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CLEMSON UNIVERSITY ENERGY RESEARCH CENTER

CLEMSON UNIVERSITY
ENERGY RESEARCH CENTER

By Mark Gesen Carroll

A terminal project submitted to the faculty of the College of Architecture, Clemson University, in partial fulfillment of the requirements for the degree of Master of Architecture.

[redacted]

Peter Lee, Committee Chairman

Donald Collins, Committee Member

[redacted]

Teoman Doruk, Committee Member

[redacted]

Gayland Witherspoon, Head, Dept. of Architectural Studies

[redacted]

Harlan E. McClure, Dean,
College of Architecture

Spring, 1980

ACKNOWLEDGEMENTS

I would like to express my deepest appreciation to the faculty of the College of Architecture for their assistance and encouragement during the past six years, with special thanks to:

Harlan E. McClure, Dean, College of Architecture

Peter R. Lee, Committee Chairman

Donald Collins, Committee Member

Teoman Doruk, Committee Member

and, to the graduate students that made life bearable when it was not.

623839

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To the memory of my grandmother and grandfather.

To my family for their continuous support.

"Foolish and ambitious persons think
they can form judgement by seeing
much art of all kinds. They see all
pictures in Italy; --all the architecture
in the world --and merely make themselves
as incapable of judgement as a worn-out
dictionary....."

John Ruskin

introduction

INTRODUCTION

The United States has enjoyed an expanding economy during most of this century. In the period following World War II especially, our prosperity and life expectations have come to depend increasingly upon the consumption of more and more energy. Until recently, energy, and especially fossil fuel, has been relatively cheap and, as a consequence, the recoverable oil and natural gas that nature slowly formed over hundreds of millions of years has been recklessly expended. This era of abundant cheap energy is now ending, and the reality of scarce expensive energy is rapidly becoming apparent to all. Because energy is used in virtually all aspects of our lives, our lifestyle cannot help being greatly altered in the forthcoming years. In the coming decade it will be necessary to develop new ways to deal more efficiently with known energy sources and additionally to explore new means of meeting the energy needs of this nation.

Currently, our major source of energy is oil, a third of which is imported from abroad. Japan and the countries of Western Europe, are even more heavily dependent on imported oil. The impact of the sharp price increase that began in January of 1974 is now being severely felt by all importing nations. Oil producing countries, like Saudi Arabis, are having to absorb large sums of foreign currency. Saudi Arabia presently has the world's fourth largest collection of United States dollars, topped only by United States, Japan, and West Germany. Large expenditures for imported oil are causing the United States and other industrialized countries to go deeper into debt. Consequently, a world-wide economic crisis is possible and even likely if drastic developments do not occur.[1]

A country's standard of living bears a close relationship to its consumption of energy. Highly industrialized countries that use the most energy per capita also have the largest Gross

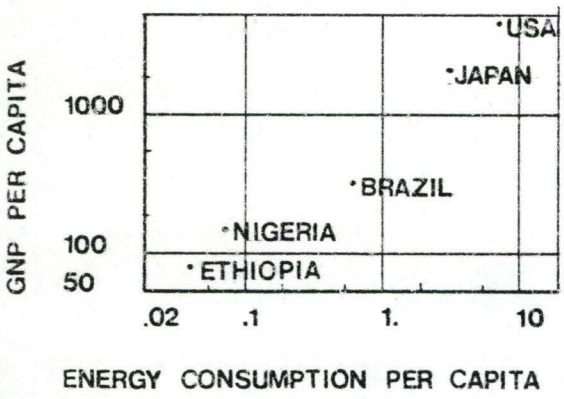


FIGURE 1.

National Product (GNP) per capita. See Figure 1, the United States has the largest GNP per capita in the world and is followed closely by Canada, and Western European countries. Most of the countries of Latin America are similar to Brazil and Argentina with a moderate energy consumption and GNP per capita as compared to the United States. Most countries of Africa are similar to Ethiopia which has a low energy consumption and a low GNP per capita as compared to the United States.[2]

Although the United States imports a third of its oil, it is not as dependent on oil imports as many countries which have little in the way of natural resources. Although known sources of oil and gas in this country are becoming seriously depleted, an abundance of coal still exists.

Several decades ago coal was the largest energy source for the United States. However, in 1950 the United States began importing oil. At first it was largely confined to residual oil,

which was sold on the east coast at a price competitive with coal. Later when there were concerns about coal's sulphur emissions, imported residual oil gradually assumed a larger role as an energy source. Consequently, the oil embargo of 1974 made it obvious that this country will be required to develop new energy sources, and better and more effective ways of using our existing sources. This can be accomplished only through intensive and innovative basic and applied research.

problem statement

PROBLEM STATEMENT

Current energy concern throughout the United States have placed many universities in a leadership role of solving energy problems. Clemson University, with its emphasis on technology among the institutions of higher learning in South Carolina, is in this leadership position in the State. Therefore, it is the logical location for a major energy research facility. This facility would accommodate administrative, educational, and research activities directed towards the study of energy problems and the development of solutions to these problems. It would coordinate energy research already being undertaken at the University and provide space and equipment for new and increased efforts in this vital area of study. Although it would be expected that a variety of research efforts would be undertaken at the facility, a major portion of them would be directed towards the needs of the State of South Carolina.

background

PRESENT AND PROPOSED ENERGY RESEARCH AT CLEMSON UNIVERSITY

Several research programs studying energy problems have been developed at Clemson University in recent years. These programs are usually sponsored by governmental agencies or private industries that have a specific interest in a particular research area and are undertaken individually by different department of the University. Despite the positive benefits of these separate efforts, there exists little opportunity to coordinate and direct them towards a comprehensive energy research program. The following pages describe current energy research being undertaken throughout Clemson University.

COLLEGE OF ENGINEERING

The College of Engineering is currently engaged in a majority of the energy research conducted at Clemson University. This is true also in resepct to the number of researchers and available funds.

The Electrical Engineering Department is currently examining stress factors in photovoltaic cells. Solar photovoltaic cells are capable of converting solar energy into electrical energy. Very little is known about how these cells will respond to terrestrial conditions and research is being conducted to determine their reaction to temperature extremities through a technique of accelerating climatic conditions. Results of this research are expected to improve the reliability and performance of solar cells in the future. Other research that the Electrical Engineering Department is investigating includes digital control and instrumentation research, and study in the area of industrial power and electronics.

Research in these fields would be of great benefit to industry because it could lead to the streamlining of industrial operations and consequent elimination of excessive energy needs.

The Mechanical Engineering Department is currently studying separation technology as it relates to the purification of water. This technology is extremely important to the textile industry, because the large amounts of water needed for dyeing fabrics and the consequent energy needed to supply this water. The environmental implications of this research are equally vital to not only the textile industry, but any industry reliant upon water as part of a manufacturing process. The Mechanical Engineering Department has also developed a conventional prime mover laboratory. This laboratory researches means of improving the efficiency of the internal combustion engine. The relevance of such research is, of course, obvious in light of today's energy crisis in the availability of fossil fuels.

Other departments in the College of Engineering, although not currently involved in specific energy related research, have at their disposal a good deal of expertise and equipment applicable to such research if space and funding were available.

COLLEGE OF SCIENCE

The College of Science is actively engaged in two energy research projects through its Department of Physics, and has the potential for research in other departments.

One study being undertaken by the Physics Department deals with cooling wire, such as lead, to near absolute zero. Wire at this temperature will conduct electricity without appreciable resistance with the result that electrical energy could be conducted more efficiently than is currently the case. Long range benefits from this research could result in being able to place nuclear power plants in locations remote from population areas served. Another area of research in the Physics Department involves the study of damage to various materials used in the construction of nuclear power reactors. Results of this research, as well as the previous study, will be beneficial in improving the safety of nuclear power generation.

The Department of Microbiology is examining the possibility of research in several areas related to energy. One of these is the study of biological conversion of solid waste to ethanol. However, present space limitations and lack of funding prevent such projects from being undertaken at the present time.

COLLEGE OF ARCHITECTURE

The College of Architecture is not directly engaged in energy research at the present time. However, one faculty member from the College works on a continuing basis with the USDA Rural Housing Research Unit located adjacent to the campus. Research conducted by this organization is directed principally towards the use of solar energy in buildings. Three test houses have been constructed which are continuously monitored to evaluate solar panel and greenhouse collection systems.

COLLEGE OF INDUSTRIAL MANAGEMENT AND TEXTILE SCIENCE

The College of Industrial Management and Textile Science has the potential for research in several areas related to energy. However, space and budget limitations currently limit its participation in this work. A study of transportation of raw and finished textile materials is being considered by the Department of Textiles, possibly in conjunction with the Department of Mathematics. Other studies the Textile Department could conduct are membrane separation, water recovery, foam finishing, dyeing technology, and waste recycling, all of which could benefit the textile industry.

COLLEGE OF FORESTRY AND RECREATIONAL RESOURCES

The College of Forestry and Recreational Resources has plans to begin research into the conversion of wood to methanol. This biomass study, as with several projects in other colleges, is currently limited by lack of space and research facilities.

COLLEGE OF AGRICULTURE

The College of Agriculture currently is not conducting any research directly related to energy. However, proposals have been made to study the benefits of solar and wind energy for agricultural use. Additionally, study in the field of biomass research is being considered. These projects are awaiting appropriate funding.

SUMMARY

A number of energy related research projects are being conducted at Clemson University and many others would be initiated if funding and space were available. It is not the purpose of this terminal project to address the issue of funding, but it is presumed that as energy issues become increasingly vital, appropriate funding will be available. The issue of research space, however, is a primary issue of this project. Rather than develop additional facilities within each of the affected colleges, this project proposes that a single research center serving all colleges of Clemson University be developed. This center would allow a much closer coordination of both current and proposed research programs and enable these programs to be directed towards specific goals consistent with energy policies of both the State and the Nation.

case studies

Project: GENERAL MOTORS TECHNICAL CENTER

Architect: Eero Saarinen

Location: Warren, Michigan

Size: 2,000,000 Square Feet

The General Motors Technical Center is one of the first triumphs of post World War II architecture in the United States, as well as being one of Eero Saarinen's first major works. The architect convinced the client that the Technical Center should be an expression of high-precision mass-production metal industry. The precise articulation of the entire complex was based on clear technical needs. The Center was designed on a five-foot module that is ever present in all the facades, ceilings, walls, and floors. This permits illumination, air conditioning and all mechanical equipment to easily fit into the consistent structural framing. The building clearly exemplifies the Miesian "Universal" space that can be adapted to continuously changing users.[3]

To humanize this otherwise austere architecture the architect used color, water, and sculpture throughout the complex.

Project: RESEARCH AND ENGINEERING CENTER FOR KIMBERLY-CLARK CORPORATION

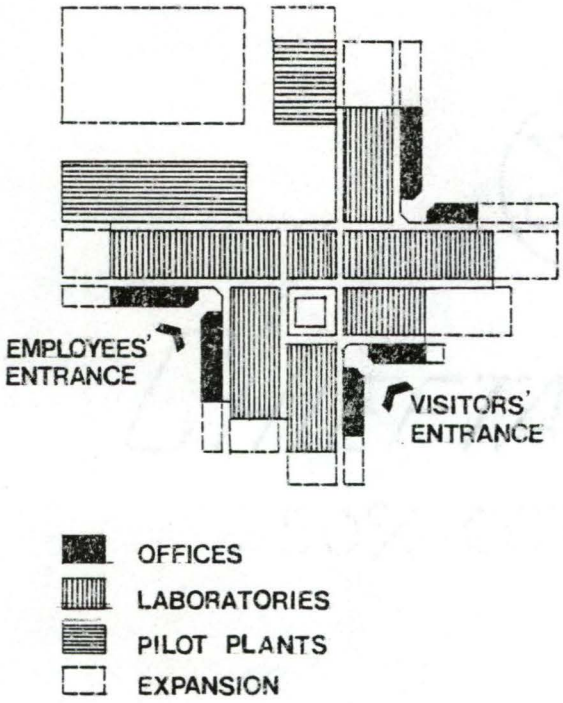
Architect: Hellmuth, Otaba & Kassabaum (HOK)

Location: Menasha, Wisconsin

Size: 352,000 Square Feet

Research and development facilities have become a showcase of today's industries. Commissions for these facilities have provided architects with some freedom from austere budgets and utilitarian materials associated with the manufacturing branch of industry. Not all such facilities are monumental or extravagant. However, the client generally considers the research and development facilities more important to the corporate image than the manufacturing plants.[4]

The Research and Engineering Center for Kimberly-Clark Corporation is a reality to the previously mentioned thinking and reflects this in terms of corporate image. This three-story building provides 325,000 square feet of space for paper industry research and product development. The Center, located in the



ORGANIZATION DIAGRAM

city of Menasha, Wiconsin, is on a one hundred and two acre site. The building contains laboratories, pilot plant, office space, food services, library, and reception areas. Central to the working space is the skylighted court. This space was designed to encourage interchange between researchers and visitors. Twin entrance ways funnel into the mezzanine level atrium in which the court is situated. A centralized reception area in the atrium between the first and second levels of the building serves as a security check-point through which all traffic must pass to enter the building. This type of control is a security measure likely to be typical to many research and development facilities in the future. Pilot plant spaces, peripheral to the laboratories, have the high bay machine oriented aspect of conventional industrial spaces.[5]

The pin wheel arrangement of working spaces around the central court make it possible to expand the building

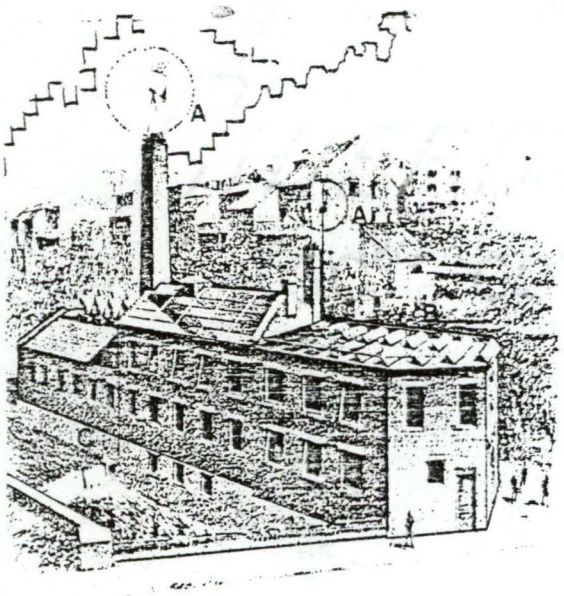
outwards in several directions. The structure was also designed for expansion by use of precast concrete columns, beams and floor system. The exterior wall panel system is composed of modular sand-blasted spandrels and insulated aluminum panels which are designed to be movable and interchangeable in the event of future changes.[6]

Project: RHODE ISLAND ENERGY CONSERVATION STATION

Architect: Research and Design Institute (REDE)

Location: Providence, Rhode Island

Size: 10,500 Square Feet



A WIND MILLS
B SOLAR COLLECTORS
C WATER WHEEL

TEST FACILITIES ARE APPLIED TO STATION

The Rhode Island Conservation Station is an adaptive reuse of an old foundry built in the 1840's. This building will become the focal point of the Moshassuck Square development. Originally, this development called for the removal of this building, but through the persuasion of the architect along with help from Brown University and Rhode Island School of Design students, as well as that of local merchants, the foundry was saved and turned into the Energy Conservation Center.[7]

The facility is used for a variety of educational purposes as well as serving as a demonstration of various energy conservation, and production techniques. Windmills, solar collectors, and a water wheel all add to the vitality and educational aspect of the Center. The building

is intended to undergo continuous changes to respond to new techniques of energy conservation and production in the future.[8]

SUMMARY

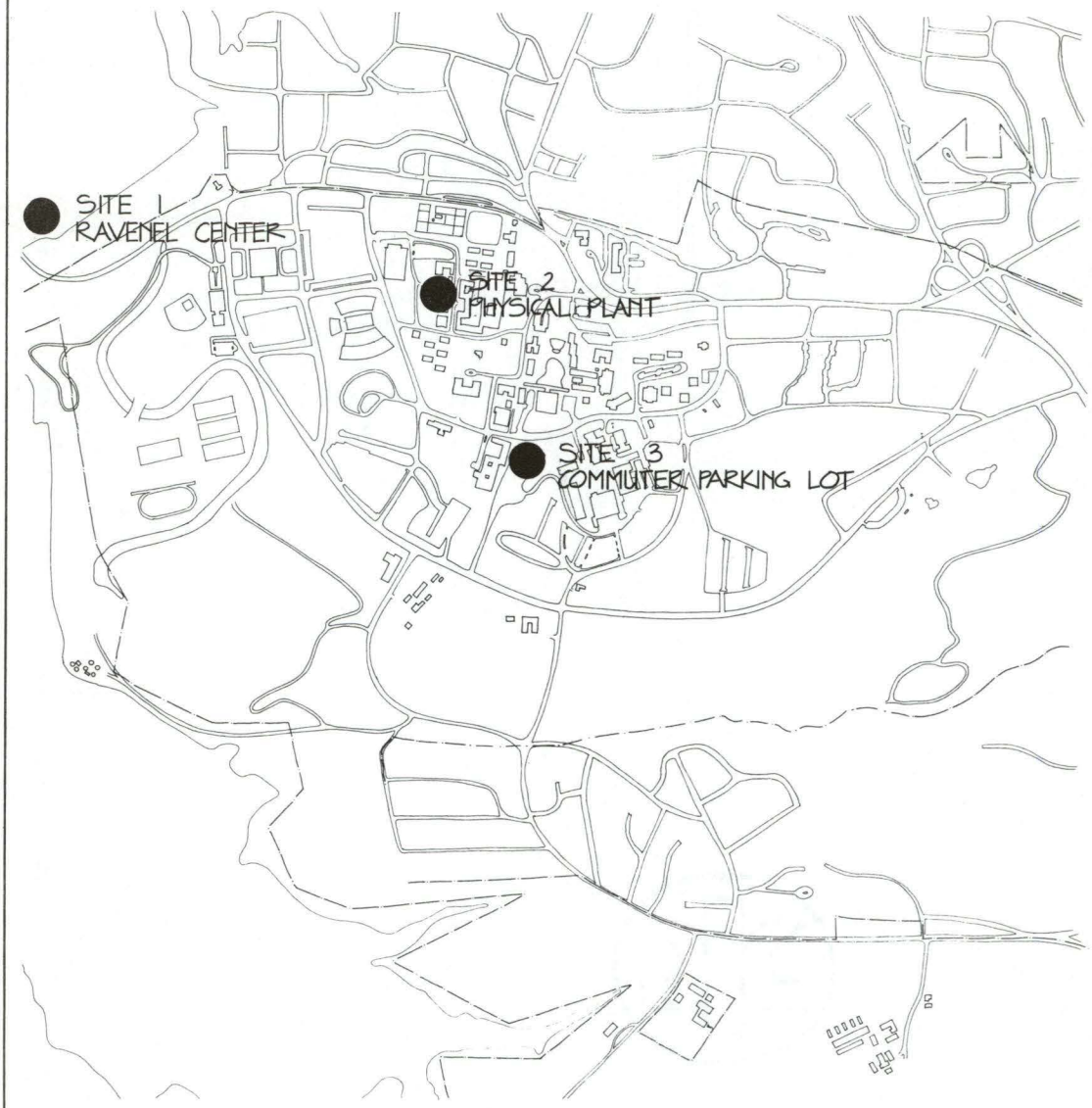
Design issues common to the foregoing case studies are flexibility and image. Flexibility in expansion is a major aspect of the Kimberly-Clark Research and Engineering Center, internal flexibility through the use of a standard building module is a principal design consideration in the General Motors Technical Center, and flexibility through addition or change of energy producing elements is possible in the Rhode Island Energy Conservation Center.

The image of the Kimberly-Clark Center is that of a prestigious corporation, the General Motors Center conveys forcefully the machine esthetic, and the Energy Conservation Center is a strong visual expression of known means of best utilizing our energy resources.

setting

SITE INVESTIGATION

Three sites on or near the Clemson University campus were examined as potential locations for the proposed Energy Research Center. A description and analysis of these sites, designated: Ravenel Center Site, Physical Plant/ Motor Pool Site, and Commuter Parking Lot Site, follows.



ENERGY RESEARCH CENTER
CLEMSON UNIVERSITY

LOCATIONS OF SITES STUDIED

RAVENEL CENTER SITE NO. 1

Ravenel Center is a Clemson University research facility currently leased to the U.S. Government for the study of cotton crops. It consists of a single research building on a one hundred and sixty acre site, located off Highway 123/76, two miles west of Clemson University. The site is bounded by Lake Hartwell on the south, Highway 76 on the north, and by additional Clemson University land on the east and west sides.

The advantages of this site are as follows: It is easily accessible by automobile because of its adjacency to a major highway. It parallels the Southern Rail Line and is near the Oconee County Airport. Other possible advantages of this site is the accessibility of a large body of water, Lake Hartwell, which borders part of the site - could be used for water related research experiments.

