a period of above average precipitation, but they are sufficiently accurate to serve as guidelines. During the winter and late spring, precipitation can be expected on nearly half of the days. Summer and fall are clearly the best months from a low precipitation standpoint, but no month can be thought of as precipitation free.

The hydrologic aspects of precipitation are treated in the hydrology section of this report.

Cloud Cover:

Estimates of cloud cover for the Red Canyon area are given in Table 6. These estimates are based on weather observations taken by the U.S. Weather Service in West Yellowstone at three hour intervals. Presented are the percent of daylight hours in each month that are clear, partly cloudy (from 1/10 to and including 5/10 of the sky covered with clouds), mostly cloudy (from 6/10 to and including 9/10 of the sky covered with clouds), and overcast. Also presented are the mean cloud cover from sunrise to sunset for each month and an estimate of the percent possible sunshine received during each month. The estimates of cloud cover do not differentiate between low heavy clouds and high thin (cirrus) clouds that rarely hide the sun, hence there are some days included in the mostly cloudy or overcast categories that are somewhat sunny even though high thin clouds are present.

The data in Table 6 show that overcast conditions are very common in winter. If the clear and partly cloudy days are considered to be nice days and the mostly cloudy and overcast days are considered as cloudy days, it is cloudy almost 70% of the time in January. In July, clear or partly cloudy weather conditions prevail about 75% of the time.

From the standpoint of outdoor recreation, the month of June requires special comment. June is usually considered to be the first month of summer and the beginning of the vacation season. However, in the Red Canyon area, June is really a spring month rather than the first month of summer. It is the month of maximum average precipitation and the skies are cloudy about 50% of the time.

Outdoor recreation can be hampered considerably by the weather during this month. This is probably the only month of the year when the weather in the Red Canyon area is just the opposite of what is desired from an outdoor recreation viewpoint. In contrast, July, August, and September tend to be sunny and dry.

Wind:

The winds in the Red Canyon area, as in most mountainous terrain, are strongly controlled by the local topography. Except for those periods when a strong pressure system, usually a low or a front in the area, overrides the local influence, a typical mountain-valley wind system prevails in Red Canyon and on the alluvial fan at the mouth of the canyon. This makes the winds in the area very predictable much of the time.

At night, the airflow at the surface is down the canyon at from five to ten miles per hour. As the canyon mouth broadens, the airflow pattern fans out in the manner

shown in the drawing entitled "Wind." During the daytime, the airflow is up the canyon basically as shown in the drawing. Although daytime airflow across the alluvial fan is basically as shown in the drawing, measurements at Grayling show that at any time it may vary from southeast to southwest. This upcanyon movement is usually reinforced by the southwest winds that prevail during daylight hours in the entire West Yellowstone basin, resulting in upcanyon wind speeds of five to ten miles per hour, which is stronger than typical upcanyon airflow. This typical diurnal airflow pattern prevails most of the time during the summer, and much of the time in the other seasons. It is best developed during good weather.

The prevailing wind at the village site is from the south or southwest. However, in terms of the total number of hours of wind from a given direction, a downcanyon (north wind) is almost as common as a south or southwest wind because of the strong topographical control of the nighttime winds.

The diurnal airflow pattern should not present any problems, except possibly in the siting of the sewage disposal facilities. It would be desirable to locate the waste water treatment facilities such that there is a minimum of air movement from the treatment plant toward the village. A site east of the abandoned town of Grayling, as suggested, is the best site north of Highway 287. This site does have the disadvantage that a southeast wind will carry odors from the treatment facility toward the village site. Although south and southwest winds are more common during the day than southeast winds, southeast winds do occur. During a three week period in June and early July, southeast winds occured at Grayling about 6% of the time.

From strictly a wind viewpoint, a site as far southeast of Grayling as possible would be the preferred location for the waste water treatment facitilies. However, wind direction is just one of several factors that must be considered in locating this plant.

Less information is available concerning the winds during storm periods than during nonstorm periods. The deflection of wind by mountains is such that strong winds other than up or down canyon will be rare in the bottom of Red Canyon. At the village site, the wind direction will be less controlled by topography. As cold fronts approach the area, the village site will be subjected to fairly strong, gusty south to southwest winds. After a cold front passes through the area, the winds will be westerly but remain strong and gusty. In either situation, sustained wind speeds greater than 25 miles per hour will be rare. However, gusts to 40 or 50 miles per hour could occur. Usually winds associated with a cold front will not be this strong.

The strongest winds in the area will probably occur during thunderstorms. It is not uncommon for peak gusts in thunderstorms to exceed 50 miles per hour.

There is nothing to suggest that the proposed village site is subject to winds that are stronger than those found in most locations. As long as all facilities are properly constructed, wind at the village site and in the bottom of Red Canyon should not present problems.

Thus far, this discussion of wind has not dealt with the important problem of wind on Mt. Hebgen. Unfortunately, the winds on Mt. Hebgen present a much more complex problem than the winds on the valley floor. About the only statement that can be made with confidence about wind speed and direction on a mountain is that each mountain or ridge must be considered by itself. Hence, little information concerning the winds on Mt. Hebgen can be obtained from any source except Mt. Hebgen itself.

The prevailing wind direction on top of Mt. Hebgen is probably southwest. There is no way of predicting wind speeds on Mt. Hebgen. It is encouraging that little evidence of wind scour or drifting has been found by those who spent time on the mountain.

It is strongly recommended that wind speed and direction measurements be taken on Mt. Hebgen during the coming winter. Discussions with Hans Geier indicate that this is planned. It should be stressed, however, that obtaining usable measurements of wind speed and direction on a mountain during winter is very difficult. Since commercial power is not available on the mountain, the measuring equipment and recorders will have to be battery powered. It may be necessary to bury the batteries to protect them from the cold. This means that the wind measuring instruments should be set up and thoroughly checked out before snow begins to accumulate on the mountain. It will also be necessary to check the instruments frequently, probably every few days, to ensure that they are working properly.

The measurement of wind speed and direction on Mt. Hebgen during winter is very important and yet will be very difficult. It is strongly suggested that a person with experience in this type of measuring problem be involved in the purchase and set up of this equipment.

Evapotranspiration:

In order to properly design the waste water treatment facilities, it is important to know as accurately as possible what the monthly and annual rates of evaporation can be expected at the mouth of Red Canyon. Unfortunately, there is no good method to calculate evaporation (or evaoptranspiration if plants are involved) and the time and financial limitations of this study have not permitted the measurement of evaporation in the area.

In order to have some estimate of evaporation in the Red Canyon area the potential evapotranspiration (the maximum amount of evapotranspiration possible when water is readily available) was calculated for the area of interest using a method developed by Thornwaite. The monthly values obtained are given in Table 7. Thornwaite assumes that there is no evapotranspiration during a month when the mean temperature is below 32° F. The estimated annual evapotranspiration by this method is 19 inches.

There are several energy budget methods of estimating evapotranspiration, but the meteorological data needed to use them are not available in the Hebgen Lake area. A study done in Australia compared measured evapotranspiration values with those obtained by several methods of calculating the evapotranspiration. The results suggest that the Thornwaite method underestimates the actual evapotranspiration. Using these results for a crude correction factor on the Red Canyon potential evapotranspiration figure suggests that actual evapotranspiration from an open water surface is probably near 30 inches per year. The monthly corrected values are given in Table 7.

Impact on Atmospheric Environment:

In all probability, the only way that the development of a year round recreation complex in and around Red Canyon can adversely affect the atmospheric environment is through air pollution. Since very stable atmospheric conditions, which tend to trap air pollutants and retain them in the area, are very common in the West Yellowstone-Hebgen Lake Basin, air pollution is definitely a potential problem.

The quality of the air in the Red Canyon is presently good. However, temperature inversions and other stable conditions develop in the area during most nights and during very cold weather. Usually, the atmosphere becomes sufficiently unstable during the day to permit pollutants trapped in the basin to be flushed out. An exception to this is during very cold periods when temperature inversions persist throughout the day.

The point of prime concern in air pollution in the Red Canyon area is not as much the violation of state and federal air pollution standards as it is the preservation of the generally good visibility that is usually present. The scenery in the Red Canyon area is one of its selling points, and any obscuration of that scenery behind a pall of smoke is undesirable.

The key to preventing air pollution in the area of concern lies in the limitation of air pollution sources. It is apparently planned to use electricity heat all facilities since natural gas is not available in the area. It is important that this be the case.

As long as a clean source of heat is used, the only apparent sources of air pollution are fireplaces and automobiles. Automobiles should not present much of a problem since their use will not be concentrated in one area. Fireplaces, however, present a different problem. A fireplace is a desirable feature in living units, but in a village as large as the one being proposed, if every living unit has a fireplace there will be times when the accumulation of air pollutants in the area will be very noticeable. The writer is not aware of any method usable within the limitations of this study to specify the maximum number of fireplaces that could be permitted before problems develop. There is an arbitrary limit on the number of fireplaces will have to be set, using as a guideline the fact that as the number of fireplaces increases, the problem increases. Even though caution should be exercised, a total ban on fireplaces is probably not called for.

During the construction phase of the proposed project, an increase in dust will probably occur, but once construction is complete, dust should not be a problem.

With respect to the impact of the project on the atmosphere in ways other than through air pollution, all such impacts are expected to be minimal and local. The clearing of areas on Mt. Hebgen for ski trails will affect the microclimate of the cleared area and may result in a change of plant species. But unless new species are deliberately introduced, the plants that move into the cleared areas will be those that are already found in the nonforested areas of the mountain.

Similarly, a change in microclimate will occur on the alluvial fan where the village is constructed. But the area affected will be limited to the immediate village area. The overall impact on the atmosphere of such actions as the clearing of ski trails or the construction of a village the size of the one planned is so small that it is of no concern.

TABLE 1

Temperature Data Estimates for Red Canyon Village Site

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	22	28	36	47	59	68	78	77	66	52	35	24	
Min	5	6	13	25	34	40	46	44	37	27	19	8	
Mean	13.5	17.0	24.5	36.0	46.5	54.0	62.0	60.5	51.5	39.5	27.0	16.0	37.3

TABLE 2

Percent of Days With Maximum Temperature at or below Selected Values

Temp °F	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Temp °F
-25	*												-25
-20	1												-20
-15	1											*	-15
-10	2											*	-10
-5	3											2	-5
0	6	1										4	0
5	10	2	*									7	5
10	16	3	1								*	12	10
15	27	8	3								*	24	15
20	44	18	6							1	4	40	20
25	60	36	12	1						1	15	60	25
30	78	60	28	2	*				*	3	32	80	30
32	86	69	36	3	*				*	5	42	88	32
35	95	83	52	9	*				1	9	58	96	35
40	99	96	73	31	3				2	18	79	99	40
45		99	85	55	10	1			6	29	92		45
50			94	77	22	6		1	12	43	97		50
55			99	90	36	14		3	19	60	99		55
60				97	54	26	1	6	30	79			60
65				99	72	41	2	9	46	90			65
70					86	59	8	17	64	97			70
75					96	76	24	33	83	99			75
80					99	92	57	57	96				80
85						99	89	89	99				85
90							99	99					90

*less than 1% but greater than 0%

TABLE 3

Percent of Days With Minimum Temperature At or Below Selected Values

Temp °F	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Temp °F
-40	1												-40
-35	2	*										*	-35
-30	3	1	*									*	-30
-25	6	2	1									2	-25
-20	10	4	4									5	-20
-15	13	8	6									10	-15
-10	19	14	12									15	-10
-5	25	22	17	1							*	21	-5
0	34	30	22	1							2	32	0
5	45	39	28	2						1	5	42	5
10	57	49	38	6						2	12	55	10
15	67	63	53	16	1					4	26	67	15
20	78	76	68	29	3				1	9	41	79	20
25	86	87	81	51	9				3	21	61	89	25
30	95	94	91	76	26	2		1	13	49	84	96	30
32	98	96	95	85	38	5	*	1	20	61	91	99	32
35	99	99	99	96	60	13	2	4	35	80	98		35
40				99	90	40	11	15	62	95			40
45					99	80	43	54	86	99			45
50						98	83	84	97				50
55						99	97	96	99				55
60							99	99					60

*less than 1% but greater than 0%

TABLE 4

Precipitation Data Estimates for Red Canyon Area (in inches)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	3.05	2.47	2.40	1.81	2.53	3.11	1.54	1.47	1.65	1.84	2.54	2.94	27.41
Std. Dev.	1.44	1.06	1.22	.97	1.26	1.54	.89	1.28	1.22	1.28	1.16	1.31	5.06
Greatest	6.90	5.33	5.06	4.50	6.02	7.50	3.86	6.28	5.42	6.22	4.80	7.10	38.06
Least	.66	.66	.52	.31	.16	.67	.30	.06	.13	0	.08	.90	19.44

TABLE 5

Estimated Average Number of Days With Measurable Precipitation

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
17	12	11	9	11	13	7	7	8	7	12	15	129

TABLE 6

Sunrise to Sunset Cloud Cover Estimates for Red Canyon Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Clear	15*	19	23	21	32	21	46	46	38	29	26	22
Partly Cloudy	15	17	19	17	24	28	32	28	25	22	17	15
Mostly Cloudy	14	17	17	20	16	24	13	13	18	20	11	10
Overcast	56	47	41	42	28	27	9	13	19	29	45	53
Mean Cloud Cover **	7.2	6.6	6.1	6.3	4.9	5.6	3.0	3.3	4.1	5.2	6.0	6.6
% Possible Sunshine	52	59	64	62	73	68	83	82	77	71	64	59

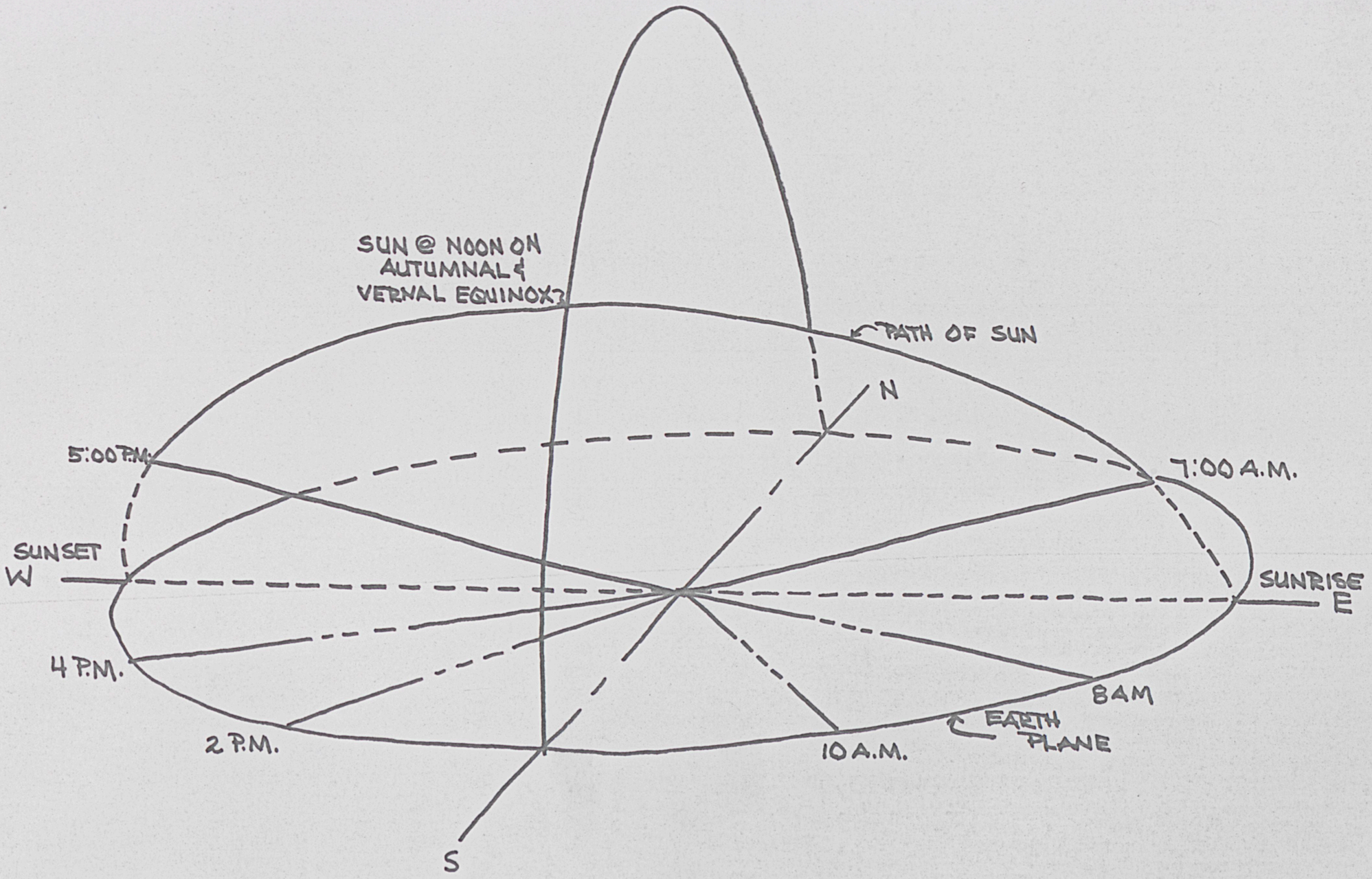
* average percent of daylight hours cloud condition prevailed.

** in tenths of the sky covered with clouds.

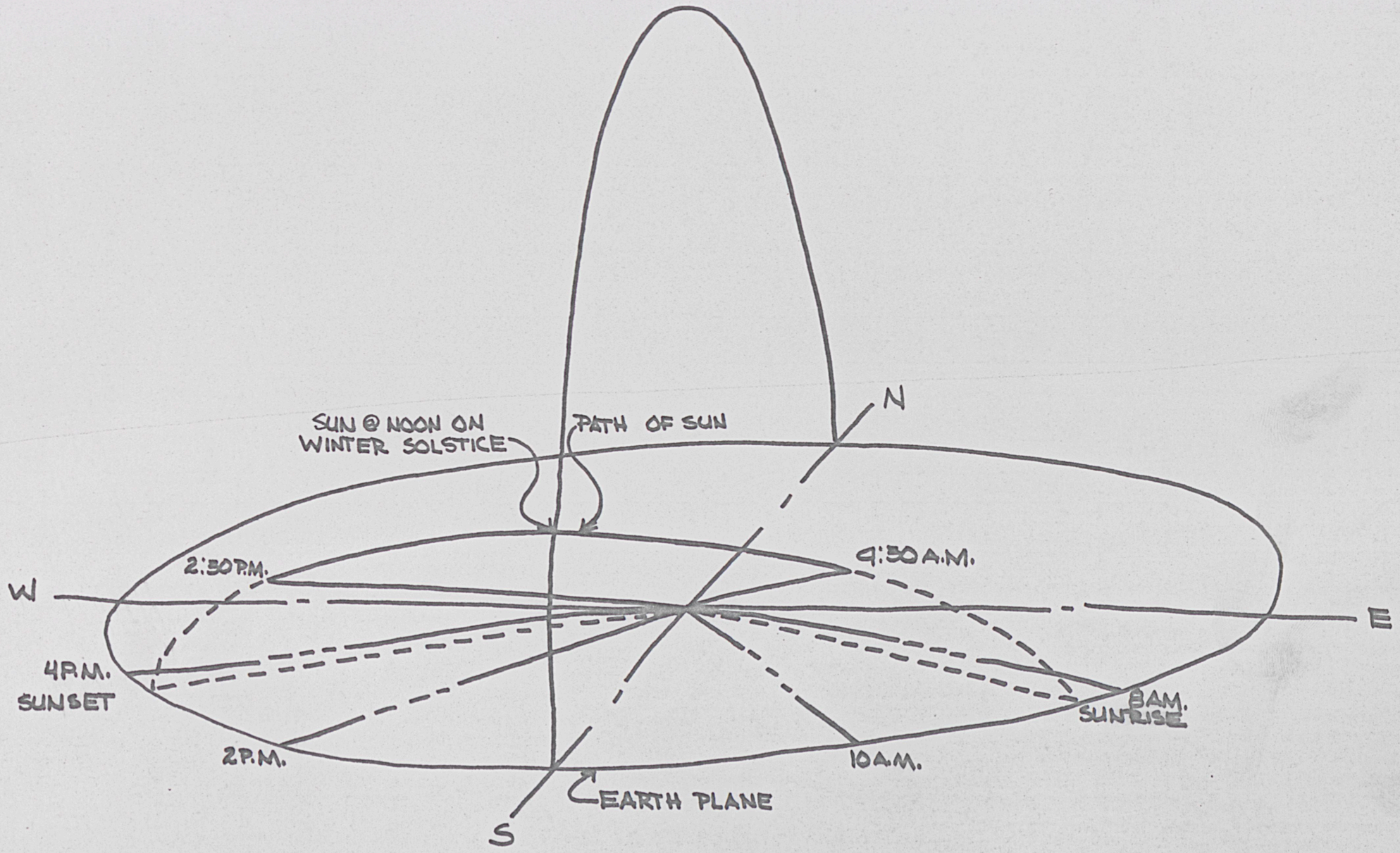
TABLE 7

Evapotranspiration Estimates (in inches)

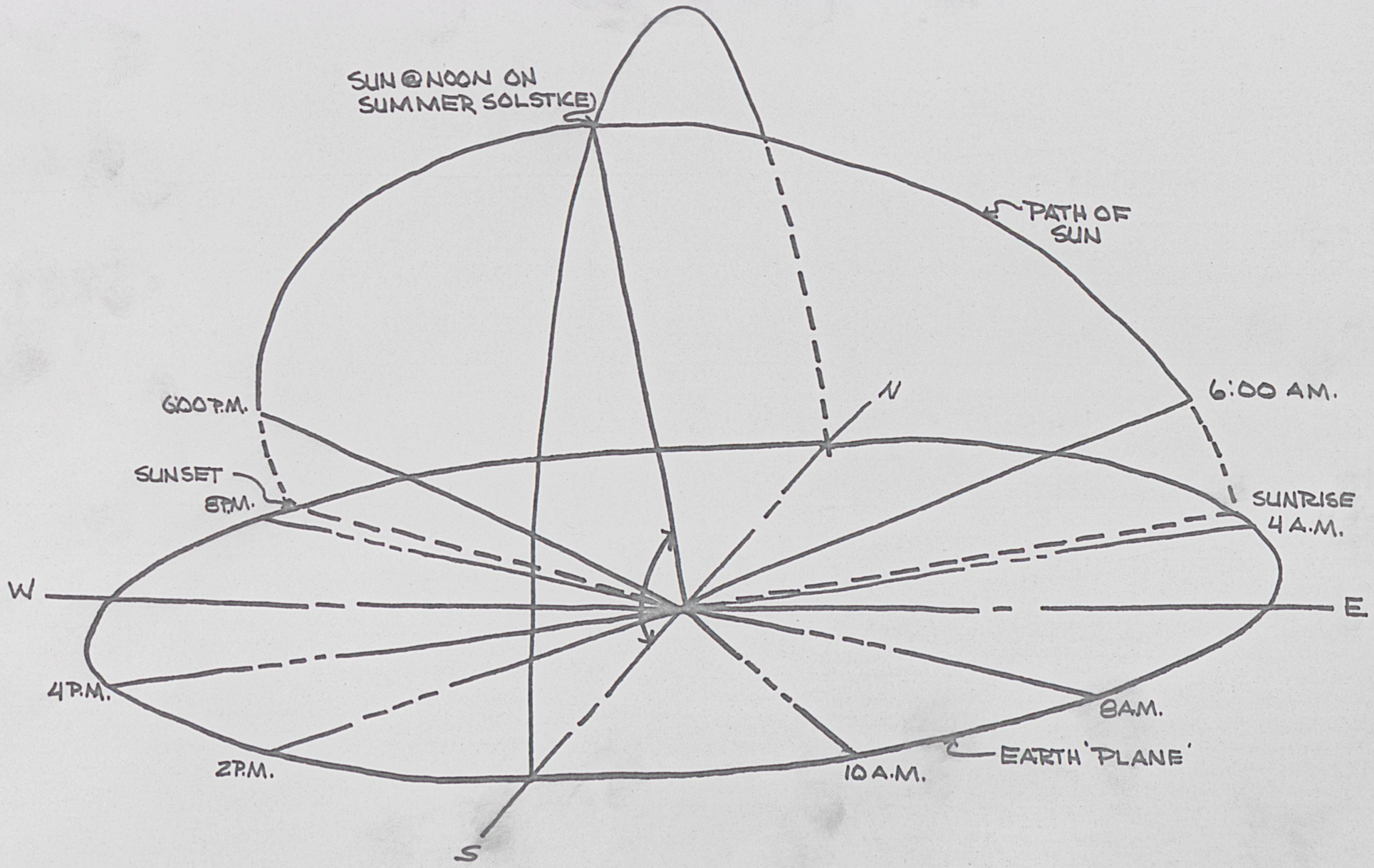
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thornwaite	0	0	0	0.7	2.3	3.5	4.8	4.0	2.5	1.2	0	0	19.0
Corrected	0	0	0	1.1	3.7	5.6	7.7	6.4	4.0	1.9	0	0	30.4

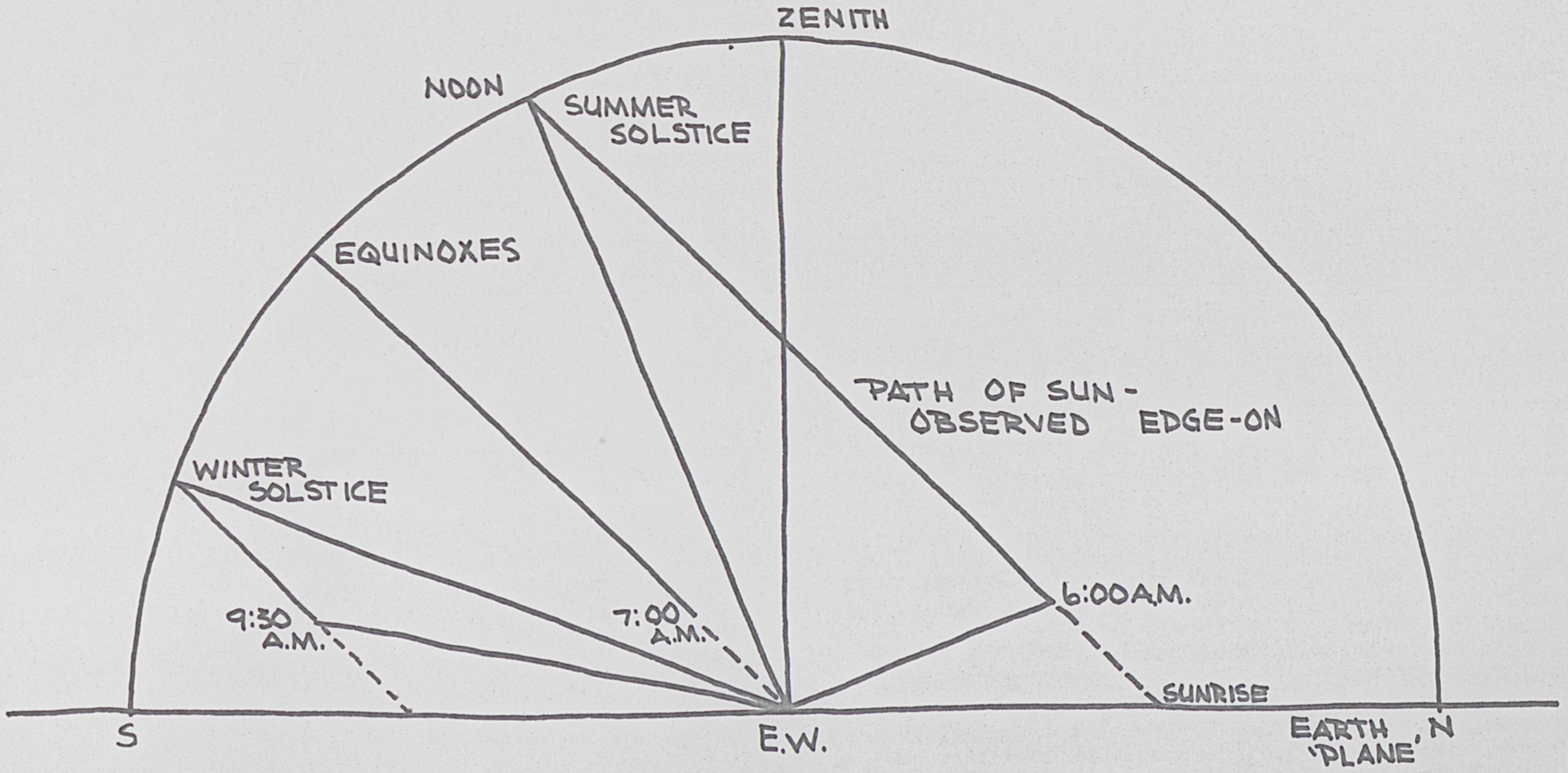

SUN @ NOON ON
AUTUMNAL &
VERNAL EQUINOX?
PATH OF SUN
N
5:00 P.M.
7:00 A.M.
SUNSET
W
SUNRISE
E
4 P.M.
8 A.M.
2 P.M.
10 A.M.
EARTH
PLANE
S

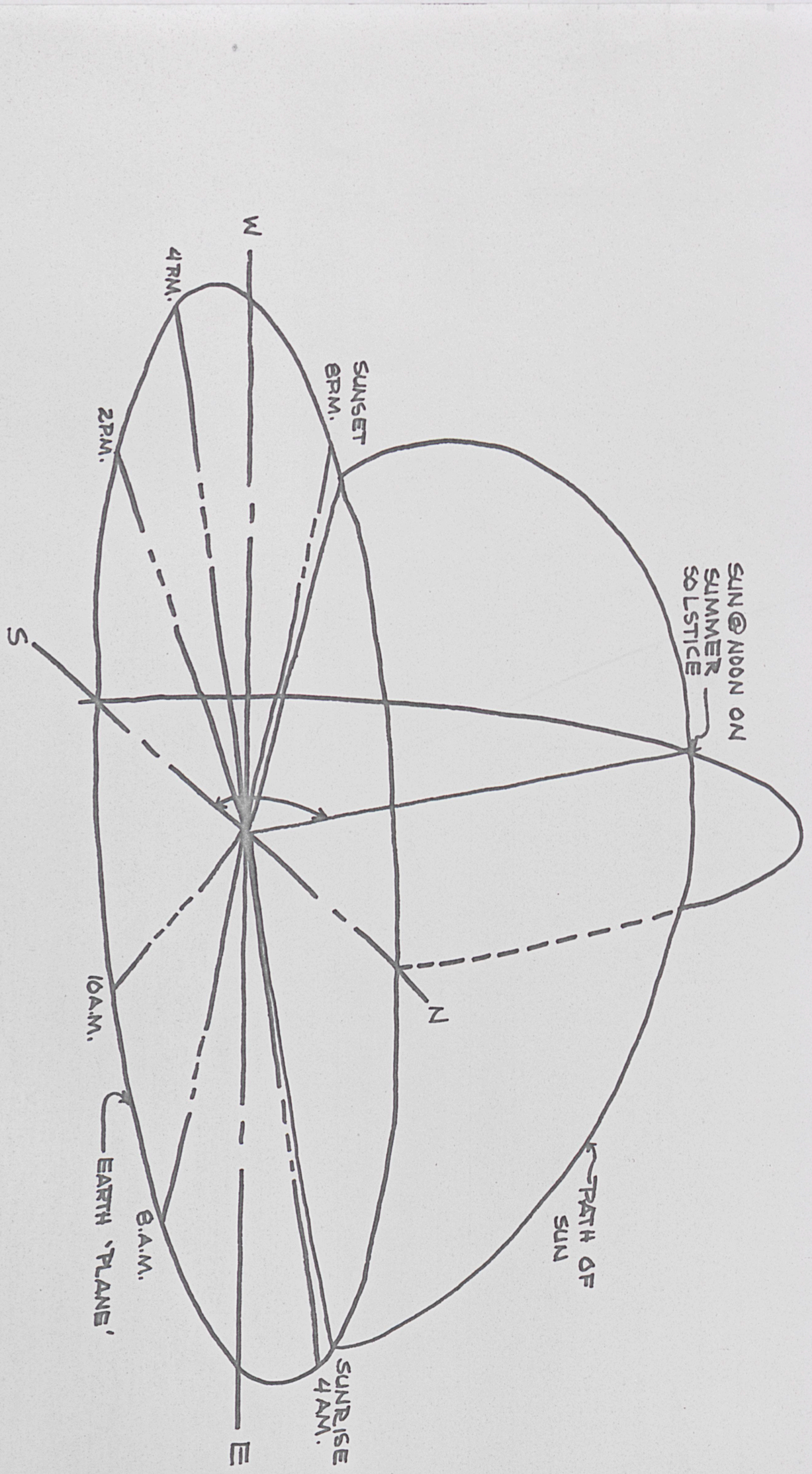
valley

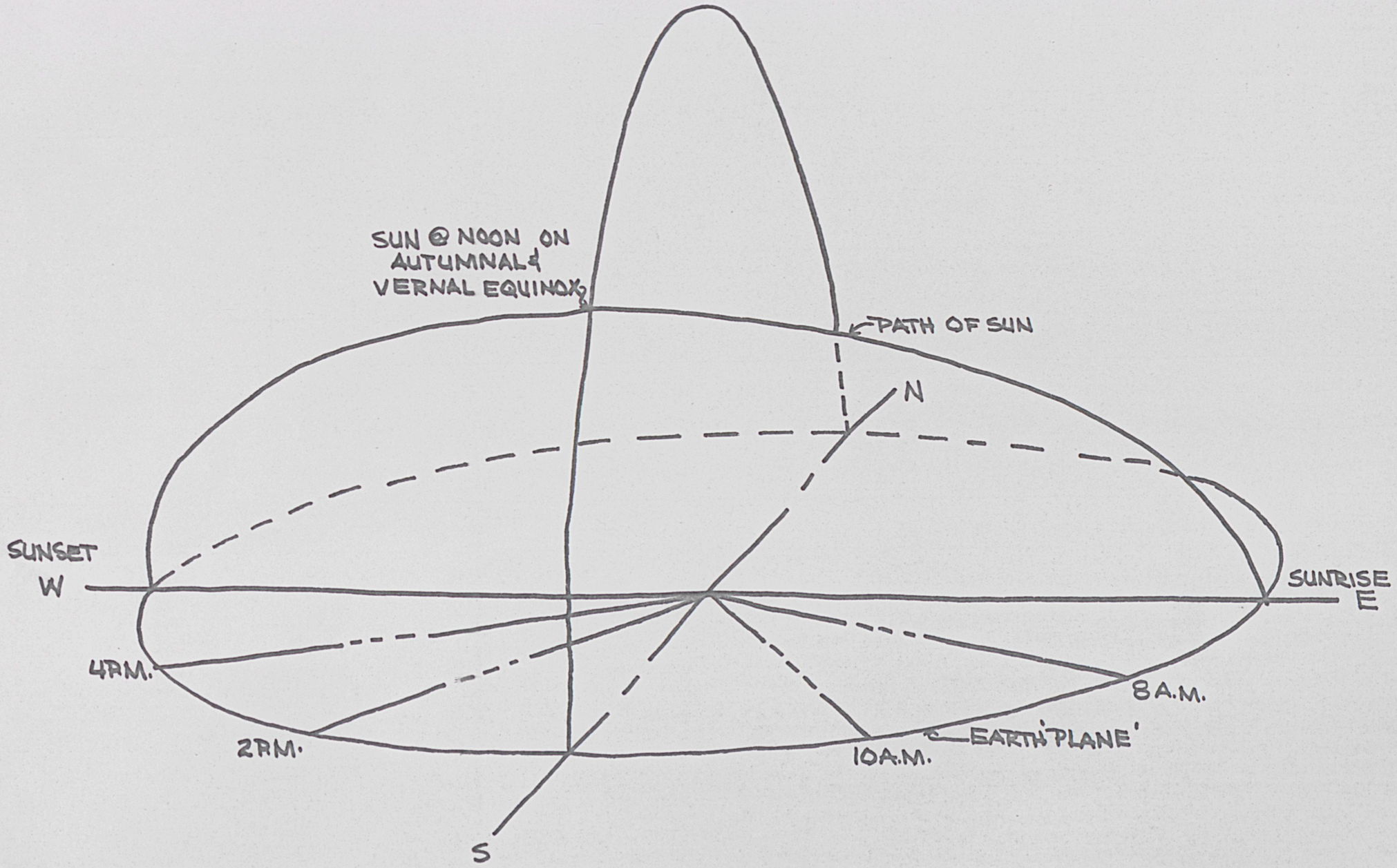

N
SUN @ NOON ON WINTER SOLSTICE
PATH OF SUN
2:30 P.M.
9:30 A.M.
W
E
4 P.M. SUNSET
8 A.M. SUNRISE
2 P.M.
10 A.M.
EARTH PLANE
S

valley

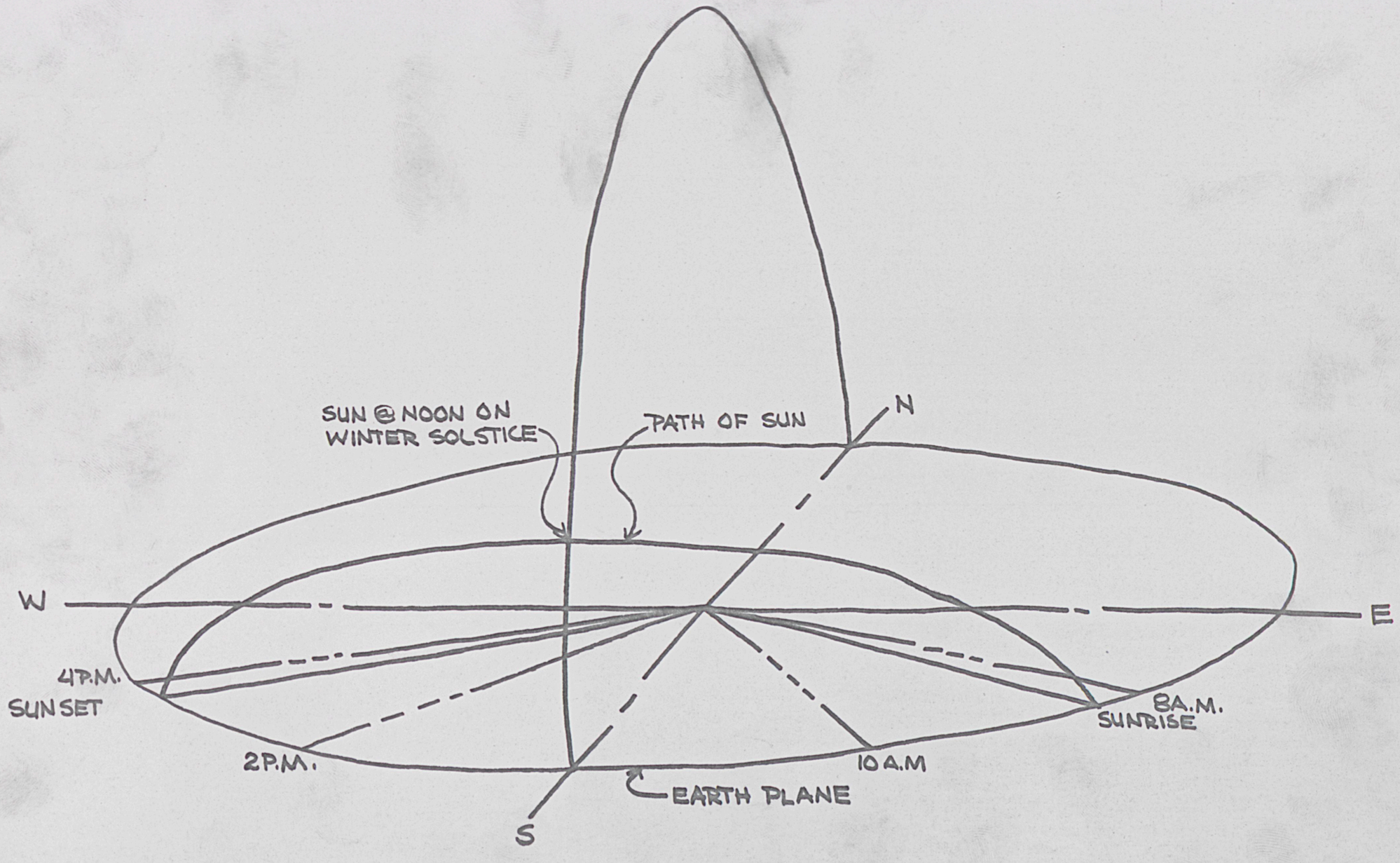

SUN @ NOON ON SUMMER SOLSTICE)
PATH OF SUN
6:00 P.M.
6:00 A.M.
N
SUNSET 8P.M.
SUNRISE 4 A.M.
W
E
4P.M.
8A.M.
2P.M.
10 A.M.
EARTH 'PLANE'
S

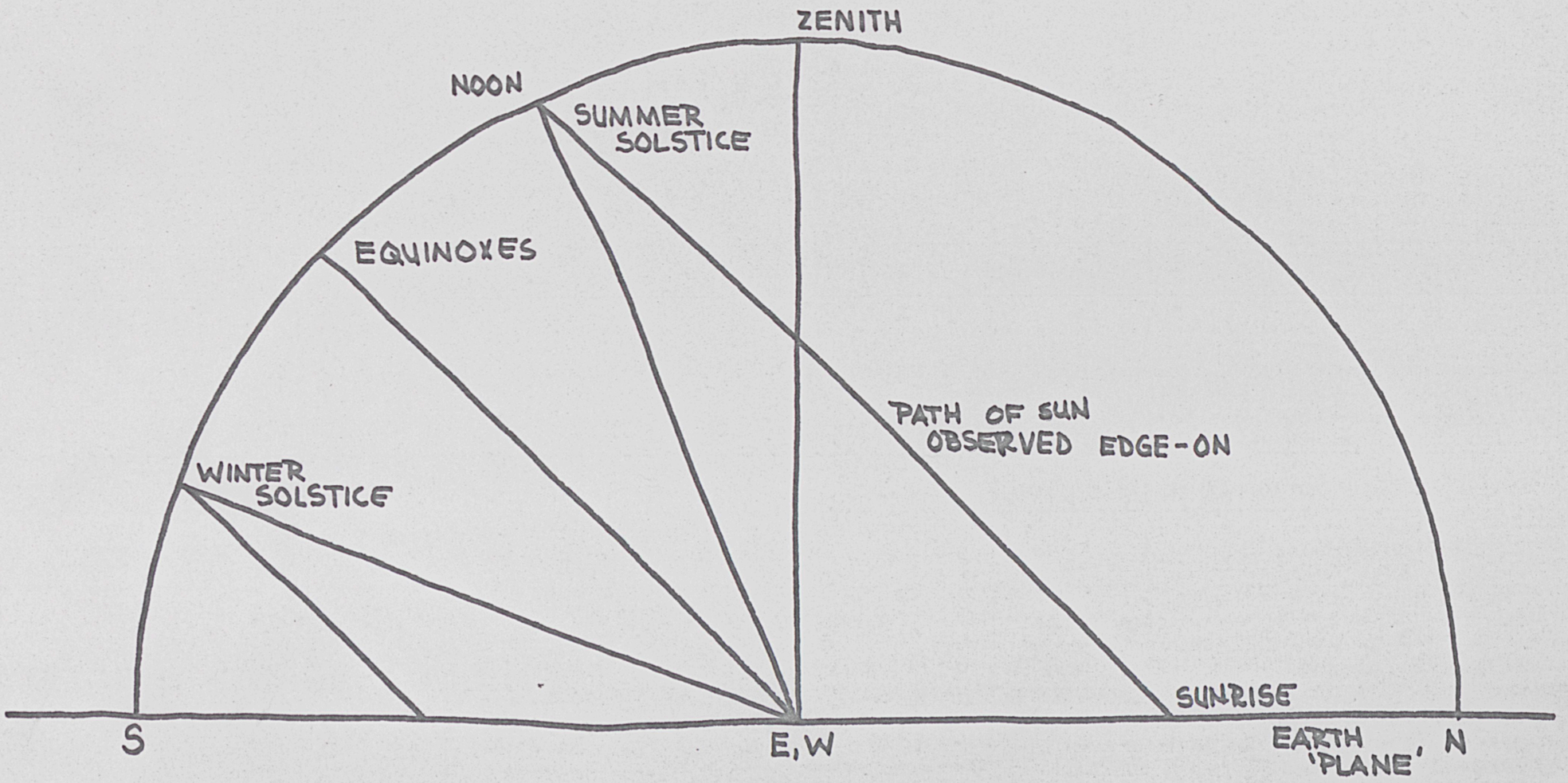

ZENITH
NOON
SUMMER SOLSTICE
EQUINOXES
PATH OF SUN - OBSERVED EDGE-ON
WINTER SOLSTICE
6:00 A.M.
9:30 A.M.
7:00 A.M.
SUNRISE
S
E.W.
N
EARTH 'PLANE'


SUN @ NOON ON SUMMER SOLSTICE
PATH OF SUN
SUNSET 8PM.
4PM.
2PM.
W
S
N
E
10A.M.
8A.M.
EARTH 'PLANE'
SUNRISE 4AM.


