GJBX-4 '79

Volume III

ENGINEERING ASSESSMENT AND FEASIBILITY STUDY OF CHATTANOOGA SHALE AS A FUTURE SOURCE OF URANIUM

Mountain States Research and Development
Tucson, Arizona

PRC Toups Corporation
Orange, California

JUNE 1978

Prepared for **THE U.S. DEPARTMENT OF ENERGY GRAND JUNCTION OFFICE**

DISCLAIMER

ENGINEERING ASSESSMENT AND FEASIBILITY STUDY OF CHATTANOOGA SHALE AS A FUTURE SOURCE OF URANIUM

Prepared For

BENDIX FIELD ENGINEERING CORPORATION
GRAND JUNCTION OPERATIONS

Commissioned By

U.S. DEPARTMENT OF ENERGY

Prepared By

MOUNTAIN STATES RESEARCH AND DEVELOPMENT
P.O. BOX 17960
TUCSON, ARIZONA 85731

and

TOUPS CORPORATION
P.O. BOX 5367
972 TOWN & COUNTRY ROAD
ORANGE, CALIFORNIA 92667

JUNE 1978

VOLUME III

APPENDICES

CONTENTS

APPENDIX A

CHATTANOOGA SHALE
PRELIMINARY MINING STUDY

PREPARED FOR

MOUNTAIN STATES RESEARCH AND DEVELOPMENT

BY

THE CLEVELAND-CLIFFS IRON COMPANY
WESTERN DIVISION

CONTENTS

LIST OF TABLES

INTRODUCTION AND SUMMARY

INTRODUCTION

Chattanooga shale, underlying some 40,000 square miles in the southeastern United States, is considered to be a potential large, low-grade source of uranium. The area in and near DeKalb County, Tennessee, is considered the most likely site for commercial development at this writing. This report deals with the mine design, mining procedures, equipment specifications, and operating and capital costs for an underground mining complex capable of producing 100,000 tons of Chattanooga shale per day for delivery to a beneficiation process.

SUMMARY

To meet production requirements a complex of three identical underground mines is recommended. Each mine will have the capability of producing up to 36,000 tons of shale per day for a daily complex output of 108,000 tons. Most of the discussion in this report concerns descriptions of mine layout and procedures for a single mine with the understanding that three such mines will be required to satisfy production criteria.

A typical room and pillar mining scheme has been selected as the most feasible for the formation under consideration. All mine openings have been sized to be 32 feet wide by 16 feet high. Access to the orebody will be gained through inclined adits. A bleeder-type ventilation system, incorporating two exhaust shafts per mine, has been designed to control the air supply. Primary crushing will be carried out underground, reducing the mined shale to a size amenable to conveyor transport to the surface.

For several reasons, the mine has been designed to advance down-dip. Such a plan allows for adit access to the mining zone, whereas a traditional up-dip advance from the lower parts of the orebody may necessitate the use of shafts and the hoisting of men, materials, and mined shale. The major considerations, however, arise from an examination of the feasibility of underground disposal of process plant tailings. Since mining will advance down-dip, the panel entries will be on the upper end of each panel. Consequently, the greatest hydrostatic head generated by the emplaced tailings will be exerted against the solid barrier pillars at the lower end of each panel and the potential for failure of the panel entry bulkheads is greatly reduced. In addition, by backfilling from the higher end of each panel, a greater volume of material can be placed in the panel, and with greater ease, since the material will tend to flow away from the panel entries. It is estimated that 70 percent of the tailings produced can be emplaced as backfilled material.

Preliminary cost estimates, as presented in Table A-1, are based on engineering studies performed by the The Cleveland-Cliffs Iron Company's mining staff and quotes from major equipment manufacturers. All costs are based on December 1977 dollars. A 2.2 year preproduction period, followed by a 20-year productive life, has been assumed.

Because the exact location of the mining complex and process plant are not now known, this report does not consider the logistics or costs of transporting the ore once it reaches the surface. Costs detailed herein assume that the mined shale will be delivered to a point 200 feet beyond the portal of each mine.

Basic Parameters

The following basic parameters were used in the engineering analysis performed for this study.

A. Formation Characteristics

1. Overburden thickness between 100 feet and 500 feet.
2. In-place density of 140 pounds per cubic foot.
3. Average water inflow rate of 5,000 gallons per minute over the entire expanse of one mine.

B. Complex Production

1. Scheduled work year of 350 days.
2. Scheduled work week of 20 shifts.
3. Production will come from three separate, independently operated mines. Process plant will require 100,000 tons of raw shale per day.
4. 11,291,000 tons of ore stockpiled on surface during preproduction period.
5. Preproduction period of 2.2 years, six month period for escalating to full capacity, 19.5 year period of full production.

C. Mine Design Criteria

1. Inclined access adits will be located in areas where overburden is 100 feet thick.
2. All mine openings are 32 feet wide by 16 feet high.
3. Panel pillars measure 60 feet by 25 feet; development pillars are 30 feet wide; barrier pillars are 75 feet wide;
4. Extraction ratio of 73 percent in-panel, 61 percent overall.

D. Backfilling Criteria

1. Size consist of tailings in the -1/4" +10 mesh range.
2. Only 70 percent of tailings produced can be disposed of underground.
3. Residual moisture in fill of 15 percent.
4. Backfilling slurry density of 50 percent solids by weight.

TABLE A-1. COST SUMMARY - THREE-MINE COMPLEX

A.	CAPITAL EXPENSE:		
	1. Preproduction Capital Requirements (Including Development Mining Costs)		$117,983,000
	2. Deferred Capital:		
	Years 2 - 10		$ 91,500,000
	Years 11 - 20		91,525,000
	3. Total Capital Requirements - Mining		$301,008,000
	4. Capital Expense - Backfilling		54,558,000
	TOTAL CAPITAL REQUIREMENTS		$355,566,000
B.	OPERATING AND MAINTENANCE COSTS: (Dollars Per Ton Mined)		
	1. Mining Costs*		
	Operating Labor	$ .8709	
	Operating Supplies	.7839	
	Maintenance Labor	.4042	
	Maintenance Supplies	.2770	
	TOTAL COST PER TON MINED	$2.3360	

* Does not include surface transportation of ore to processing facility.

2.	Backfilling Costs:	
	Operating Labor	$ .2100
	Operating Supplies	.1920
	Maintenance Labor	.0510
	Maintenance Supplies	.0310
	TOTAL COST PER TON MINED	$ .4840

C. MANPOWER REQUIREMENTS:

Hourly Personnel	2,154
Salaried Personnel	267
TOTAL MANPOWER	2,421

D. OVERALL PRODUCTIVITY: 60.1 Tons Per Manshift

GEOTECHNICAL INVESTIGATIONS

Chattanooga shale, which underlies about 40,000 square miles in the southeastern United States, is a large potential, low-grade source of uranium. Deposits occurring in Dekalb County, Tennessee, are considered most favorable with respect to uranium content. In the Smithville and Sligo Bridge quadrangles, the U. S. Bureau of Mines studied the Chattanooga shale from 1948 through 1953 by sampling outcrops, drilling, and driving a 100-foot adit. The oil content of the shale ranges from 0.5 to 14.9 gallons per ton, and the uranium percentage averages 0.0006 percent [Wilson 1968]. This section contains brief discussions on the geology, hydrology, and rock mechanics of the formation.

GEOLOGY

The Chattanooga shale, considered to be of late Devonian age, lies unconformably on many formations ranging in age from Middle Ordovician to Middle Devonian [Conant 1961]. It is overlain by the Maury Formation, which is overlain by the Fort Payne and Warsaw limestone formations. The Fort Payne and Warsaw Formations vary in thickness from 100 to about 350 feet, and the Maury Formation is one to four feet thick. The Chattanooga shale in this area, about 30 feet thick, consists of the Gassaway (upper) and the Dowelltown (lower) Members. The Gassaway Member has a higher uranium (U_3O_8) content of 0.007 percent. On the basis of core drilling, the U. S. Bureau of Mines estimated measured and inferred reserves for the Gassaway Member as 85.6 billion tons of shale containing 6.4 million tons of uranium (U_3O_8).

The topography in the project area generally consists of narrow valleys and the steep sides of narrow ridges [Moore 1972]. Outcrops consist principally of the Warsaw and Fort Payne Formations, and Chattanooga shale [Wilson 1968]. The overburden thickness in the area varies from about 100 feet in the west to approximately 600 feet in the east. The strike of the shale beds is about NE-SW, with a dip from almost horizontal to about 30 feet per mile (0.57 percent) to the southeast. The major joint set strikes approximately NE-SW, with the minor joint set at about N15°W. Most joints have an approximate vertical dip.

HYDROLOGY

The project area is located in the Center Hill Lake Region (909 square miles) of Tennessee. Average precipitation is 53 inches of water per year of which 36 inches is consumed by evaporation and transpiration, and the remaining 17 inches leaves the area as streamflow. The average streamflow in the region is 1.5 cubic feet per second per square mile of drainage area. The largest reservoir in the region is the Center Hill Lake which is tenuous and about 64 miles long. The reservoir transects the Sligo Bridge quadrangle; however, it does not affect the Smithville quadrangle where mining is planned initially. Total lake storage capacity at the top of the flood control pool is two million acre-feet of water. The mean elevation of the reservoir is 650 feet, about 100 feet below the Chattanooga shale in the area of interest. Most of the water used in the region is from the Center Hill Lake and other surface supplies. Raw water from streams generally meets the chemical standards recommended for drinking water [Moore 1972].

Soils, alluvium, and solution cavities in limestone bedrock are the sources of groundwater. Maximum potential well yields are 100 gpm from the soils, 200 gpm from alluvium, and several thousand gpm from solution cavities. Most springs in the area are small but 25 percent have flows ranging from 50 to 2,000 gpm. Horizontal, sheetlike openings and complex cavities yield substantial amounts of water with no region extrapolations possible. The upper Fort Payne Formation is quite permeable since weathering action has created rubble zones. Sheetlike cavities in the Fort Payne decrease in abundance with depth [Moore 1972]. In addition, core recovered from the lower part of the Fort Payne in the project area indicates competent rock with little or no fracturing. Hence, the lower part of the Fort Payne, which will serve as the mine roof, may serve as a relatively impermeable barrier between the mine and the permeable portions of the Fort Payne and Warsaw Formations. However, complex solution cavities may overlie local areas within the mine and produce large inflows of water. Based on the above-mentioned limited information, a pumping rate of 5,000 gpm per mine has been estimated. Ground water generally meets the chemical standards for drinking water; hence, discharge of excess water into streams might be possible without any treatment.

ROCK MECHANICS

Conventional rock mechanics analyses were performed to determine room spans and pillar dimensions. Geological and hydrological data discussed above, laboratory determined rock strength parameters, and review of core from one core hole drilled in the project area, served as input for the analyses. Average rock strength parameters for the Fort Payne chert, Chattanooga shale, and the underlying Chickamauga limestone are presented in Table A-2 [Blair 1954]. Review of core from the lower part of the Fort Payne Formation and the Maury Formation leads to two conclusions: 1) the Fort Payne Formation is a strong cherty limestone and will serve as a good mine roof; 2) the Maury Formation is relatively competent but has very thin parting planes (0.01 to 1.5 inches thick) which will pose a perennial roof control problem. An experimental 100-feet-long adit driven by the Bureau of Mines in 1949 in the Sligo Bridge quadrangle indicated that the Maury Formation, a green mudstone or glauconitic sandstone with phosphate nodules, is not a good roof. Hence, it was assumed that the Maury Formation would be mined along with the Gassaway Member, leaving the Fort Payne Formation as the mine roof.

Since the mine will be wet and water has a weakening effect on rock, a conservative approach was taken toward roof span design. Using elastic beam theory and assuming a beam thickness of at least five feet and a factor of safety of 16, the maximum roof span at intersections cannot exceed 45 feet. This leads to a maximum room span of 32 feet. Roof bolting with six-foot-long bolts on five-foot centers is planned and will be varied as dictated by in situ roof conditions. Since rectangular pillars have several operational advantages, pillars were sized 25 feet wide by 60 feet long. The tributary area load theory, a mining height of 16 feet, a blast damage zone of about five feet into the pillar, and an average overburden thickness of 500 feet, were used in determining pillar sizes. In order to adequately isolate mining panels, support abutment loads, and resist pressures exerted by the backfill, a barrier pillar width of 75 feet is planned. Based on the joint patterns described under the geology section, a direction of N15°W has been selected for orienting the main entries and ensuring their long-term stability.

TABLE A-2. ROCK STRENGTH PARAMETERS FOR THE ZONES OF INTEREST [a]
Pine Creek and Sligo Sites, DeKalb County, Tennessee

Rock Type	Average Thickness (Feet)	Compressive Strength (psi)	Direct Tensile Strength (psi)	Modulus of Rupture (psi)	Static Young's Modulus ($x 10^6$ psi)	Static Poisson's Ratio	Sclero-scope Hardness	Porosity (%)	Density (pcf)
Fort Payne Chert	151.8	30,500	740	3,780	8.99	0.20	71	4.3	165
Chattanooga Shale									
a. Maury Member	0.9	-	-	-	-	-	-	-	168.5
b. Gassaway Member	15.0	16,150	120	350	2.05	0.16	49	1.6	143.5
c. Dowelltown Member	14.8	12,200	-	58	1.80	0.14	43	-	158
Chickamauga Limestone	-	25,100	103	925	6.71	0.26	53	2.5	171

[a] Average values from three hole at Pine Creek and two holes at Sligo.

MINE PLANNING AND DESIGN

GENERAL ASSUMPTIONS AND CONDITIONS

The mining complex will be required to produce 100,000 tons of shale per day for delivery to a beneficiation process. Three separate mines, each capable of producing up to 36,000 tons per day, will be established to meet process plant requirements. The complex will produce a maximum of 108,000 tons per day. The excess tonnage will be stockpiled on the surface for use during those periods when mine output is less than full capacity.

A complex of three smaller mines has several advantages over a single large mine producing the same total tonnage. With each mine contributing a portion of daily requirements, total production is not dependent on any single system and problems temporarily affecting production in one mine do not drastically decrease complex output. The logistics of support activities and supervision are simplified by the reduced areal extent of smaller mines. The volume of air that must be circulated through the mine for adequate ventilation is severely decreased due to the lesser equipment requirements of smaller mines. Furthermore, it is felt that the overall efficiency will not be adversely affected since the size of the smaller mines is large enough to permit efficient operation.

Each of the three mines will be identical in layout, operation, and production. Descriptions of mining procedures, equipment requirements, and other features are given for a single mine with the understanding that three such mines are necessary to meet production requirements. Operating and maintenance costs, as detailed in the section entitled, "Operating and Maintenance Costs," are computed for a single mine. While total costs for the mine complex will be triple those of one mine, overall costs per ton for the complex will be identical to those developed for the single case.

Each mine will be a separate entity with its own complement of machinery and workers. A manager of mines and common engineering staff will serve the entire complex but, otherwise, each mine will be a separate unit operating independently of the others.

The mines are scheduled to work 20 shifts per week for 350 days each year. The 21st shift in each week will be devoted to maintenance. Each mine has been designed for a 20-year life.

MINE LAYOUT

A typical room and pillar mining scheme has been selected as most feasible for the ore zone under consideration. Such a system has the advantages of a relatively high resource recovery ratio, no "lost" development tonnage since all development work is carried out in the ore zone, and a comparatively simple ventilation plan. Generally, mining will advance down-dip so as to facilitate backfilling as detailed in the section entitled "Backfilling."

Surface Adits and Main Entries

Access to each mine will be gained through three surface adits. It has been assumed that the adits will be located in an area where overburden is 100 feet thick. The adits will be driven downhill from the surface at a 10 percent grade for a distance of 1,000 feet. At this point, the mining zone will have been reached and the adits will flatten out to a .6 percent grade to follow the dip.

The set of three adits will broaden into five main entries at their junction with the mining zone (Figure A-1). The surface adits will measure 32 feet wide by 16 feet high and will be separated by pillars 30 feet wide by 200 feet long. The main entries and their associated pillars will have the same dimensions.

Panel Access Entries

At the junction of the mining zone and the surface adits, the first set of panel access entries will be driven along the strike in both directions from the mains. Each set of panel access entries will consist of three drifts, each 32 feet wide by 16 feet high, separated by pillars 30 feet wide by 152 feet long (Figure A-1).

The entries will provide access to 18 mining panels, nine on either side of the main entries. The length of each wing will be 7,737 feet for a total width of just over three miles.

Successive sets of panel access entries will be developed from the main entries at intervals of 1,934 feet (the length of one panel). In all, twelve rows of panels will be required for a total mine length of 4.6 miles (see Typical Mine Plan, Figure A-17).

Mining Panels

Panels will be developed only on the down-dip side of the panel access entries. Panels will be nine rooms wide and 29 crosscuts deep. Rooms and crosscuts will be 32 feet wide by 16 feet high. Pillars within the panel will be 60 feet by 25 feet, the shorter dimension being measured in the direction of drive. Panels will be bounded by 75-foot-thick barrier pillars on all sides (Figure A-2). Recovery ratio within the panels will be 73 percent while a 61 percent overall recovery is anticipated mine-wide.

Bleeder Entries

Bleeder entries will be driven around the periphery of the mine to carry exhaust air to the ventilation shafts. The entries will consist of two drifts, each 32 feet wide by 16 feet high, separated by 30-foot pillars (see Typical Mine Plan, Figure A-17).

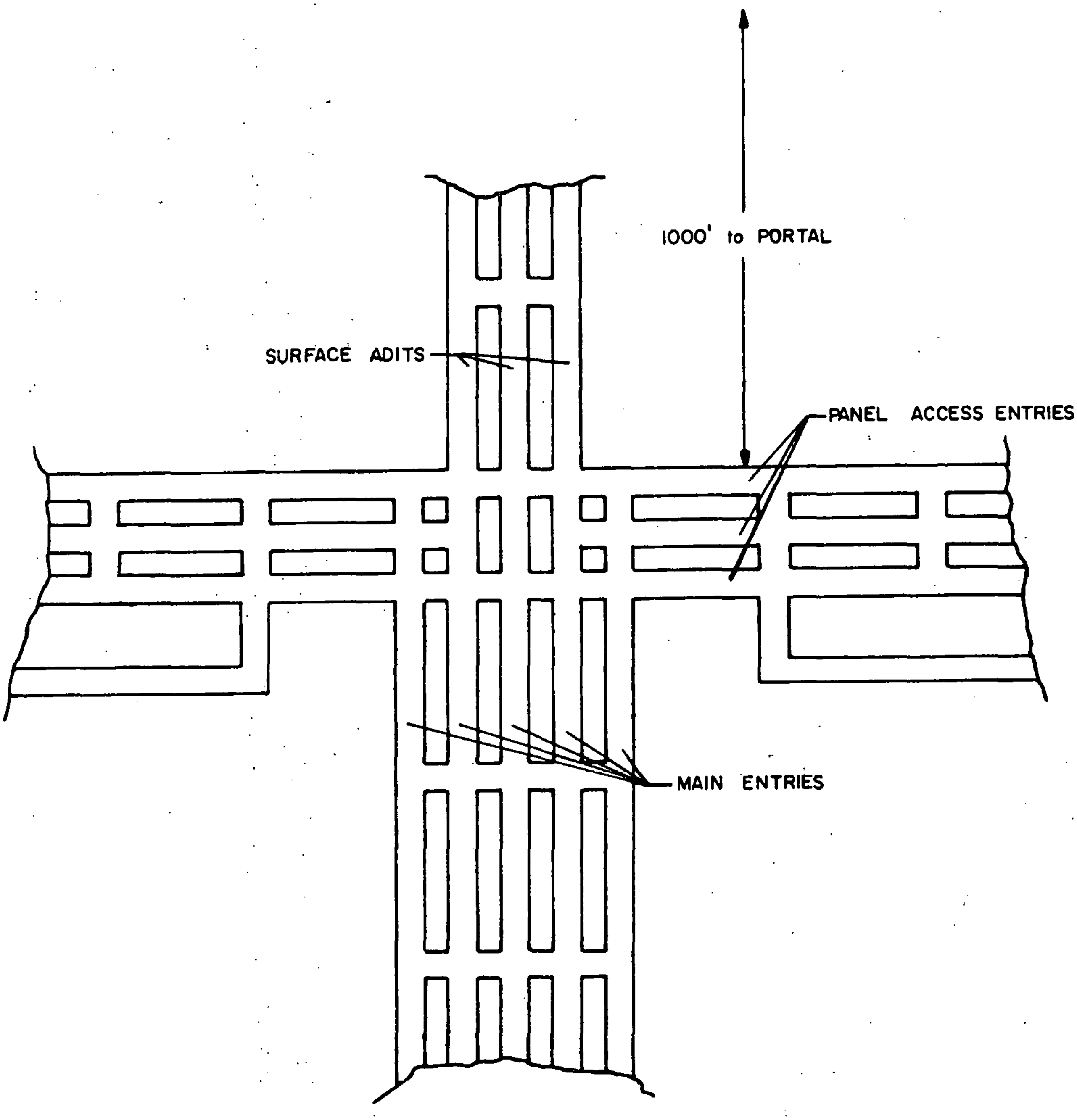


FIGURE A-1 DETAIL OF ADIT ACCESS TO MINING ZONE

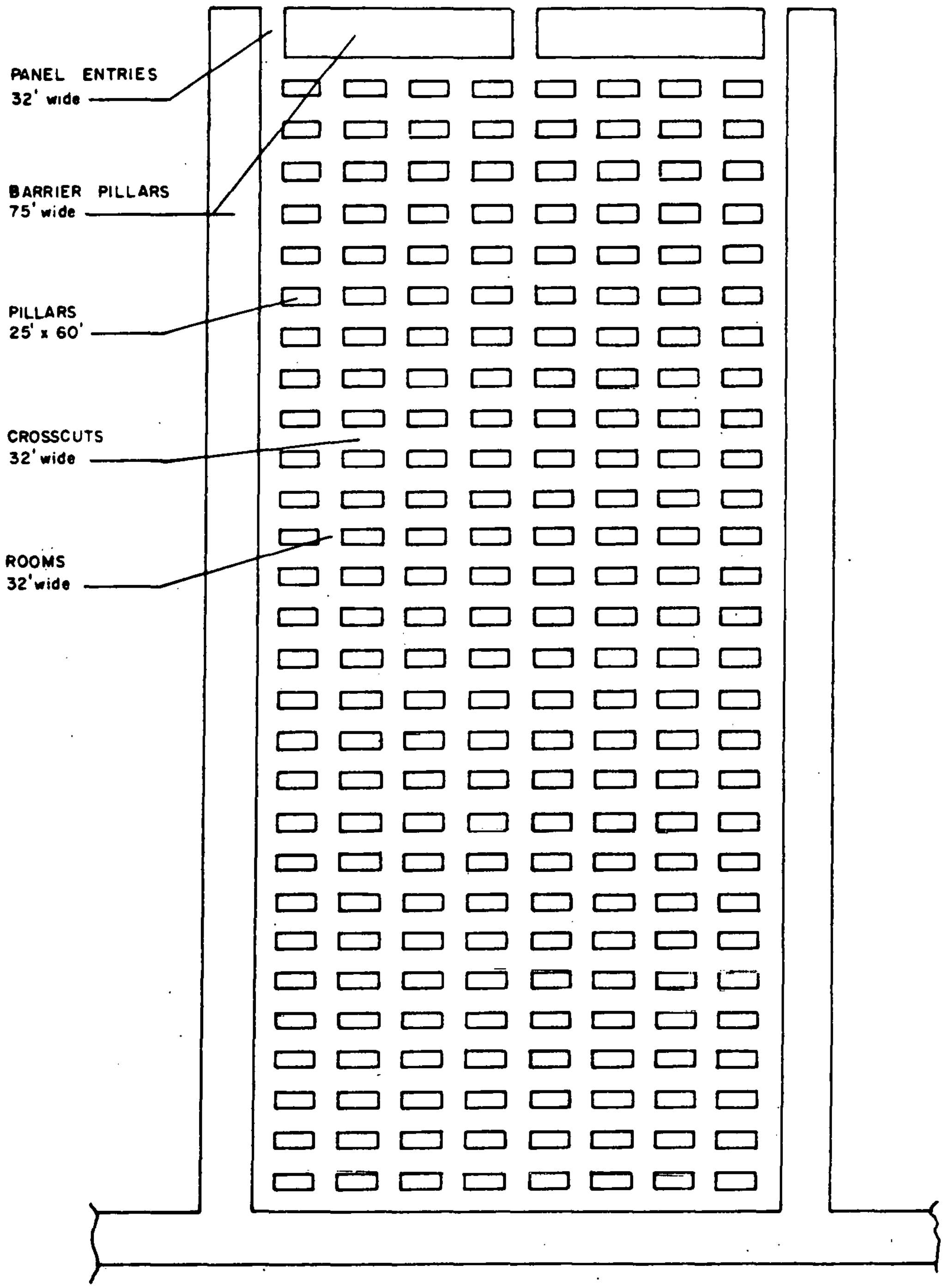


FIGURE A-2 TYPICAL PANEL LAYOUT

Ventilation Shafts

Two ventilation shafts will be required to exhaust mine air during the life of the mine. One shaft will service each side of the mine and will be located at the intersection of the bleeder entries and the first set of panel access entries (see Typical Mine Plan, Figure A-17).

Each shaft will be 20 feet in diameter, approximately 100 feet in depth, and concrete lined. Two ten-foot-diameter axial fans, rated at 400,000 cfm each, will exhaust each shaft.

MINING SCHEDULE

Preproduction Development

A period of 2.2 years is required to develop the mine to the point that full production can begin. At that point, two full-time crews will begin driving the first panel access entries while a third crew will have extended the main entries as far as the service area and will have mined enough space for the shop, warehouse, main sump, and mine offices (Figure A-3).

Concurrent with this underground development, the ventilation shafts will be sunk, lined, and equipped. They will be ready for operation by the time the panel access entries have been extended to intersect the shafts.

A total of 11,291,000 tons of ore will be mined during this period and will be stockpiled on the surface for process plant start-up.

Following development, a period of six months will be required to bring the mine into full production. This additional time allows for the recruiting and training of the large numbers of workers required to operate the mine at full capacity.

Production

Once full production rates have been achieved, it will require .55 years to completely mine one panel. At any one time, a total of six panels will be producing at an average rate of 5,106 tons per day each. Mine expansion will be symmetrical with three producing panels on either side of the main entries. It will require 1.65 years to completely mine one row of panels. A detailed description of mining methods and equipment is found in the section entitled "Mining Methods and Equipment."

Development

Mine development will be an on-going activity throughout the life of the mine. Three full-time crews will produce an average of 5,387 tons per day from development headings.

While production crews are mining in one row of panels, development crews will be opening panel access entries for the next row of panels. In addition, they will extend the main entries deeper into the ore body

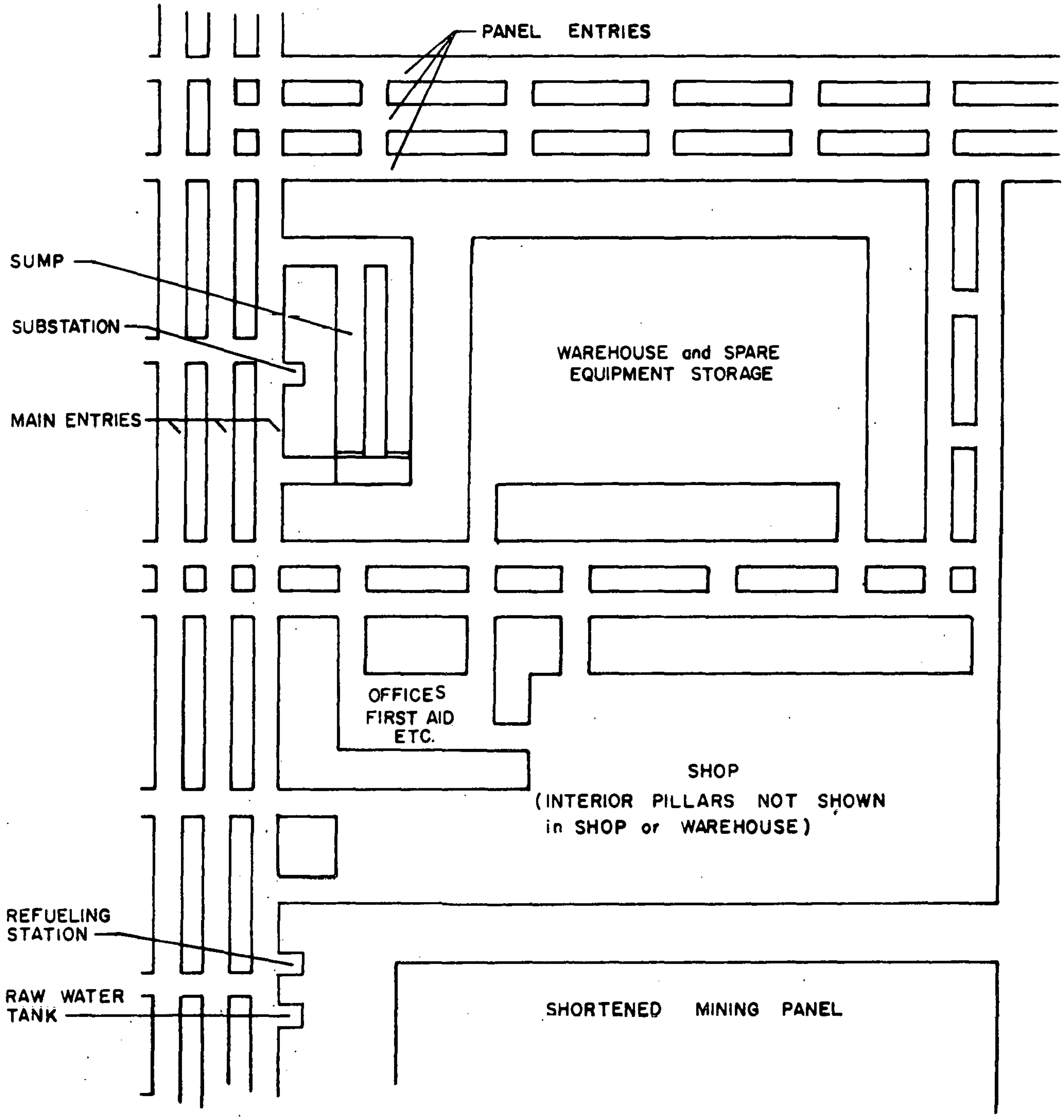


FIGURE A-3 SERVICE AREA DETAIL

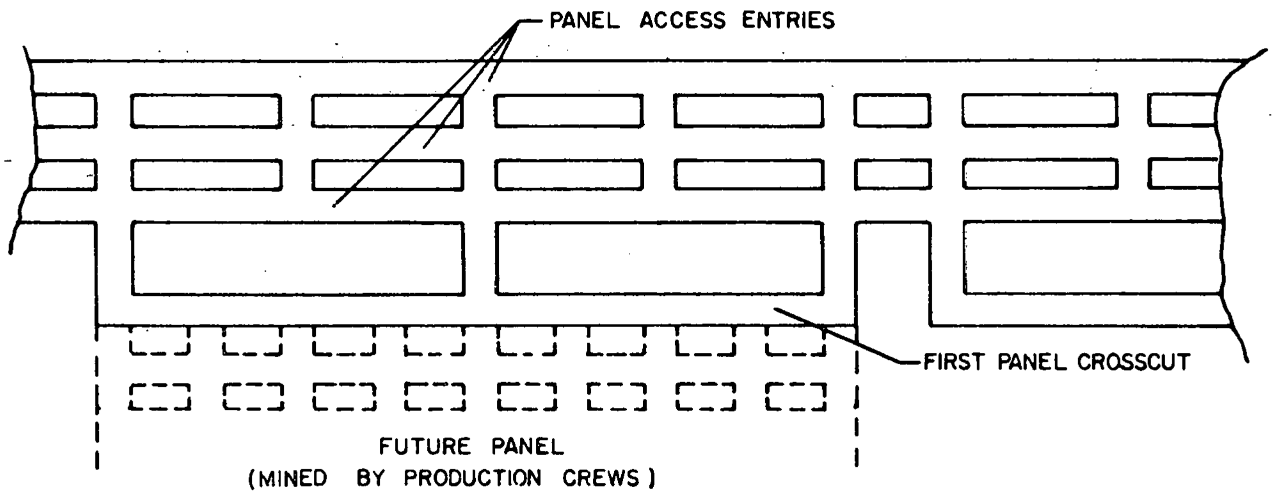


FIGURE A-4 PANEL ACCESS ENTRY DEVELOPMENT

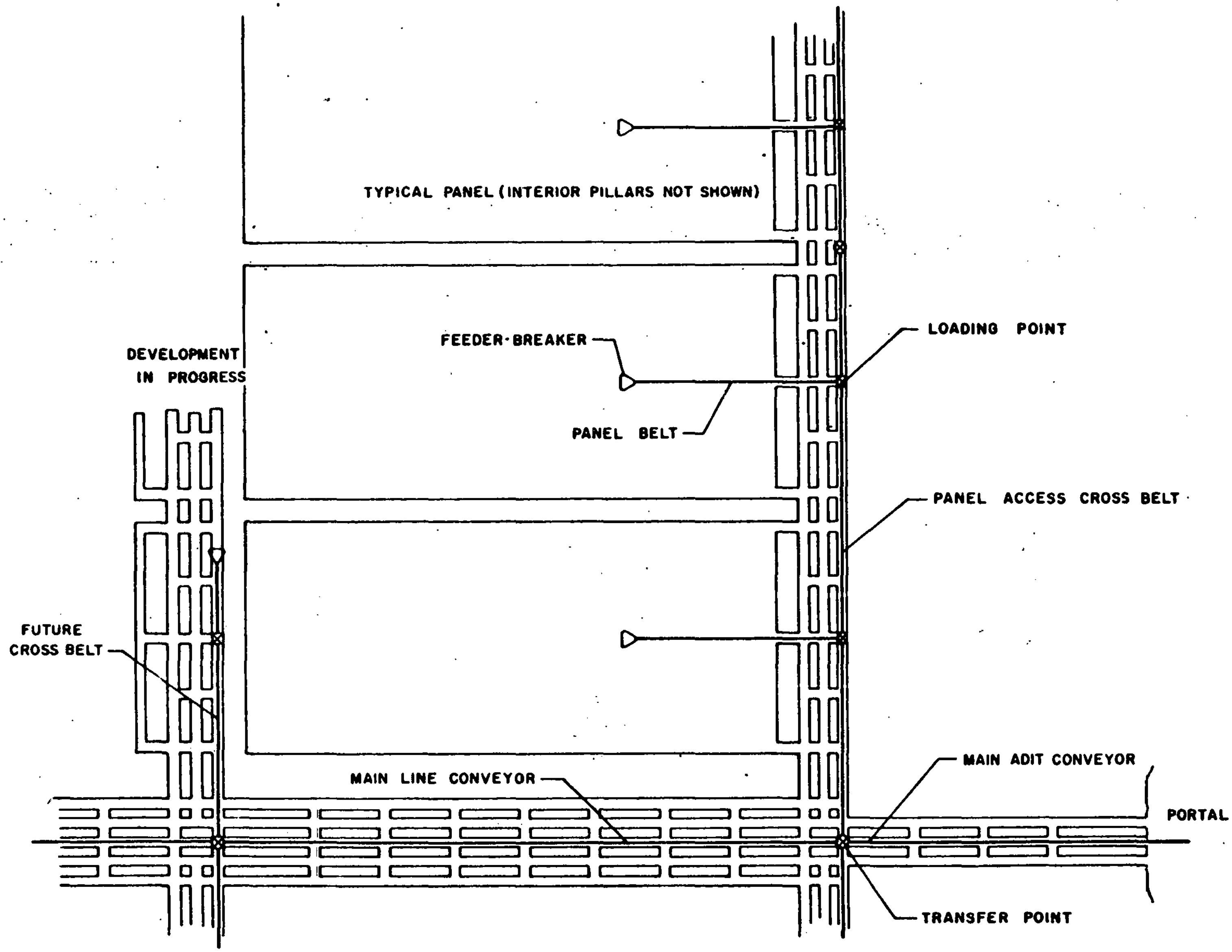


FIGURE A-5 TYPICAL CONVEYOR LAYOUT

and will drive the bleeder entries to tie into the ventilation system. Total time required to completely develop a row of panels for production mining will be 1.65 years.

As panel access entries are driven, development crews will also open panel entries and will mine the first crosscut in each panel (Figure A-4). This "head start" will allow production crews to avoid a significant drop in production tonnage that would ordinarily be caused by the limited number of working faces available during the initiation of mining in a new panel.

ORE HANDLING

Broken shale will be carried from the mines by a system of conveyor belts (Figure A-5). Conveyor belts located in the center room of each panel will transport ore from the panel to a crossbelt located in the panel access entries. These crossbelts will carry material to a main conveyor line located in the center drift of the main entries. The main conveyor line will transport ore to the surface through the central surface adit. A detailed description of the conveyor belt system is given in the section entitled "Mining Methods and Equipment."

Production Tonnage

The broken shale produced by each round will be handled initially by load-haul-dump (LHD) units. These mucking machines will carry ore to a feeder-breaker located in the central drift of each panel. The feeder-breaker will reduce the shale to -12 inch size and feed it onto a conveyor belt carrying the material to the crossbelts.

For optimum efficiency, LHD haulage distance is limited to a maximum of 800 feet one way. This necessitates the advance of the feeder-breaker and an associated extension of the panel belt twice during the life of a panel. Each advance will be 600 feet in length and will occur approximately every two months. Figure A-6 shows the initial crusher location, its position after each advance, and the area of the panel mined from each location.

Following panel completion, the crusher and belt will be removed for use in the next panel to be mined.

Development Tonnage

Development crews will also be served by LHD units and an advancing feeder-breaker. As development proceeds, LHD units will carry muck to the crusher which, in turn, will feed the conveyor belt. Maximum haul distance is again limited to 800 feet one way.

Crusher advances in the panel access entries will occur approximately every two months and will cover roughly 600 feet. As the feeder-breaker advances, belt installation crews will extend the conveyor belt as needed. The belt installed will not be a temporary one, however, but will remain in the panel access entries to serve as the crossbelt during production mining. The belt line will be reclaimed only when the entire

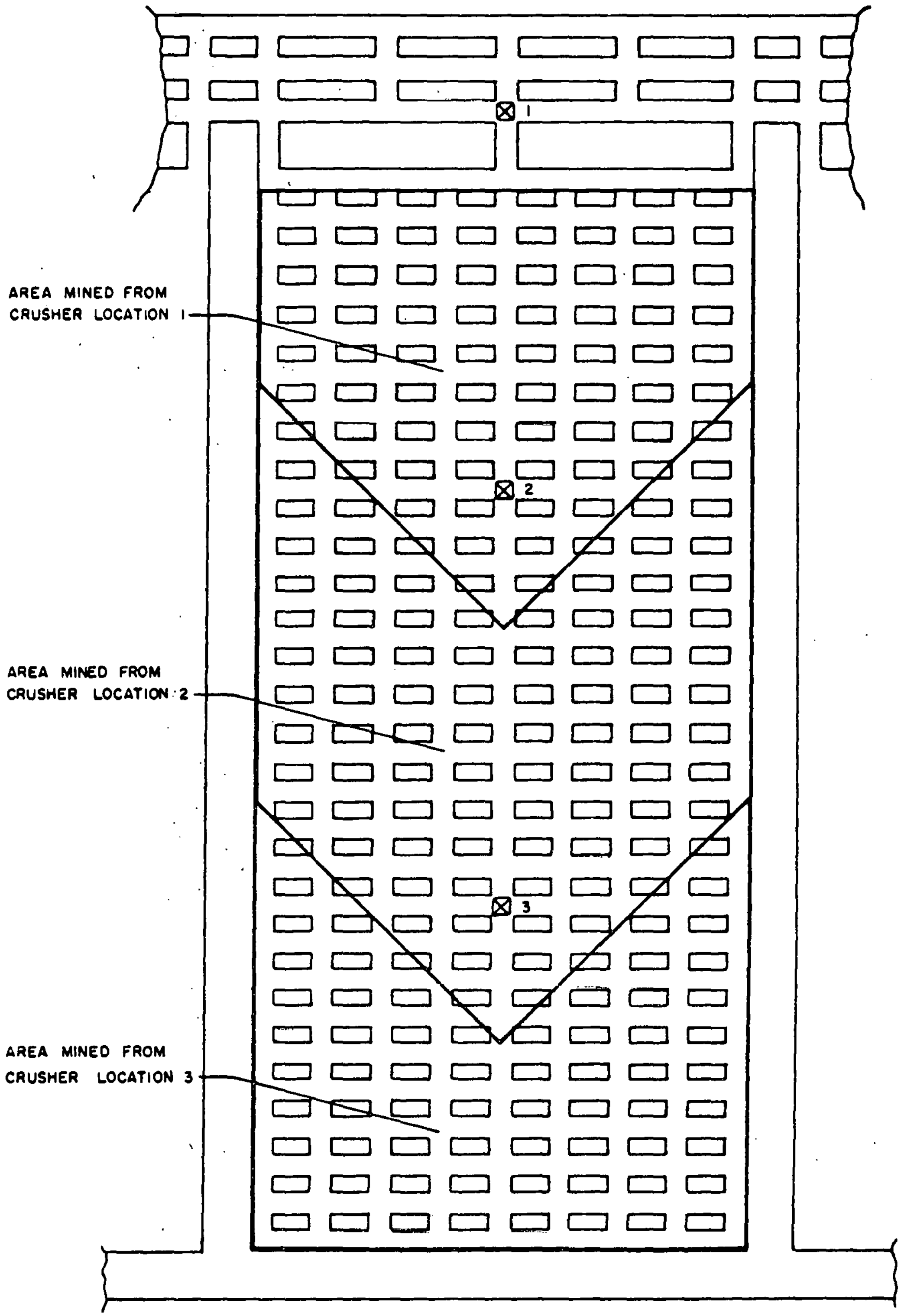


FIGURE A-6 CRUSHER POSITIONS DURING PANEL MINING row of panels has been mined. In a similar manner, development crews driving the main entries will be extending the main belt line as they advance.

MINE DRAINAGE

For safety and operational considerations during backfilling, mining will be down-dip. Consequently, there will be no natural drainage from the mine and all ground water inflow will have to be pumped from the lowest headings. The mine pumping system has been designed to handle an average inflow estimated at 5,000 gallons per minute over the entire mine.

Main Sump

A main sump will be located in the service area of the mine. The sump has been designed to hold the expected inflow during four hours, or 1.2 million gallons. A detail of the sump is shown in Figure A-7.

Water pumped from the lower areas of the mine will enter the sump through one of two settling ramps. The ramps are 32 feet wide, 250 feet long, and are 16 feet deep at the lower end. At the end of each ramp, clear water will flow over 15-foot-high weirs into a common pumping well. Periodically, each settling ramp will be closed and all material that has collected behind the weirs will be mucked out. During this cleaning process, water will be diverted to the other settling ramp.

The pumping well will be 16 feet deep, 32 feet wide, and 94 feet long. Water in the pumping well will be pumped to the surface through 14-inch-diameter pipe by a 500-horsepower main pump capable of handling 5,000 gallons per minute. It has been assumed that mine water will be of sufficient quality to permit stream discharge, and no facilities for water impoundment or treatment have been considered.

Auxiliary Sumps

Auxiliary sumps will be established throughout the mine to collect water from working areas for pumping to the main sump. Each panel will have its own sump, and development crews will construct temporary sumps in crosscuts on an "as needed" basis.

Panel sumps are designed to store the inflow during four hours, or 170,000 gallons. The sump will be located in a partially completed room near the front of the panel. During mining of the room that will ultimately become the panel sump, the last round will not be shot so that breakthrough to crosscut is not achieved. A six-inch-thick concrete wall will then be constructed across the open end of the room to a height of 15 feet. A portable 60-horsepower pump capable of handling 1,000 gallons per minute will be installed to pump water from the panel sump to the main sump through an eight-inch-diameter pipe.