The major disadvantage of this site is its remoteness from the Clemson

University campus. Faculty researchers and students would need to commute to and from the site creating little opportunity for the Center's activities to be functionally and visually integrated into day-to-day campus activities.

PHYSICAL PLANT/MOTOR POOL SITE NO. 2

The physical plant/motor pool site currently contains a number of university facilities, including the physical plant offices and maintenance shops, the motor pool, steam power plant, water treatment facility, police station, fire station, and laundry. The site is bounded on the east by Klugh Road, on the north by Fike Fieldhouse, and on the southwest by Williamson Road.

The advantages of this site are as follows: It is easily accessible from all parts of the campus, it is highly visible from Williamson which is an awareness route for campus visitors, and certain energy related facilities on the site could be incorporated into the Center.

The principal disadvantage of this site is that is is presently occupied by a number of facilities which would need to be moved to make way for the Center.

COMMUTER PARKING LOT SITE NO. 3

The commuter parking lot site is in a natural ravine area below Williamson Road as it passes behind the Cooper Library. This site is bounded by Lowry Hall and Lee Hall to the west and Barre Hall to the east. It is accessible from Perimeter Road on the south.

The advantages of this site are as follows: Like the physical plant site, it is easily accessible and is quite visible from Williamson Road. Access from Perimeter Road would facilitate parking and building service.

The major disadvantage of this site is that within the campus master plan, it is proposed as the site of another university facility.

SITE SELECTION

The site selected for the development of the proposed Energy Research Center is the physical plant/motor pool site. Its principal advantages over the other sites explored is its close relationship to various colleges of the University that would make use of its facilities and its potential availability.

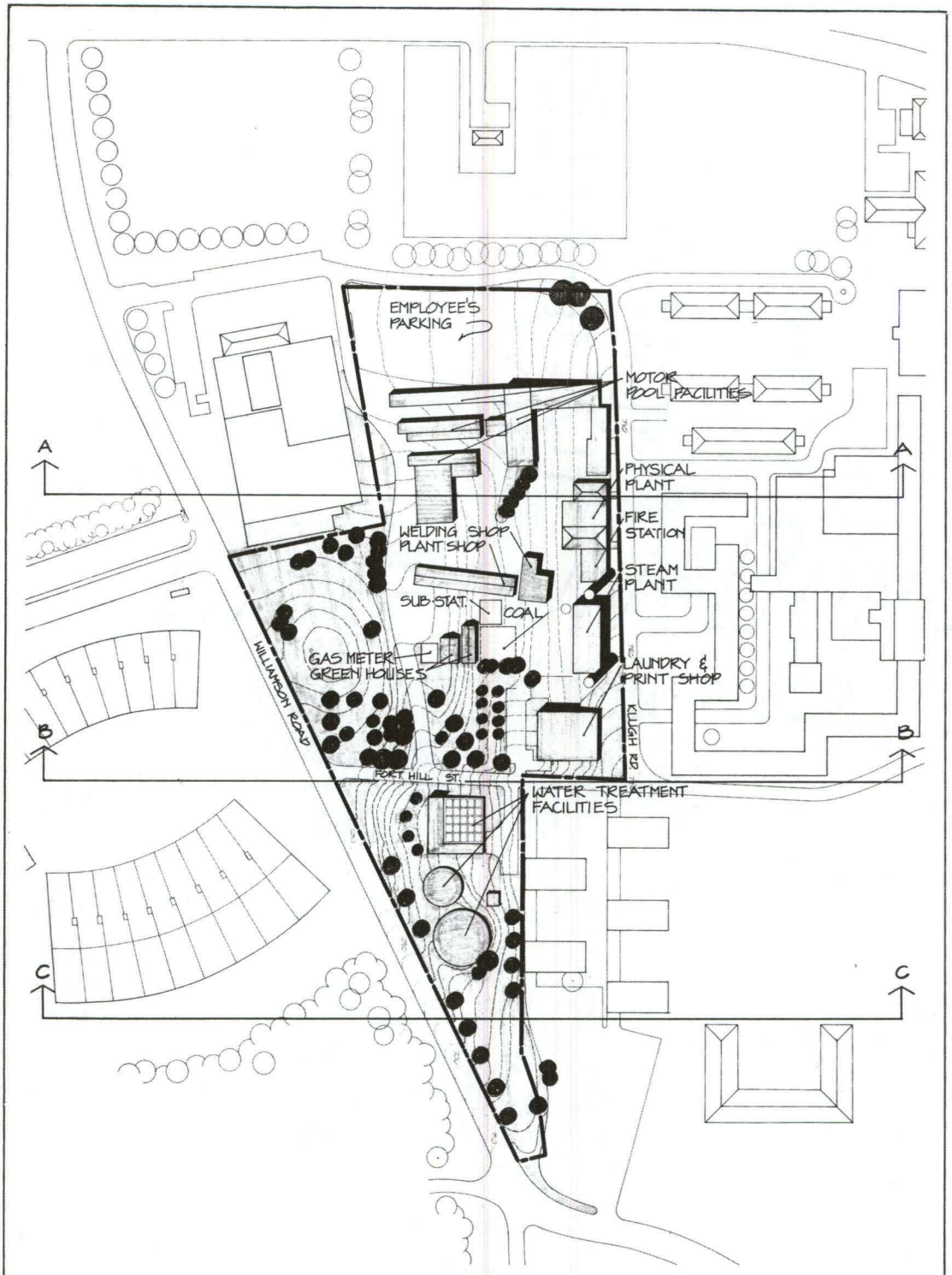
Although the site is currently occupied by a number of campus support activities, a majority of them are intended to be moved from the area in the near future to locations better suited to their use. These would include the physical plant offices and shops, campus security and fire department, and the motor pool. The central power plant, which would remain on the site would form a logical adjunct to the Research Center.

In addition to its convenient location in terms of users and participants, the site has a high visibility to both students and general public, because of its setting off Williamson Road, adjacent

to the football stadium. It thus offers the opportunity of projecting the image of the Energy Center as a vital contributor to both the University and the State.

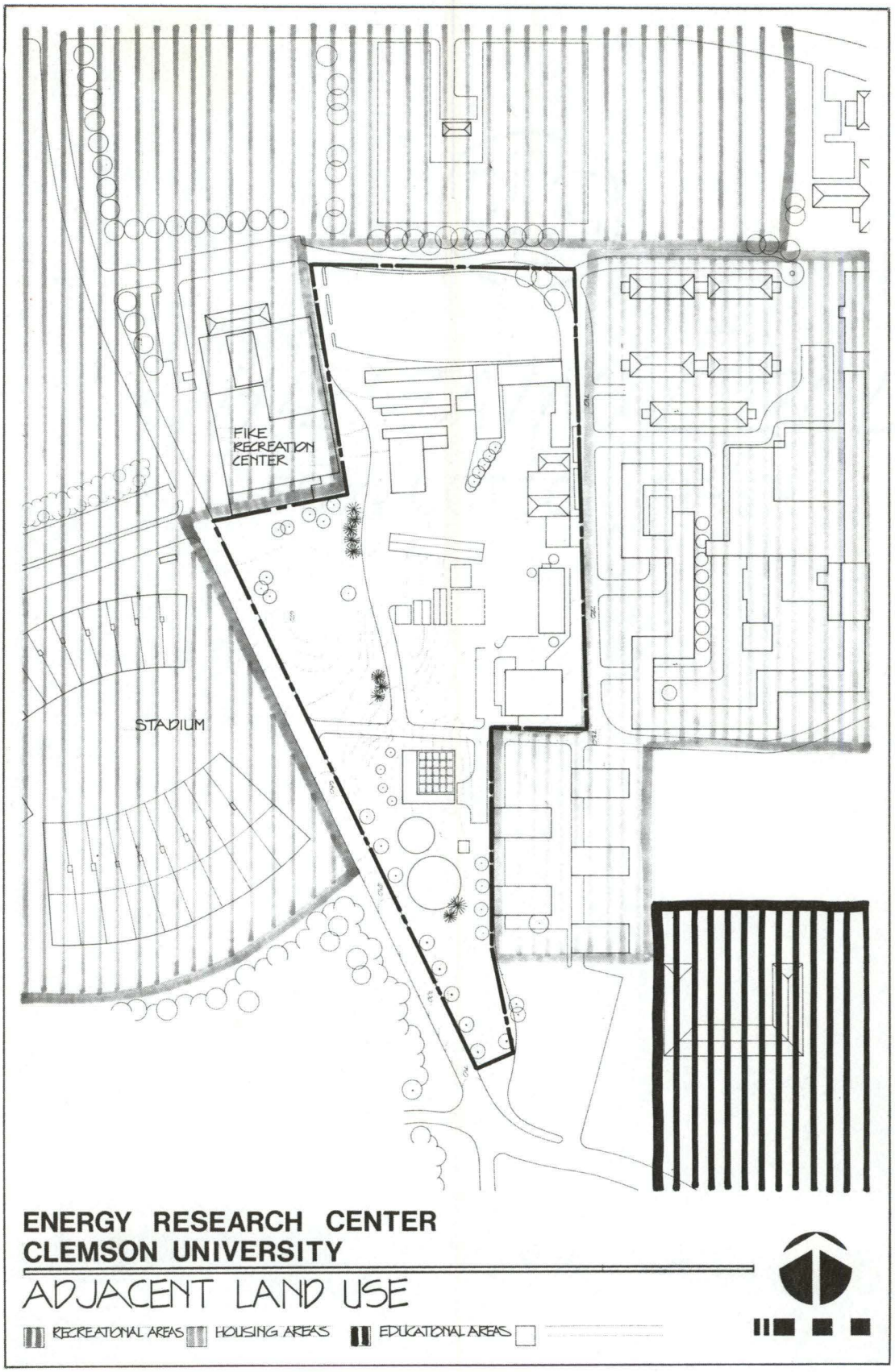
SITE ANALYSIS

Analysis of the selected site included studies of existing facilities, adjacent land use, building function analysis, vehicular and pedestrian circulation, wind and solar analysis, visual analysis, and a functional analysis. Additional studies dealt with selecting new sites for activities currently on the site and proposing future uses for land areas adjacent to the proposed Center. These studies, which are illustrated, provided the base for developing building design proposals.



ENERGY RESEARCH CENTER
CLEMSON UNIVERSITY

EXISTING FACILITIES



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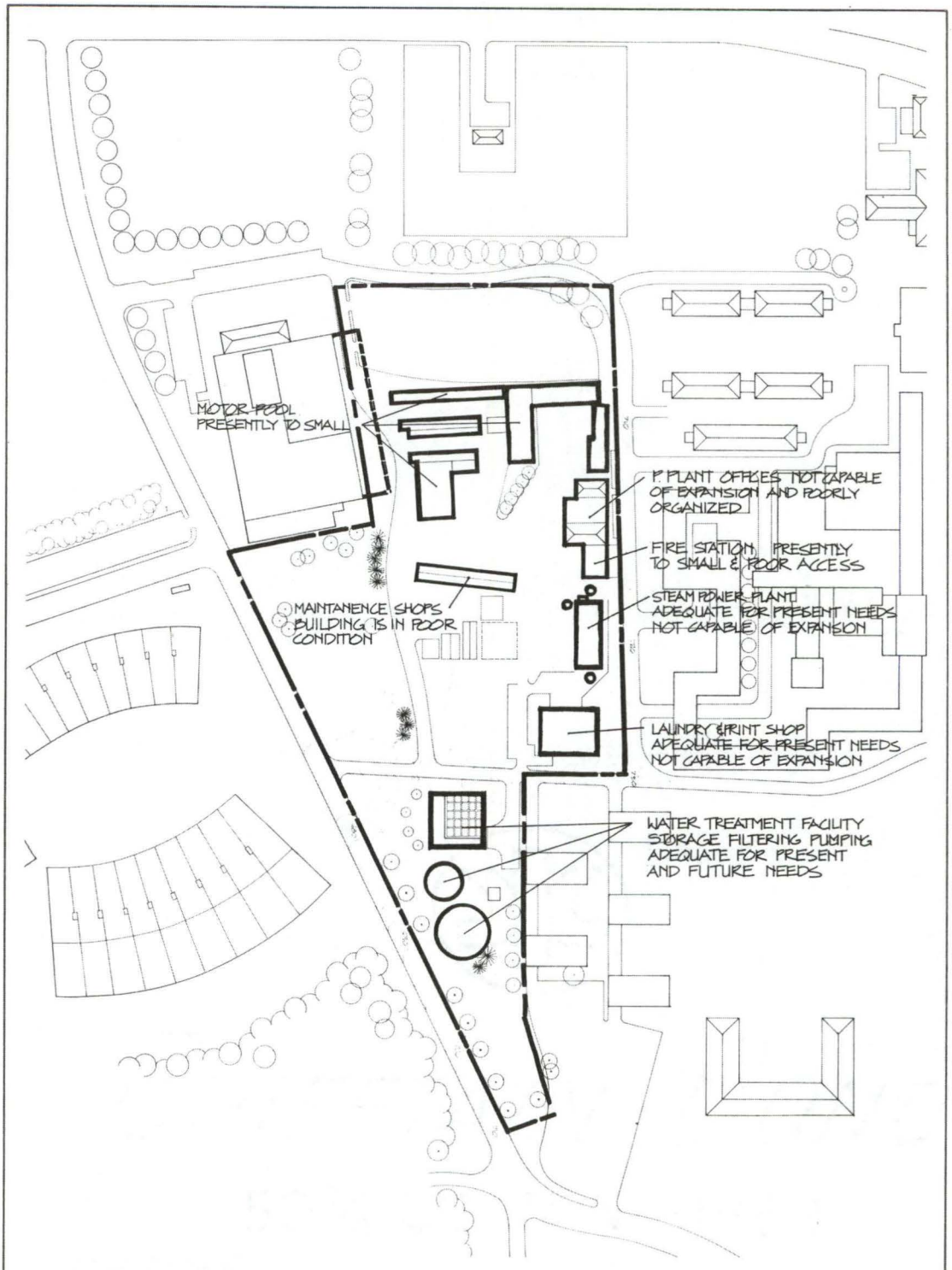
ADJACENT LAND USE

RECREATIONAL AREAS HOUSING AREAS EDUCATIONAL AREAS

CLEMSON UNIVERSITY LIBRARY



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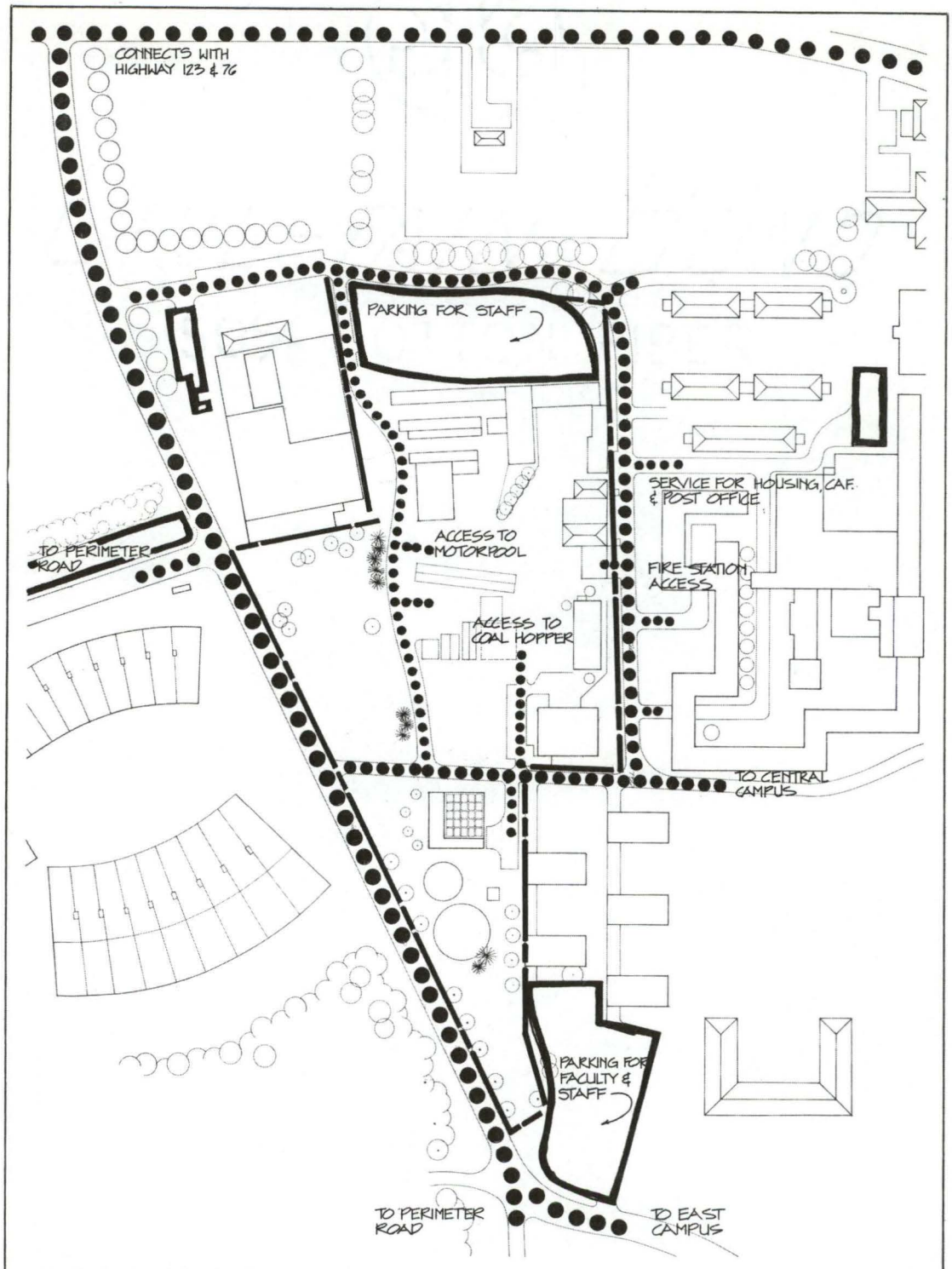
BUILDING FUNCTION ANALYSIS