SUN @ NOON ON
AUTUMNAL &
VERNAL EQUINOX
PATH OF SUN
N
SUNSET
W
SUNRISE
E
4PM.
8A.M.
2PM.
10A.M.
EARTH 'PLANE'
S

mountain


SUN @ NOON ON
WINTER SOLSTICE
PATH OF SUN
N
W
E
S
4P.M.
SUN SET
2P.M.
10A.M
8A.M.
SUNRISE
EARTH PLANE


ZENITH
NOON
SUMMER SOLSTICE
EQUINOXES
WINTER SOLSTICE
PATH OF SUN OBSERVED EDGE-ON
SUNRISE
S
E, W
EARTH 'PLANE'
N

mountain

8000

8000

8400

7600

7200

6800

* MAGNIFICENT 360° VIEW
* BEDROCK LIMITATION
* HIGH WIND PROBLEM
* STRONG SOLAR IMPACT
* SNOW BUILD UP
* SEWAGE DISPOSAL

8752

* LIMITED VIEW
* SOME SOFT FOUNDATION PROBLEMS
* FLOODING
* WATERPROOFING
* LIMITED SOLAR HRS.

8000

7600

7200

6800

grayling

the narrows

hebgen lake

n

sites

0 2000

summary

8000

8400

7600

7200

6800

MADISON LIMESTONE BEDROCK

8000

7752

7600

7200

6800

grayling

ACTIVE COLLAPSE FEATURES

POTENTIAL COLLAPSE FEATURES

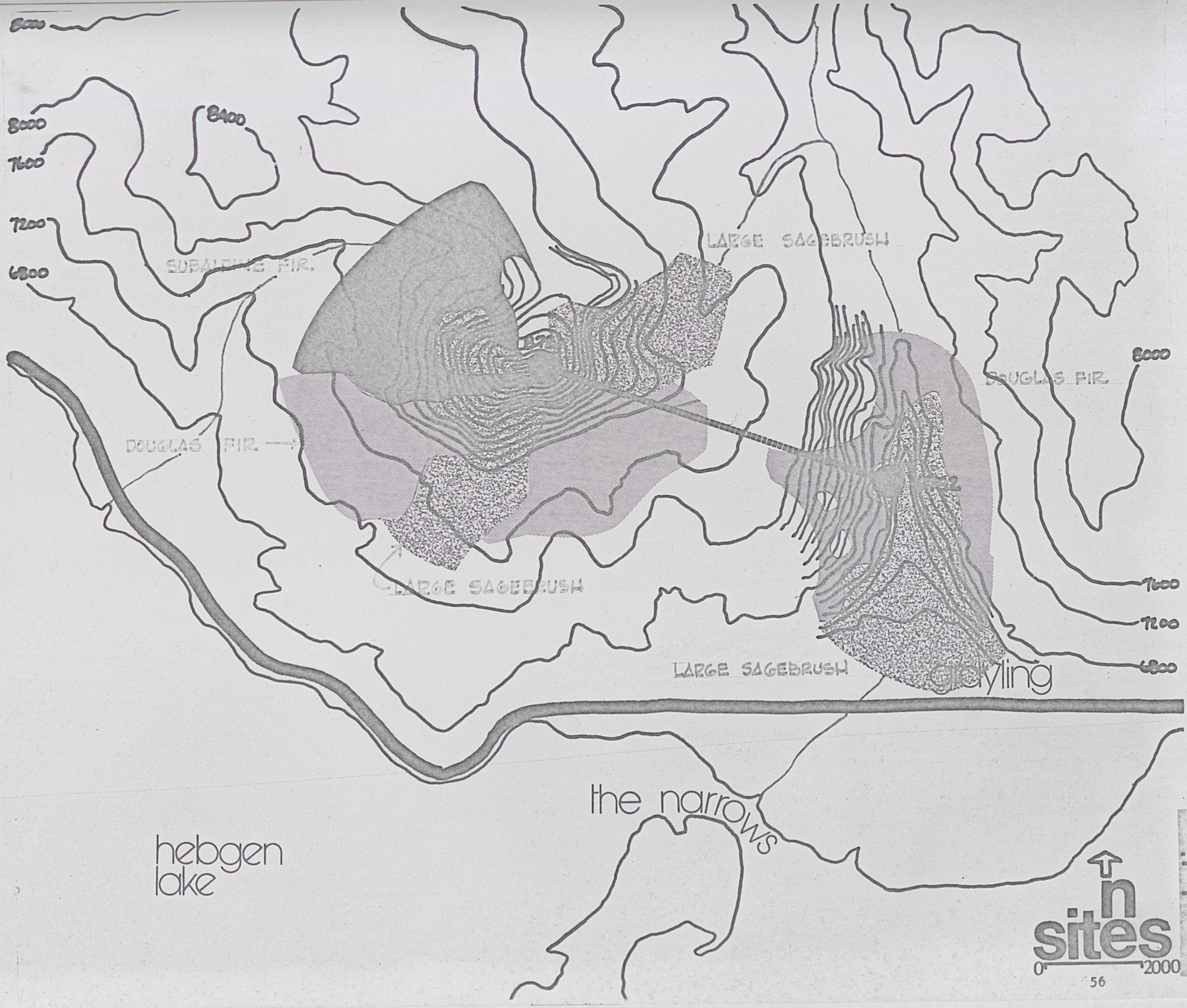
the narrows

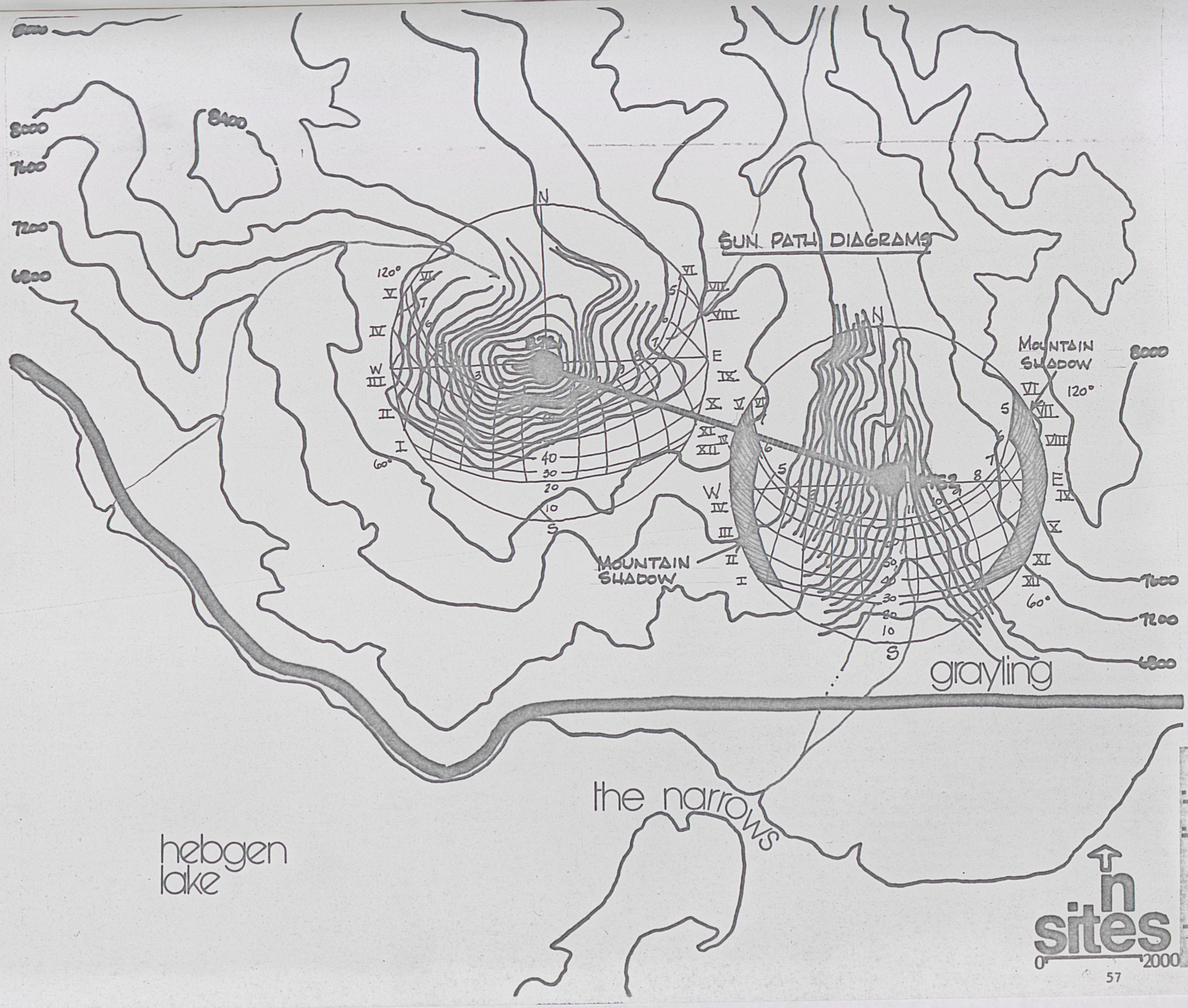
hebgen lake

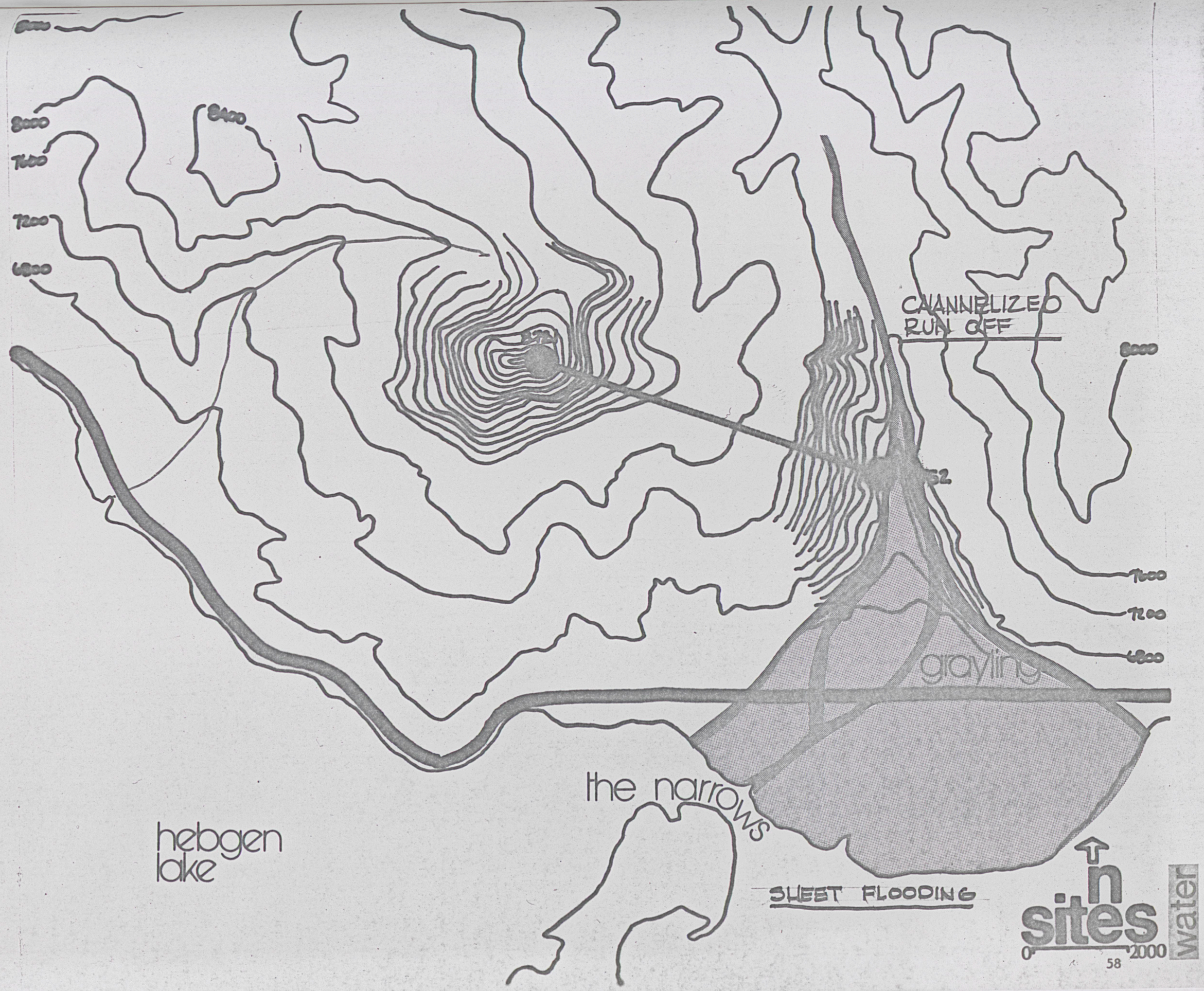
N

insites seismic

0 2000


8000
8000
8400
7600
7200
6800
SUBALPINE FIR.
LARGE SAGEBRUSH
DOUGLAS FIR.
DOUGLAS FIR.
LARGE SAGEBRUSH
LARGE SAGEBRUSH
8000
7600
7200
6800
grayling
the narrows
hebgen
lake
n
sites
0
2000
vegetation


SUN PATH DIAGRAMS
MOUNTAIN SHADOW
MOUNTAIN SHADOW
8000
8400
7600
7200
6800
N
E
S
W
120°
60°
40
30
20
10
grayling
the narrows
hebgen lake
n
sites
0
2000
solar radiation


8000
8400
7600
7200
6800
CHANNELIZED
RUN OFF
8000
7600
7200
6800
grayling
the narrows
hebgen
lake
SHEET FLOODING
n
sites
water
0
2000

8000

8400

8000

7600

7200

6800

FINE RESIDUUM
HIGH SHRINK S
FROST HEAVE
POTENTIAL

IDUUM COARSE
SHALLOW DEPTH
TO BEDROCK

752

SHALLOW DEPTH
TO BEDROCK

8000

7600

7200

6800

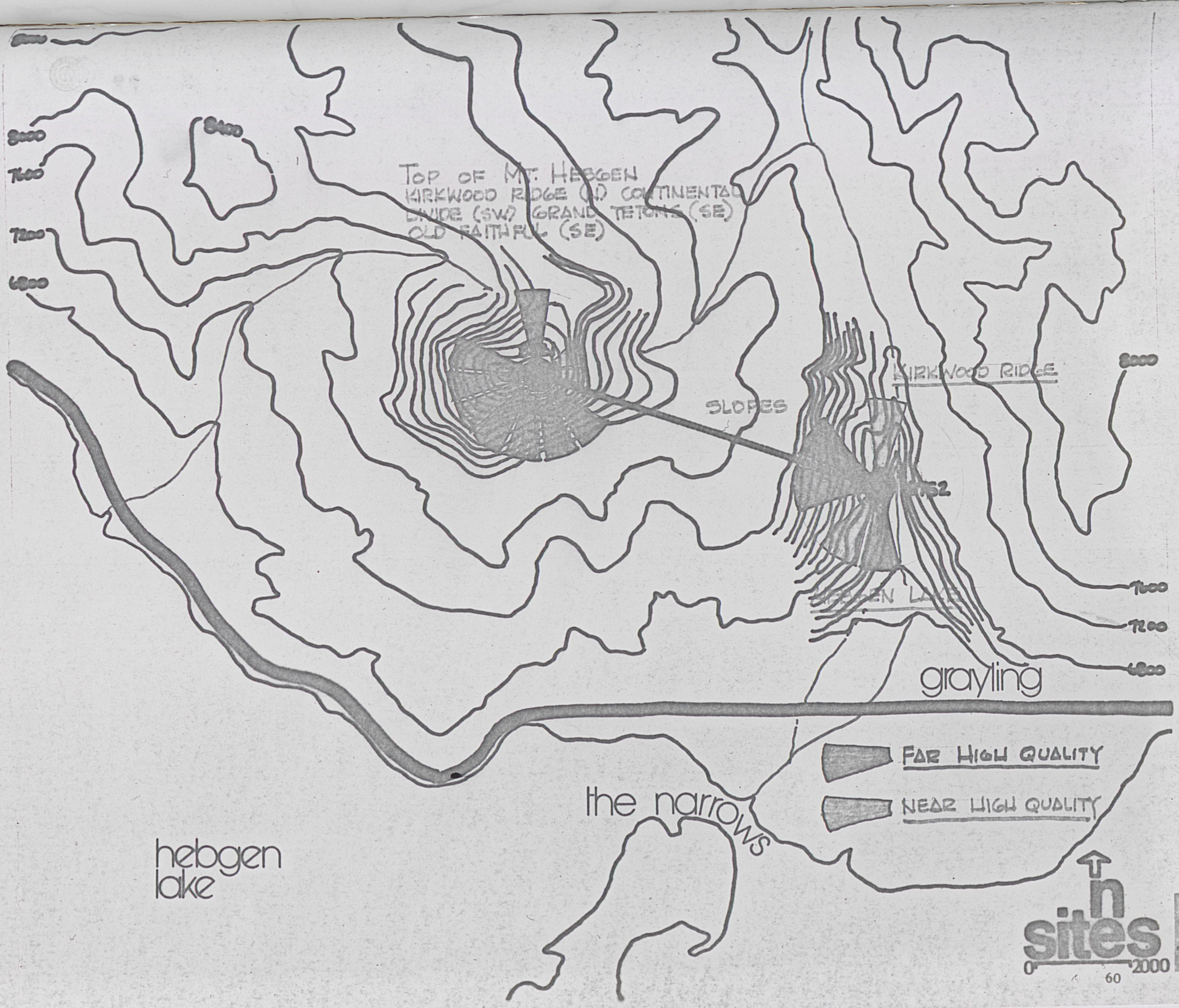
grayling

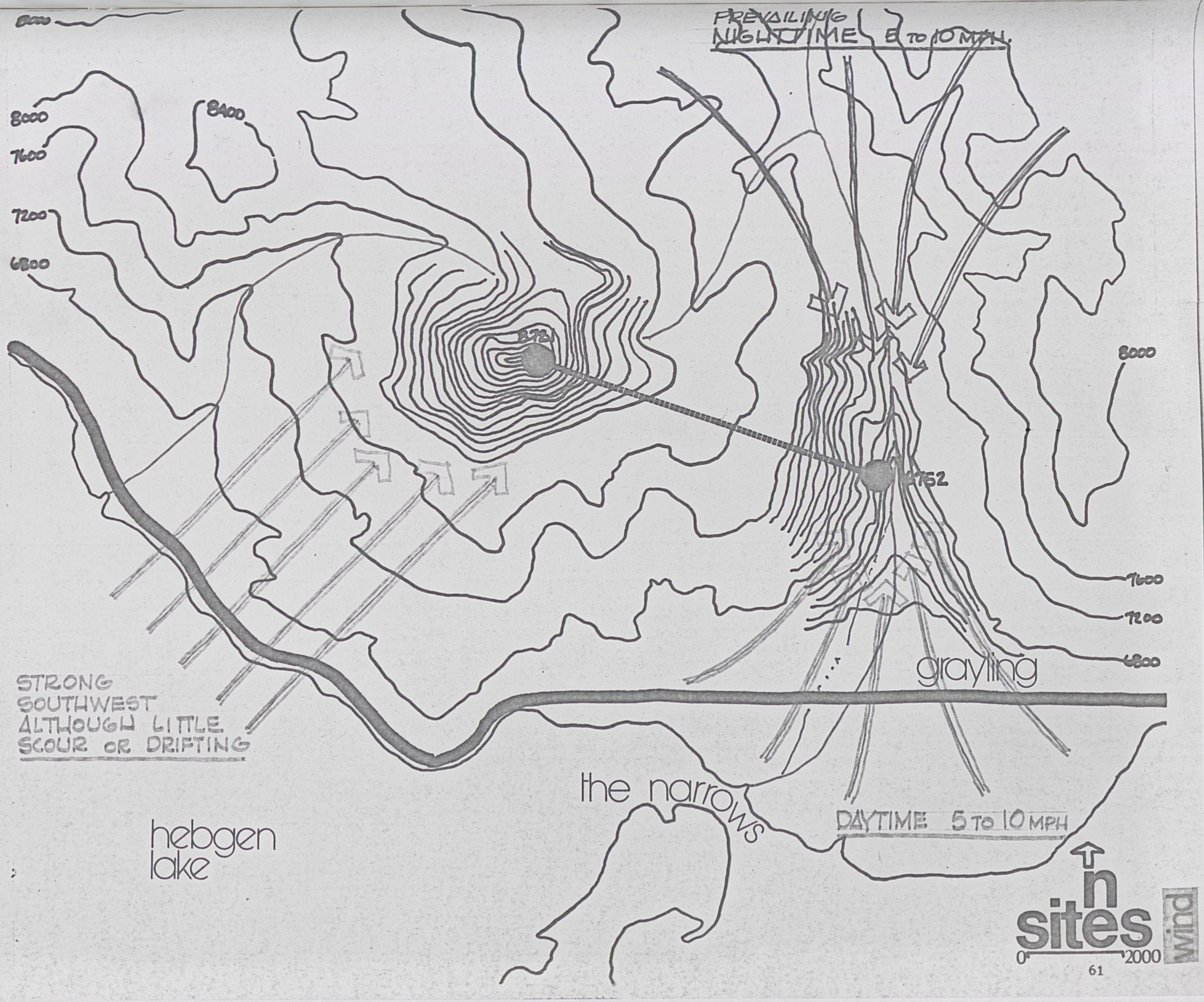
the narrows

hebgen
lake



geology


8000
8400
7600
7200
6800
TOP OF MT. HEBGEN
KIRKWOOD RIDGE (W) CONTINENTAL
DIVIDE (SW) GRAND TETONS (SE)
OLD FAITHFUL (SE)
SLOPES
KIRKWOOD RIDGE
8000
7600
7200
6800
grayling
FAR HIGH QUALITY
NEAR HIGH QUALITY
the narrows
hebgen
lake
in sites
0
2000
view


PREVAILING
NIGHTTIME 5 TO 10 MPH.
8000
8000
8400
7600
7200
6800
8781
8752
8000
7600
7200
6800
grayling
STRONG
SOUTHWEST
ALTHOUGH LITTLE
SCOUR OR DRIFTING
the narrows
DAYTIME 5 TO 10 MPH
hebgen
lake
n
sites
wind
0
2000

Physical Implication:

The previous material demonstrates the forces of the environment that effect the architectural solution through modification of energy conserving principles. This modification leads directly to physical implications for each building, its corresponding site and its influences.

The following sheets demonstrate only a few of the implications for each building.

Process Synthesis:

The process synthesis sheets that follow the physical implication material demonstrate the use of the principles and their site modified physical implication in the architectural solution for this thesis.

mountain

DAY CARE CENTER HAS HIGHEST NEED - LONG TERM ACTIVITY W/ WARM CLOTHING

* NEEDS ORIENTATION TO SUN WARMED OUTDOORS

valley

ROOM ORIENTATION

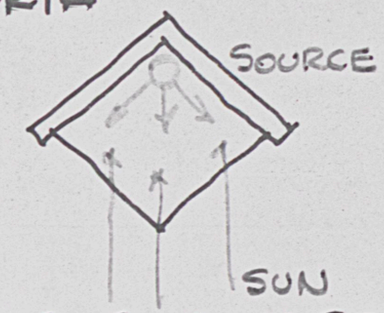
mountain

FEW ACTIVITIES

USE OF OPEN SPACE
TO ALLOW HEAT SHARE

THICK NORTH WALLS

HEAT SOURCE NEAR
NORTH



USE SUN ON SOUTH

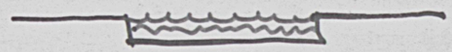
DARK COLORS

SEPARATION OF ACTIVITIES
W/ GLASS OR HIGH TRANS. MAT'L.
SEE HEAT TRANSFER.

DARK COLORS

TEMPERATURE INVERSION
REQUIRES GREATER HEAT STORAGE

WATER POOLS

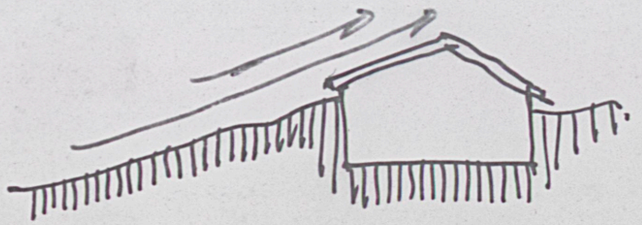


DARK COLORS

valley

mountain

MAINTAIN LOW PROFILE



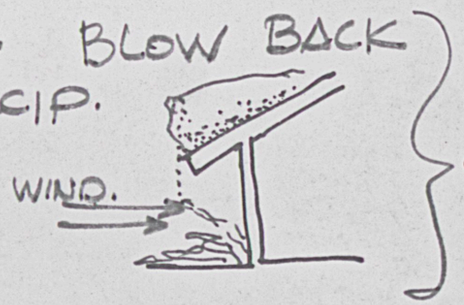
ORIENT BEHIND EXISTING PINES



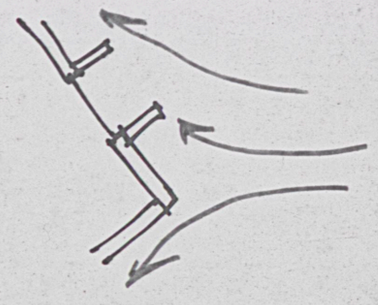
USE OF SLANTED ROOF

ORIENT WIND AWAY FROM GONDOLA ENTRANCE.

✓ PREVENT BLOW BACK OF PRECIP.



ORIENT WINDOWS OUT OF DIRECT WIND FLOW.

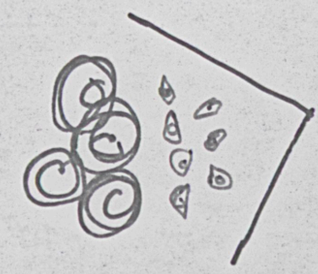


BURMS



- ROOF LINES TO COMPLIMENT BURMING.
- PROVIDE DRAINAGE AREA FOR BURM BACKWASH.

DIRECT WIND AWAY FROM PED. GATHERINGS



valley

mountain

ORIENT TO EATING AREA

BAR

EAST & SOUTH WALLS

HEAT STORAGE WALLS
ORIENTED TO EAST & SOUTH

ACTIVITIES IN PROXIMITY
INCLUDE:

- LONG TERM
  DAY CARE CENTER

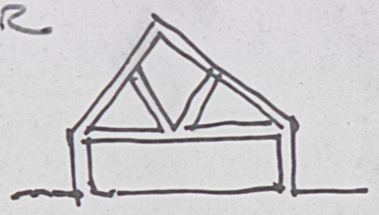
- SHORT TERM
  LITTLE NEED
  (HAVE COATS ON)

valley

mountain

120" SNOWFALL

STRUCTURE SIGNIFICANTLY STRONGER



DRAINAGE AWAY

ORIENT ROOF FOR WIND ASSISTED REMOVAL



USE AS ADDED INSULATION
REMOVAL NOT DESIRABLE

USE MATERIAL RESISTANT TO EXPANSION & CONTRACTION

√ SOD



HIGH NEED TO ORIENT ROOF DRAINAGE AWAY FROM SKIERS



LONG OVERHANGS

1. PROTECT BUILDING
2. " PEDESTRIAN

DELIVER DRAINAGE CLOSE TO GROUND

1. PROTECT WIND BLOW BACK



LARGER STRUCTURE
" PROBLEM

USE DRAINAGE MATERIALS NOT SUSEPTIBLE TO EXPANSION - CONTRACTION DAMAGE

valley

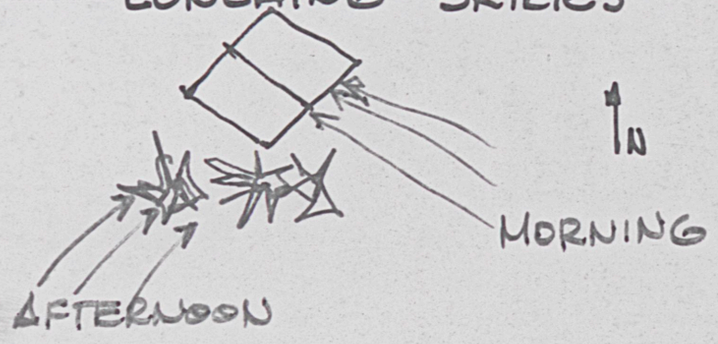
60" SNOWFALL

PRELIMINARY

mountain

EXPOSE TO CATCH MORNING RADIATION

HEAT BLDG FOR LUNCHING SKIERS



PROTECT WESTERN WALL

SPECIAL ACTIVITY ORIENT TO SETTING SUN

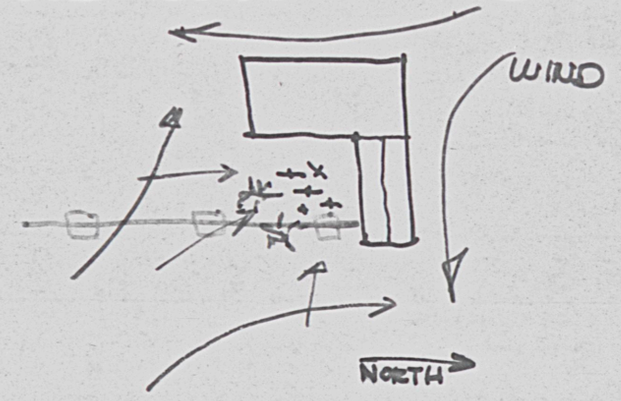
BAR

ORIENT FOR PROTECTED SOLAR COURT

- SUN TRAP
- WIND PROTECTED

PROMENADE FOR SKIERS

PRODUCE LONGER SE EXPOSURE



EXPOSE LITTLE WALL TO WEST EXPOSURE

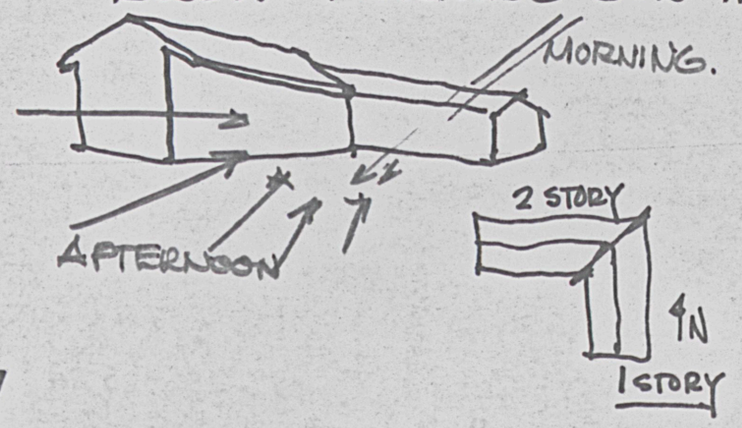
WEST EXPOSURE

NEED SUN IN LATE AFTERNOON

ALSO MORNING

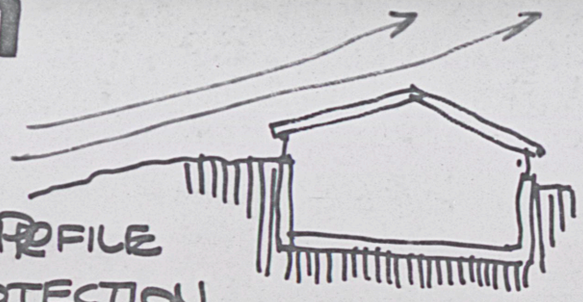
ORIENT TRAP TO SW

ALLOW MORNING SUN IN



valley

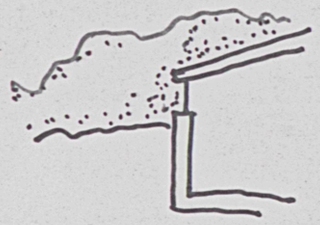
mountain



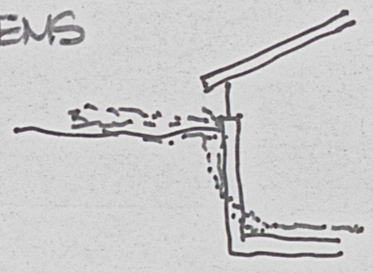
UNDERGROUND
- OFFERS LOW PROFILE FOR WIND PROTECTION
- EARTH INSULATION

INWARD DIRECTED ACTIVITIES W/ LITTLE NEED FOR VIEW
- SHOULD CAPITALIZE ON EARTH INSUL. VALUE
- ALSO ALLOWS EASY ACCESS TO PRIMARY USE FACILITIES

MUST REGARD SNOW DEPTH



WATERPROOF PROBLEMS



PROVIDE DENUMIDIFICATION DEVICE

EXCAVATION INTO BEDROCK WILL ALLOW

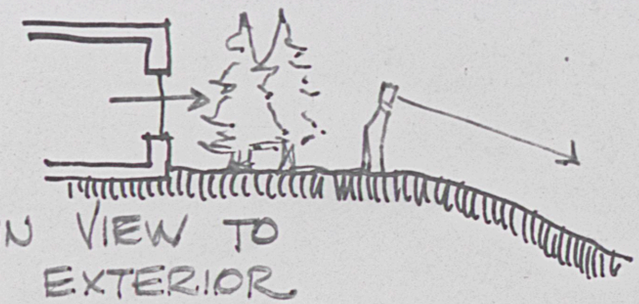
1. USE OF EXCESS FOR BLDG. PURPOSE
2. GRAVITY CAN HELP TRANSPORT STONE TO LOWER SITE W/ LITTLE ENERGY EXPENDITURE

valley

UNDERGROUND

mountain

BUILDING WILL USE WINDOWS FOR SHORT VIEW



MAIN VIEW TO BE EXTERIOR

BUILDING LOOKOUT AS POSSIBILITY



DINING ORIENTED W/ WINDOWS FOR SHORT VIEW

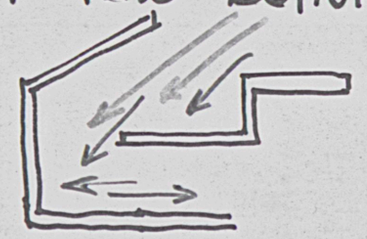
DINING ON LOOKOUT TERRACE

CLERESTORY WINDOWS
- TO CAPTURE LIGHT
- VIEW DESCENDING SKIERS



VIEWS OF PEDESTRIAN ACTIVITY
- WINDOWS ORIENTED FOR SHORT VIEW

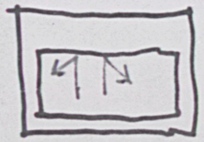
INWARD TYPE ACTIVITY
- WINDOWS USED TO LIGHT THIS ACTIVITY.



valley

mountain

* PROTECT AGAINST UNDESIRABLE NORTH WALL TRANSFER



* LARGELY OPEN IN PLAN

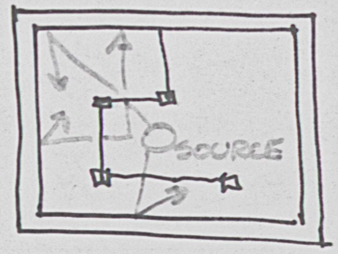
HEAT SOURCE PLACEMENT
NEAR NORTH EAST & NORTH WEST WALLS

THICKNESS INCREASE N. WALLS

STONE
WOOD
CONCRETE
EARTH

INTERIOR WALLS TO BE BUILT W/ HIGH U-VALUE TO ALLOW TRANSFER & ⁂ HEAT SHARE

- GLASS
  ALLOWS TRANSFER AND VISUAL ACTIVITY.

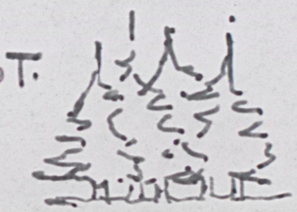


STONE
WOOD
CONCRETE
EARTH

valley

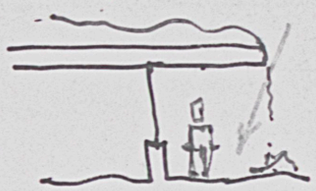
mountain

BUILD NORTH OF EXIST. STAND OF PINES



USE OF LONG HORIZONTAL OVERHANGS

- PERMIT WIDE HORI. VIEW
- SHIELD SUN
- AID WIND DIVERSION
- PROTECT PEDESTRIAN (SKIERS)



FEW WINDOWS IN SIZE & NUMBER

DOUBLE GLAZING

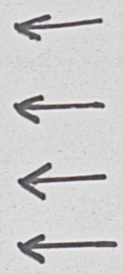
TINTED GLASS (REFLECTIVE HAS HIGH IMPACT)

SHUTTERS (EXT.)

* USE OF SUN AS HEATING METHOD ALMOST SOLELY.