Water will be pumped from the lowest headings in a panel to the panel sump by pumps carried on the face equipment. Drill jumbos and roof bolters will have five-horsepower pumps rated at 200 gpm mounted on their carriers. Upon entering a heading, workers will connect the face

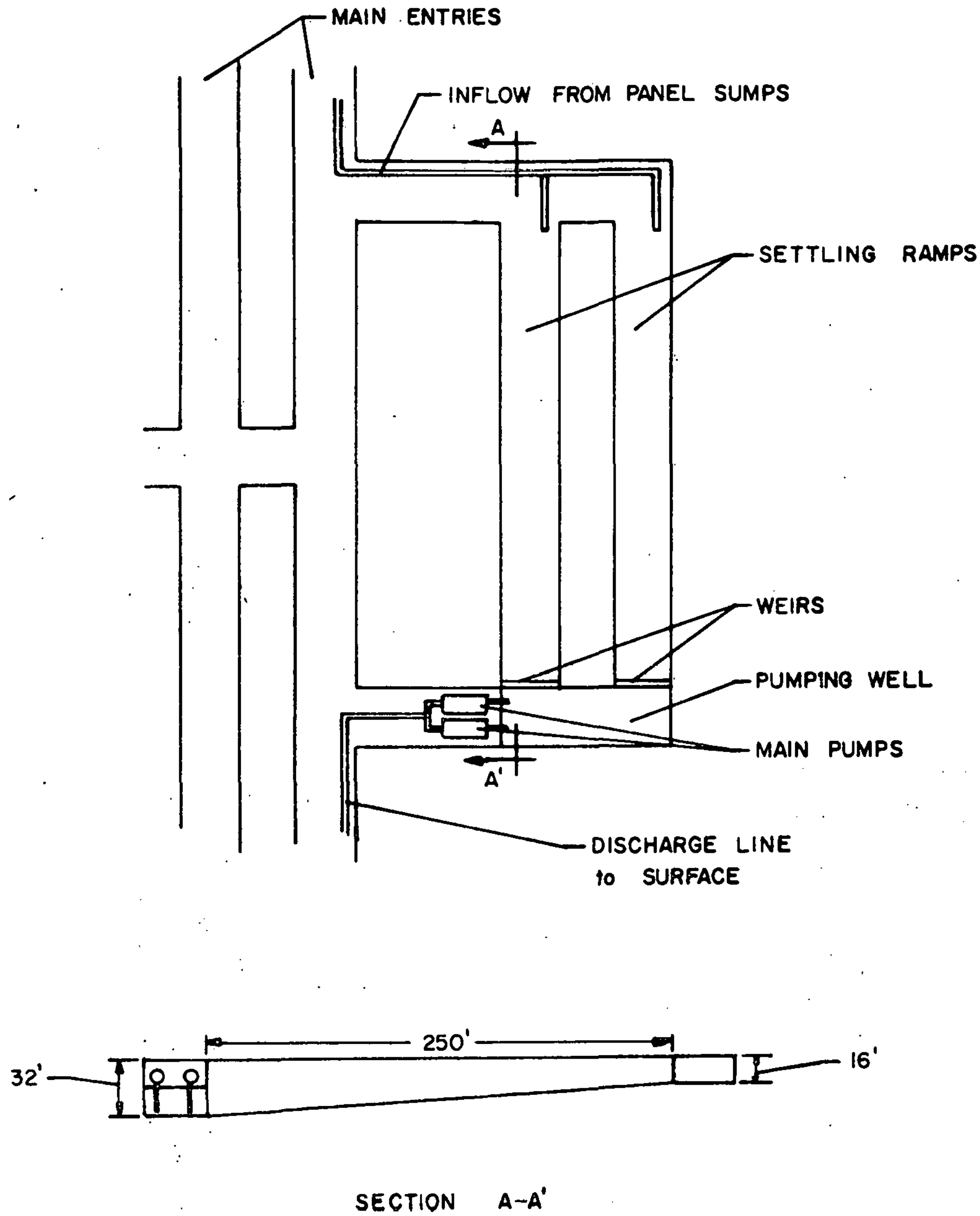


FIGURE A-7 MAIN SUMP DETAIL

pumps to a manifold system carrying water to the panel sump. Pumping time has been built into the cycle times for face drilling and roof bolting.

The panel manifold system will be roof mounted and will be advanced periodically. Special installation crews will maintain the system and will move it forward every fourth crosscut. The system will be constructed of four-inch-diameter pipe and will contain check valves to permit flow in the direction of the sump only. Figure A-8 depicts a typical drainage system, showing a panel sump and its associated manifold and piping.

Temporary sumps for the development crews will be constructed and maintained in the same manner as the panel sumps.

MINE VENTILATION

The mine ventilation system will be similar to a typical coal mine installation in that brattices, stoppings, overcasts, and auxiliary fans will be used to control and direct air flow to the various working areas.

Permanent brattices will be used to seal crosscuts along fresh and exhaust airways. These structures will be made of concrete block with a foam sealant between the brattice and the rock walls to minimize leakage. Some will have doors for foot travel while others will have larger doors for vehicular traffic.

Temporary stoppings will be constructed of brattice cloth held in place by timbers bolted to the rock walls. These will be installed as needed in the development headings by a special ventilation crew. Temporary brattices in the working panels will be constructed by closing off crosscuts with muck piles to be reclaimed upon panel completion.

Fixed opening regulators will be installed as needed in both permanent and temporary brattices to control volume of air apportioned for that particular work area.

Overcasts will be required near the working panels and at other locations in the mine where one air course must cross another. These will be of welded steel construction and will be installed by the ventilation crew.

Preproduction Ventilation

During the preproduction development phase of operations, all airflow to and from the working faces will be through the three surface adits. One adit will be sealed off from the others and an exhaust fan will be installed at the portal. The two remaining adits will be used for fresh air intake. The airflow pattern is shown in Figure A-9. Ventilation requirements during this period will be 400,000 cfm.

Once the first set of panel access entries has been driven to their intersection with the ventilation shafts, all mine air will be exhausted through the shafts. The exhaust fan will be removed from the portal and all three surface adits will be used as fresh air intake.

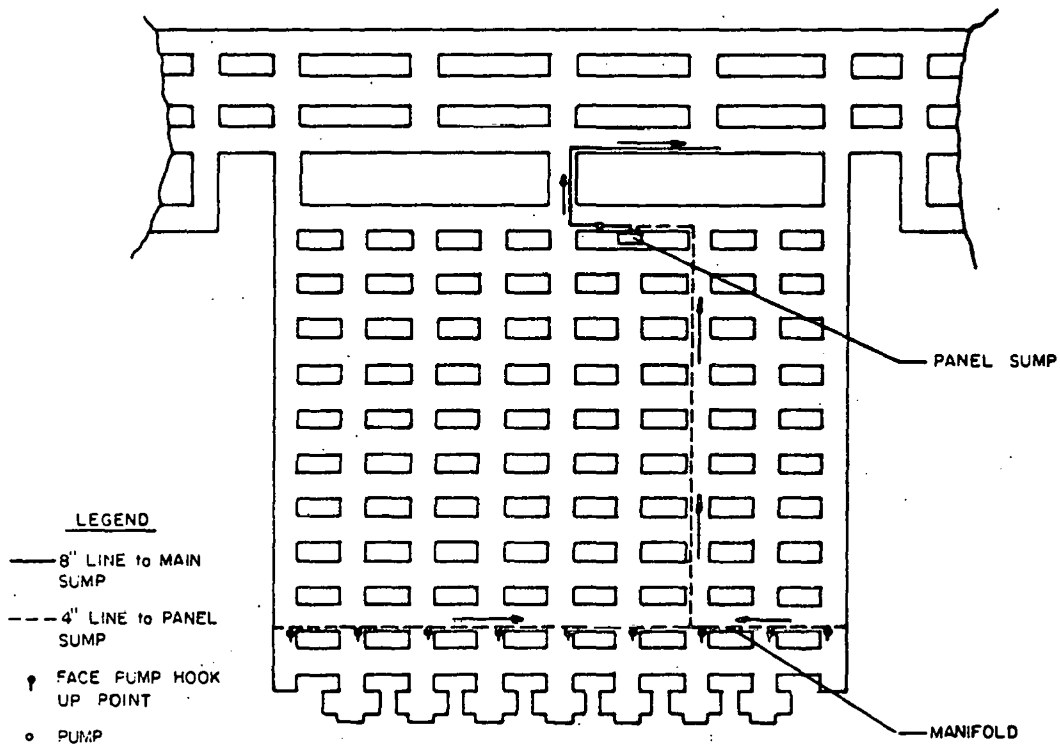


FIGURE A-8 TYPICAL PANEL PUMPING SYSTEM

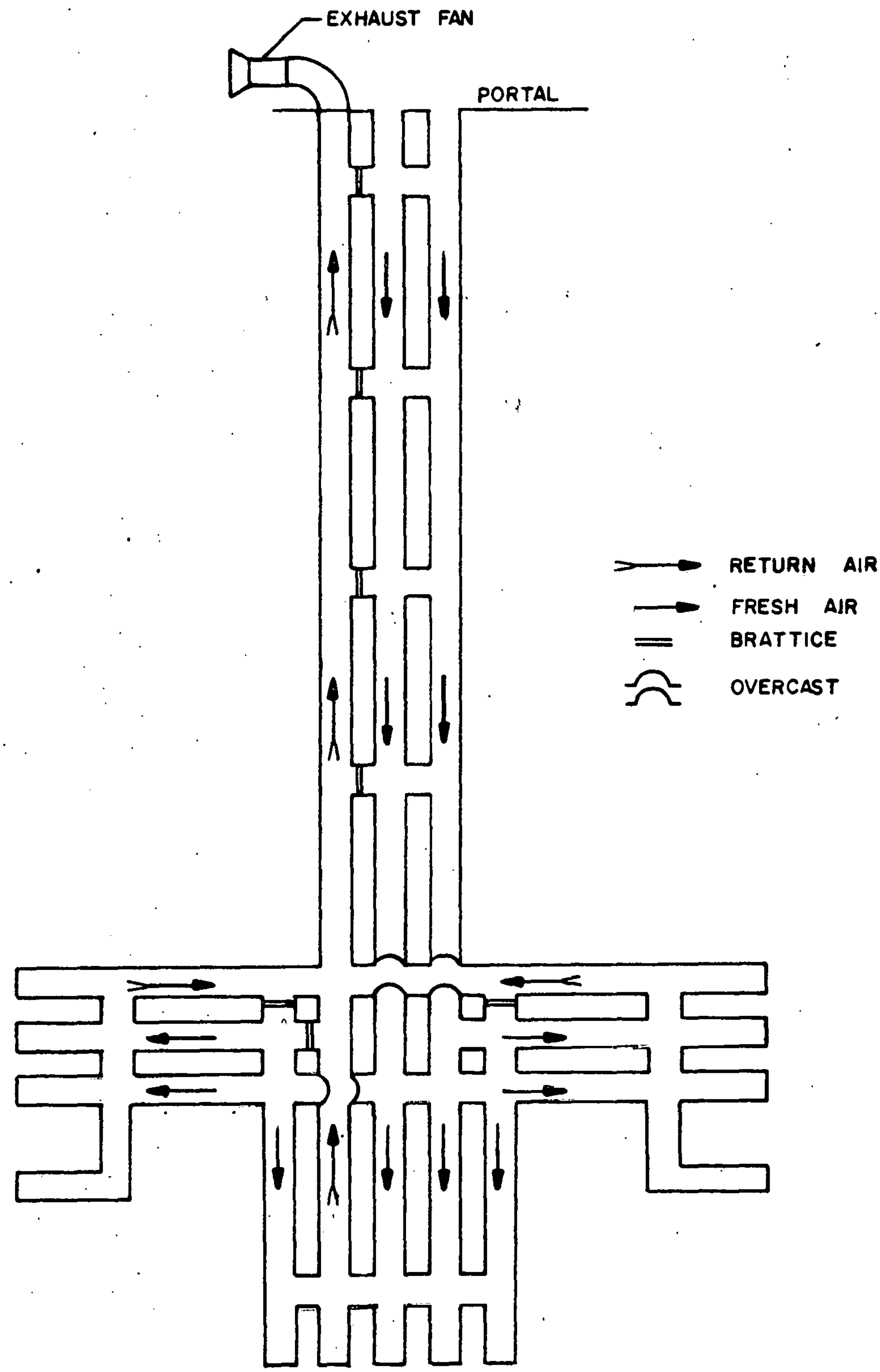


FIGURE A-9 PREPRODUCTION DEVELOPMENT VENTILATION PATTERN

Production Ventilation

In general, fresh air will be brought into the mine through the main entries, circulated through the working areas and exhausted through the bleeder entries and ventilation shafts. Splits of fresh air for the service area and development work areas will be controlled by regulators, but the bulk of the air will be required by the production mining crews.

Total ventilation requirements for the mine at full production will be 1.6 million cfm. Since mining activity will be equally divided between each side of the mine, ventilation requirements will also be equal and, consequently, each exhaust shaft has been sized to handle 800,000 cfm.

Each wing of working panels will require approximately 500,000 cfm. Two of the three panel access entries will carry fresh air into the wing while the third drift will carry exhaust air to the bleeder entries. The return air courses will also house the cross conveyor belts. Exhaust air from the working panels will be moved to the return air course via overcasts.

As splits of fresh air are taken into the panels and return air is exhausted, airway requirements will change. Between the second and third working panel in each wing, one fresh air course will be converted to return air so that the rest of the wing will be served by one fresh air entry and two exhaust entries, as depicted in Figure A-10.

Figure A-11 illustrates how a working panel will be ventilated. Fresh air will be brought into the panel through the two outer entries and exhausted through the central conveyor drift. Temporary brattices will direct fresh air to the last open crosscut before the mining faces where it will be swept toward the central drift by two auxiliary fans. Brattices will be constructed of muck and will be reclaimed upon panel completion. A full time crew operating one LHD unit and one small crawler dozer will be required for brattice construction throughout the mine.

The overcasts used to move panel exhaust air to the return air course will also house the panel conveyors as they carry muck to the crossbelts located in the return air course. The conveyors, normally supported by floor stands, will be roof mounted as they cross the fresh air courses in the overcasts. Overcasts will be of welded steel construction and sized large enough to carry the conveyor line without restricting airflow.

Development Ventilation

Each development crew will require approximately 85,000 cfm. The crew driving the main entries will require 110,000 cfm due to their use of an extra LHD unit. Air will be circulated generally as described in Figure A-12. In all cases the return air course will be that entry used for conveying.

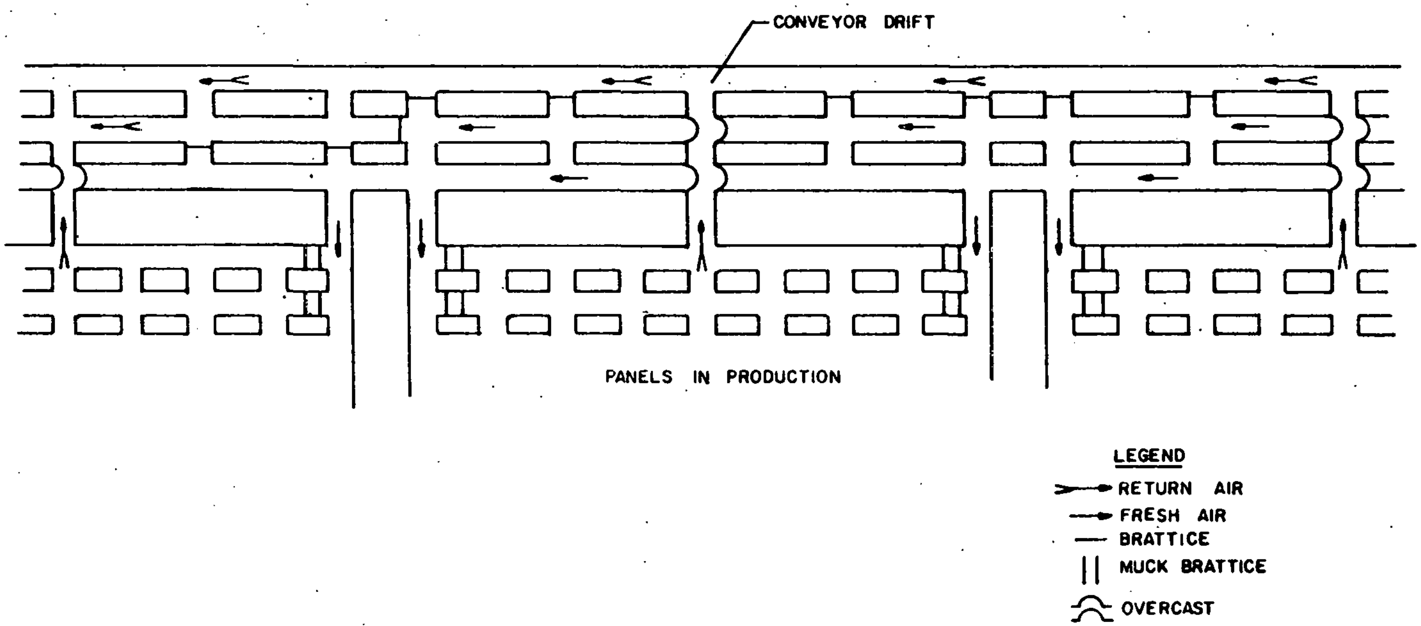


FIGURE A-10 PANEL ACCESS ENTRY VENTILATION PATTERN

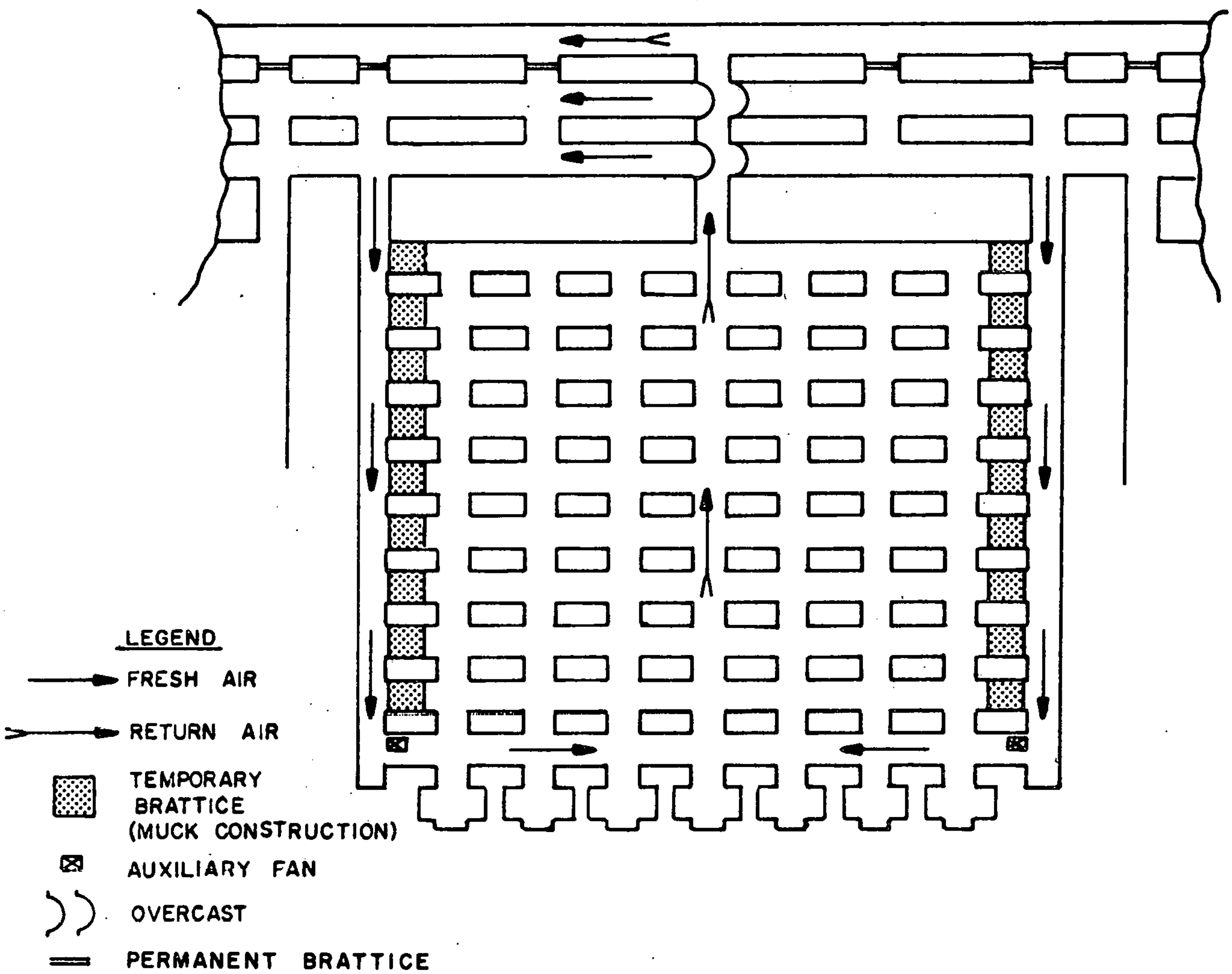


FIGURE A-11 PANEL VENTILATION PATTERN

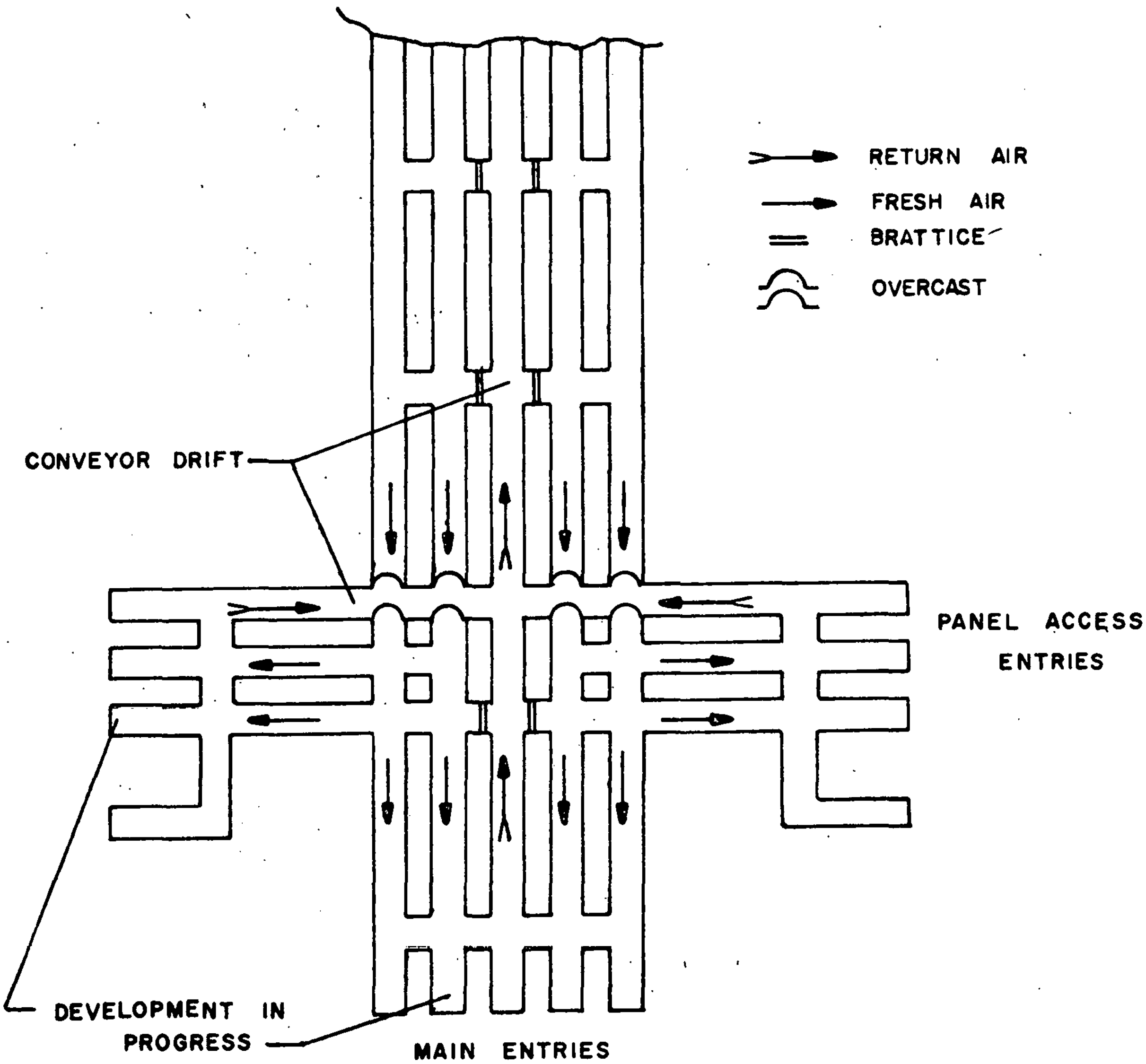


FIGURE A-12 DEVELOPMENT VENTILATION PATTERN

ANCILLARY OPERATION

This section describes the various support functions that must supplement the mining effort, thereby assuring an orderly continuance of the production activities.

Power Distribution

Electric power will be delivered to a permanent surface substation located near the portal of each mine. The substation will supply power to the underground mine as well as to surface units such as the exhaust fans. One 13.2 KV feeder line will supply all mine power requirements and will be run to a substation in the service area. From there, electrical power will be supplied to the rest of the mine at 4,160 volts. The main pumps and all conveyor and crusher drives will be operated at this voltage.

Portable power centers located in each panel will supply reduced voltages to the face equipment, auxiliary fans, lighting, etc. Power installation crews will extend feeder lines as each panel advances so that outlets can be kept within a reasonable distance from the face.

Conveyor Installation and Extension

Conveyor installation and maintenance will be performed by a special crew under the supervision of a conveyor leadman. As crusher advances are made, this crew will install or extend conveyor lines as needed. Special equipment envisioned for this crew includes a flatbed truck equipped with power-take-off to operate belt and cable winders and a small hoist for belt reel handling.

Maintenance

Achieving scheduled production will depend on maximum availability of mechanized equipment. Both preventive maintenance and emergency repair service will be provided underground.

Equipment breakdowns will be initially inspected by the maintenance field foreman and, if possible, repairs will be made on the spot by a mobile maintenance crew. If major repairs are warranted, the equipment will be moved to the underground shop for service and a spare machine will be put to work in its place.

The underground shop will be located in the service area of the mine. The shop will consist of a number of repair bays adequately sized to handle the largest units. The floor will be concreted throughout and the walls will be sprayed with a sealer that will provide a good light-reflective surface. The area will be adequately ventilated with its own split of fresh air. All preventive maintenance will be carried out in the shop.

Supply Handling

Underground Warehouse

All expendable supplies as well as replacement parts for machinery will be hauled into the mine on five-ton flatbed trucks and stored in a 100,000-square-foot warehouse located in the service area. Two-ton flatbed and one-ton pickup trucks will be used to distribute the supplies to the points of use.

Explosives Supply

The principal blasting agent will be ammonium nitrate and fuel oil (AN/FO). One day's supply will be taken underground in a specially built bulk carrier and parked in a magazine area located away from normal travel routes. AN/FO will be transported from the magazine area to the faces by the individual explosive loaders. Detonators will be stored in separate approved magazines and will be taken to the working areas as needed by specially equipped vehicles.

Water Supply

Raw water will be piped into the mine and stored in a tank located in the service area. Pipelines will supply water to dust suppression and fire control systems located at the crushers and along the conveyor belt lines. One 2,500-gallon tanker will supply water to drill jumbos and roof bolters in the working areas. Two 2,500-gallon tankers, one for either side of the mine, will be equipped with spray nozzles for muck pile and roadway wetting.

Potable water will be piped into the mine and supplied to the service area and to various points along the main entries.

MINING METHODS AND EQUIPMENT

FUNCTION DESCRIPTION

This section describes mining methods and machinery selected for use in the mining complex.

Face Drilling

All openings in the mine will be 32 feet wide by 16 feet high. Rounds are designed to advance headings 12 feet with each blast. A total of 430 tons of broken shale will be produced in each round.

A typical V-cut drill pattern has been developed and is shown in Figure A-13. The round will consist of 28 holes, each hole being two inches in diameter, with an average hole length of 13.2 feet.

The round will be drilled by an electric-hydraulic drill jumbo. The jumbo will be fitted for one-man operation and will be capable of drilling the entire round from a single setup. The jumbo will carry two hydraulic drills mounted on extendible booms equipped with hydraulic screw feeds. Drills will carry 16-foot drill steel allowing holes to be drilled in a single pass. Bit action will be percussion with independent rotation. Electric power for the hydraulic system will be supplied by power centers located near the face.

The jumbo will be mounted on a four-wheel, pneumatic-tired articulated undercarriage. Tramming power will be supplied by a 70-horse-power, air cooled diesel engine. The jumbo will be equipped with water and fuel tanks large enough to contain a full shift's requirements. In addition, the jumbo will carry a hydraulic-powered electric cable reel, drill and tram lights, compressor, and a small self-priming pump for heading dewatering.

Charging and Blasting

Following drilling, drill holes will be primed with a high strength primer and an electric blasting cap and will be pneumatically loaded with a mixture of ammonium nitrate and fuel oil (AN/FO). Approximately 280 pounds of AN/FO will be used per round, yielding a powder factor of .65 pounds per ton broken.

AN/FO prills will be blown into the holes via a hand-held lance connected to a pressure vessel. The explosives loader will be equipped to carry enough AN/FO to meet powder requirements for a complete shift.

The explosives loader will incorporate a diesel-powered undercarriage and will be equipped with a scissors-type elevating platform for charging the upper holes. Power for the air compressor and for operating the hydraulic system will be supplied by the carrier engine. Two setups will be required to charge each round. The explosives loader is designed for two-man operation. Blasting will be carried out during shift changes.

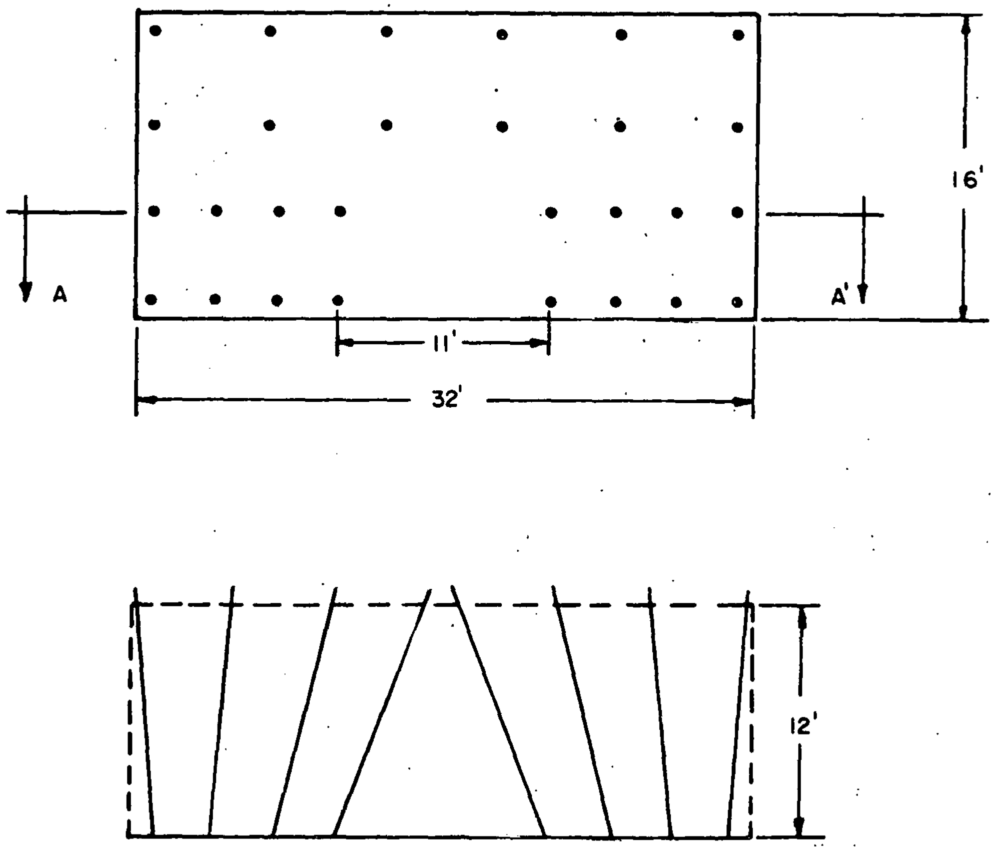


FIGURE A-13 TYPICAL DRILL PATTERN

Mucking

Mucking will be accomplished by eight-cubic-yard capacity load-haul-dump (LHD) units. The units will be powered by 225-horsepower air-cooled diesel engines. The vehicle frames will be articulated for maneuverability with four-wheel drive as standard. In this application, bucket capacity is rated at 7.56 tons. Holes will be placed in the bucket to allow water to drain from the muck. Maximum one-way haulage distance will be 800 feet with the average distance computed to be 500 feet.

Scaling

Upon completion of the mucking portion of the mining cycle, a mechanical scaling unit will be used to scale loose rock from the heading face, ribs, and roof, thus ensuring a safe working area. The scaling unit will be a modified backhoe equipped with a ripper tooth for raking and prying loose material from the mine walls and roof. The unit will be operated by one man. Loose material scattered in the area and against the face as a result of scaling will be cleaned up by an LHD unit prior to roof bolting.

Roof Bolting

Six-foot-long, point-anchor type roof bolts will be systematically installed in the mine back on an approximate five-foot grid pattern. Approximately 16 bolts per round will be required.

The roof bolting jumbo will be designed for one-man operation. It will be equipped with a basket-type elevating platform on which two hydraulic drills will be mounted. Electric power for the hydraulic system will be supplied at the face by a portable power center. Two setups will be required to completely bolt one heading.

The jumbo will be mounted on a rubber-tired carrier powered by a diesel engine. In addition, the jumbo will be equipped with drill and tram lights, a water tank for dust suppression, a hydraulic electric cable reel, and a small self-priming pump for heading dewatering.

Crushing and Conveying

LHD units will carry muck from the headings to a feeder-breaker located in the central drift of each panel. The feeder-breaker will operate continuously and will have a hopper capacity twice the size of an LHD bucket. A flight conveyor moving along the floor plate of the hopper will carry material to the breaker station. The rotary breaker will be equipped with replaceable carbide-tipped breaker picks and will be set to reduce the shale to 12-inch size. Broken material will then be fed onto a conveyor belt for transport to surface. The unit will be equipped with two 100-horsepower electric motors, one to drive the flight conveyor, and one for rotary breaker operation.

The mine conveyor system will transport ore from all working panels and development headings to the surface. It consists of one main adit conveyor, panel access crossbelts, and panel belts (Figure A-5). All conveyors will be supported on wire rope mounted on floor stands. All carrying idlers will be 20° equal-roll, heavy-duty troughing idlers installed on five-foot centers, and return idlers will be mounted on ten-foot spacings. Rope anchors will be installed every 300 feet to minimize sag in the belt line.

The main adit conveyor will carry ore from the mining zone to a point 200 feet beyond the portal for a total conveyor length of 1,200 feet.

It will be capable of carrying 2,200 tons per hour at a speed of 600 feet per minute. Belting will be 48 inches wide and will have a tension rating of 720 pounds per inch-width. Power will be supplied by twin 200-horsepower electric motors. Head and drive pulleys will be lagged with 1/2-inch thick herringbone-grooved rubber. An automatic hydraulic take-up unit will be installed just behind the drive assembly. All splices on this belt will be vulcanized.

Main-line conveyors will be installed in the central drift of the main entry system. They will collect material from the crossbelts and transport it to the main adit conveyor. They will be installed as the main entries are developed and each will be approximately 1,950 feet long, the distance between panel access entries. Belting will be 48 inches wide and will carry a tension rating of 720 pounds per inch-width. Twin 100-horse-power electric motors will be required to drive the belt. The head and drive pulleys will be lagged with 1/2-inch herringbone-grooved rubber.

The crossbelts, located in the panel access entries, will collect material from the panel belts and carry it to the main-line conveyors. They will be capable of handling 1,100 tons per hour at 300 feet per minute. Belting will be 36 inches wide with a tension rating of 540 pounds per inch-width. A single 100-horsepower motor will be required to drive the belt. Again, head and drive pulleys will be lagged as described before. Splices will be mechanical hinge-pin type to facilitate belt reclamation.

Maximum length of the crossbelts will be held to 1,960 feet for each unit, providing some degree of standardization for the conveying system. Four such belts will be required to serve each wing of the mine. They will be installed as the panel access entries are developed and will be left in place until that wing of panels has been completely mined. Impact idlers, skirt boards, and other loading-point equipment will be built into the line as it is installed at those points where panel belts will ultimately discharge ore onto the crossbelts.

The panel belts will carry shale from the feeder-breakers to the crossbelts. At the initial crusher location (Figure A-6), the belts will be short but, as the crusher advances into the panel, the belts will be extended incrementally to a maximum length of 1,200 feet. They will be designed to carry 700 tons per hour at 200 feet per minute. Belting will be 36 inches wide and will have a maximum tension rating of 540 pounds per inch-width. Splices will be mechanical hinge-pin type so as to facilitate installation and removal of belting. The lagged head pulley will be driven by a 75-horsepower electric motor.

EQUIPMENT CYCLE TIMES

In order to accurately predict equipment requirements and productivity, theoretical cycle times have been computed. These estimates of machine performance cover the five basic constituents of the mining cycle, that is, drilling, charging, mucking, scaling, and roof bolting. The elemental times assigned each component of the cycle are based on The Cleveland-Cliffs Iron Company's experience and observations in similar operations.

Drilling

A.	Drilling		
	1. Position boom and collar hole	1.8 Min.	
	2. Drill @ 5 FPM	2.6 "	
	3. Retract drill and purge hole	0.6 "	
	4. Total time per hole	5.0 Min.	
	5. Total drilling time per round (28 holes x 5 min/hole ÷ 1.9*)		74 Min.
B.	Place change		3 Min.
C.	Prepare to drill (mark face, connect electrical cable, etc.)		20 "
D.	Bit change (one per round assumed)		5 "
E.	Tear down and move out		10 "
F.	Service jumbo (30 minutes per shift prorated)		10 "
G.	Miscellaneous delays (45 minutes per shift prorated)		16 "
	Theoretical cycle time		138 Min.
	Efficiency factor (18%)		25 "
	Dewatering factor (20%)		28 "
	Total drilling time		191 Min.

* Adjustment factor for one-man operation of two drills (= 2 men and 0.95 interference factor)

Charging

A.	Charging		
	1. Move to each hole	0.6 Min.	
	2. Make primer	0.4 "	
	3. Insert primer and charge hole	0.8 "	
	4. Tie in leg wires	0.5 "	
	5. Total time per hole	2.3 Min.	
	6. Total charging time per round (28 holes x 2.3 min/hole ÷ 1.9**)		34 Min.

** Adjustment factor for interference between the two operators (= 2 men and 0.95 interference factor)

B.	Place change	3 Min.
C.	Prepare to charge	5 Min.
D.	Tie in round	2 Min.
E.	Tear down and move out (two per round)	10 "
F.	Stock explosives (20 minutes per shift prorated)	3 "
G.	Service explosives loader (ten minutes per shift prorated)	2 "
H.	Delays (45 minutes per shift prorated)	7 "
	Theoretical cycle time	66 Min.
	Efficiency factor (18%)	12 "
	Total charging time	78 Min.

Mucking

A. For the average haul distance of 500 feet (one way), the cycle time is:

1.	Doze muckpile	0.09 Min.
2.	Fill bucket	0.16 "
3.	Back and turn (two per cycle)	0.39 "
4.	Dump bucket	0.08 "
5.	Haul (4.5 MPH)	1.26 "
6.	Return (5 MPH)	1.14 "
7.	Service LHD unit (15 minutes per shift prorated)	0.16 "
8.	Miscellaneous delays (30 minutes per shift prorated)	0.32 "
	Theoretical cycle time	3.60 Min.
	Efficiency factor (18%)	0.65 "
	Actual cycle time	4.25 Min.

B. Bucket capacity is computed to be 7.56 tons.

Total mucking time per round (430 tons per round ÷ 7.56 tons per cycle x 4.25 minutes per cycle)	242 Min.

Scaling

A.	Scaling (1,280 square feet per round ÷ 55 square feet per minute)	23 Min.
B.	Place change	3 "
C.	Tear down and move out	3 "
D.	Service scaler (10 minutes per shift prorated)	1 "

E.	Miscellaneous delays (45 minutes per shift prorated)	4 "
	Theoretical cycle time	34 Min.
	Efficiency factor (18%)	6 "
	Total scaling time	40 Min.

Roof Bolting

A. Bolting

1.	Spot platform	1.5 Min.	
2.	Collar and drill hole	3.5 "	
3.	Retract drill	0.3 "	
4.	Insert bolt and tighten	1.1 "	
5.	Total time per bolt	6.4 Min.	
6.	Total bolting time per round (16 bolts per round x 6.4 minutes per bolt ÷ 1.5*)		68 Min.

B.	Place change	3 "
C.	Prepare for bolting (connect electrical cable, etc.)	21 "
D.	Tear down and move out (two per round)	8 "
E.	Service rig (30 minutes per shift prorated)	9 "
F.	Miscellaneous delays (45 minutes per shift prorated)	14 "
	Theoretical cycle time	123 Min.
	Efficiency factor (18%)	22 "
	Dewatering factor (20%)	25 "
	Total roof bolting time	170 Min.

* Adjustment factor for one-man operation of two drills.

PRODUCTIVE WORK TIME

Equipment productivity is dependent on productive working time per shift. Each shift will be eight hours long, portal to portal. Reductions in possible working time per shift are estimated as follows:

A.	Travel to work station	10 Min.
B.	Lunch	30 "
C.	Personal	15 "
D.	Supervision	15 "
E.	Travel to surface	10 "
	Total nonproductive time	80 Min.

Allowing for nonproductive time, a total of 400 minutes per shift is available for productive activities. Equipment productivity, as well as operating and maintenance costs, are based on this figure.

EQUIPMENT REQUIREMENTS

Production

Each working panel is designed for unit operation. That is, machinery and production miners will not shuttle between panels but, instead, will be assigned to a particular panel throughout its operational life.

The mining rate is determined by the face drills. All other production equipment requirements are sized to support a given number of drill jumbos operating at a specified rate. In the section on drilling under "Equipment Cycle Times," it was determined that one jumbo can drill one round in 191 minutes. In the section entitled "Productive Work Times," it was shown that productive work time during one shift is 400 minutes. Consequently, one jumbo can drill 2.1 rounds per shift. Two drill jumbos will be assigned to each panel and will produce at a rate of 4.2 rounds per shift.

Requirements for all other panel mining equipment are geared toward maintaining a production rate of 4.2 rounds per shift per panel. A complete complement of mining equipment for one panel will consist of :

- 2 - Drill Jumbos
- 1 - Explosives Loader
- 3 - LHD Units
- 1 - Scaler
- 2 - Roof Bolters

A total of six panels will be mined concurrently. Equipment requirements for the entire mine are listed in Table A-3.

Development

Due to the limited number of working faces available to development crews, productivity will be lower than that achieved by panel mining crews. In the main entries, two rounds per shift will be completed. One round per shift will be the advance rate in the bleeder entries, while 1.5 rounds per shift will be accomplished in the panel access entries.

Three drill jumbos will be assigned to full time development work. Each jumbo will be supported by an equipment ensemble consisting of one explosives loader, one LHD unit, one scaler, and one roof bolter. The development crew driving the main entries will require an additional LHD unit. Total development equipment needs are shown in Table A-3.

Ancillary Equipment

In addition to mobile mining equipment, a large fleet of service and supply vehicles will be a requisite for the orderly continuance of production and development activities. Such requirements include water trucks, supervisors' pickup trucks, field maintenance trucks, personnel carriers, and so on. Ancillary equipment requirements are detailed in Table A-3.

CAPITAL EXPENDITURE DETAIL

Capital requirements are shown in Tables A-4 and A-5. Table A-4 details preproduction capital and development costs, while Table A-5 lists capital expenditures for the full-production portion of the mine's life. (The mine is scheduled to reach full capacity in the second half of year +1.) Costs are presented for a single mine with the understanding that total costs for the mine complex will be triple those of the single case. Costs are listed in December 1977 dollars.

VENTILATION REQUIREMENTS

The amount of fresh air that must be circulated through the mine is a function of the total diesel horsepower operating underground. The number of required machines and their associated horsepower ratings are given in Table A-6. Generally, 100 cfm is supplied for every horsepower except in the case of the LHD units which require 25,000 cfm each. At full production, a total of 1,554,800 cfm will be required. The mine ventilation system has been sized to circulate 1.6 million cfm.