☐ GOOD FACILITY ☐ ADEQUATE FACILITY ☐ POOR FACILITY ☐ POSSIBLE EXPANSION



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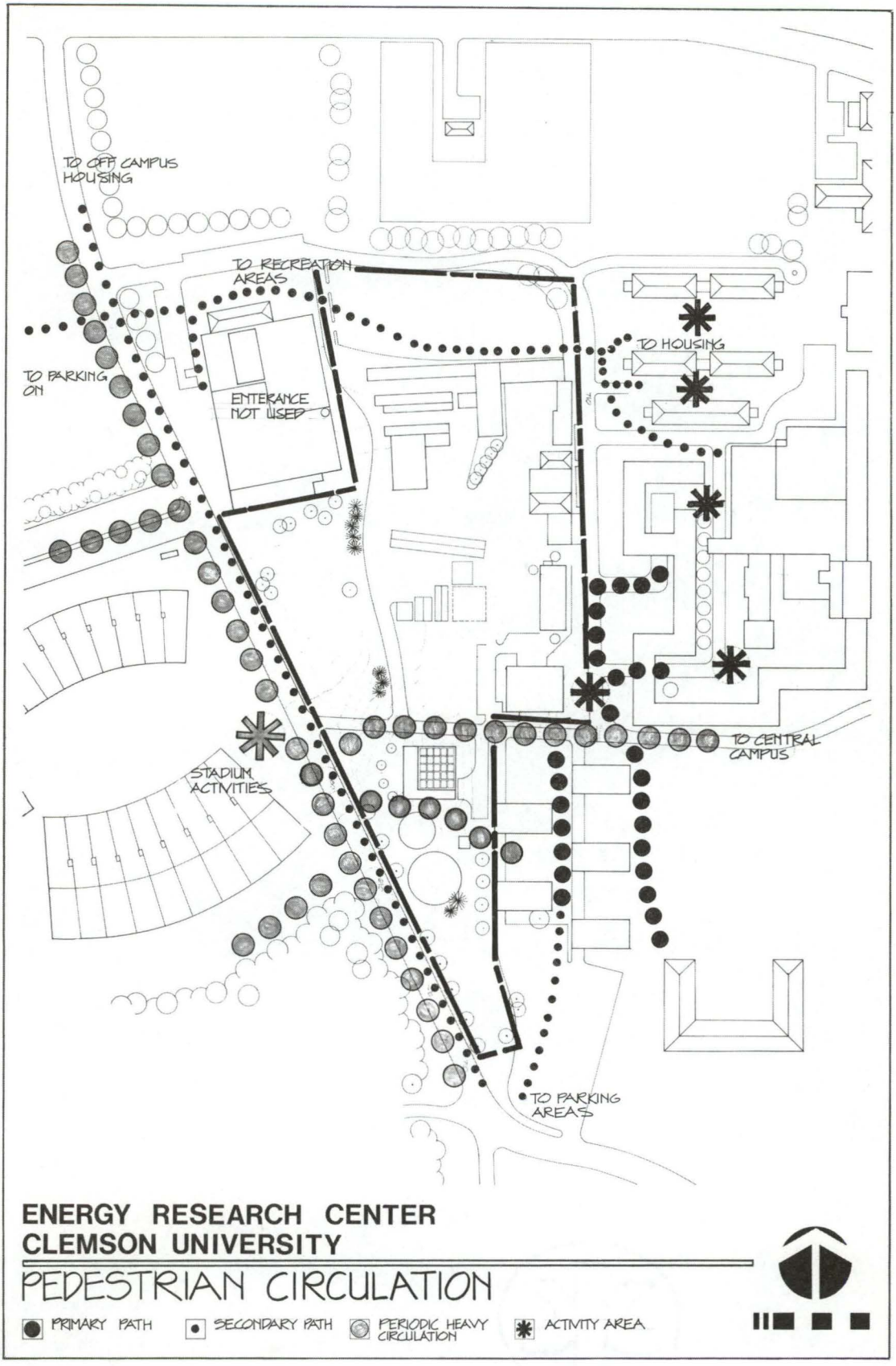
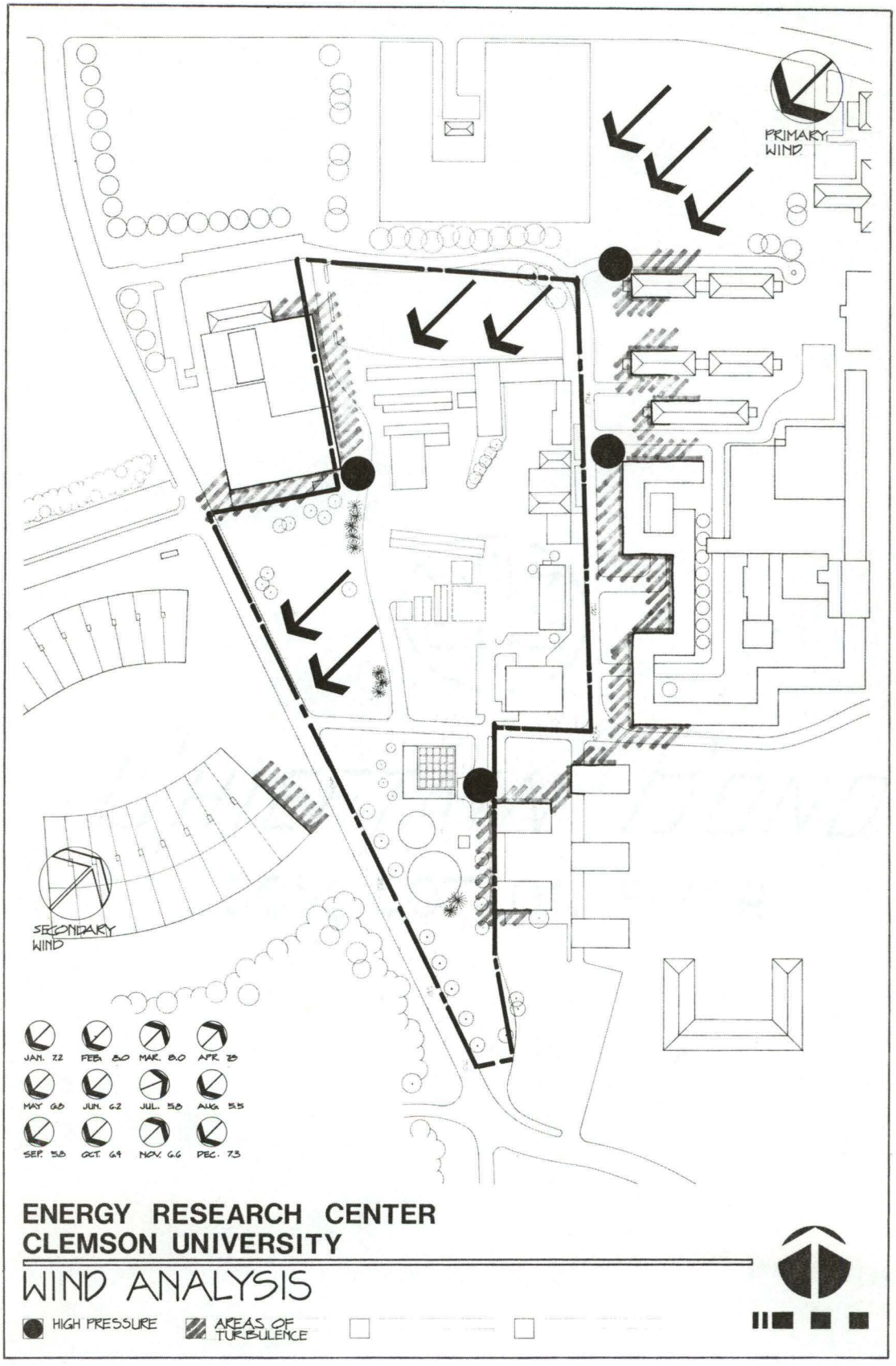
VEHICULAR CIRCULATION

PRIMARY ROADS SECONDARY ROADS SERVICE ROADS FOUR LANE HIGHWAY


TO OFF CAMPUS HOUSING
TO RECREATION AREAS
TO HOUSING
TO PARKING ON
ENTERANCE NOT USED
TO CENTRAL CAMPUS
STADIUM ACTIVITIES
TO PARKING AREAS
ENERGY RESEARCH CENTER
CLEMSON UNIVERSITY
PEDESTRIAN CIRCULATION
PRIMARY PATH
SECONDARY PATH
PERIODIC HEAVY CIRCULATION
ACTIVITY AREA



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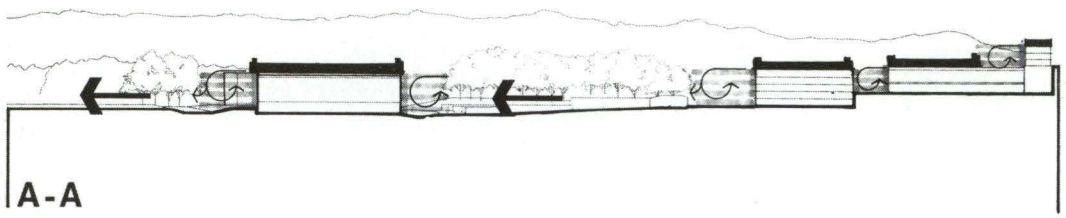
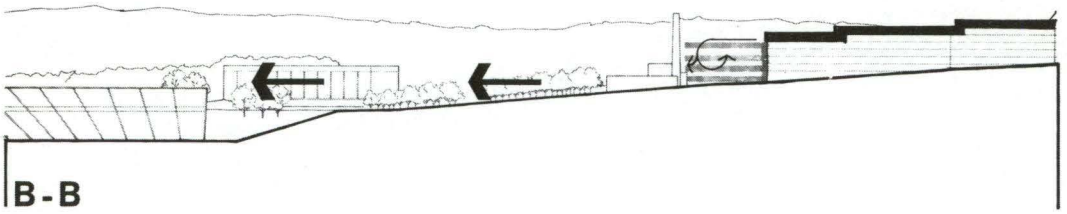
WIND ANALYSIS

HIGH PRESSURE

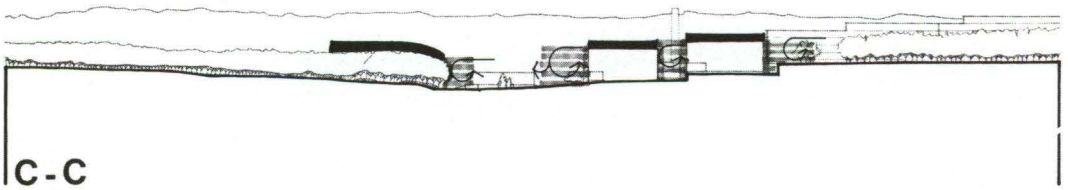
AREAS OF TURBULENCE



A-A



B-B

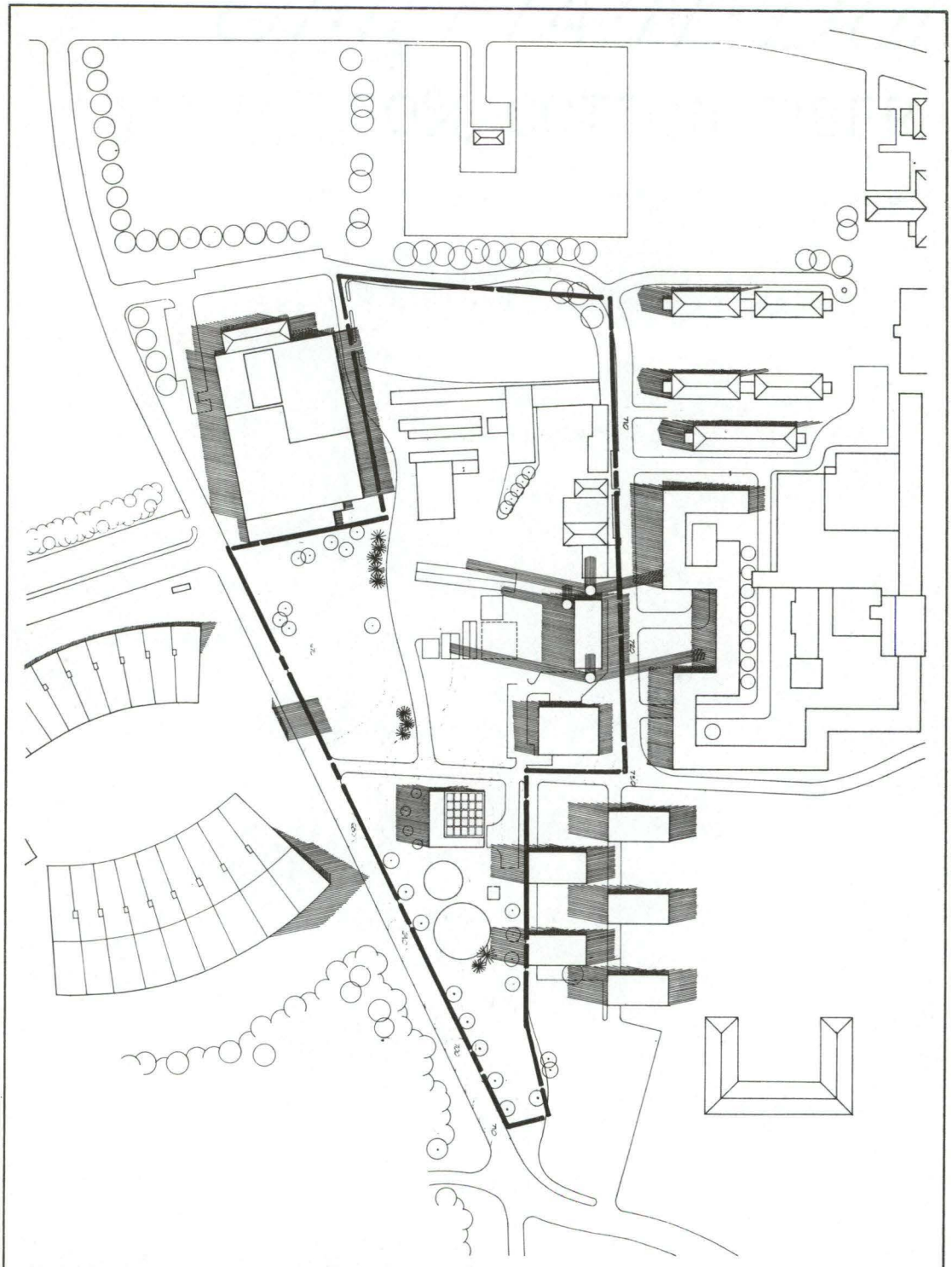


C-C

ENERGY RESEARCH CENTER
CLEMSON UNIVERSITY

WIND ANALYSIS

HIGH PRESSURE AREAS OF TURBULENCE



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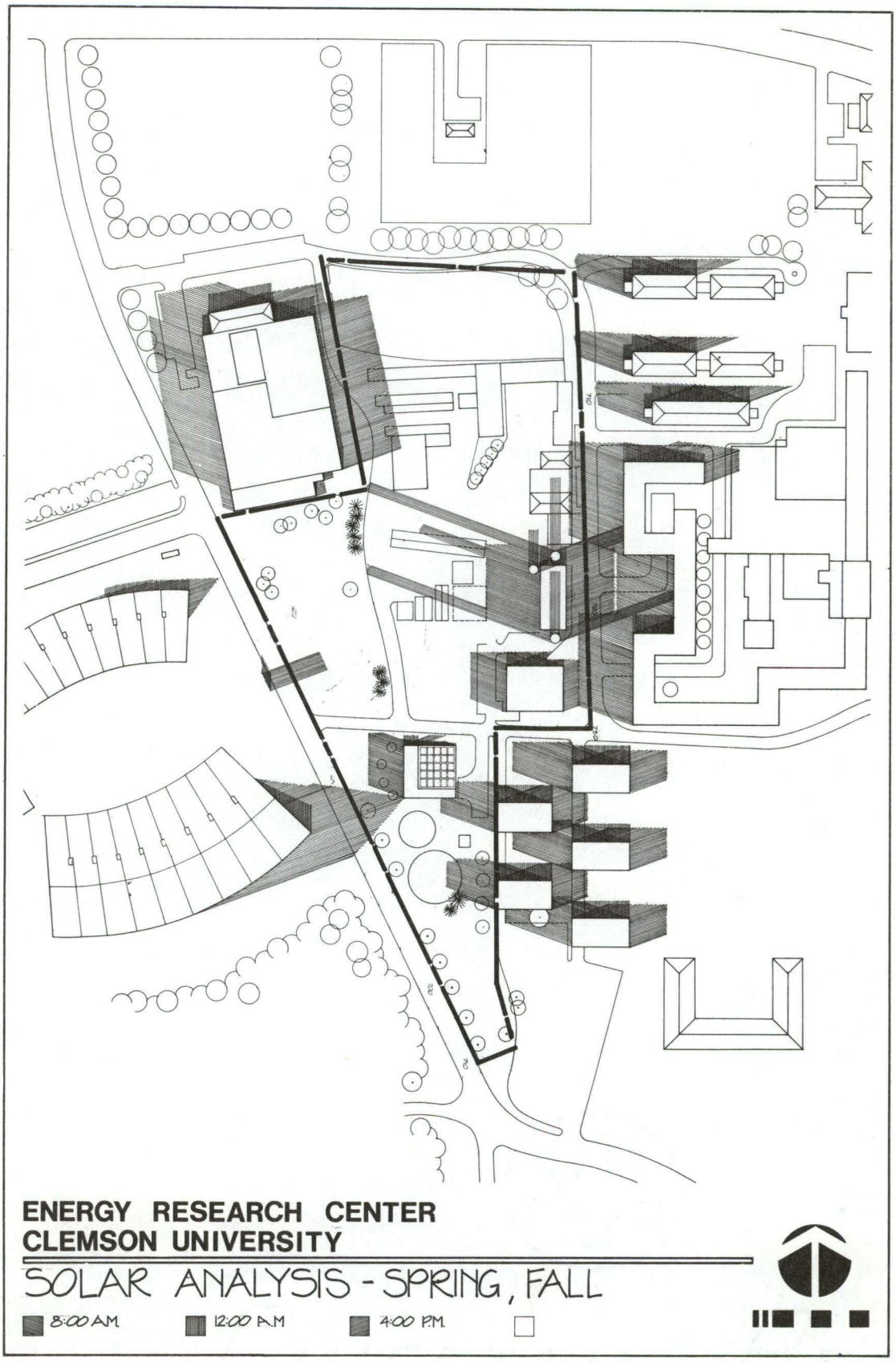
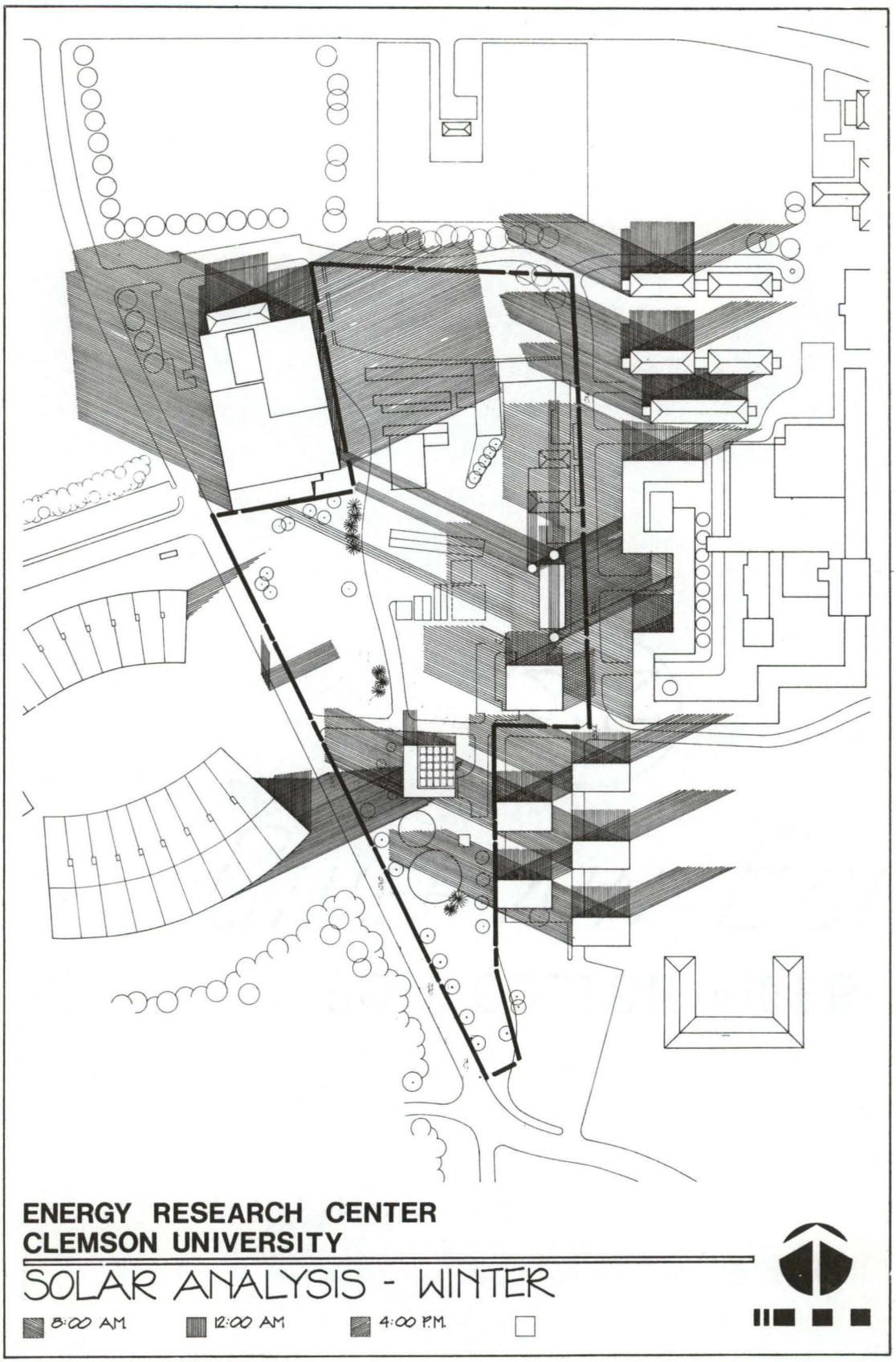
SOLAR ANALYSIS - SUMMER

8:00 A.M. 12:00 A.M. 4:00 P.M.


ENERGY RESEARCH CENTER
CLEMSON UNIVERSITY
SOLAR ANALYSIS - SPRING, FALL
8:00 A.M.
12:00 A.M.
4:00 P.M.