PLANTING IS POSSIBLE WATER AVAILIBICITY

LONG HORIZONTAL OVERHANGS



WINDOWS

DOUBLE GLAZED
TINTED

INCREASED NUMBER (MORE ACTIVITY)

SHUTTERS

LIMITED VIEW ALLOWS VERTICAL SHIELD

valley

mountain

LEAN & CLEAN

- ALLOWS ELEVATED ENTRANCE BECAUSE OF SNOW DEPTH
- LARGER VOLUME FOR LARGER GROUPS



BALCONIES UTILIZE RISING HEAT

SIMPLIFIED PLANS YIELD SIMPLIFIED ELEVATION

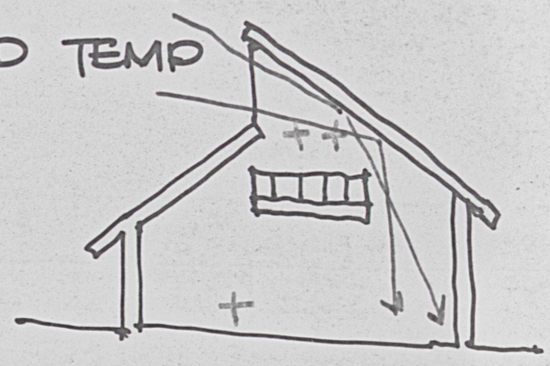
REDUCE IRREGULAR PLANS

LEAN & CLEAN

TWO STORY BLDG. YIELDS MORE EFFICIENT RATIO

ALSO ALLOWS

- REACH FOR SUN
- GRADUATED TEMP RANGE



valley

mountain

OPENINGS TO BE SHIELDED ON HIGHEST AIR MOVEMENT SIDE

USE OF VEGETATION

ENTRANCE

THROUGH PROTECTED GONDOLA ENTRANCE

SMALL WINDOWS

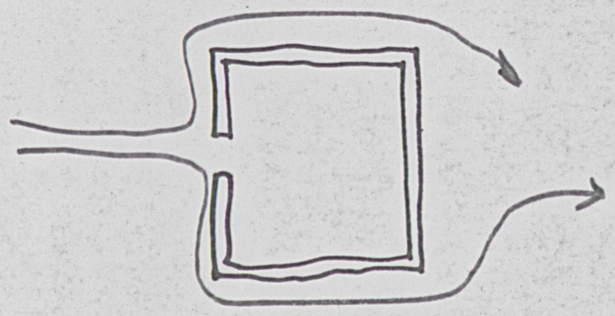
- SMALL PERIMETER
- FOR LIGHT

VIEW (IN TURN WINDOW LIMITATION) LIMITED TO EXTERIOR OBSERVATION

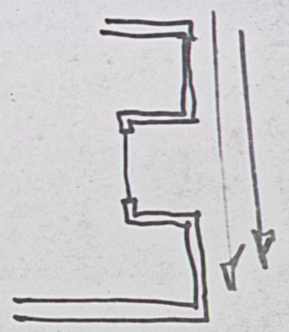
FRAMES

- SIMPLE DETAILS
- HIGH HEAT STORAGE (WOOD)

FEW OPENINGS ON SIDE OF WIND SHADOW

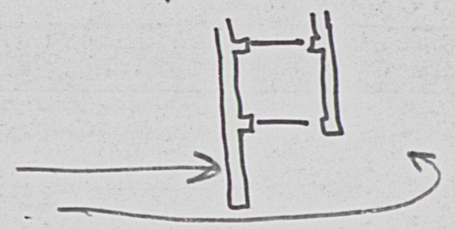


WINDOWS INSET



LOW PROFILE RELATIVE TO WIND W/ USE OF BURMS

DOUBLE PROTECTED OPENINGS

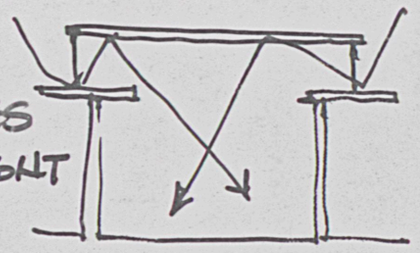


valley

mountain

SMALL WINDOWS
PROTECT SOLAR HEAT GAIN
STRATEGICALLY PLACED

LARGE GATHERINGS
REQUIRE LARGE SPACES
∴ GENERAL LIGHT BROUGHT IN HIGH

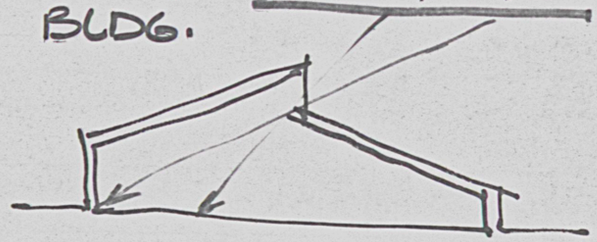


* USE LIGHT TO HEIGHTEN OUTDOOR EXPERIENCE, INDOOR

ALMOST ENTIRELY
NATURALLY LIGHTED.

LONGER TERM ACTIVITIES
DICTATE MORE CONTROLLED
COMFORT LEVEL

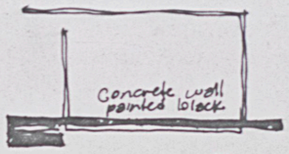
NEED TO USE LIGHT IN SUCH A WAY AS TO PENETRATE LARGER BLDG.

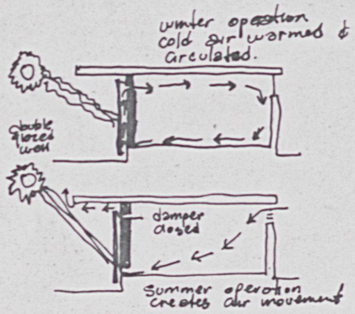


ACTIVITIES THAT EXTEND BEYOND AND BEGIN BEFORE GENERAL USE HOURS NEED MORE LIGHT TO LIMIT ANY MECHANICAL LOAD.

FIND COMPROMISE BETWEEN
LIGHT AMOUNT DESIGNED FOR
CLOUD COVER & SOLAR OVERLOAD

valley





- solar wall idea enlarged to circulation way

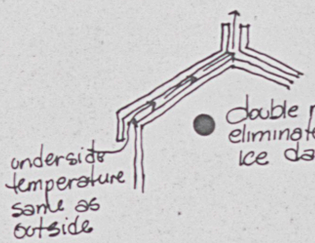
- building configuration & orientation reduce storm impacts

- selective view

- lean & clean elevations oriented to storm sides reduce infiltration

- few windows double glazed

- reduced temperature design



- double roof eliminates ice damming

interior shutters

- operable windows & vented skylight produce cross ventilation

- use of natural lighting through clerestory

- selective view

long overhangs prevent precipitation blow back

- pedestrian protection with long overhangs

- increased insulation levels determined by marginal analysis

- task lighting in all areas

- use of solar type wall

- roofs oriented to protect pedestrian movement

- enclosed circulation way (unheated)

- heat share

shops & lobby share through glass partitions

heat share

- sun court

- selective view

- day care skylight orientation to morning sun

- roof drain away from pedestrian area

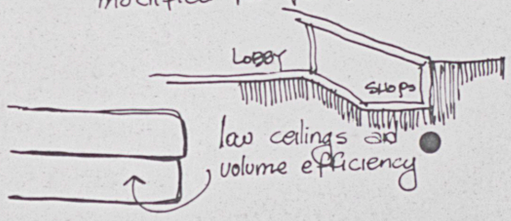
- volume efficiency through second level utilization

- double doors provide air lock at entrances

- orientation provided with double southeast exposures (provides reduction of summer heat gain)

- sun court & corresponding solar wall oriented to south east for high winter heat gain.

- original intention to bury large extent of building (inward oriented activity esp. shops, daycare, mech. etc.) modified for functional reasons

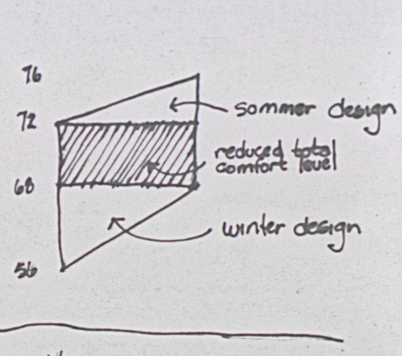


- low ceilings and volume efficiency

- mechanical design

1. radiant coils in lobby to heat slab & evaporate water in carpet (allows reduced heat in lobby
2. sun court deck utilizes radiant to melt precipitation
   heat exchangers to utilize excess heat from court at night
   heat exchangers to utilize excess heat from exhaust air
3. fin tube radiant heat in long term activity areas

- structural strength expressed because of high snow loads
- long overhangs
- double story aids
- Volume effect reduces roof area & corresponding heat loss
- elevated floor levels aid entrance in deep snow
- double roof system eliminate ice damming
- northern storms diverted with roofs & orientation
- long overhangs prevent ice & snow & water blow back
- all windows double glazed & sealed
- double door lock
- heat share
- naturally north lighted
- bar & cafeteria
- heat share
- deck activity protected by building & trees
- cross ventilation w/ operable windows
- interior shutters
- roofs slopes oriented away from pedestrian activity
- infiltration assisted by window orientation double glass extra sealing
- structure expressed to Gondola arrival
- bar and deck oriented to capture afternoon sunlight
- bar & cafeteria oriented to view gondola arrival
- roof slope
- Siting behind trees
- & back from edge provide wind protection from high southwest winds
- Use of lookout as entity rather than building
- building setback eliminates obtrusion to skyline.
- radiation control through orientation of plan & siting
- major expanse of roofs directed for heat gain
- twice wall oriented to south east for winter heat gain & summer heat gain reduction
- column & glulam construction method reduce energy expenditure & provide conscious site conservation effort (eliminates excavation & soil disturbance.)
- low temperature design



Sewer transported to valley for disposal rather than contaminate mountain top

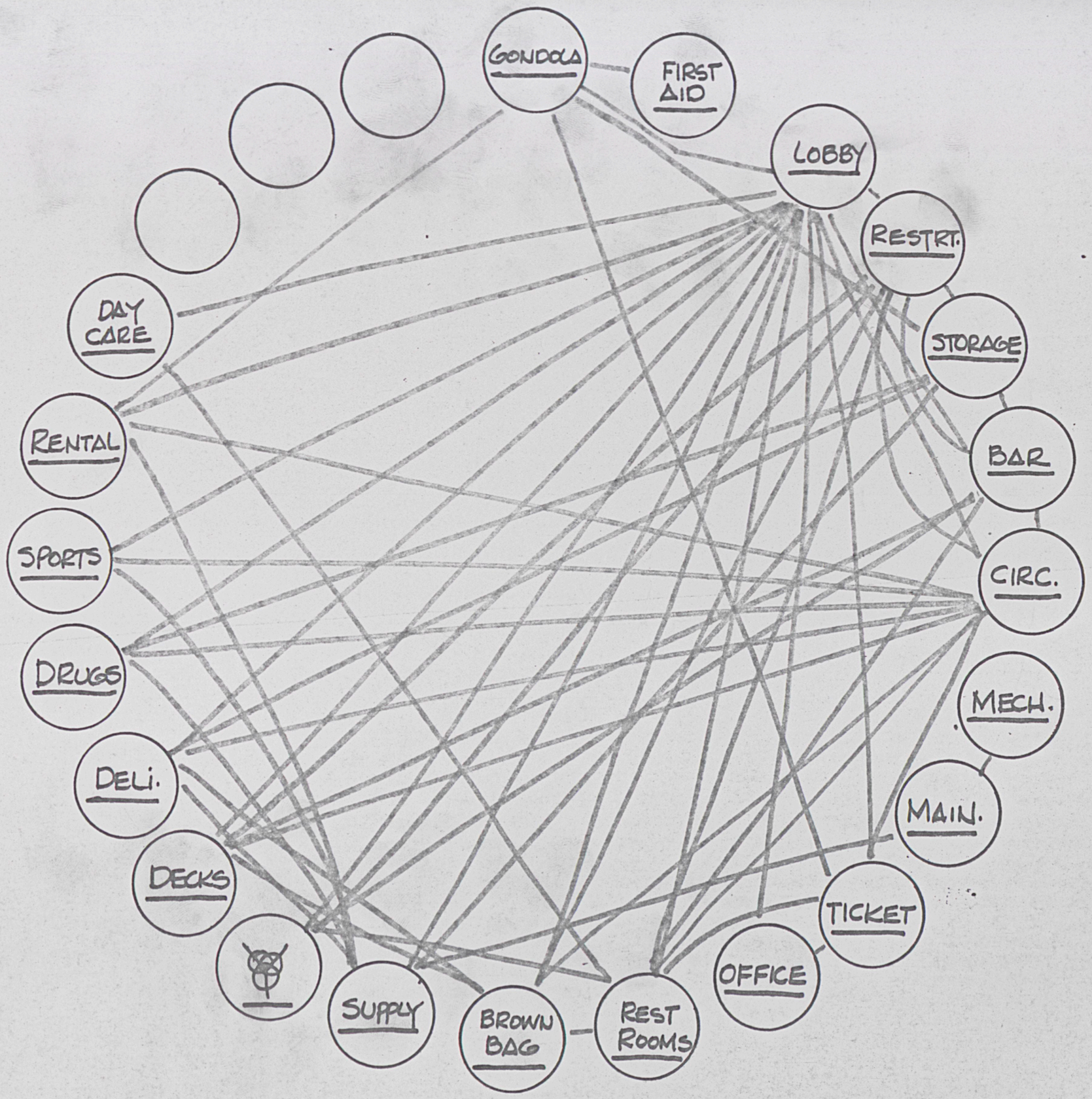
PROGRAM

PROGRAM

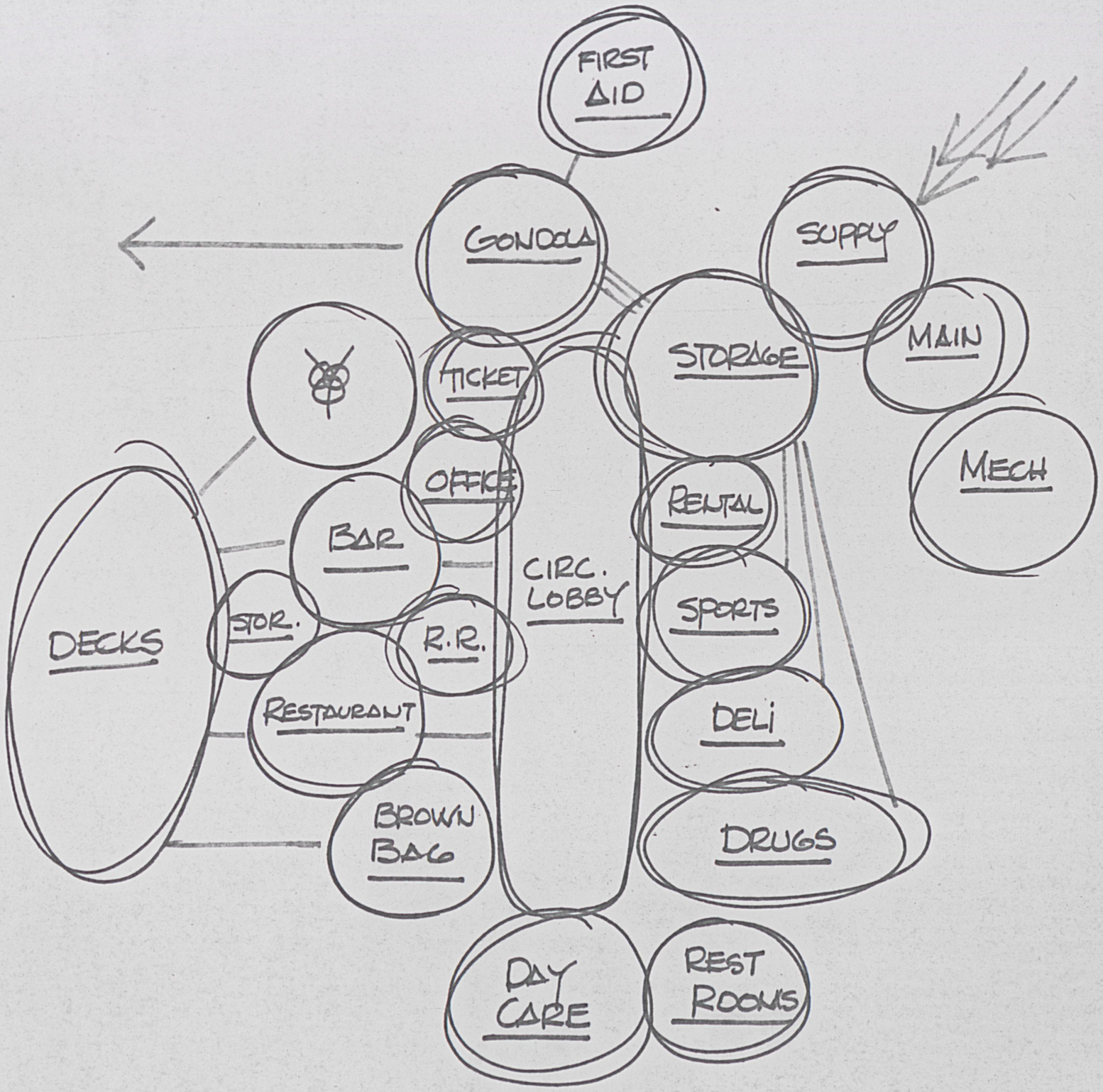
The following section tabulates the functions and square footage requirements of both the mountain top restaurant and the valley commercial day center. Each sheet diagrams the relation of the function to all other functions as well as a diagram representing a schematic of each function.

GONDOLA AREA
FIRST AID & RESCUE
LOBBY
RESTAURANT · CAFTR.
STORAGE
BAR
CIRCULATION
MECHANICAL
BLDG. MAINTENENCE
TICKETING
OFFICES
RESTROOMS
BROWN BAG
SUPPLY
SKI YELLOWSTONE H.
OBSERVATION DECKS
DELI · GROCERY
DRUGS
SPORTS
RENTAL
DAY CARE

valley


GONDOLA
FIRST AID
LOBBY
RESTRT.
STORAGE
BAR
CIRC.
MECH.
MAIN.
TICKET
OFFICE
REST ROOMS
BROWN BAG
SUPPLY
DECKS
DELI.
DRUGS
RENTAL
SPORTS
DAY CARE

valley


FIRST AID
GONDOLA
SUPPLY
MAIN
STORAGE
TICKET
MECH
OFFICE
RENTAL
BAR
CIRC. LOBBY
SPORTS
DECKS
STOR.
R.R.
RESTAURANT
DELI
BROWN BAG
DRUGS
DAY CARE
REST ROOMS

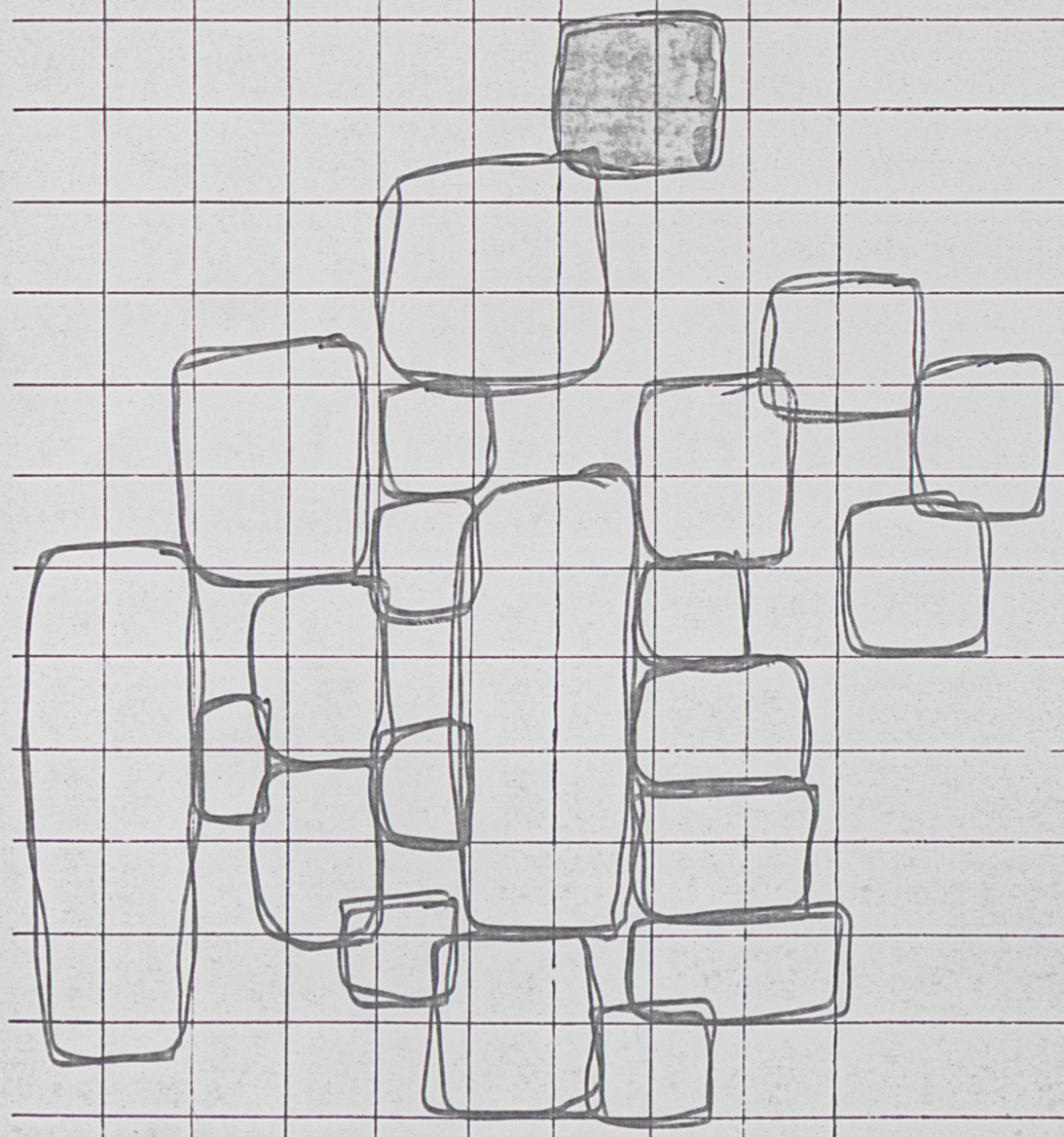
valley

activity: FIRST AID + RESCUE

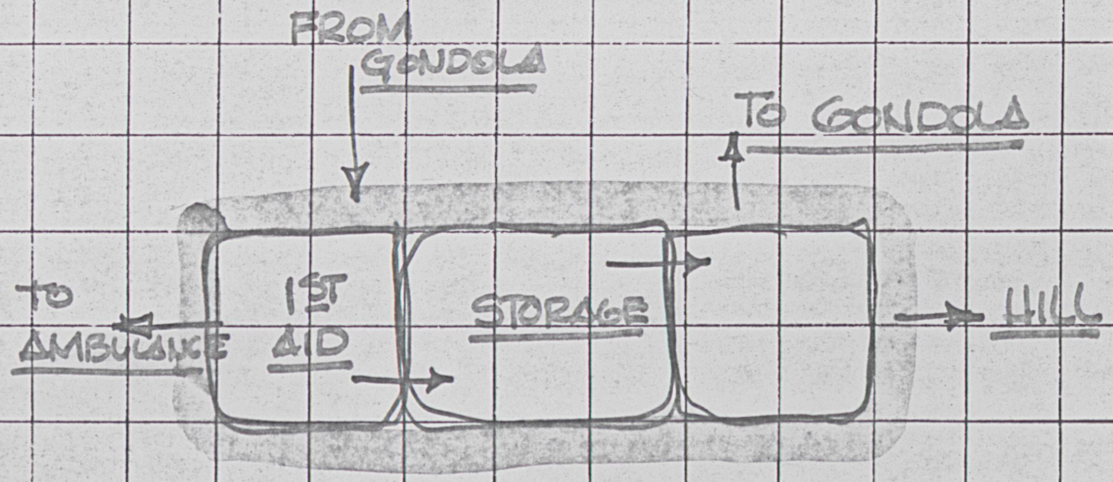
space: 700 SQ. FT.

SKI PATROL STATION
TOBOGGAN STORAGE
MARKERS
COT (MEDICAL AREA)

relation:



schematic:

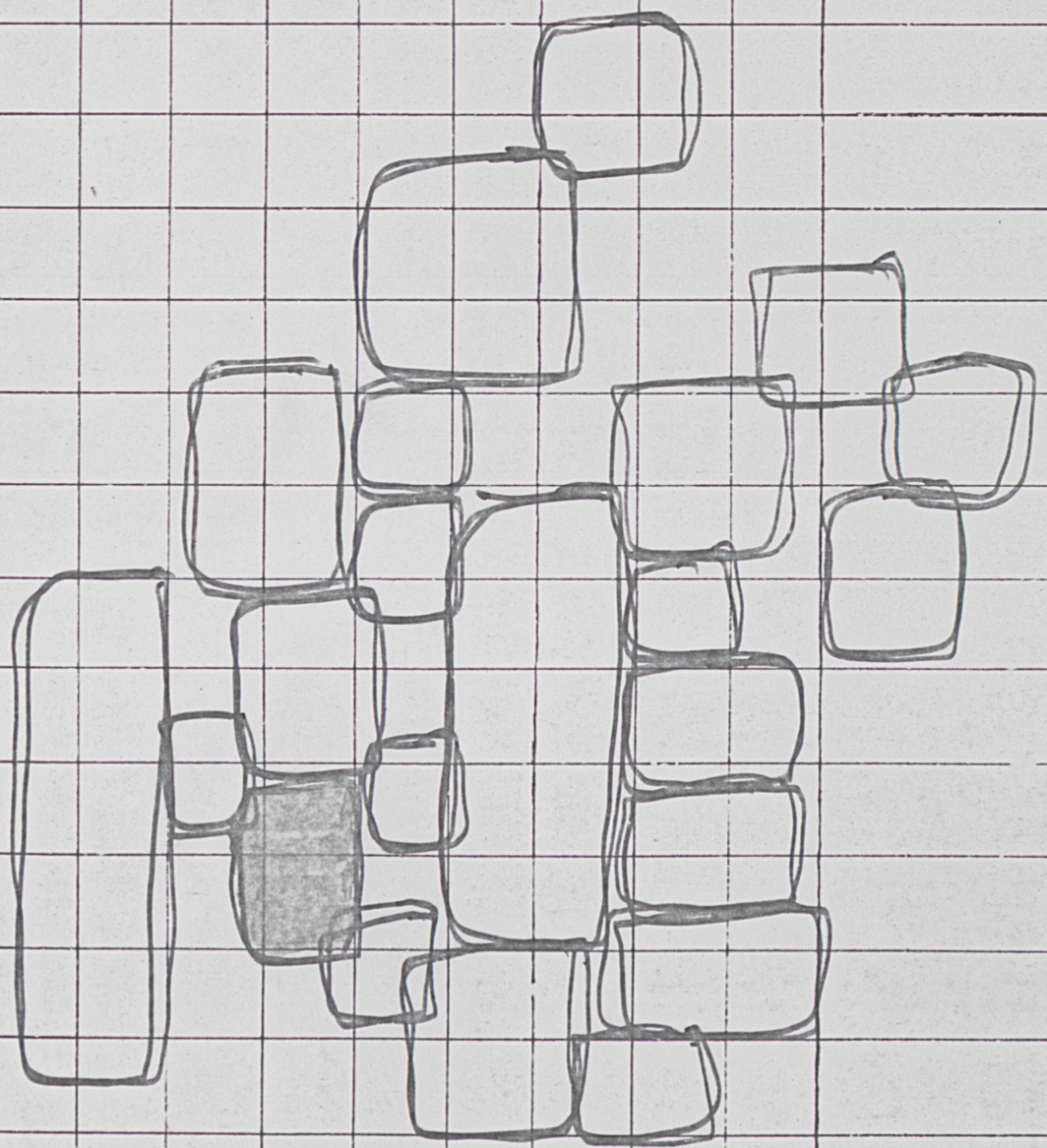


activity: RESTAURANT ... CAFTR.

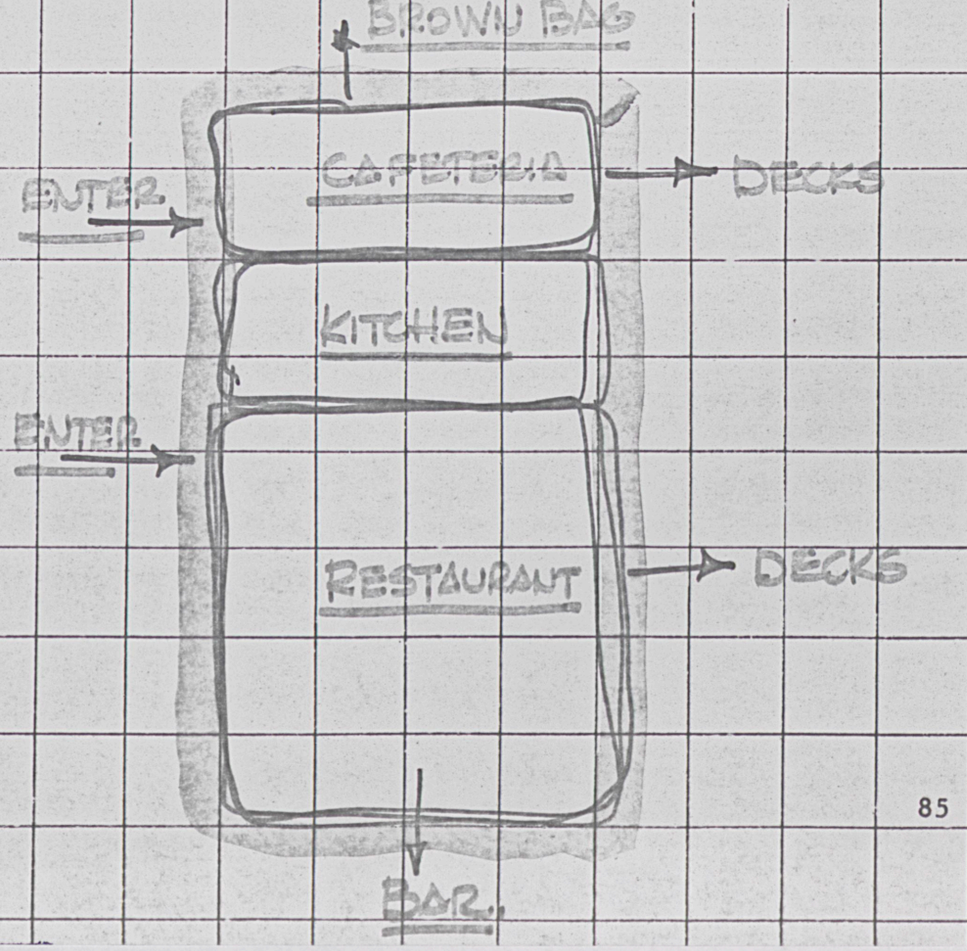
space: 3400 SQ. FT.

FOOD
FROZEN
DRY
CANNED
COOKING
RESTAURANT
CAFITERIA

relation:



schematic:

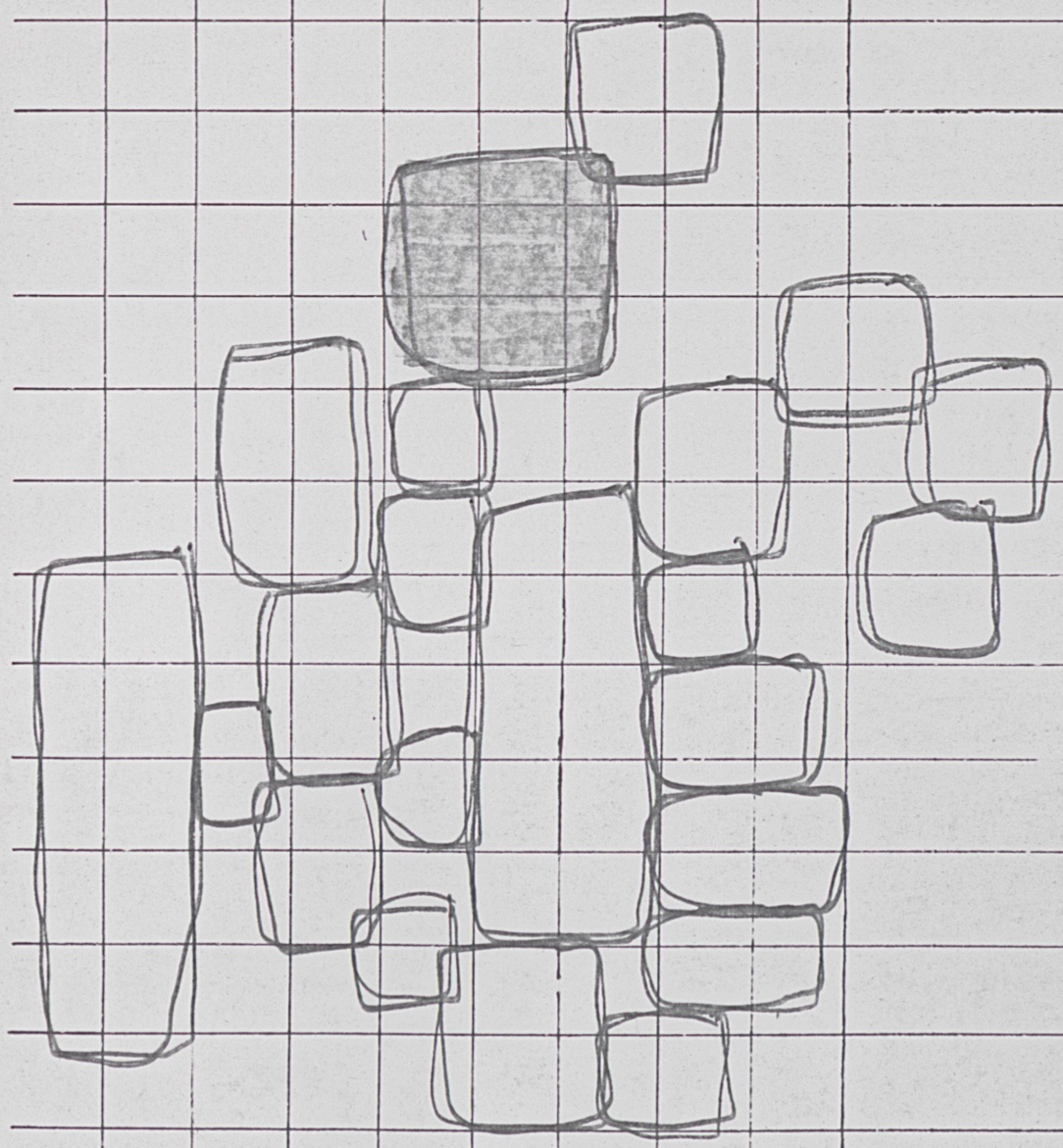


activity: GONDOLA AREA

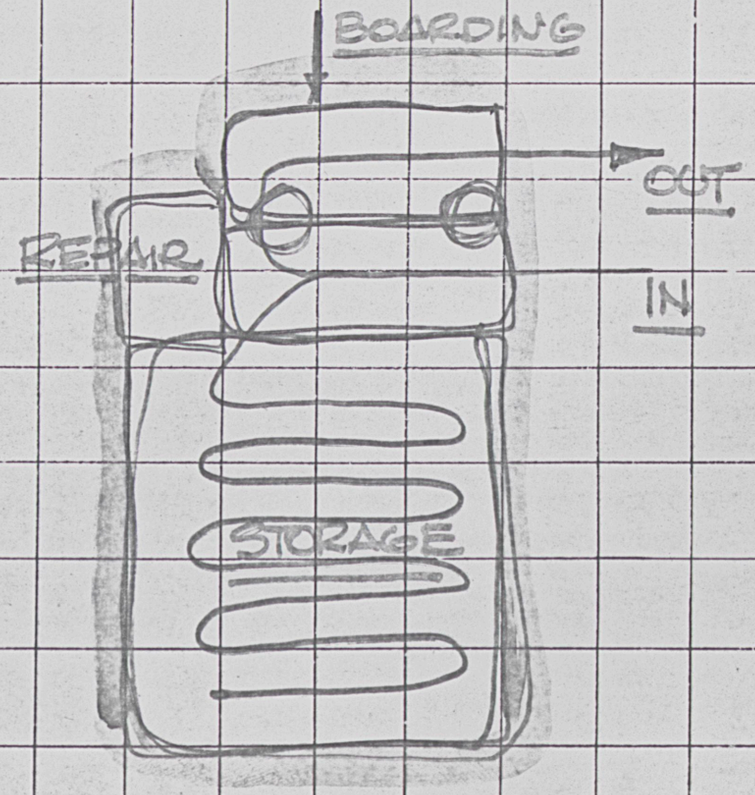
space: 6400 SQ. FT.

GON. IN
GON. OUT
GON. STORAGE 2/3
REPAIR CAR
SKIER ENTER
ENGINE

relation:



schematic:

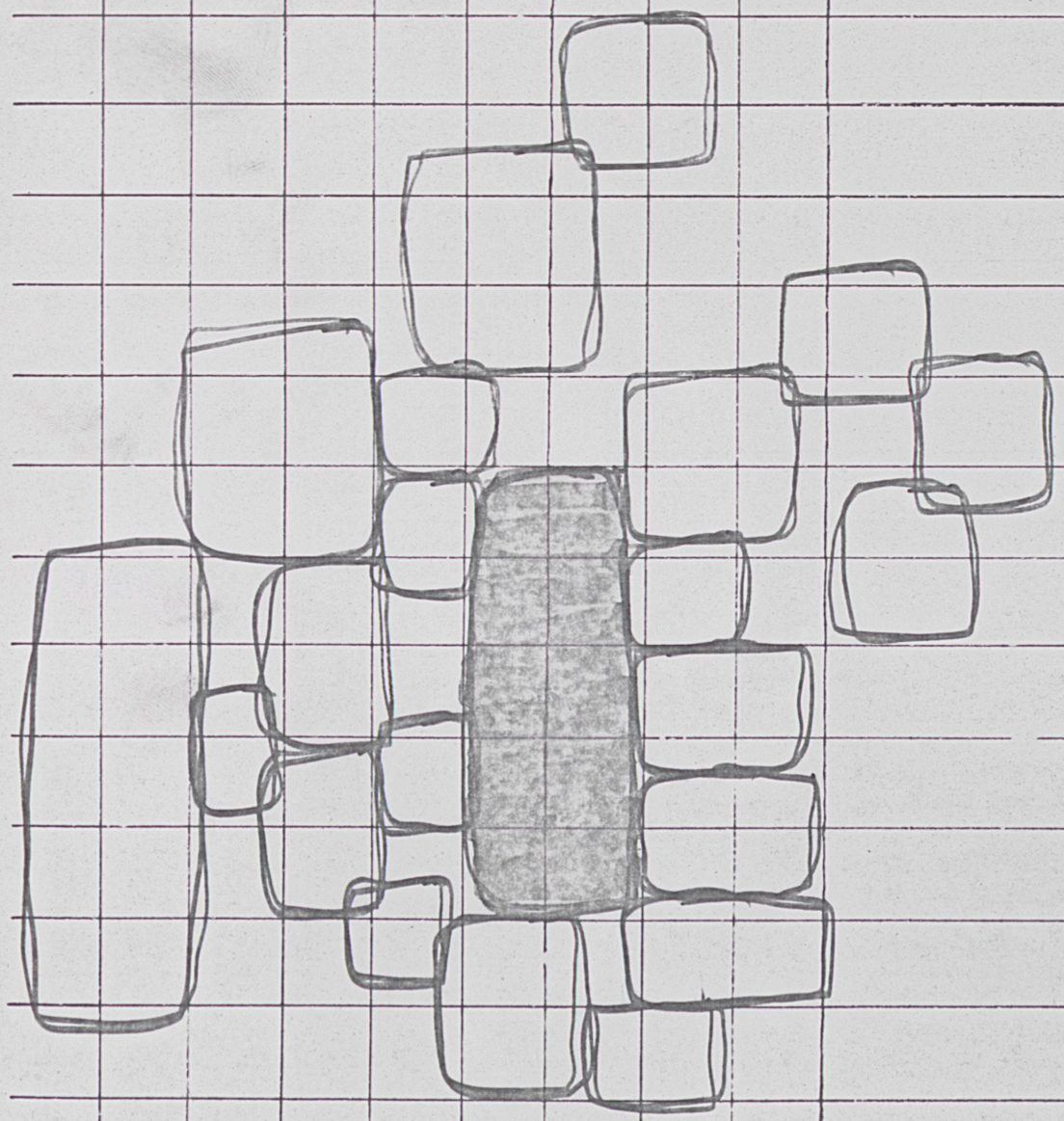


activity: LOBBY ... CIRCULATION

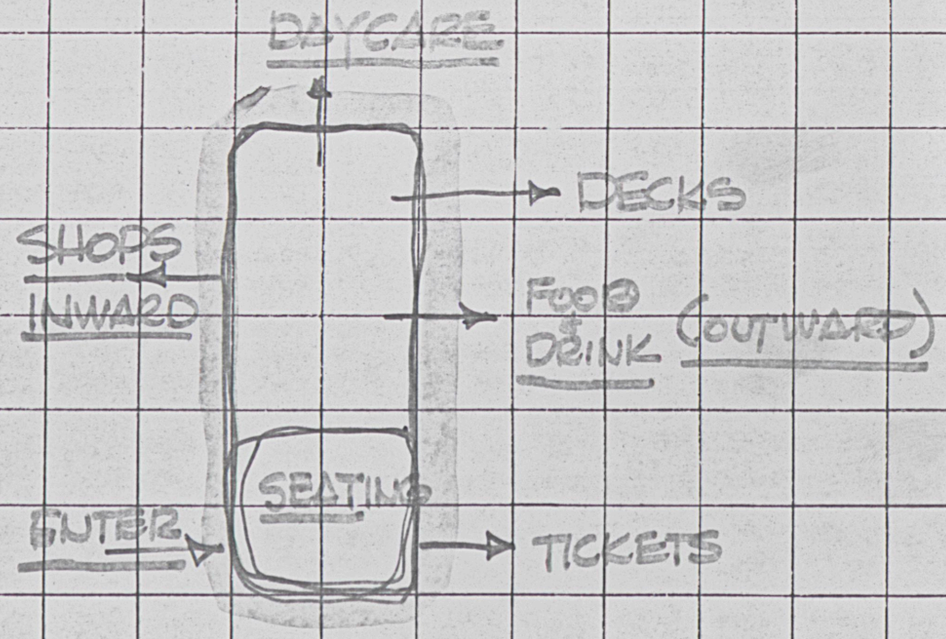
space: 11,000 SQ. FT.