TABLE A-3. EQUIPMENT REQUIREMENTS - ONE MINE [a]

EQUIPMENT	AVAILABILITY FACTOR	NUMBER OF UNITS REQUIRED Production	Development	Spares	TOTAL
Drill Jumbo	.75	12	3	5	20
Explosives Loader	.75	6	3	3	12
LHD Unit (8-Yard)	.55	18	4	18	40
Scaler	.65	6	3	5	14
Roof Bolter	.75	12	3	5	20
5-Yard Loader					2
Crawler Dozer					2
Water Truck (2,500 Gal.)					4
Fuel Truck (1,500 Gal.)					3
Supply Truck (5 Ton)					2
Supply Truck (2 Ton)					3
Utility Truck (2 Ton)					3
AN/FO Trailer					2
Supply Pickup (1 Ton)					3
Supervisor Pickup					30

TABLE A-3. EQUIPMENT REQUIREMENTS - (Continued)

EQUIPMENT	AVAILABILITY FACTOR	NUMBER OF UNITS REQUIRED Production	Development	Spares	TOTAL
Reel and Winch Truck					1
Elevating Platform					4
Lube Truck					3
Maintenance Truck					3
Motor Grader					2
Personnel Carriers (15 Man)					9
Personnel Carriers (8 Man)					4
Ambulance					2

[a] Total equipment requirements for the mine complex will be triple those for one mine.

TABLE A-4. PREPRODUCTION CAPITAL COST DETAIL - ONE MINE

	UNIT COST	LIFE IN YEARS	-3	-2	-1	+1	TOTAL PREPRODUCTION
I. MOBILE EQUIPMENT							
Drill Jumbo	$207,000	8.0	414,000	414,000	207,000	3,105,000	$ 4,140,000
Explosives Loader	61,800	9.3	123,600	123,600	-	494,400	741,600
LHD Unit	145,000	4.1	435,000	435,000	290,000	4,640,000	5,800,000
Scaler	71,200	10.6	142,400	142,400	-	712,000	996,800
Roof Bolter	119,000	6.0	238,000	238,000	119,000	1,785,000	2,380,000
5-Yard Loader	129,800	8.0	-	-	-	129,800	129,800
Crawler Dozer	184,300	6.0	-	-	-	184,300	184,300
Water Truck (2,500 Gal.)	55,280	6.0	55,280	55,280	-	110,560	221,120
Fuel Truck (1,500 Gal.)	38,500	6.0	38,500	38,500	-	38,500	115,500
Supply Truck (5 Ton)	20,910	4.0	-	-	20,910	20,910	41,820
Supply Truck (2 Ton)	19,330	4.0	19,330	38,660	-	-	57,990
Supply Pickup (1 Ton)	17,910	4.0	17,910	17,910	17,910	-	53,730
Utility Truck (2 Ton)	19,330	4.0	-	19,330	19,330	19,330	57,990
AN/FO Trailer	21,260	10.0	-	21,260	-	21,260	42,520
Reel & Winch Truck	27,000	4.0	-	27,000	-	-	27,000
Elevating Platform	39,900	5.0	39,900	39,900	79,800	-	159,600
Lube Truck	41,000	4.0	41,000	-	41,000	41,000	123,000
Maintenance Truck	14,600	4.0	14,600	-	14,600	14,600	43,800
Motor Grader	62,770	6.0	62,770	-	-	62,770	125,540
Supervisor's Pickup	10,500	4.0	63,000	84,000	84,000	84,000	315,000
Personnel Carrier (15 Man)	32,880	10.0	-	-	65,760	230,160	295,920
Personnel Carrier (8 Man)	24,500	10.0	49,000	49,000	-	-	98,000
Ambulance	18,550	10.0	18,550	-	-	18,550	37,100
Subtotal			1,772,840	1,743,840	958,310	11,712,140	16,188,130
II. CRUSHING AND CONVEYING			200,000	1,625,000	1,205,000	2,645,000	5,675,000
III. VENTILATION			14,000	99,000	290,000	112,000	515,000
IV. SPARE PARTS			-	-	341,980	594,930	936,910
V. SHOP & WAREHOUSE			-	-	1,272,000	2,406,000	3,678,000
VI. ELECTRICAL			28,000	65,000	231,100	25,000	349,100
VII. MISCELLANEOUS							
Fueling Station			-	-	100,000	25,000	125,000
Mine Dewatering			18,875	54,715	154,026	215,585	443,200
Raw & Potable Water			-	-	22,000	-	22,000
Safety Equipment			3,000	10,000	10,000	12,600	35,600
Cap Lamps			5,000	10,000	10,640	-	25,640
Subtotal			268,875	1,863,715	3,636,745	6,036,115	11,805,450
VIII. DEVELOPMENT							
Ventilation Shafts			-	-	500,000	-	500,000
Preproduction Mining			325,200	5,902,600	4,606,200	-	10,834,000
Subtotal			325,200	5,902,600	5,106,200	-	11,334,000
GRAND TOTAL			2,366,915	9,510,155	9,702,255	17,748,255	$39,327,580

TABLE A-5. PRODUCTION CAPITAL COST DETAIL - ONE MINE

		UNIT COST	LIFE IN YEARS	+2	+3	+4	+5	+6	+7	+8	+9	+10	SUBTOTAL YEARS 2-10
I.	MOBILE EQUIPMENT												
	Drill Jumbo	$207,000	8.0	-	-	-	-	414,000	414,000	207,000	3,105,000	-	$ 4,140,000
	Explosives Loader	61,800	9.3	-	-	-	-	-	123,600	123,600	-	494,400	741,600
	LHD Unit	145,000	4.1	435,000	435,000	290,000	4,640,000	435,000	435,000	290,000	4,640,000	435,000	12,035,000
	Scaler	71,200	10.6	-	-	-	-	-	-	142,400	142,400	-	284,800
	Roof Bolter	119,000	6.0	-	-	238,000	238,000	119,000	1,785,000	-	-	238,000	2,618,000
	5-Yard Loader	129,800	8.0	129,800	-	-	-	-	-	-	129,800	129,800	389,400
	Crawler Dozer	184,300	6.0	184,300	-	-	-	-	184,300	184,300	-	-	552,900
	Water Truck (2,500 Gal.)	55,280	6.0	-	-	55,280	55,280	-	110,560	-	-	55,280	276,400
	Fuel Truck (1,500 Gal.)	38,500	6.0	-	-	38,500	38,500	-	38,500	-	-	38,500	154,000
	Supply Truck (5 Ton)	20,910	4.0	-	-	20,910	20,910	-	-	20,910	20,910	-	83,640
	Supply Truck (2 Ton)	19,330	4.0	19,330	38,660	-	-	19,330	38,660	-	-	19,330	135,310
	Supply Pickup (1 Ton)	17,910	4.0	17,910	17,910	17,910	-	17,910	17,910	17,910	-	17,910	125,370
	Utility Truck (2 Ton)	19,330	4.0	-	19,330	19,330	19,330	-	19,330	19,330	19,330	-	115,980
	AN/FO Trailer	21,260	10.0	-	-	-	-	-	-	-	21,260	-	21,260
	Reel & Winch Truck	27,000	4.0	-	27,000	-	-	-	27,000	-	-	-	54,000
	Elevating Platform	39,900	5.0	-	39,900	39,900	79,800	-	-	39,900	39,900	79,800	319,200
	Lube Truck	41,000	4.0	41,000	-	41,000	41,000	41,000	-	41,000	41,000	41,000	287,000
	Maintenance Truck	14,600	4.0	14,600	-	14,600	14,600	14,600	-	14,600	14,600	14,600	102,200
	Motor Grader	62,770	6.0	-	-	62,770	-	-	62,770	-	-	62,770	188,310
	Supervisor's Pickup	10,500	4.0	63,000	84,000	84,000	84,000	63,000	84,000	84,000	84,000	63,000	693,000
	Personnel Carrier (15 Man)	32,880	10.0	-	-	-	-	-	-	-	-	65,760	65,760
	Personnel Carrier (8 Man)	24,500	10.0	-	-	-	-	-	-	49,000	49,000	-	98,000
	Ambulance	18,550	10.0	-	-	-	-	-	-	18,550	-	-	18,550
	Subtotal			904,940	661,800	922,200	5,231,420	1,123,840	3,340,630	1,252,500	8,307,200	1,755,150	23,499,680
II.	CRUSHING AND CONVEYING			1,585,000	-	325,000	-	325,000	-	525,000	200,000	325,000	3,285,000
III.	VENTILATION			-	-	-	-	-	-	14,000	7,000	14,000	35,000
IV.	SPARE PARTS			1,726,545	956,460	-	248,790	-	-	136,045	-	-	3,067,840
V.	SHOP & WAREHOUSE			-	-	-	-	121,000	-	-	-	-	121,000
VI.	ELECTRICAL			4,750	9,750	4,750	9,750	4,750	9,750	4,750	9,750	4,750	62,750
VII.	MISCELLANEOUS												
	Fueling Station			-	-	-	5,000	-	-	-	-	5,000	10,000
	Mine Dewatering			-	-	18,875	54,715	38,205	215,585	-	-	18,875	346,255
	Raw & Potable Water			-	-	-	-	-	-	-	-	-	-
	Safety Equipment			5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	46,800
	Cap Lamps			-	5,100	-	-	5,100	-	-	15,440	-	25,640
	Subtotal			3,321,495	976,510	353,825	323,455	499,255	230,535	684,995	237,390	372,825	7,000,285
VIII.	DEVELOPMENT												
	Ventilation Shafts			-	-	-	-	-	-	-	-	-	-
	Preproduction Mining			-	-	-	-	-	-	-	-	-	-
	Subtotal			-	-	-	-	-	-	-	-	-	-
	GRAND TOTAL			4,226,435	1,638,310	1,276,025	5,554,875	1,623,095	3,571,165	1,937,495	8,544,590	2,127,975	$30,499,965

TABLE A-5. PRODUCTION CAPITAL COST DETAIL - ONE MINE (Continued)

	+11	+12	+13	+14	+15	+ 16	+17	+18	+19	+20	SUBTOTAL YEARS 11-20	GRAND TOTAL ONE MINE
I. MOBILE EQUIPMENT												
Drill Jumbo	$ -	-	-	414,000	414,000	207,000	3,105,000	-	-	-	$ 4,140,000	$ 12,420,000
Explosives Loader	-	-	-	-	-	123,600	123,600	-	494,400	-	741,600	2,224,800
LHD Unit	435,000	290,000	4,640,000	435,000	435,000	290,000	4,640,000	435,000	435,000	290,000	12,325,000	30,160,000
Scaler	712,000	-	-	-	-	-	-	142,400	142,400	-	996,800	2,278,400
Roof Bolter	238,000	119,000	1,785,000	-	-	238,000	238,000	119,000	1,785,000	-	4,522,000	9,520,000
5-Yard Loader	-	-	-	-	-	-	129,800	129,800	-	-	259,600	778,800
Crawler Dozer	-	-	184,300	184,300	-	-	-	-	184,300	184,300	737,200	1,474,400
Water Truck (2,500 Gal.)	55,280	-	110,560	-	-	55,280	55,280	-	110,560	-	386,960	884,480
Fuel Truck (1,500 Gal.)	38,500	-	38,500	-	-	38,500	38,500	-	38,500	-	192,500	462,000
Supply Truck (5 Ton)	-	20,910	20,910	-	-	20,910	20,910	-	-	20,910	104,550	230,010
Supply Truck (2 Ton)	38,660	-	-	19,330	38,660	-	-	19,330	38,660	-	154,640	347,940
Supply Pickup (1 Ton)	17,910	17,910	-	17,910	17,910	17,910	-	17,910	17,910	17,910	143,280	322,380
Utility Truck (2 Ton)	19,330	19,330	19,330	-	19,330	19,330	19,330	-	19,330	19,330	154,640	328,610
AN/FO Trailer	21,260	-	-	-	-	-	-	-	21,260	-	45,520	106,300
Reel & Winch Truck	27,000	-	-	-	27,000	-	-	-	27,000	-	81,000	162,000
Elevating Platform	-	-	39,900	39,900	79,800	-	-	39,900	39,900	79,800	319,200	798,000
Lube Truck	-	41,000	41,000	41,000	-	41,000	41,000	41,000	-	41,000	287,000	697,000
Maintenance Truck	-	14,600	14,600	14,600	-	14,600	14,600	14,600	-	14,600	102,200	248,200
Motor Grader	-	-	62,770	-	-	62,770	-	-	62,770	-	188,310	502,160
Supervisor's Pickup	84,000	84,000	84,000	63,000	84,000	84,000	84,000	63,000	84,000	84,000	798,000	1,806,000
Personnel Carrier (15 Man)	230,160	-	-	-	-	-	-	-	-	65,760	295,920	657,600
Personnel Carrier (8 Man)	-	-	-	-	-	-	-	49,000	49,000	-	98,000	294,000
Ambulance	18,550	-	-	-	-	-	-	18,550	-	-	37,100	92,750
Subtotal	1,935,650	606,750	7,040,870	1,229,040	1,115,700	1,212,900	8,510,020	1,089,490	3,549,990	817,610	27,108,020	66,795,830
II. CRUSHING AND CONVEYING	600,000	425,000	-	325,000	-	325,000	-	200,000	200,000	-	2,075,000	11,035,000
III. VENTILATION	112,000	-	-	-	-	-	-	14,000	7,000	14,000	147,000	697,000
IV. SPARE PARTS	-	77,800	-	-	-	77,800	-	-	-	-	155,600	4,160,350
V. SHOP & WAREHOUSE	121,000	-	-	-	-	121,000	-	-	-	-	242,000	4,041,000
VI. ELECTRICAL	9,750	4,750	9,750	4,750	9,750	4,750	9,750	4,750	9,750	4,750	72,500	484,350
VII. MISCELLANEOUS												
Fueling Station	-	-	-	-	5,000	-	-	-	-	-	5,000	140,000
Mine Dewatering	54,715	38,205	215,585	-	-	18,875	54,715	38,205	215,585	-	635,885	1,425,340
Raw & Potable Water	-	-	-	-	-	-	-	-	-	-	-	22,000
Safety Equipment	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	52,000	134,400
Cap Lamps	-	5,100	-	-	5,100	-	-	5,100	-	-	15,300	66,580
Subtotal	902,665	556,055	230,535	334,950	25,050	552,625	69,665	267,255	437,535	23,950	3,400,285	22,206,020
VIII. DEVELOPMENT												
Ventilation Shafts	-	-	-	-	-	-	-	-	-	-	-	500,000
Preproduction Mining	-	-	-	-	-	-	-	-	-	-	-	10,834,000
Subtotal	-	-	-	-	-	-	-	-	-	-	-	11,334,000
GRAND TOTAL	$2,838,315	1,162,805	7,271,405	1,563,990	1,140,750	1,765,525	8,579,685	1,356,745	3,987,525	841,560	$30,508,305	$100,335,850

TABLE A-6. MINE VENTILATION REQUIREMENTS

MACHINE	HORSEPOWER PER UNIT	UNITS OPERATING	TOTAL HORSEPOWER
A.			
1. Drill Jumbo	75	15	1,125
2. Explosives Loader	69	9	621
3. Scaler	66	9	594
4. Roof Bolter	75	15	1,125
5. 5-Yard Loader	260	1	260
6. Crawler Dozer	105	1	105
7. Water Truck	200	3	600
8. Fuel Truck	160	2	320
9. Supply Truck (5 Ton)	250	1	250
10. Supply Truck (2 Ton)	150	2	300
11. Supply Pickup (1 Ton)	150	2	300
12. Utility Truck (2 Ton)	150	3	450
13. Reel & Winch Truck	200	1	200
14. Elevating Platform	45	4	180
15. Supervisor's Pickup	150	20	3,000
16. Lube Truck	69	2	138
17. Maintenance Truck	150	2	300
18. Motor Grader	180	1	180
TOTAL			10,048 HP

B. LHD Requirements: 22 LHD's operating x 25,000 cfm[a] = 550,000 cfm.

C. Total Ventilation Requirements:

1.	LHD's	550,000 cfm
2.	10,048 HP x 100 cfm per HP	1,004,800
3.	Total	1,554,800 cfm

[a] USBM Standard

OPERATING AND MAINTENANCE COSTS

GENERAL

This section details anticipated operating and maintenance costs for a single mine. Costs have been developed on a weekly basis assuming 20 operating shifts per week. Average weekly production from one mine is computed to be 242,463 tons. The section entitled "Operating and Maintenance Cost Detail" presents a detailed description of cost computation methods and the section entitled "Manpower Requirements" lists wage rates and manpower requirements used in cost development.

Total weekly expenses are presented here for one mine and must be tripled to reflect those expected for the mine complex. However, unit costs per ton, although developed from data generated for the single case, are applicable to production from the entire mine complex. Table A-7 summarizes operating and maintenance costs for mining one ton of ore.

OPERATING AND MAINTENANCE COSTS DETAIL

The various mining and support functions have been broken down into separate cost centers for analysis. These have been further divided into four component parts, namely, operating labor, operating supplies, maintenance labor, and maintenance supplies.

Capital requirements listed in Tables A-4 and A-5 are not included as part of these costs. Backfilling costs have been considered separately and are summarized in a separate section of this report.

TABLE A-7. OPERATING AND MAINTENANCE COST SUMMARY (Dollars Per Ton) [a]

	OPERATING		MAINTENANCE		
Cost Center	Labor	Supplies	Labor	Supplies	TOTAL
Drilling	$.0938	$.0937	$.0199	$.0108	$.2182
Charging & Blasting	.0766	.1546	.0038	.0032	.2382
Mucking	.1189	.1217	.1207	.1072	.4685
Scaling	.0197	.0037	.0087	.0142	.0463
Roof Bolting	.0835	.1284	.0090	.0097	.2306
Primary Crushing & Conveying (Year 10)	.0253	.1072	.1040	.0530	.2895
Conveyor Installation	.0099	.0013	.0009	[illegible]	.01[illegible]
Supply Haulage	.0755	.0143	.0081	.0108	.108[illegible]
Mine Ventilation	.0446	.0628	.0213	.0111	.1398
Power Supply	.0197	.0181	.0003	.0010	.0391
Mine Dewatering	.0097	.0251	.0080	.0080	.0508
Development (Incremental)	.0250	.0226	.0116	.0080	.0673
Other Mine Expense	.0952	.0179	.0452	.0301	.1884
Salaried Personnel	.1734	.0125	.0427	.0089	.2375
TOTAL COST PER TON	$.8709	$.7839	$.4042	$.2770	$2.3360

[a] These unit costs apply equally to a single mine or to the entire complex of three mines.

Drilling

Cost Per Ton:	Operating	$ .1875
	Maintenance	.0307
	Total	$ .2182

Operating Labor

A.	280.7 Manshifts Per Week x $59.35 Per Manshift	$ 16,620
B.	Fringe Benefits @ 35%	5,831
C.	Shift Differential @ $.93 Per Manshift	261
	TOTAL WEEKLY COST	$ 22,752
	COST PER TON	$ .0938

Operating Supplies

A.	Drill Steel (216,997 Feet Drilled Per Week x $.0625 Per Foot)	$ 13,562
B.	Drill Bits (216,997 Feet Drilled Per Week x $0.019 Per Foot)	4,123
C.	Jumbo:	
	1. Drilling (852.3 Hours Per Week x $0.74 Per Hour)	631
	2. Place Change (39.2 Hours Per Week x $2.89 Per Hour)	113
D.	Water (216,997 Feet Drilled Per Week x .1 Gallons Per Foot Drilled x $0.54 Per M Gallons)	12
E.	Detergent (216,997 Feet Drilled Per Week x $.0005 Per Foot)	108
F.	Power (852.3 Hours Per Week x 107.9 KW Per Hour x $.03 Per KWH)	2,759
G.	Miscellaneous Supplies (587.8 Rounds Per Week x $2.38 Per Round)	1,399
	TOTAL WEEKLY COST	$ 22,707
	COST PER TON	$ .0937

Maintenance Labor

A.	Drill Machine & Jumbo	
	1. Drilling (852.3 Drilling Hours Per Week x $3.75 Per Hour)	$ 3,196

	2.	Place Change (39.2 Hours Per x $2.69 Per Hour)	105
B.		Bit Sharpener	
	1.	(20 Manshifts Per Week x $56.22 Per Manshift)	1,124
	2.	(Fringe Benefits @35%)	393
	3.	(Shift Differential @ $.93 Per Shift)	19
		TOTAL WEEKLY COST	$ 4,837
		COST PER TON	$ .0199

Maintenance Supplies

A.		Drill Machine & Jumbo	
	1.	Drilling (852.3 Drilling Hours Per Week x $2.22 Per Hour)	$ 1,892
	2.	Place Change (39.2 Hours Per Week x $1.71 Per Hour)	67
B.		Grinding Wheels (216,997 Feet Drilled Per Week x $.003 Per Foot)	651
		TOTAL WEEKLY COST	$ 2,610
		COST PER TON	$ .0108

Charging and Blasting

Cost Per Ton:	Operating	$ .2312
	Maintenance	.0070
	Total	$ .2382

Operating Labor

A.	229.2 Manshifts Per Week x $59.35 Per Manshift	$ 13,603
B.	Fringe Benefits @35%	4,761
C.	Shift Differential @ $.93 Per Manshift	213
	TOTAL WEEKLY COST	$ 18,577
	COST PER TON	$ .0766

Operating Supplies

A.	AN/FO (164,574 Pounds Per Week x $.0975 Per Pound)	$ 16,046
B.	Blasting Caps (16,457 Units Per x $.75 Per Unit)	12,343
C.	Primer (16,457 Units Per Week x $.388 Per Unit)	6,385

D.	Charging Hose (95 Feet of Hose Per Week x $144 Per 40 Feet of Hose)	342	
E.	Carrier		
	1. Charging (568.2 Hours Per Week x $1.12 Per Hour)	636	
	2. Place Change (88.2 Hours Per Week x $1.53 Per Hour)	135	
F.	Miscellaneous Supplies (Leadwire, strippers, tape, etc.) (587.8 Rounds Per Week x $2.71 Per Round)	1,593	
	TOTAL WEEKLY COST	$ 37,480	
	COST PER TON	$ .1546	

Maintenance Labor

A.	AN/FO Placing Equipment (568.2 Hours Per Week x .26 Per hour)	$ 148	
B.	Carrier		
	1. Charging (568.2 Hours Per Week x $1.23 Per Hour)	699	
	2. Place Change (88.2 Hours Per Week x $.77 Per Hour)		68
	TOTAL WEEKLY COST		$ 915
	COST PER TON		$ .0038

Maintenance Supplies

A.	AN/FO Placing Equipment (568.2 Hours Per Week x $.09 Per Hour)	$ 51
B.	Carrier	
	1. Charging (568.2 Hours Per Week x $1.16 Per Hour)	659
	2. Place Change (88.2 Hours Per Week x $.71 Per Hour)	63
	TOTAL WEEKLY COST	$ 773
	COST PER TON	$ .0032

Mucking

Cost Per Ton:	Operating	$ .2406
	Maintenance	.2279
	Total	$ .4685

Operating Labor

A.	355.6 Manshifts Per Week x $59.35 Per Manshift	$ 21,105
B.	Fringe Benefits @35%	7,387
C.	Shift Differential @ $.93 Per Manshift	331
	TOTAL WEEKLY COST	$ 28,823
	COST PER TON	$ .1189

Operating Supplies

2,370.8 Hours Per Week x $12.45 Per Hour	$ 29,516
COST PER TON	$ .1217

Maintenance Labor

2,370.8 Hours Per Week x $12.34 Per Hour	$ 29,256
COST PER TON	$ .1207

Maintenance Supplies

2,370.8 Hours Per Week x $10.96 Per Hour	$ 25,984
COST PER TON	$ .1072

<u>Scaling</u>

Cost Per Ton:	Operating	$ .0234
	Maintenance	.0229
	Total	$ .0463

Operating Labor

A.	58.8 Manshifts Per Week x $59.53 Per Manshift	$ 3,490
B.	Fringe Benefits @ 35%	1,222
C.	Shift Differential @ $.93 Per Manshift	55
	TOTAL WEEKLY COST	$ 4,767
	COST PER TON	$ .0197

Operating Supplies

391.9 Hours Per Week x $2.30 Per Hour	$ 901
COST PER TON	$ .0037

Maintenance Labor

391.9 Hours Per Week x $5.36 Per Hour	$ 2,101
COST PER TON	$ .0087

Maintenance Supplies

391.9 Hours Per Week x $8.76 Per Hour	$ 3,433
COST PER TON	$ .0142

Roof Bolting

Cost Per Ton:	Operating	$	.2119
	Maintenance		.0187
	Total	$	.2306

Operating Labor

A.	249.8 Manshifts Per Week x $59.35 Per Manshift	$ 14,826
B.	Fringe Benefits @ 35%	5,189
C.	Shift Differential @ $.93 Per Manshift	232
	TOTAL WEEKLY COST	$ 20,247
	COST PER TON	$ .0835

Operating Supplies

A.	Roof bolts, plates & shells (9,405 Units Per Week x $2.63 Per Unit)	$ 24,735
B.	Drill Steel (56,425 Feet Drilled Per Week x $.03 Per Foot)	1,693
C.	Drill Bits (56,425 Feet Drilled Per Week x $.033 Per foot)	1,862
D.	Bolter	
	1. Bolting (666.2 Hours Per Week x $1.14 Per Hour)	759
	2. Place Change (68.6 Hours Per Week x $1.53 Per Hour)	105
E.	Power (666.2 Hours Per Week x 86 KW Per Hour x $.03 Per KWH)	1,719
F.	Drill Water & Detergent (56,425 Feet Drilled Per Week x $.0006 Per Foot)	34
G.	Miscellaneous (Torque wrenches, etc.) (9,405 Bolts Per Week x $.023 Per Bolt)	216
	TOTAL WEEKLY COST	$ 31,123
	COST PER TON	$ .1284

Maintenance Labor

A.	Bolter	
	1. Bolting (666.2 Hours Per Week x $2.64 Per Hour)	$ 1,759
	2. Place Change (68.6 Hours Per Week x $0.77 Per Hour)	53

B. Bit Sharpener			
1. (5 Manshifts Per Week x $56.22 Per Manshift)			281
2. Fringe Benefits @ 35%			98
TOTAL WEEKLY COST		$	2,191
COST PER TON		$	.0090

Maintenance Supplies

A. Bolter		
1. Bolting (666.2 Hours Per Week x $2.45 Per Hour)	$	1,632
2. Place Change (68.6 Hours Per Week x $.71 Per Hour)		49
B. Grinding Wheels (56,425 Feet Drilled Per Week x $.012 Per Foot)		677
TOTAL WEEKLY COST	$	2,358
COST PER TON	$	.0097

<u>Primary Crushing & Conveying (Year 10)</u>

Cost Per Ton:	Operating	$	.1325
	Maintenance		.1570
	Total	$	.2895

Operating Labor

A. 80 Manshifts Per Week x $56.22	$	4,498
B. Fringe Benefits @35%		1,574
C. Shift Differential @ $.93 Per Manshift		74
TOTAL WEEKLY COST	$	6,146
COST PER TON	$	.0253

Operating Supplies

A. Crusher		
1. Breaker Picks (242,463 Tons Per Week x $.033 Per Ton)	$	8,001
2. Power (200 Horsepower x .7457 KW Per Horsepower x 1,187.4 Hours Per Week x $.03 Per KWH)		5,313
B. Conveyors		
1. Belting (242,463 Tons Per x $.0139 Per Ton)	$	3,370
2. Power (3,050 Horsepower x .7457 KW Per Horsepower x 131.9 Hours Per Week x $.03 Per KWH)		9,000

C.	Miscellaneous Supplies (Lube, etc.) (242,463 Tons Per x $.001 Per Ton)		242
D.	Dust Suppression (242,463 Tons Per Week x .5 Gallons Per Ton x $.54 Per M Gallons)		65
	TOTAL WEEKLY COST		$ 25,991
	COST PER TON		$ .1072

Maintenance Labor

A.	Crusher & Conveyor (242,463 Tons Per Week x $.104 Per Ton)	$ 25,216
	COST PER TON	$ .1040

Maintenance Supplies

A.	Crusher & Conveyor (242,463 Tons Per Week x $.053 Per Ton)	$ 12,851
	COST PER TON	$ .0530

Conveyor Installation

Cost Per Ton:	Operating	$ .0112
	Maintenance	$ .0019
	Total	$ .0131

Operating Labor

Labor costs for this section include production labor used for belt extension.

A.	Conveyor Leadman (5 Manshifts Per Week x $59.35 Per Manshift)	$ 297
	Conveyor Installation Crew (10 Manshifts Per Week x $56.22 Per Manshift)	562
	Production Crew (15.1 Manshifts Per Week x 59.35 Per Manshift)	896
	Subtotal	$ 1,755
B.	Fringe Benefits @35%	614
C.	Shift Differential @ $.93 Per Shift	28
	TOTAL WEEKLY COST	$ 2,397
	COST PER TON	$ .0099

Operating Supplies

A.	Supply Truck (33.3 Hours Per Week x $2.40 Per Hour)	$	80
B.	Belt Handling Truck (33.3 Hours Per Week x $4.72 Per Hour)		157
C.	Pickup Truck (33.3 Hours Per Week x $1.14 Per Hour)		38
D.	Miscellaneous Supplies (Hand tools, etc. @$50 Per Week)		50
	TOTAL WEEKLY COST	$	325
	COST PER TON	$	.0013

Maintenance Labor

A.	Supply Truck (33.3 Hours Per Week x $1.76 Per Hour)	$	59
B.	Belt Handling Truck (33.3 Hours Per Week x $4.03 Per Hour)		134
C.	Pickup Truck (33.3 Hours Per Week x $.82 Per Hour)		27
	TOTAL WEEKLY COST	$	220
	COST PER TON	$	.0009

Maintenance Supplies

A.	Supply Truck (33.3 Hours Per Week x $1.79 Per Hour)	$	60
B.	Belt Handling Truck (33.3 Hours Per Week x $4.24 Per Hour)		141
C.	Pickup Truck (33.3 Hours Per Week x $1.04 Per Hour)		35
	TOTAL WEEKLY COST	$	236
	COST PER TON	$	.0010

Supply Haulage

Cost Per Ton:	Operating	$	.0898
	Maintenance	$	.0189
	Total	$	.1087

Operating Labor

A.	Supply Truck Driver (200 Manshifts Per Week x $56.22 Per Manshift)	$ 11,244
	Underground Laborer (40 Manshifts Per Week x $53.71 Per Manshift)	2,148
	Subtotal	$ 13,392
B.	Fringe Benefits @ 35%	4,687
C.	Shift Differential @ $.93 Per Manshift	223
	TOTAL WEEKLY COST	$ 18,302
	COST PER TON	$ .0755

Operating Supplies

A.	Water Truck - 400 hours x $3.17 per hour	$ 1,268
B.	Fuel Truck (266.7 Hours Per Week x $2.78 Per Hour)	741
C.	5-Ton Supply Truck (88.9 Hours Per Truck x $2.40 Per Hour)	213
D.	2-Ton Supply Truck (266.7 Hours Per Week x $1.53 Per Hour)	408
E.	5-Yard End Loader (44.5 Hours Per Week x $9.95 Per Hour)	443
F.	Pickup Truck (266.7 Hours Per Week x $1.14 Per Hour)	304
G.	AN/FO Supply Truck (14 Hours Per Week x $6.65 Per Hour)	93
	TOTAL WEEKLY COST	$ 3,470
	COST PER TON	$ .0143

Maintenance Labor

A.	Water Truck (400 Hours Per Week x $1.30 Per Hour)	$ 520
B.	Fuel Truck (266.7 Hours Per Week x $1.15 Per Hour)	307
C.	5-Ton Supply Truck (88.9 Hours Per Week x $1.76 Per Hour)	156
D.	2-Ton Supply Truck (266.7 Hours Per Week x $.77 Per Hour)	205

E.	5-Yard End Loader (44.5 Hours Per Week x $10.78 Per Hour)		480
F.	Pickup Truck (266.7 Hours Per Week x$.82 Per Hour)		219
G.	AN/FO Supply Truck (14 Hours Per Week x $4.68 Per Hour)		66
	TOTAL WEEKLY COST	$	1,953
	COST PER TON	$	.0081

Maintenance Supplies

A.	Water Truck (400 Hours Per Week x $2.00 Per Hour)	$	800
B.	Fuel Truck (266.7 Hours Per Week x $1.88 Per Hour)		501
C.	5-Ton Supply Truck (88.9 Hours Per Week x $1.79 Per Hour)	$	159
D.	2-Ton Supply Truck (266.7 Hours Per Week x $.71 Per Hour)		189
E.	5-Yard End Loader (44.5 Hours Per Week x $13.78 Per Hour)		613
F.	Pickup Truck (266.7 Hours Per Week x $1.04 Per Hour)		277
G.	AN/FO Supply Truck (14 Hours Per Week x $4.91 Per Hour)		69
	TOTAL WEEKLY COST	$	2,608
	COST PER TON	$	.0108

Mine Ventilation

Cost Per Ton:	Operating	$	..1074
	Maintenance		.0324
	Total	$	.1398

Operating Labor

A.	Ventilation Leadman (20 Manshifts Per Week x $59.35 Per Manshift)	$	1,187
	Equipment Operators (40 Manshifts Per Week x $59.35 Per Manshift)		2,374

	Ventilation Men (20 Manshifts Per Week x $56.22 Per Manshift)	1,124
	Underground Laborers (60 Manshifts Per Week x $53.71 Per Manshift)	3,223
	Subtotal	$ 7,908
B.	Fringe Benefits @ 35%	2,768
C.	Shift Differential @ 93¢ Per Manshift	130
	TOTAL WEEKLY COST	$ 10,806
	COST PER TON	$ .0446

Operating Supplies

A.	Track Dozer (133.3 Hours Per Week x $1.98 Per Hour)	$ 264
B.	LHD Unit (133.3 Hours Per Week x $12.45 Per Hour)	$ 1,660
C.	2-Ton Supply Truck (66.7 Hours Per Week x $1.53 Per Hour)	102
D.	Pickup Truck (133.3 Hours Per Week x $1.14 Per Hour)	152
E.	Fans:	
	1. Surface (800 Horsepower x 168 Hours x .7457 KW Per Horsepower x $.03 Per KWH)	3,007
	2. Auxiliary (1,020 Horsepower x 168 Hours x .7457 KW Per Horsepower x $.03 Per KWH)	3,833
F.	Brattice and Stoppings	
	1. Permanent (.6 Stoppings Per Week x $665 Each)	399
	2. Temporary (.8 Brattices Per Week x $500 Each)	400
G.	Overcasts (.3 Overcasts Per Week x $18,000 Each)	5,400
H.	Elevating Platform (66.7 Hours Per Week x $.29 Per Hour)	19
	TOTAL WEEKLY COST	$ 15,236
	COST PER TON	$ .0628

Maintenance Labor

A.	Track Dozer (133.3 Hours Per Week x $4.96 Per Hour)	$	661
B.	LHD Unit (133.3 Hours Per Week x $12.34 Per Hour)		1,645
C.	2-Ton Supply Truck (66.7 Hours Per Week x $.77 Per Hour)		51
D.	Pickup Truck (133.3 Hours Per Week x $.82 Per Hour)		109
E.	Fans (20 Manshifts Per Week x $133 Per Manshift)		2,660
F.	Elevating Platform (66.7 Hours Per Week x $.61 Per Hour)	$	41
	TOTAL WEEKLY COST	$	5,167
	COST PER TON	$	.0213

Maintenance Supplies

A.	Track Dozer (133.3 Hours Per Week x $4.66 Per Hour)	$	621
B.	LHD Unit (133.3 Hours Per Week x $10.96 Per Hour)		1,461
C.	2-Ton Supply Truck (66.7 Hours Per Week x $.71 Per Hour)		47
D.	Pickup Truck (133.3 Hours Per Week x $1.04 Per Hour)		139
E.	Fans		
	1. Surface (2% of Capital Cost Per Year)		89
	2. Auxiliary (10% of Capital Cost Per Year)		291
F.	Elevating Platform (66.7 Hours Per Week x $.59 Per Hour)		39
	TOTAL WEEKLY COST	$	2,687
	COST PER TON	$	.0111

Power Supply

Cost Per Ton:	Operating	$	.0378
	Maintenance		.0013
	Total	$	.0391

Operating Labor

A.	Electrician (20 Manshifts Per Week x $62.81 Per Manshift)	$	1,256
	Installation Crew (40 Manshifts Per Week x $56.22 Per Manshift)		2,249
	Subtotal	$	3,505
B.	Fringe Benefits @ 35%		1,227
C.	Shift Differential @ $.93 Per Manshift		56
	TOTAL WEEKLY COST	$	4,788
	COST PER TON	$	.0197

Operating Supplies

A.	Cable (984 Feet Per Week x $4.044 Per Foot)	$	3,979
B.	Pickup (33.3 Hours Per Week x $1.14 Per Hour)		38
C.	2-Ton Utility Truck (33.3 Hours Per Week x $1.53 Per Hour)		51
D.	Elevating Platform (33.3 Hours Per Week x $.29 Per Hour)		10
E.	Miscellaneous Supplies		300
	TOTAL WEEKLY COST	$	4,378
	COST PER TON	$	.0181

Maintenance Labor

A.	Pickup (33.3 Hours Per Week x $.82 Per Hour)	$	27
B.	2-Ton Utility Truck (33.3 Hours Per Week x $.77 Per Hour)		26
C.	Elevating Platform (33.3 Hours Per Week x $.61 Per Hour)		20
	TOTAL WEEKLY COST	$	73
	COST PER TON	$	.0003

Maintenance Supplies

A.	Cable (30 Feet Per Week x $4.044 Per Foot)	$	121

B.	Pickup (33.3 Hours Per Week x $1.04 Per Hour)			35
C.	2-Ton Utility Truck (33.3 Hours Per Week x $.71 Per Hour)			24
D.	Elevating Platform (33.3 Hours Per Week x $.59 Per Hour)			20
E.	Miscellaneous Supplies			50
	TOTAL WEEKLY COST		$	250
	COST PER TON		$	.0010

Mine Dewatering

Cost Per Ton:	Operating	$	.0348
	Maintenance		.0160
	Total	$	.0508

Operating Labor

A.	Pipe Leadman (10 Manshifts Per Week x $59.35 Per Manshift)	$	594
	Pipe Installers (20 Manshifts Per Week x $56.22 Per Manshift)		1,124
	Subtotal	$	1,718
B.	Fringe Benefits @ 35%		601
C.	Shift Differential @ $.93 Per Manshift		28
	TOTAL WEEKLY COST	$	2,347
	COST PER TON	$	.0097

Operating Supplies

A.	Pipe			
	1.	4" Diameter (690.3 Feet Per Week x $2.58 Per Foot)	$	1,781
	2.	8" Diameter (66.7 Feet Per Week x $7.60 Per Foot)		507
B.	Power			
	1.	Face Pumps (4,200 Hours Per Week x 5 Horsepower x .7457 KW Per Horsepower x $.03 Per KWH)		470
	2.	Panel Pumps (840 Hours Per Week x 60 Horsepower x .7457 KW Per Horsepower x $.03 Per KWH)		1,128

3. Main Pump (164 Hours Per Week x 500 Horsepower x .7457 KW Per Horsepower $.03 Per KWH)	1,834
C. 2-Ton Supply Truck (66.7 Hours Per Week x $1.53 Per Hour)	102
D. Pickup Truck (33.3 Hours Per Week x $1.14 Per Hour)	38
E. Elevating Platform (66.7 Hours Per Week x $.29 Per Hour)	19
F. Miscellaneous Supplies	200
TOTAL WEEKLY COST	$ 6,079
COST PER TON	$ .0251

Maintenance Labor

A. Pumps	
1. Face Pumps (4,200 Hours Per Week x $.17 Per Hour)	$ 714
2. Panel Pumps (840 Hours Per Week x $1.29 Per Hour)	1,084
3. Main Pump (4% of Capital Cost Per Year)	31
B. 2-Ton Supply Truck (66.7 Hours Per Week x $.77 Per Hour)	51
C. Pickup Truck (33.3 Hours Per Week x $.82 Per Hour)	27
D. Elevating Platform (66.7 Hours Per Week x $.61 Per Hour)	41
TOTAL WEEKLY COST	$ 1,948
COST PER TON	$ .0080

Maintenance Supplies

A. Pumps	
1. Face Pumps (4,200 Hours Per Week x $.16 Per Hour)	$ 672
2. Panel Pumps (840 Hours Per Week x $1.26 Per Hour)	1,058
3. Main Pumps (6% of Capital Cost Per Year)	46
B. 2-Ton Supply Truck (66.7 Hours Per Week x $.71 Per Hour)	47

C.	Pickup Truck (33.3 Hours Per Week x $1.04 Per Hour)		35
D.	Elevating Platform (66.7 Hours Per Week x $.59 Per Hour		39
E.	Miscellaneous Supplies		50
	TOTAL WEEKLY COST	$	1,947
	COST PER TON	$	.0080

Mine Development (Incremental)

It is assumed that development costs will exceed normal mining costs by 20 percent. The resulting incremental development cost is calculated to be:

Cost Per Ton:	Operating	$	.0477
	Maintenance	$	.0196
	Total	$	.0673

Operating Labor

A.	Additional Development Cost (35,931 Development Tons Per Week x $.8458 Per Ton x 20%)	$	6,078
	COST PER TON	$	.0251

Operating Supplies

A.	Additional Development Cost (35,931 Development Tons Per Week x $.7613 Per Ton x 20%)	$	5,471
	COST PER TON	$	.0226

Maintenance Labor

A.	Additional Development Cost (35,931 Development Tons Per Week x $.3926 Per Ton x 20%)	$	2,821
	COST PER TON	$	.0116

Maintenance Supplies

A.	Additional Development Cost (35,931 Development Tons Per Week x $.2690 Per Ton x 20%)	$	1,933
	COST PER TON	$	.0080

Other Mine Expense

Cost Per Ton:	Operating	$	.1131
	Maintenance	$	.0753
	Total	$	.1884

Changehouse

An 850-man changehouse, containing staff offices, self-service mine lamp racks, safety equipment, storage, and a first-aid station.

Cost Per Ton:	Operating	$	.0062
	Maintenance	$	.0139
	Total	$	.0201

A.	Operating Supplies			
	1.	Heating ($17,650 Per Year ÷ 52 Weeks Per Year)	$	339
	2.	Potable Water (210 M Gallons Per Week x $.80 Per M Gallons)		168
	3.	Power (33,000 KWH Per Week x $.03 Per KWH)		990
		TOTAL WEEKLY COST	$	1,497
		COST PER TON	$	.0062
B.	Maintenance Labor			
	1.	Lampman (10 Manshifts Per Week x $56.22 Per Manshift)	$	562
		Janitor (20 Manshifts Per Week x $53.71 Per Manshift)		1,074
		Repairman (10 Manshifts Per Week x $56.22 Per Manshift)		562
		Electrician (1 Manshift Per Week x $62.81 Per Manshift)		63
		Subtotal	$	2,261
	2.	Fringe Benefits @35%		791
	3.	Shift Differential @ $.93 Per Manshift		38
		TOTAL WEEKLY COST	$	3,090
		COST PER TON	$	.0127
C.	Maintenance Supplies			
	1.	Mine Lamps ($2,600 Per Year ÷ 52 Weeks Per Year)	$	50
	2.	Janitorial ($3,500 Per Year ÷ 52 Weeks Per Year)		67
	3.	Heating ($9,000 Per Year ÷ 52 Weeks Per Year)		173
		TOTAL WEEKLY COST	$	290
		COST PER TON	$	.0012

Underground Shop & Warehouse

This section describes costs for an underground shop capable of servicing and repairing all underground equipment. Mobile field repair units and lube trucks will operate from the shop. Also, an underground parts warehouse is included.