ENERGY RESEARCH CENTER
CLEMSON UNIVERSITY
SOLAR ANALYSIS - WINTER
8:00 AM
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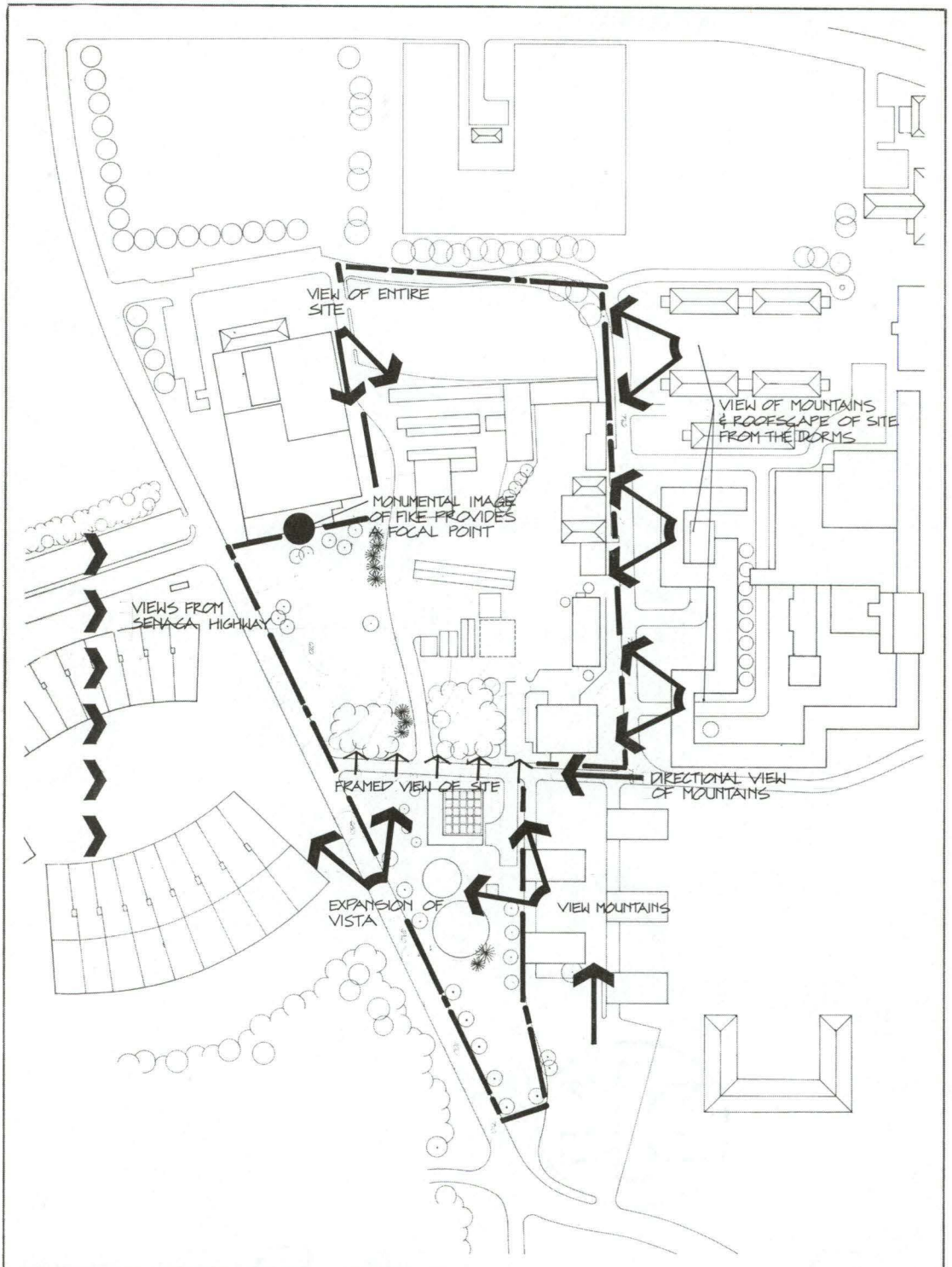

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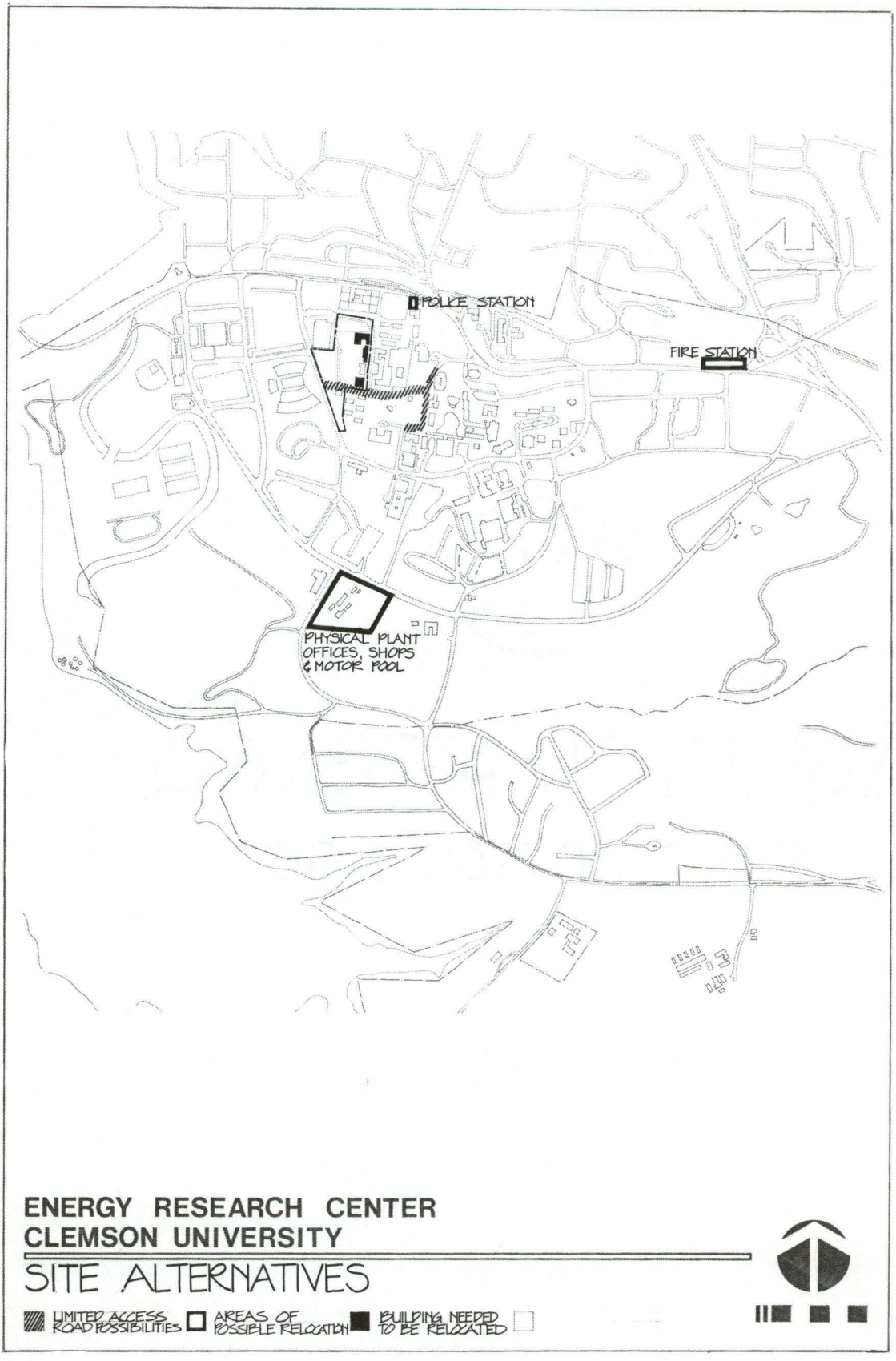
VISUAL ANALYSIS

FOCAL POINT VISTA DIRECTIONAL VIEW DISTANT VIEW



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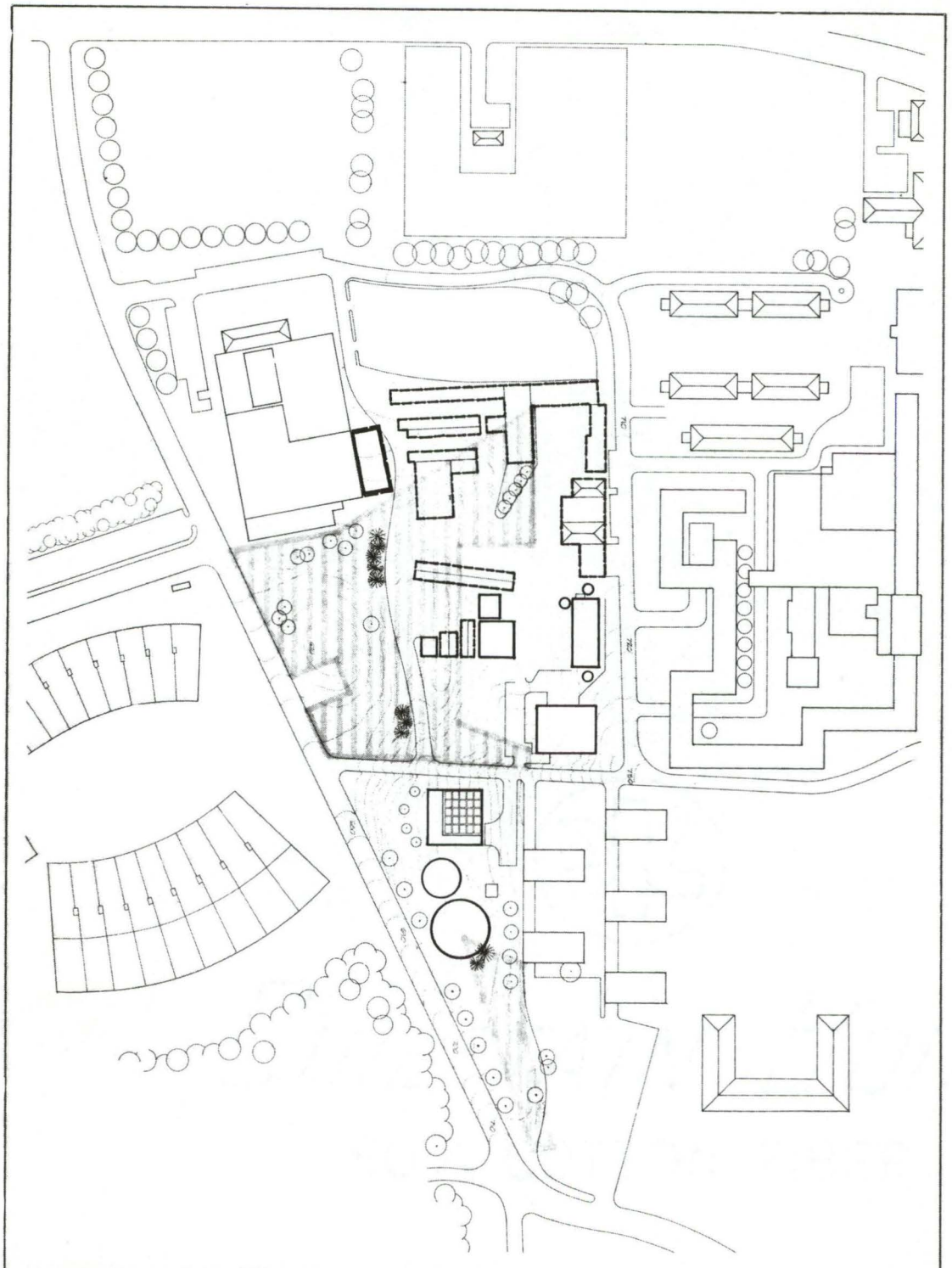
SITE ALTERNATIVES



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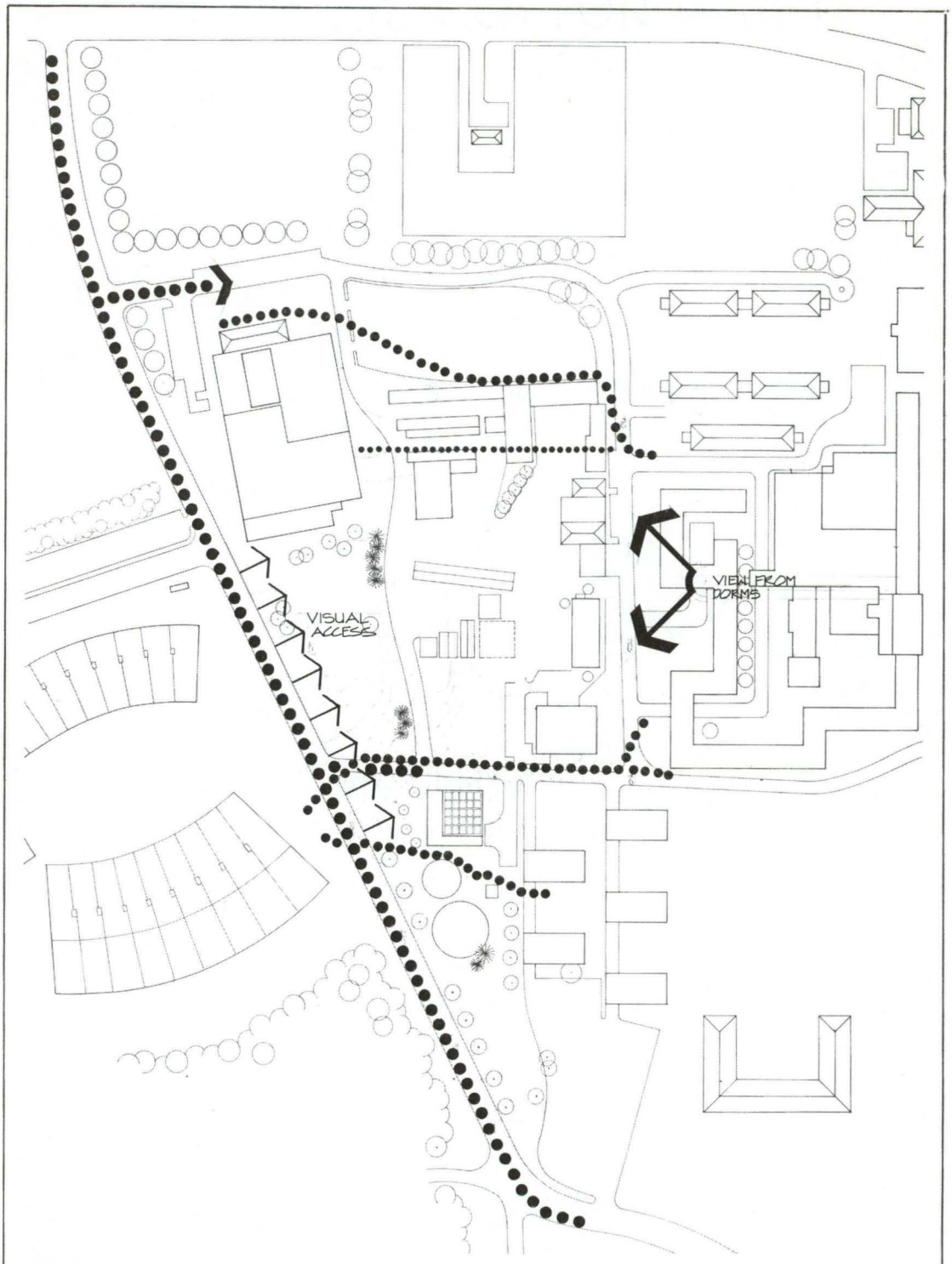
SPACE CONCLUSION

☐ REMOVE ☐ KEEP ☐ POSSIBLE ADD. ☐ CONSTANT SOLAR EXPOSURE



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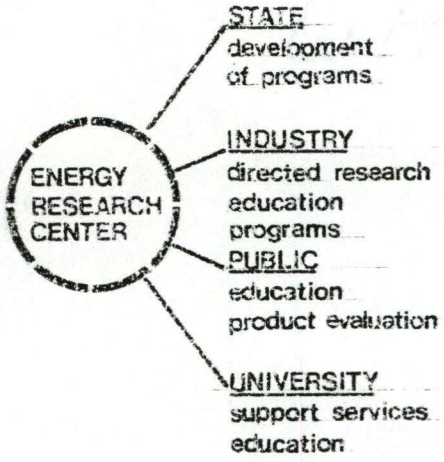
CIRCULATION CONCLUSIONS

VEHICULAR CIRC. PEDESTRIAN CIRC. POSSIBLE CIRC.

needs

ENERGY RESEARCH CENTER
GOALS AND OBJECTIVES

Clemson University is proposing the establishment of an energy research center that will have the goal of investigating existing and new sources of energy and their most effective application to our life needs.



The objectives of the center will be to relate the benefits of this research to the State of South Carolina, its industry and its populace, and to Clemson University through increasing the availability of energy sources, and improving the efficiency of their use, through education in general and specific aspects of energy, and through a continuing advancement in research and study in this critical area.

SCENARIO NO. 1

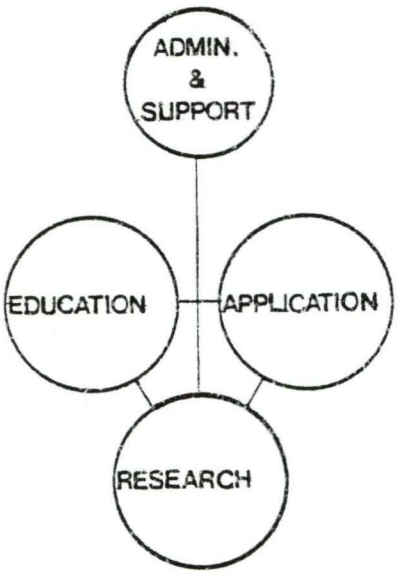
A professor of Clemson University's Physics Department teaches morning classes at Kinard Laboratory. After lunch at the "Study Hall" he walks to the Research Center where his graduate assistant is collecting data from solar collectors mounted on the roof of the Research Center. This professor is working with a Chemical Engineering professor in studying different types of black absorbing surfaces that can be used in the collectors. The tests involve determining what tones of black are best suited for absorbing solar energy at different light frequencies, as well as the adhering properties of different paints under various heating, cooling, expansion and contraction conditions experienced in flat plate collectors. After the day's data has been evaluated with the assistant, it is stored in the Center's computer. The professor then spends several hours in his office at the Center working on a report before proceeding home.

SCENARIO NO. 2

Following work, the plant engineer of one of the local textile mills drives to the Energy Research Center for a bi-weekly seminar. He parks his car in the Center's parking area and goes to a classroom where energy saving procedures for textile plants are to be studied. The seminar this night concerns environmental controls of a large mill and how to attain maximum working comfort with minimum energy use. Before returning home, the engineer spends some time in the Center's library looking for energy saving home improvement ideas.

SCENARIO NO. 3

A campus visitor from Greenville arrives at the Center to participate in an energy display and demonstration. After entering the foyer she is given a program which describes the activities of the day. Her first stop is the exhibition terrace where various pieces of equipment are displayed. Following this, she and other visitors are taken on a guided tour through the facility. She ovserves work in the various laboratories, goes through the greenhouses and observes the salt ponds and adjacent windmill. After the tour, an audio visual presentation is given in the auditorium on current tax incentives for energy efficient buildings. Before leaving she acquires several publications on energy research in the Center's bookstore.



USERS ACTIVITIES

The Energy Research Center for Clemson University will consist of four major activity groups. These groups are: administration and support, education, research and application. For the Center to function properly, a close interrelationship of these activities will be necessary.

ADMINISTRATION AND SUPPORT AREAS

The administration area will contain a reception space, secretarial stations, work and storage areas, administration offices, and a conference room. The receptionist station would be located in a position to provide control for all visitors. The secretary stations, administrative offices and conference room need to be in a common area to facilitate easy communication.

The support area will consist of a machine shop, print shop, computer lab, employees lounge, storage area and loading dock. These activities will be organized in a manner permitting easy movement of materials and services between the support and laboratory areas.

EDUCATION AREAS

Educational areas will include classrooms, a library, auditorium, bookstore, and indoor and outdoor display areas. Classrooms will be used primarily for seminar groups. The library will serve the entire University in addition to the Center's research faculty. The auditorium will be used principally for large gatherings for lectures and demonstrations directed towards students and the general public. Consequently, it should be located adjacent to the public entrance. The bookstore will contain publications developed by the Center, and will be controlled by the receptionist. Display areas will be located in a manner to provide easy access by the public while still being provided with the proper degree of control.

RESEARCH AREAS

The principal research areas of the Center will be bench laboratories, wet laboratories and combustion laboratories. These laboratories will need to be flexible in design to accommodate expansion or contraction of spaces depending upon the needs of various research projects. The combustion laboratories will need special exhaust equipment to handle combustion gases.

In addition to the laboratories, the Center will contain greenhouses, a salt pond experimentation area, and a wind power research facility. Adjacent to the greenhouses would be a headhouse for greenhouse storage and servicing. All research areas will be organized in a manner to permit ease of service from the support areas.

APPLICATION AREAS

Application areas will consist principally of outdoor spaces suitable for testing products or techniques developed through research in the Center. Such areas would include test growing areas and solar power experimentation areas for the present, with adequate space provided for full scale testing of other equipment or devices in the future. These areas would have to be located to take full advantage of natural energy sources where applicable, have proper security and be accessible to service equipment.