ACCESS TO:
FOOD & DRINK
SHOPS
SEATING
LOCKERS
DAYCARE

relation:



schematic:

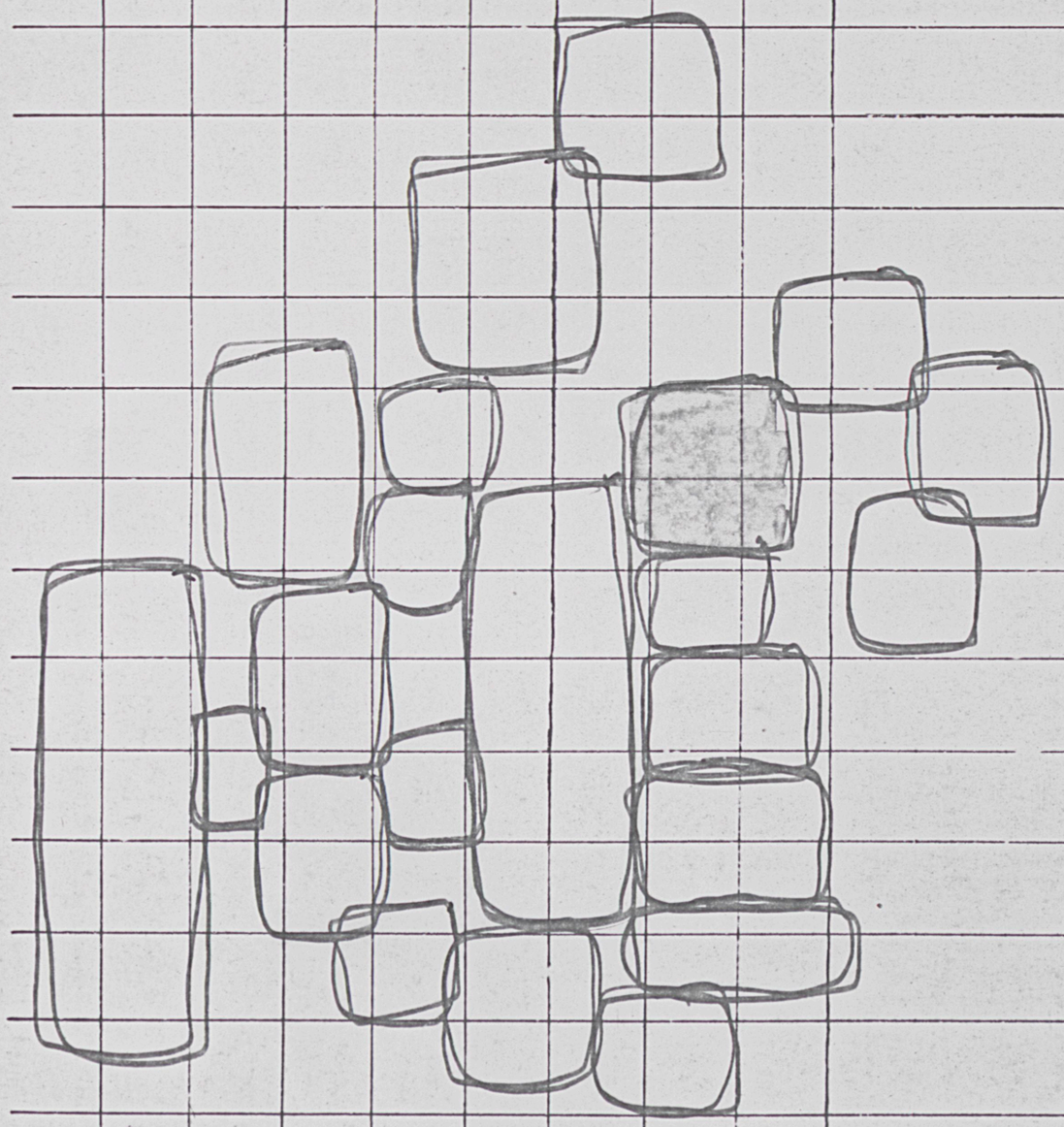


activity: STORAGE

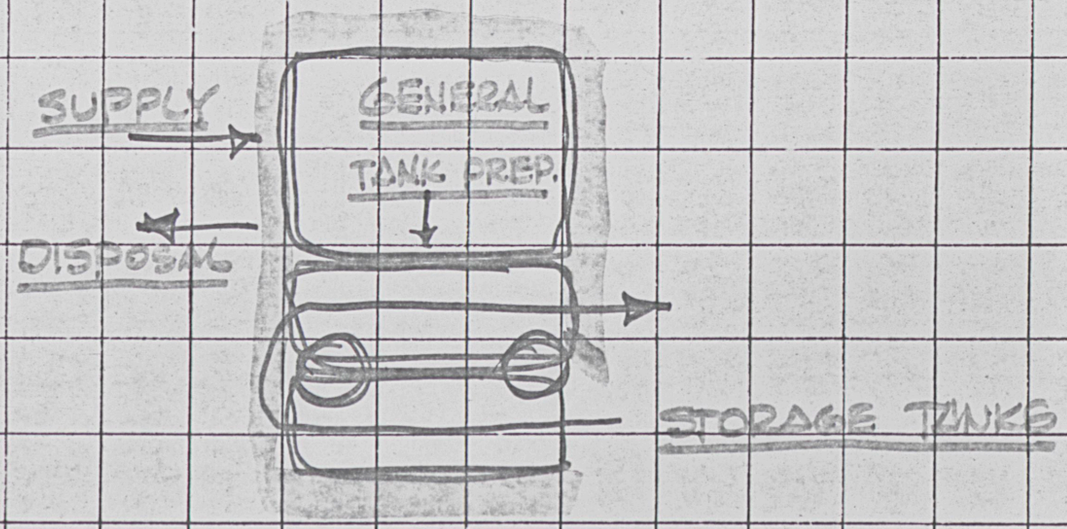
space: 1000 SQ. FT.

GENERAL
WATER
SHOP MERCHANDISE
SOLID WASTE
CONTAINER DISPOSAL
& CLEANING.

relation:



schematic:

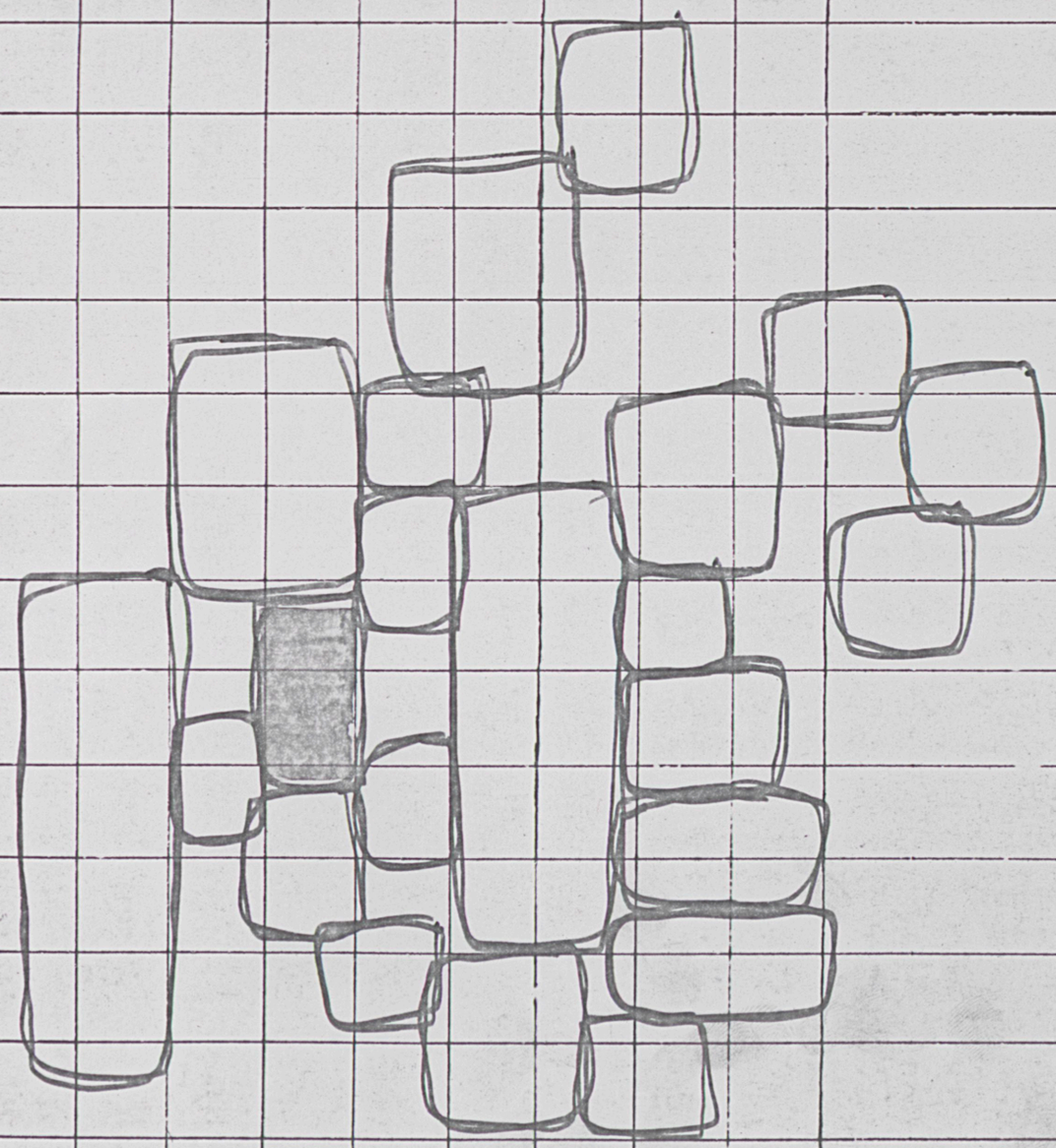


activity: BAR

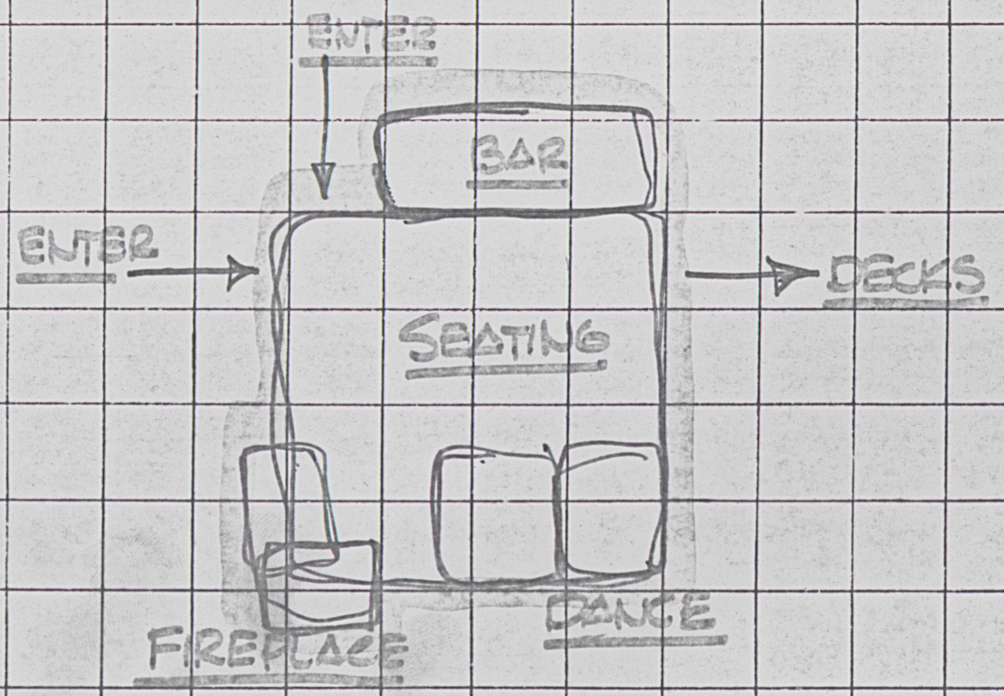
space: 1400 SQ. FT.

BAR
TABLES
COOLER (STORAGE)
BAND (STAGE)
DANCE FLOOR
SERVICE AREA

relation:



schematic:

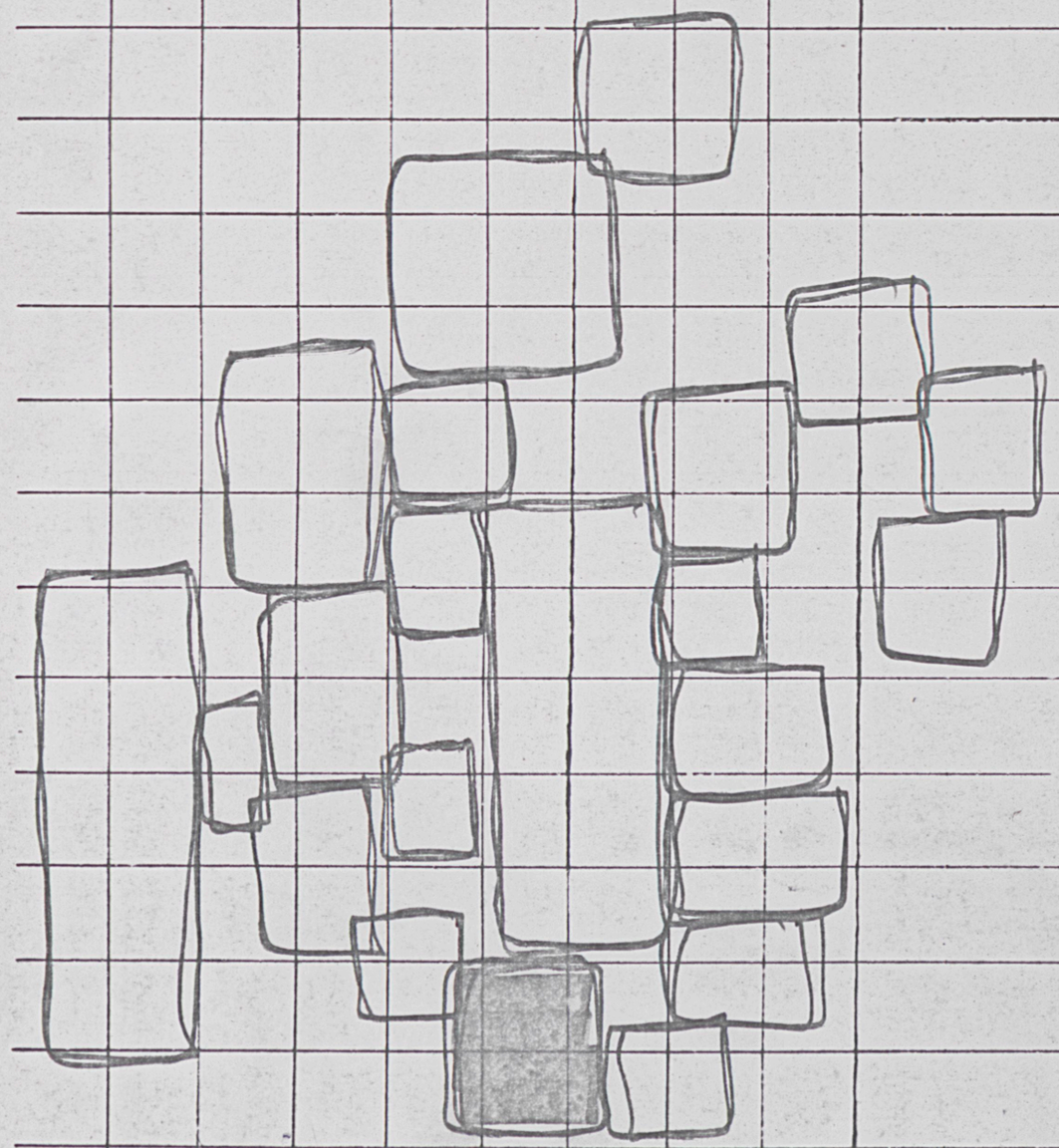


activity: DAY CARE CENTER

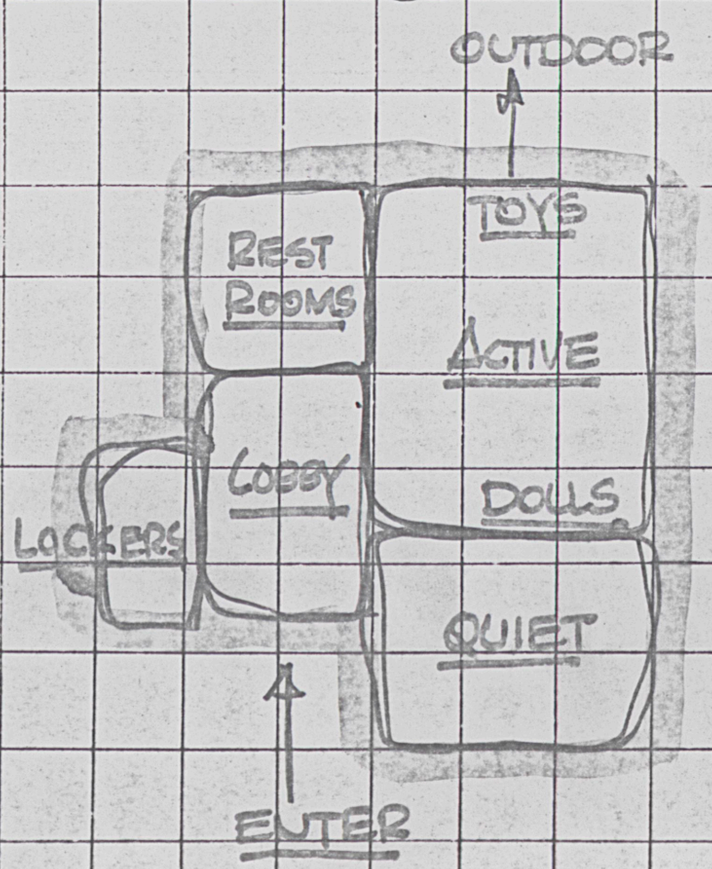
space: 2000 SQ. FT.

LOBBY
LOCKERS
RESTROOMS
QUIET (INFANTS)
ACTIVE (TODDLERS)
LUNCH AREA
OUTDOOR ACCESS

relation:



schematic:

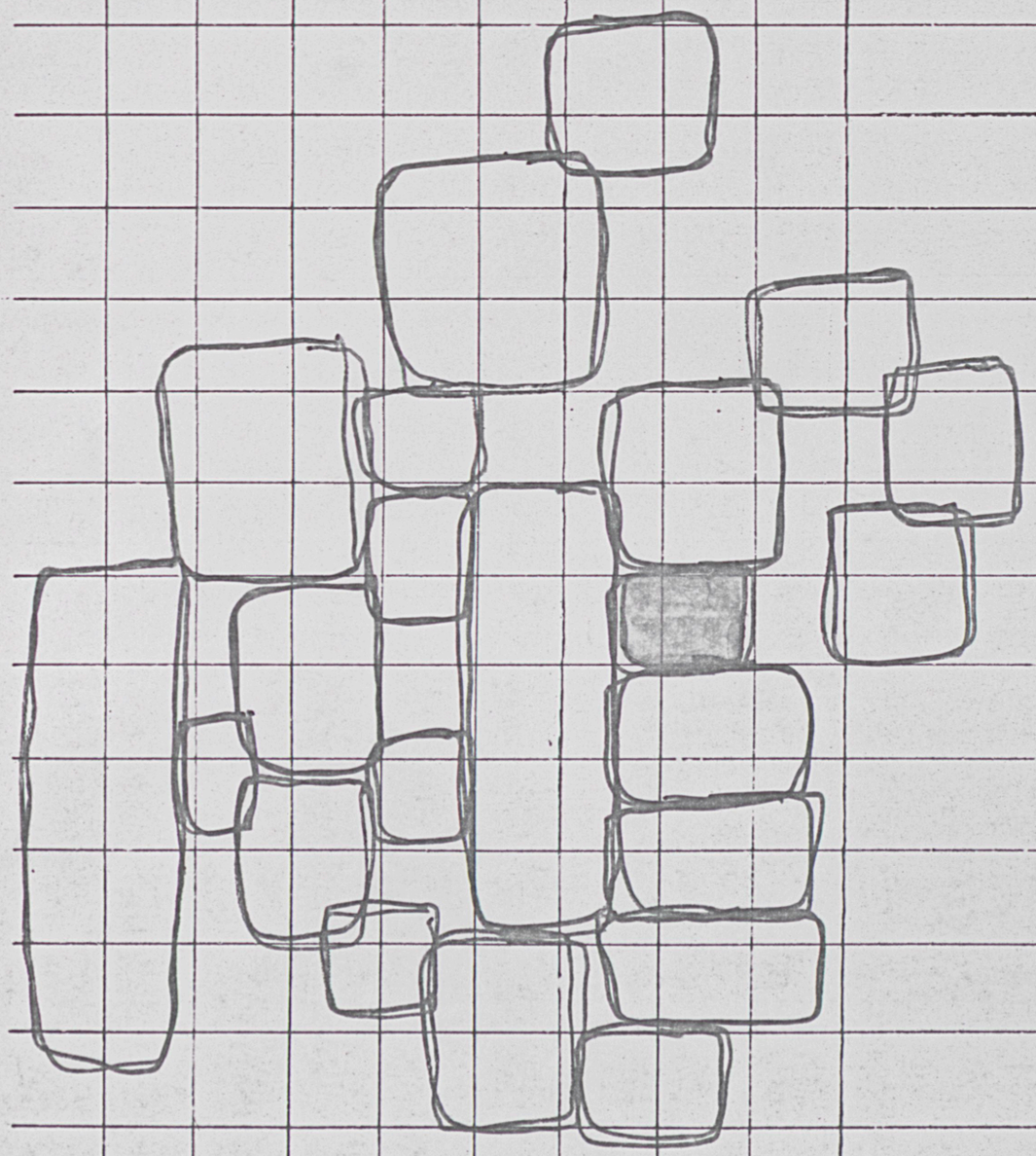


activity: RENTAL

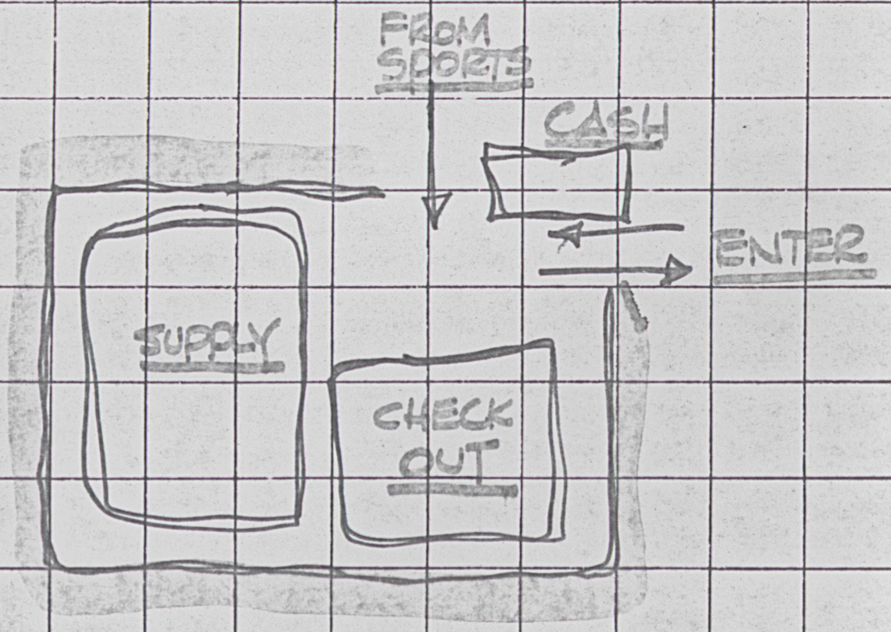
space: 1000 SQ. FT.

REPAIR
DISPLAY
TRY ON
CASH
CHECH IN

relation:



schematic:

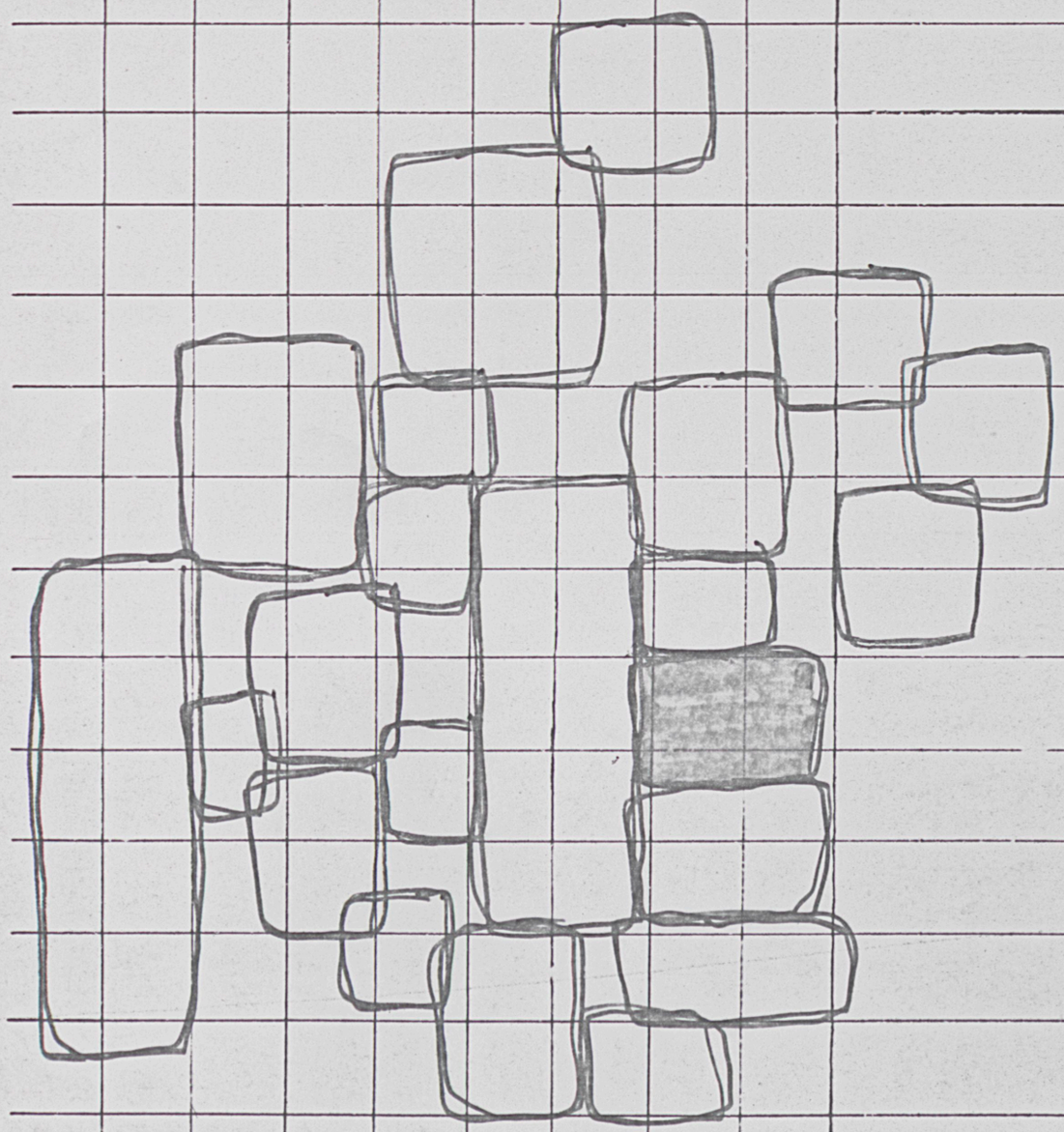


activity: SPORTING GOODS

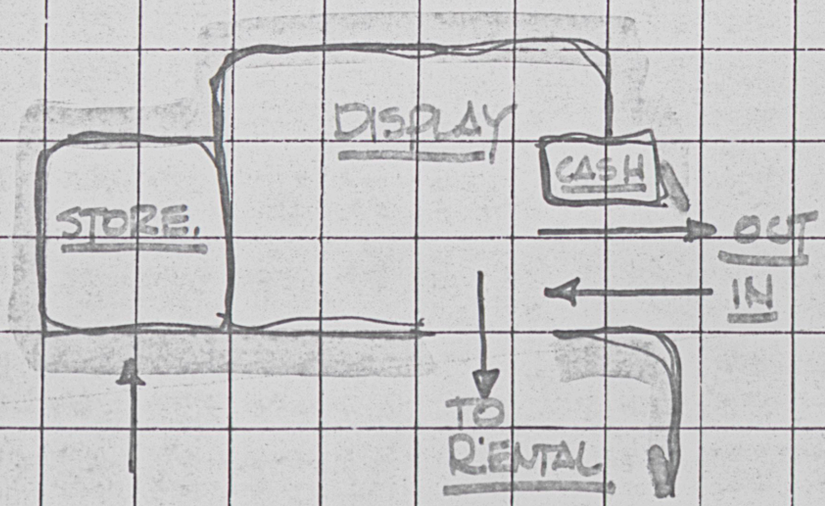
space: 1000 SQ. FT.

STORAGE
DISPLAY
CASH

relation:



schematic:

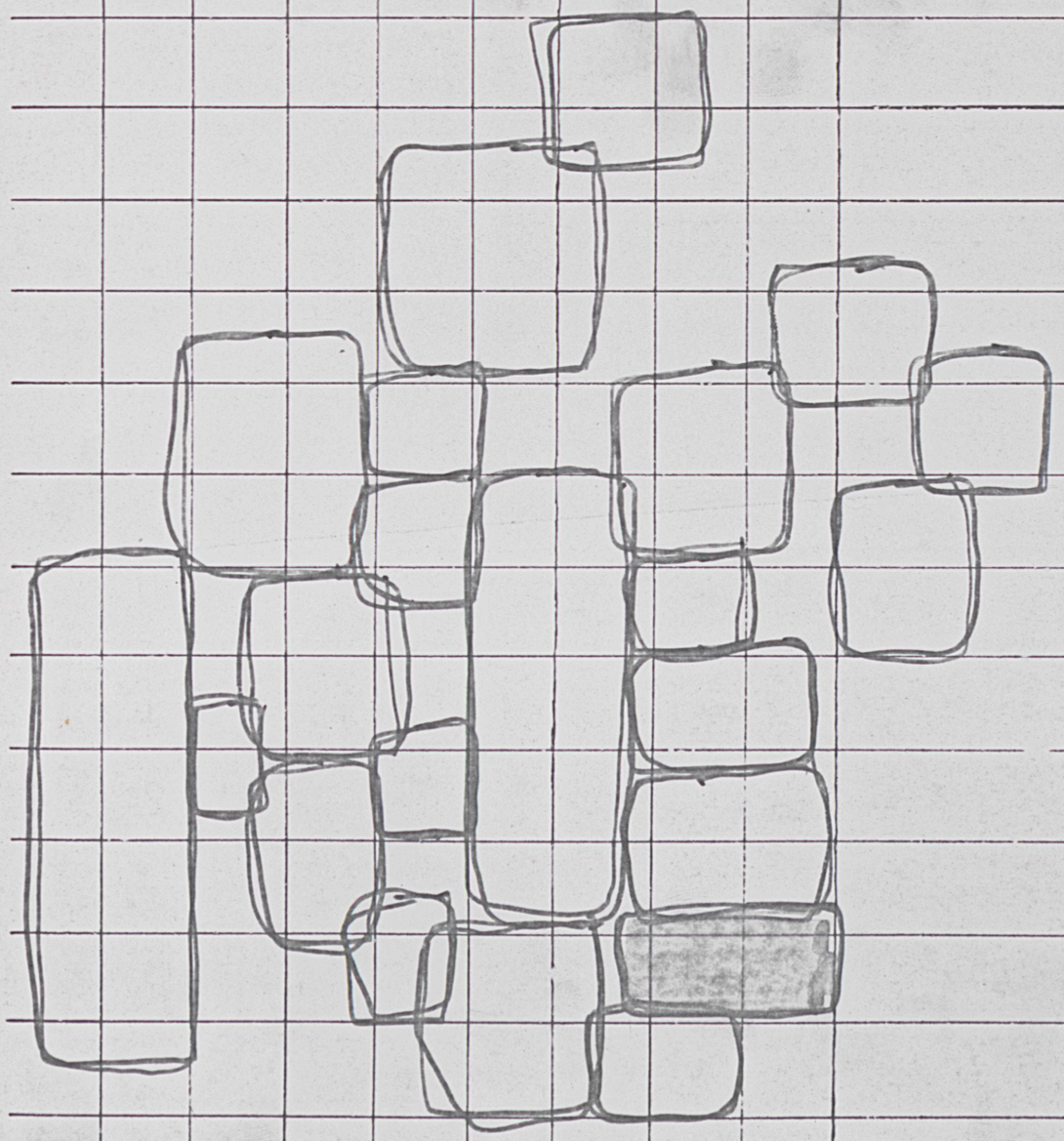


activity: DRUG STORE

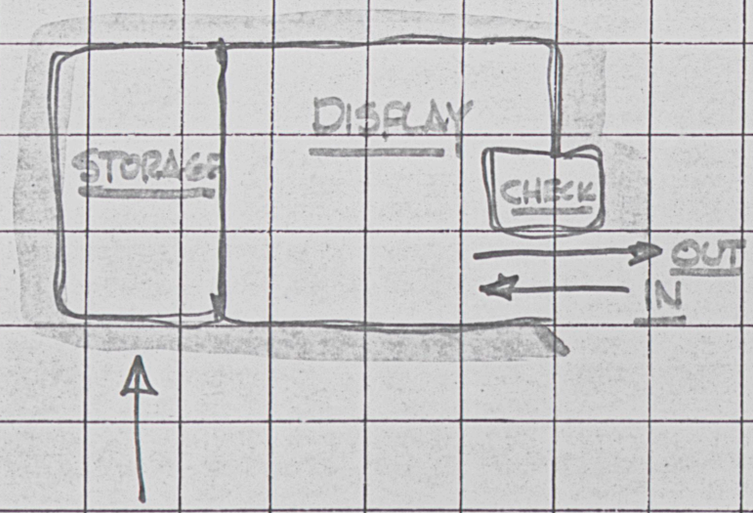
space: 1000 SQ. FT.

CASH (CHECK POINT)
DISPLAY

relation:



schematic:

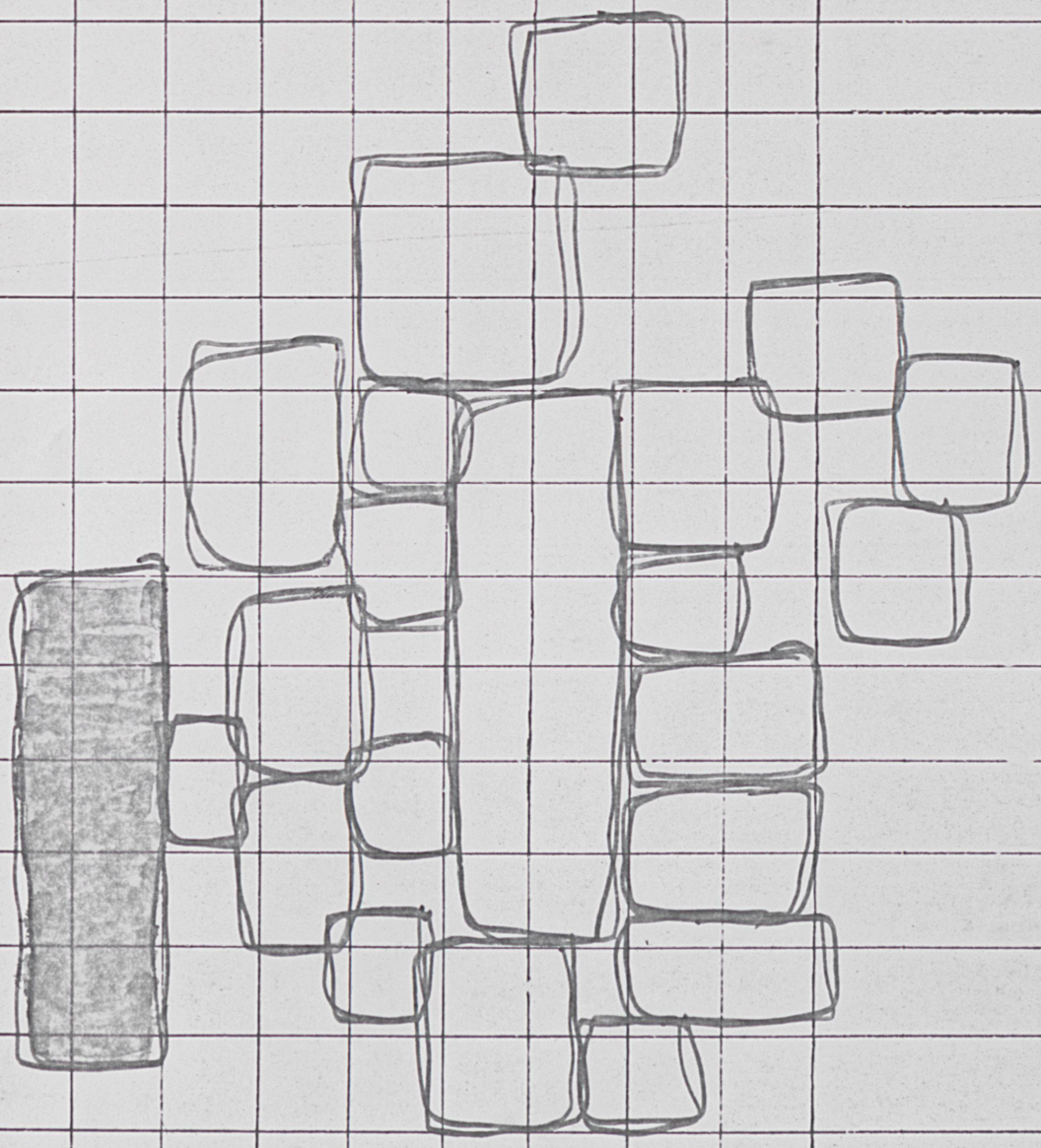


activity: OBSERVATION DECKS

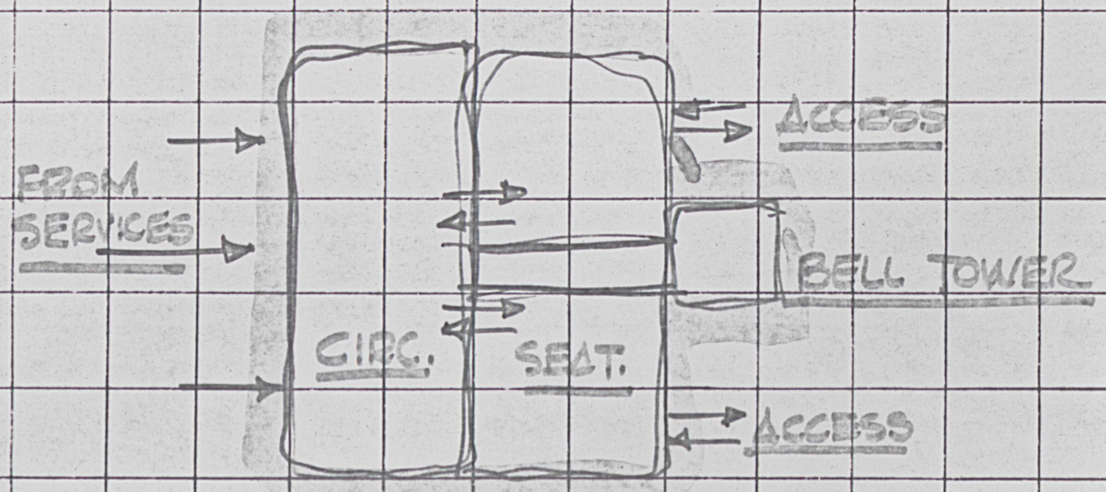
space: 750 SQ. FT.