Cost Per Ton:	Operating	$	.0040
	Maintenance		.0470
	Total	$	.0510

A.	Operating Supplies			
	1.	Field Repair Trucks (266.7 Hours Per Week x $1.68 Per Hour)	$	448
	2.	Lube Trucks (266.7 Hours Per Week x $1.68 Per Hour)		448
	3.	Pickup (66.7 Hours Per Week x $1.14 Per Hour)		76
		TOTAL WEEKLY COST	$	972
		COST PER TON	$	.0040
B.	Maintenance Labor			
	1.	Mechanic (40 Manshifts Per Week x $62.81 Per Manshift)	$	2,512
		Electrician (5 Manshifts Per Week x $62.81 Per Manshift)		314
		Janitor (20 Manshifts Per Week x $53.71 Per Manshift)		1,074
		Subtotal	$	3,900
	2.	Fringe Benefits @35%		1,365
	3.	Shift Differential @ $.93 Per Manshift		60
	4.	Field Repair Trucks (266.7 Hours Per Week x $.85 Per Hour)		227
	5.	Lube Trucks (266.7 Hours Per Week x $.85 Per Hour)		227
	6.	Pickup (66.7 Hours Per Week x $.82 Per Hour)		55
		TOTAL WEEKLY COST	$	5,834
		COST PER TON	$	.0241

C. Maintenance Supplies:

1. Power (145,000 KWH Per Week x $.03 Per KWH)	$ 4,350
2. Field Repair Trucks (266.7 Hours Per Week x $.78 Per Hour)	208
3. Lube Trucks (266.7 Hours Per Week x $.78 Per Hour)	208
4. Pickup (66.7 Hours Per Week x $1.04 Per Hour)	69
5. Miscellaneous Supplies	708
TOTAL WEEKLY COST	$ 5,543
COST PER TON	$ .0229

Fueling Station

An underground self-service refueling station for all service and supply equipment.

Cost Per Ton (Maintenance)	$ .0010
A. Maintenance Labor	$ 125
COST PER TON	$ .0005
B. Maintenance Supplies	125
COST PER TON	$ .0005

Communications System

A low-frequency radio system for communication between different areas of the mine.

Cost Per Ton (Maintenance) $ .0096

A. Maintenance Labor

1. Electrician (20 Manshifts x $62.81 Per Manshift)	$ 1,256
2. Fringe Benefits @35%	440
3. Shift Differential @93¢ Per Manshift	19
TOTAL WEEKLY COST	$ 1,715
COST PER TON	$ .0071

B. Maintenance Supplies

1. Miscellaneous	$ 600
COST PER TON	$ .0025

Raw & Potable Water Systems

Cost Per Ton:	Operating	$	.0043
	Maintenance		.0004
	Total	$	.0047

A. Operating Supplies

1. Raw Water System
   - a. 4" Pipe (23.3 Feet Per Week x 2.58 Per Foot) — $ 60
   - b. 2" Pipe (515 Feet Per Week x $.95 Per Foot) — 489
2. Potable Water System (23.3 Feet of 2" Pipe Per Week x $.95 Per Foot) — 22
3. Miscellaneous Supplies — 100
4. Power (200 Horsepower x 12 Hours Per Day x 7 Days Per Week x .7457 KW Per Horsepower x $.03 Per KWH) — 376

TOTAL WEEKLY COST — $ 1,047
COST PER TON — $ .0043

B. Maintenance Labor — $ 72
TOTAL WEEKLY COST — $ .0003
COST PER TON

C. Maintentance Supplies — $ 36
TOTAL WEEKLY COST — $ .0001
COST PER TON

Safety Equipment

First-aid supplies, fire extinguishers, personal safety equipment, etc.

Cost Per Ton:	Operating	$	.0014
	Maintenance		.0034
	Total	$	.0048

A. Operating Supplies

1. First-aid material — $ 345
   COST PER TON — $ .0014

B. Maintenance Labor
TOTAL WEEKLY COST — $ 125
COST PER TON — $ .0005

C. Maintenance Supplies
TOTAL WEEKLY COST — $ 700
COST PER TON — $ .0029

Labor Pool

A crew of miners and laborers to perform odd jobs in the mine as well as fill in for spot absenteeism.

Cost Per Ton (Operations)	$ .0972	
A. Operating Labor		
1. Miners (176 Manshifts Per Week x $59.35 Per Manshift)		$ 10,446
2. Laborers (120 Manshifts Per Week x $53.71 Per Manshift)		6,445
Subtotal		$ 16,891
3. Fringe Benefits @35%		5,912
4. Shift Differential @ $.93 Per Manshift		275
TOTAL WEEKLY COST		$ 23,078
COST PER TON		$ .0952
B. Operating Supplies		
1. Miscellaneous Supplies		$ 480
COST PER TON		$ .0020

Salaried Personnel

Cost Per Ton:	Operating	$ .1859
	Maintenance	.0516
	Total	$ .2375

Operating Supervision

Cost Per Ton:	Operating	$ .1380
	Maintenance	$ .0081
	Total	$ .1461

A. Operating Labor	
1. General Mine Superintendent (5 Manshifts Per Week x $140.00 Per Manshift)	$ 700
Production Superintendent (10 Manshifts Per Week x $128.46 Per Manshift)	1,285
Shift Foreman (40 Manshifts Per Week x $105.00 Per Manshift)	4,200
Utilities Foreman (20 Manshifts Per Week x $75.77 Per Manshift)	1,515

Training Foreman (5 Manshifts Per Week x $75.77 Per Manshift)		379
Surface Foreman (5 Manshifts Per Week x $75.77 Per Manshift)		379
Panel Boss (120 Manshifts Per Week x $75.77 Per Manshift)		9,092
Development Boss (60 Manshifts Per Week x $75.77 Per Manshift)		4,546
Subtotal	$	22,096
2. Fringe Benefits @45%		9,943
TOTAL WEEKLY COST	$	32,039
COST PER TON	$	.1321

B. Operating Supplies

1. Transportation (1,060 Hours Per Week x $1.14 Per Hour)	$	1,208
2. Miscellaneous Supplies (53 Personnel x $225 Per Person Per Year ÷ 52 Weeks Per Year)		229
TOTAL WEEKLY COST	$	1,437
COST PER TON	$	.0059

C. Maintenance Labor

1. Transportation (1,060 Hours Per Week x $.82 Per Hour)	$	869
COST PER TON	$	.0036

D. Maintenance Supplies

1. Transportation (1,060 Hours Per Week x $1.04 Per Hour)	$	1,102
COST PER TON	$	.0045

Maintenance Supervison

Cost Per Ton (Maintenance) $ .0406

1. Maintenance Superintendent (5 Manshifts Per Week x $128.46 Per Manshift)	$	642
Shop Foreman (20 Manshifts Per Week x $81.92 Per Manshift)		1,638
Field Foreman (20 Manshifts Per Week x $81.92 Per Manshift)		1,638

	Warehouseman (20 Manshifts Per Week x $56.15 Per Manshift)			1,123
	Dispatcher (20 Manshifts Per Week x $58.46 Per Manshift)			1,169
	Subtotal		$	6,210
2.	Fringe Benefits @45%			2,795
3.	Transportation (180 Hours Per Week x $.82 Per Hour)			148
	TOTAL WEEKLY COST		$	9,153
	COST PER TON		$	.0378

B. Maintenance Supplies

1.	Transportation			
	a. Operating (180 Hours Per Week x $1.14 Per Hour)		$	205
	b. Maintenance (180 Hours Per Week x $1.04 Per Hour)			187
2.	Miscellaneous Supplies (18 Personnel x $225 Per Person (Per Year ÷ 52 Weeks Per Year)			78
3.	Warehouse Supplies ($10,500 Per Year ÷ 52 Weeks Per Year)			202
	TOTAL WEEKLY COST		$	672
	COST PER TON		$	.0028

Service Department

Cost Per Ton:	Operating	$	.0412
	Maintenance		.0027
	Total	$	.0439

A. Operating Labor

1.	Electrical Engineer (5 Manshifts Per Week x $110.77 Per Manshift)	$	554
	Rock Mechanics Engineer (5 Manshifts Per Week x $110.77 Per Manshift)		554
	Mechanical Engineer (5 Manshifts Per Week x $110.77 Per Manshift)		554
	Ventilation/Safety Engineer (5 Manshifts Per Week x $93.46 Per Manshift)		467
	Geologist (5 Manshifts Per Week x $93.46 Per Manshift)		467

		Surveyor/Draftsman (5 Manshifts Per Week x $53.85 Per Manshift)	269
		Surveyor Helper (10 Manshifts Per Week x $45.77 Per Manshift)	458
		Assistant Industrial Engineer (5 Manshifts Per Week x $93.46 Per Manshift)	467
		Chief Clerk (5 Manshifts Per Week x $75.77 Per Manshift)	379
		Clerk (10 Manshifts Per Week x $58.46 Per Manshift)	585
		Stenographer (5 Manshifts Per Week x $43.46 Per Manshift)	217
		Security Guards (20 Manshifts Per Week x $46.15 Per Manshift)	923
		Subtotal	$ 5,894
	2.	Fringe Benefits @45%	2,652
		TOTAL WEEKLY COST	$ 8,546
		COST PER TON	$ .0352
B.	Operating Supplies		
	1.	Transportation (340 Hours Per Week x $1.14 Per Hour)	$ 388
	2.	Elevating Platforms (16 Hours Per Week x $.29 Per Hour)	5
	3.	Miscellaneous Supplies (17 Personnel x $50 Per Week Per Person)	850
	4.	Accounting Supplies ($10,500 Per Year) ÷ 52 Weeks Per Year)	202
		TOTAL WEEKLY COST	$ 1,445
		COST PER TON	$ .0060
C.	Maintenance Labor		
	1.	Transportation (340 Hours Per Week x $.82 Per Hour)	279
	2.	Elevating Platform (16 Hours Per Week x $.61 Per Hour)	10
		TOTAL WEEKLY COST	$ 289
		COST PER TON	$ .0012

D. Maintenance Supplies		
1. Transportation (340 Hours Per Week x $1.04 Per Hour)	$	354
2. Elevating Platform (16 Hours Per Week x $.59 Per Hour)		9
TOTAL WEEKLY COST	$	363
COST PER TON	$	.0015

General Mines Office

Costs for this section are divided evenly between the three mines.

Cost Per Ton:	Operating	$	.0067
	Maintenance		.0002
	Total	$	.0069

A. Operating Labor		
Mine Manager (5 Manshifts Per Week x $173.85 Per Manshift)	$	869
Chief Engineer (5 Manshifts Per Week x $128.46 Per Manshift)		642
Planning Engineer (5 Manshifts Per Week x $36.92 Per Manshift)		554
Industrial Engineer (5 Manshifts Per Week x $110.77 Per Manshift)		554
Stenographer (10 Manshifts Per Week x $43.46 Per Manshift)		435
Subtotal	$	3,054
2. Fringe Benefits @ 45%		1,374
TOTAL WEEKLY COST	$	4,428
WEEKLY COST - ONE MINE	$	1,476
COST PER TON	$	.0061

B. Operating Supplies:		
1. Transportation:		
a. Automobiles (2 Units x $80 Per Week)	$	160
b. Pickup Trucks (80 Hours Per Week x $1.14 Per Hour)		91
		144
2. Expense Account ($7,500 Per Year ÷ 52 Weeks Per Year)		

	3.	Miscellaneous Expense (6 Personnel x $225 Per Year Per Person ÷ 52 Weeks Per Year)	26
		TOTAL WEEKLY COST	$ 421
		WEEKLY COST - ONE MINE	$ 140
		COST PER TON	$ .0006
C.	Maintenance Labor:		
	1.	Transportation (80 Hours Per Week x $.82 Per Hour)	$ 66
		WEEKLY COST - ONE MINE	$ 22
		COST PER TON	$ .0001
D.	Maintenance Supplies:		
	1.	Transportation (80 Hours Per Week x $1.04 Per Hour)	$ 83
		WEEKLY COST - ONE MINE	$ 28
		COST PER TON	$ .0001

MANPOWER REQUIREMENTS

This section of the report deals with manpower requirements, both salaried and hourly. Wage and labor rates used in computing operating and maintenance costs are also included.

Table A-8 summarizes total mine complex requirements. Tables A-9 and A-10 list hourly and salaried personnel required by each mine, and Table A-11 describes the supervisory and engineering staff that will serve all three mines. Table A-12 shows labor rates according to job classification.

TABLE A-8. CHATTANOOGA SHALE STUDY MINE COMPLEX MANPOWER REQUIREMENTS

	Requirements - One Mine	Requirements - Mine Complex
Hourly Personnel	718	2,154
Salaried Personnel	78	234
Common Managerial & Engineering	--	33
TOTAL MANPOWER	796	2,421
AVERAGE TONS PER MANSHIFT: 60.1 Tons		

TABLE A-9. CHATTANOOGA SHALE STUDY HOURLY PERSONNEL REQUIREMENTS - ONE MINE

Job	Number Of Workers	Hourly Rate[a]
A. OPERATIONAL MANPOWER		
Electrical Leadman	4	$7.85
Driller	48	7.42
Blaster	48	7.42
LHD Operator	72	7.42
Scaler	24	7.42
Roof Bolter	48	7.42
Development Miners	48	7.42
Ventilation Leadman	4	7.42
Conveyor Leadman	1	7.42
Pipe Leadman	2	7.42
Equipment Operator	8	7.42
Crusher/Conveyor Attendent	16	7.03
Conveyor Installation Crewman	2	7.03
Supply Truck Driver	40	7.03
Ventilation Man	4	7.03
Electrical Installation Crewman	8	7.03
Pipe Installation Crewman	4	7.03
General Laborer	44	6.71
Subtotal	425	
B. MAINTENANCE PERSONNEL [b]		
Machinist	8	$7.85
Mechanic A	30	7.85
Electrician A	20	7.85
Mechanic B	42	7.42
Electrician B	16	7.42
Welder	24	7.42
Bit Sharpener	5	7.03
Lube Man	21	7.03
Mechanic Helper	20	7.03
Electrician Helper	12	7.03
Welder Helper	12	7.03
Lampman	2	7.03
Dryman	2	7.03
Janitor	8	6.71
Subtotal	222	

TABLE A-9. HOURLY PERSONNEL REQUIREMENTS (Continued)

C. TOTAL HOURLY REQUIREMENT	
Operating Personnel	425
Maintenance Personnel	222
Vacation Replacement	39
Absentee Allowance	32
TOTAL - ONE MINE	718

[a] Hourly rate does not include 35% fringe benefits or shift differential. Wage rates are taken from the prevailing union scale for coal miners in south-central Tennessee.

[b] Hourly rate does not include 35% fringe benefits or shift differential.

TABLE A-10. CHATTANOOGA SHALE STUDY
SALARIED PERSONNEL REQUIREMENTS - ONE MINE

Title	Number Required	Annual Salary[a]
General Superintendent	1	$36,400
Production Superintendent	2	33,400
Maintenance Superintendent	1	33,400
Maintenance Shop Foreman	4	21,300
Maintenance Field Foreman	4	21,300
Warehouseman	4	14,600
Dispatcher	4	15,200
Shift Foreman	8	27,300
Panel Boss	24	19,700
Development Boss	12	19,700
Utilities Foreman	4	19,700
Surface Foreman	1	19,700
Training Foreman	1	19,700
Chief Clerk	1	19,700
Clerk	2	15,200
Stenographer	1	11,300
Security Guard	4	12,000

[a] Annual salary does not include 45% fringe benefits.

TABLE A-11. CHATTANOOGA SHALE STUDY
ADDITIONAL SALARIED PERSONNEL - MINE COMPLEX [a]

Title	Number Required	Annual Salary[b]
Manager of Mines	1	$45,200
Chief Engineer	1	33,400
Electrical Engineer	3	28,800
Rock Mechanics Engineer	3	28,800
Planning Engineer	1	28,800
Industrial Engineer	1	28,800
Mechanical Engineer	3	28,800
Ventilation/Safety Engineer	3	24,300
Assistant Industrial Engineer	3	24,300
Geologist	3	24,300
Surveyor/Draftsman	3	14,000
Surveyor Helper	6	11,900
Stenographer	2	11,300

[a] Personnel listed in this Table will serve the full complex of three mines.
[b] Annual salaries do not include 45% fringe benefits.

TABLE A-12. CHATTANOOGA SHALE STUDY
WAGE SCHEDULE

Class	Job	Dollars/Hour	Dollars/Hour With 35% Fringe
4	Electrician A Mechanic A Machinist Electrical Leadman	$7.85	$10.60
3	Electricain B Mechanic B Welder Driller Blaster LHD Operator Scaler Roof Bolter Development Miners Ventilation Leadman Conveyor Leadman Pipe Leadman Equipment Operator	$7.42	$10.02
2	Electrician Helper Mechanic Helper Welder Helper Lube Man Bit Sharpener Crusher/Conveyor Attendent Conveyor Installation Man Electrical Installation Man Pipe Installation Man Ventilation Man Supply Truck Driver Lampman Dryman	$7.03	$ 9.49
1	General Laborer Janitor	$6.71	$ 9.06

BACKFILLING

In addition to the mining procedures, the feasibility of hydraulic backfilling with process plant tailings has been considered. For operational and safety considerations during backfilling, the mine has been designed so that advance will be in the down-dip direction and panels have been laid out with 75-foot thick barrier pillars on all sides. Additional operational expense over and above mining costs is expected to be $.4840 per ton mined. Additional capital requirements for the backfilling system are estimated to be $54,558,000 over the life of the project.

It has been assumed that 70 percent of the tailings produced by the process plant can be placed underground as backfilled material. This estimate is based on an in-place density of 98 pounds per cubic foot, 90 percent panel filling due to deltas formed at the deposition points and 15 percent residual moisture in the fill following dewatering. The general size consist of tailings leaving the plant has been estimated by others to fall in the -1/4 inch +10 mesh range. Degradation will occur during transport, so excessive void space in the fill is not likely to be a problem. The backfilling procedure is discussed in three phases, transporting, stowing, and costs.

TRANSPORTING

It has been assumed that the tailings will be pumped to the mine site from a processing plant at an undetermined distance from the mines. This section deals with the handling of the tailings after arrival at the mine site.

The tailings will be delivered to each mine area at approximately 3,900 gallons per minute with a density of 50 percent solids by weight. The incoming flow will be split and directed to two boreholes for transport to the mining zone. The boreholes will be drilled from the surface to intersect the panel access entries for the row of panels currently being backfilled. One borehole will serve each side of the mine. The boreholes will be lined with 16-inch O.D. casing cemented into place and will discharge into a continuation of the 16-inch pipe carrying the material along the panel access entries to the panels currently being backfilled.

STOWING

Panels will be backfilled by a system of roof-hung feeder and distribution lines (Figure A-14). A 14-inch feeder line will extend into the panel through each panel entry and will carry material to a 14-inch manifold running the length of the first crosscut which, in turn, will feed five six-inch distribution lines. The distribution lines will run the entire length of the panel and will have discharge spigots installed at each crosscut.

A system of horizontal underdrains and vertical perforated drains will be installed to remove excess water from the stowed tailings (Figures A-15 and A-16). All drain lines will be wrapped with burlap to restrict

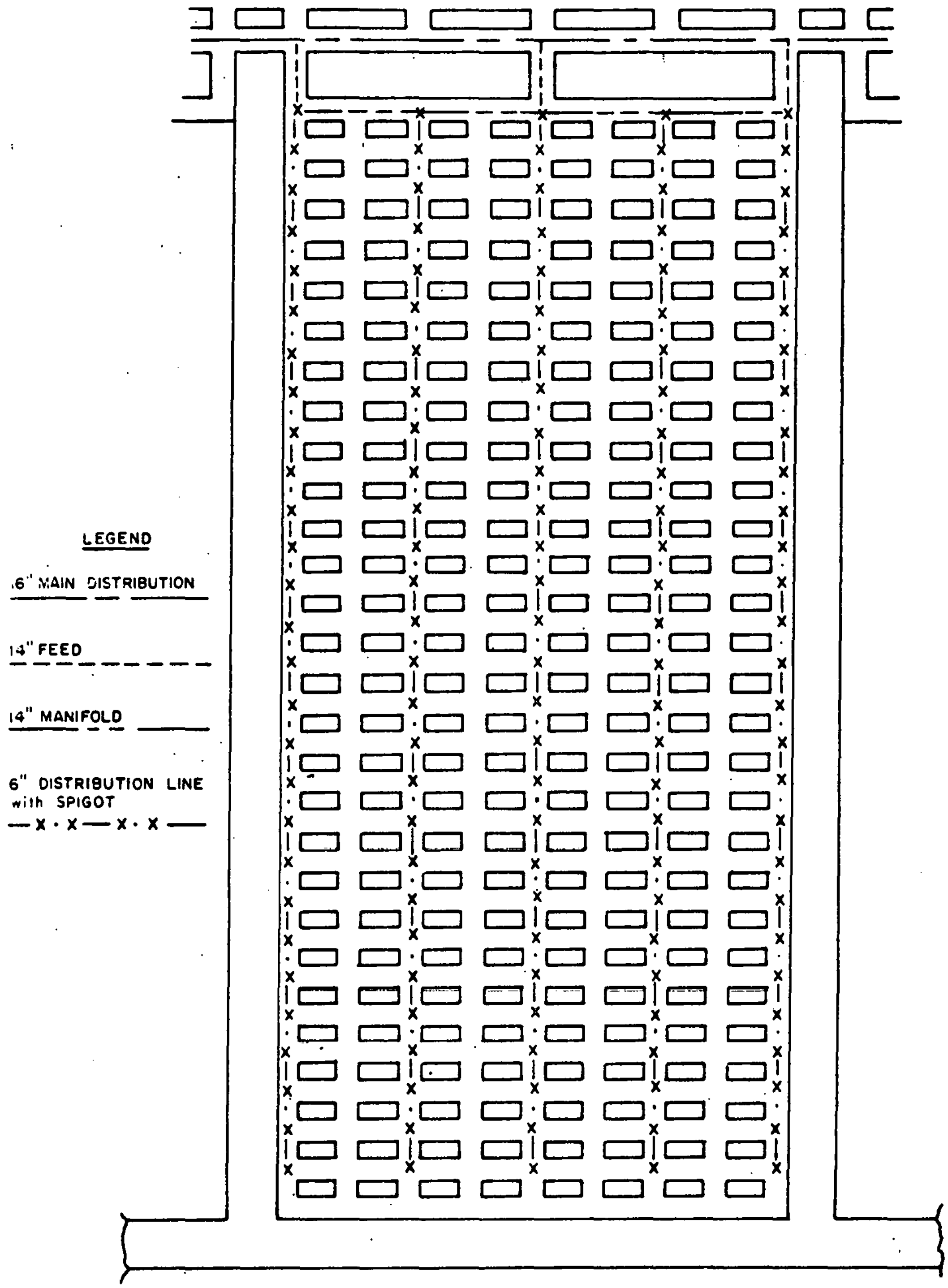


FIGURE A-14 PANEL BACKFILLING DISTRIBUTION SYSTEM

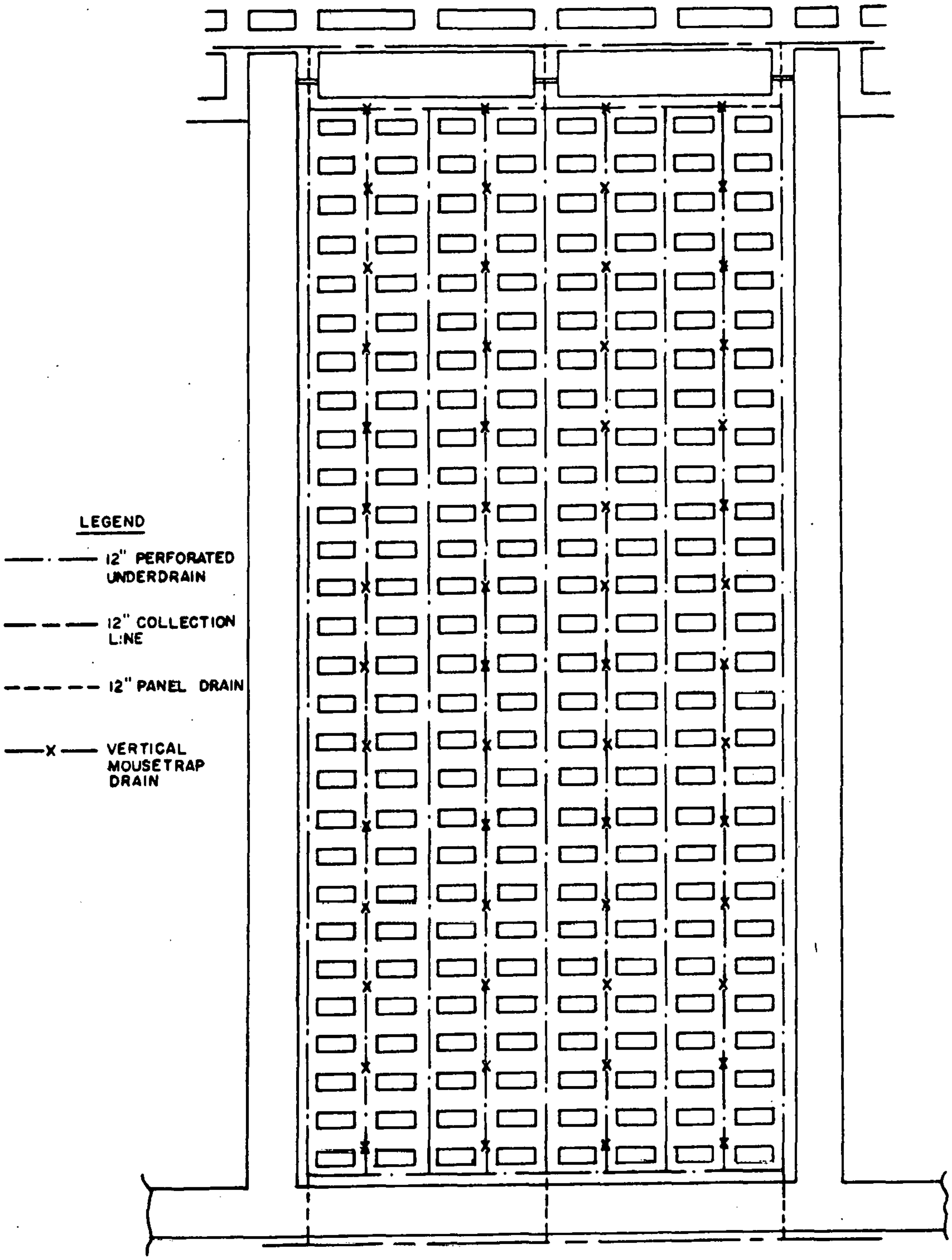


FIGURE A-15 PANEL BACKFILLING DEWATERING SYSTEM

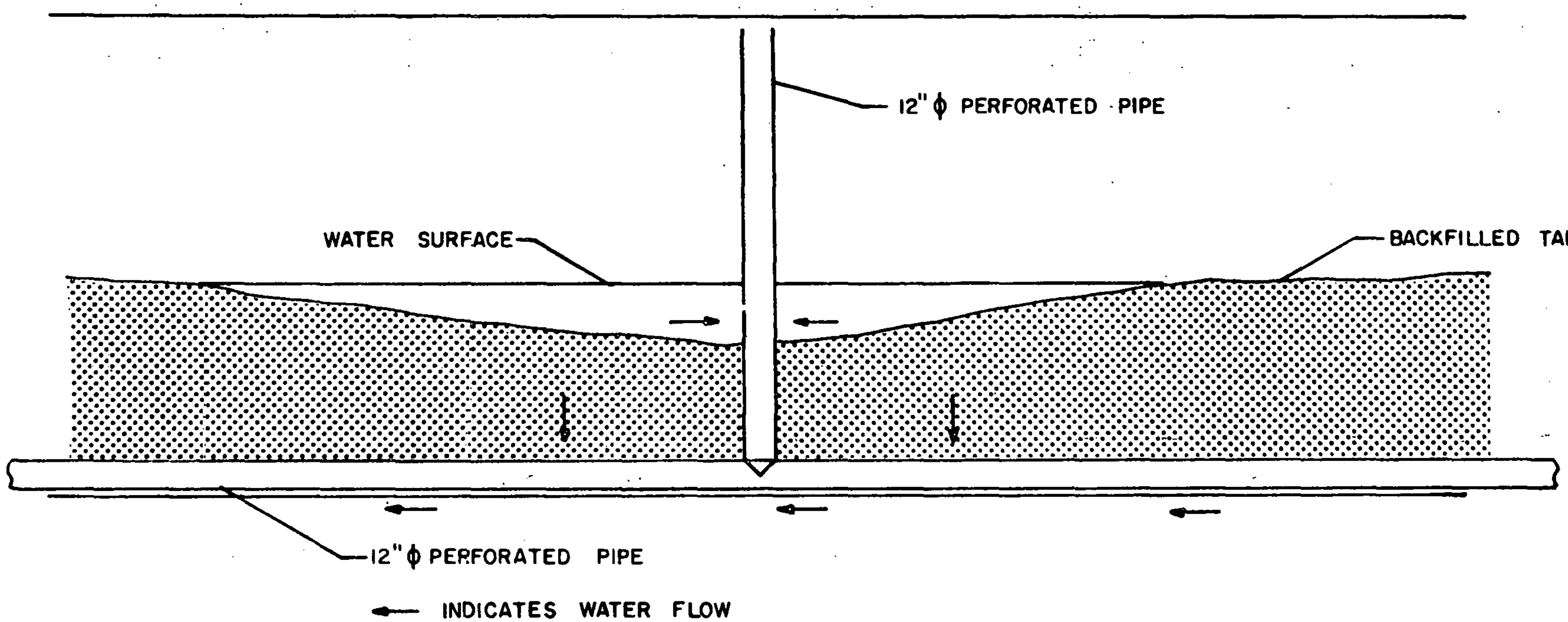


FIGURE A-16 VERTICAL MOUSETRAP DRAIN DETAIL the loss of fine material from the fill. Water will be removed from the panel through pipes set in holes bored through the rear barrier pillar and through the panel entry bulkheads.

Timber bulkheads will be installed in each panel entry. Each bulkhead will be equipped with a drain line to facilitate fill dewatering. The side of the bulkhead away from the backfill will be supported with mine-run rock to help withstand the hydrostatic pressure of the emplaced tailings.

Each panel will be filled at a rate which will permit drainage of the excess water. The filling cycle will include periods of nonplacement to insure maximum dewatering and, therefore, maximum fill density. Normally, two panels on each side of the main entries will be filled concurrently. Based on the assumption that the backfilled material will retain approximately 15 percent of its moisture, water from the panel drainage system will be collected and pumped to the surface at a rate of 2,150 gallons per minute. This water will be returned to the process plant for recycling. All drainage and discharge pipes in a panel will be abandoned following completion of backfilling activity in that panel.

BACKFILLING COSTS

Capital and operating costs for underground disposal of 70 percent of process plant tailings have been estimated and are shown in Table A-13. Costs per ton are based on total tons of ore mined and are equally valid for a single mine or the complex of three mines as a whole. Capital costs are presented for the entire mine complex.

A workforce of 160 men will be required at each of the three mines to install, operate, and supervise the backfilling system.

TABLE A-13. CHATTANOOGA SHALE STUDY
CAPITAL AND OPERATING COSTS FOR UNDERGROUND BACKFILLING

A.	CAPITAL COSTS (Three-Mine Complex)	
	Initial Installation and Start Up	$40,461,000
	Operational Period (20-Year Life)	14,097,000
	TOTAL	$54,558,000
B.	OPERATIONAL AND MAINTENANCE COSTS (Dollars Per Ton Mined)	
	Operating Labor	$ 0.2100
	Operating Supplies	0.1920
	Maintenance Labor	0.0510
	Maintenance Supplies	0.0310
	TOTAL COST PER TON MINED	$ 0.4840

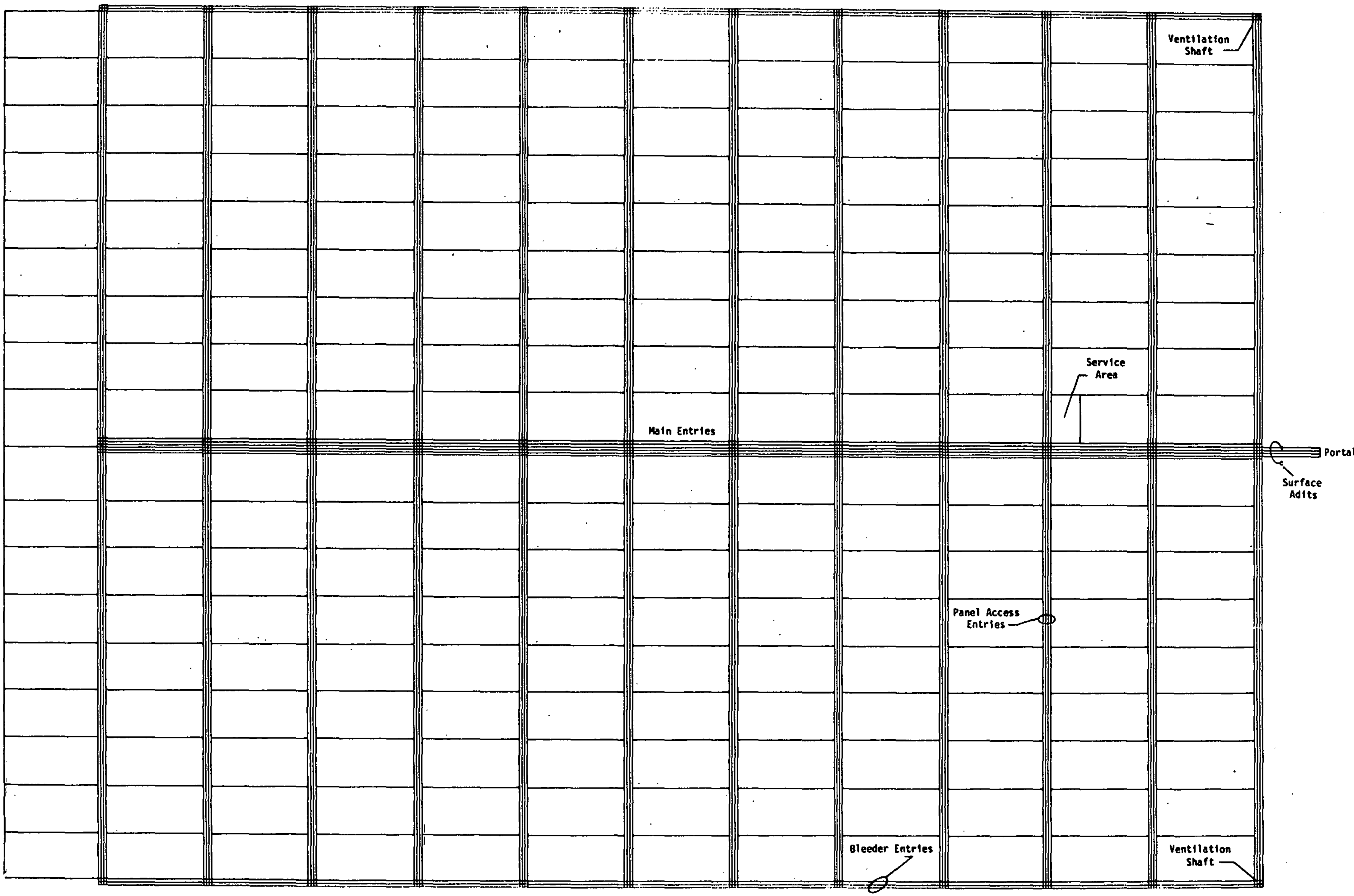


FIGURE A-17 TYPICAL MINE PLAN

REFERENCES

Blair, B.E. "Physical Properties of Chert, Shale and Limestone from the Pine Creek and Sligo Sites in DeKalb County, Tennessee." Report No. E12.2 (El-99), U.S. Bureau of Mines, College Park, Maryland. 1954.

Conant, L.C. and V.E. Swanson. "Chattanooga Shale and Related Rocks of Central Tennessee and Nearby Areas." U.S.G.S. Project Paper 357. 1961.

Moore, G.K. and J.M. Wilson. "Water Resources of the Center Hill Lake Region, Tennessee." Water Resources Series No. 9, Tennessee Division of Water Resources. 1972.

Wilson, C.W. "Mineral Resources Summary - Smithville and Sligo Bridge Quadrangles, Tennessee." Tennessee Division of Geology, Nashville, Tennessee. 1968.

APPENDIX B

SOILS DATA

TABLE B-1. COMPOSITION AND CHARACTERISTICS OF SUBUNIT DOMINATED BY UTISOLS

Map Unit Symbol	Map Unit Name	Physical Character		General Use and Suitability
		Relief	Parent Material	
U9	Paleudults Other	Rolling to steep	Marine and fluvial deposits	Primarily in forest with limited suitability for pasture and row crops.
U13	Paleudults Eutrochrepts Hapludults Other	Rolling karst upland and hills	Cherty limestone shale and shaley limestone	Limited cropland of corn, soybeans and tobacco. Mostly pasture and forest. Shallow soils offer major limitations.
U15	Paleudults Fragiudalfs Paleudalfs Other	Nearly level to hilly	Marine sediments and thin	Primarily pasture and forest crops. Row occur on nearly level well drained soils.
U16	Paleudults Paleudalfs Other	Rolling uplands and undula-ting sloping ridge tops	Limestone and thin loess caps over limestone	Generally suited for row crops and pasture. Ridge tops and steep slopes in forest.
U21	Paleudults Fragiudults Other (Thermic)	Gently sloping hilly ridges and valleys	Cherty limestone thin loess cap or lolluvium	Suitable for agricultural crops and pasture. Forest adapted to hilly areas.
U22	Paleudults Fragiudults Other (Mesic)	Hilly to undulating ridge tops	Cherty limestone and loess over limestone residuum	Pasture and general crop land (mainly corn and tobacco) with steep areas in forest.

TABLE B-1. COMPOSITION AND CHARACTERISTICS OF SUBUNIT DOMINATED BY UTISOLS (Continued)

Map Unit Symbol	Map Unit Name	Physical Character		General Use and Suitability
		Relief	Parent Material	
U27	Paleudults Hapludults Fragiudults Other	Gently rolling to steep	Limestone, shale and sandstone	Fair to good for row crops and pasture. Steep side slopes primarily in forest with limited pasture. Some low areas have severe restrictions for urban development.
U36	Hapludults Dystrochrepts Other (Steep)	Gently sloping to steep side slopes	Sandstone shale and limestone	Gently sloping. Suited for row crops, pasture and woodlands. Steep slopes best suited for forestry.
U41	Hapludults Dystrochrepts Paleudalfs Other	Gently sloping to steep	Sancstone, shales and siltstones	Broad valleys and mountain plateaus best suited to range and pasture. Gently sloping areas well suited for row crops pasture. Hay range and forest. Steep areas suited for forest.
U42	Hapludults Dystrochrepts Paleudults Other	Gently sloping to steep mountain slopes	Sandstone, limestone and shale	General row crops, hay and pasture. The steep mountain slopes are forested.
U47	Hapludults Hapludalfs Paleudults Other	Rolling to steep	Limestone	Fair to good for general row crops, pasture and forage. Steep areas in forest.

TABLE B-1. COMPOSITION AND CHARACTERISTICS OF SUBUNIT DOMINATED BY UTISOLS (Continued)

Map Unit Symbol	Map Unit Name	Physical Character		General Use and Suitability
		Relief	Parent Material	
U50	Hapludults Paleudults Dystrochrepts Other	Rolling ridges and steep side slopes	Sandstone, shale, and cherty limestone	Fair row crop and good pasture and forest production on rolling sites. Steep side slopes in forest.

TABLE B-2. COMPOSITION AND CHARACTERISTICS OF SUBUNIT DOMINATED BY INCEPTISOLS

Map Unit Symbol	Map Unit Name	Physical Character		General Use and Suitability
		Relief	Parent Material	
I27	Eutrochrepts Dystrochrepts Other	Rolling to very steep	Shaly limestone, calcareous silt-stones, acid shales	Forest; some low-grade pasture and subsistence cropping. Limiting factors; steep slopes and shallow soils.
I31	Dystrochrepts Hapludults Haplumbrepts Other	Undulating to very steep	Acid igneous, metamorphic and sedimentary rocks	Forest and pasture dominant; some subsistent cropping and fruit on smoother areas. Limiting factors: steep slopes and shallow soils.

TABLE B-3. COMPOSITION AND CHARACTERISTICS OF SUBUNIT DOMINATED BY ALFISOLS

Map Unit Symbol	Map Unit Name	Physical Character: Relief	Physical Character: Parent Material	General Use and Suitability
A36	Paleudalfs Paleudults Other	Undulating to rolling	20-40 in. of loess, over limestone & limestone residuum	Mostly corn and soybeans. Considerable tobacco and small grains. Estimated 1/3 pasture and hayland. Limitations are slight to moderate for most uses.
A46	Hapludalfs Paleudults Rockland Other	Undulating to hilly	Residuum from limestone	Mainly used for pasture and hayland with some areas of cropland on gentle slopes. Rock land areas are low quality woodland. Rock is a severe limitation for most uses whenever it occurs.
A50	Hapludalfs Rockland Paleudalfs Other	Undulating to rolling	Residuum from limestone	Hay and pasture is major land use with some cultivated crops such as corn on gentle slopes. Rockland is low quality woodland of red cedar. Steep slopes and rock outcrops are serious limitations for most uses.

APPENDIX C

METEOROLOGIC DATA

Part C-1

Location identifiers of climatic data resources in the Chattanooga Shale study area

ALABAMA CLIMATIC STATIONS

STATION #	LOCATION	COUNTY	LATITUDE (deg.min)	LONGITUDE (deg.min)	ELEVATION (feet)
1	Addison	Winston	3412	8711	unk.
2	Addison Central Tower	Lawrence	3421	8720	990
3	Albertville	Marshall	3415	8613	1114
4	Arley	Winston	3404	8713	500
5	Ashville	St. Clair	3350	8616	570
6	Birmingham	Jefferson	3332	8650	694
7	Boaz	Marshall	3413	8610	1075
8	Bridgeport	Jackson	3456	8545	660
9	Carbon Hill	Walker	3354	8732	430
10	Collinsville	DeKalb	3415	8552	734
11	Cordova	Walker	3346	8711	334
12	Decatur	Morgan	3437	8658	573
13	Falls City	Winston	3404	8720	650
14	Florence	Lauderdale	3448	8740	581
15	Florence Lock	Lauderdale	3447	8740	450
16	Fort Payne	DeKalb	3426	8543	879
17	Godsden	Etowah	3401	8600	554
18	Gorgas	Walker	3339	8713	300
19	Guntersville	Marshall	3421	8618	580
20	Haleyville	Winston	3414	8737	947
21	Huntsville	Madison	3442	8635	610
22	Leeds	Jefferson	3333	8633	636
23	Leesburg	Cherokee	3411	8546	589
24	Madison	Madison	3442	8645	573
25	Magella	Jefferson	3330	8651	654
26	Maple Grove	Cherokee	3412	8548	620
27	McCalla	Jefferson	3321	8659	550
28	Oneonta	Blount	3357	8629	857
29	Palmerdale	Jefferson	3344	8641	798
30	Parrish	Walker	3343	8713	unk.
31	Sayre	Jefferson	3343	8658	304
32	Scottsboro	Jackson	3441	8602	660
33	Trafford	Jefferson	3349	8644	490
34	Valley Head	DeKalb	3434	8536	1031
35	Walnut Grove	Etowah	3404	8619	850
36	Waterloo	Lauderdale	3455	8804	445

GEORGIA CLIMATIC STATIONS

STATION #	LOCATION	COUNTY	LATITUDE (deg.min)	LONGITUDE (deg.min)	ELEVATION (feet)
1	Beaverdale	Whitfield	3455	8451	800
2	Chatsworth	Murray	3446	8446	750
3	Curryville	Floyd	3427	8506	700
4	Dalton	Whitfield	3446	8459	759
5	Fairmount	Gordon	3426	8442	735
6	LaFayette	Walker	3442	8578	810
7	Resaca	Murray	3435	8457	650
8	Rome	Floyd	3415	8510	615
9	Summerville	Chattooga	3429	8522	700

KENTUCKY CLIMATIC STATIONS

STATION #	LOCATION	COUNTY	LATITUDE (deg.min)	LONGITUDE (deg.min)	ELEVATION (feet)
1	Adolphus	Allen	3639	8616	600
2	Bowling Green	Warren	3700	8626	536
3	Bowling Green Airport	Warren	3658	8626	534
4	Burnside	Pulaski	3659	8437	640
5	Campbellsville	Taylor	3720	8521	777
6	Columbia	Adair	3706	8518	729
7	Dunnville	Casey	3713	8458	unk.
8	Eadsville Lock 21	Wayne	3654	8453	622
9	Edmonton	Metcalf	3700	8537	600
10	Eubank	Pulaski	3716	8439	1177
11	Franklin	Simpson	3643	8634	691
12	Frenchburg*	Menifee	3757	8339	930
13	Glasgow	Barren	3700	8555	780
14	Greensburg	Green	3716	8530	581
15	Liberty	Casey	3721	8455	unk.
16	Monticello	Wayne	3650	8451	940
17	Munfordville	Hart	3716	8553	600
18	Russellville	Logan	3651	8653	590
19	Science Hill	Pulaski	3710	8438	1115
20	Scottsville	Allen	3645	8612	770
21	Smiths Grove	Warren	3706	8613	607
22	Stearns	McCreary	3643	8429	1375
23	Waynesburg	Lincoln	3722	8434	1215
24	Wolf Creek Dam	Russell	3652	8509	585

*Incorrectly listed in Weather Bureau publication as located in Simpson County—not in study area.