PROGRAM OF SPACES

Administration and Support Areas

Space	Area Sq Ft	Quantity	Total Area Sq Ft
Lobby	--		--
Receptionist	120	1	120
Administration Offices	150	3	450
Conference Room	400	1	400
Secretary Pool	600	1	600
Storage	300	1	300
Lounge	500	1	500
Computer Room	1,000	1	1,000
Terminals	1,000	1	1,000
Print Shop	5,000	1	5,000
Machine Shop	10,000	1	10,000
Storage	2,000	1	2,000
Loading Dock	--		--
Parking	--		--
Sub-Total			21,370

Education Areas

Space	Area Sq Ft	Quantity	Total Area Sq Ft
Auditorium	3,000	1	3,000
Bookstore	500	1	500
Classrooms	600	5	3,000
Library	3,000	1	3,000
Outside Display	--		--
Sub-Total			9,500

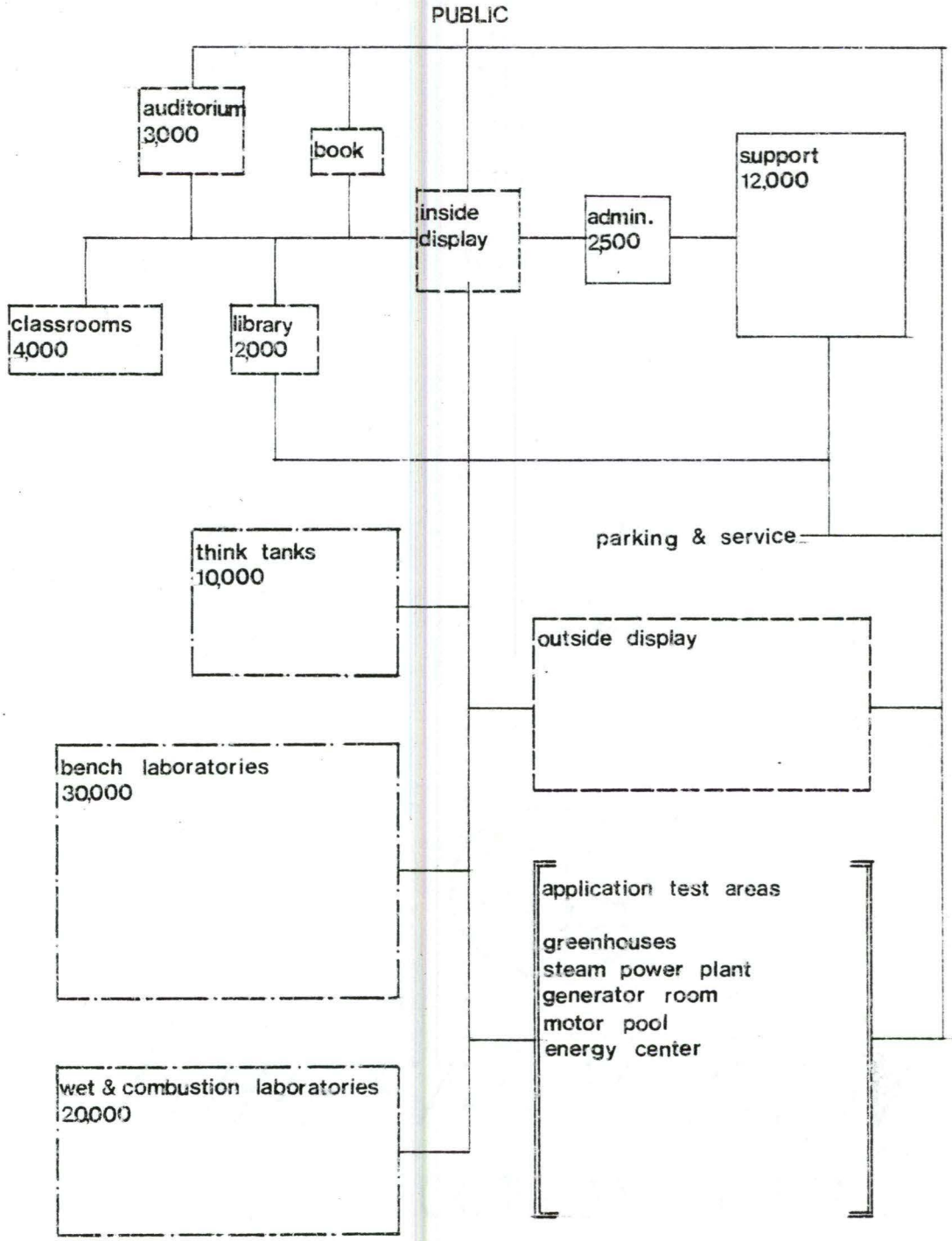
Research Areas

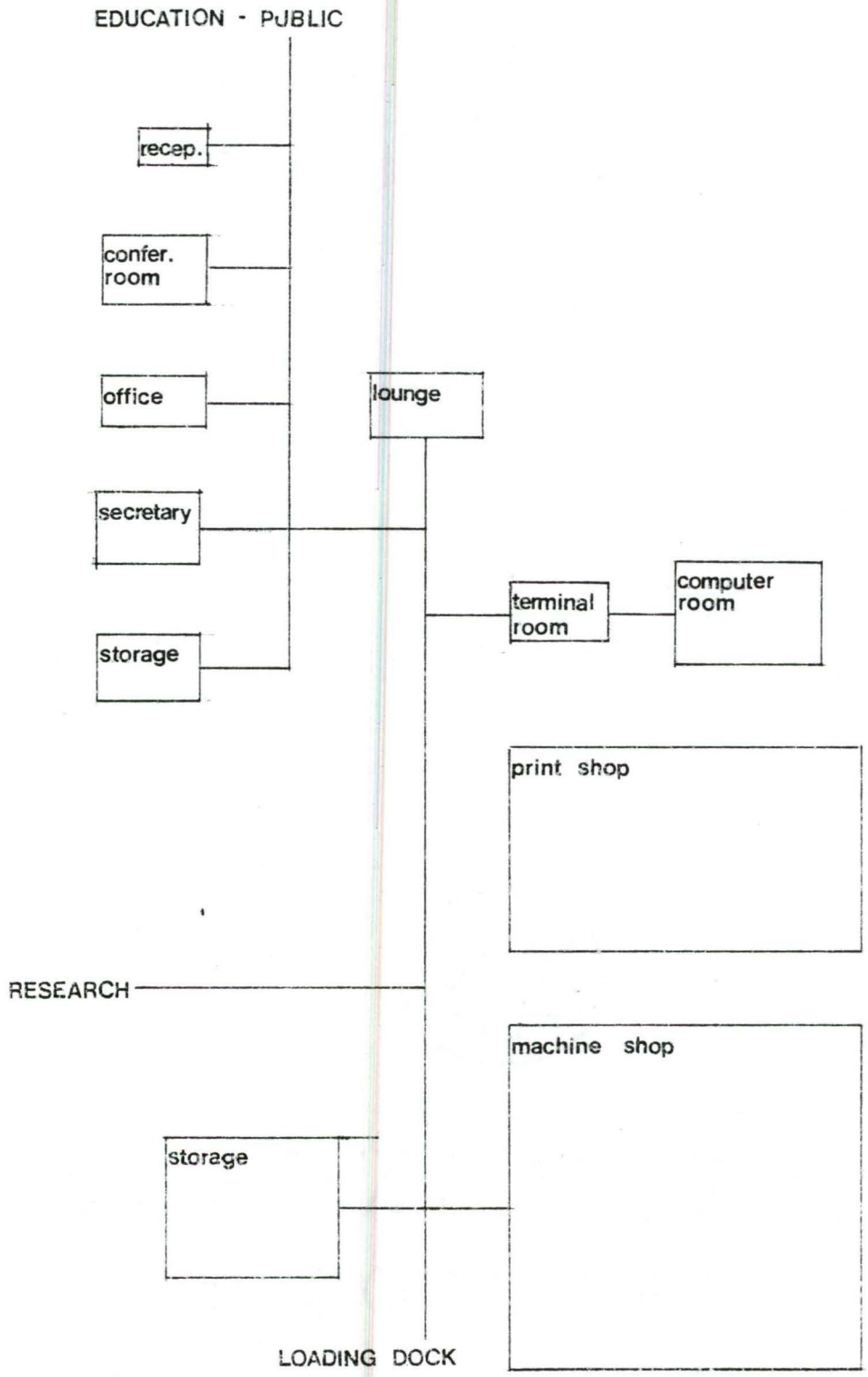
Space	Area Sq Ft	Quantity	Total Area Sq Ft
Bench Labs	1,500	20	30,000
Wet Labs	2,000	15	30,000
Combustion Labs	2,000	5	10,000
Greenhouse	5,000	1	5,000
Headhouse	1,000	1	1,000
Sub-Total			76,000

Application Areas

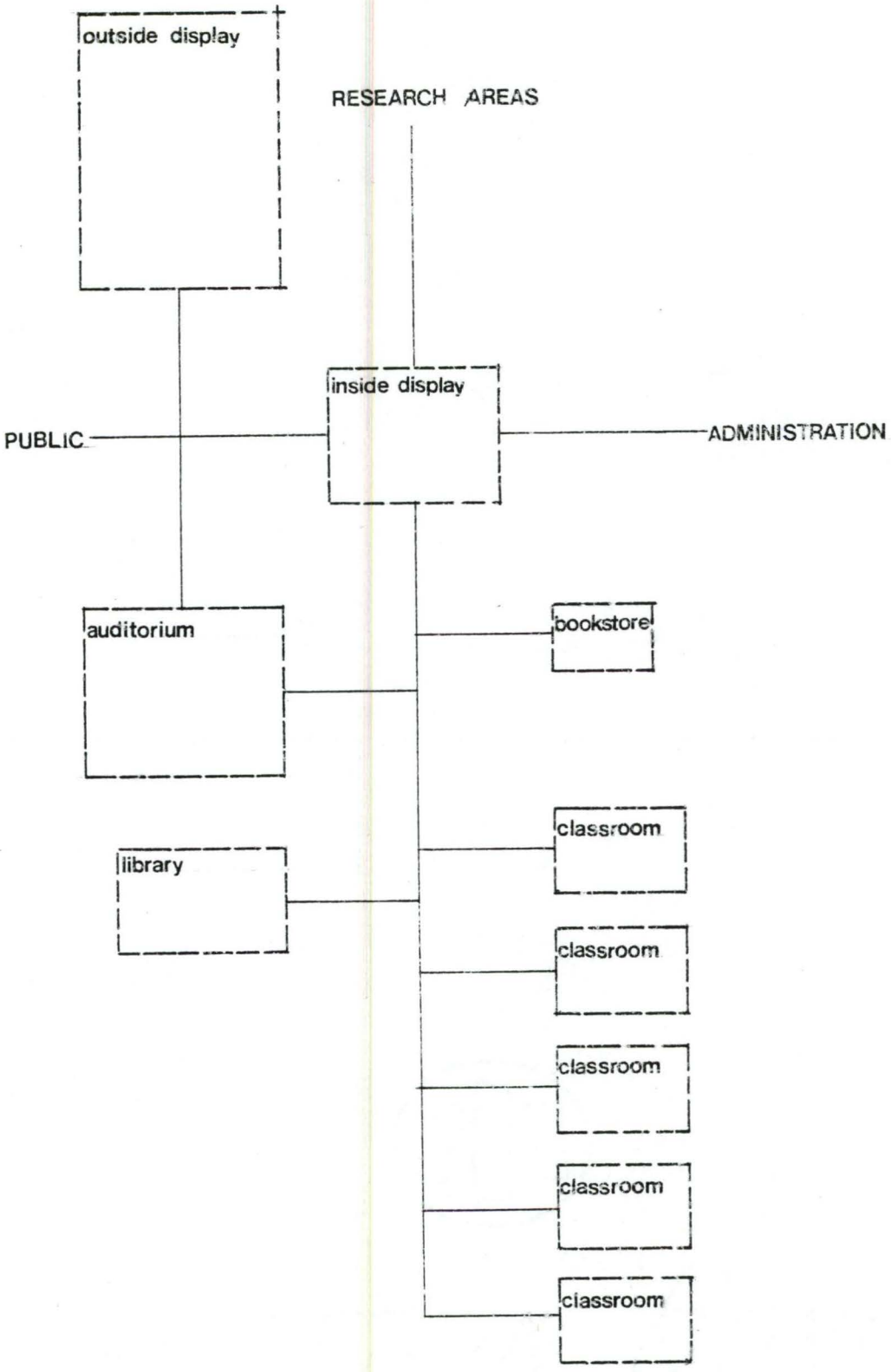
Space	Area Sq Ft	Quantity	Total Area Sq Ft
Generator Room	3,000	1	3,000
Energy Storage	3,000		3,000
Windmill	--		--
Solar Collectors	--		--
Salt Ponds	--		--
Sub-Total			6,000

Admin. & Support Area	21,730
Education Area	9,500
Research Area	76,000
Application Area	6,000
Net Area	113,230
Circulation, Mechanical, and Structural @ 25%	28,300
Gross Area	141,530

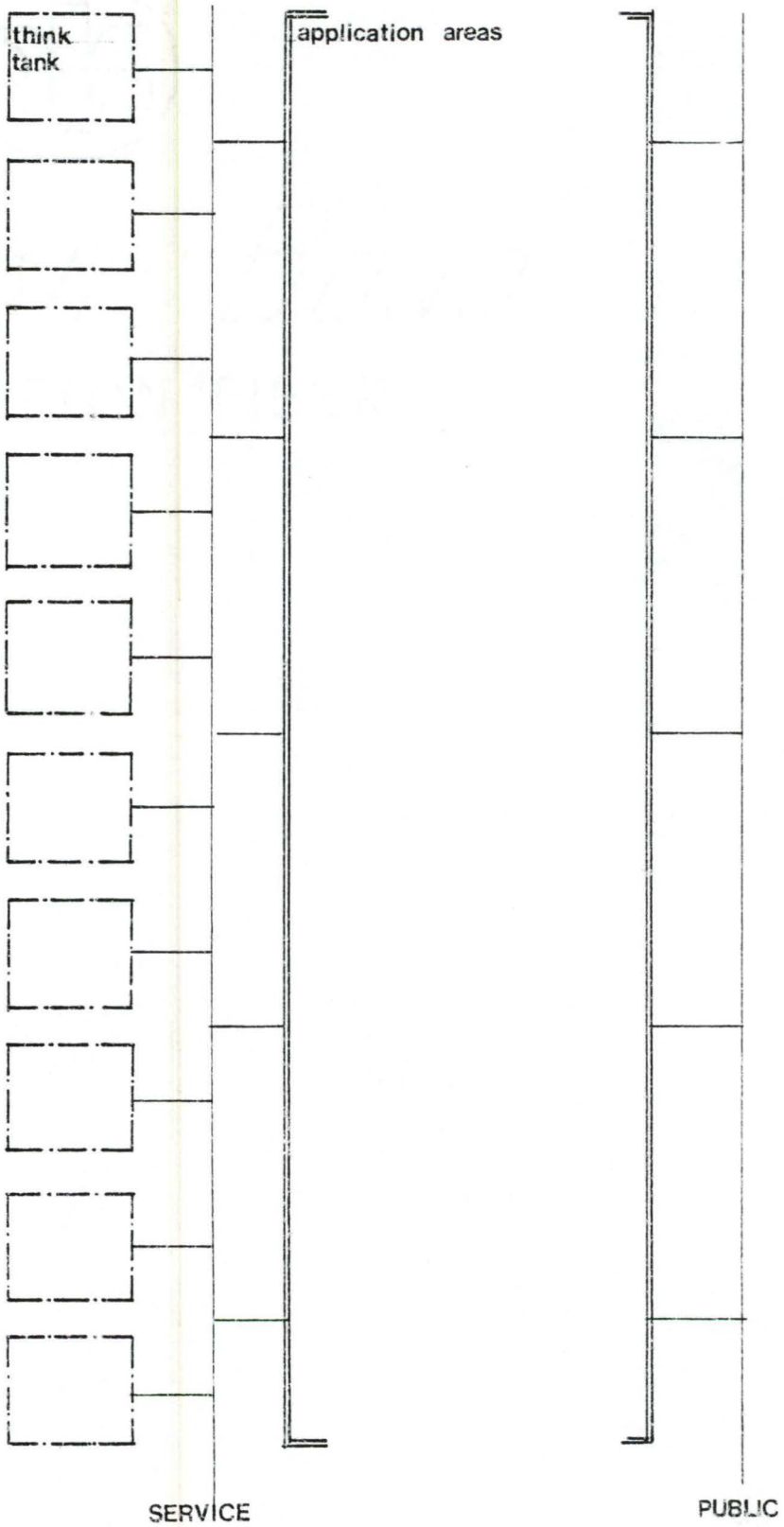

PUBLIC
auditorium
3,000
book
support
12,000
inside
display
admin.
2,500
classrooms
4,000
library
2,000
parking & service
think tanks
10,000
outside display
bench laboratories
30,000
application test areas
greenhouses
steam power plant
generator room
motor pool
energy center
wet & combustion laboratories
20,000



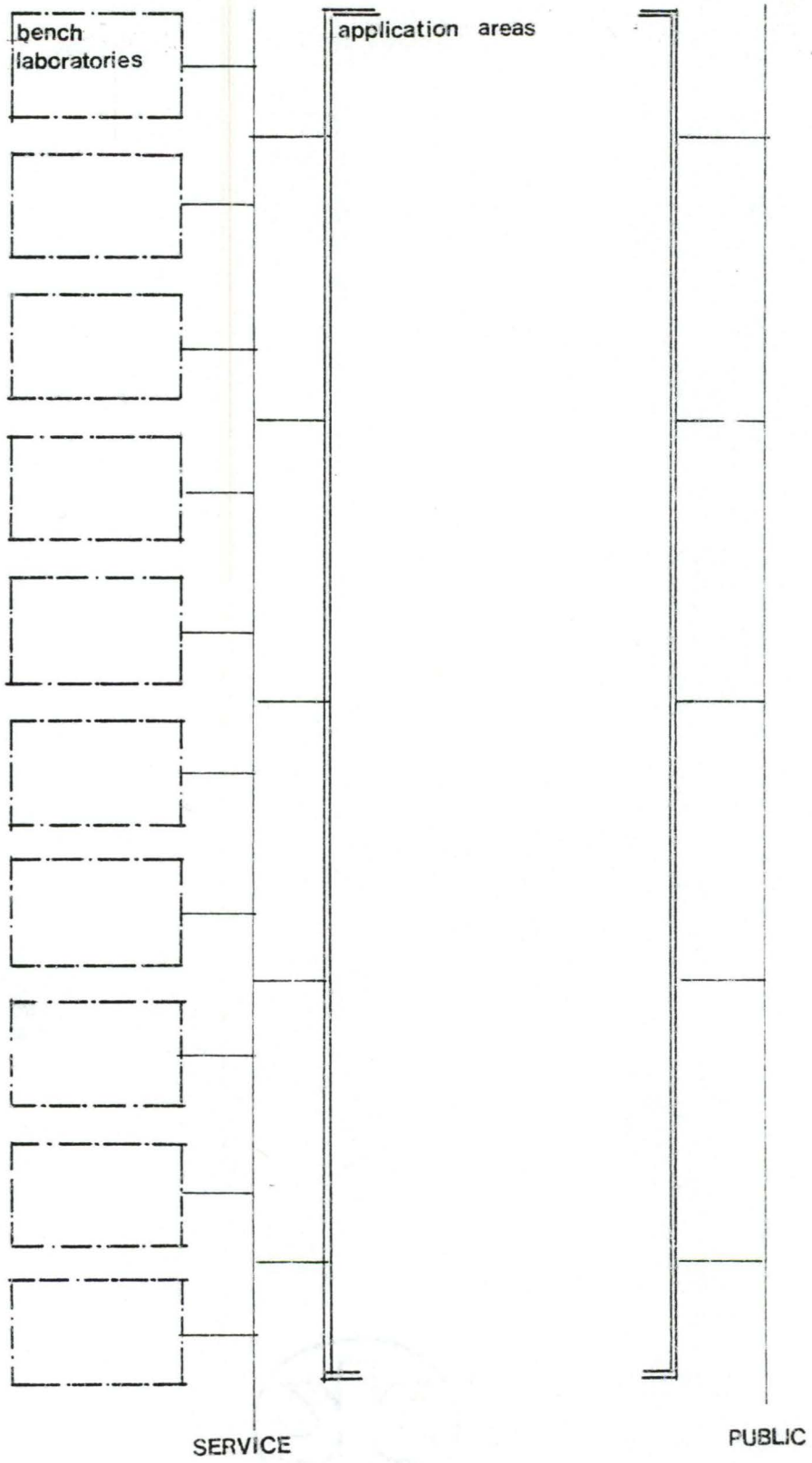
ADMINISTRATION & SUPPORT


outside display
RESEARCH AREAS
inside display
PUBLIC
ADMINISTRATION
auditorium
bookstore
library
classroom
classroom
classroom
classroom
classroom