SEATING
CIRCULATION
OBJECT OF ORIENTATION
BELL TOWER

relation:



schematic:

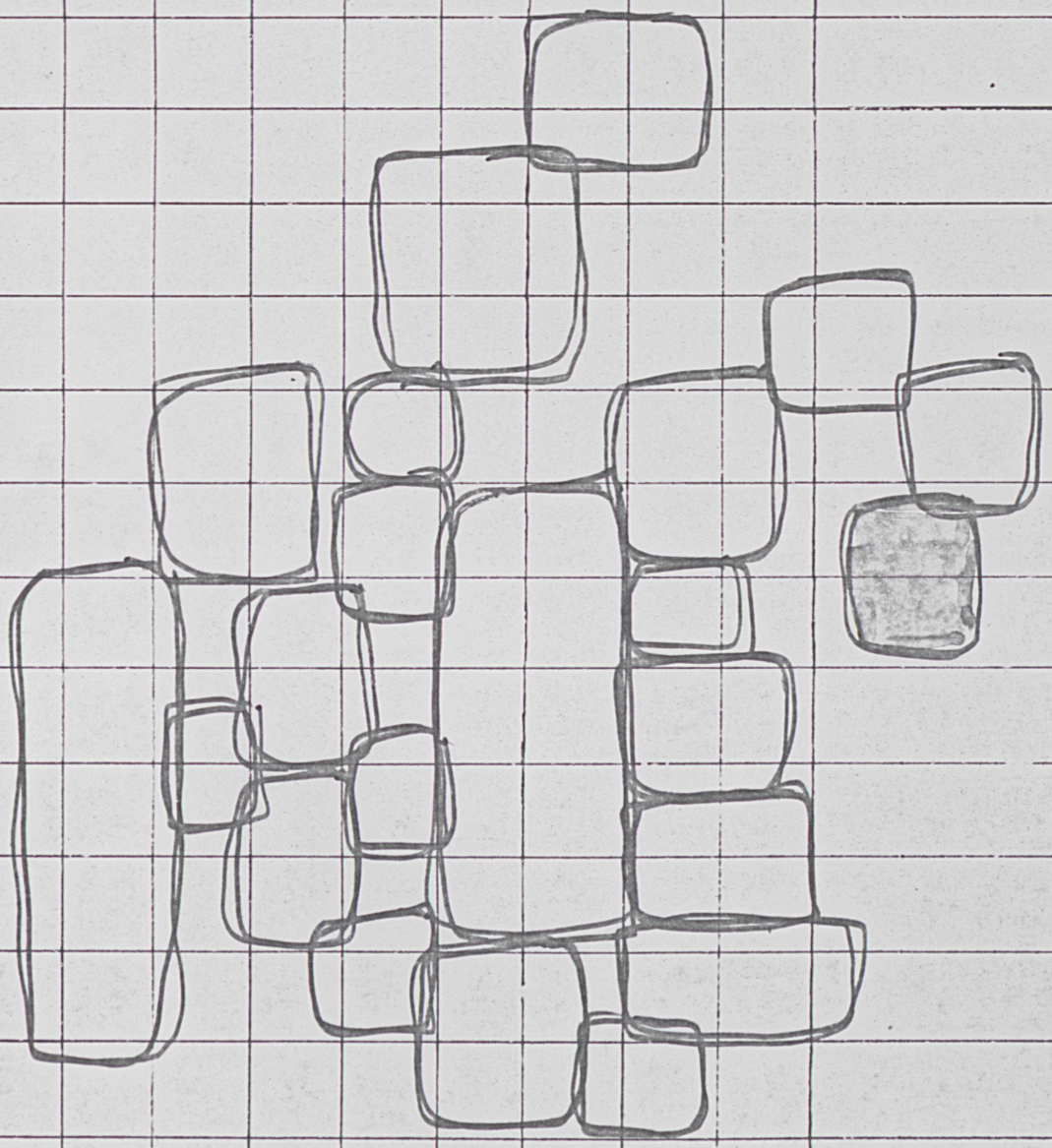


activity: MECHANICAL

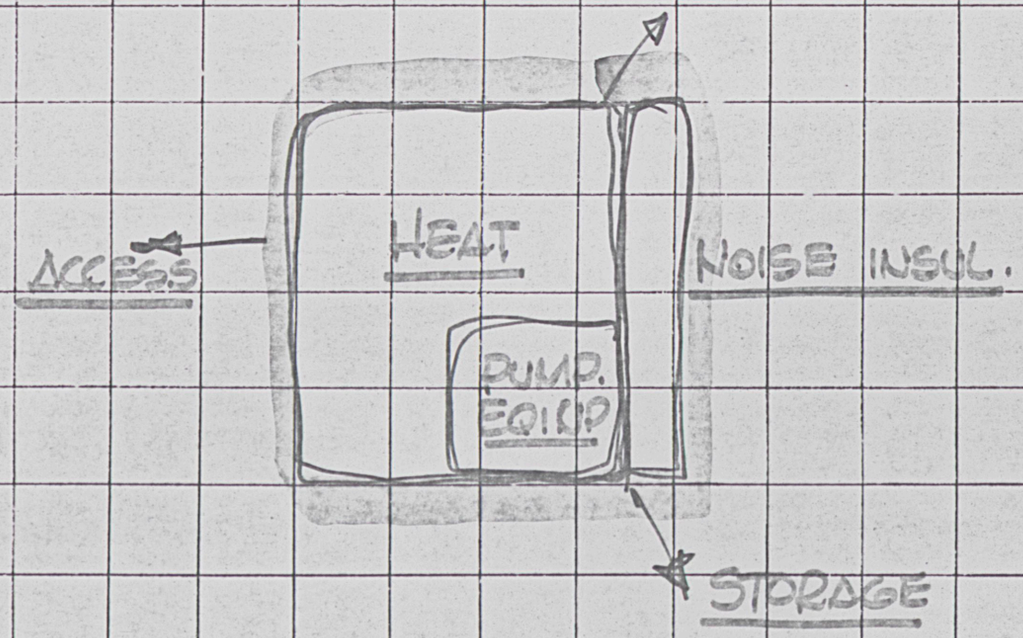
space: 1000 SQ. FT.

HEATING
PUMPING EQUIP.
NOISE INSULATION

relation:



schematic:

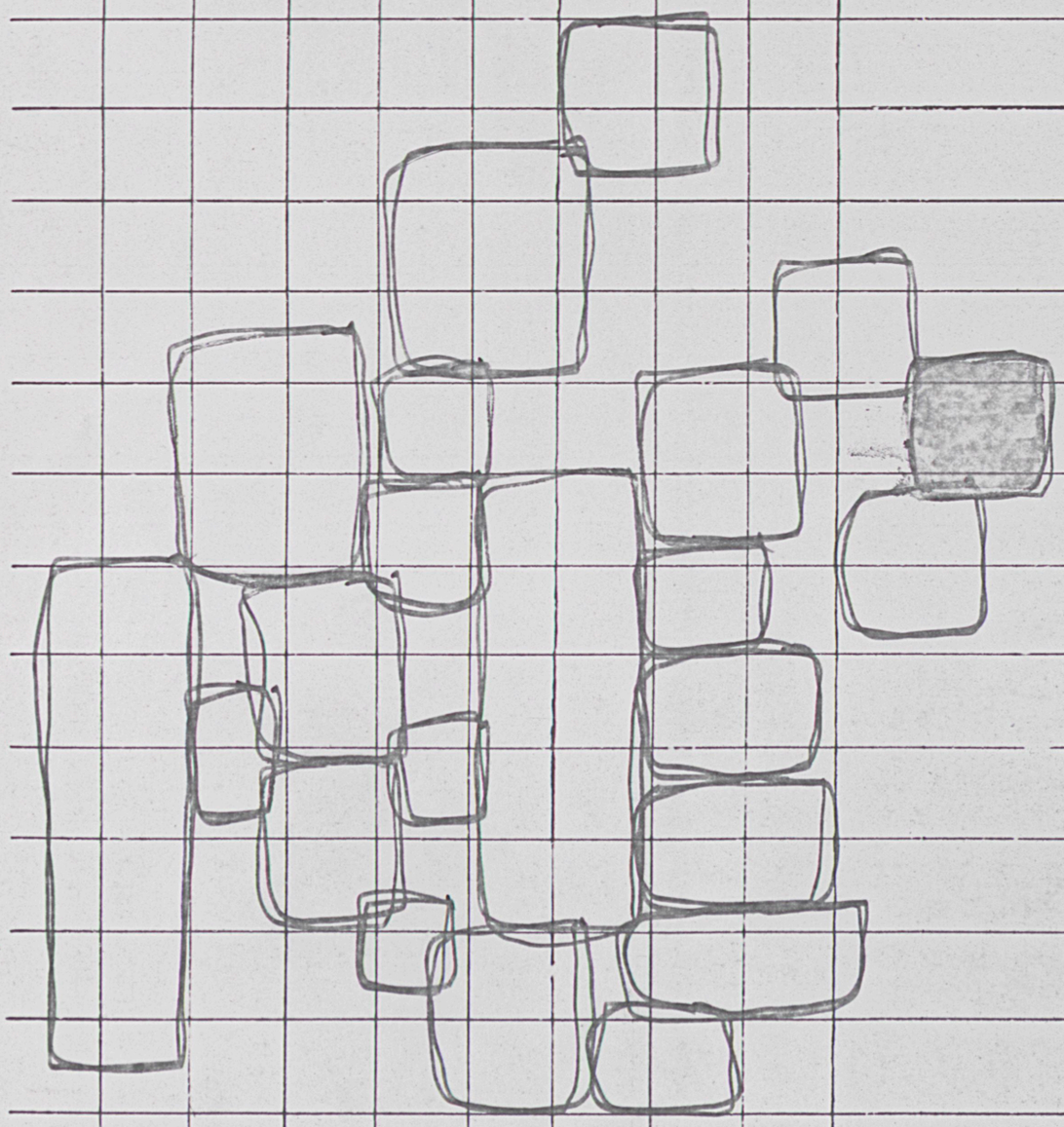


activity: BLDG. MAINTENANCE

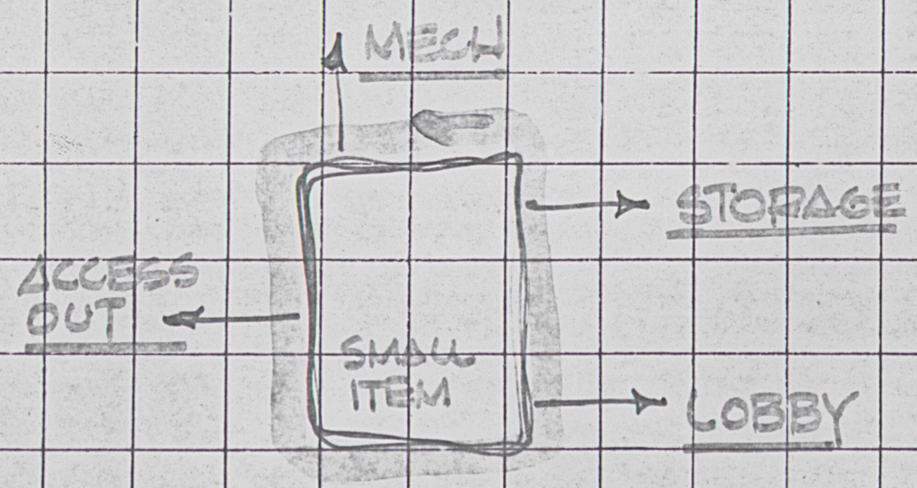
space: 225 SQ. FT.

JANITOR
STORAGE
ACCESS IN-OUT
TO MAIN STORAGE

relation:



schematic:

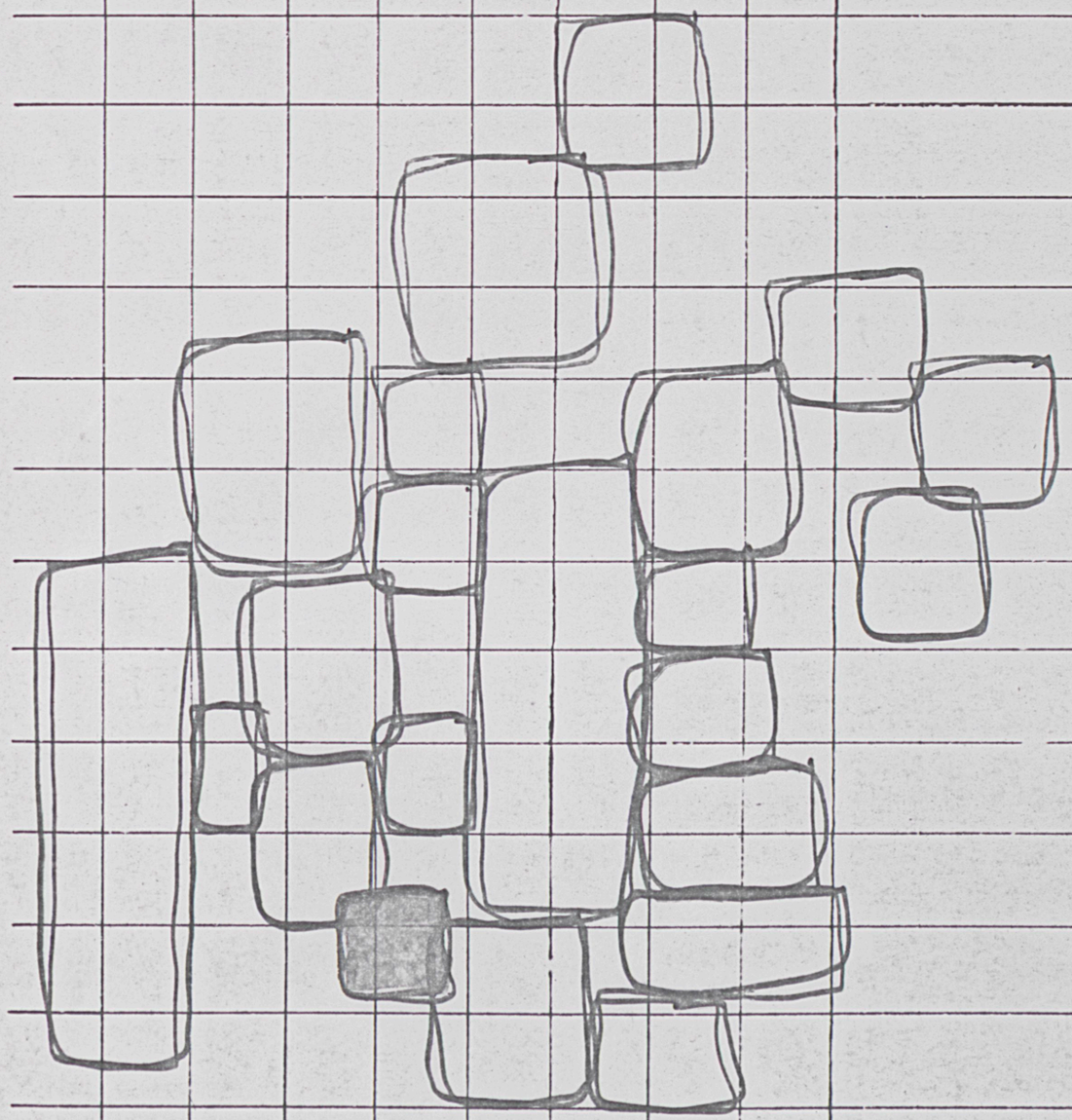


activity: BROWN BAG

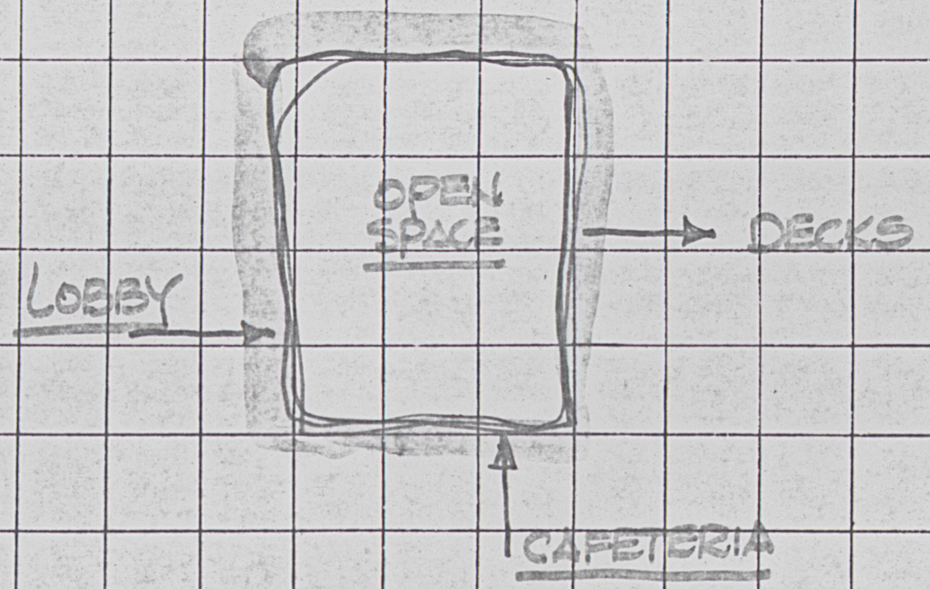
space: 800 SQ. FT.

DISPOSAL
TABLES
ACCESS TO DECKS.

relation:



schematic:

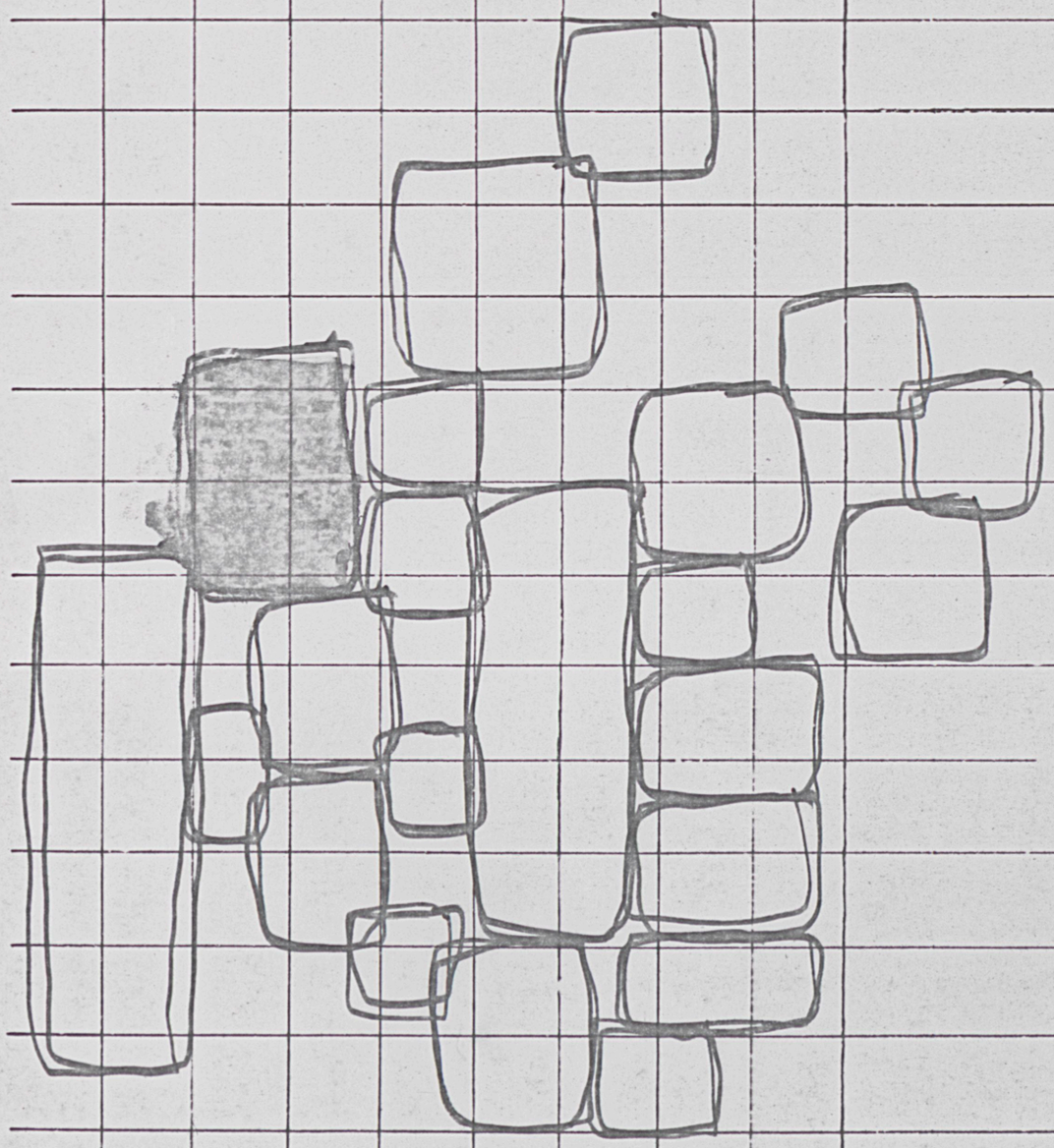


activity: SKI YELLOWSTONE H.

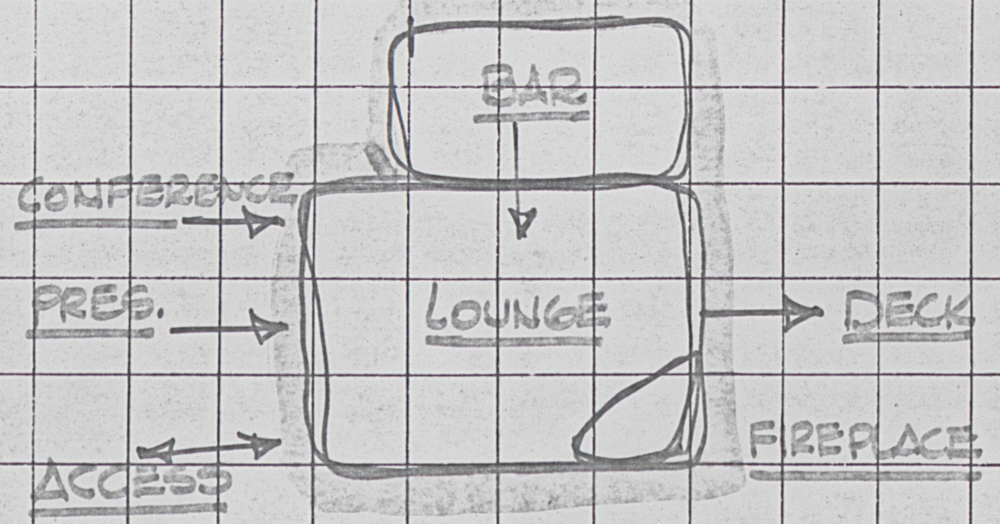
space: 300 SQ FT.

LOUNGE
BAR
SEATING
FIREPLACE

relation:



schematic:

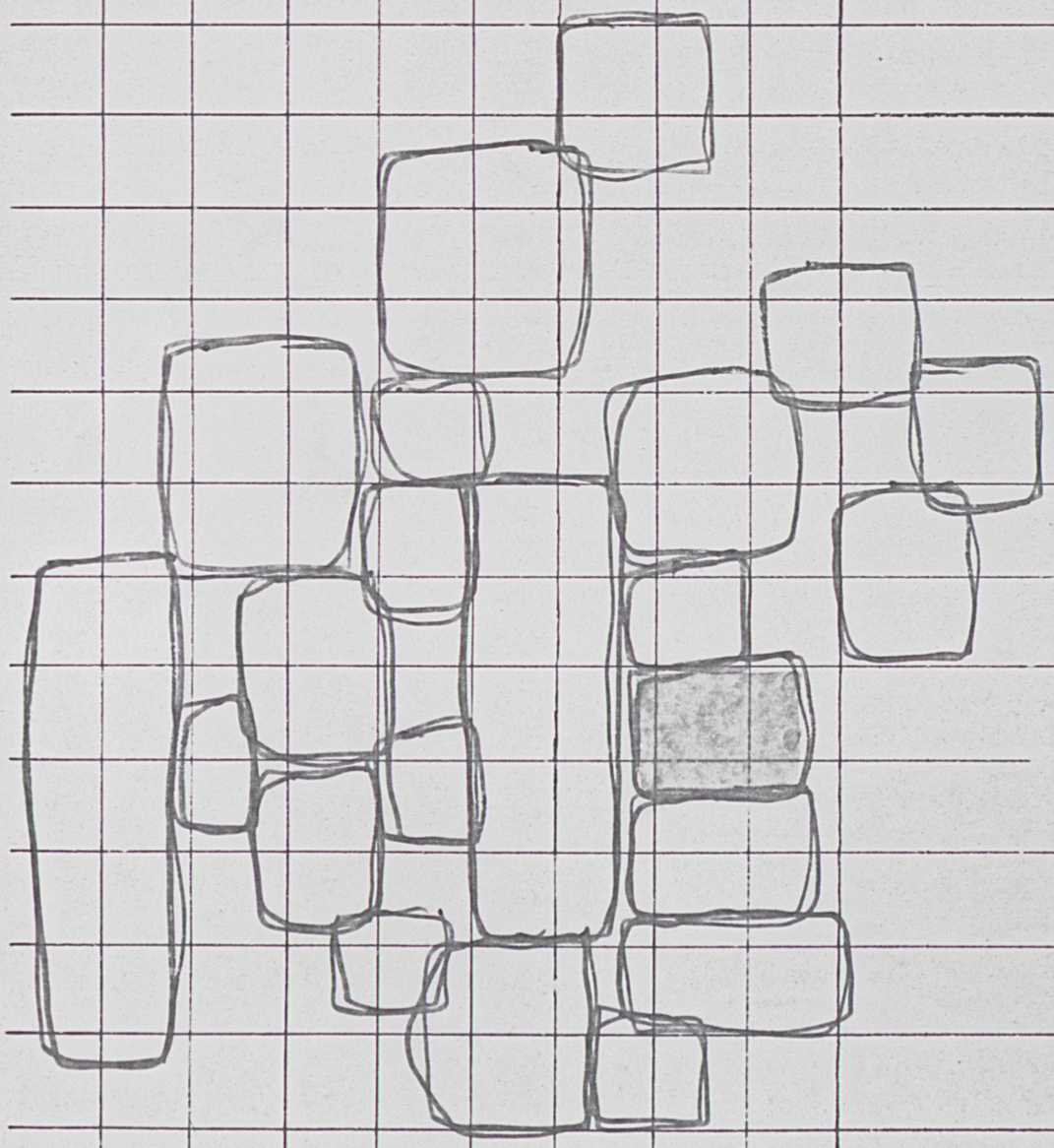


activity: DELI - GROCERY

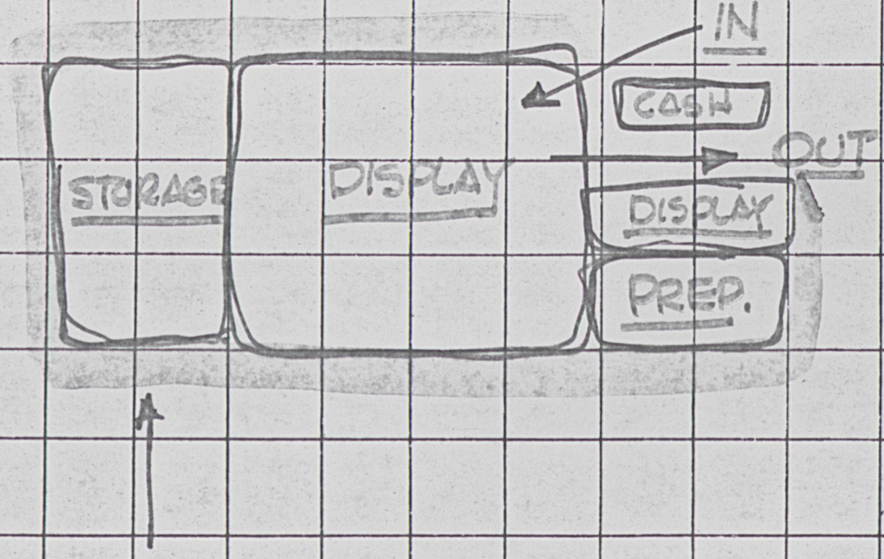
space: 1000 SQ. FT.

GROCERY (IN)
STORAGE
DELI DISPLAY (OUT)
DELI PREPARATION

relation:



schematic:

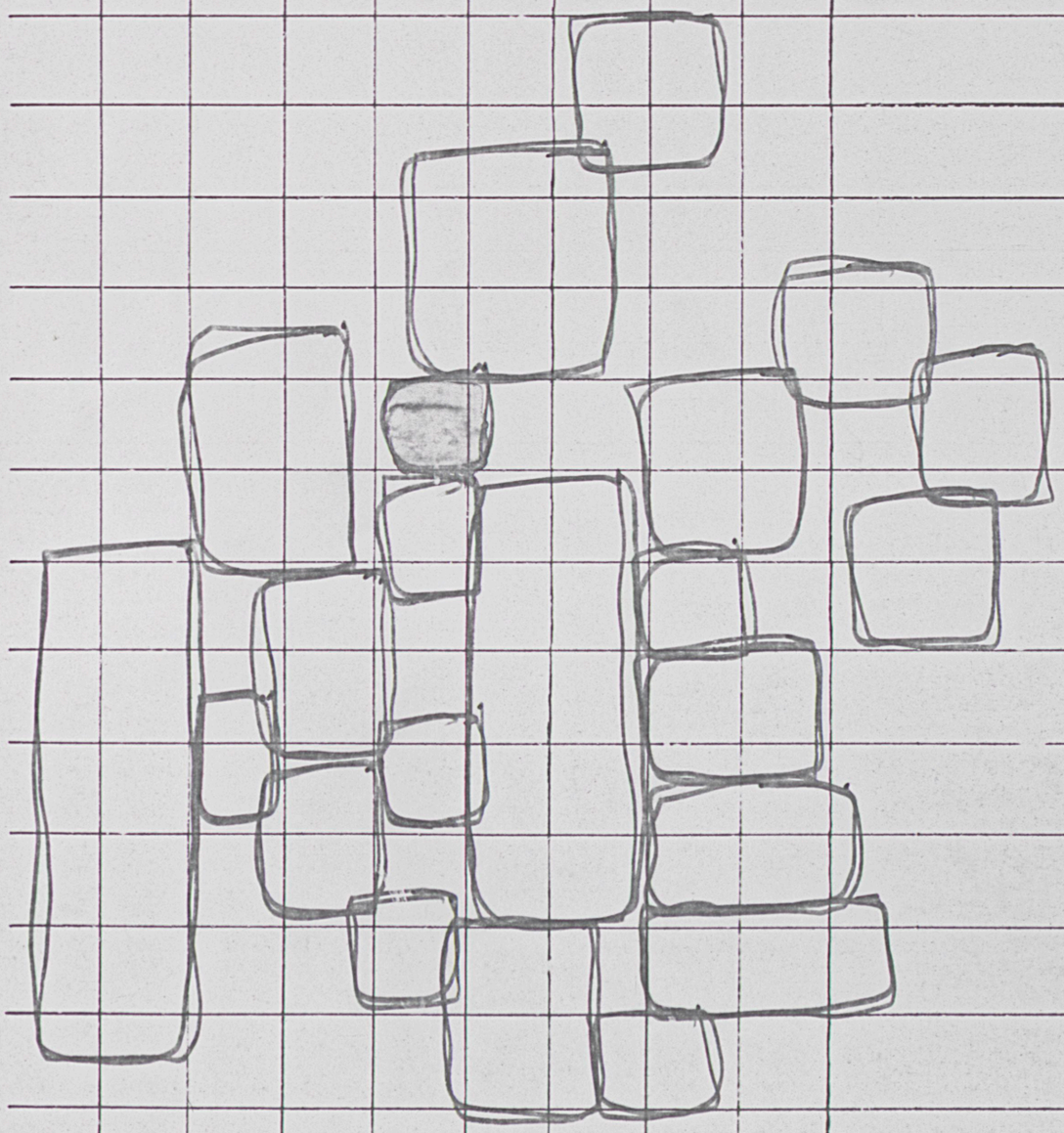


activity: TICKETING

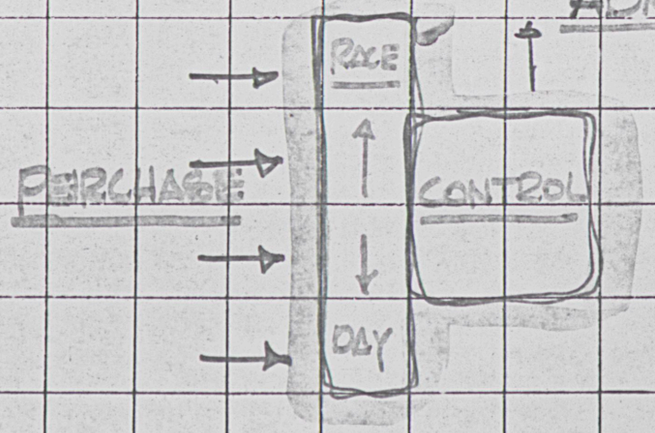
space: 300 SQ. FT.

CONTROL
WINDOWS
ACCESS (PURCHASE)
PROXIMITY TO ADMIN.

relation:



schematic:

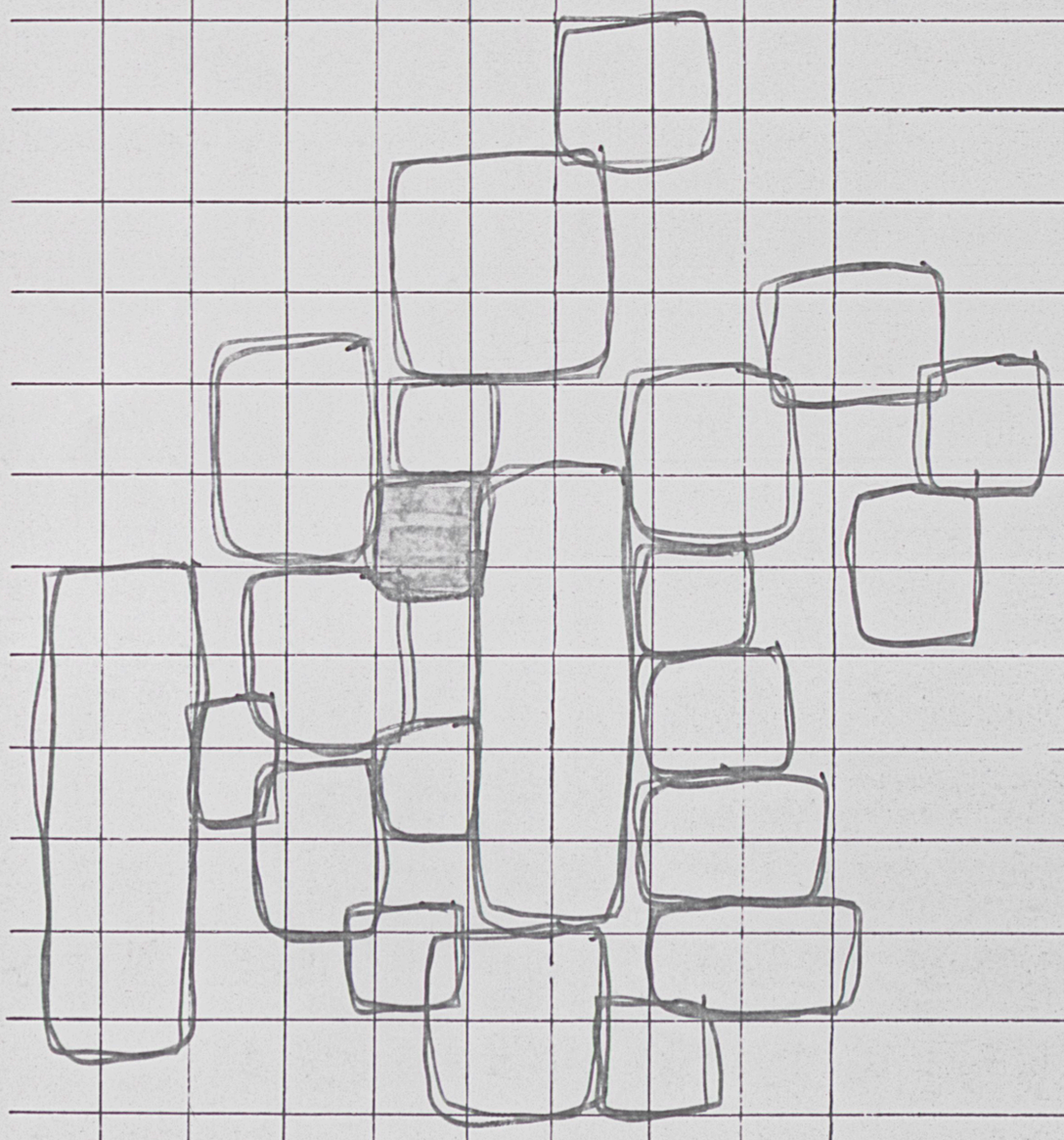


activity: OFFICES

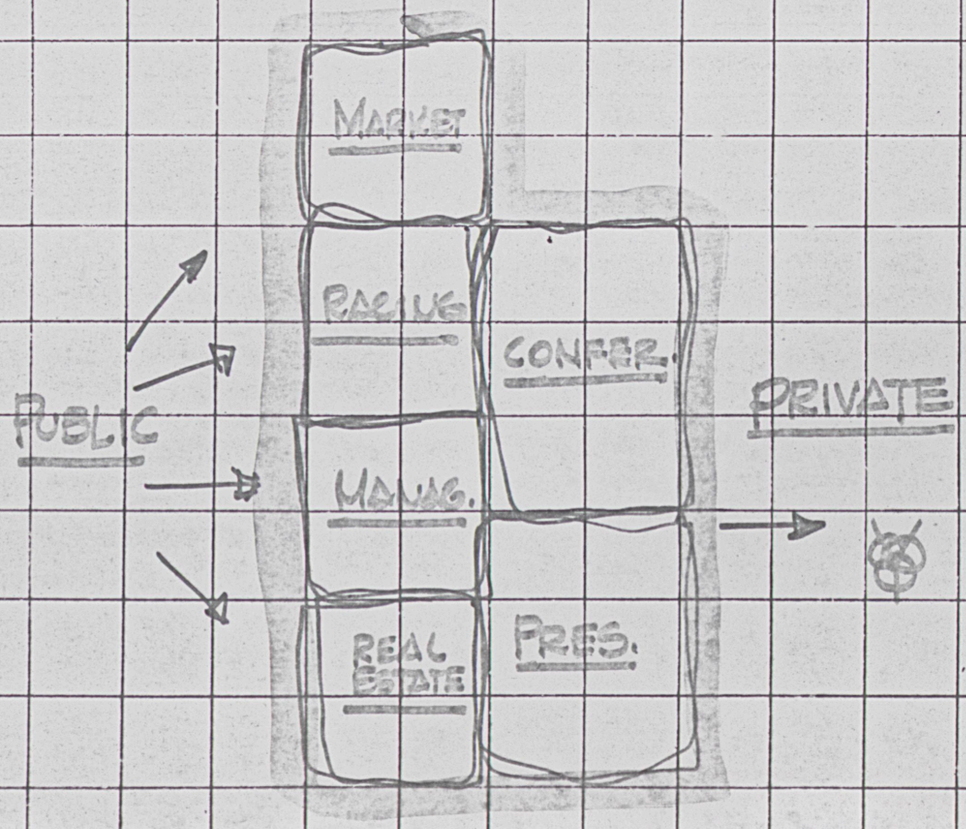
space: 750 SQ. FT.