TENNESSEE CLIMATIC STATIONS

STATION #	LOCATION	COUNTY	LATITUDE (deg.min)	LONGITUDE (deg.min)	ELEVATION (feet)
1	Ashwood	Maury	3536	8709	725
2	Buffalo Valley	Putnam	3609	8548	550
3	Byrdstown	Pickett	3634	8509	1027
4	Carthage	Smith	3616	8526	540
5	Carthage Lock 7	Smith	3618	8602	480
6	Cedar Hill	Robertson	3633	8745	625
7	Celina	Clay	3633	8531	560
8	Center Hill Dam	DeKalb	3606	8549	581
9	Charleston	Bradley	3517	8446	720
10	Coldwater	Lincoln	3505	8646	645
11	Columbia	Maury	3537	8703	672
12	Cookeville	Putnam	3610	8530	1150
13	Crossville	Cumberland	3601	8508	1810
14	Dale Hollow Dam	Clay	3632	8527	580
15	Decatur	Meigs	3532	8447	875
16	Dickson	Dickson	3604	8724	800
17	Dover	Stewart	3629	8750	492
18	Fayetteville	Lincoln	3509	8634	670
19	Franklin	Williamson	3556	8651	625
20	Gainesboro	Jackson	3622	8537	500
21	Hales Bar	Marion	3503	8533	670
22	Hall's Hill	Rutherford	3552	8614	610
23	Hohenwald	Lewis	3533	8732	983
24	Kingston	Roane	3552	8431	751
25	Kingsboro Springs	Cheatham	3607	8708	450
26	Lewisburg	Marshall	3527	8648	787
27	Liberty	DeKalb	3602	8557	672
28	Linden	Perry	3537	8750	672
29	Lock B	Montgomery	3625	8717	400
30	Lock C	Montgomery	3626	8734	380
31	Lock 2	Davidson	3615	8642	430
32	Lock 3	Sumner	3617	8639	430
33	Lock 4	Sumner	3619	8628	450
34	Lock 5	Wilson	3619	8615	460
35	Lock 6	Trousdale	3621	8609	490
36	Lock 8	Smith	3617	8555	490
37	Madison College	Davidson	3616	8641	500
38	McEwen	Humphreys	3602	8739	532
39	McMinnville	Warren	3541	8548	900
40	Monteagle	Grundy	3515	8551	1918

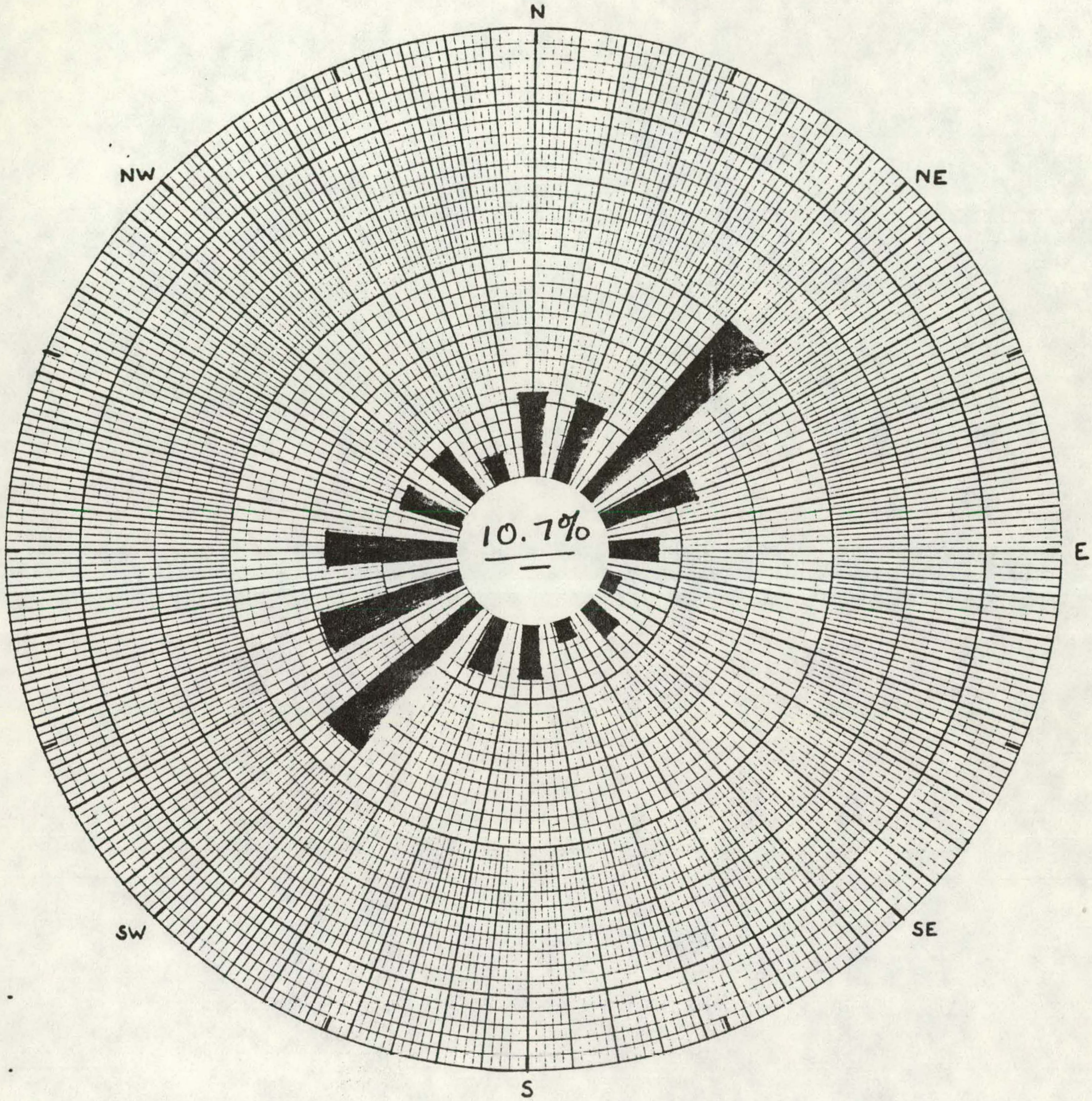
TENNESSEE CLIMATIC STATIONS
(continued)

STATION #	LOCATION	COUNTY	LATITUDE (deg.min)	LONGITUDE (deg.min)	ELEVATION (feet)
41	Monterey	Putnam	3609	8516	1868
42	Murfreesboro	Rutherford	3551	8624	608
43	Neptune	Chatham	3619	8711	408
44	New River	Scott	3623	8434	1165
45	Palmetto	Bedford	3529	8625	770
46	Perryville	Decatur	3538	8802	430
47	Point Pork	Hamilton	3500	8522	2000
48	Portland	Sumner	3635	8631	920
49	Red Boiling Springs	Macon	3634	8553	750
50	Rock Island	Warren	3548	8538	900
51	Sewanee	Franklin	3512	8555	1910
52	Smithville	DeKalb	3555	8549	1073
53	Smyrna	Rutherford	3600	8628	500
54	Sparta	White	3557	8530	900
55	Springfield	Robertson	3626	8651	1000
56	Tullahoma	Coffee	3522	8612	1075
57	Waynesboro	Wayne	3518	8748	753
58	Worsham	Sumner	3620	8641	550
59	Johnsonville	Humphreys	3601	8803	364
60	Nashville	Davidson	3607	8641	577

PART C-2

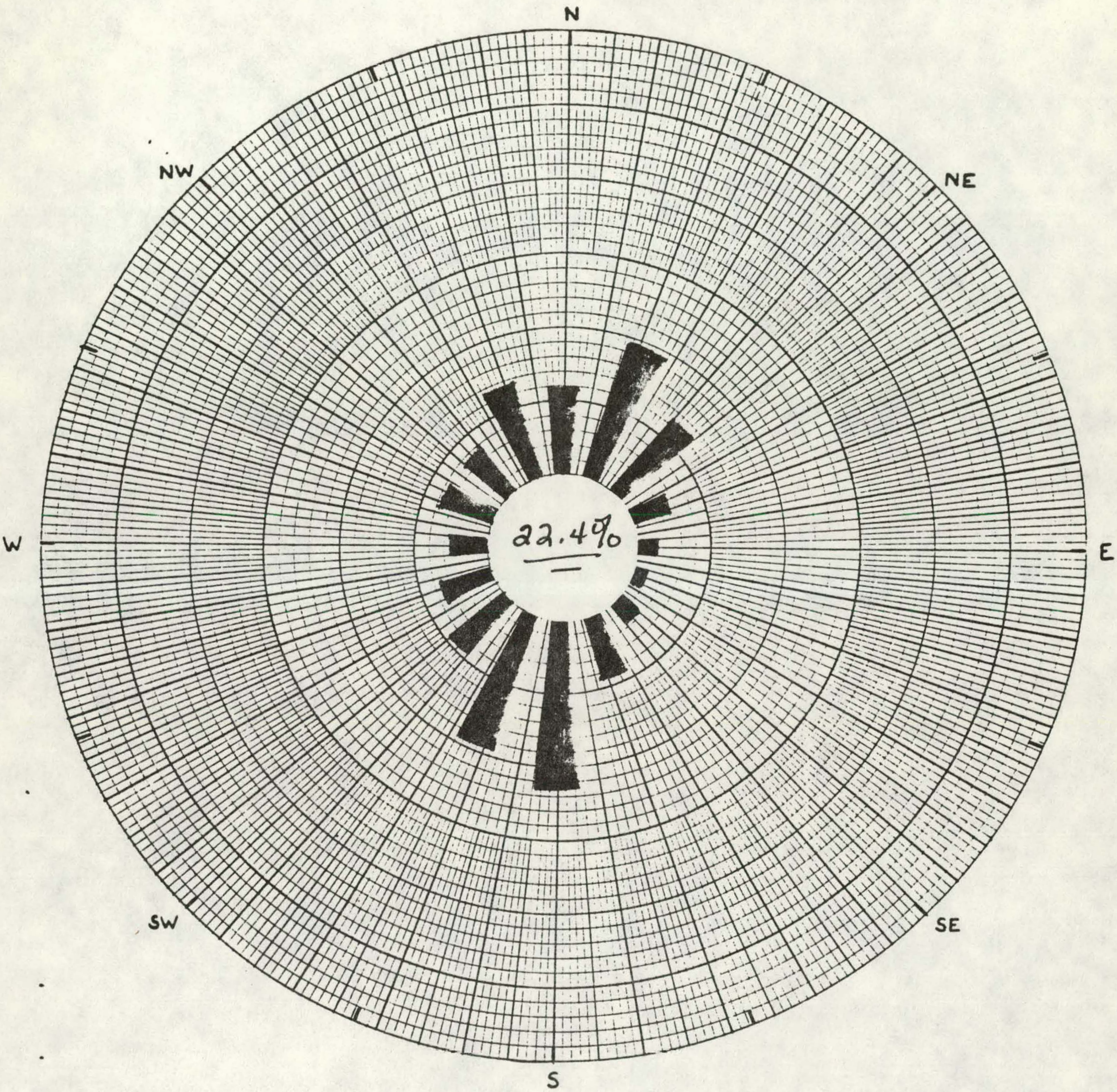
SURFACE WIND ROSES FROM STATIONS USED TO CHARACTERIZE REGIONAL WINDFIELD CLIMATOLOGY

LOCATION KNOXVILLE, TENN (1951-1960)



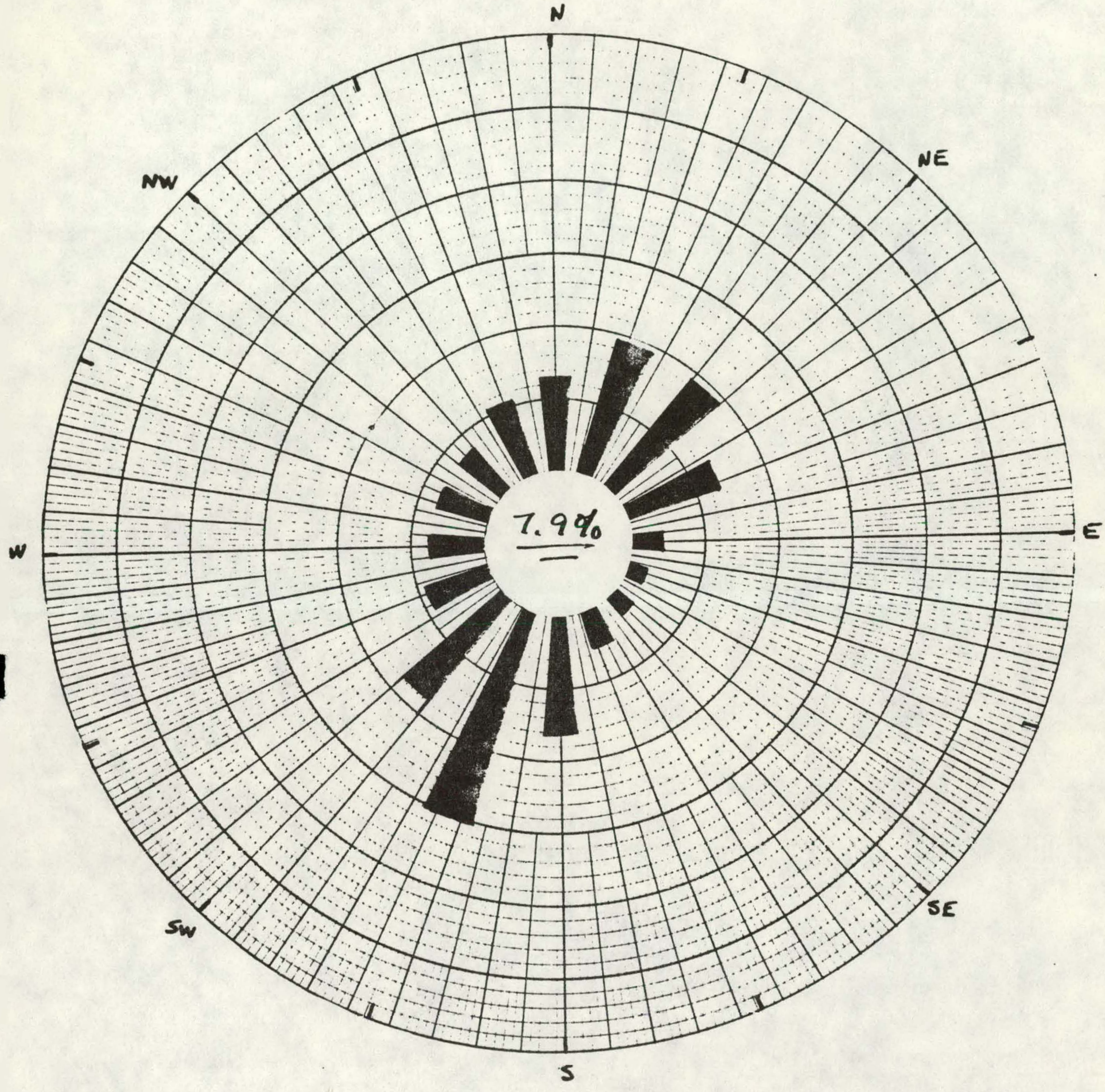
AVG. SPEED 7.5 mph

LOCATION CHATTANOOGA (1951-1960)



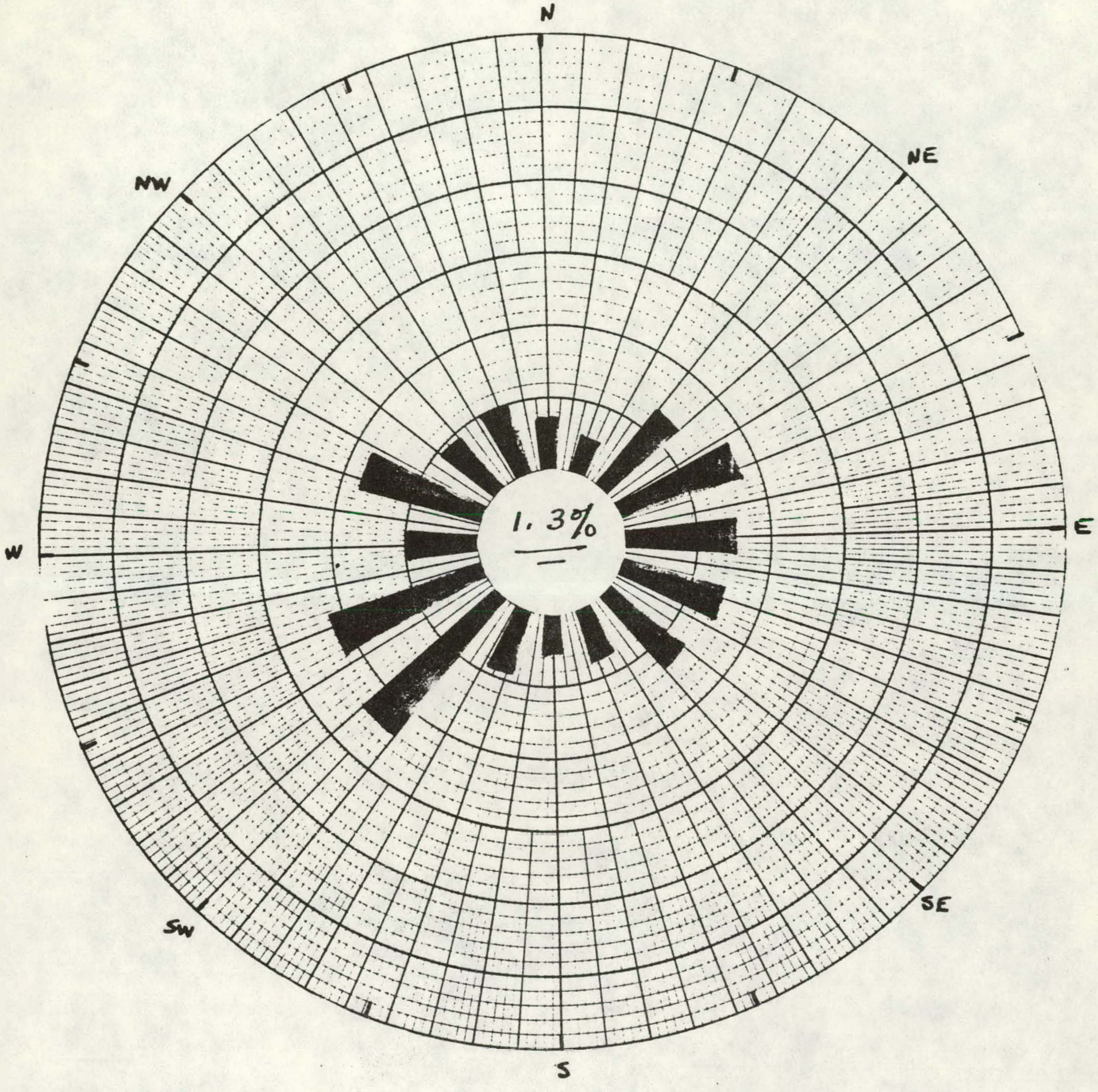
AVG. SPEED 6.1 mph

LOCATION WATTS BAR NUCLEAR PLANT



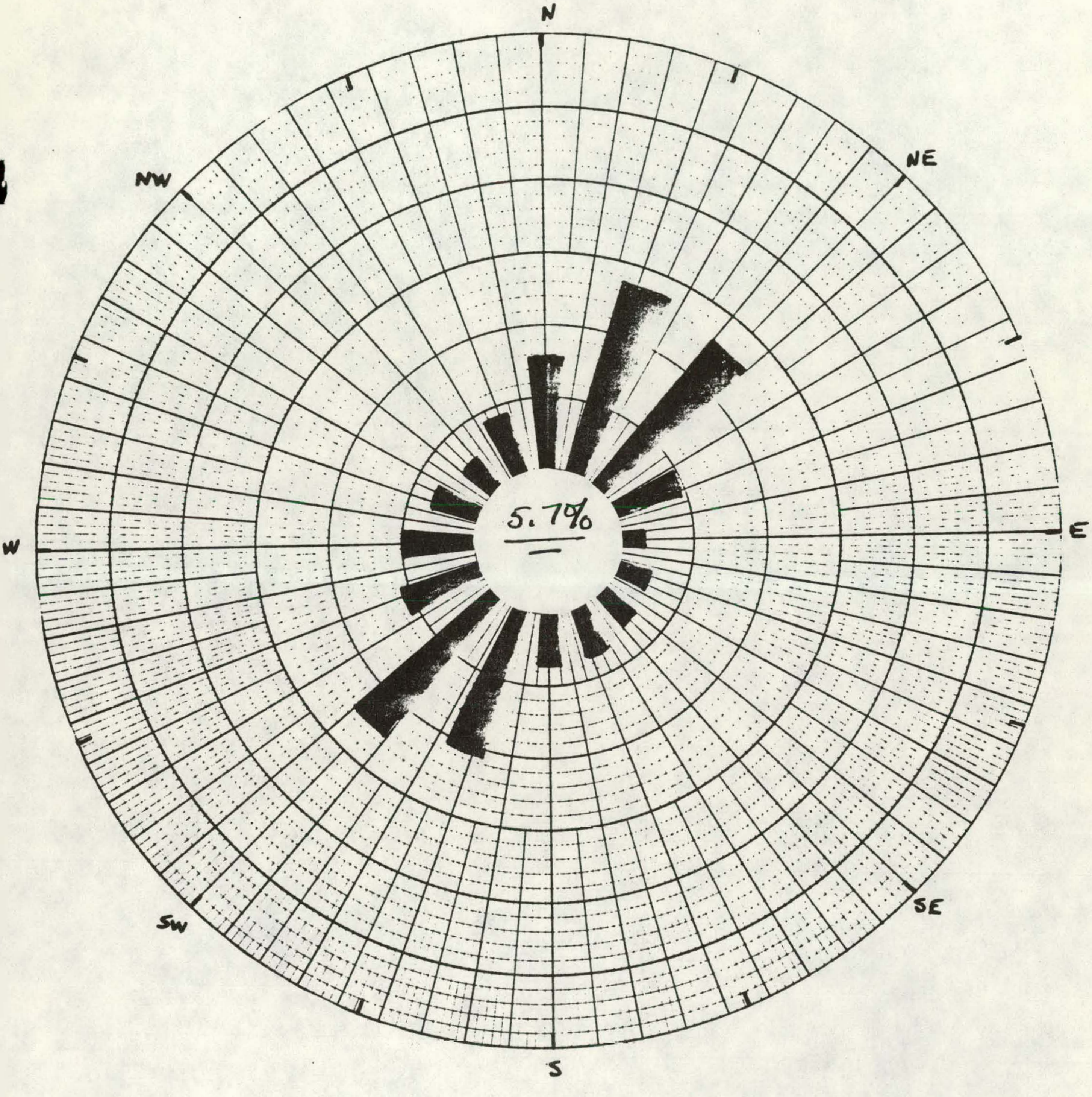
AVERAGE SPEED ~ 4.8 mph

LOCATION CLINCH RIVER (CRBRP) - OAK RIDGE

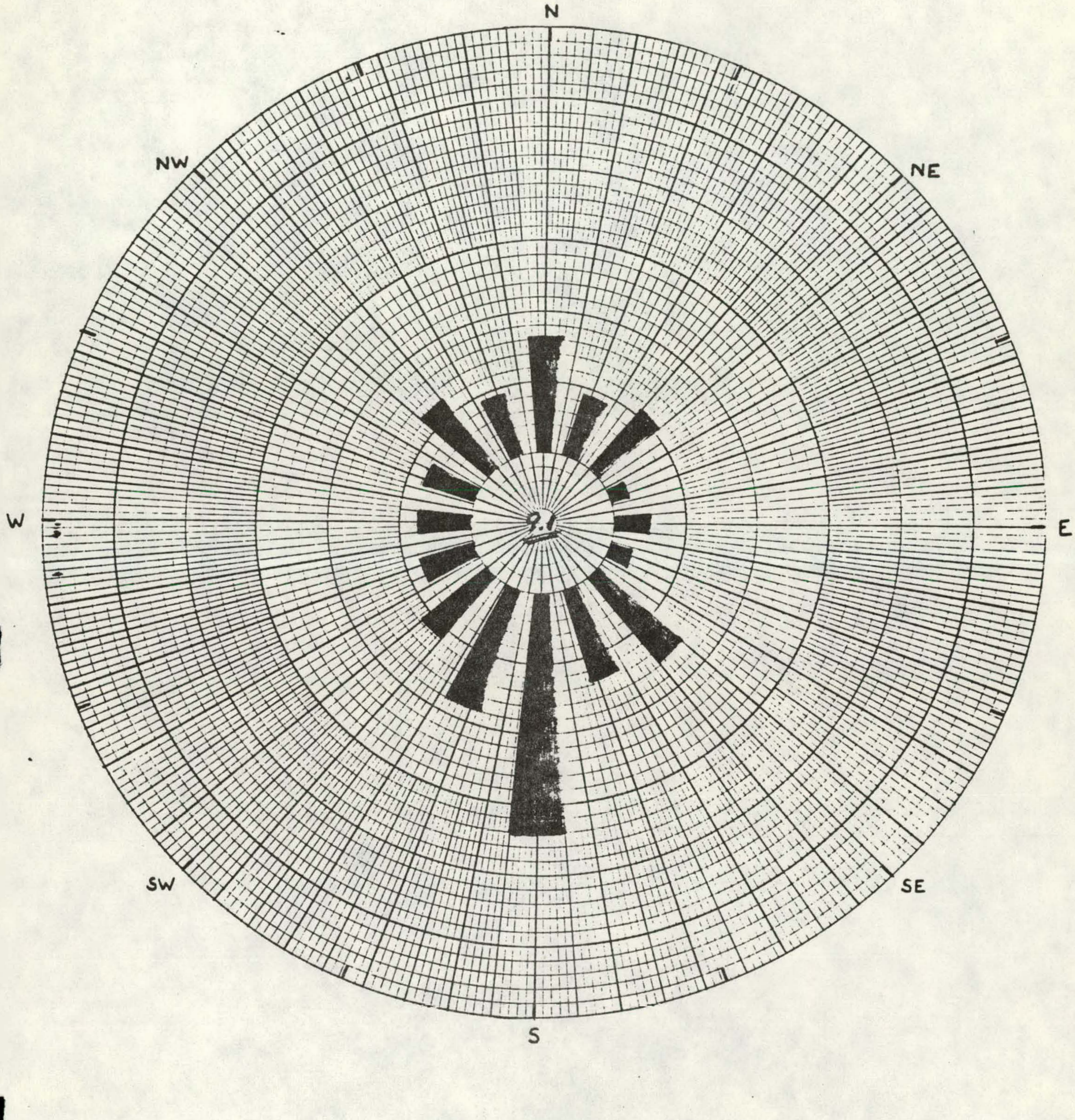


AVERAGE SPEED = 3.1 mph

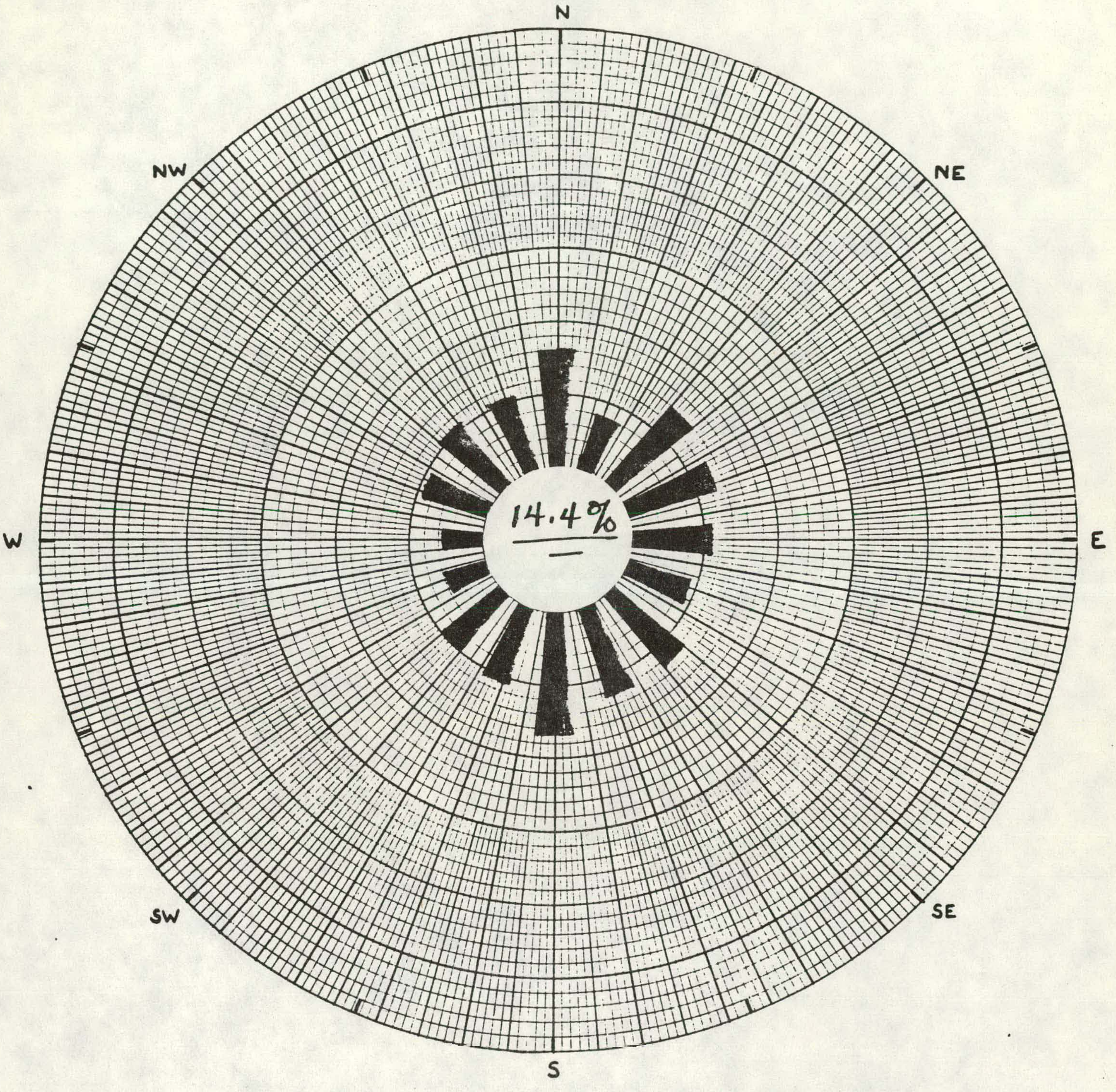
LOCATION BELLEFONTE NUCLEAR PLANT



LOCATION SMITHVILLE, TENNESSEE (5/37 - 12/40)

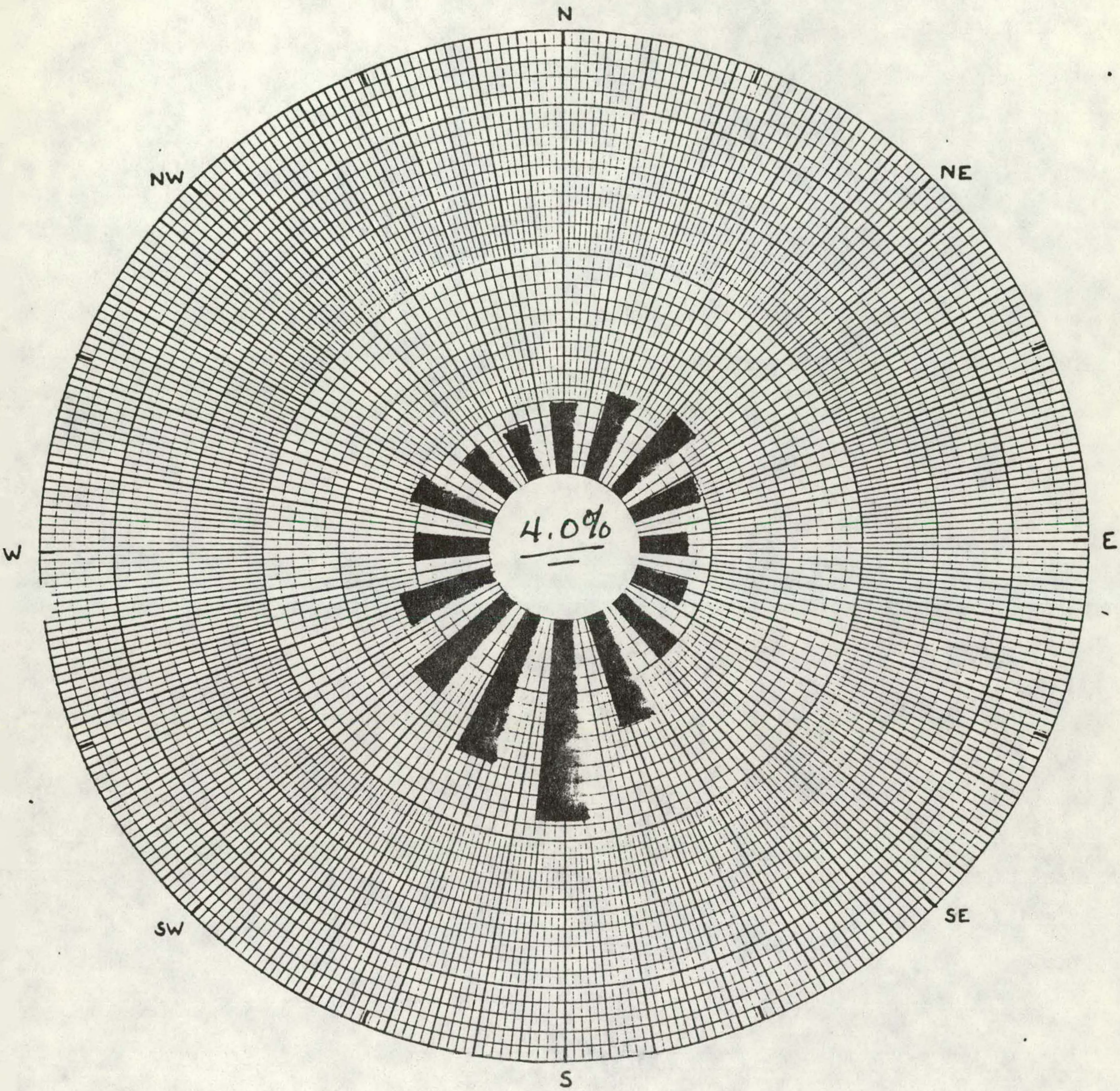


LOCATION BIRMINGHAM, ALABAMA



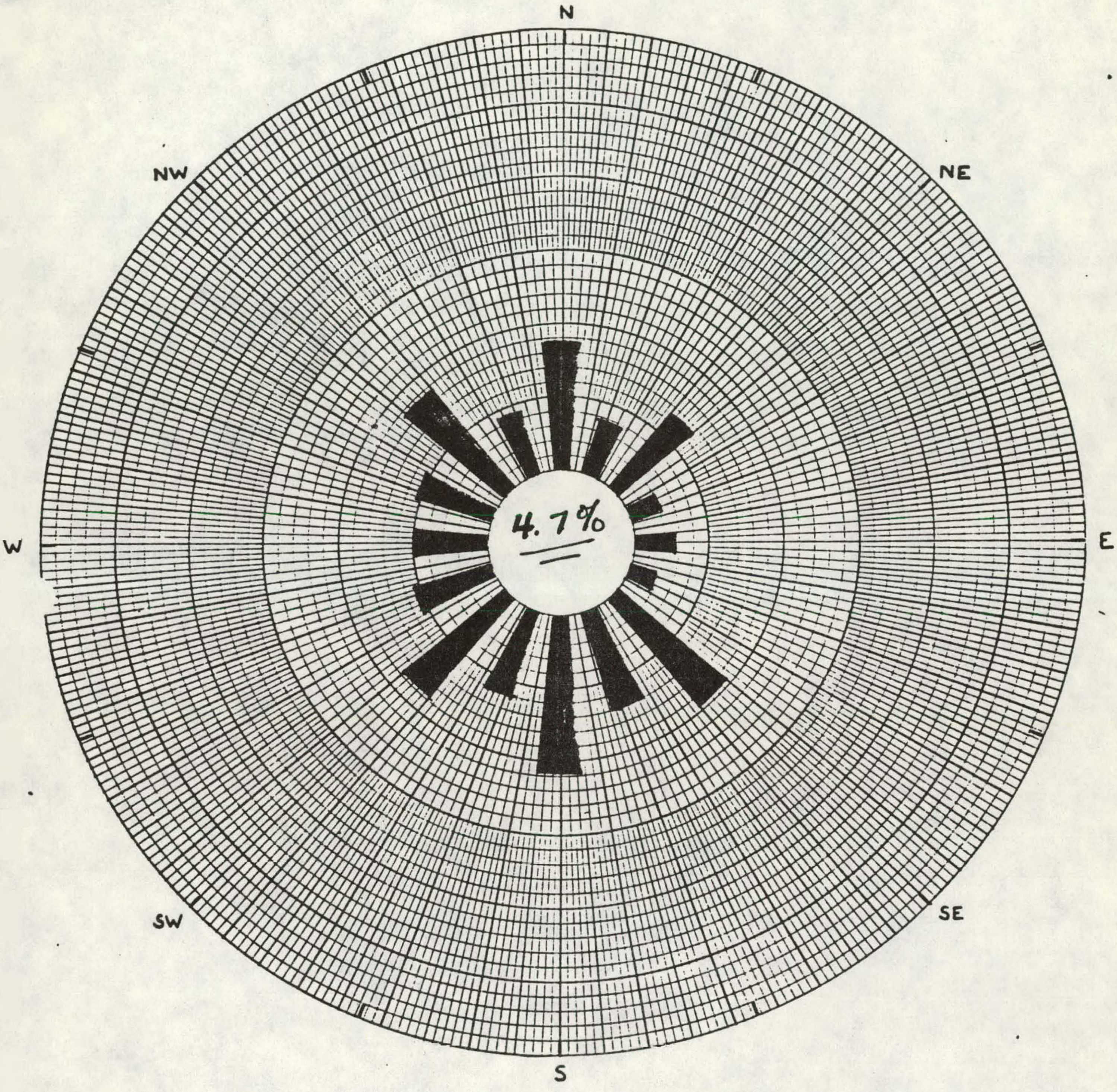
AVG. SPEED 7.9 mph

LOCATION LEXINGTON, KENTUCKY



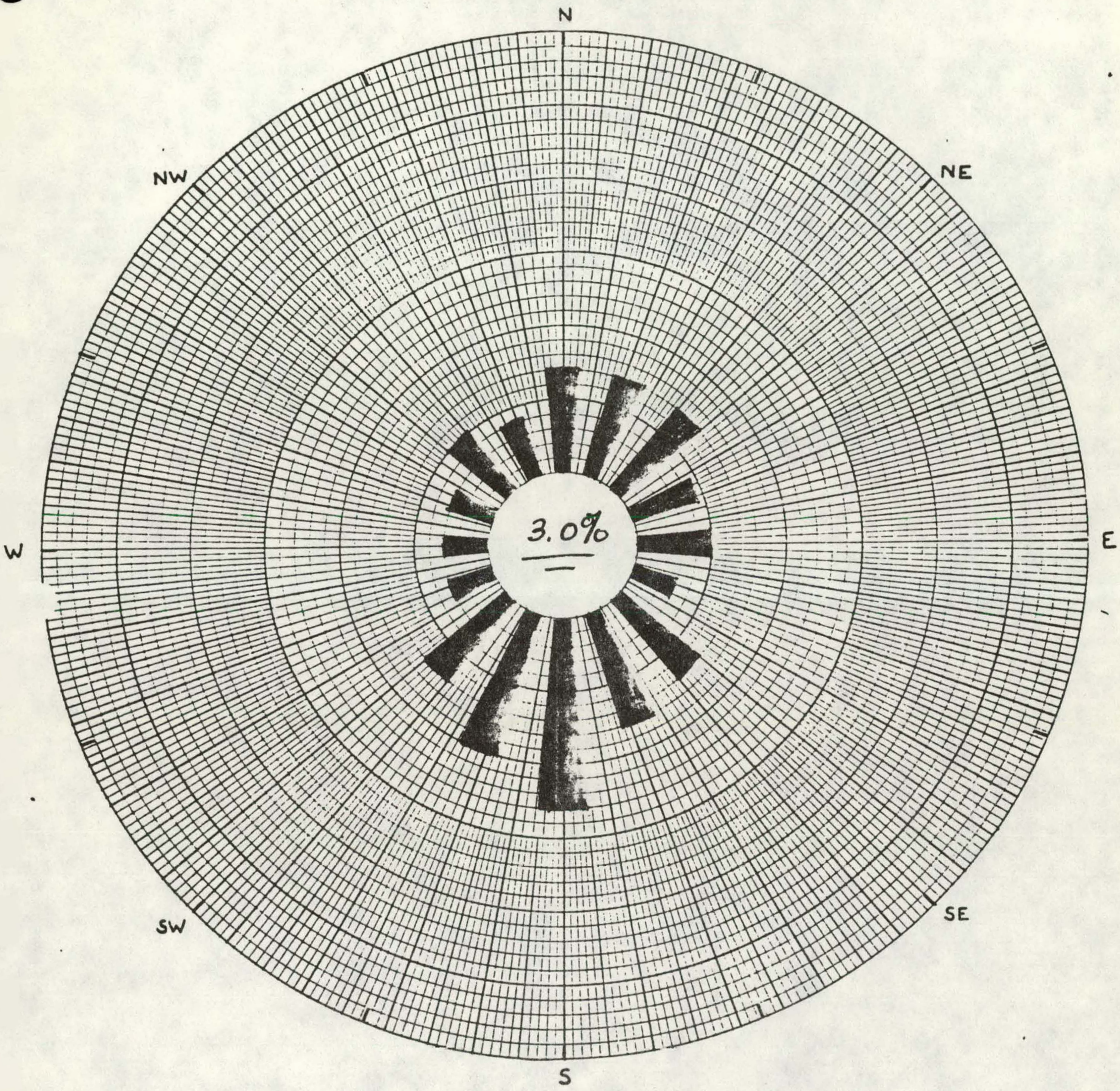
AVG SPEED - 10.1 mph

LOCATION LOUISVILLE, KENTUCKY



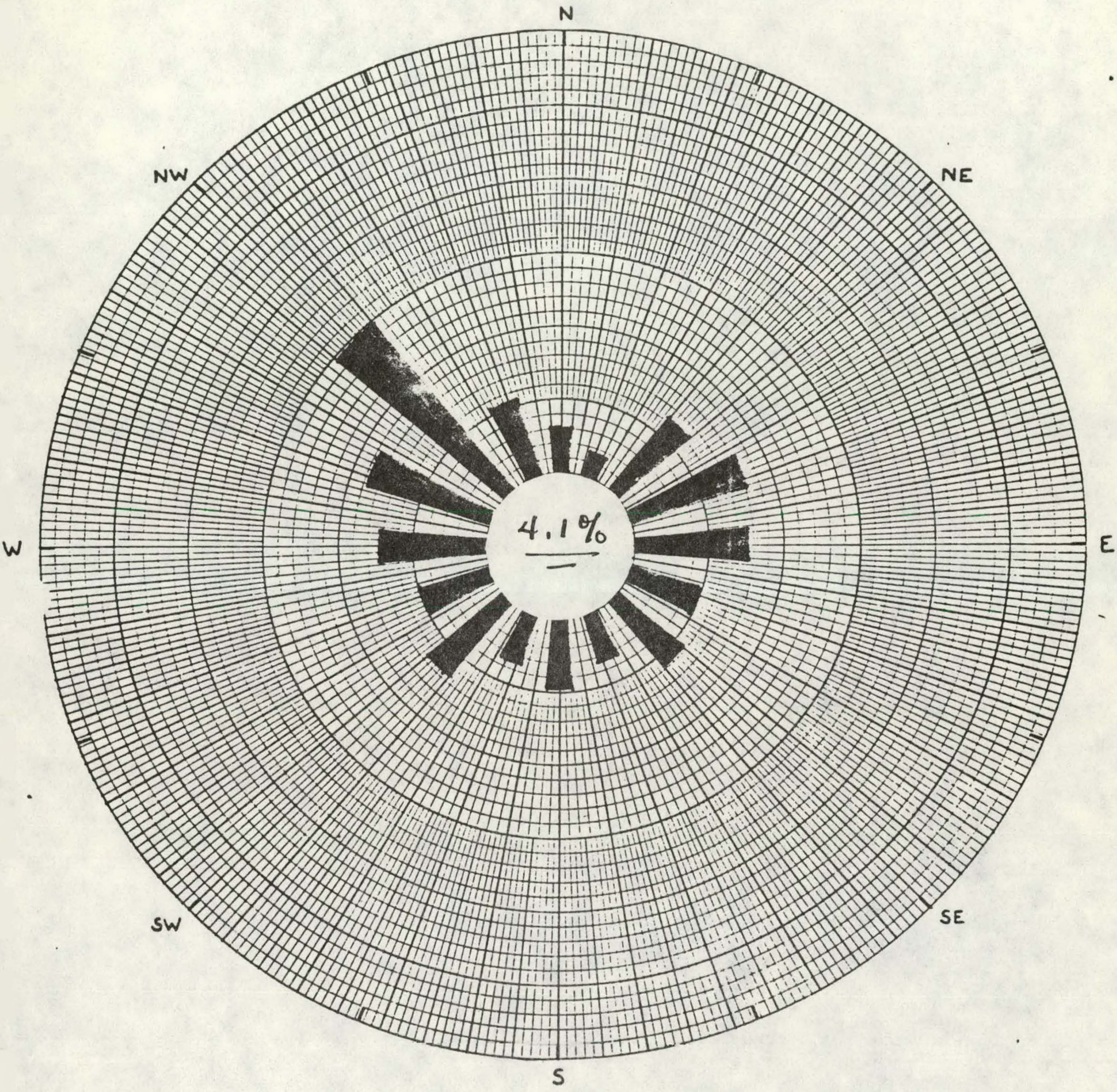
AVG. SPEED - 8.8 mph

LOCATION MEMPHIS, TENN. (1951-1960)