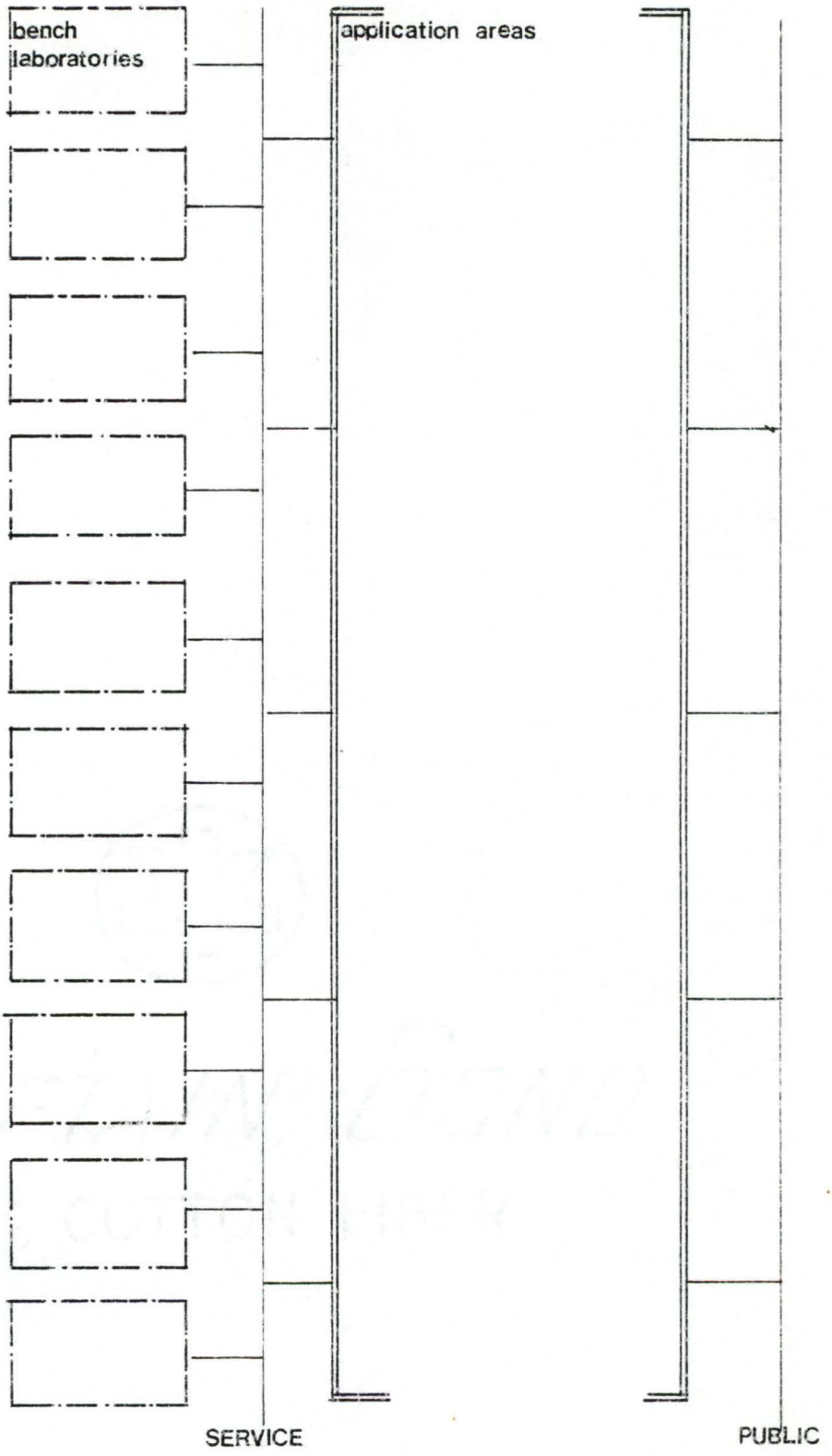
EDUCATION



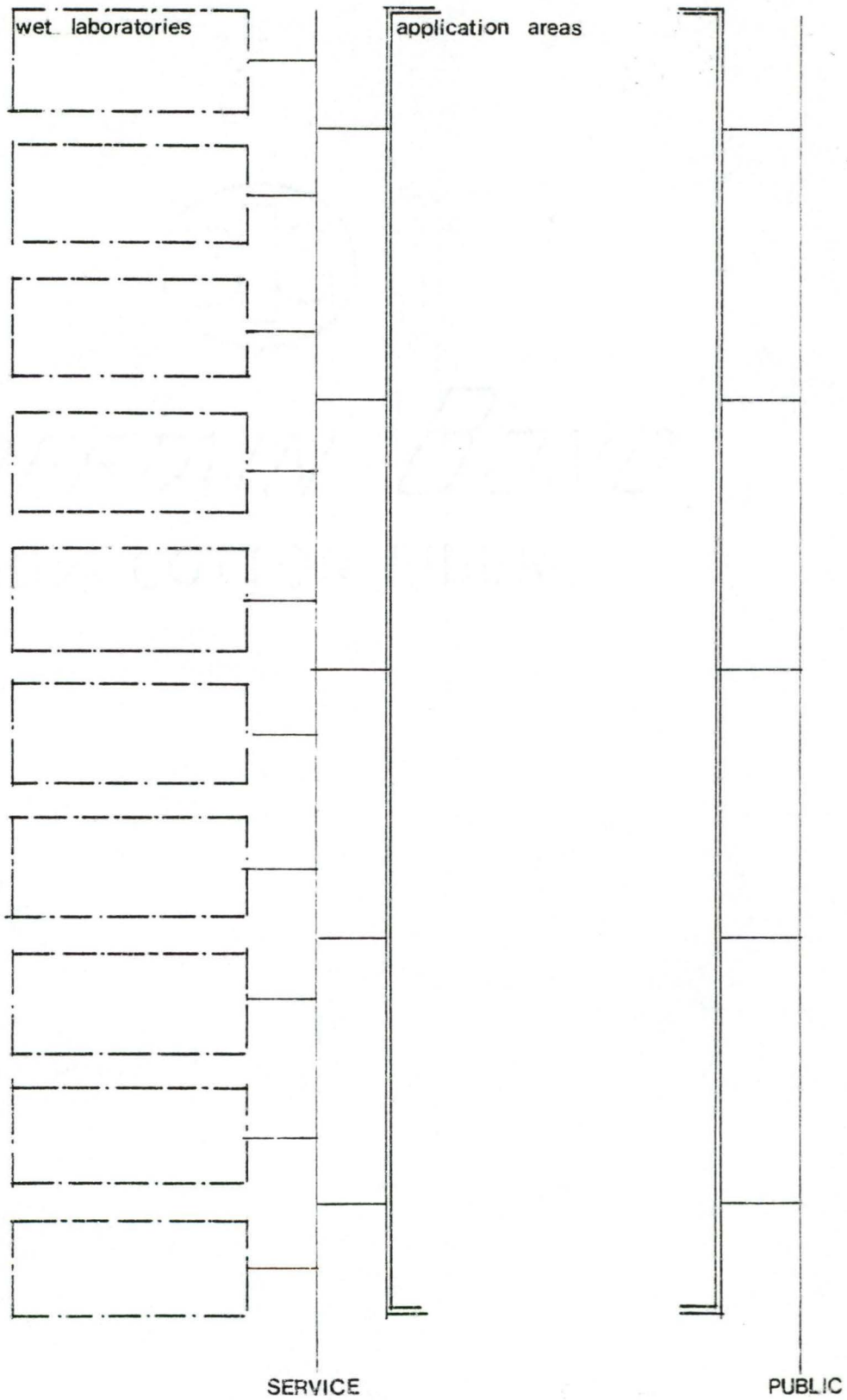
RESEARCH



RESEARCH



RESEARCH



RESEARCH

CODES

The following requirements set forth in the Standard Building Code by the Southern Building Code Congress International apply to the proposed building.

Occupancy Classification:

Occupancy classification: mixed occupancy. Principal intended use is education.

Construction type: Type I or Type II

Maximum allowable height: Type I - no limit; Type II - 80 feet.

Maximum allowable floor area: Type I - no limit; Type ii - not limit.

Exit Requirements

Maximum distance of travel of an exit: unsprinklered - 150 feet; sprinklered - 200 feet.

Occupancy per floor, concentrated use: 1 occupant per 50 square feet net area.

Capacity of means of egress: 100 persons per 22" level travel, 60 persons per 22" stairs.

44" minimum exitway

Accessibility for the Physically Disabled and/or Handicapped

Corridors: 44" minimum

Door: 32" minimum

Ramps: 1 in 12 maximum rise, 4' minimum width with level area every 30 feet.

Parking: level space must be 12' minimum width.

Toilets: one per floor per sex.

Live Load Criteria

Assembly fixed seats: 50 lbs. per sq. ft.

Corridors public: 100 lbs. per sq. ft.

Libraries: 125 lbs. per sq. ft.

Offices: 50 lbs. per sq. ft.

Press rooms: 150 lbs. per sq. ft.

Storage: 125 lbs. per sq. ft.

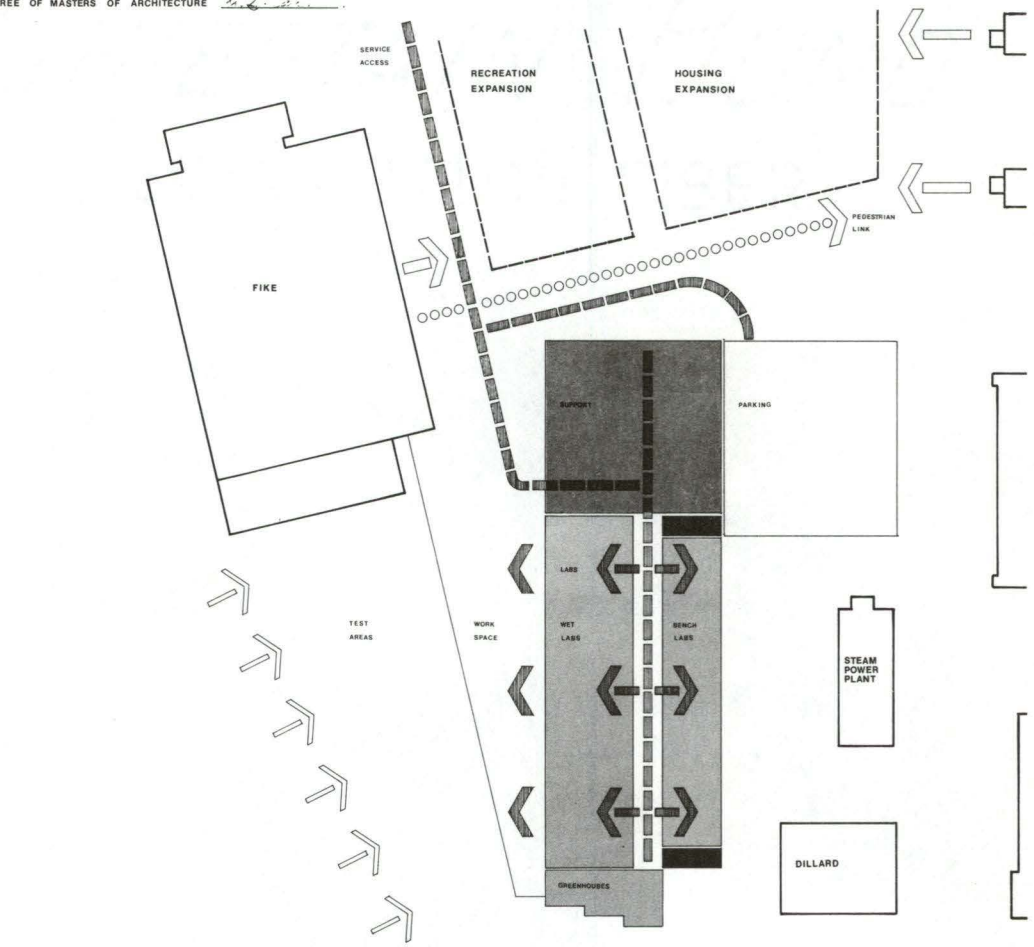
Sprinklers:

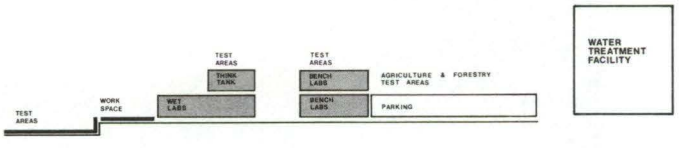
Not required except as previously noted.

proposal

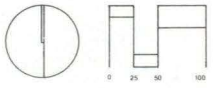
ENERGY RESEARCH CENTER

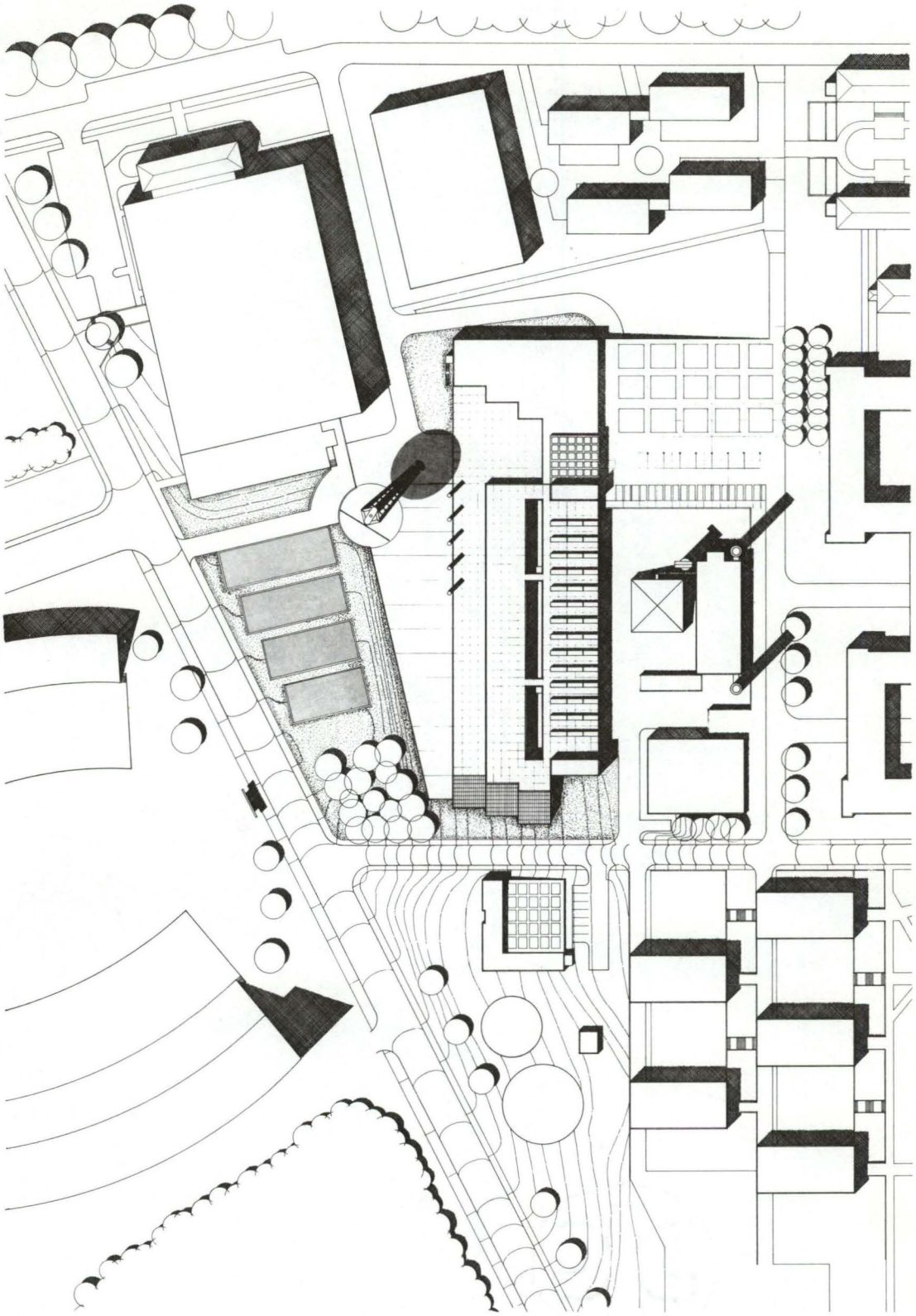
A TERMINAL PROJECT SUBMITTED TO THE FACULTY OF THE COLLEGE OF ARCHITECTURE, CLEMSON UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF ARCHITECTURE