PRESIDENT
MARKETING
COMPLEX MANAGEMENT
RACING
REAL ESTATE

relation:



schematic:

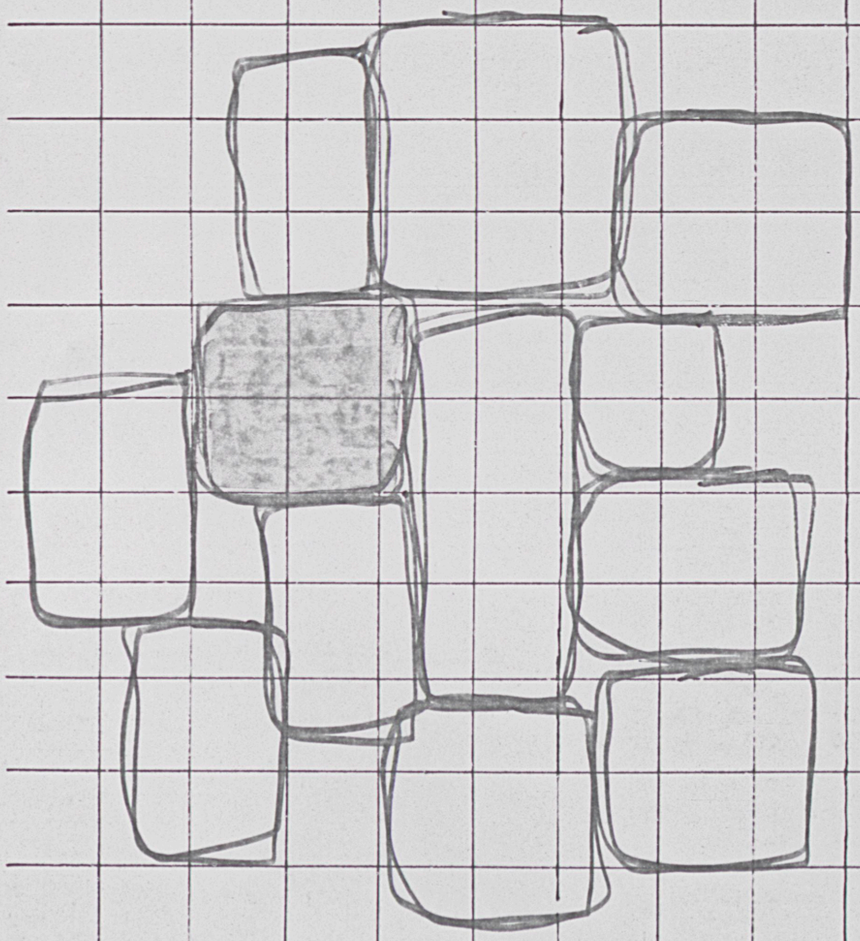


activity: FOOD PREPARATION

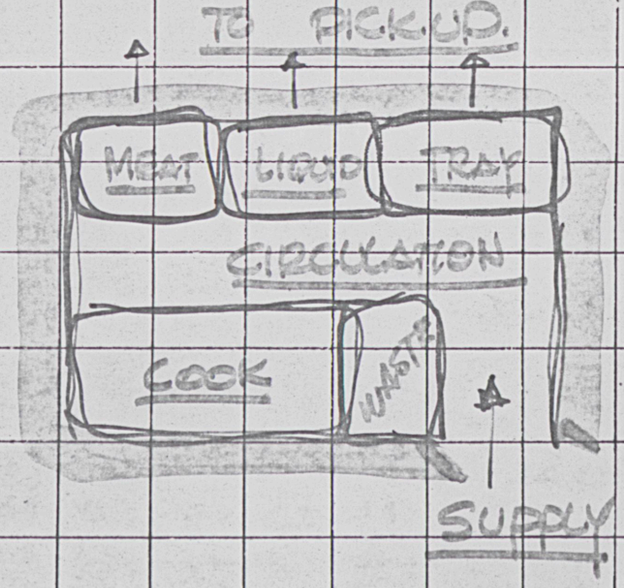
space: 400 SQ. FT.

COOKING
CLEANING
WATER STORAGE.
WASTE DISPOSAL

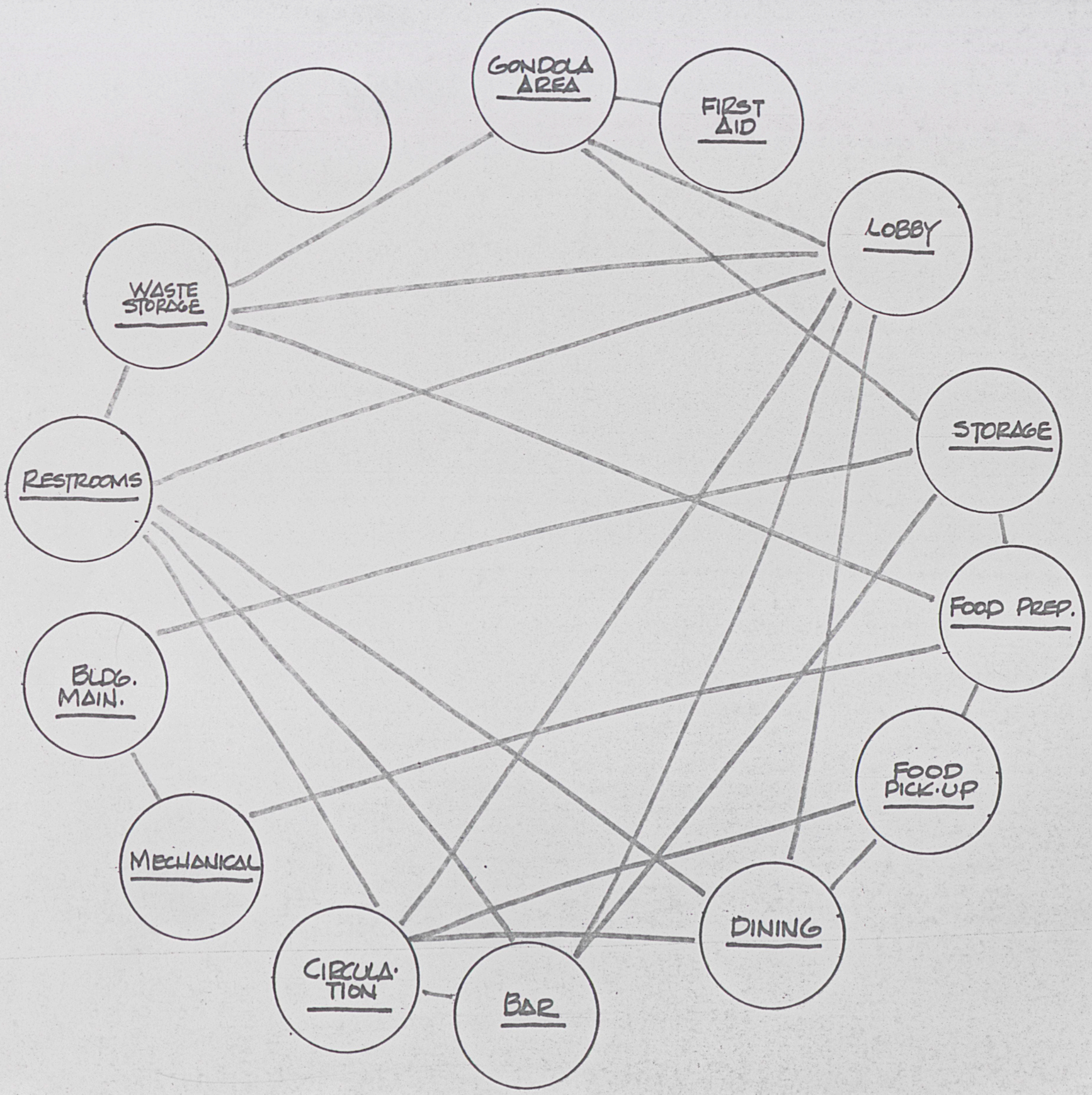
relation:

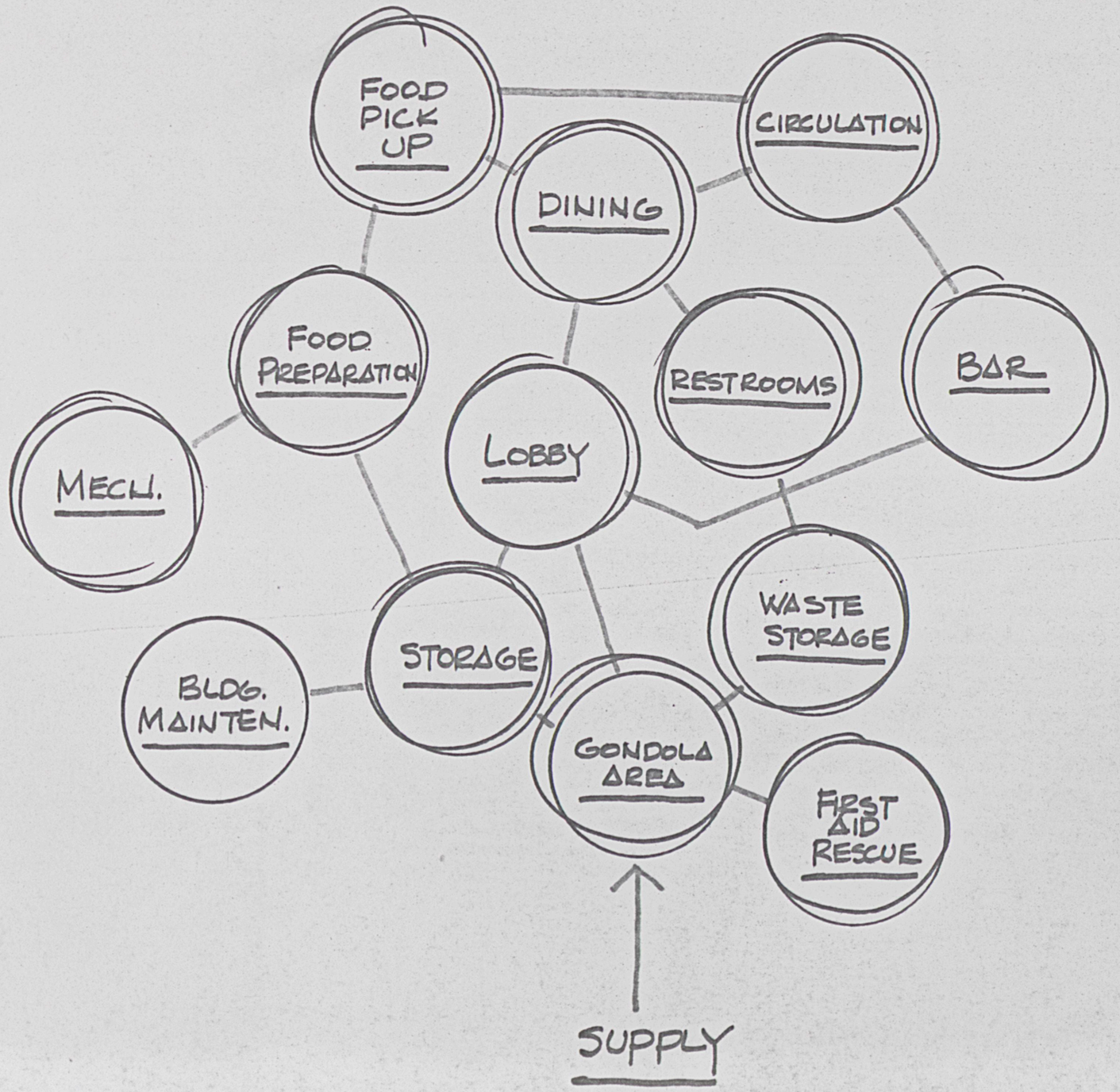


schematic:



GONDOLA AREA
FIRST AID & RESCUE
LOBBY
STORAGE
FOOD PREP.
FOOD PICK-UP
DINING
BAR
CIRCULATION
MECHANICAL
BLDG. MAINTENENCE
REST ROOMS
WASTE STORAGE


GONDOLA AREA
FIRST AID
LOBBY
WASTE STORAGE
STORAGE
RESTROOMS
FOOD PREP.
BLDG. MAIN.
FOOD PICK-UP
MECHANICAL
DINING
CIRCULA-TION
BAR


FOOD PICK UP
CIRCULATION
DINING
FOOD PREPARATION
RESTROOMS
BAR
MECH.
LOBBY
WASTE STORAGE
STORAGE
BLDG. MAINTEN.
GONDOLA AREA
FIRST AID RESCUE
SUPPLY

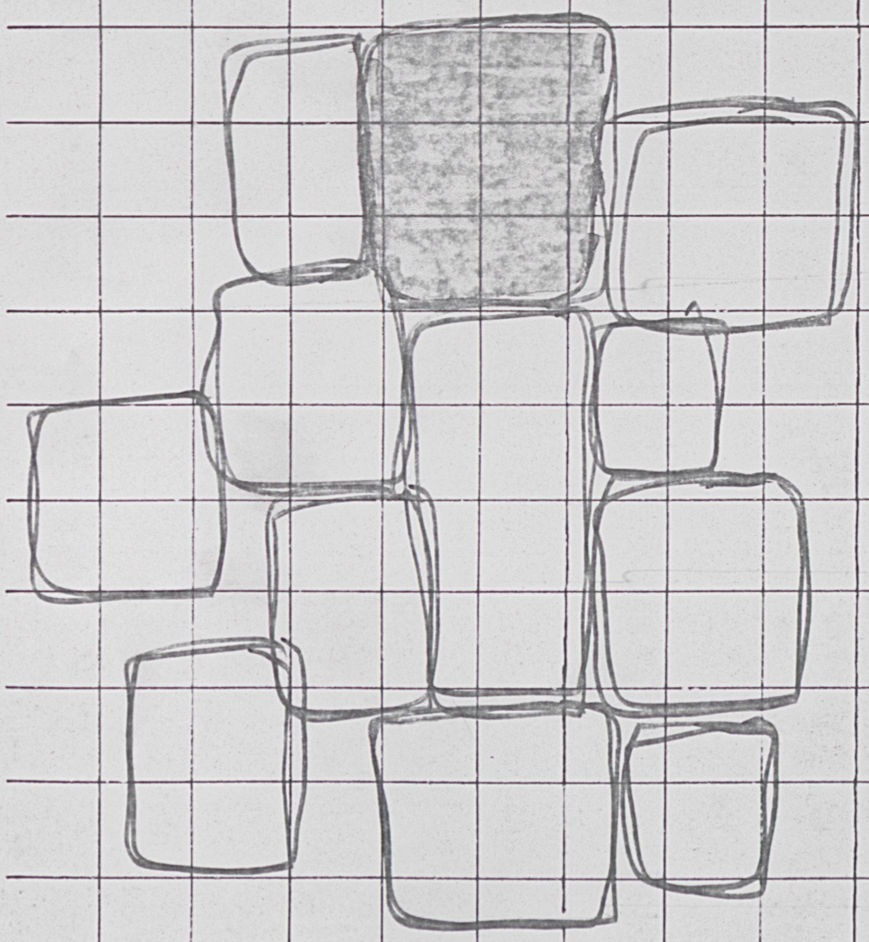
mountain

activity: DINING

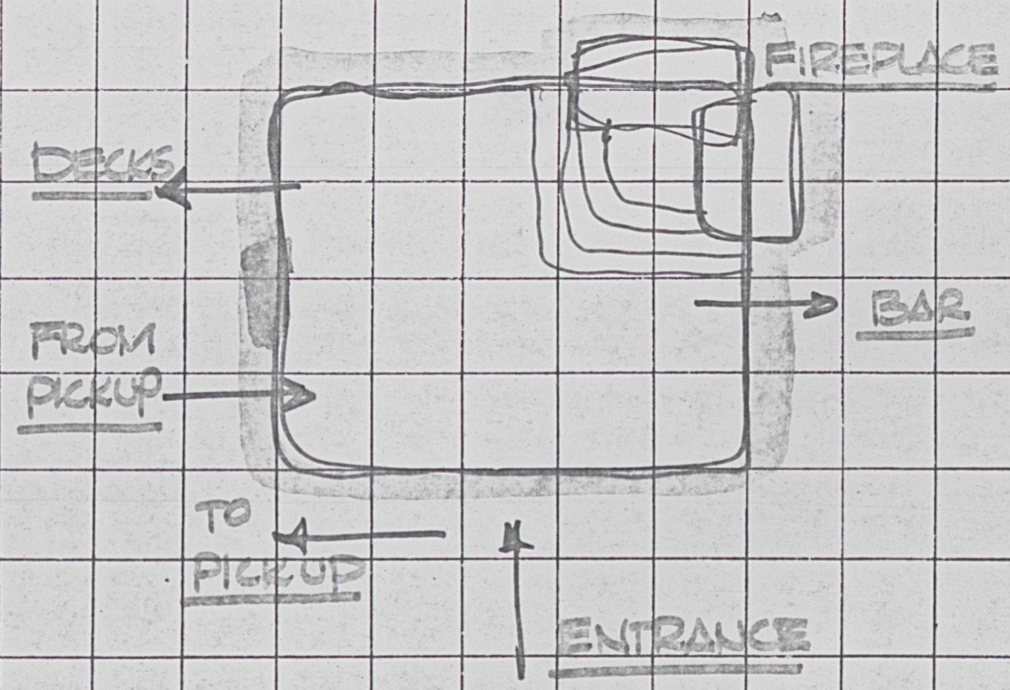
space: 2,000 SQ. FT.

ACCESS TO DECKS
SEATING
TABLES
FLOOR
FIREPLACE

relation:



schematic:

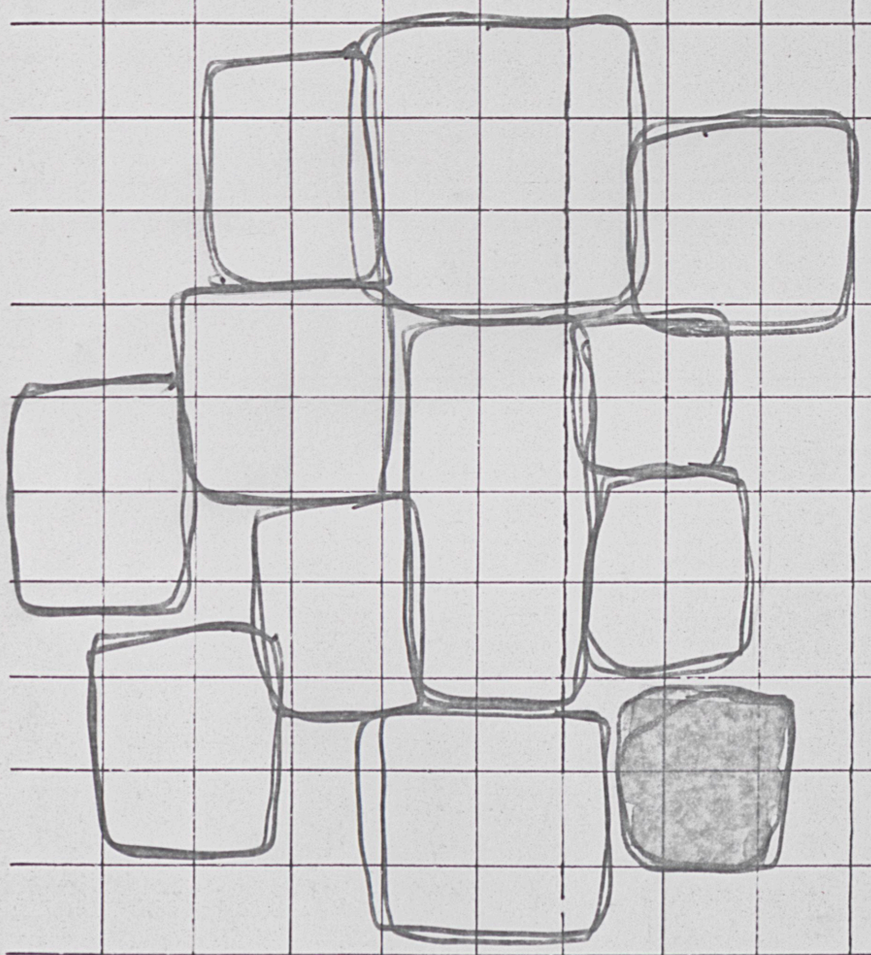


activity: FIRST AID & RESCUE

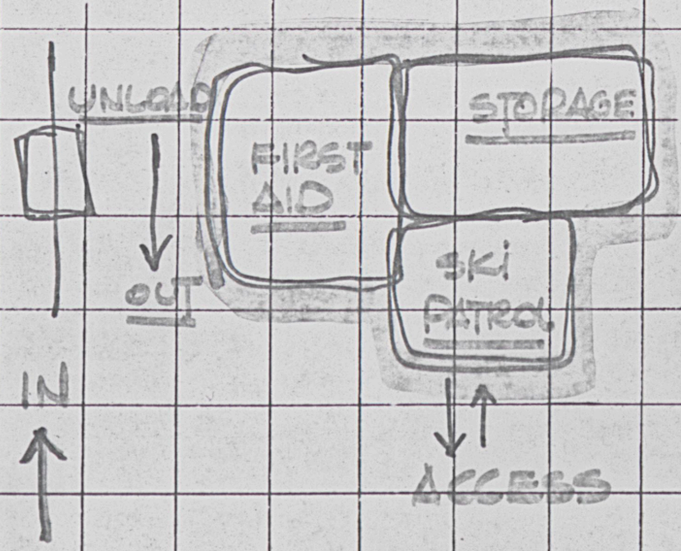
space: 400 SQ.FT.

TOBOGGAN STORAGE (8-10)
AVALANCHE POLES
MARKERS
SKI PATROL OFFICE
FIRST AID STATION

relation:



schematic:

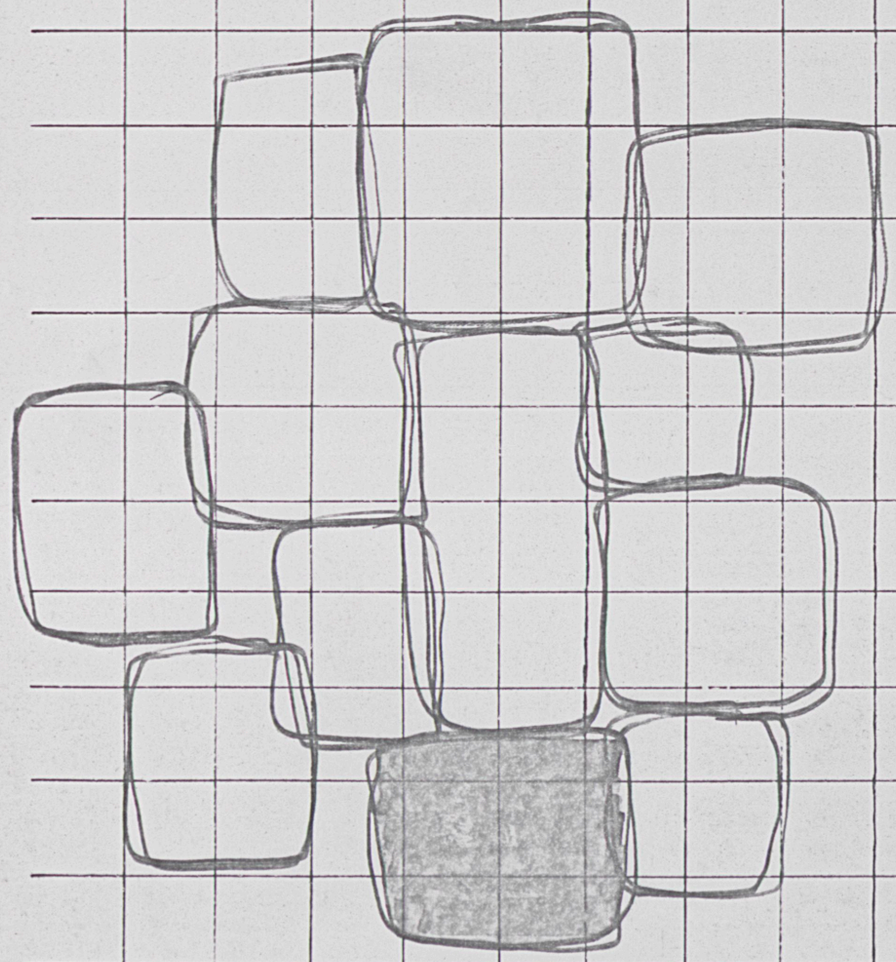


activity: GONDOLA AREA

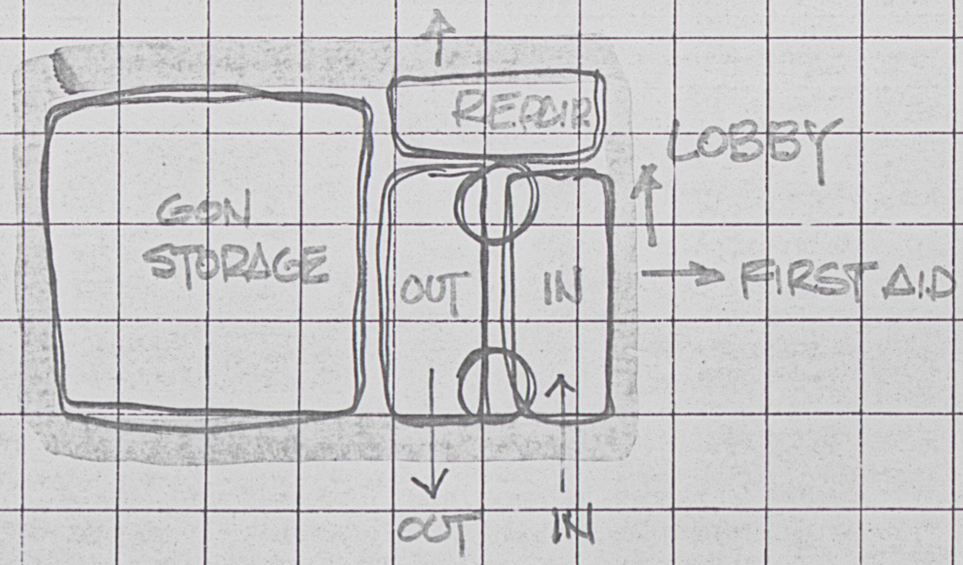
space: 1600 SQ. FT.

GONDOLA IN
GONDOLA OUT
GONDOLA STORAGE 1/3 CARS
REPAIR CAR TRACK
STORAGE CAR TRACK
SKIER DISEMBARK

relation:



schematic:

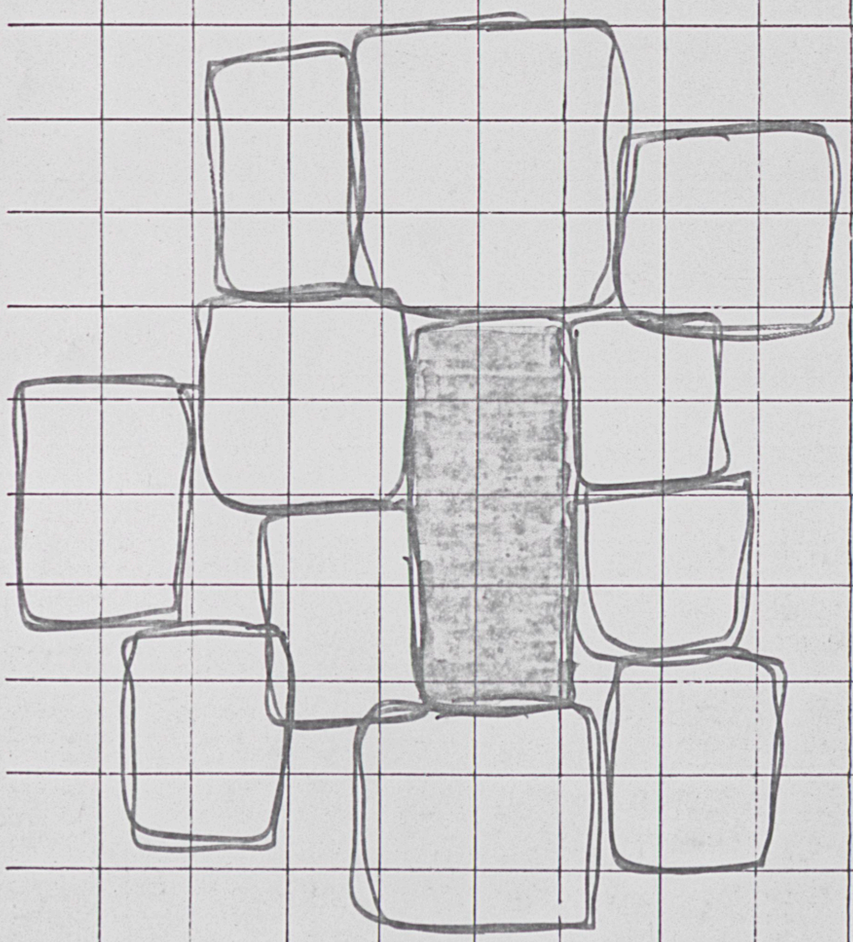


activity: LOBBY - CIRCULATION

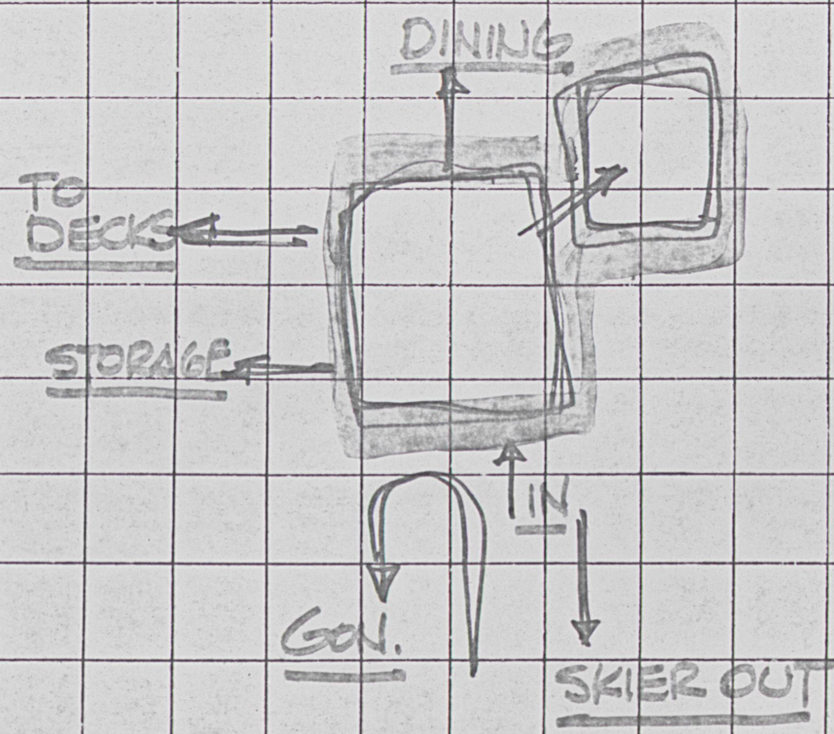
space: 400 SQ. FT.

CIRCULATION
STAIRS
EXITS

relation:



schematic:



activity: FOOD PICK-UP

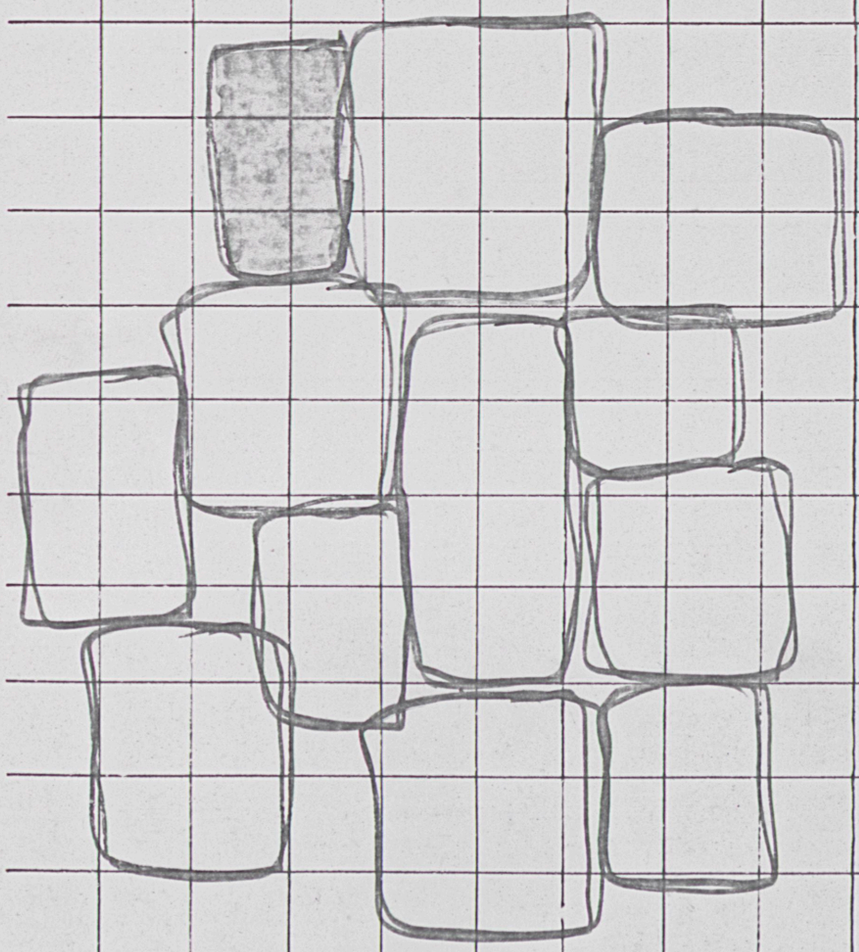
space: 300 SQ. FT.

LIQUID
- BEER
- MILK
- POP
- JUICES
- WATER

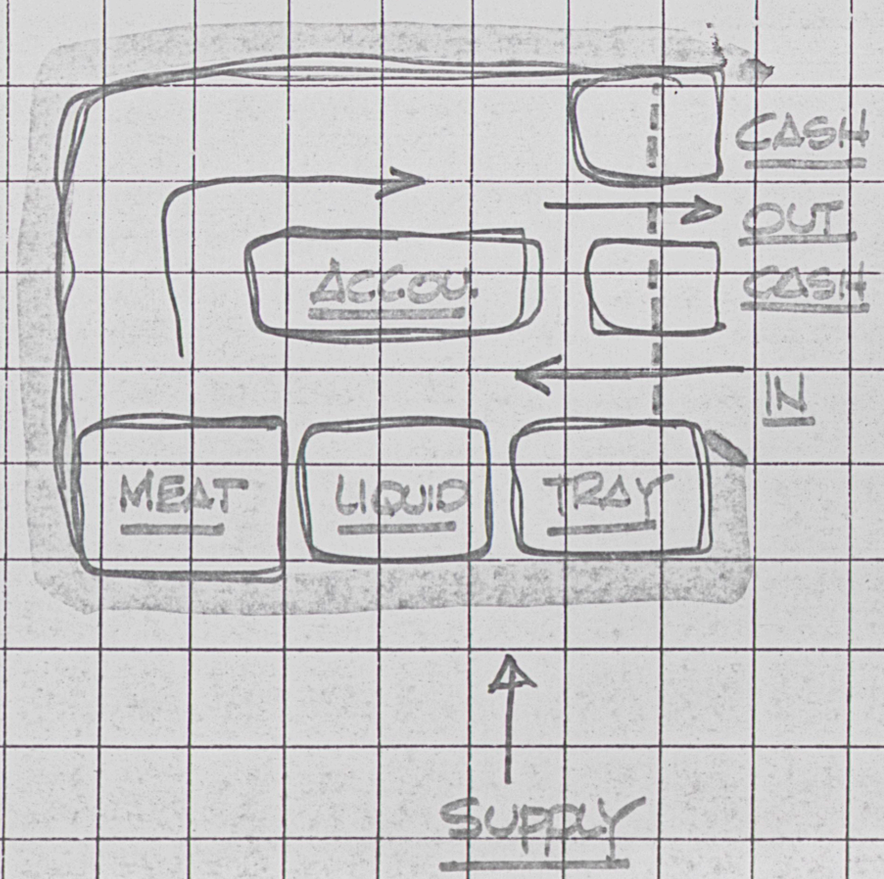
FOOD

ACCOUTREMENTS
PLATES TRAYS SILVERWARE ETC.

relation:



schematic:

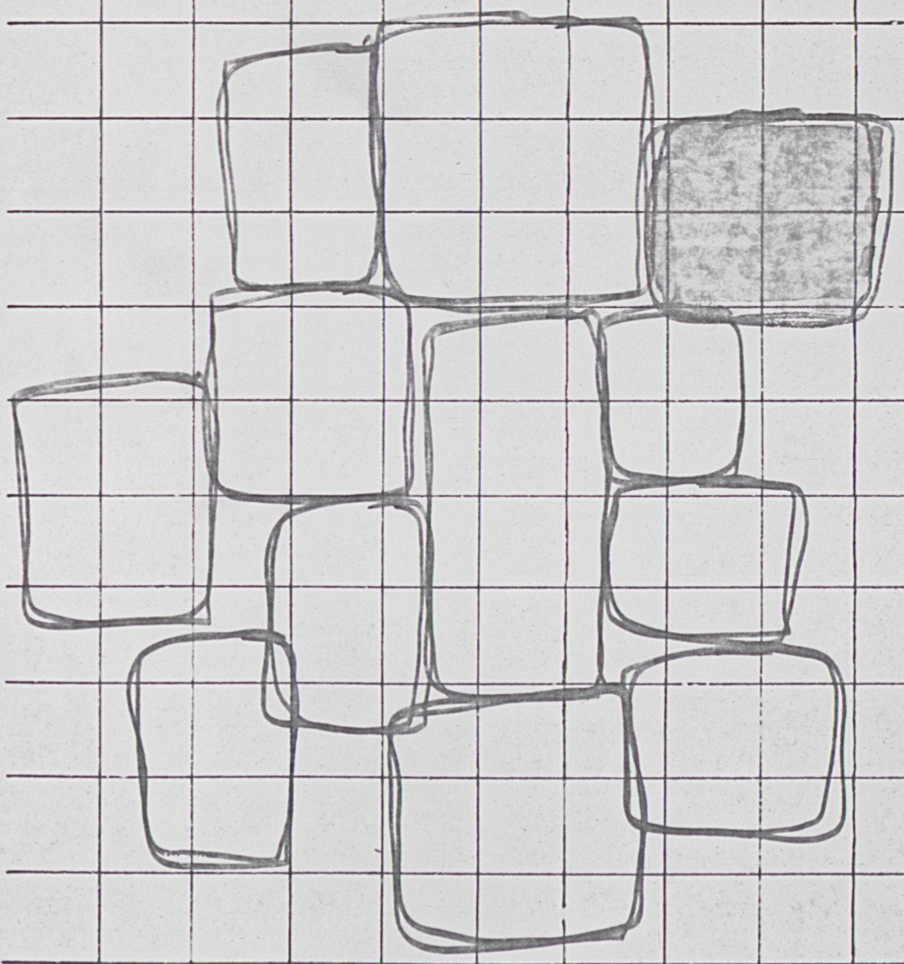


activity: BAR

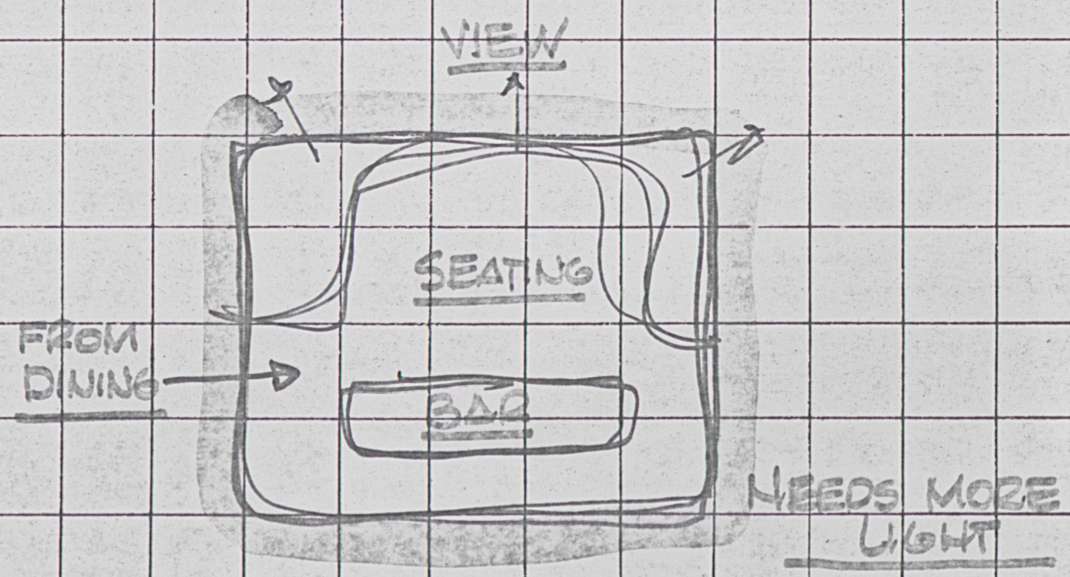
space: 800 SQ. FT.