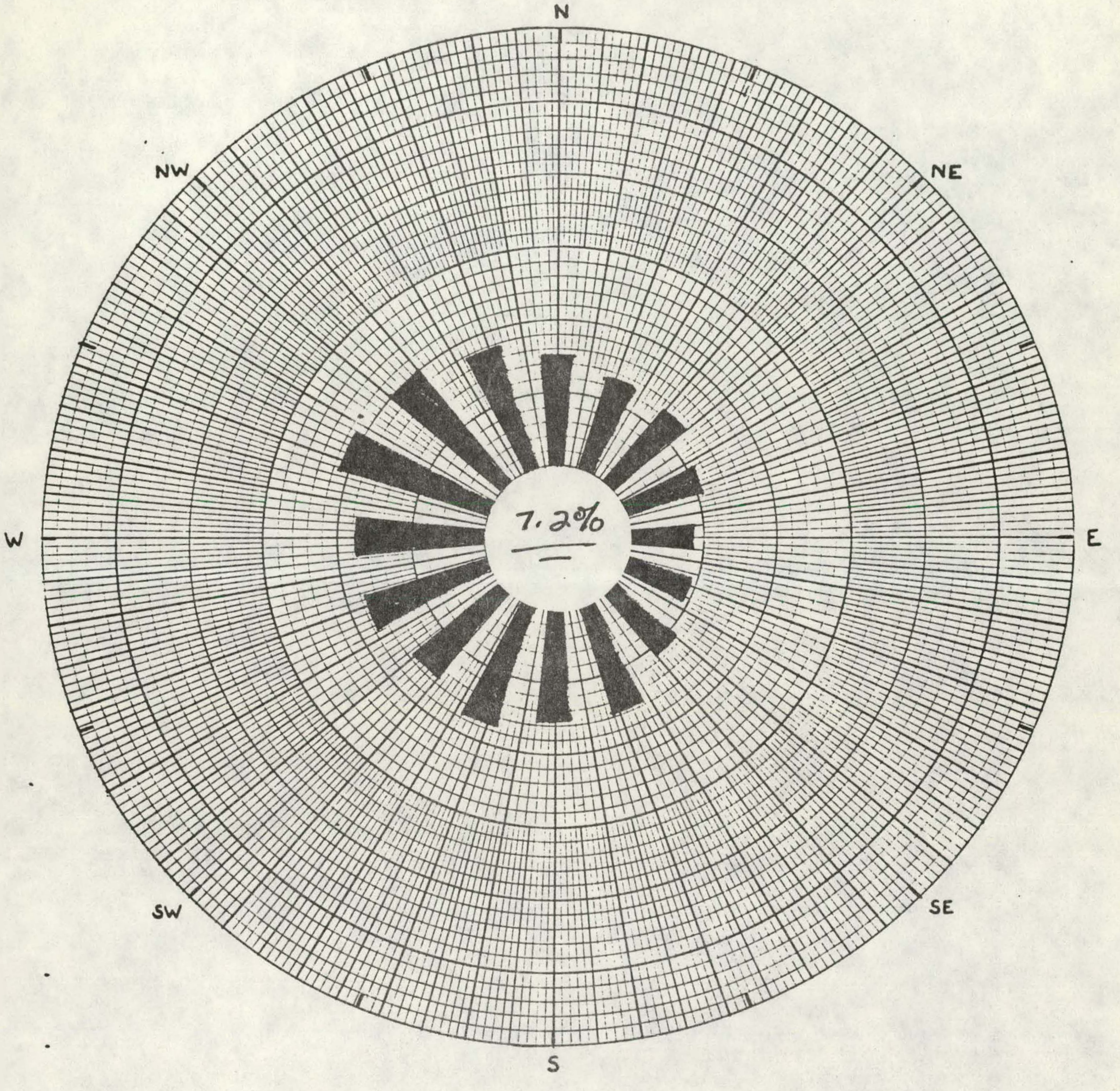
AVG. SPEED 9.4 mph

LOCATION ATLANTA, GEORGIA



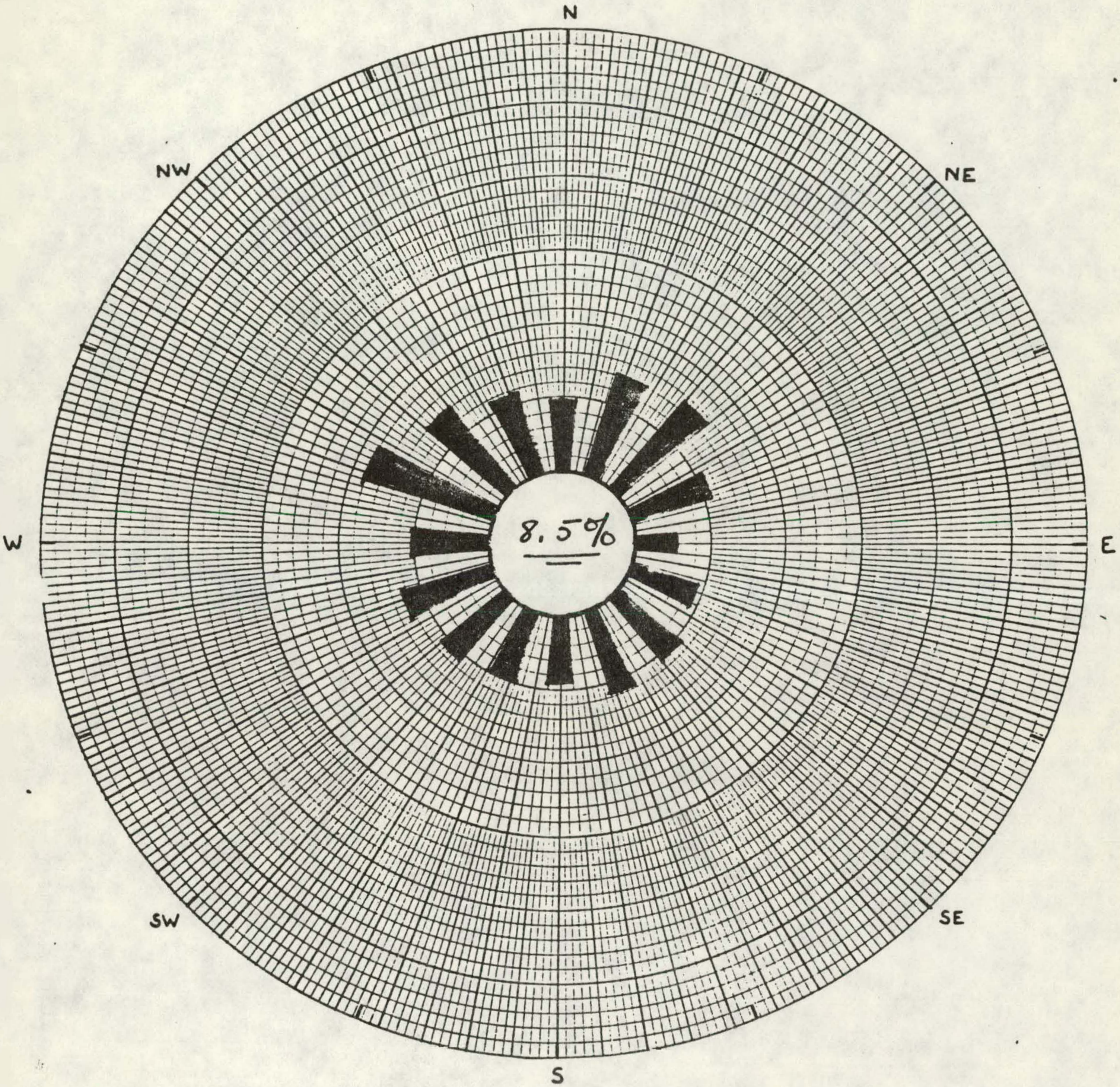
AVG. SPEED 9.7 mph

LOCATION NASHVILLE - ANNUAL - 1951-1960



AVG. SPEED 7.2 mph

LOCATION MACON, GEORGIA

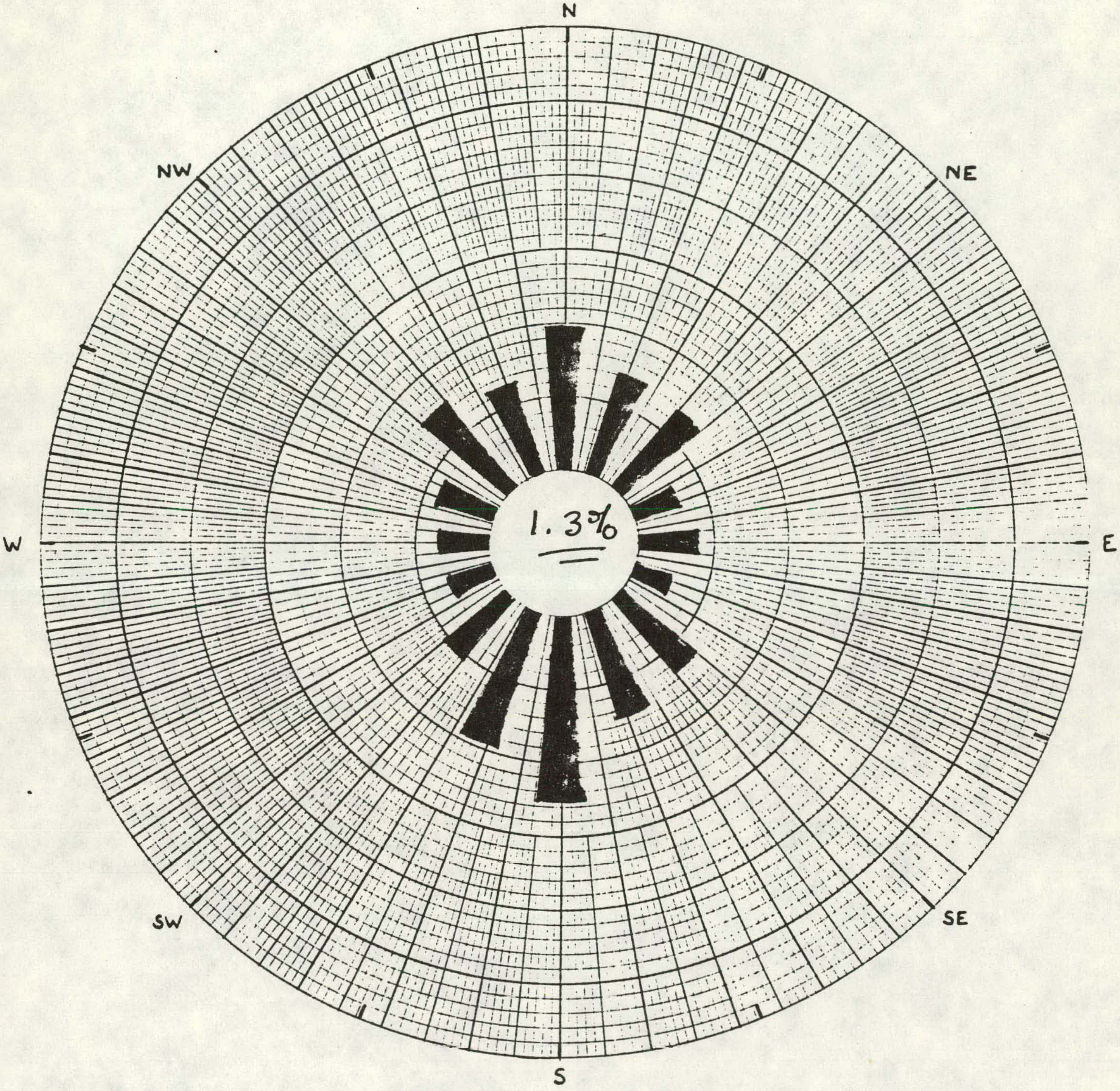


AVG. SPEED 8.9 mph

Part C-3

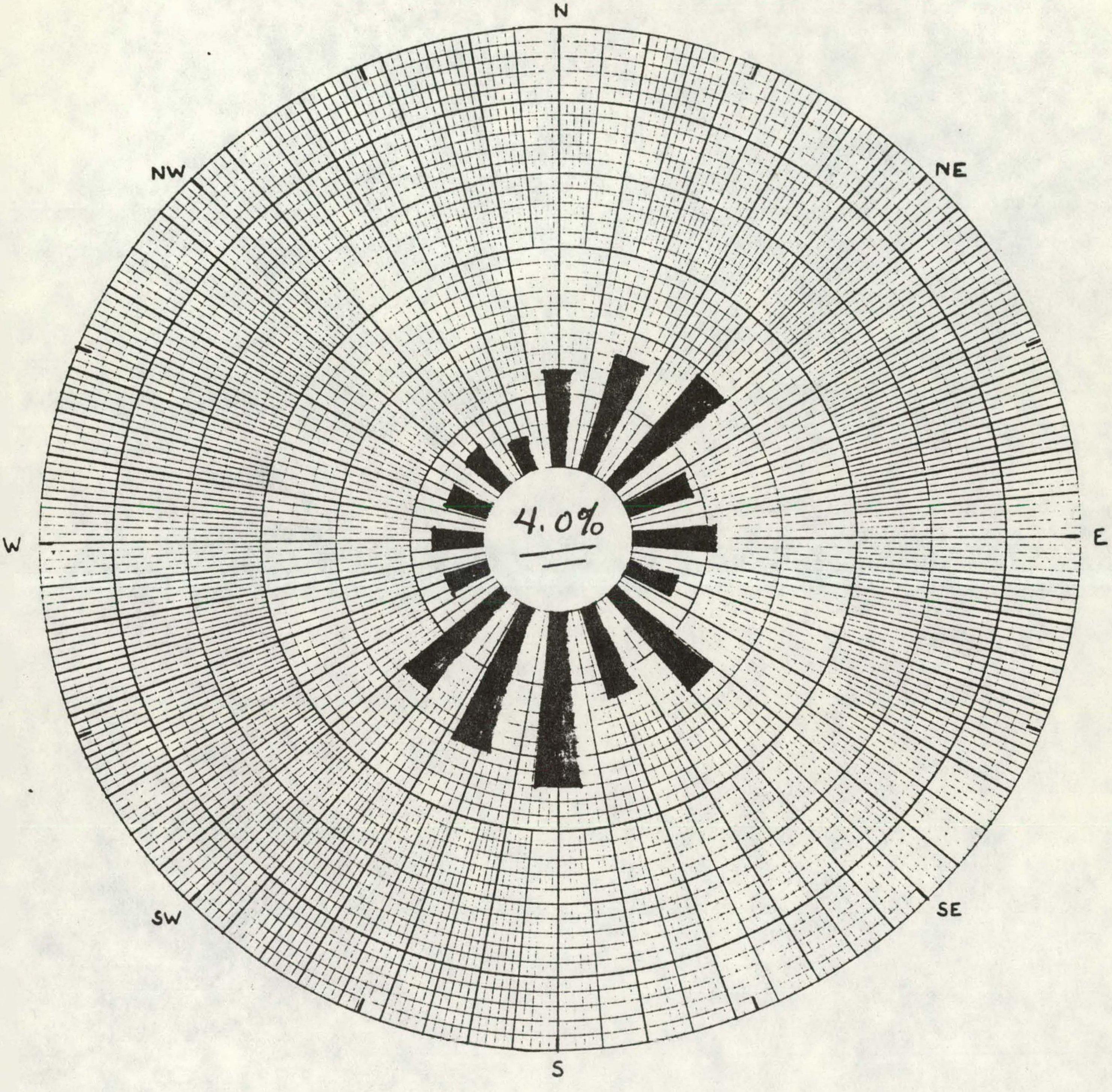
Seasonal Wind Roses for the Chattanooga Shale Resource Regional Study Area