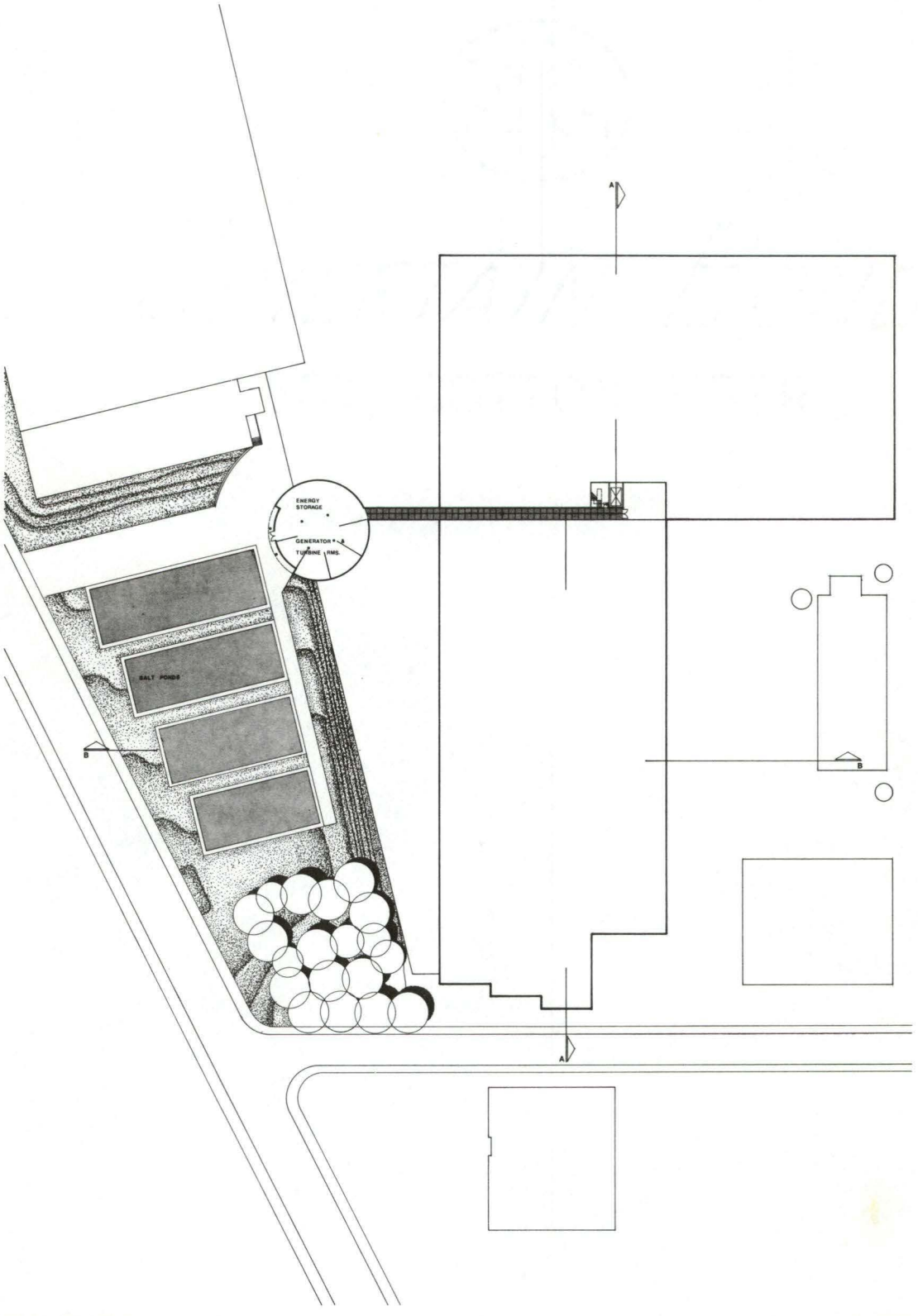


CONCEPT



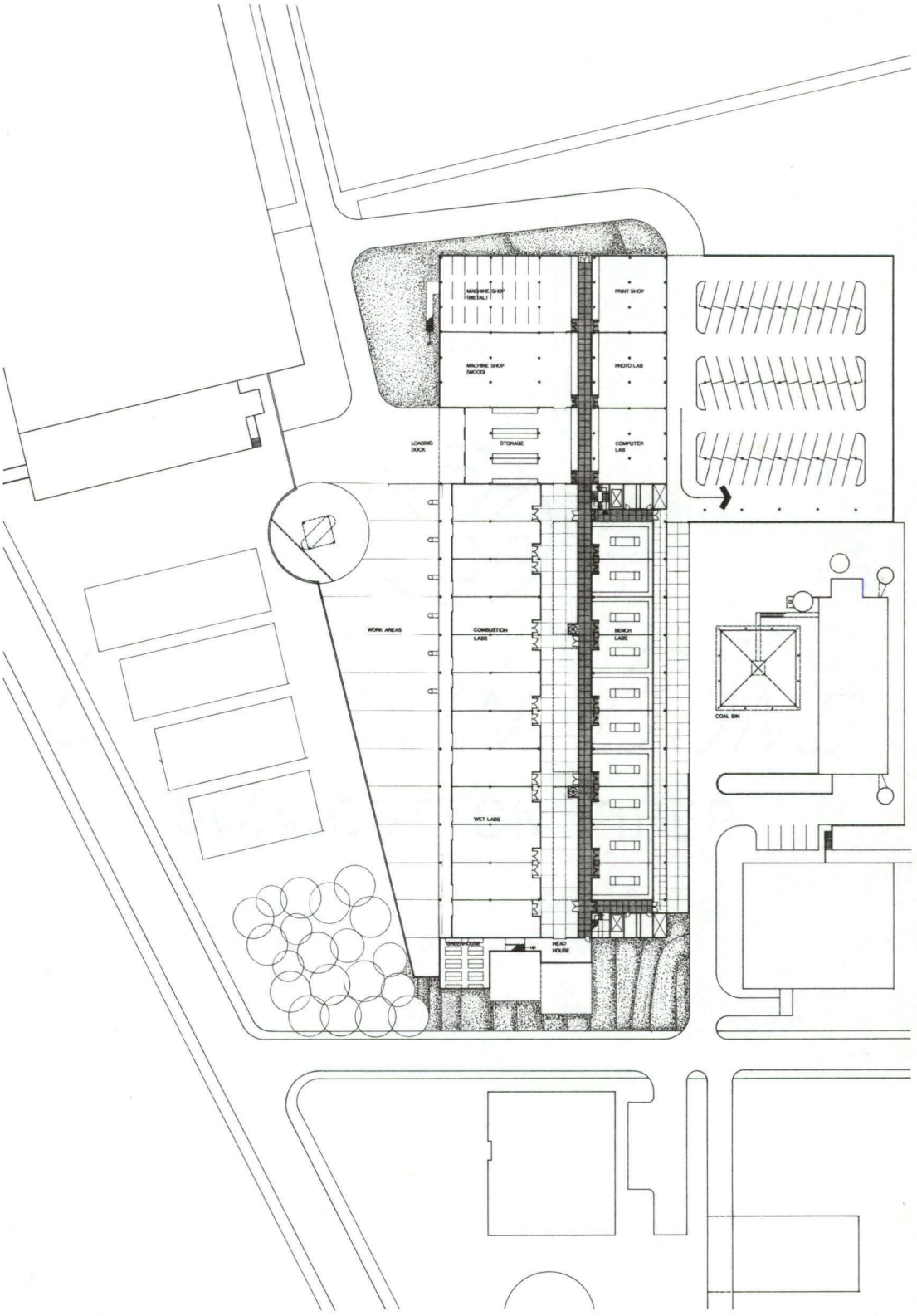


SITE PLAN

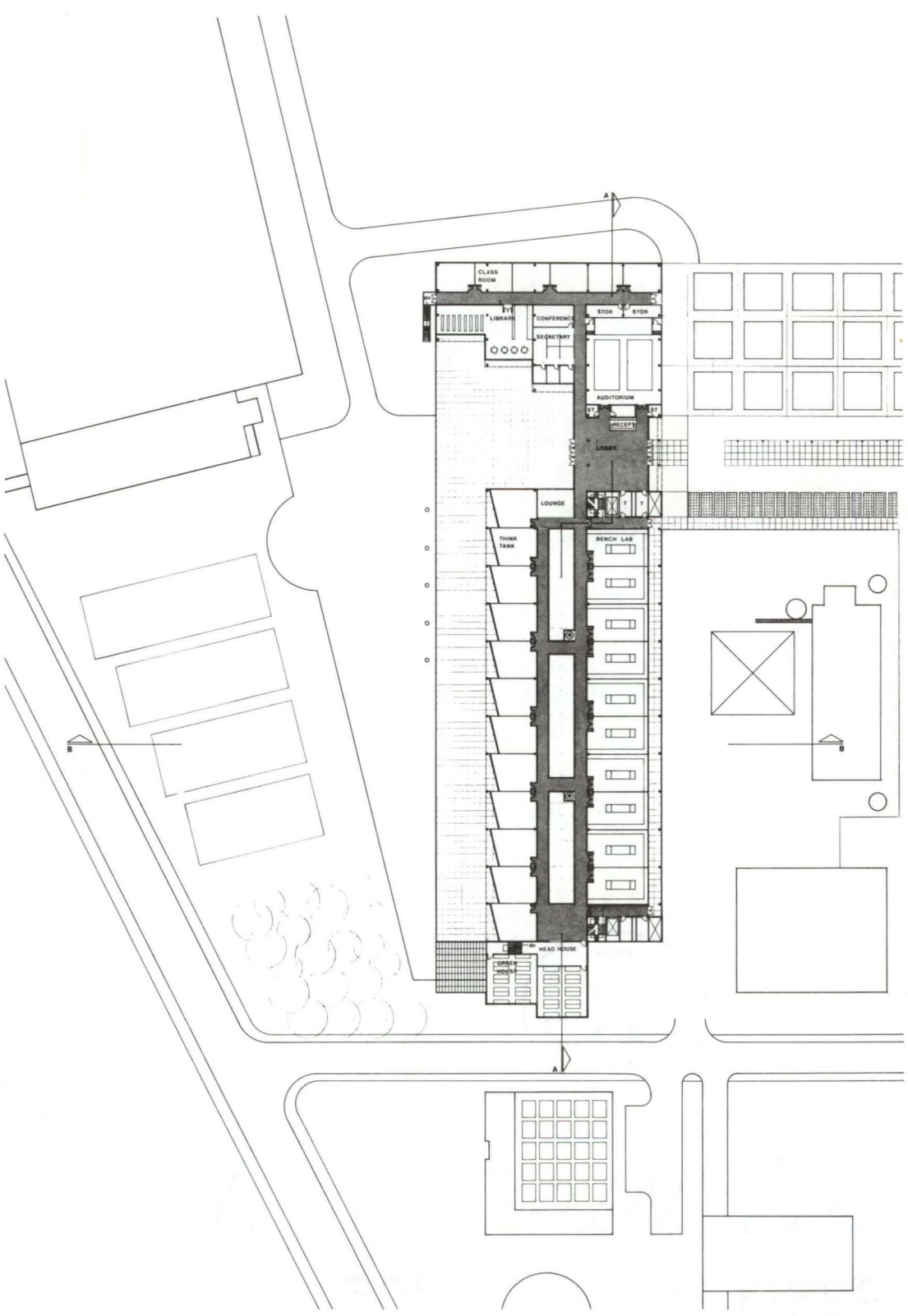


LEVEL ONE

0 16 32 64

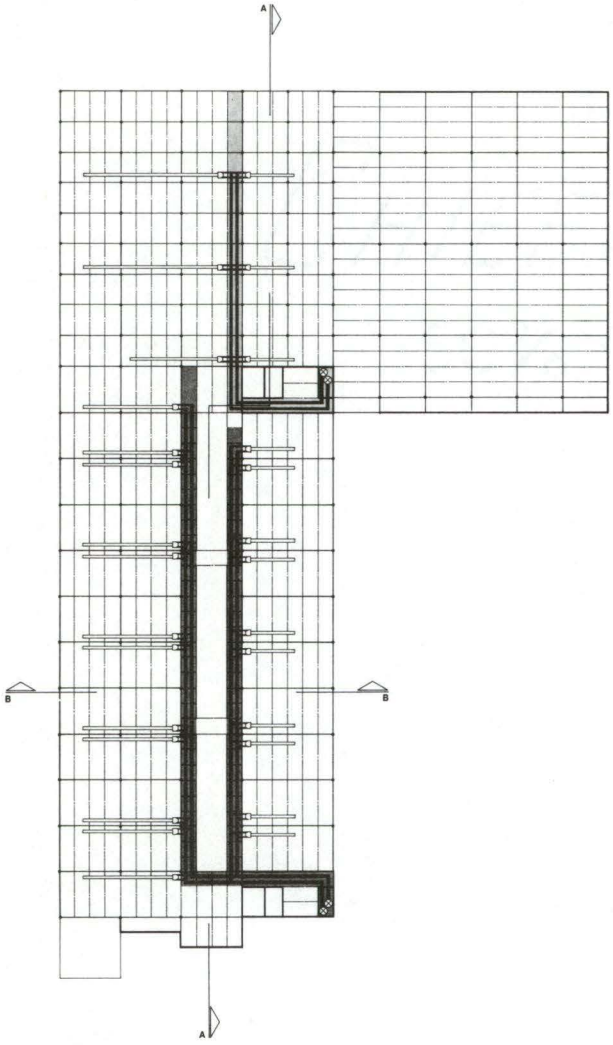

MACHINE SHOP (METAL)
PRINT SHOP
MACHINE SHOP (WOOD)
PHOTO LAB
LOADING DOCK
STORAGE
COMPUTER LAB
WORK AREAS
COMBUSTION LABS
BENCH LABS
COAL BIN
WET LABS
GREENHOUSE
HEAD HOUSE
0
16
32
64