BAR
TABLES
STORAGE
SERVICE

relation:



schematic:

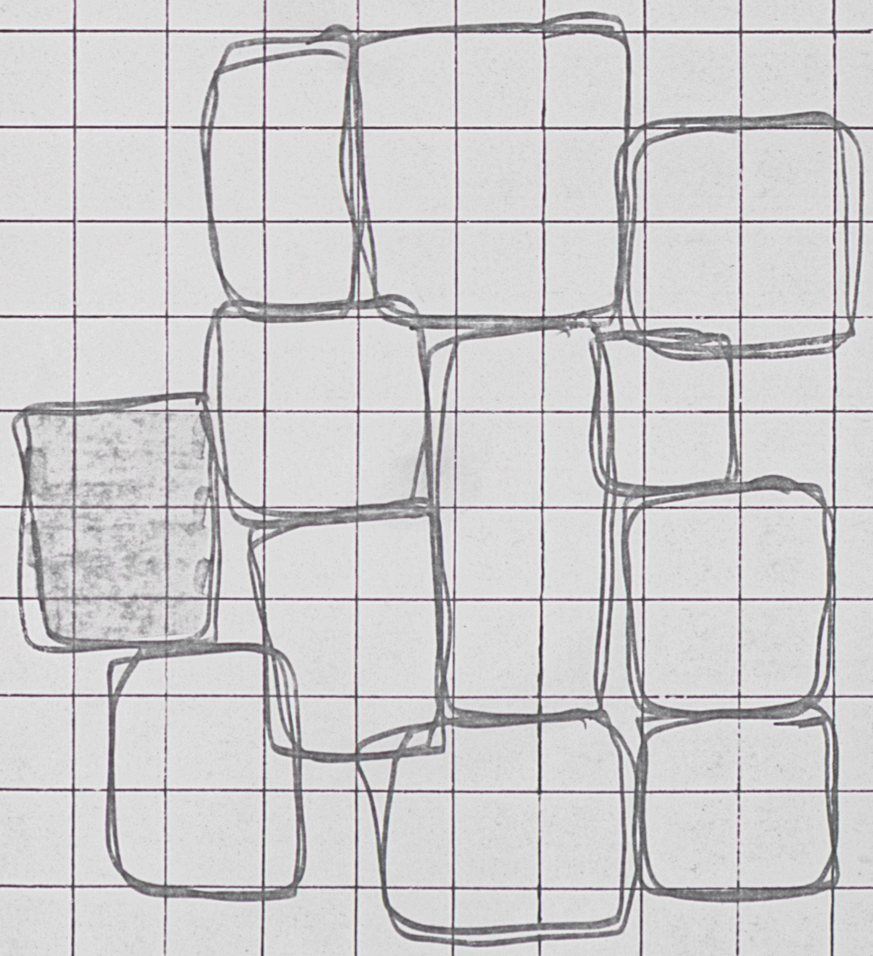


activity: MECHANICAL

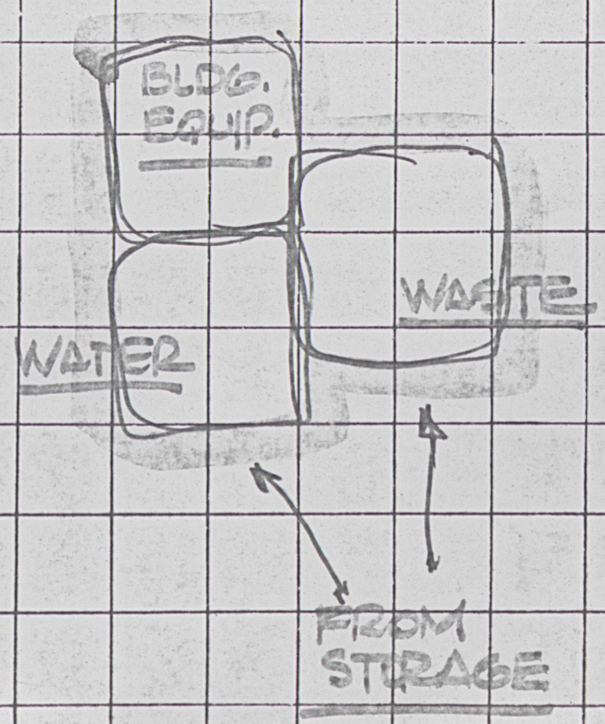
space: 400 SQ. FT.

HEAT PUMPS FOR WATER WASTE

relation:



schematic:

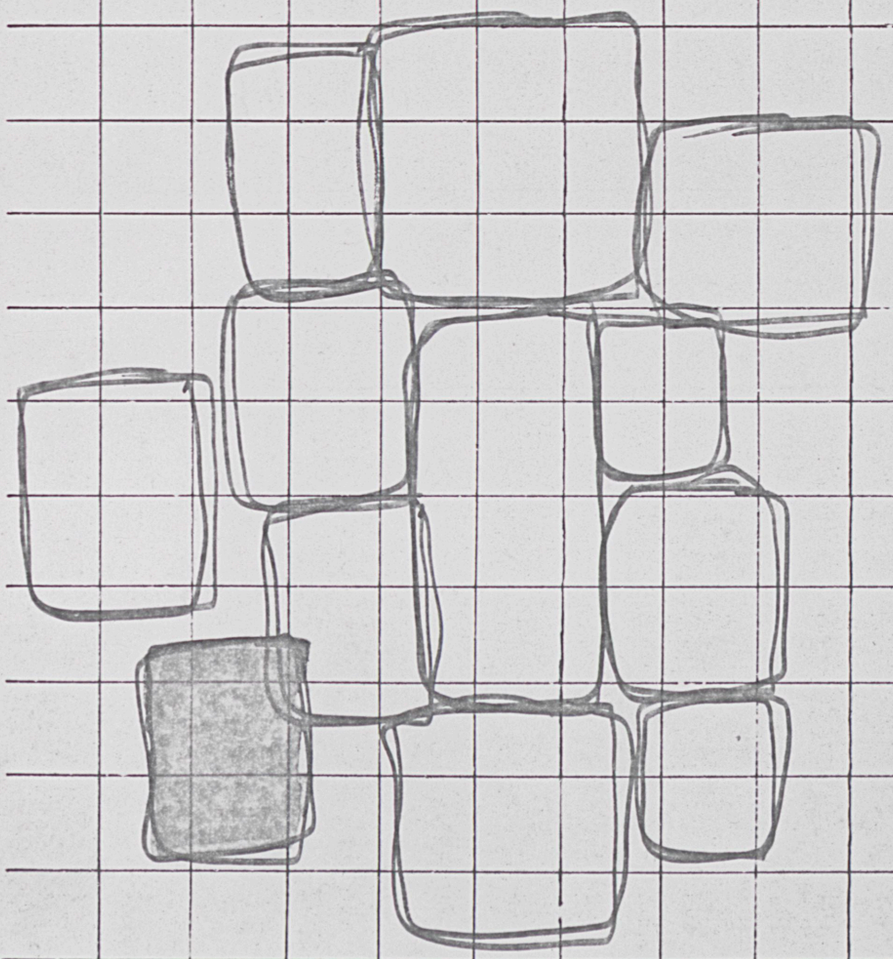


activity: BLDG. MAINTENANCE

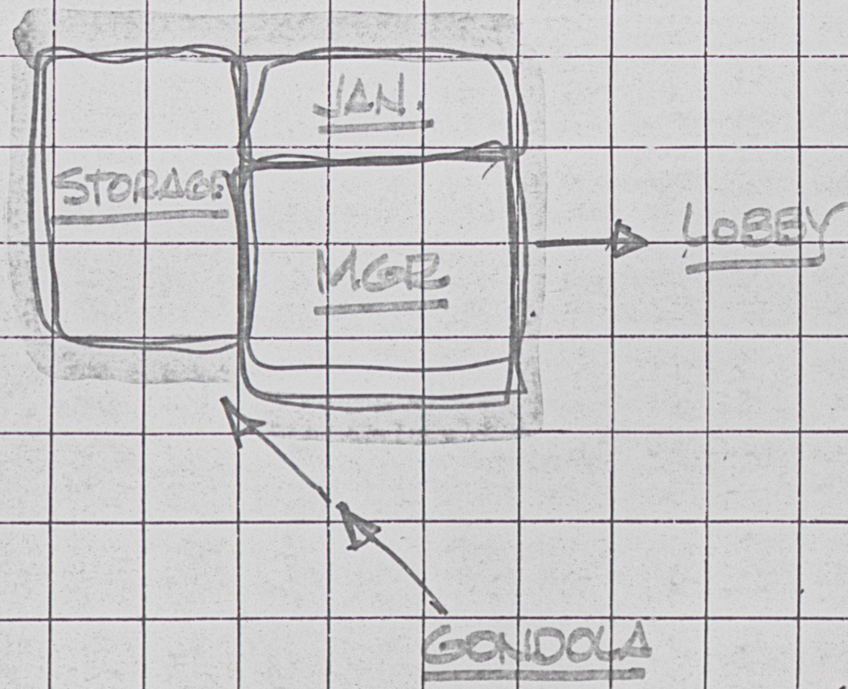
space: 100 SQ. FT.

JANITOR
MGR. OFFICE
STORAGE

relation:



schematic:

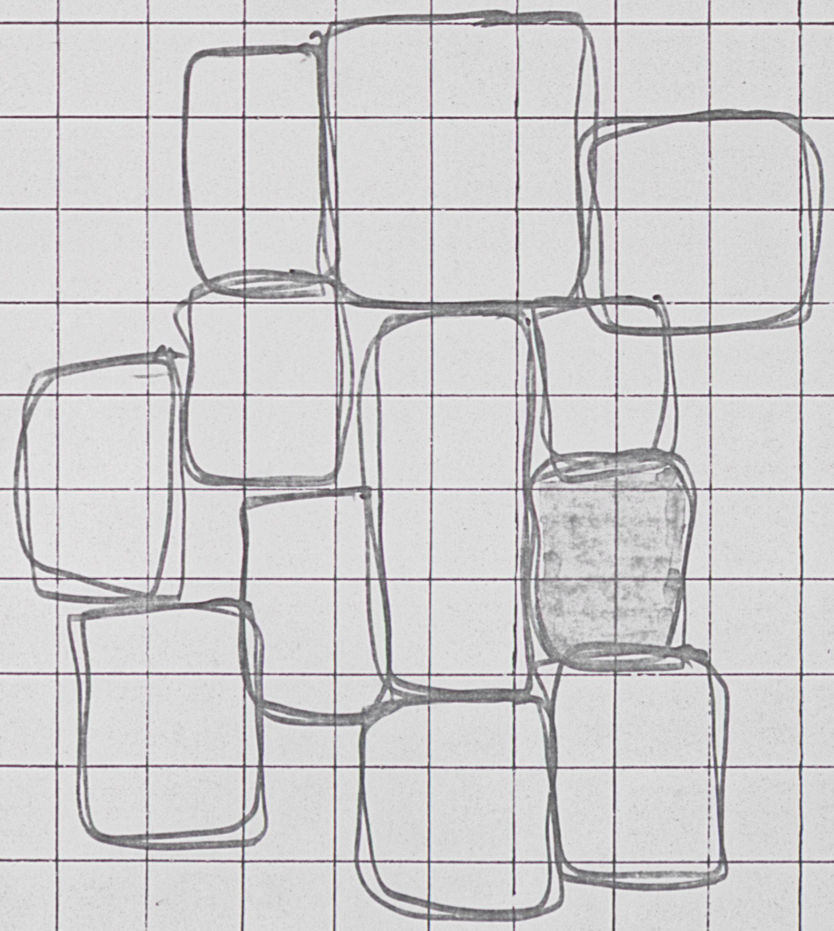


activity: WASTE STORAGE.

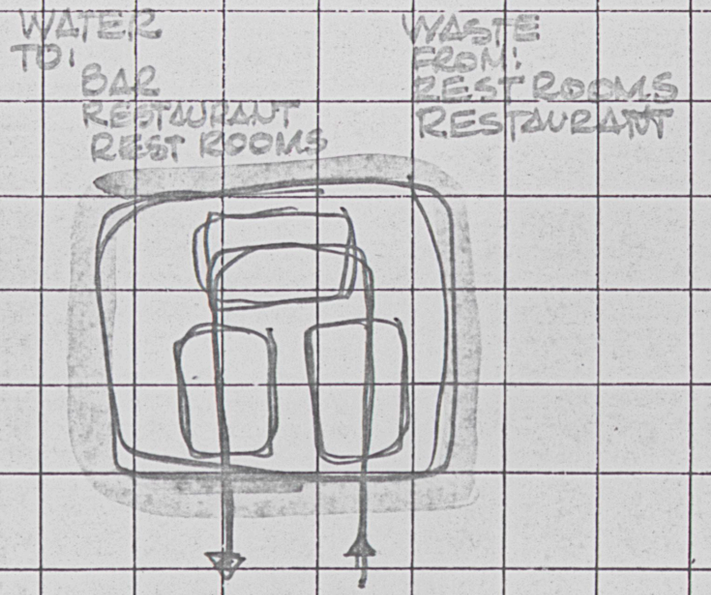
space: 400 SQ. FT.

CONTAINERIZED
WASTE STORAGE
PUMPED TO
TANKS
TRANSPORTED TO GONDOLA
ON TRACK.

relation:



schematic:

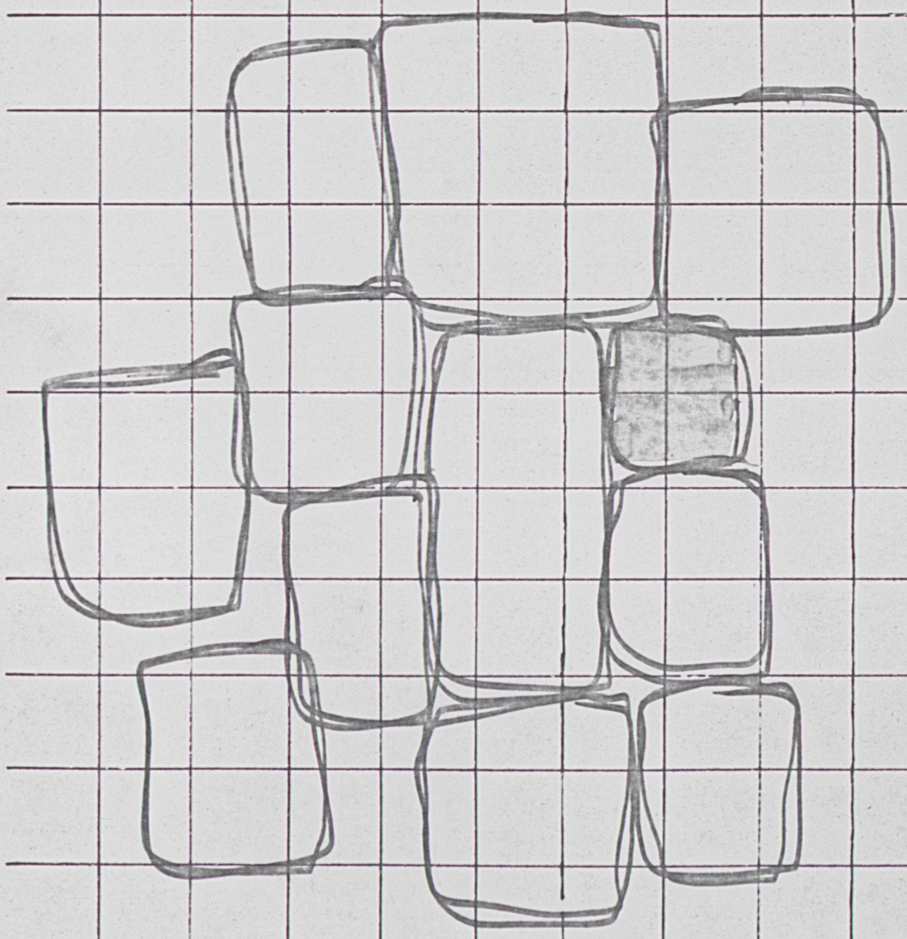


activity: RESTROOMS

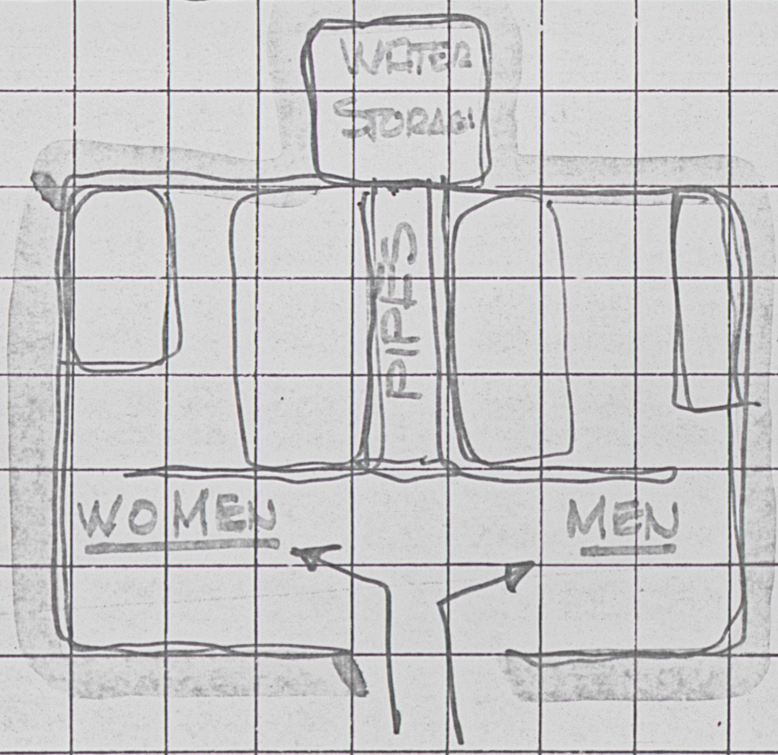
space: 400 SQ. FT. 200 E.A.

WOMEN (6 STALLS)
MEN (3 STALLS)

relation:



schematic:



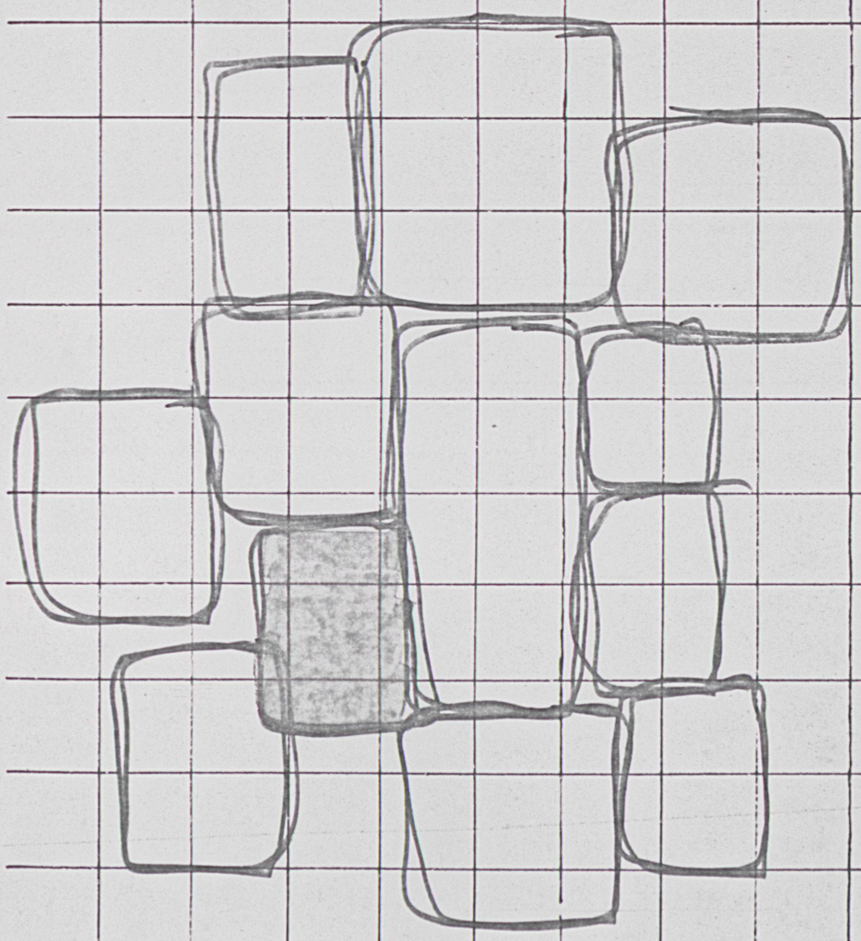
activity: STORAGE

space: 200 SQ. FT.

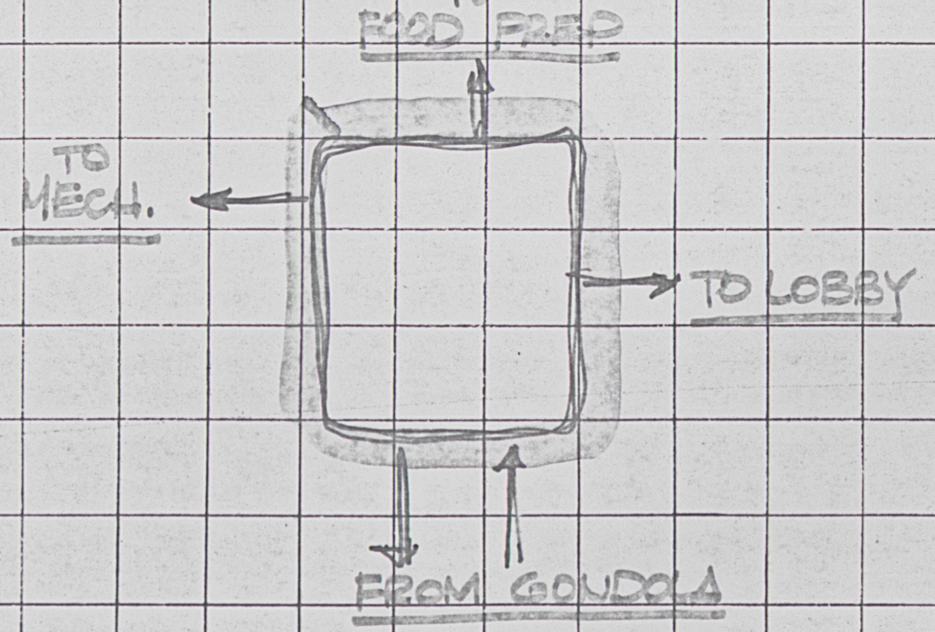
FOOD
- CANNED
- DRIED
- FROZEN

LIQUOR
FIRE WOOD
WATER } CONTAINERIZED
WASTE }

relation:



schematic:



DESIGN

The following section discusses the general design concepts and their relationship to the functional requirements, the environmental modification from the physical implications of the analysis synthesis section and the final drawings of the architectural solution.

Concept Formulation:

1. valley (first)

To gain advantage of earth as insulation, it occurred to me to study the nature of the spaces involved with the building in order to develop a priority for light and view. It appears that since it is relatively simple to get light underground, view to the outside contradicts the use of the earth as insulation since it removes earth from the walls. Therefore, those activities that are interior oriented, i.e. mechanical, shops, offices, etc., could be located below the grade. It would be desirable to allow natural light into the underground spaces and imperative to provide view into the shops from the pedestrian areas in order that items for sale would be visually merchandisable.

Accordingly, the functions that require short-term turnover and have a need to view pedestrian activity would be placed in a heirarchy of circulation that would allow the various needs to occur. As a result, the restaurant and brown bag areas were to be placed at grade level and the longer term later day activities, i.e. the bar, would be situated at the second level.

Because of the nature of the flat site, in order to maintain the correct elevation to the mountain, the gondola required a second story exit from the day center. As a result, this gondola restriction also had a major influence in the general concept formulation.

2. valley (second)

The second major design concept came from the use of the building as a sun trap oriented to the skier traffic. This concept became a modifier in two ways. First, in order that the building operate efficiently as a sun trap in the winter and reduce heat gain in the summer, the building configuration needed to be elongated in one direction and oriented so that the elongated side face southeast. Second, as a destination resort, the sun court would be more effectively situated so as to consume the bulk of the skiers from the resort lodging locations. By placing the building on the west side of the valley, the gondola lines are shorter and the sun court operates in efficient conjunction with the resort circulation.

3. mountain (first)

Because of the commanding panarama available to anyone standing at the summit of Mt. Hebgen, I was tempted to allow the amenities of view overcome the reality of the

problem of high southwest winds. If the restaurant were to be placed on the summit's edge, it would be critical to maintain a low profile so as to 1. limit the wind effect on the building, i.e. infiltration, structural wracking, etc. 2. provide an inconspicuous addition to the summit as viewed from Hebgen Lake and the highway.

Because of the soil instability and excavation difficulty, the concept of low profile was eliminated. In addition, the snow depth of approximately 120" would offer great difficulty to a compressed solution.

As a result of site analysis, I felt that the best placement of the mountain top restaurant would be moved back from the edge and provide an observation deck at the crest.

The building was sited back from the edge approximately 50 feet behind an existing stand of pines and the observation deck connected with the building via an elevated walkway.

As previously mentioned, the geology dictated as little soil disturbance as possible, and therefore, the structural concept that came to mind was one of concrete embedded poles bearing glulaminated timbers.

4. mountain (second)

The second major design concept for the mountain building was derived from the method of arrival, the gondola. It seemed that the conclusion to the journey could use the building as a focus of arrival and in turn the people in the building could take advantage of the arrival of the gondola as a focus for social interaction. Thus the building, designed with the above in mind, would allow a convenient waiting and meeting point for alpine skiers, hikers, cross-country skiers, all users.

Functional Requirements:

After having laid the foundations for design with the establishment of concepts for building use, the next major objective was to establish a functional requirement for the building. (The concepts being formed with a primary understanding of the spaces and their uses). This process required an indepth understanding of each space, its use, its effect on adjacent spaces, its equipment requirements within as well as outside its own space.

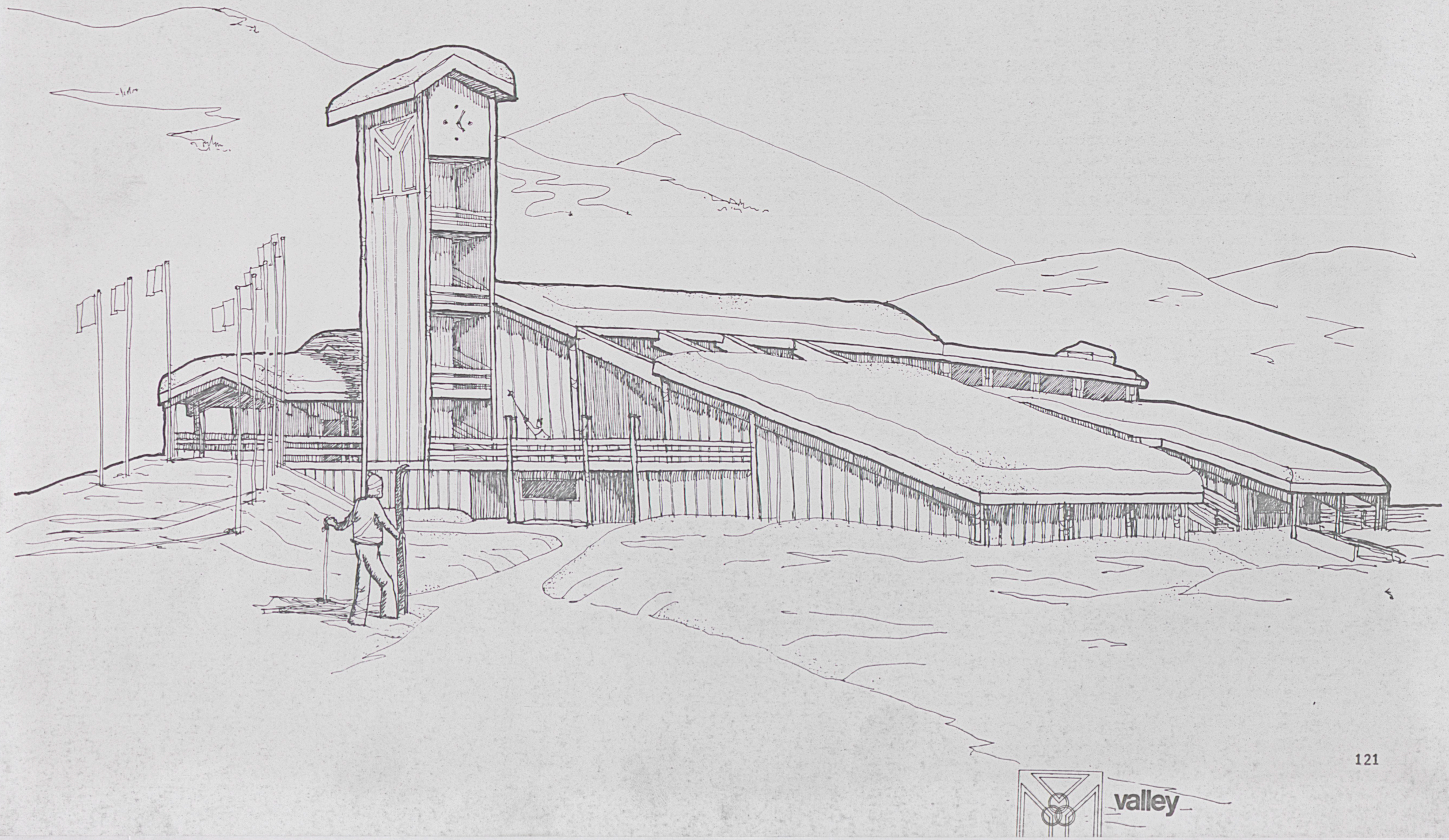
This study led to a more detailed understanding of each space and its relation to the others. At this point, with the use of the design programming method discussed in Design in Architecture by Broadbert. Each space was set up in a grid that allows a comparison of each space to every other space (See Program).

An essential-nonessential value was placed on each space relation as they were compared to each other. This information was applied to another relationship diagram that grapihcally allowed one to connect essentially related spaces. This was done by drawing the title of each space in a bubble each bubble being arranged in a large circle. For any one area a line was drawn to every other area that was essentially related. The resulting diagram is a ma e of overlapping lines. This ma e is systematically eliminated by redrawing the bubbles as many times as necessary so as to eliminate all overlapping lines. The final form yields a schematic diagram of area relationships. This schematic bubble-diagram is then modified so as to accommodate the original concepts.

Environmental Modification:

The next step was to apply the physical implications from the environmental principles mentioned in analysis and synthesis. This procedure further molded the schematic bubble diagram into the architectural solution that follows.

valley site



valley



valley upper level

RESTAURANT

KITCHEN

CAFETERIA

BROWN BAG

DUCT VERT. CHASE

MECH.

DELI

DELUGE

CURIO

UPHOLSTER

OPEN

LOBBY

RENTAL

EXIT

TICKETS

ENTER

UP

DN

sw

nw

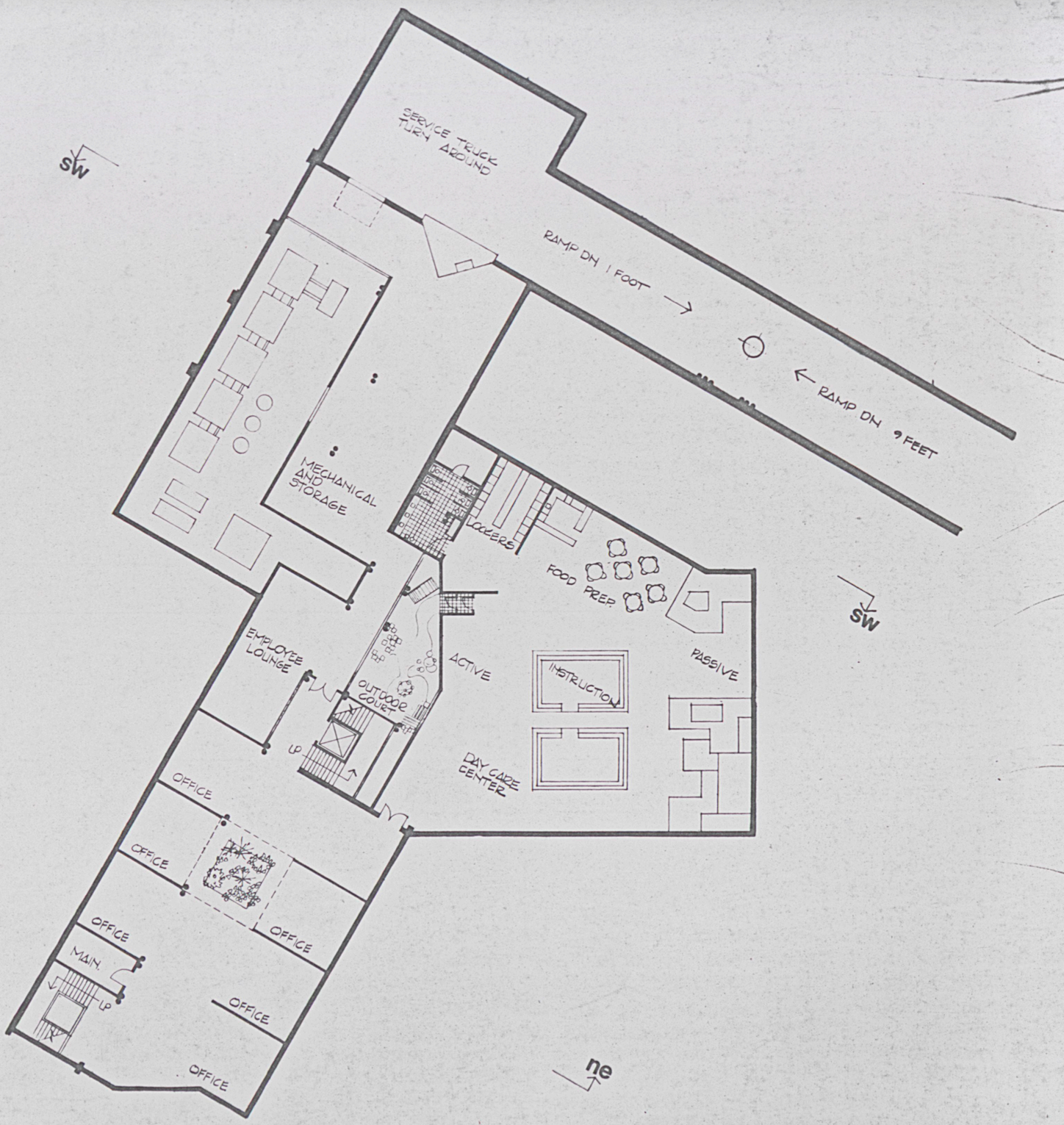
FIN TUBE - WATER

RADIANT COILS - WATER

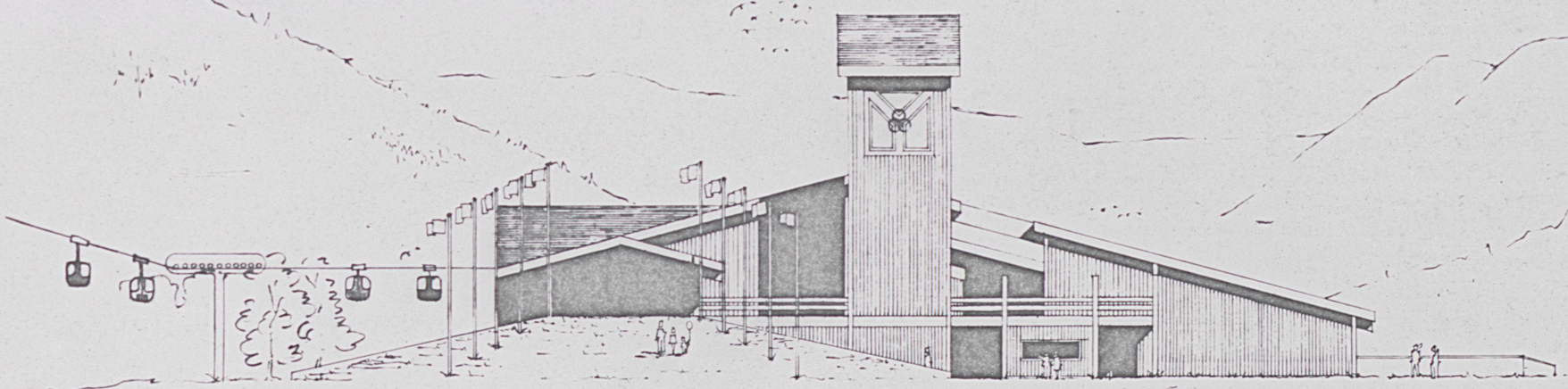
RADIANT COILS - ETHYLENE GLYCOL

valley
main level

0 8 16 32 48 64



valley lower level



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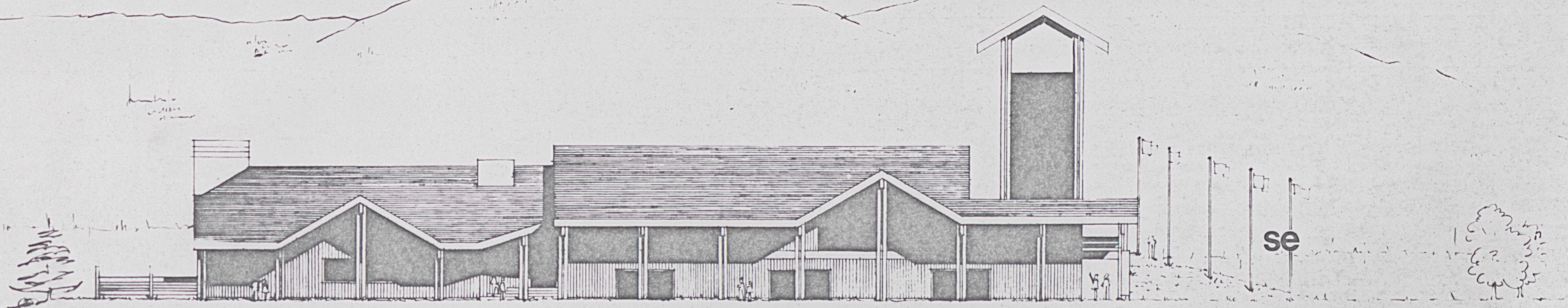

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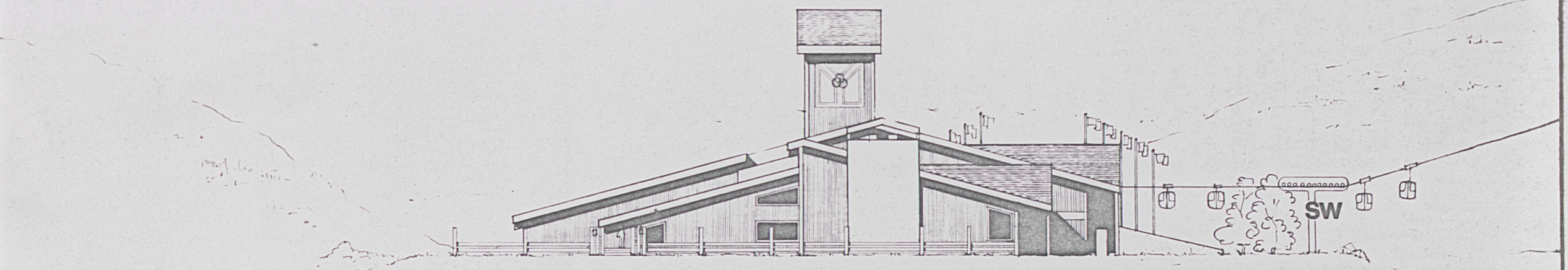
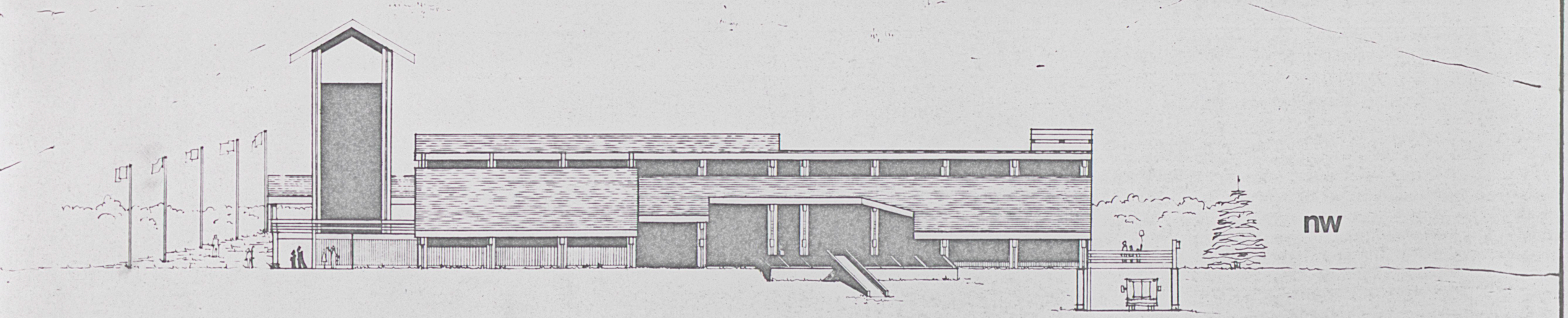
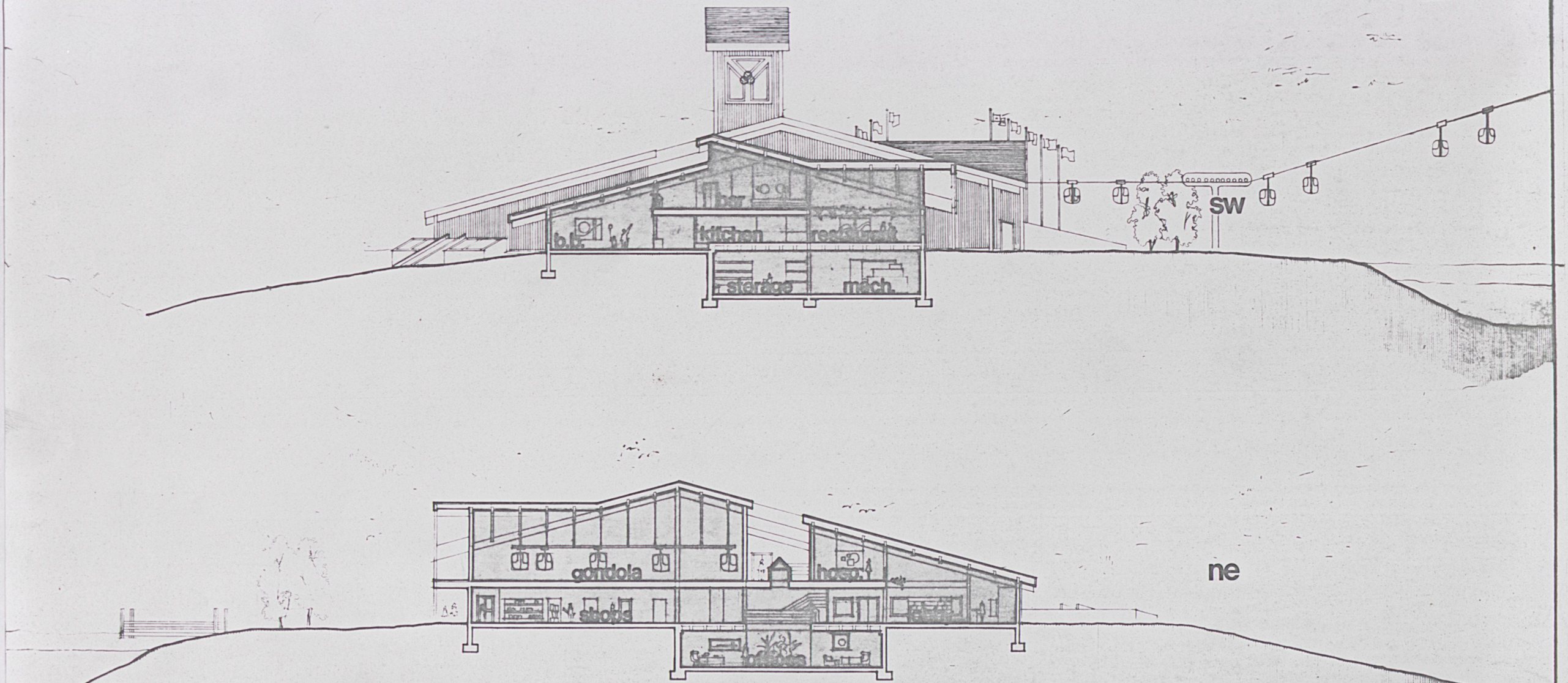
valley elevations