LOCATION MEMPHIS, Winter



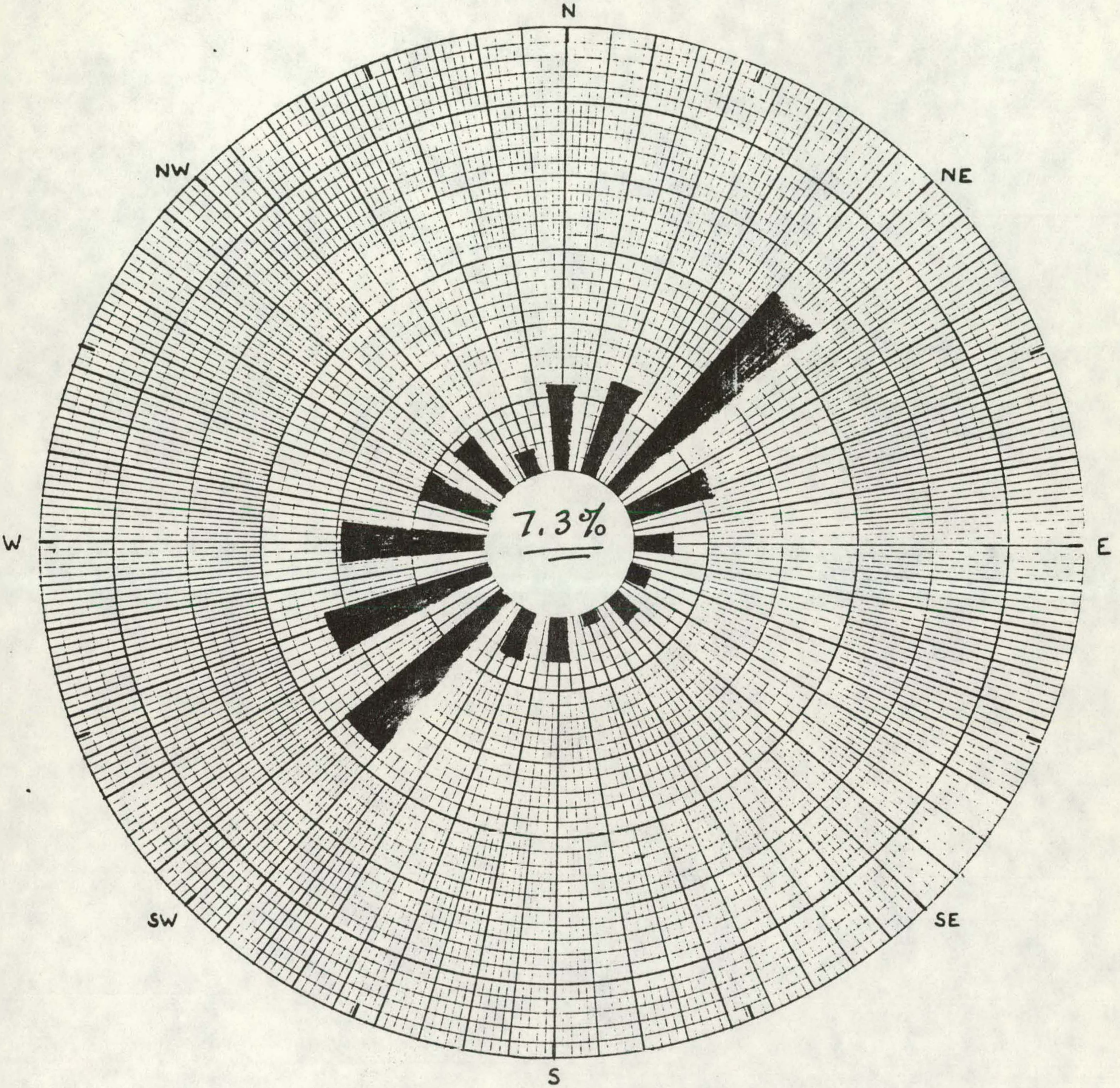
AVERAGE SPEED = 10.9 mph

LOCATION MEMPHIS, Summer



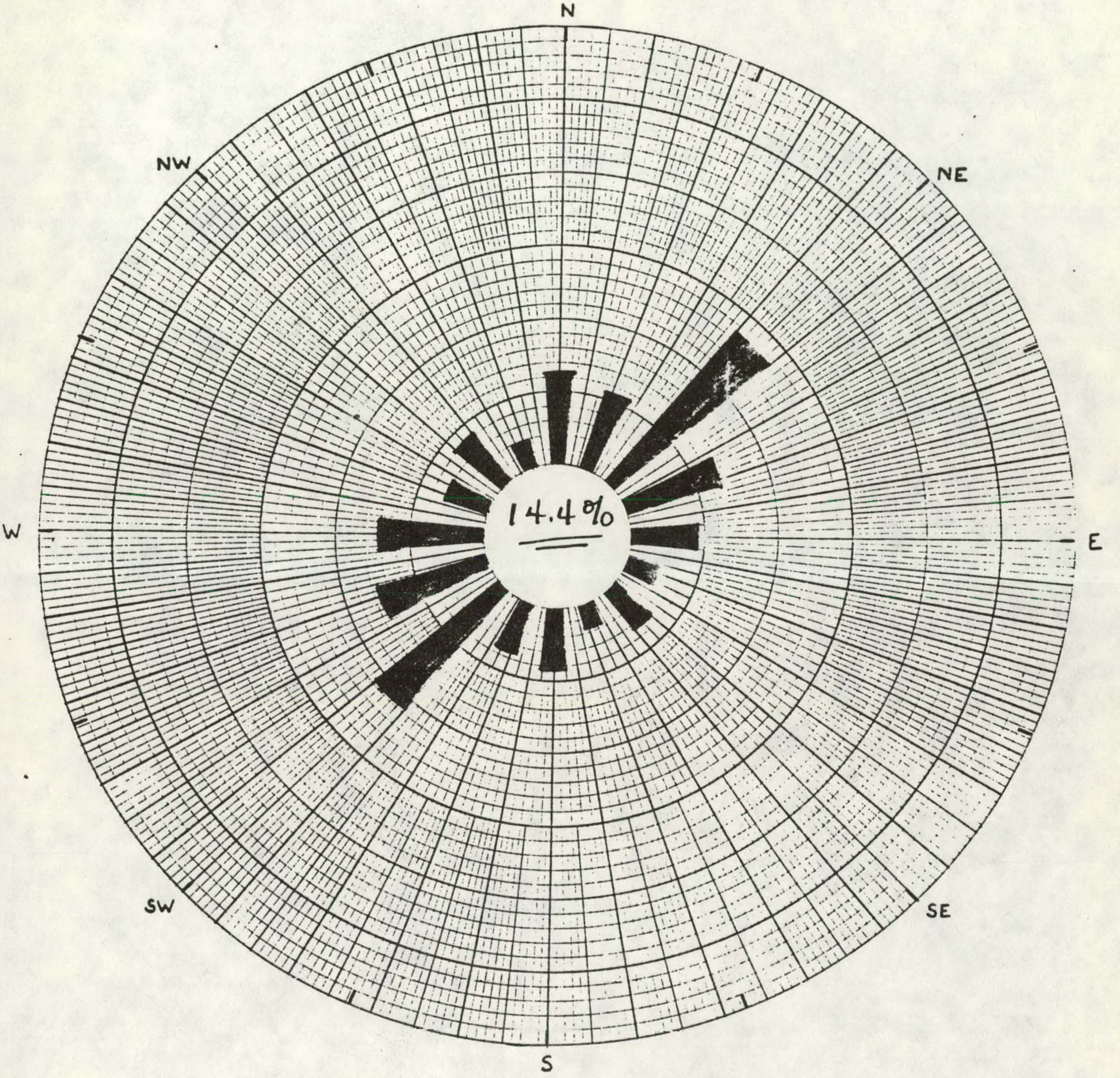
AVERAGE SPEED = 7.6 mph

LOCATION Knoxville, Winter



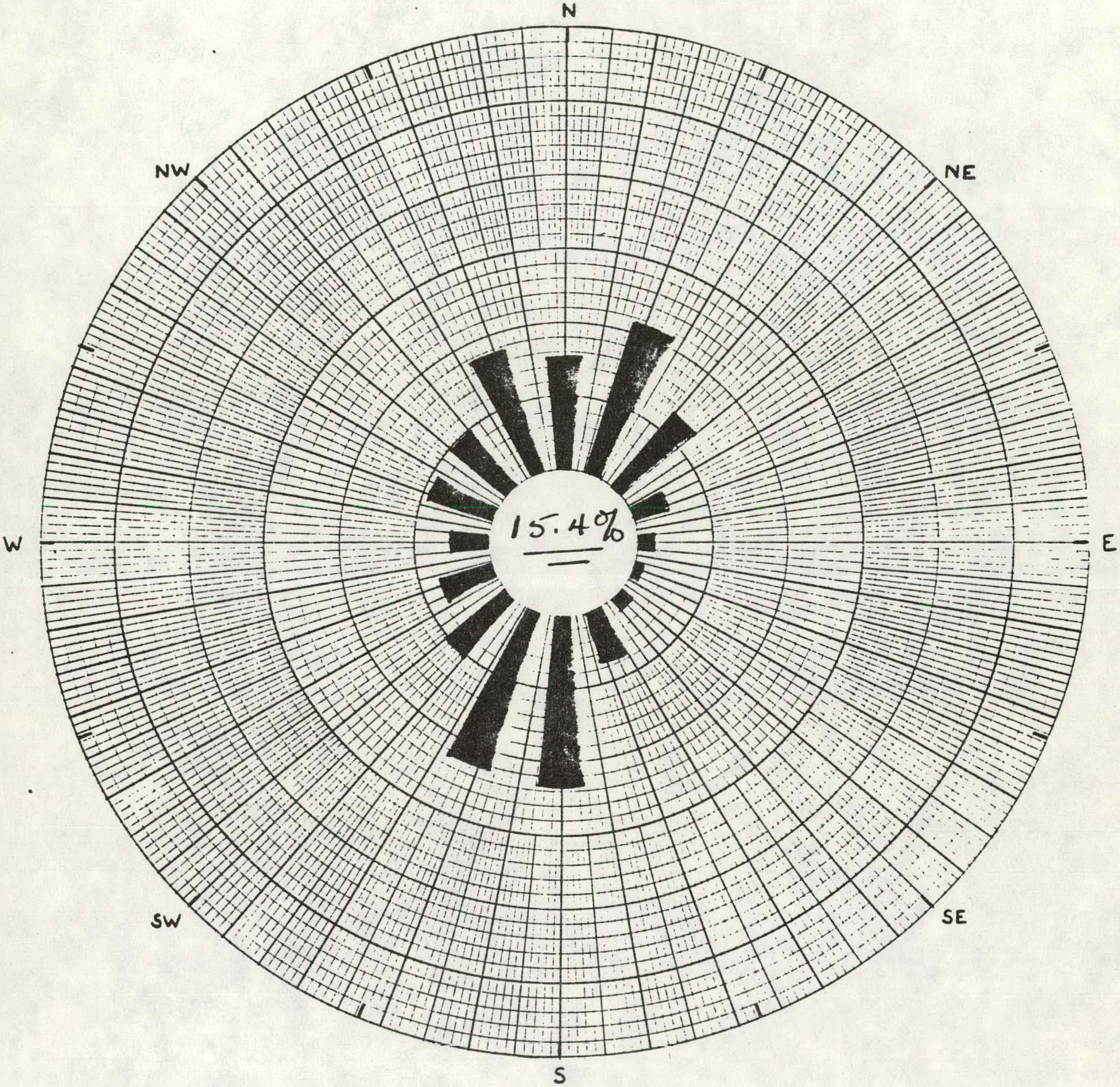
AVERAGE SPEED = 8.9 mph

LOCATION Knoxville, Summer



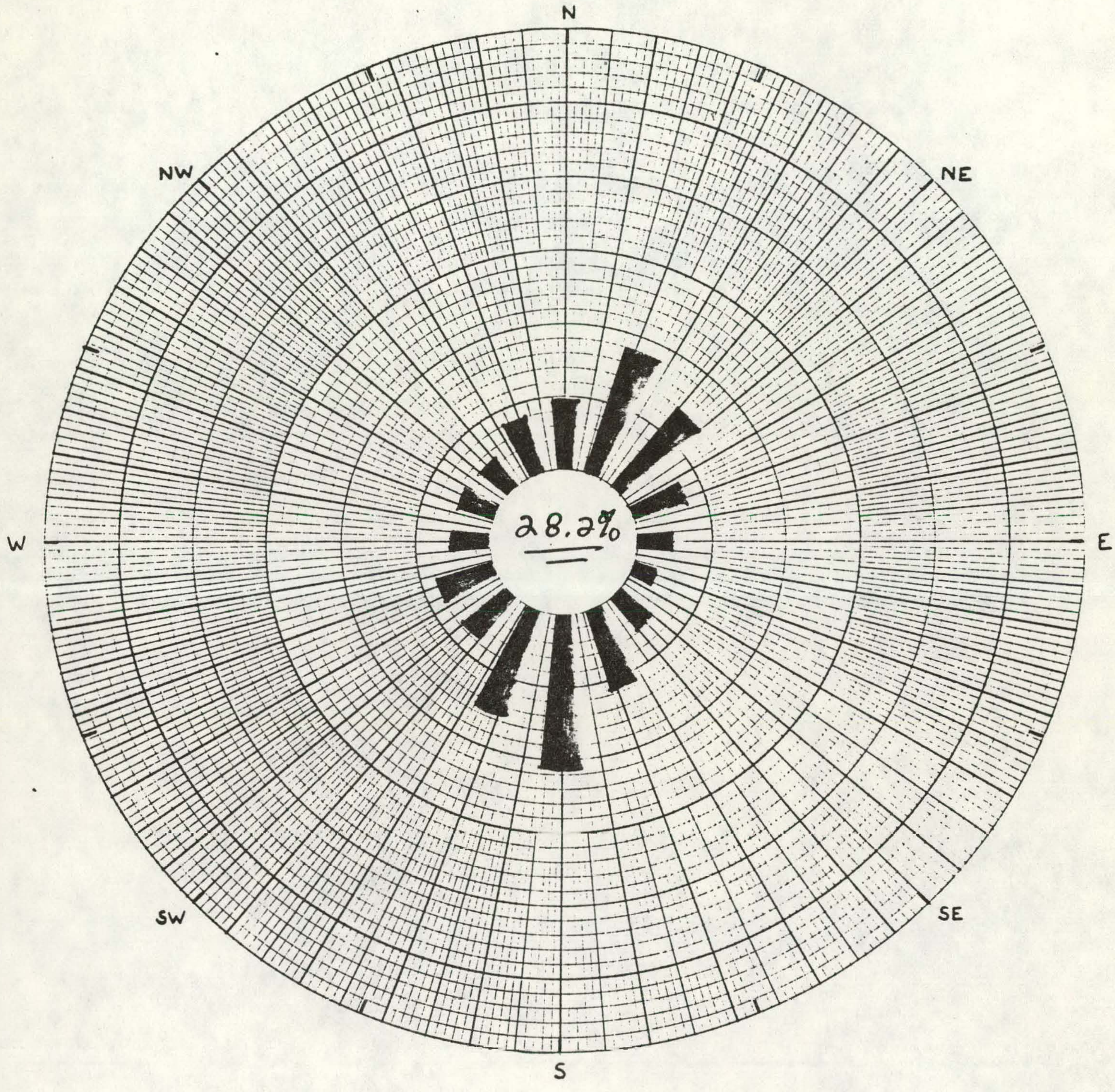
AVERAGE SPEED = 6.3 mph

LOCATION CHATTANOOGA, Winter



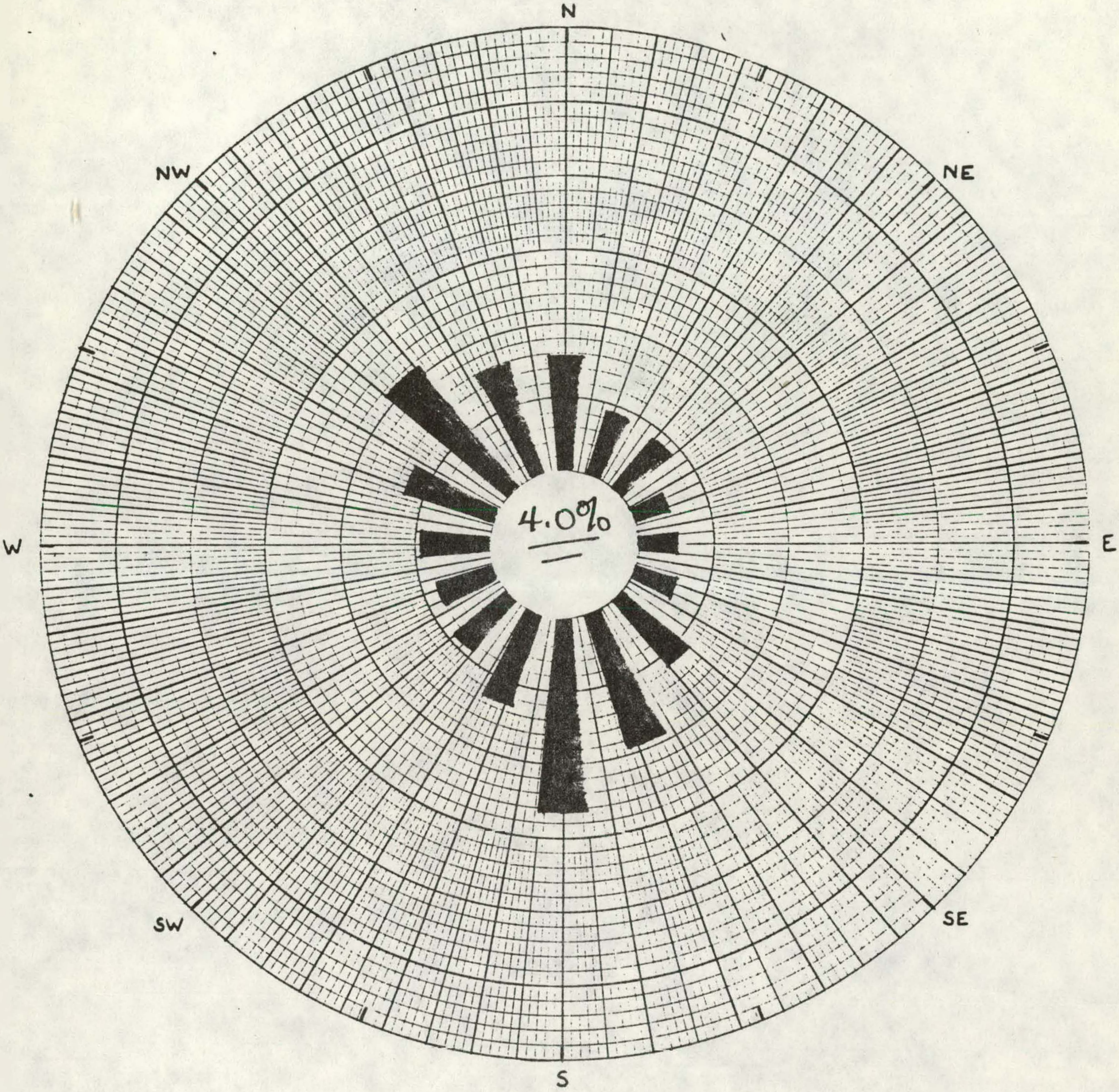
AVERAGE SPEED = 7.6 mph

LOCATION CHATTANOOGA, Summer



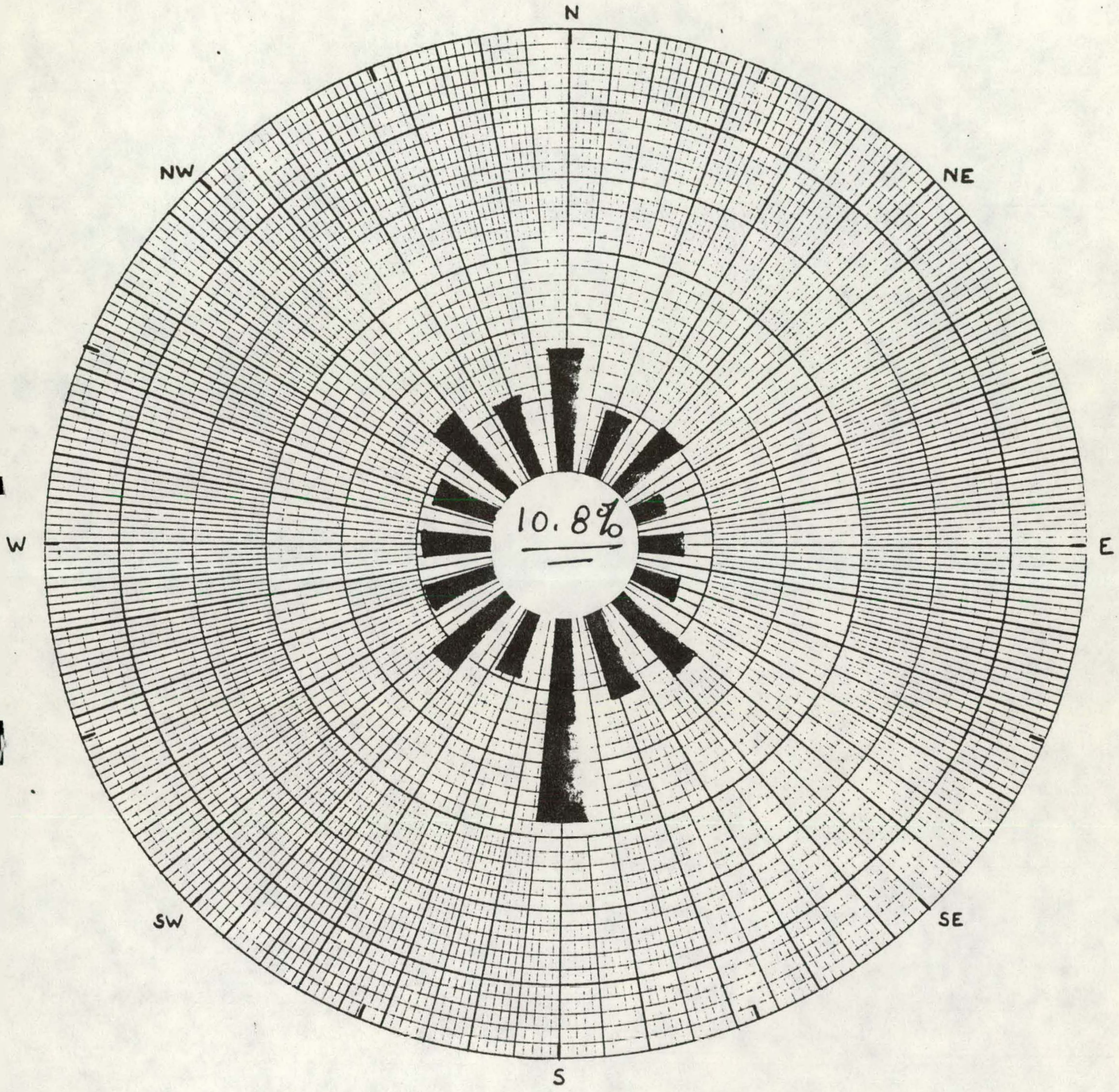
AVERAGE SPEED = 4.6 mph

LOCATION NASHVILLE, Winter



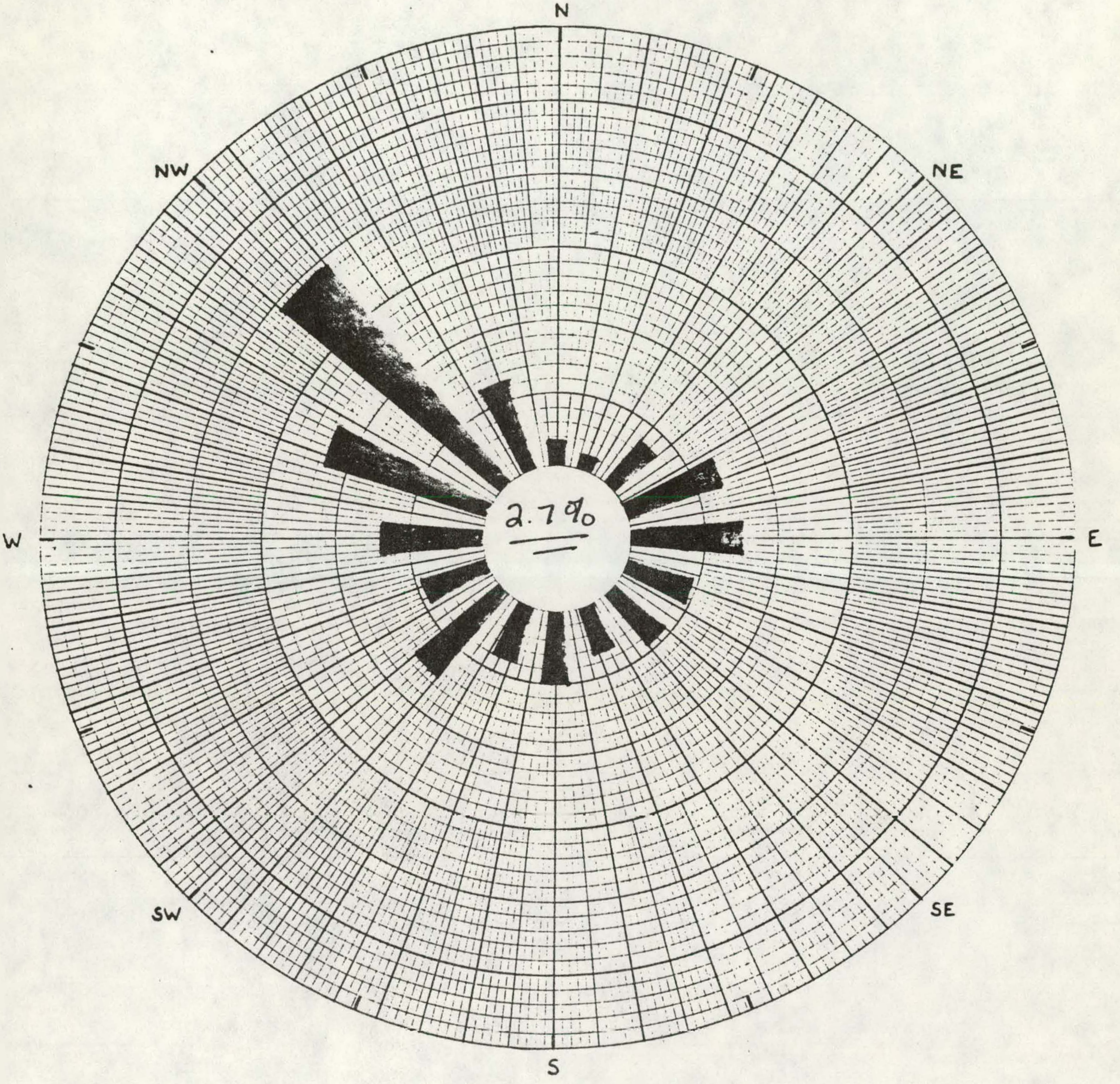
AVERAGE SPEED = 8.8 mph

LOCATION NASHVILLE, Summer



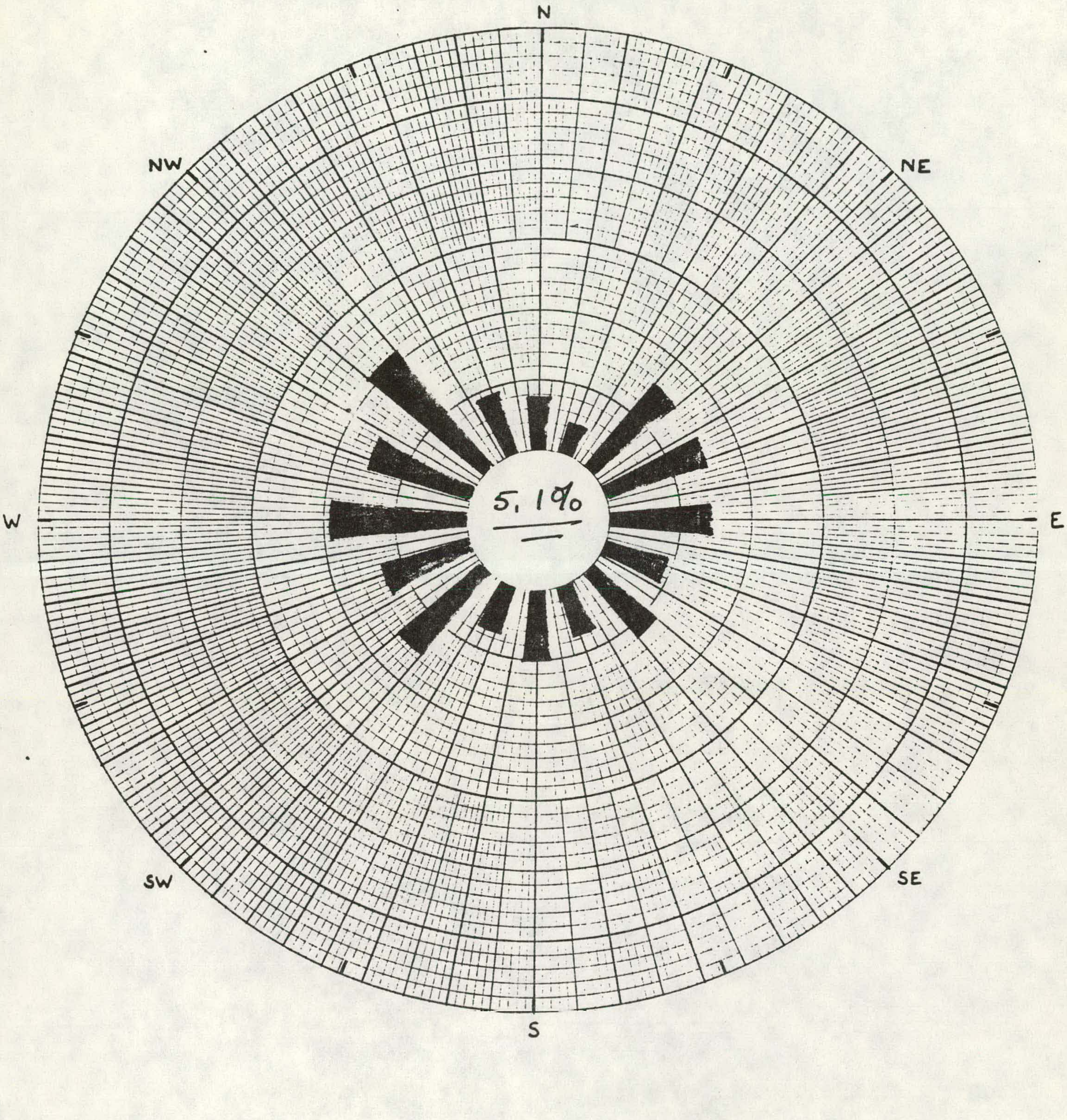
AVERAGE SPEED = 5.5 mph

LOCATION Atlanta, Winter



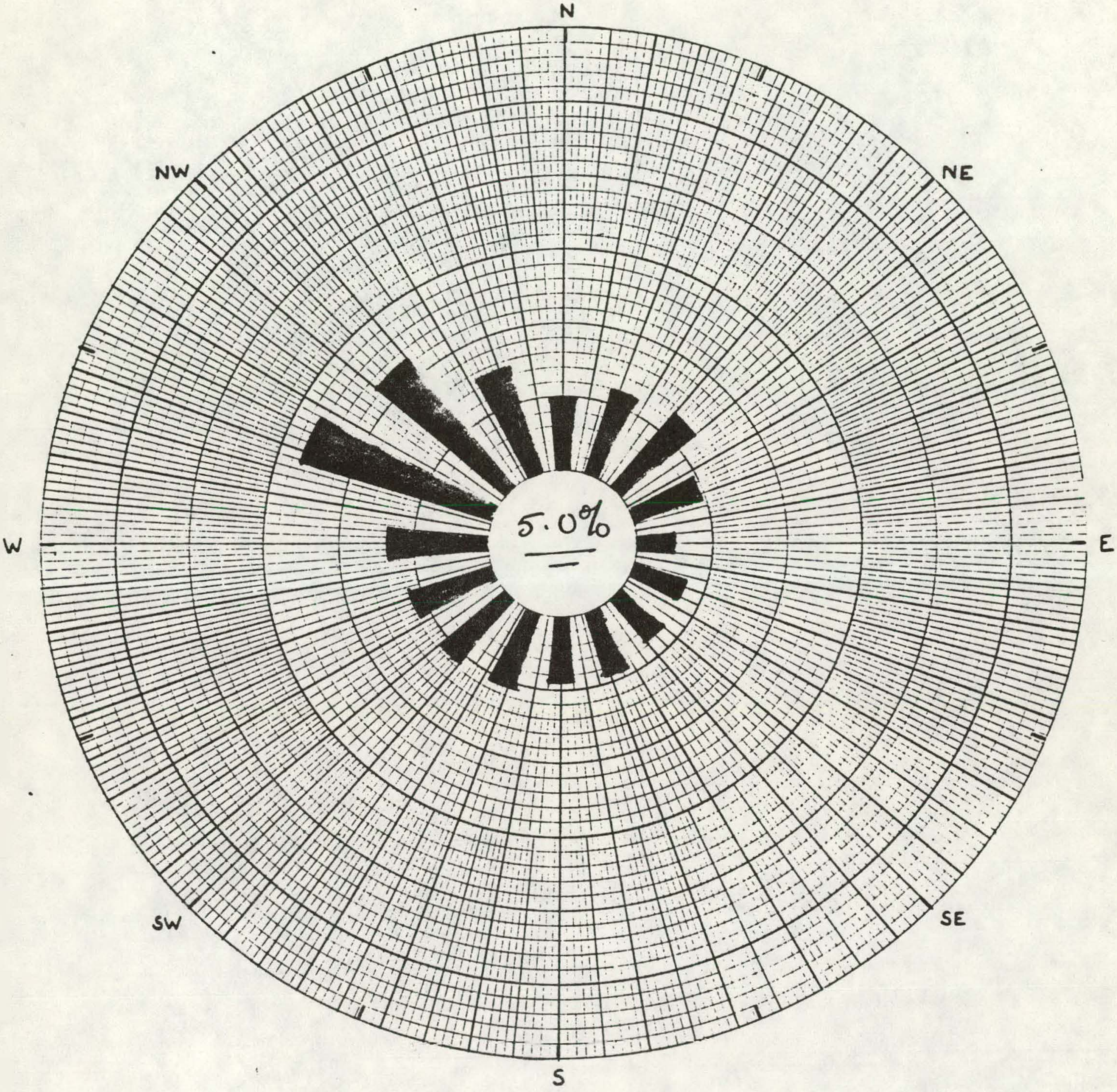
AVERAGE SPEED = 11.8 mph

LOCATION ATLANTA, Summer



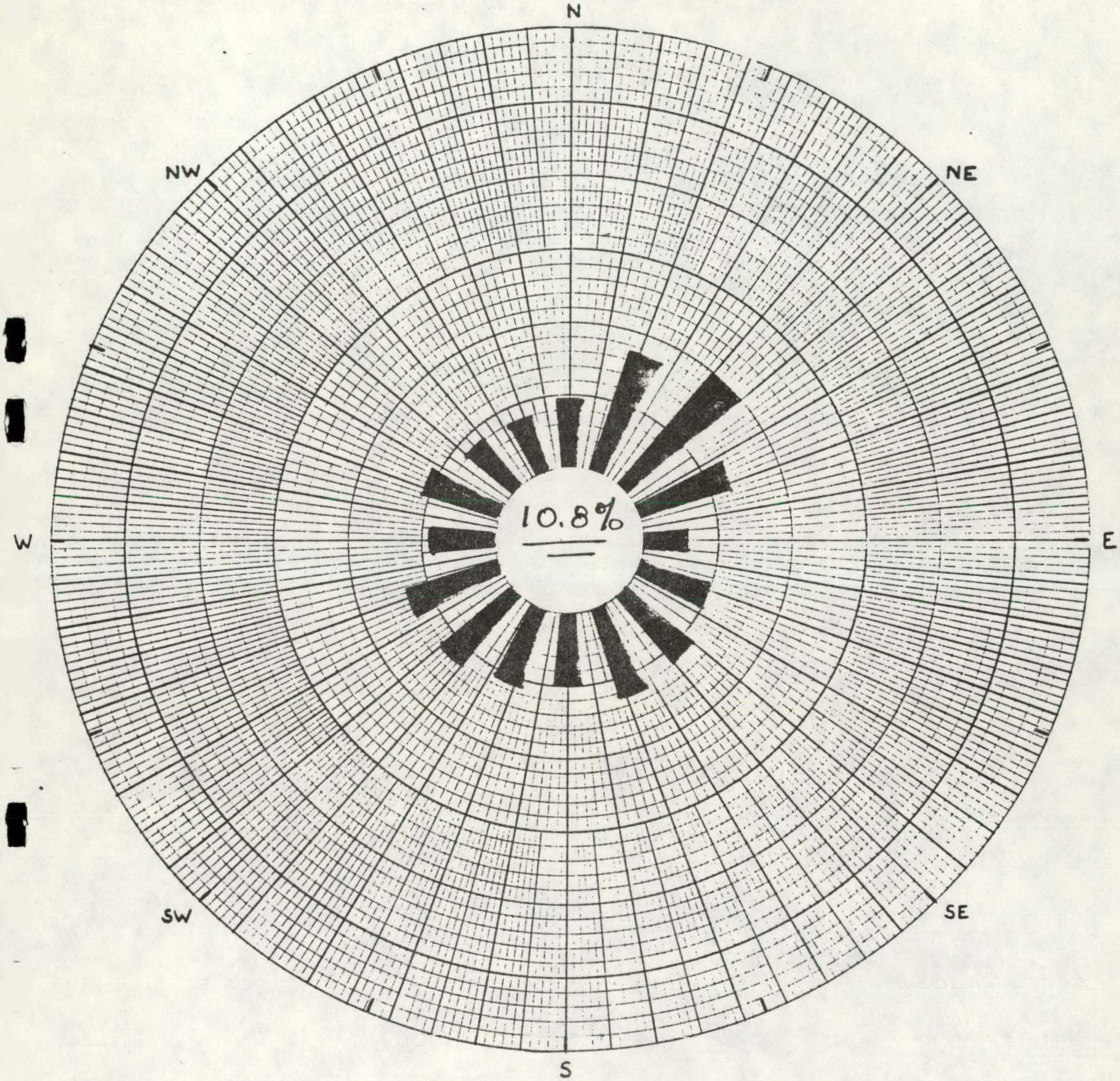
AVERAGE SPEED = 7.9 mph

LOCATION Macon, Winter



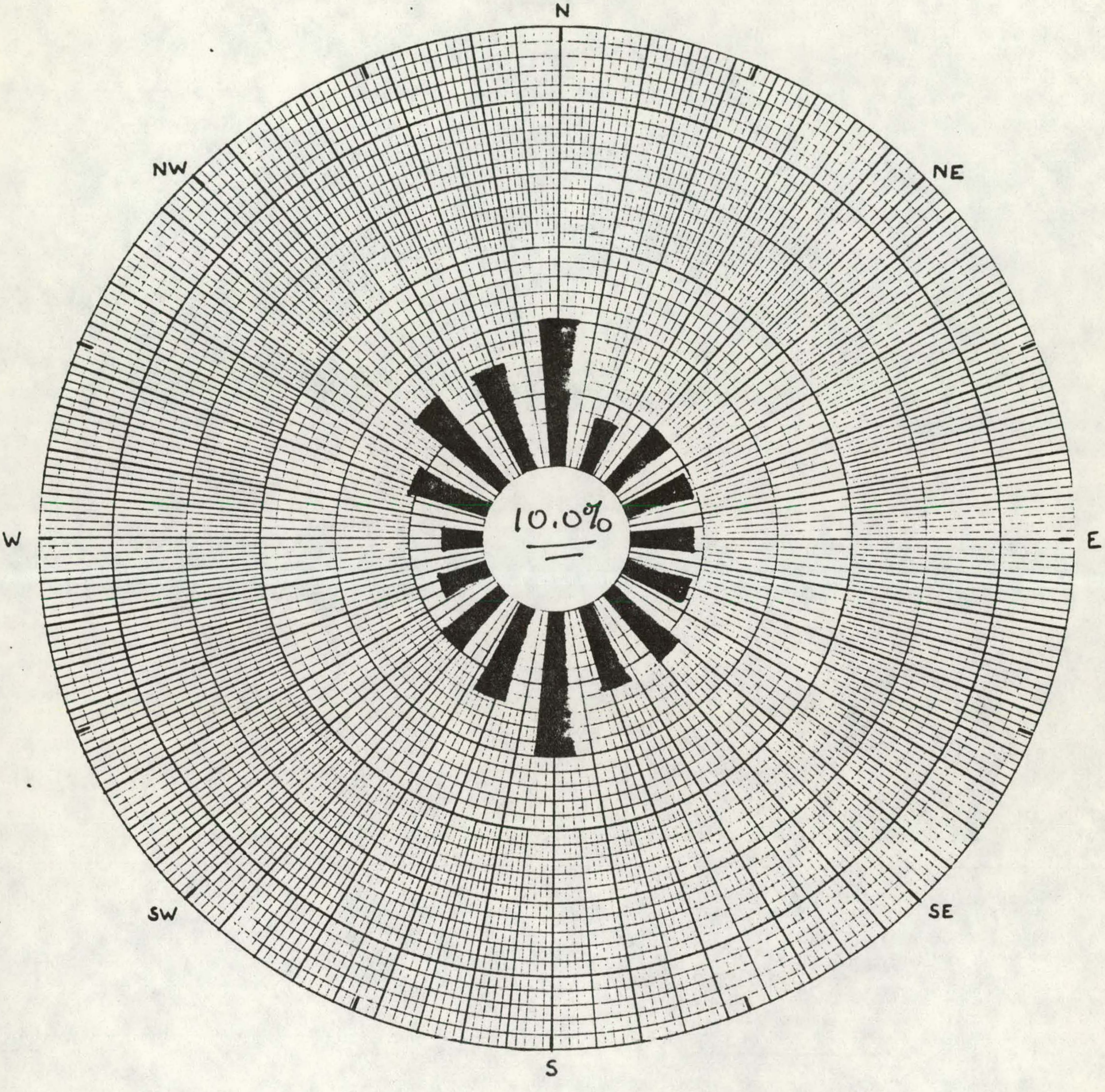
AVERAGE SPEED = 10.2 mph

LOCATION Macon, Summer



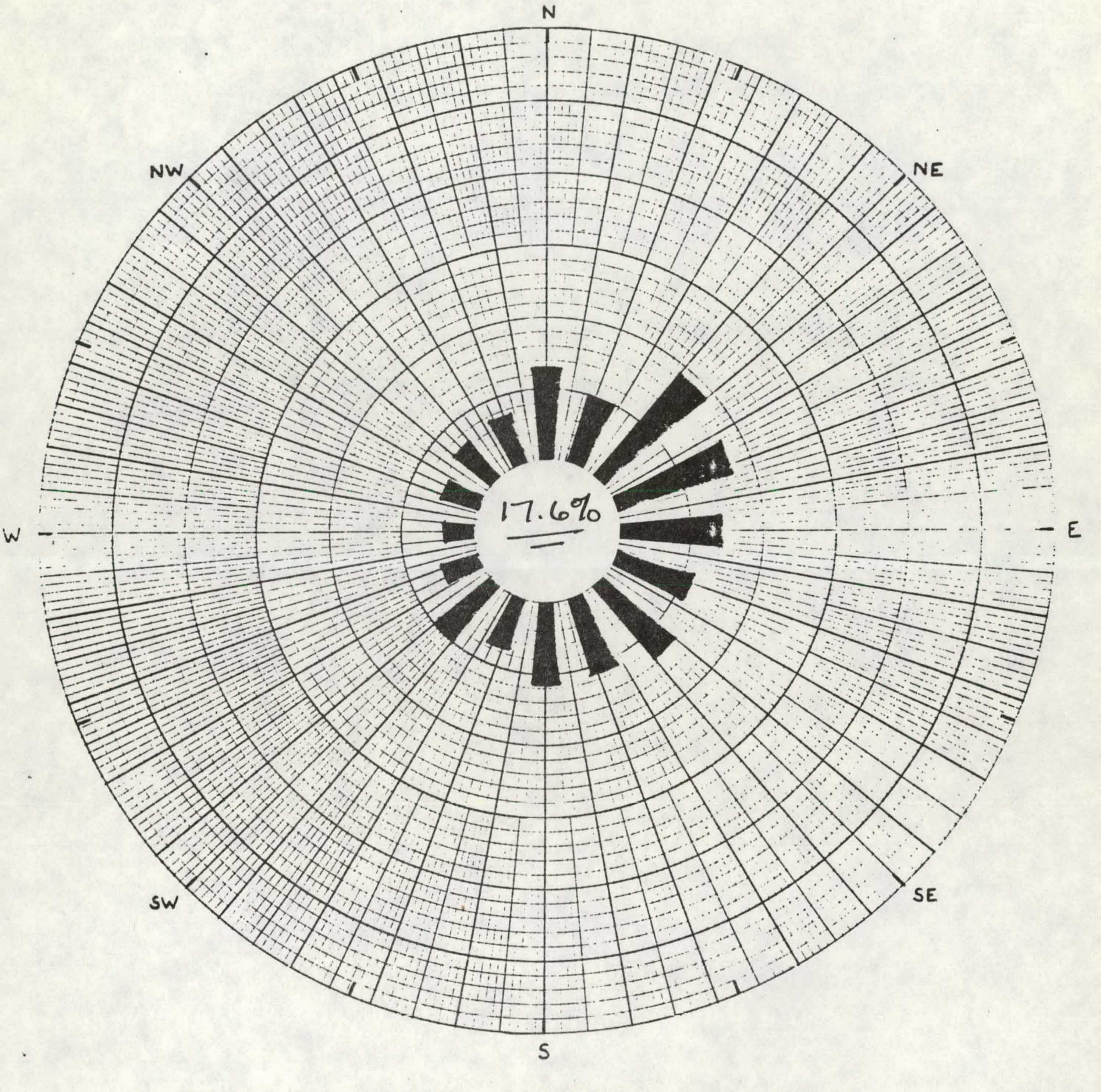
AVERAGE SPEED = 7.9 mph

LOCATION Birmingham, Winter



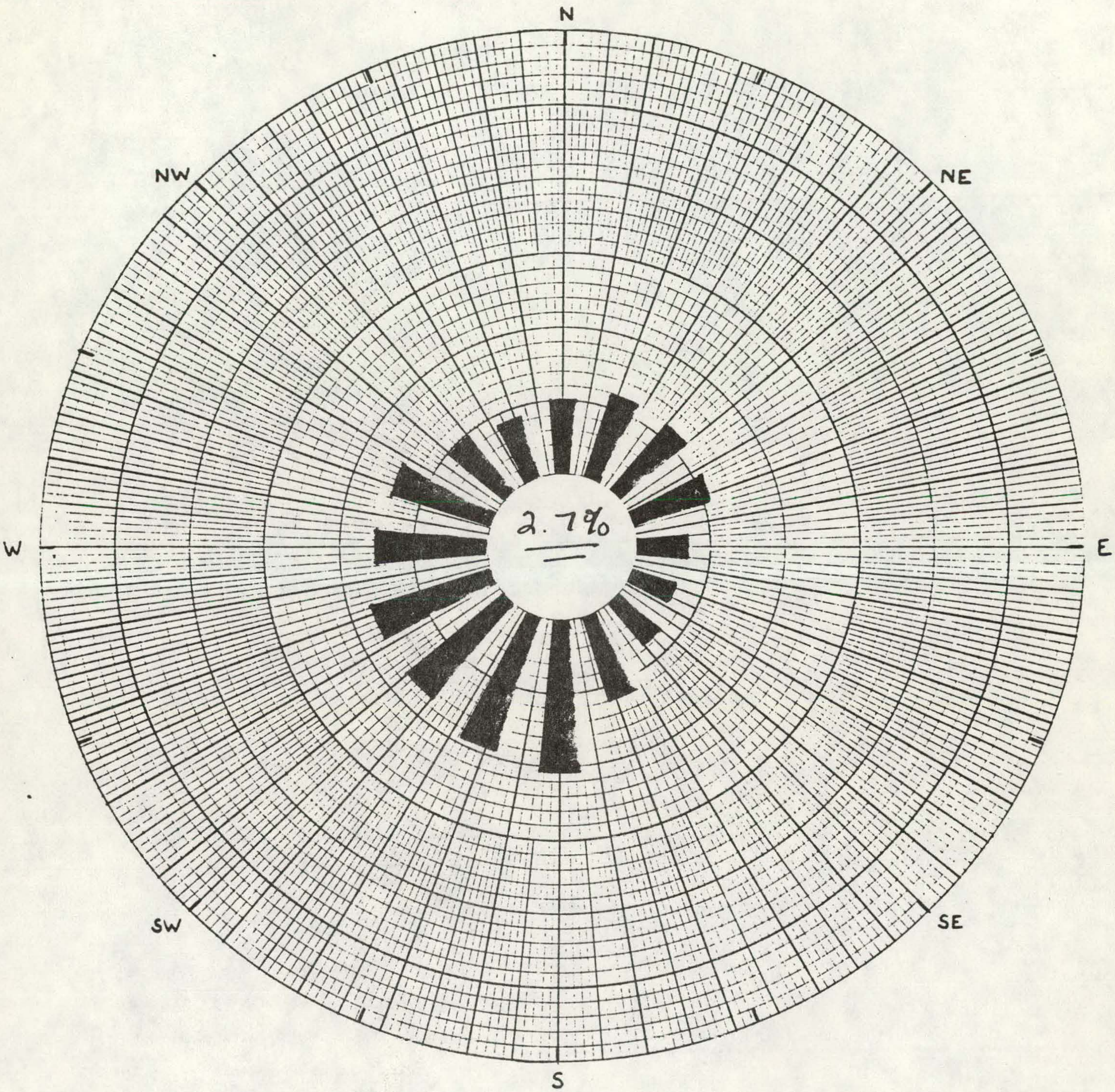
AVERAGE SPEED = 9.6 mph

LOCATION Birmingham, Summer



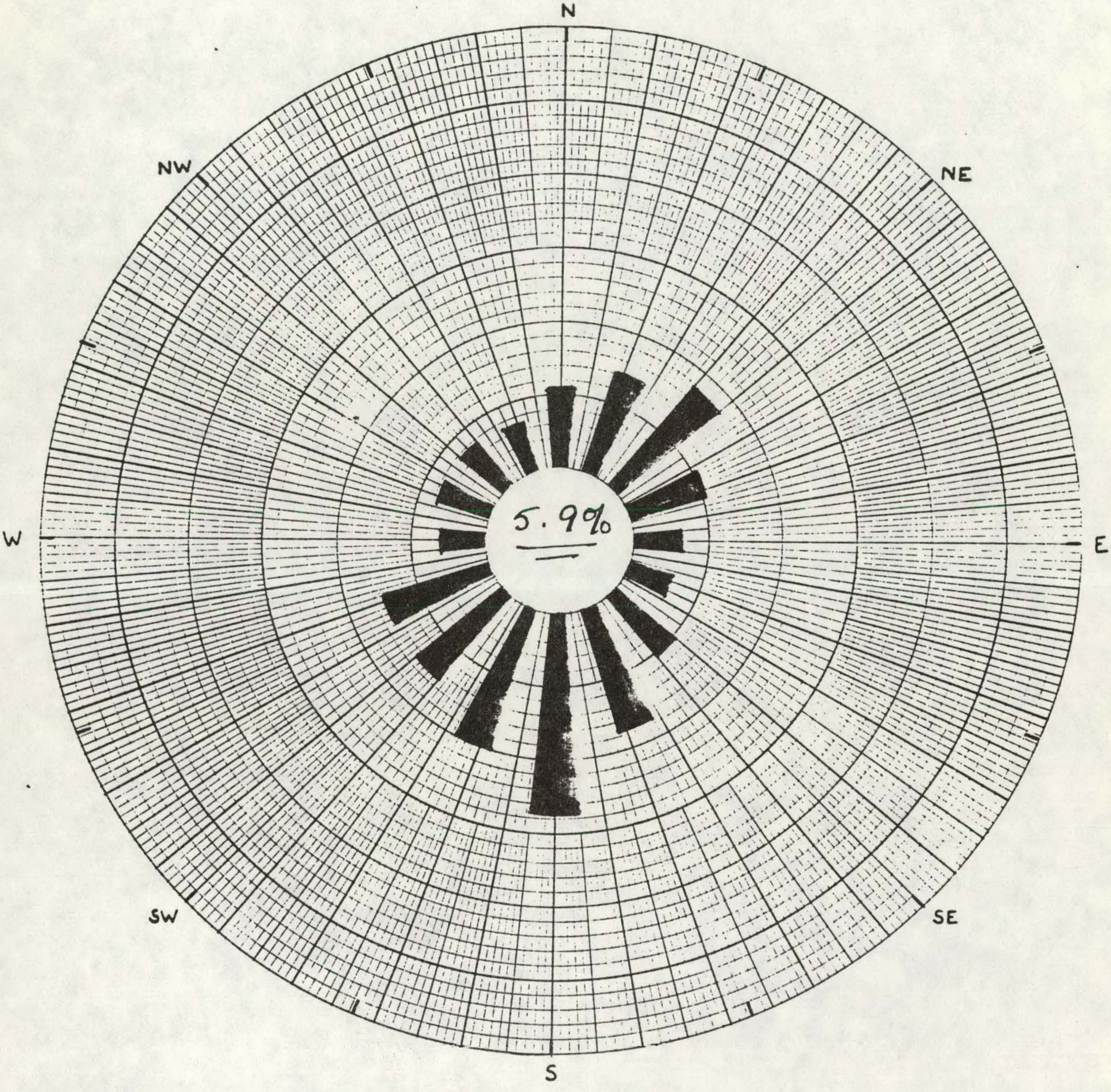
AVERAGE SPEED = 6.4 mph

LOCATION Lexington, WINTER



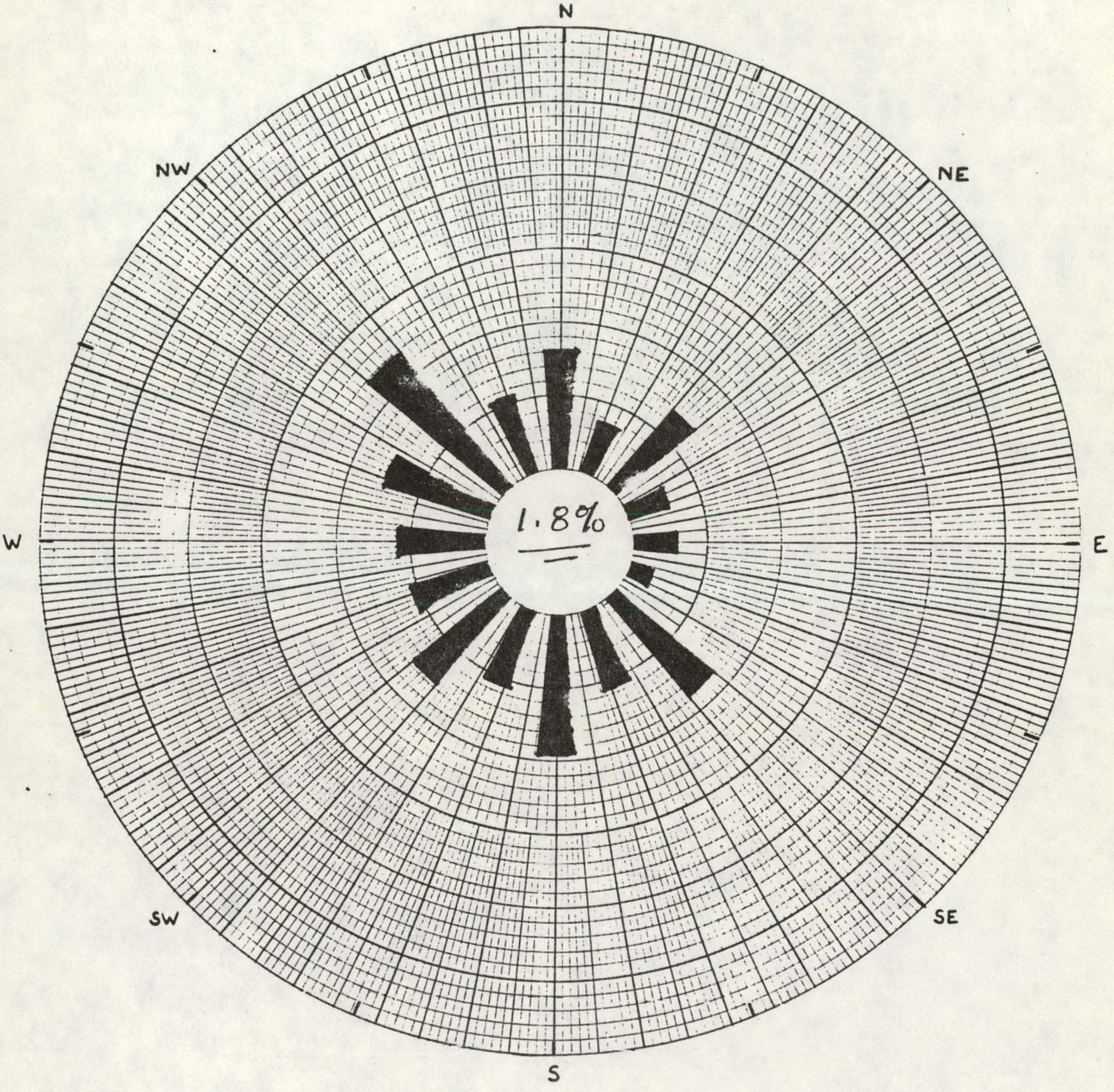
AVERAGE SPEED = 11.6 mph

LOCATION Lexington, Summer



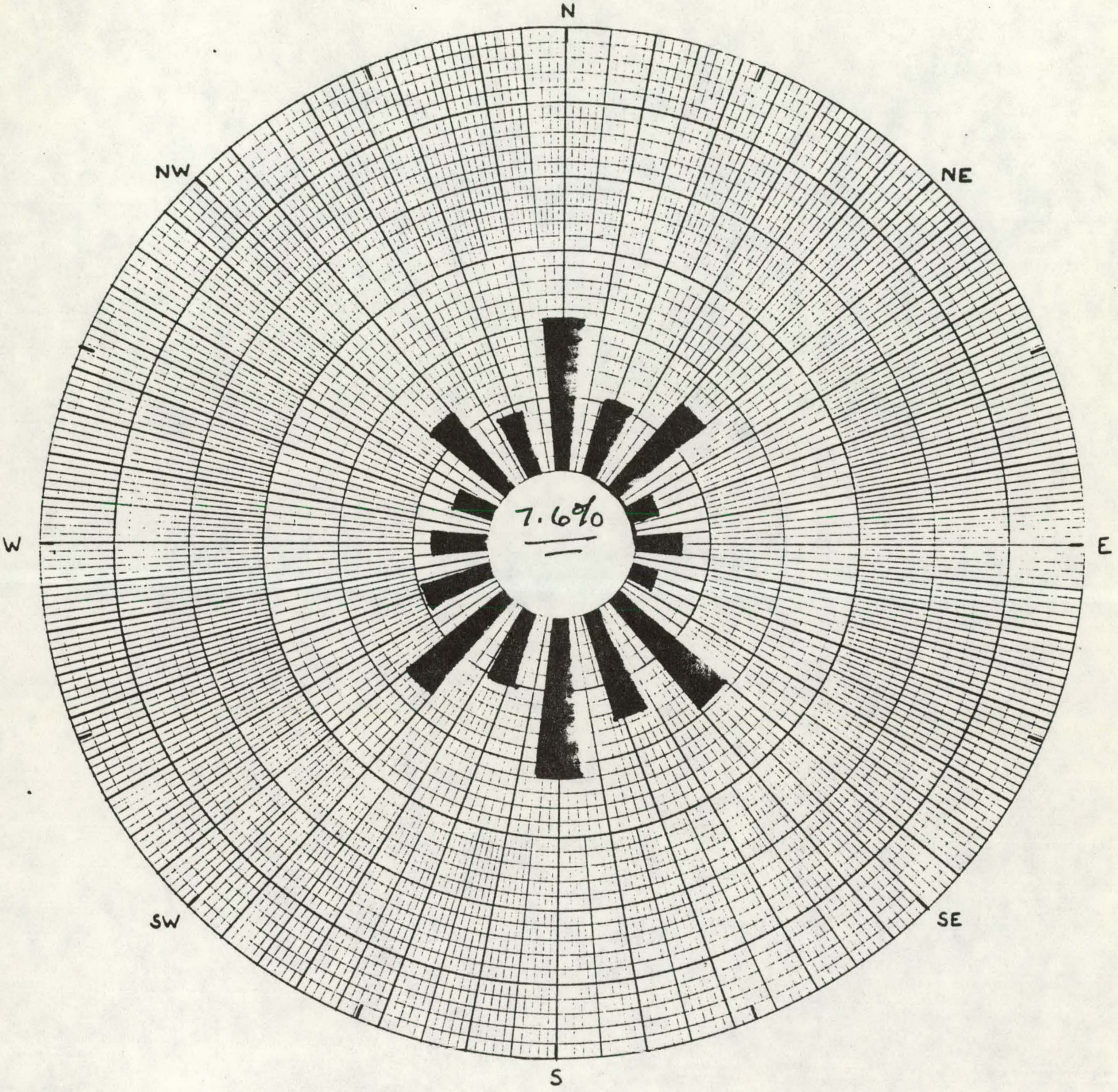
AVERAGE SPEED = 8.2 mph

LOCATION Louisville- WINTER



AVERAGE SPEED = 10.5 mph

LOCATION Louisville, - SUMMER

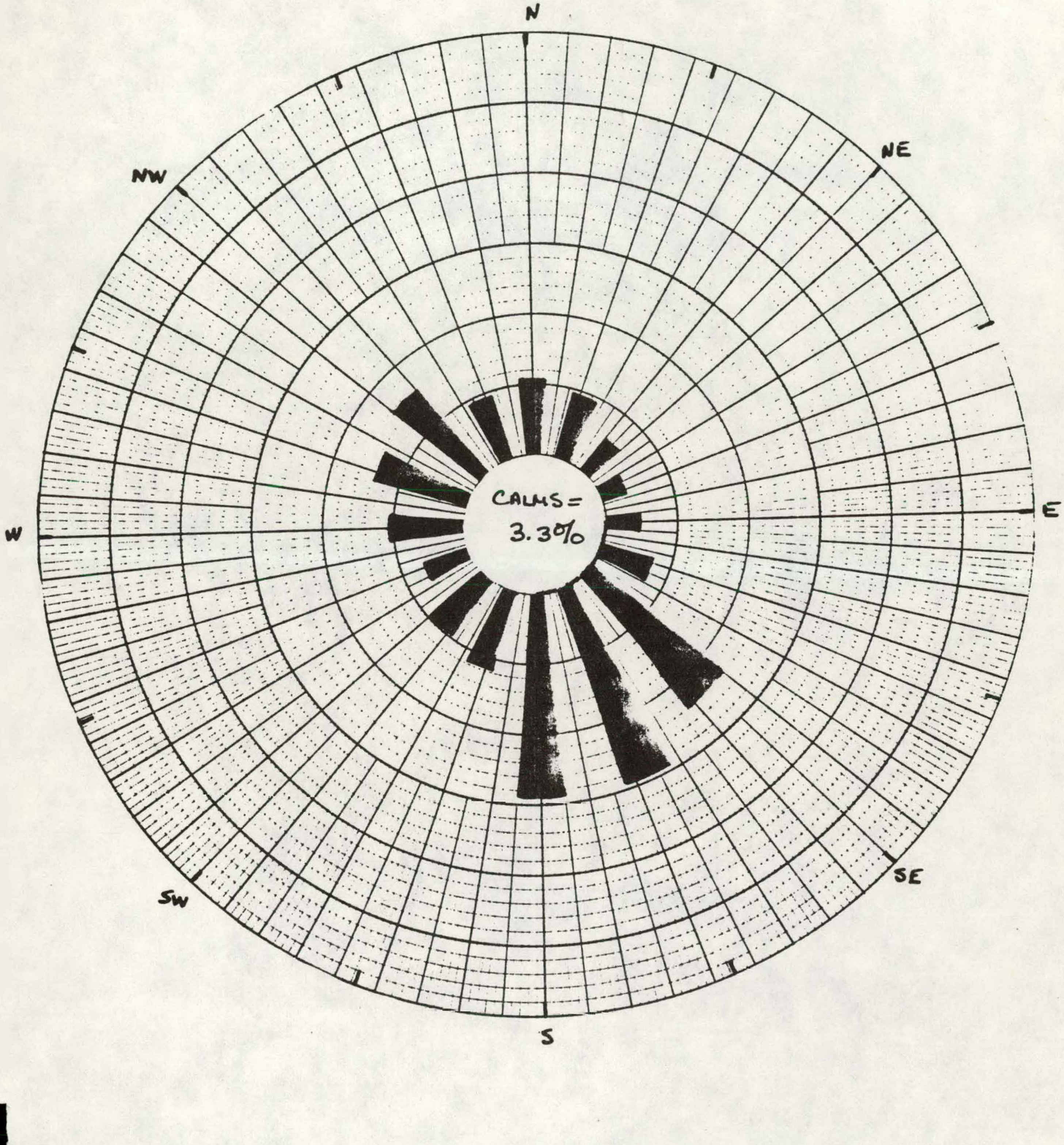


AVERAGE SPEED = 6.8 mph

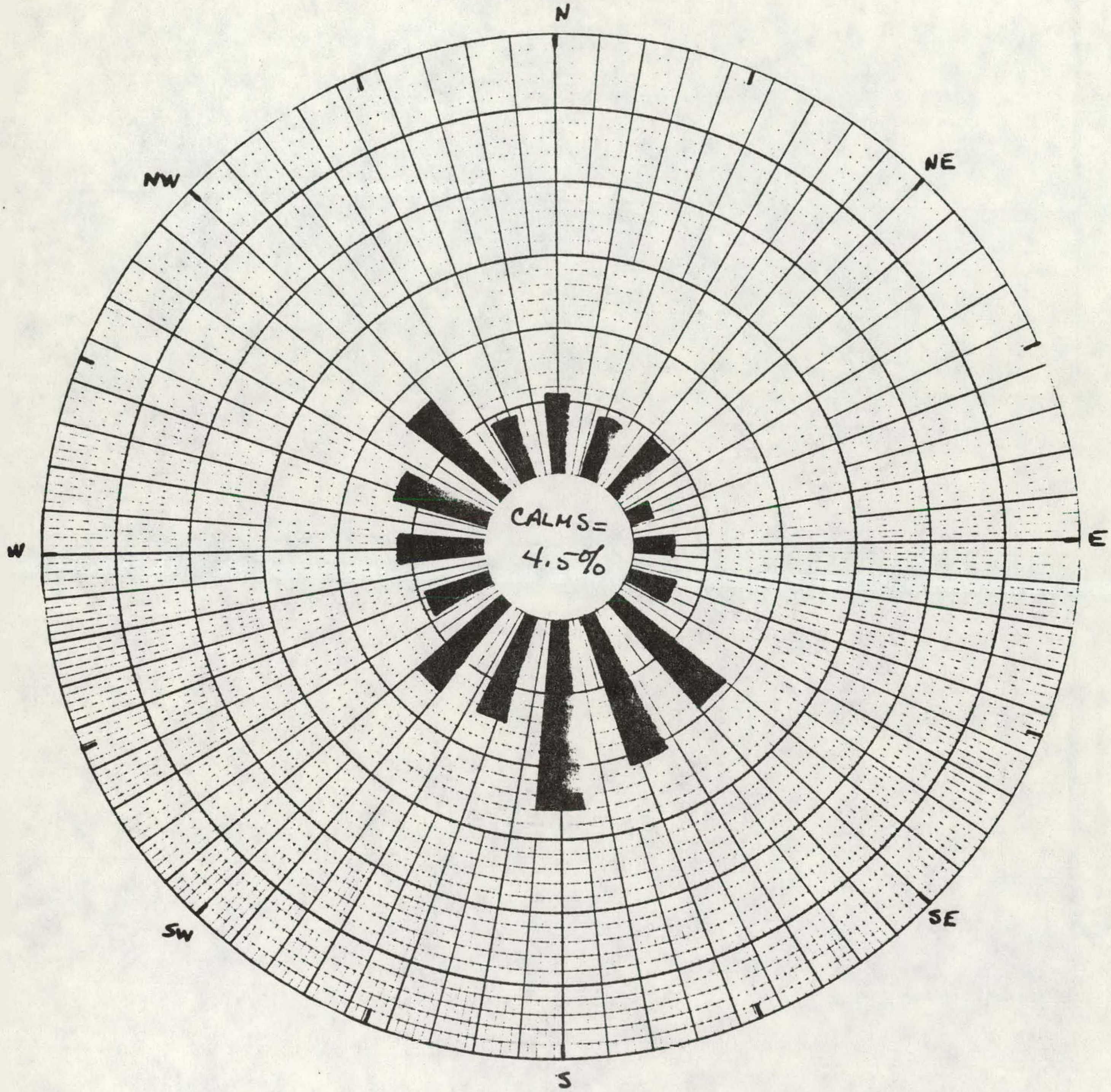
PART C-4

SMITHVILLE (DEKALB COUNTY) AIRPORT
WIND ROSE STRATIFIED BY SEASON AND BY
PASQUILL-GIFFORD STABILITY CLASSES

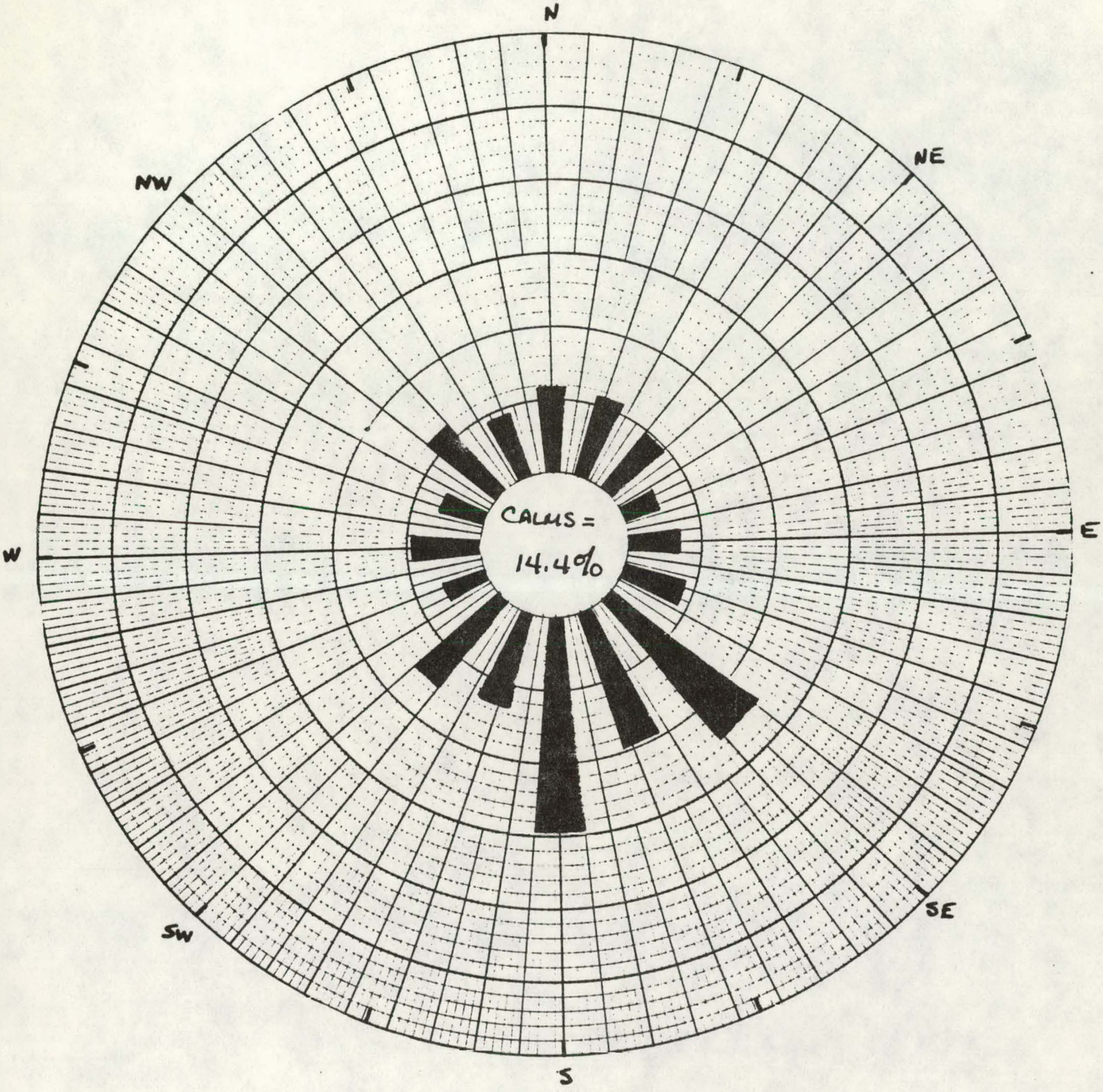
LOCATION SMITHVILLE, TN (WINTER)