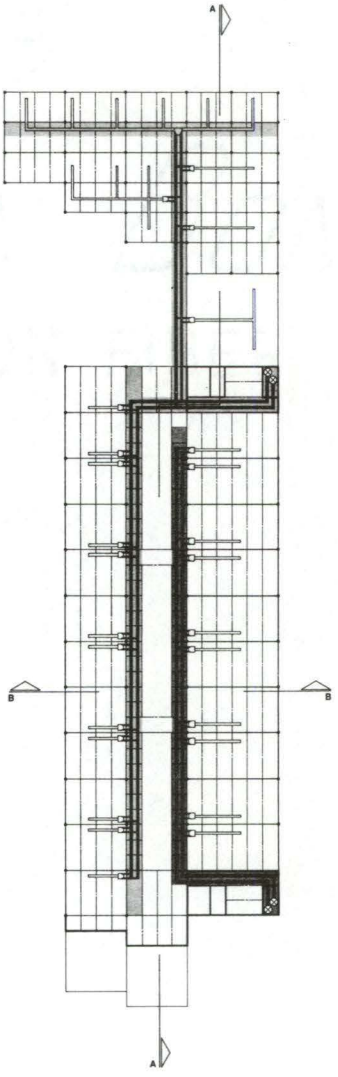
LEVEL TWO



LEVEL THREE

0 16 32 64



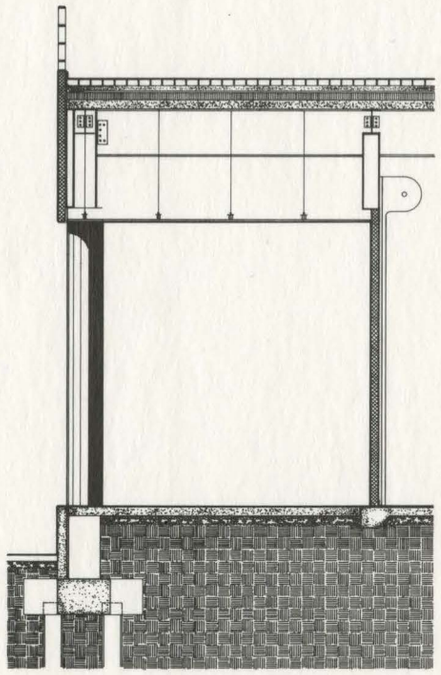


LEVEL TWO

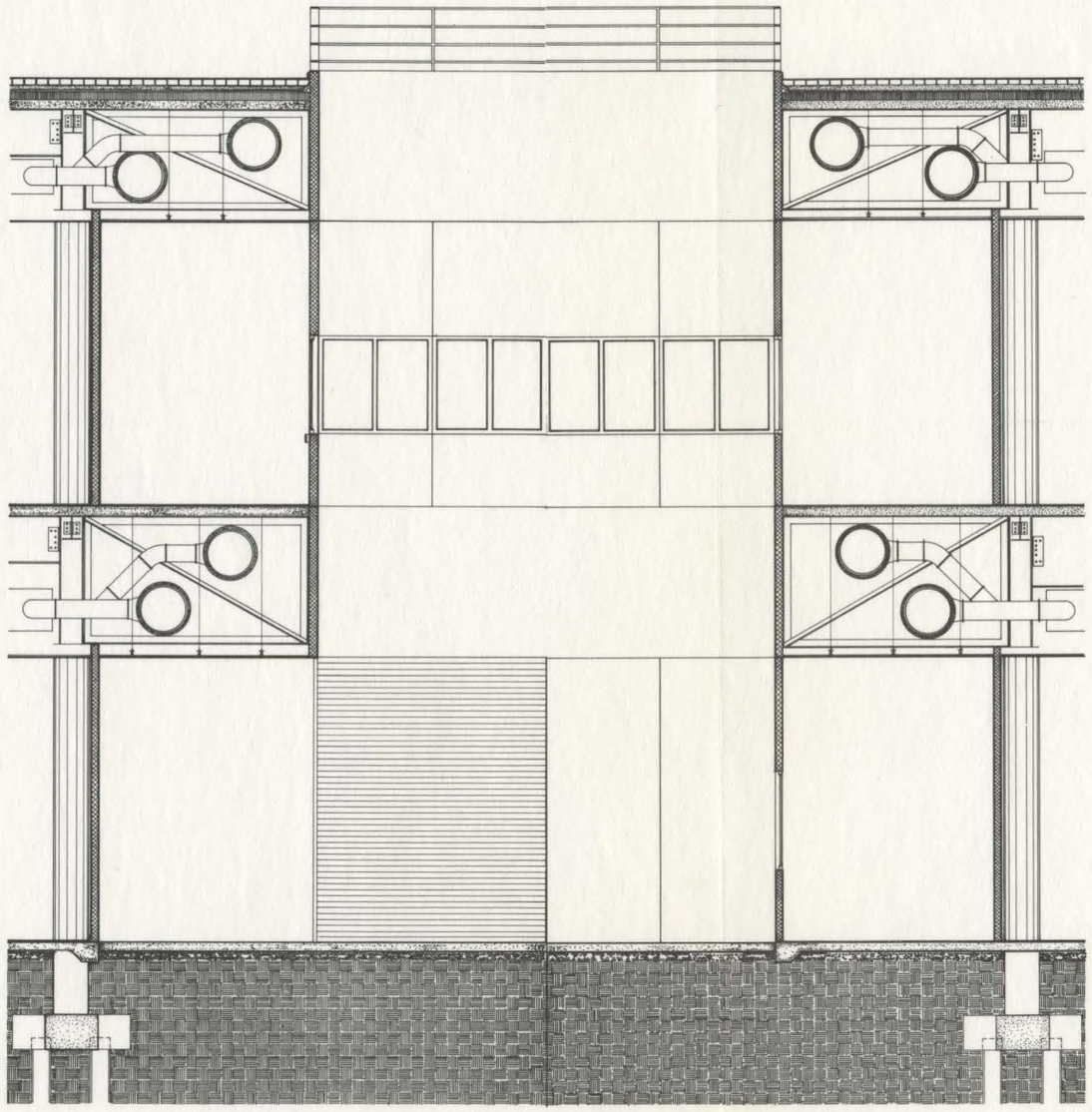
LEVEL THREE

SYSTEMS

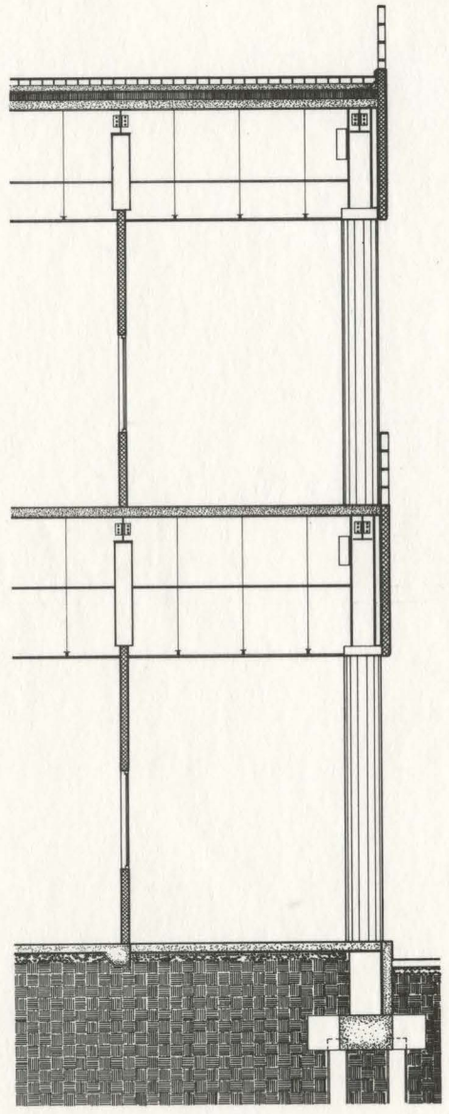
0 16 32 64



1

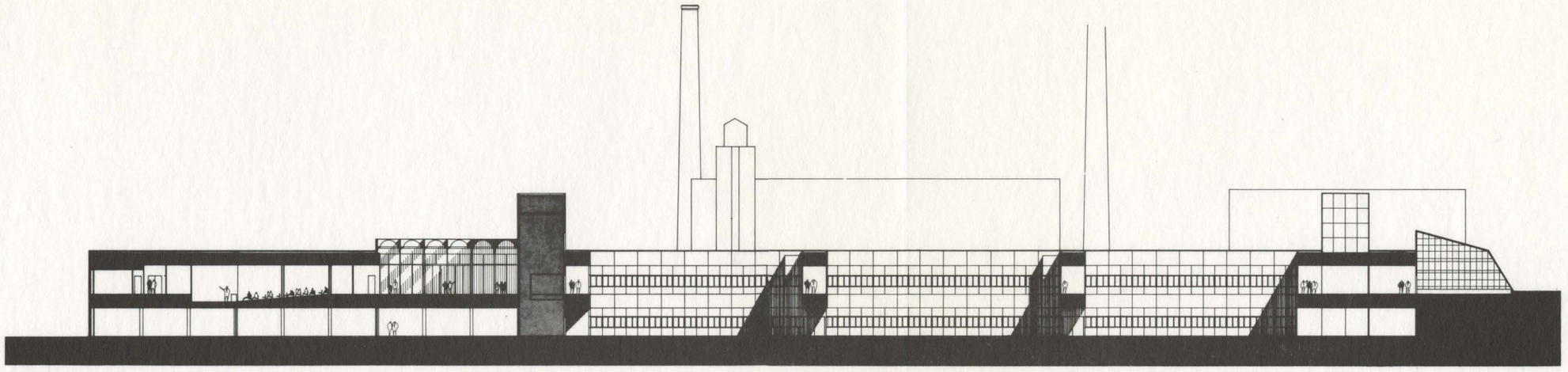


2

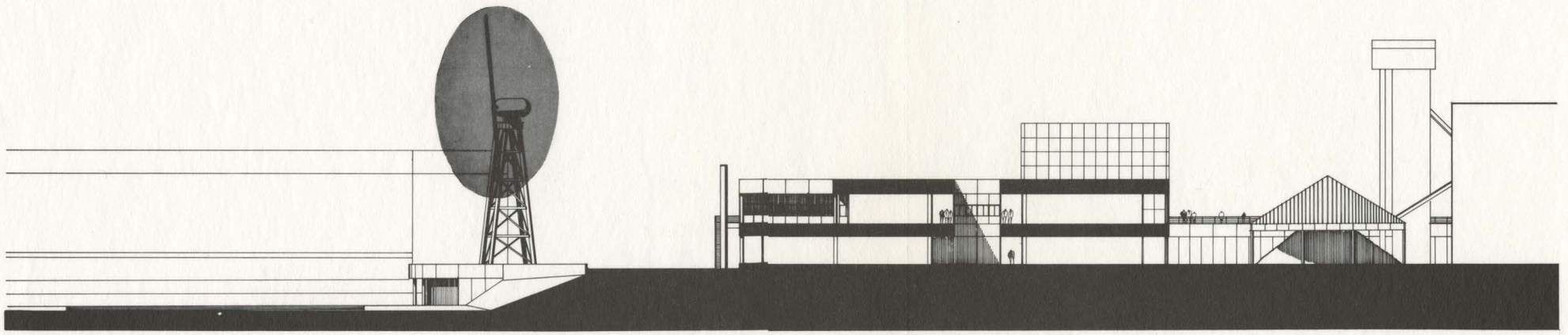


3

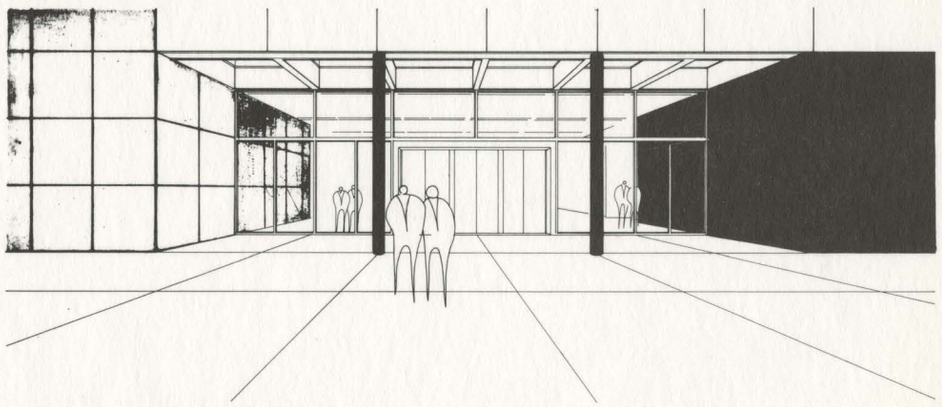
DETAILS



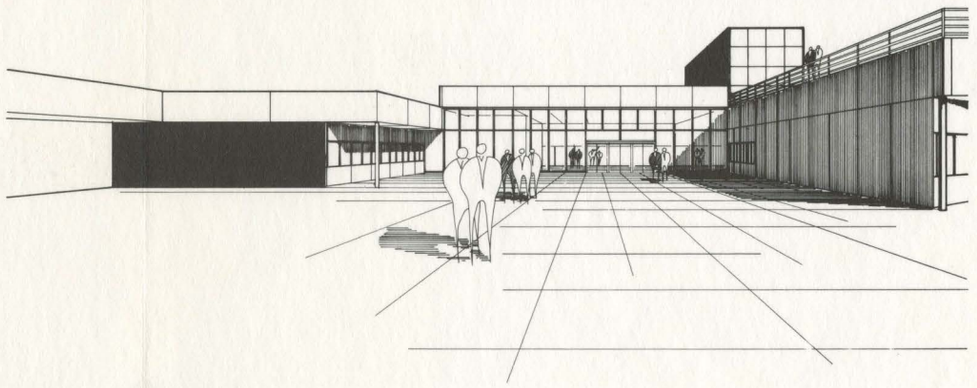
SECTION A-A



SECTION B-B

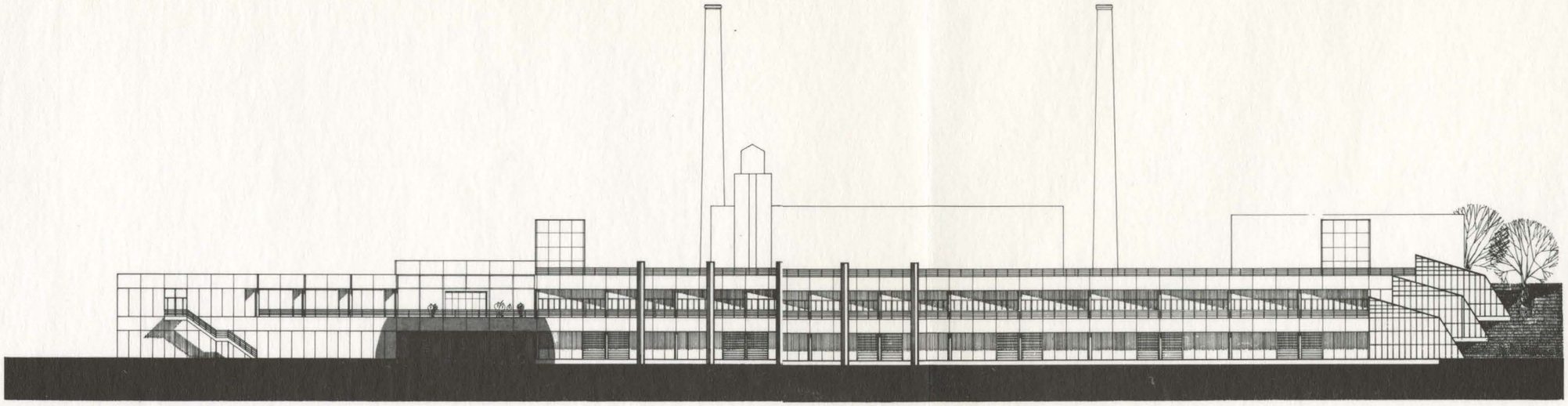


LOBBY ENTRANCE

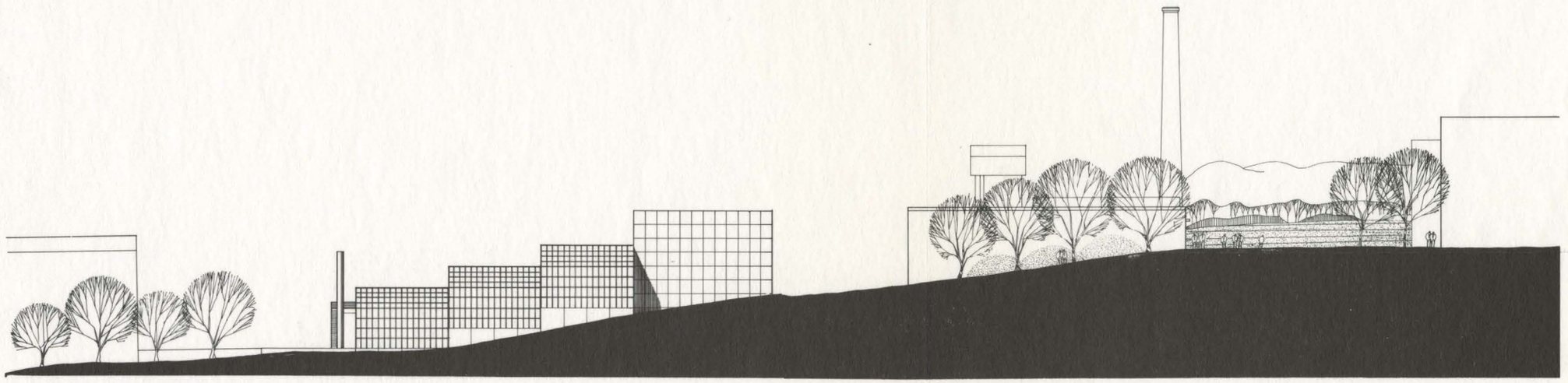


WEST TERRACE

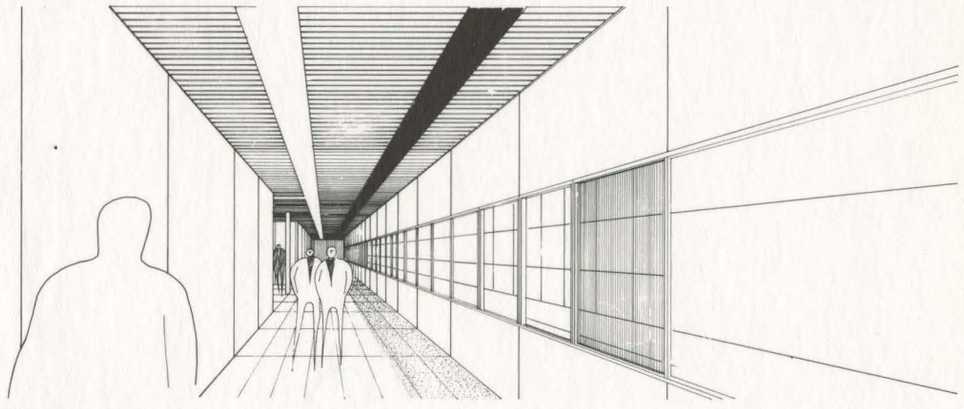
BUILDING SECTIONS



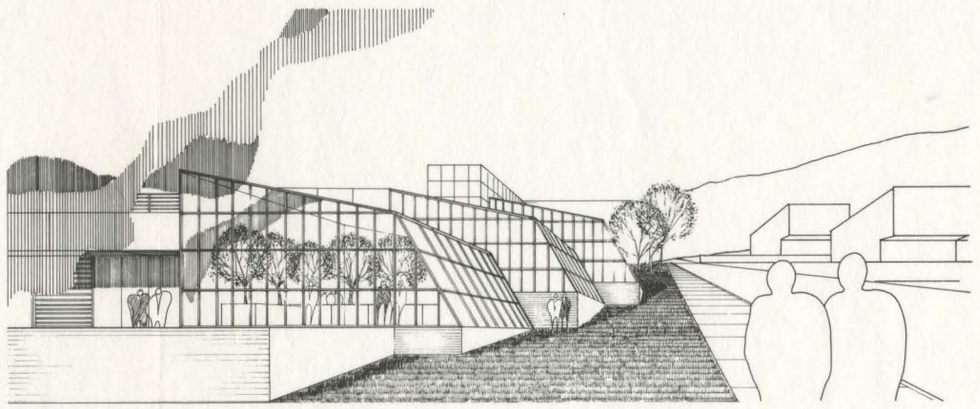
WEST ELEVATION



SOUTH ELEVATION

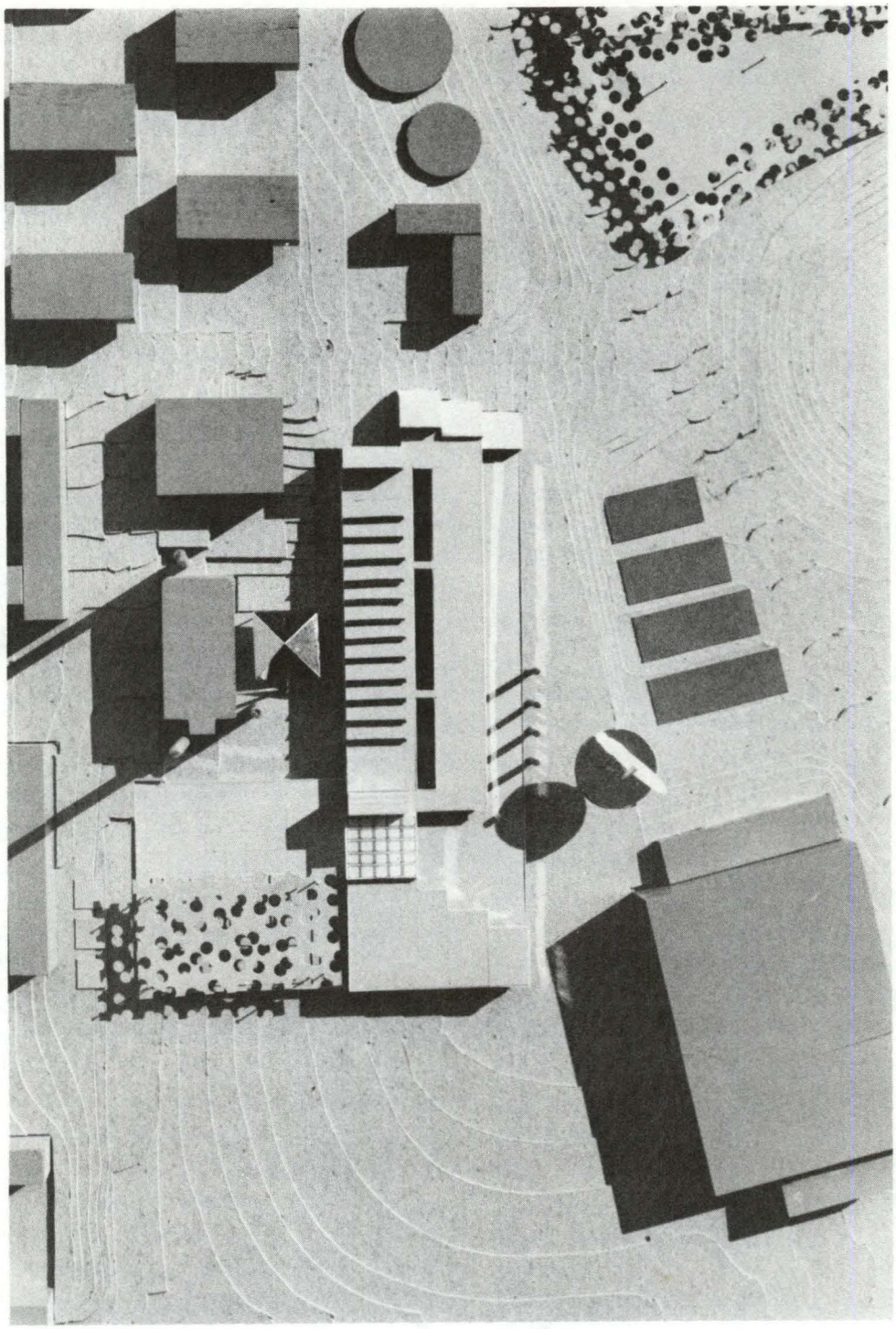


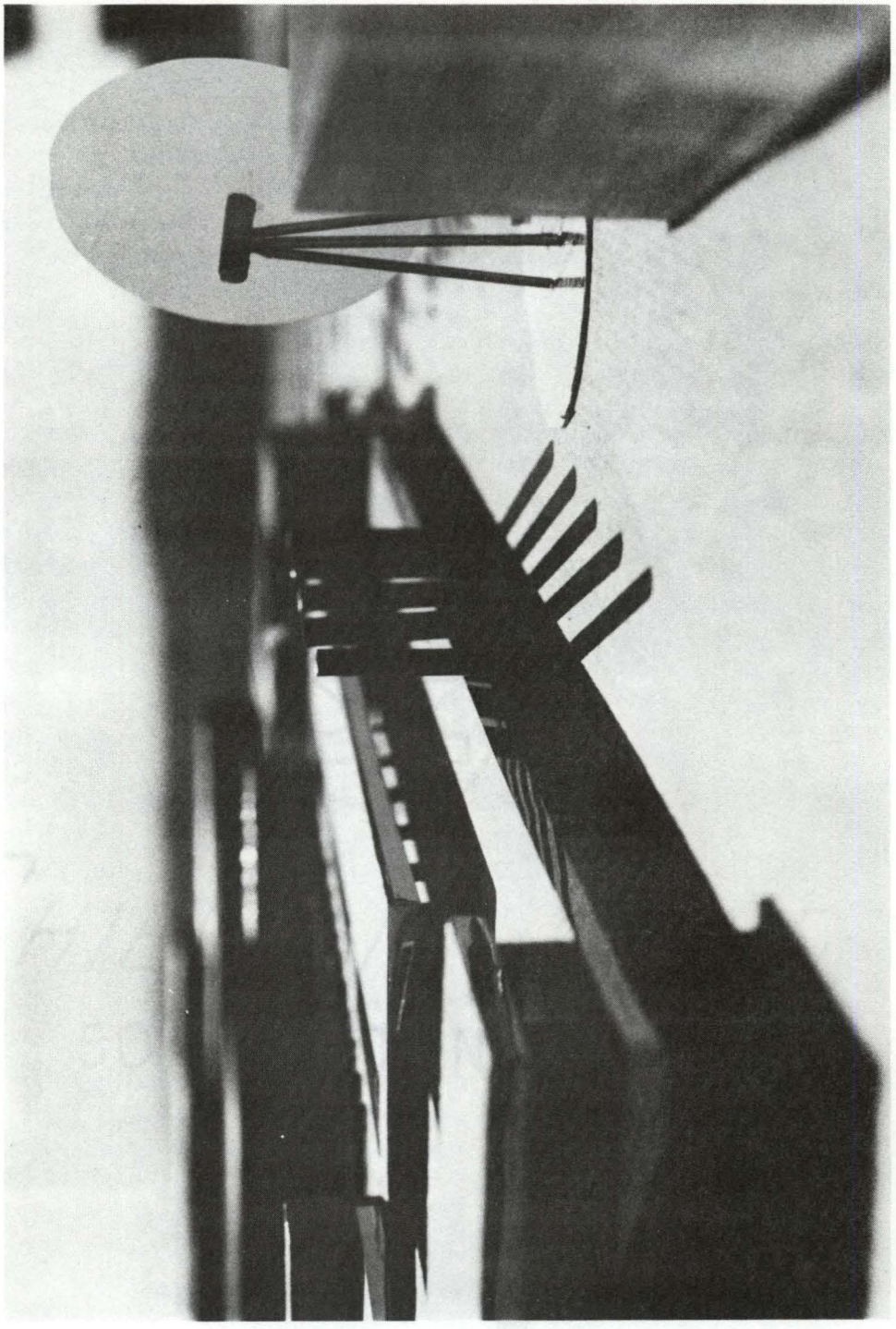
CORRIDOR

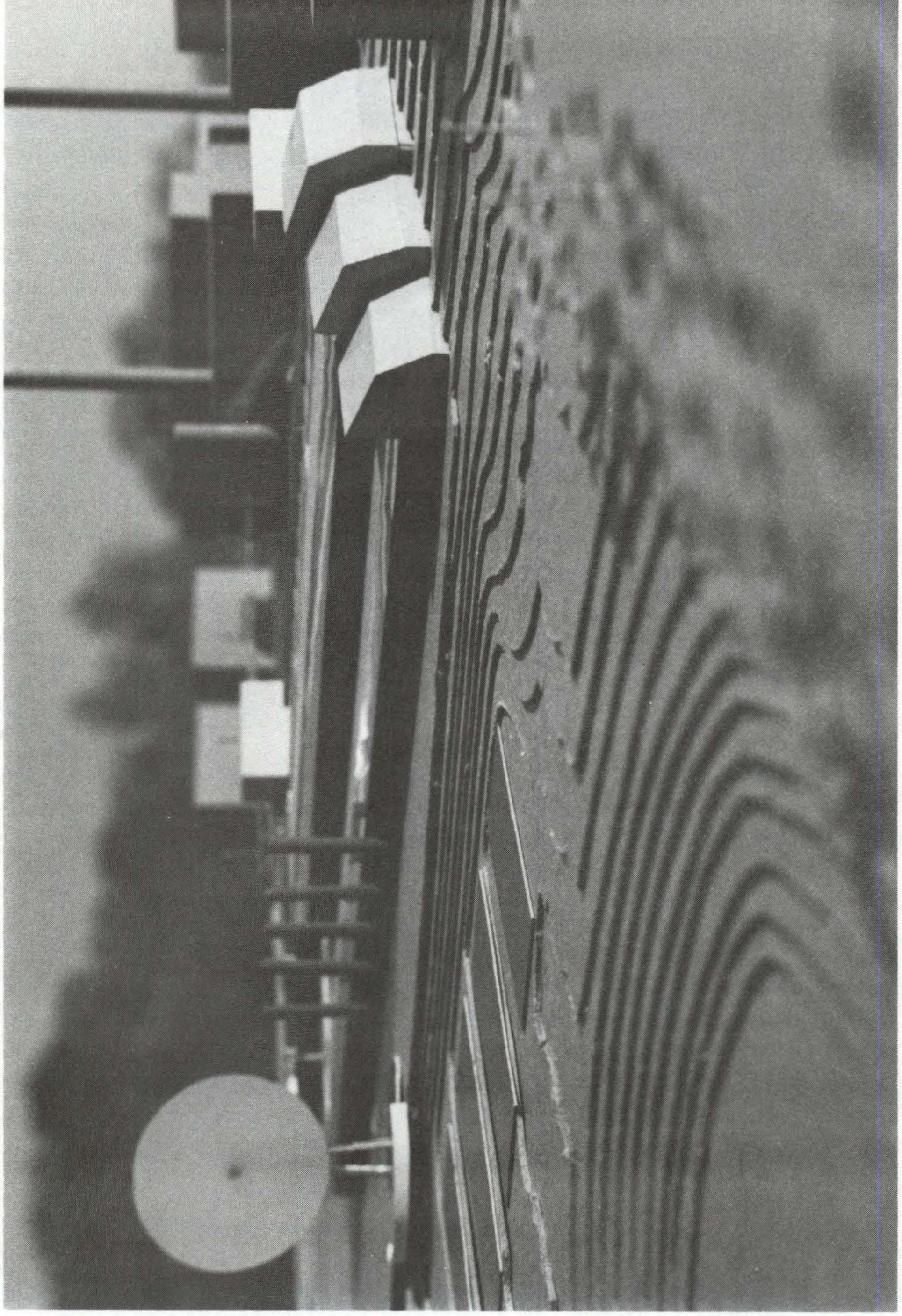


GREENHOUSES

ELEVATION







appendix

ENERGY RESEARCH CENTER QUESTIONNAIRE

1) Name of college and department:

2) List and briefly discuss any areas of study that would involve your department as it relates to an Energy Research Center at Clemson University.

3) What facilities would be needed to adequately support the areas of study that would concern your department?

4) How much space would be needed?

5) Do you have any specific recommendations or suggestions for the location of the Energy Research Center? Please consider the location as it relates to other existing or necessary facilities.

6) Are there presently any research areas that provide your department with the items you listed in number two?

7) If so, where are they located?

As a sixth year graduate student in the field of architecture, I am presently doing research for my thesis or "terminal project." My proposed topic of study is an Energy Research Center for Clemson University. Such a Center would provide Clemson with research labs as well as a complete line of developmental facilities. (For instance, the Center would include marketing and publicity space so that any new concepts developed in the research labs could be properly introduced to the public by the Energy Research Center staff.)

You, as a department head, are one of many key links to the attitudes and ideas of the University staff and students. Thus, I would certainly appreciate you taking the time to complete this brief questionnaire concerning some of the basic programmatic material of the Energy Research Center.

Thank you for your time and interest.

Sincerely,

Mark G. Carroll

Mark G. Carroll

FOOTNOTES

1. Philip H. Abelson, Energy For Tomorrow, Seattle Washington: University of Washington Press, 1975, p. 11.

2. Ibid., p. 13.

3. Allan Temko, Eero Saarinen, New York: George Braziller, Inc., 1962, pp. 20-22.

4. William B. Foxhall, "Architecture For Industry," Architectural Record, May, 1973, p. 156.

5. Ibid., p. 157.

6. Jim Murphy, "By All Means," Progressive Architecture, May, 1975, p. 68.

7. Ibid., p. 72.

8. Ibid., p. 75.

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