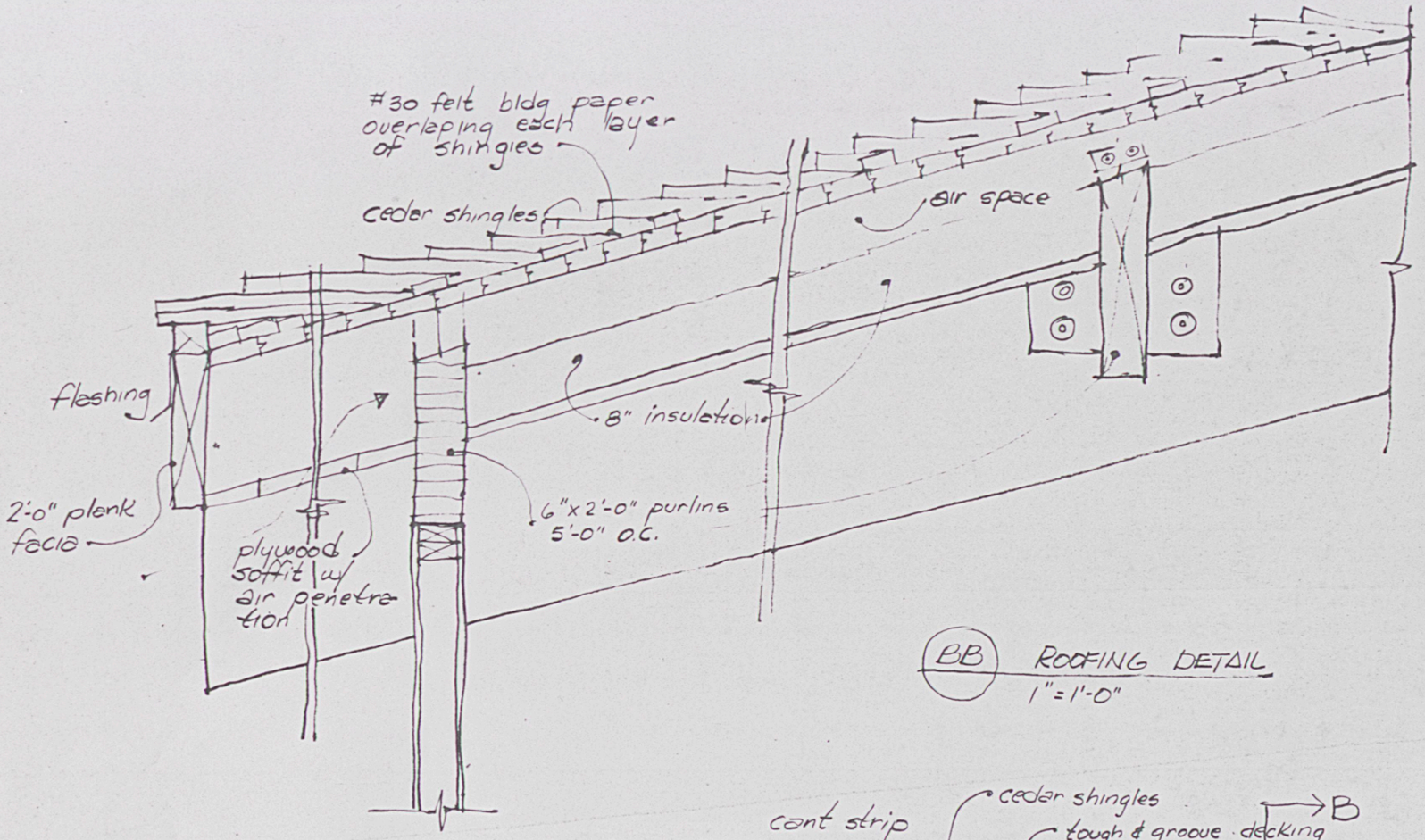




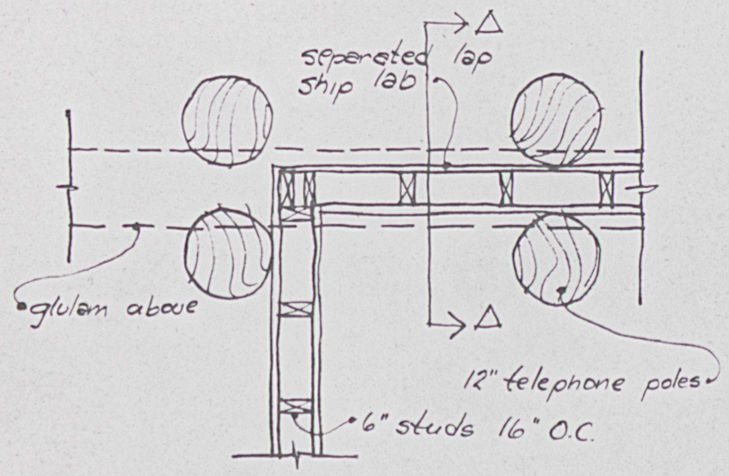
valley elevations



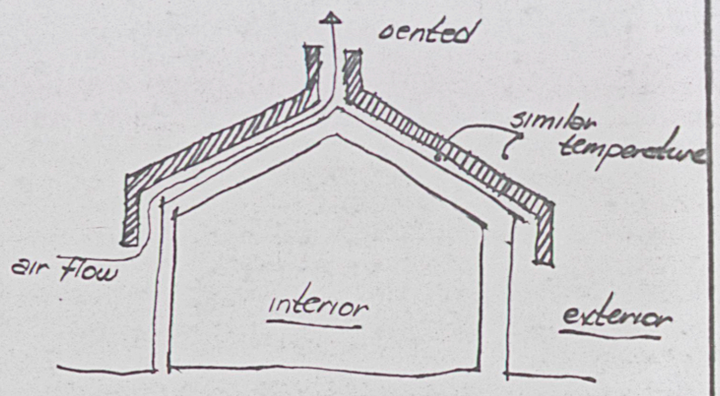
valley sections



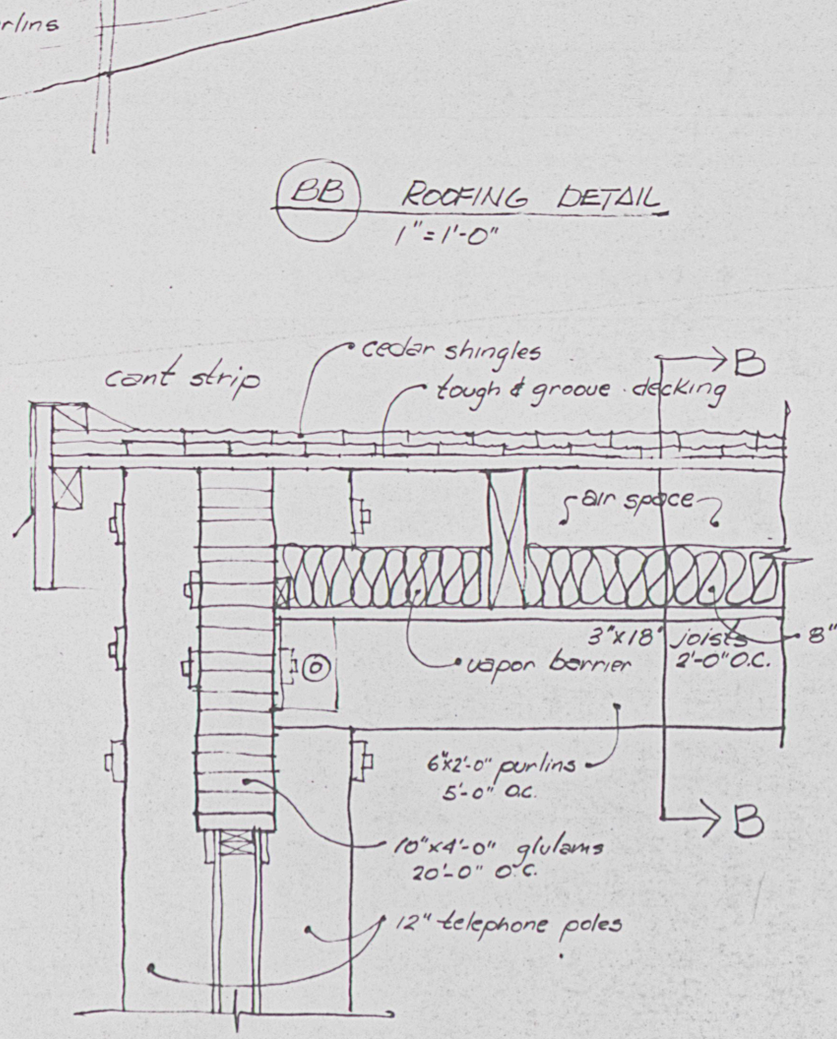
EAVE DETAIL
1"=1'-0"



CORNER DETAIL
1"=1'-0"

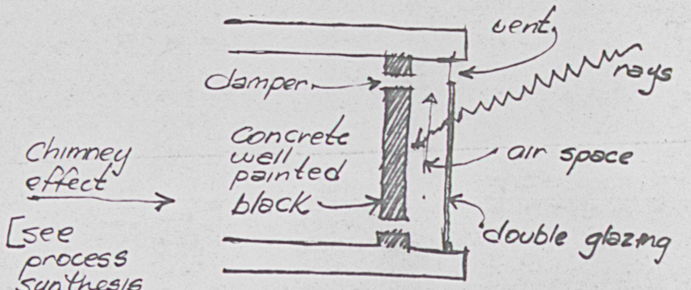


DOUBLE ROOF SCHEMATIC
no scale

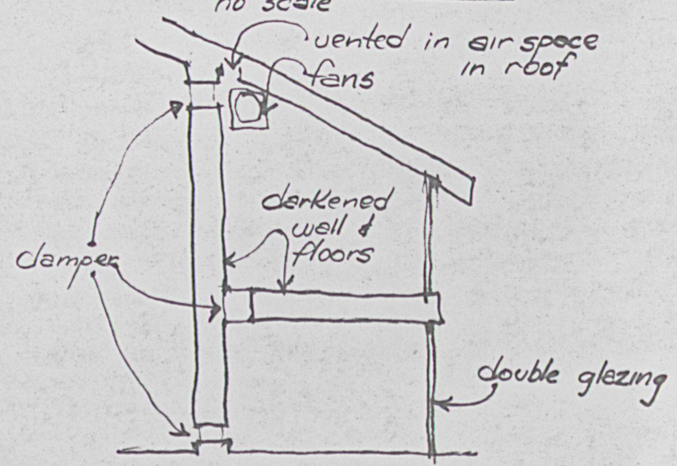


BB ROOFING DETAIL
1"=1'-0"

GLULAM DETAIL
1"=1'-0"



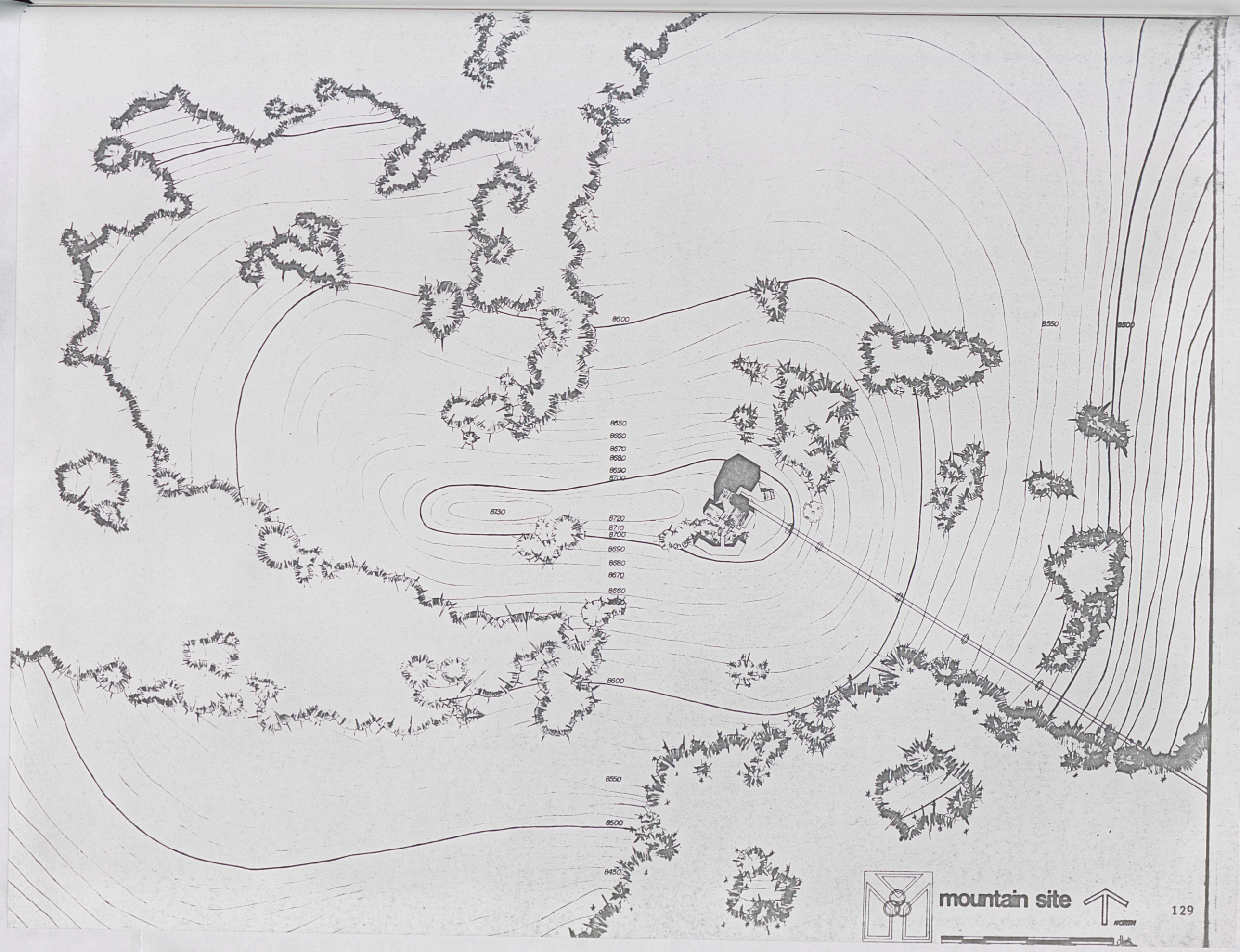
SOLAR WALL DETAIL
no scale



ENCLOSED UNHEATED CIRCULATION WAY
no scale



valley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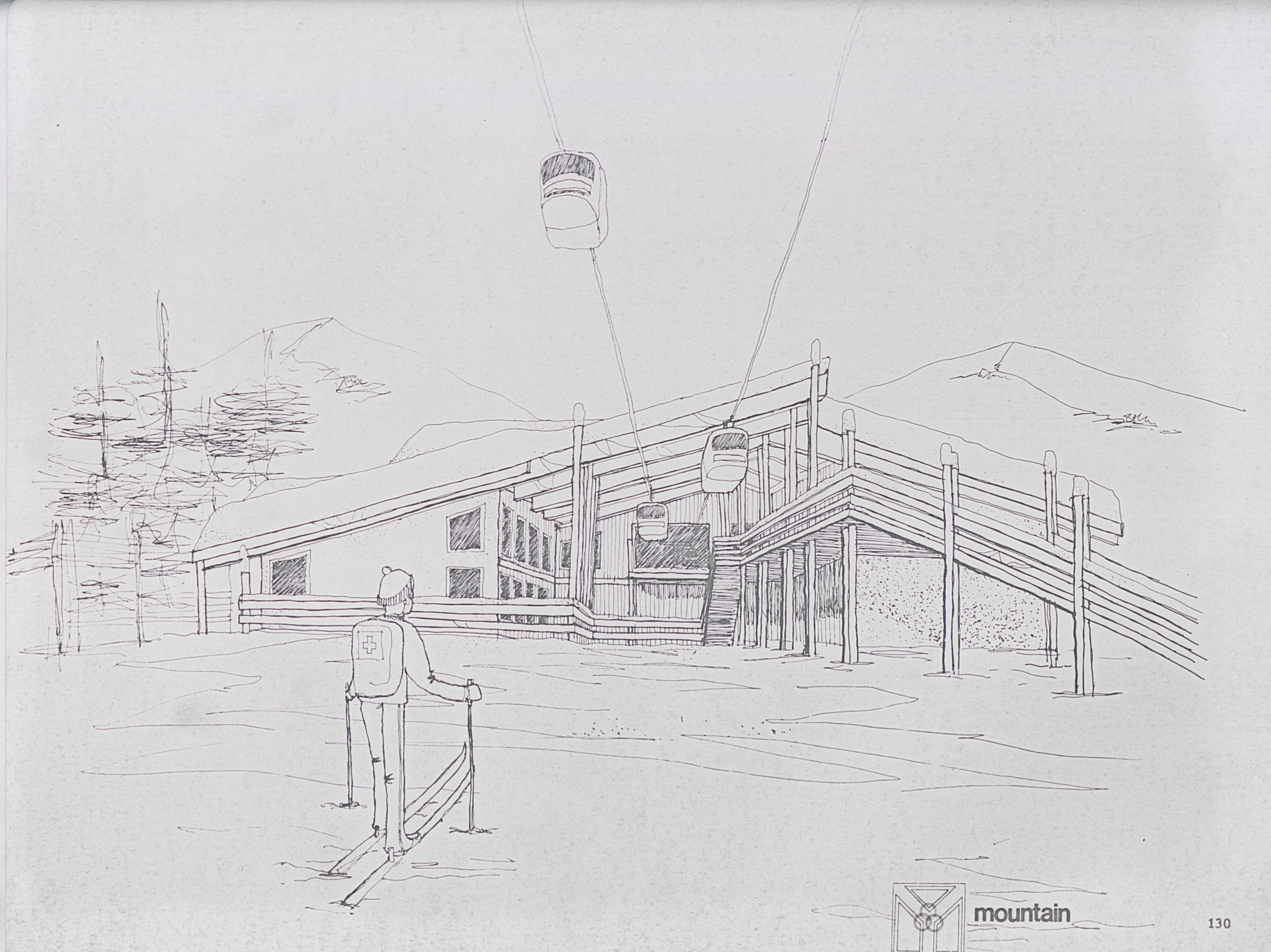
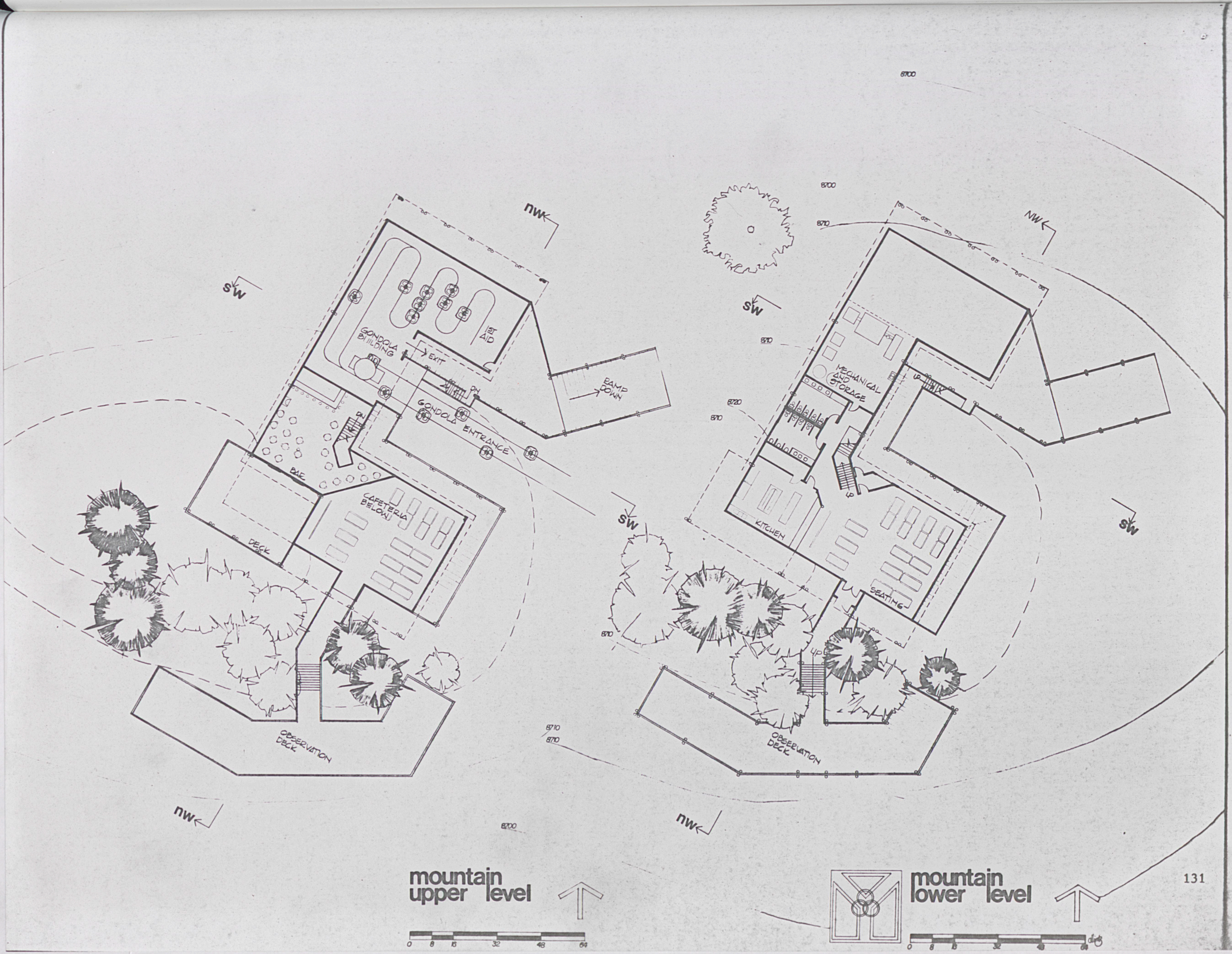
mountain site
NORTH





mountain upper level

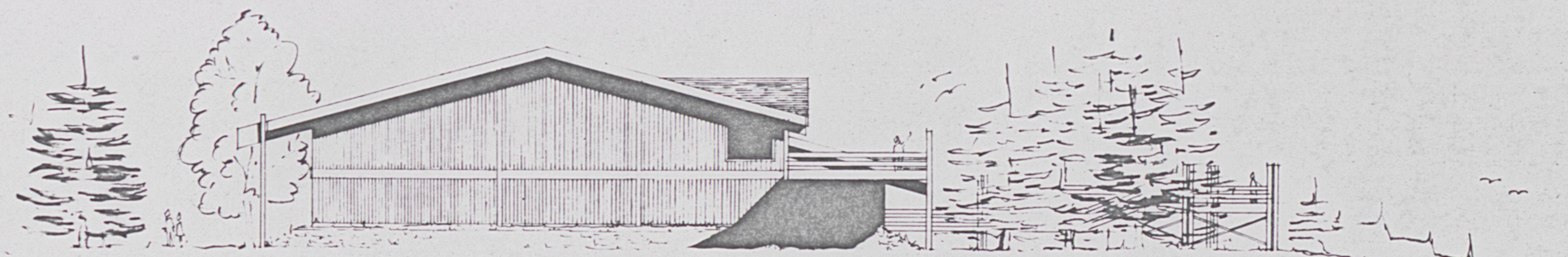
0 8 16 32 48 64

mountain lower level

0 8 16 32 48 64 diet8



mountain sections



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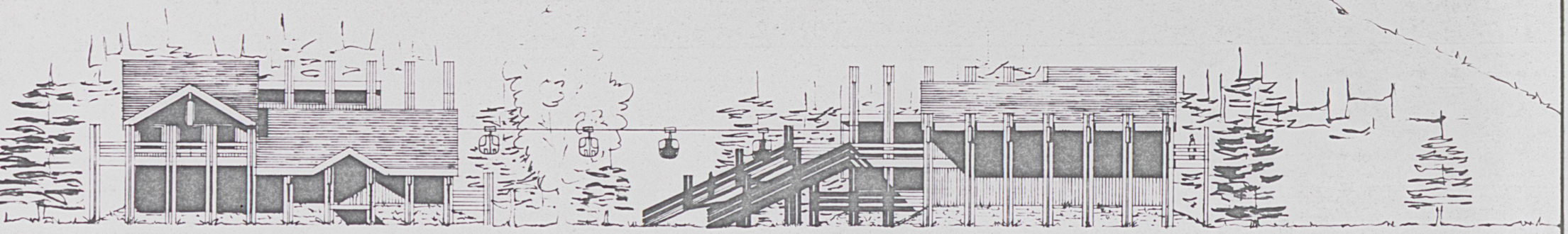

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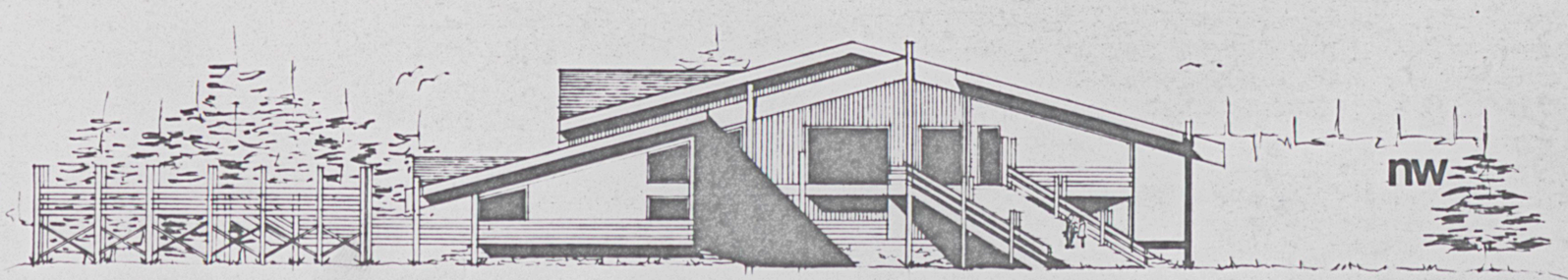

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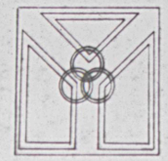
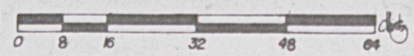
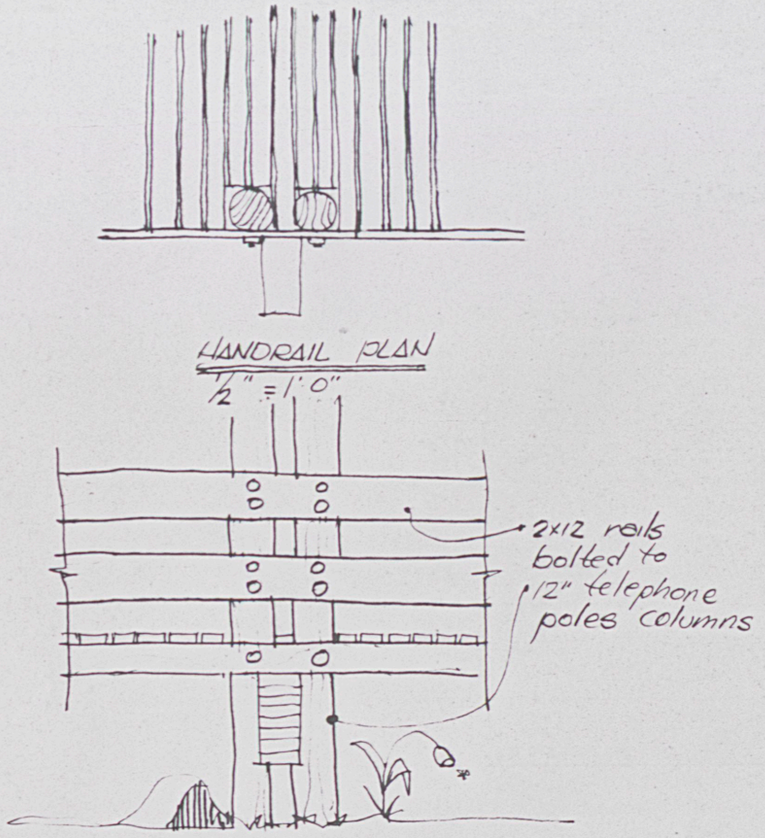
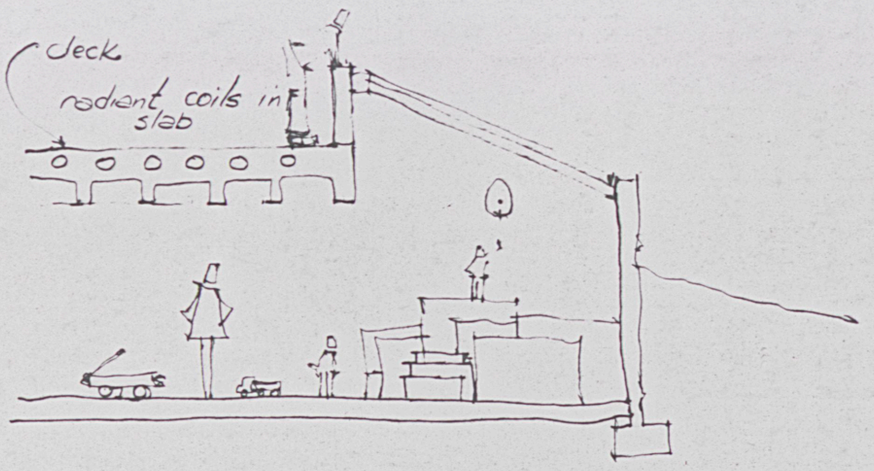


mountain elevations

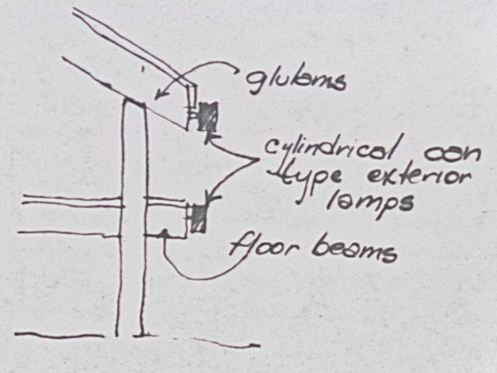




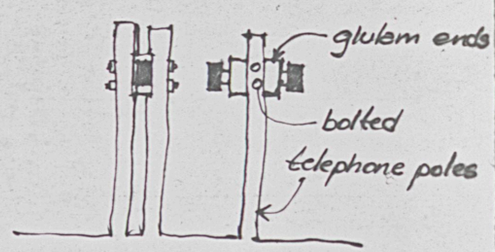
HANDRAIL PLAN
1/2" = 1'-0"



DAY CARE SKYLIGHT SCHEMATIC

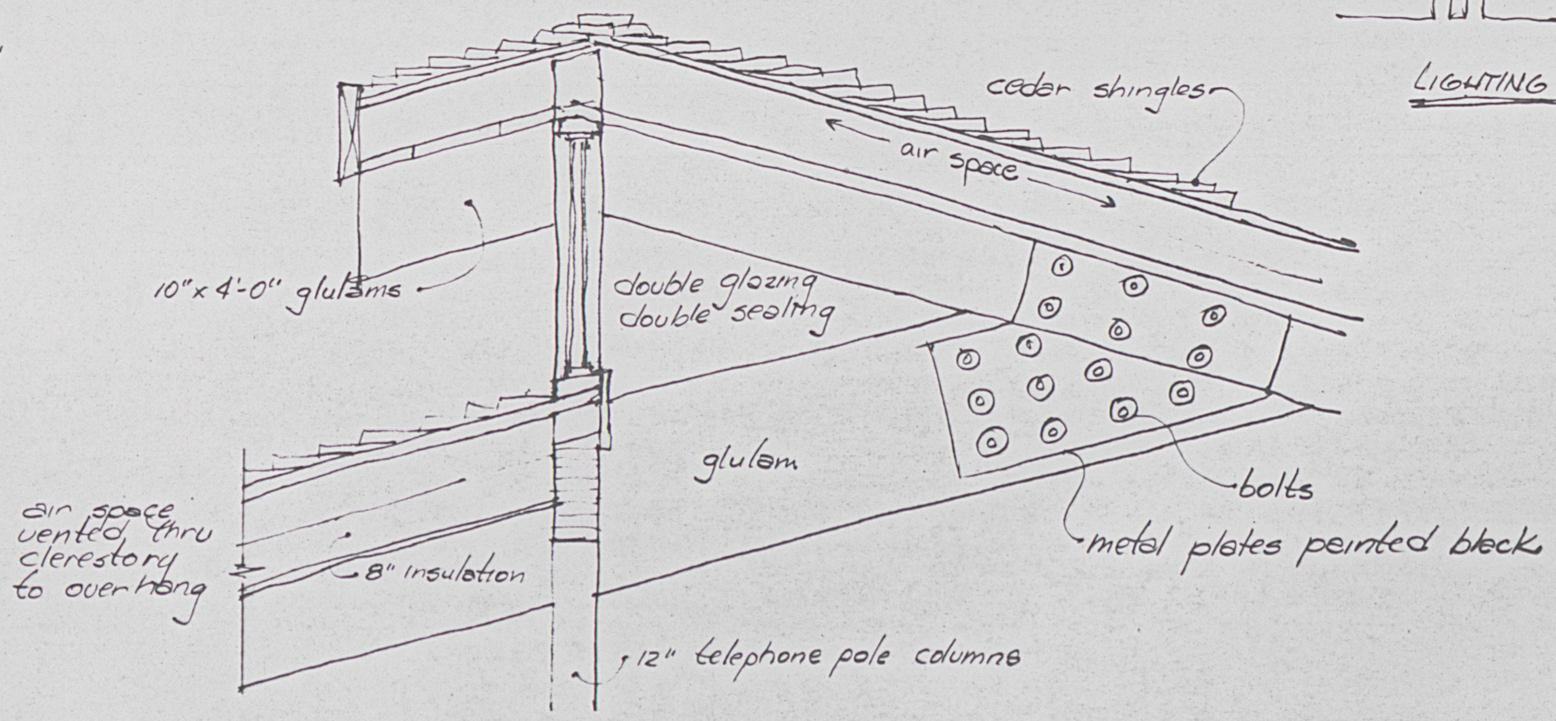


LIGHTING CONCEPTS

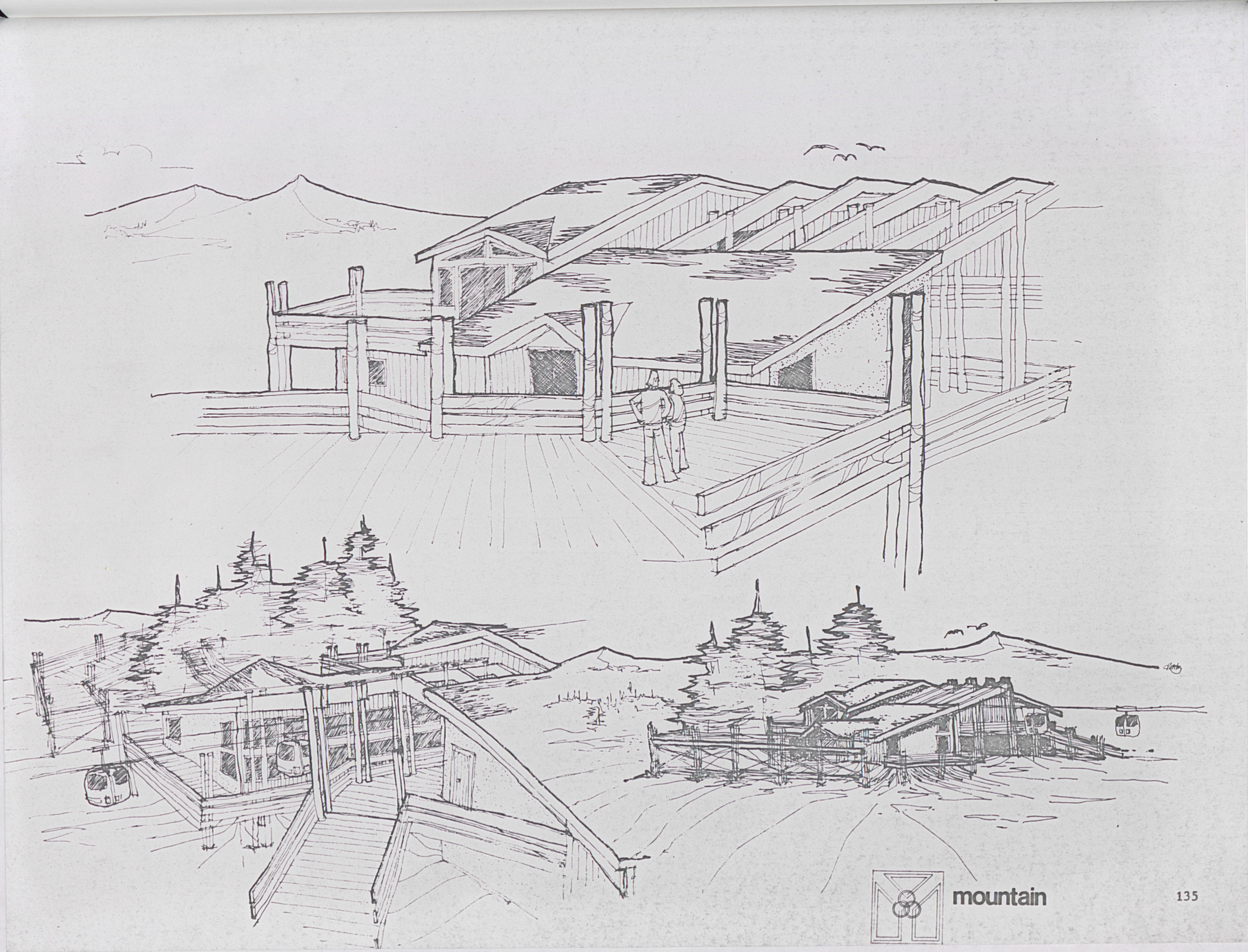


LIGHTING POLES

HANDRAIL & DECK ELEVATION
1/2" = 1'-0"



CLERESTORY DETAIL
1" = 1'-0"



site sections

NORTH

0 30 100 200 300 400 FEET

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