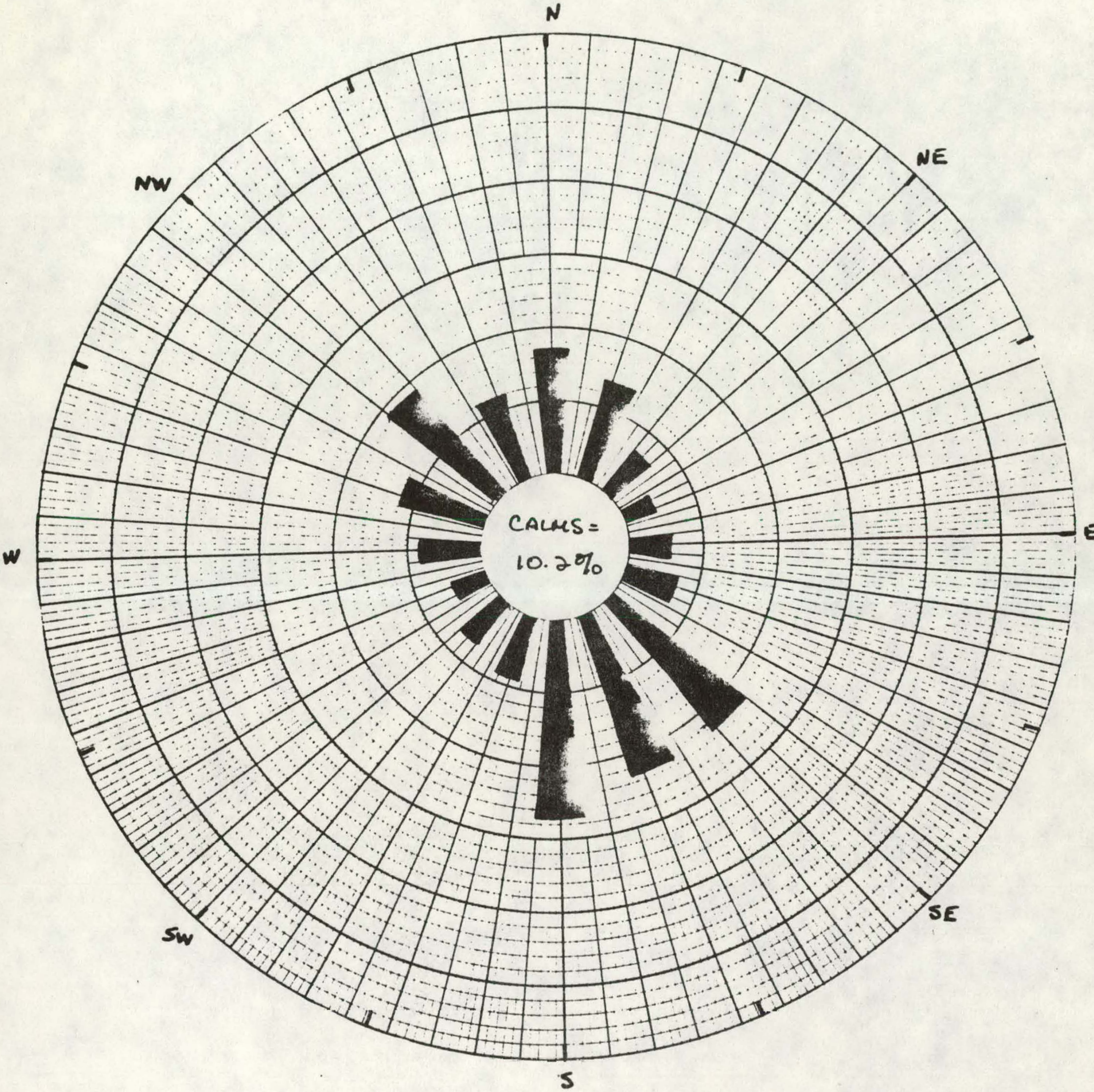
LOCATION SMITHVILLE, TN (SPRING)



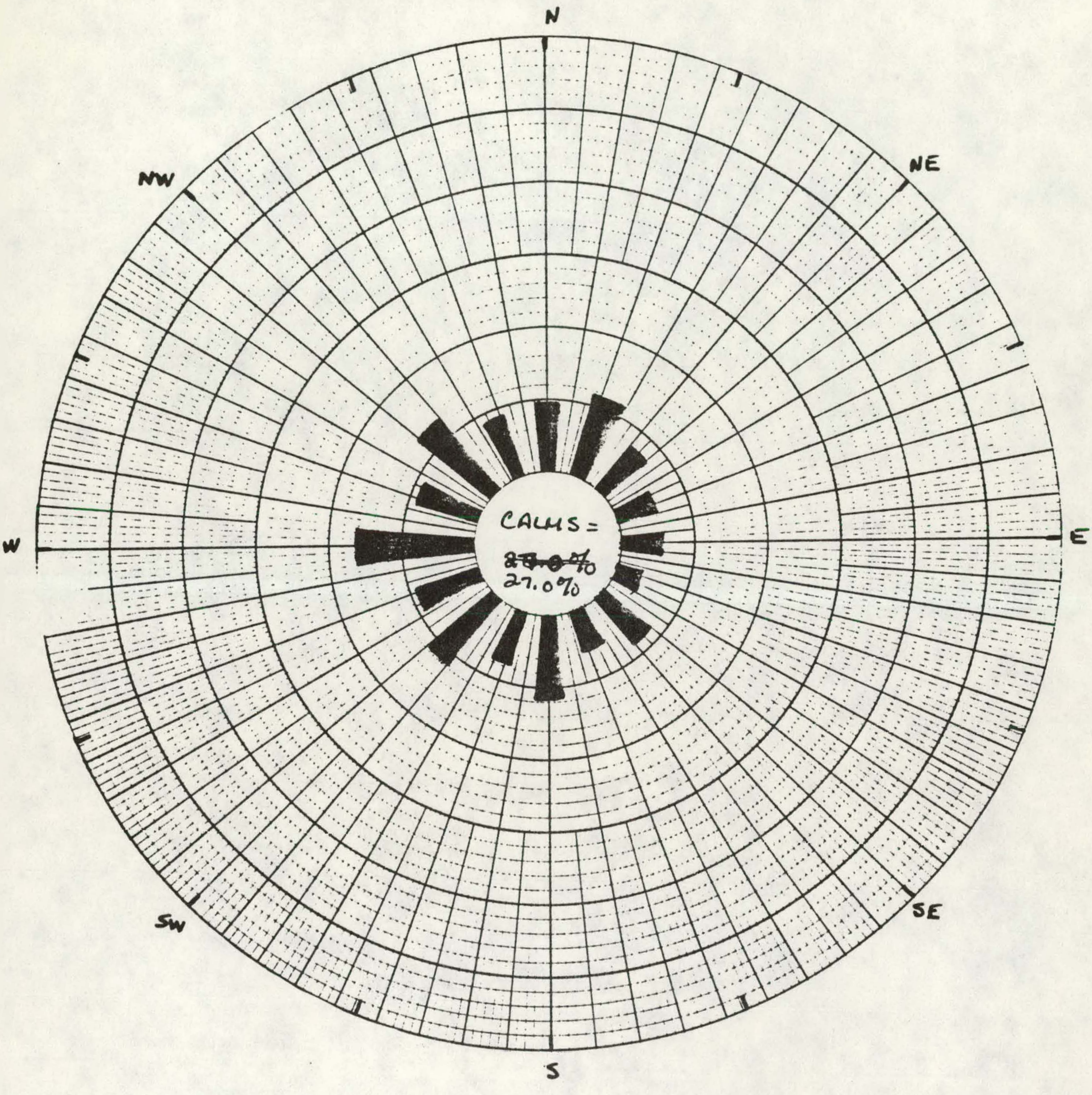
LOCATION SMITHVILLE, TN (SUMMER)



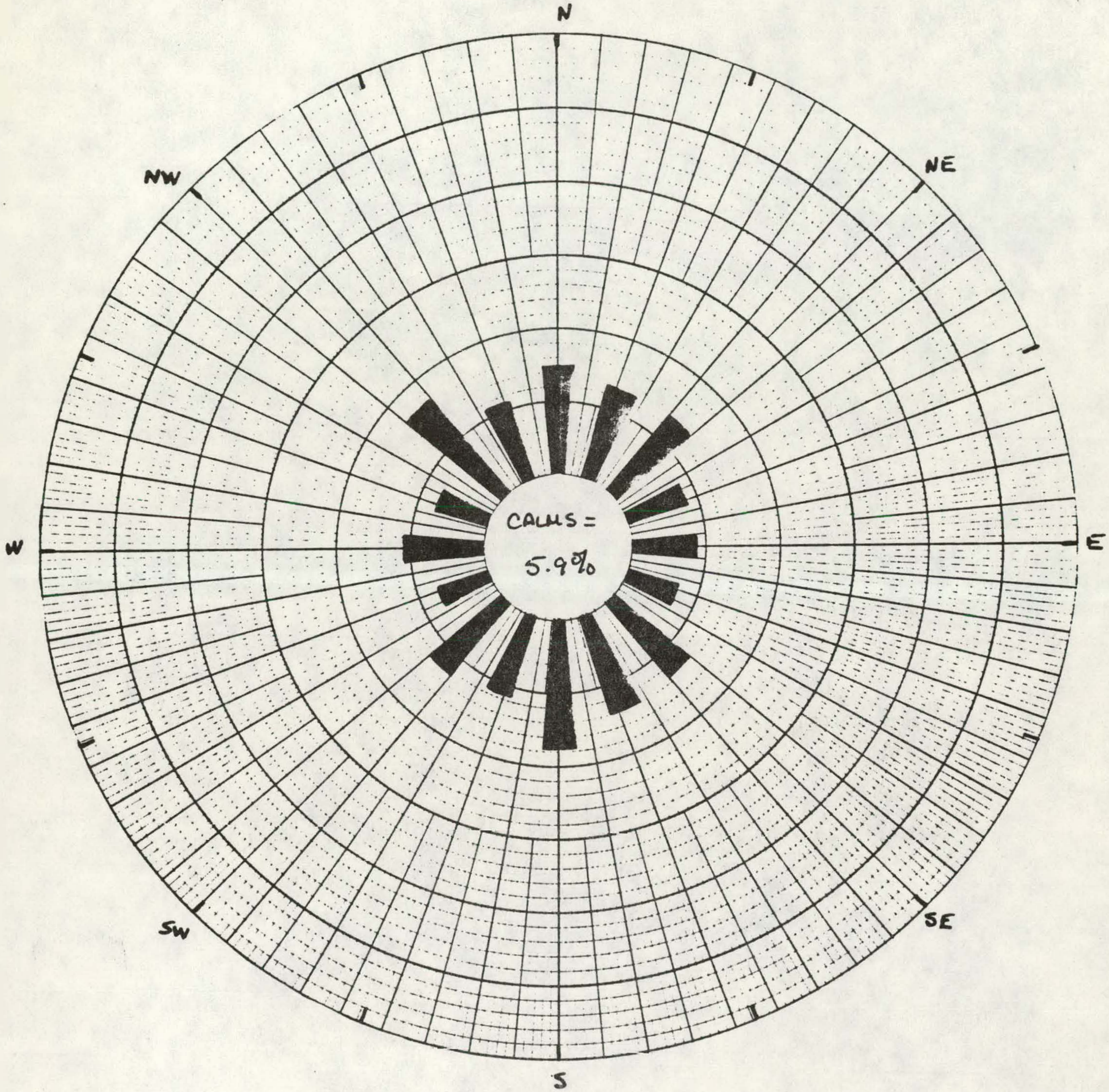
LOCATION SMITHVILLE, TN (FALL)



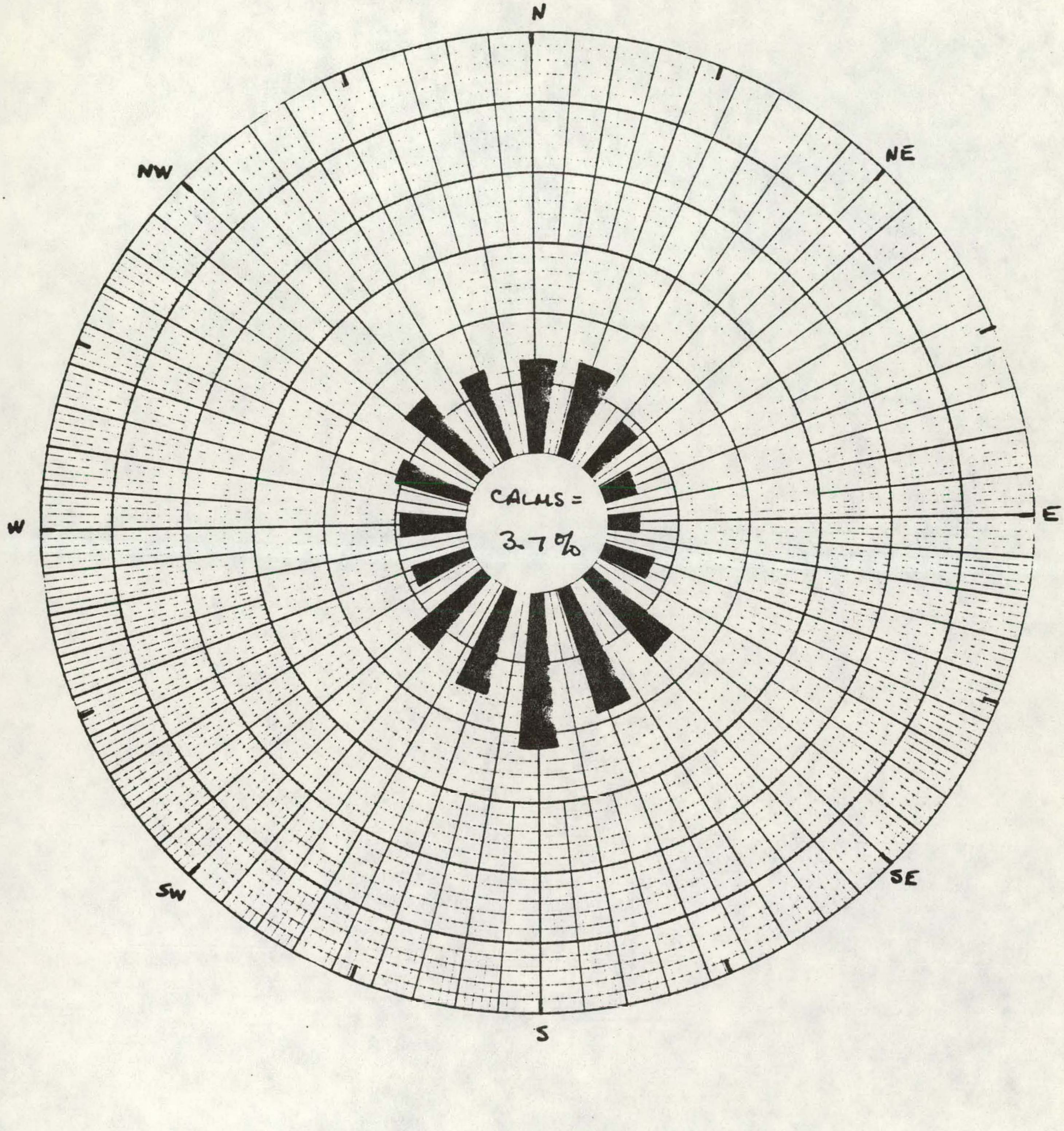
LOCATION SMITHVILLE, TN (ANNUAL) - STABILITY CLASS A



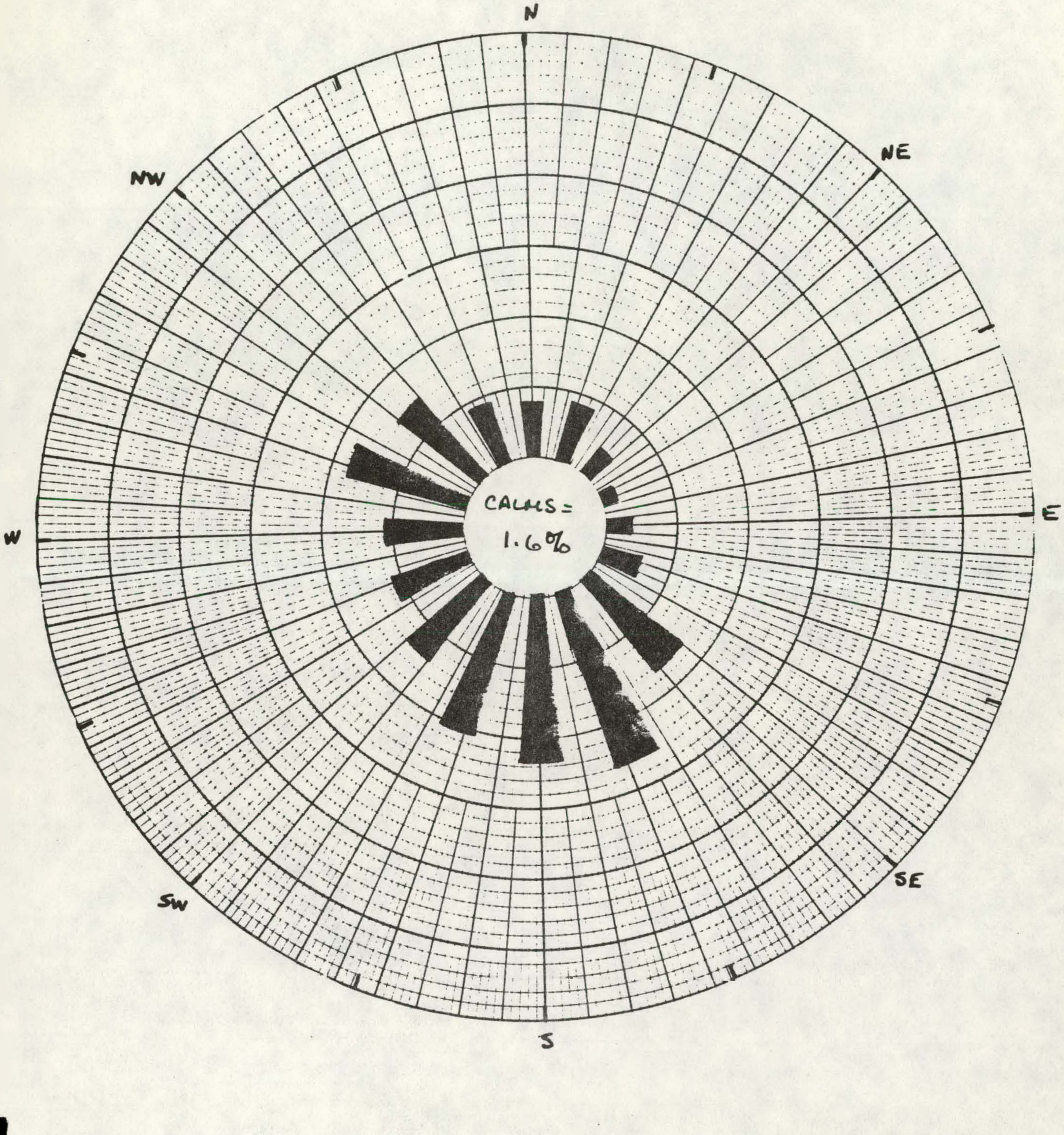
LOCATION SMITHVILLE, TN (ANNUAL) - STABILITY CLASS B



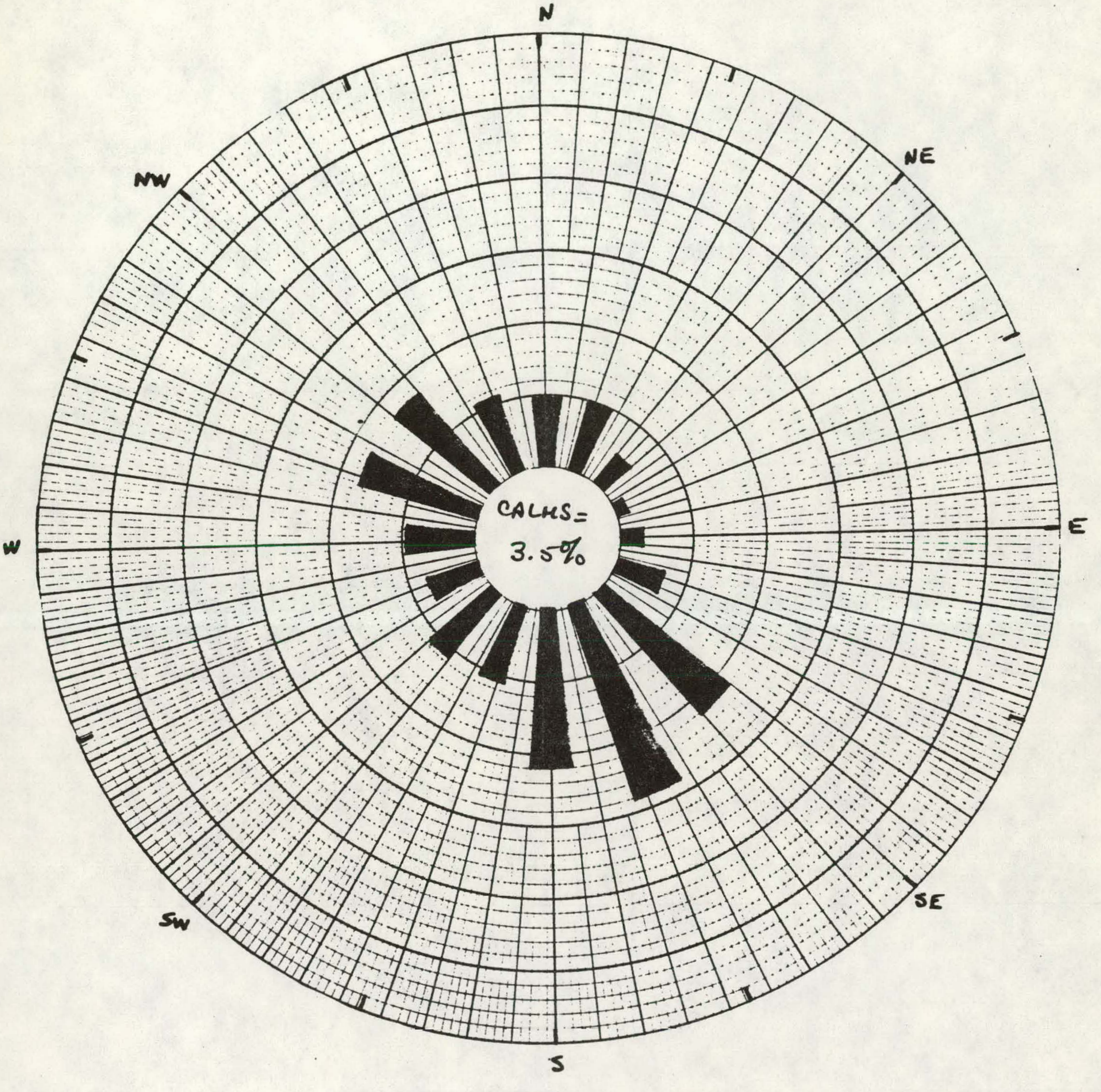
LOCATION SMITHVILLE, TN (ANNUAL) - STABILITY CLASS C



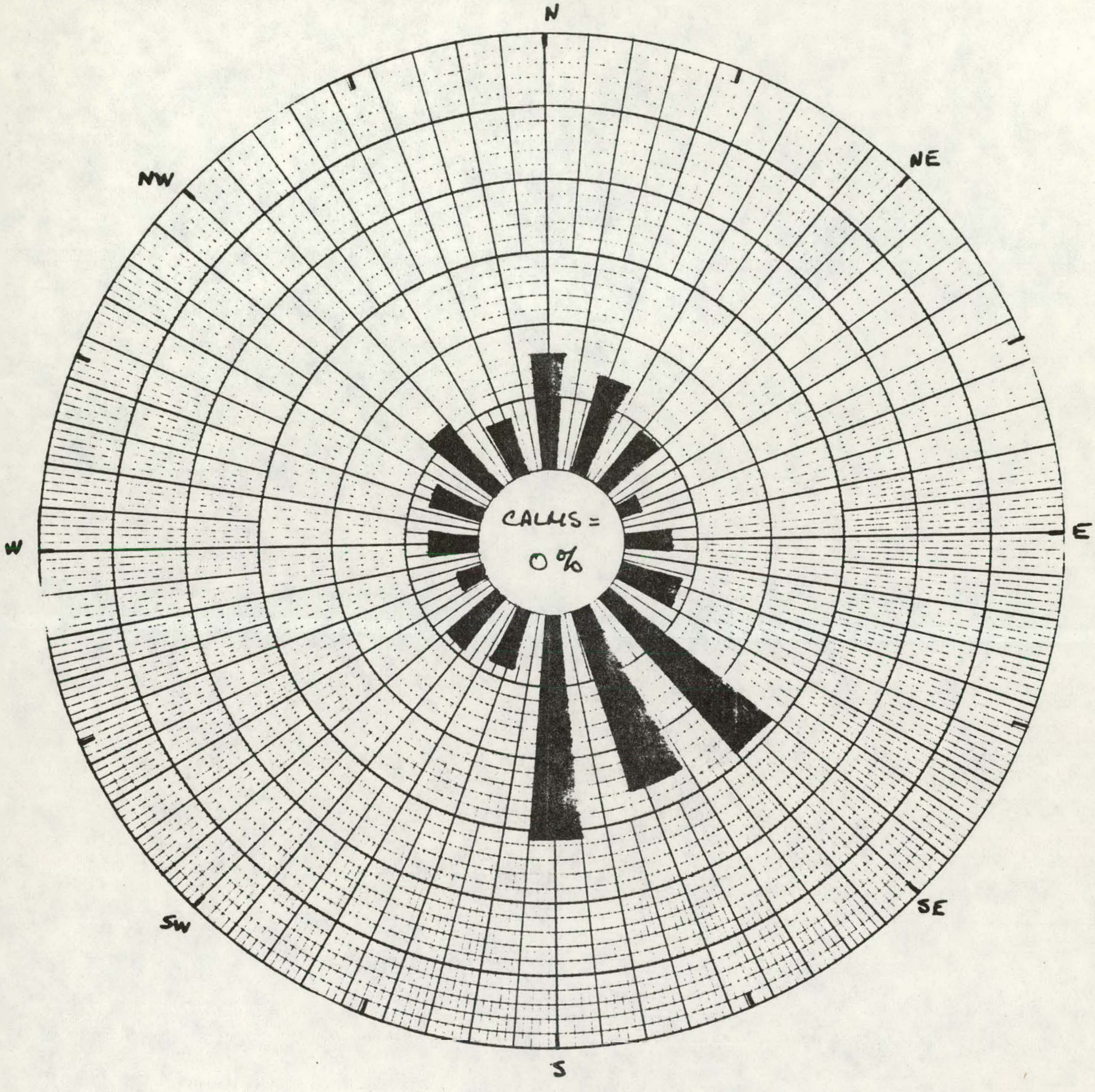
LOCATION SMITHVILLE, TN (ANNUAL) - STABILITY CLASS D (daytime)



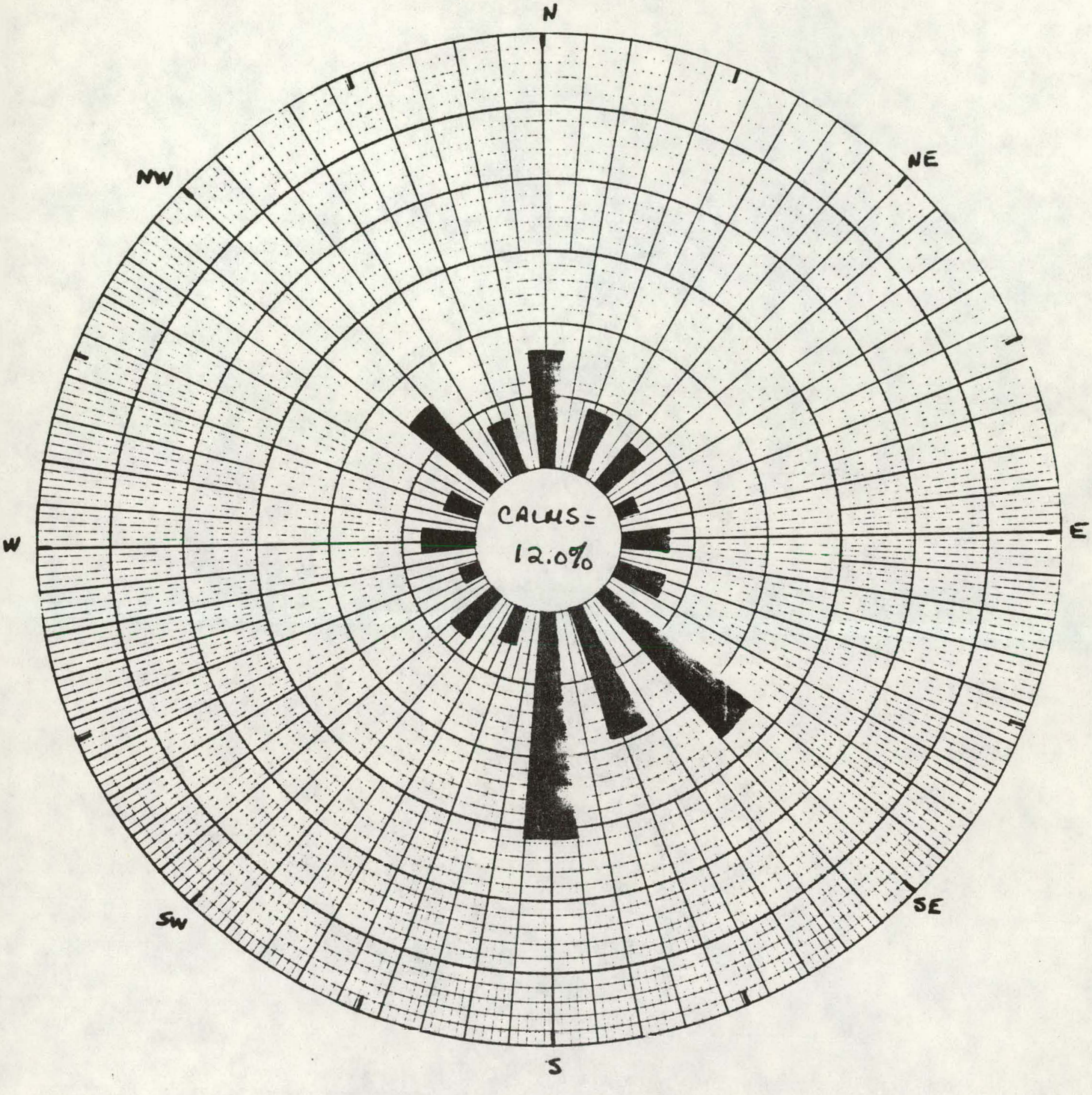
LOCATION SMITHVILLE, TN (ANNUAL) - STABILITY CLASS D (nighttime)



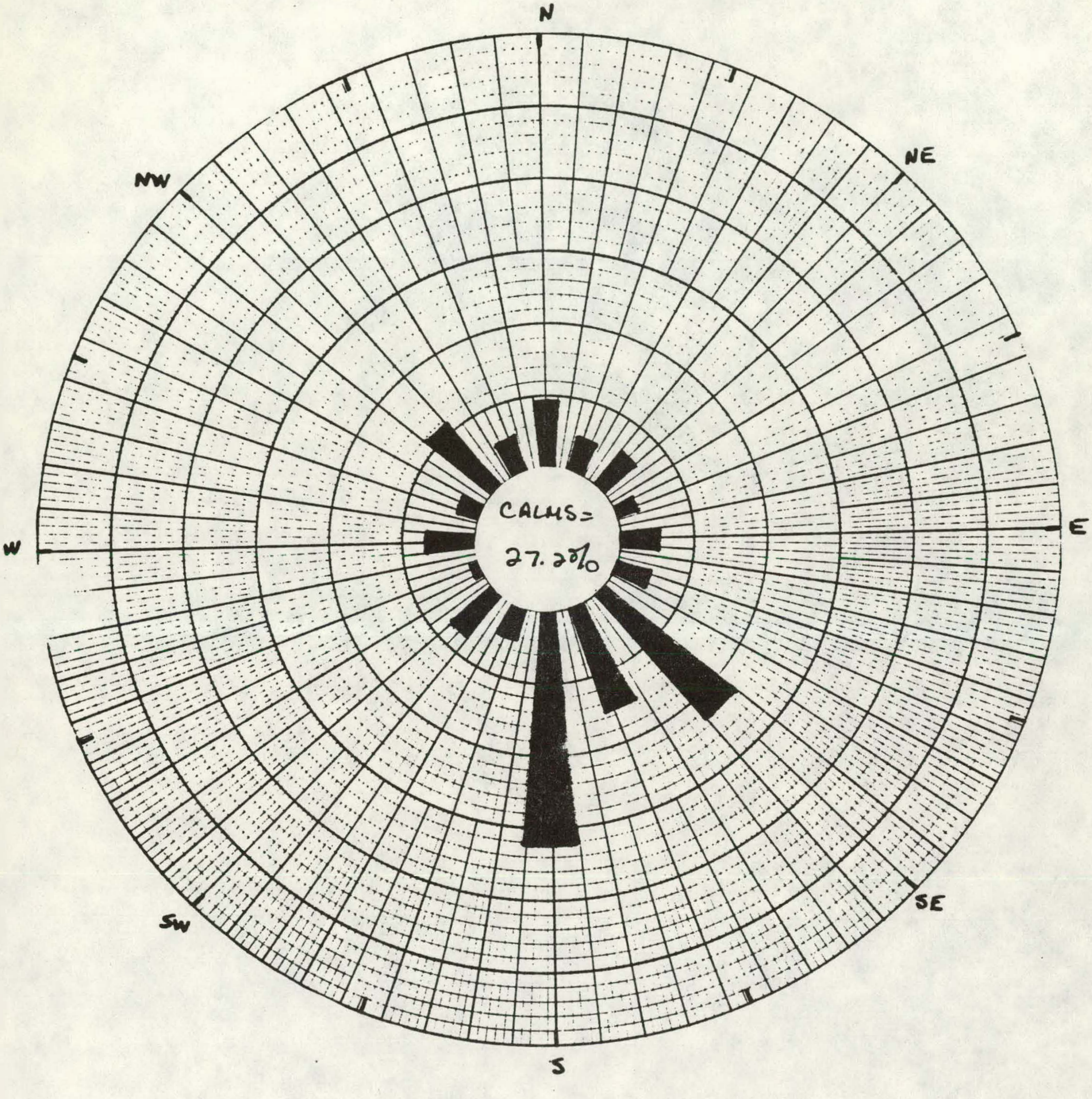
LOCATION SMITHVILLE, TN (ANNUAL) - STABILITY CLASS E



LOCATION SMITHVILLE, TN (ANNUAL) - STABILITY CLASS F



LOCATION SMITHVILLE, TN (ANNUAL) - STABILITY CLASS G



Part C-5

Regional Total Suspended Particulate Data (1975-76) from Stations in Kentucky, Tennessee, and Alabama

(Refer To Figure XII-1 for location of each indicated station.)

	1976				1975			
	#OBS	AGM	24-hour max.	2nd 24-hour max.	#OBS	AGM	24-hour max.	2nd 24-hour max.
1. Russellville, Ky. (Logan Elementary School)	59	47	116	***	40	38	122	***
2. Franklin, Ky. (Main & Breckinridge Sts.)	52	61	197	***	56	50	124	***
3. Bowling Green, Ky. (Colonnade Building)	59	46	169	***	59	38	118	***
4. Glasgow, Ky. (City Hall Building)	58	61	181	***	56	50	107	***
5. Somerset, Ky. (College Street)	50	47	107	***	53	50	116	***

*** indicates data not available or not reported

	1976				1974-75			
	#OBS	AGM	24-hour max.	2nd 24-hour max.	#OBS	AGM	24-hour max.	2nd 24-hour max.
12. Russellville, AL (Franklin County)	39	46	93	83	16	47	128	78
13. Flatrock, AL (Jackson County)	48	77	665	720	47	67	388	359
14. Scottsboro, AL (Health Department)	25	70	150	129	7	48	82	77
15. Florence, AL (Lauderdale County)	59	70	179	175	57	66	162	157
16. Moulton, AL (Lawrence County)	54	45	111	105	39	50	126	110
17. Athena, AL (Limestone County)	53	54	127	115	59	54	127	115
18. Huntsville, AL (North Memorial Parkway)	57	45	101	79	54	43	136	112
19. Guntersville, AL (Marshall County)	33	49	144	83	45	49	163	118
20. Decatur, AL (Morgan County)	53	53	164	130	60	57	164	137
21. Hartselle, AL (Morgan County)	58	41	101	92	53	43	89	84

		1976				1974-75			
		#OBS	AGM	24-hour max.	2nd 24-hour max.	#OBS	AGM	24-hour max.	2nd 24-hour max.
12.	Franklin, TN (Health Center)	51	68	172	154	61	51	211	166
13.	Gallatin, TN (Guild Elementary School)	55	53	124	111	60	44	105	102
14.	Harriman, TN (City Municipal Building)	59	64	114	113	59	55	135	116
15.	Kimball, TN (New Fire Hall)	49	55	152	152	45	44	214	136
16.	Kingston, TN (Sewage Treatment Station)	58	64	162	147	61	60	189	177
17.	Knoxville, TN (Asheville & Tulane Aves.)	52	47	88	86	44	52	102	95
18.	LaFollette, TN (City Electric Department)	56	75	266	175	61	72	195	165
19.	Lawrenceburg, TN (New County High School)	20	40	101	86	58	39	153	136
20.	Lebanon, TN (Health Center)	54	50	103	91	61	47	105	103
21.	McMinnville, TN (Health Department Building)	55	57	117	112	55	41	89	84
22.	Maryville, TN (Health Center)	59	72	208	187	61	58	139	119

		1976				1974-75			
		#OBS	AGM	24-hour max.	2nd 24-hour max.	#OBS	AGM	24-hour max.	2nd 24-hour max.
23.	Morristown, TN (Public Works Department)	59	75	146	143	61	58	193	136
24.	Murfreesboro, TN (MTSU Campus)	54	55	123	107	62	38	118	82
25.	Nashville, TN (Kings Lane)	39	38	68	64	37	60	167	140
26.	Oak Ridge, TN (Public Works Department)	56	63	106	103	60	52	115	107
27.	Paris, TN (New High School)	50	47	91	88	59	37	102	95
28.	Rockwood, TN (Telephone Company office)	61	88	208	182	61	47	198	179
29.	Shelbyville, TN (Downtown Fire Station)	55	63	140	119	60	47	109	106
30.	Springfield, TN (Electric Department Bldg.)	53	68	145	122	57	59	134	122
31.	Tullahoma, TN (Downtown Water Tower)	54	70	189	131	60	31	81	78

	1976				1974-75			
	#OBS	AGM	24-hour max.	2nd 24-hour max.	#OBS	AGM	24-hour max.	2nd 24-hour max.
1. Anniston, AL (Health Department)	47	49	110	100	40	44	97	55
2. Gadsden, AL (Goldenrod)	32	48	80	74	45	31	62	61
3. Oneonta, AL (Blount County)	33	57	132	130	32	56	141	127
4. Bessemer, AL (Jefferson County)	294	107	458	348	292	101	298	280
5. Birmingham, AL (Woodlawn)	57	80	161	158	58	92	256	236
6. Leeds, AL (Jefferson County)	286	146	583	579	259	139	599	559
7. Pell City, AL (St. Clair County)	35	50	190	109	24	92	299	181
8. Jasper, AL (Walker County)	67	79	264	209	24	92	317	204
9. Muscle Shoals, AL (Colbert County)	58	64	155	129	56	62	168	133
10. Cullman, AL (Cullman County)	54	63	150	143	40	66	151	129
11. Fort Payne, AL (DeKalb County)	***	***	***	***	22	42	156	69

	1976				1974-75			
	#OBS	AGM	24-hour max.	2nd 24-hour max.	#OBS	AGM	24-hour max.	2nd 24-hour max.
1. Alcoa, TN (City Hall)	61	86	249	181	61	68	141	140
2. Athens, TN (Health Center)	42	53	113	110	60	47	130	123
3. Chattanooga, TN (Lovell Field Airport)	59	52	140	104	58	69	434(?)	280(?)
4. Clarksville, TN (Health Department)	55	44	90	82	62	41	118	97
5. Cleveland, TN (Fire Station)	52	61	129	122	56	47	105	109
6. Clinton, TN (Clinton Elementary School)	56	65	117	114	61	56	115	108
7. Columbia, TN (Health Department)	51	84	182	172	59	44	122	114
8. Cookeville, TN (Rescue Squad Center)	65	42	97	88	62	31	90	87
9. Copperhill, TN (Rescue Squad Center)	59	68	149	148	59	63	151	140
10. Crossville, TN (Health Center)	54	41	85	82	57	30	116	84
11. Fayetteville, TN (Health Center)	56	66	122	114	60	48	116	109

APPENDIX D

WATER RESOURCES DATA

TABLE D-1. COMMUNITY WATER SUPPLY SYSTEMS IN DEKALB AND SURROUNDING COUNTIES [a]

				DeKalb and Adjacent Counties		
County	System	Source	Treatment [b]	Direct Connections	Direct Population Served	Capacity (mgd) [c]
DeKalb	Alexandria	Smith U.D.	By Smith U.D.	425	1,125	-
	Casey's Cove Land Dev.	Center Hill Lake	CFD	11	30	-
	DeKalb U.D.	Smithville	By Smithville	1,200	3,252	-
	Dowelltown-Liberty	Wells (2)	D	284	770	0.29
	Smithville	Center Hill Lake	CSFDL Fl	1,450	3,930	1.01
Cannon	Cannon U.D.	Woodbury	By Woodbury	229	611	-
	Woodbury	Spring	CSFD Fl	863	2,304	0.83
Coffee	Glenburg	Spring	None	50	148	-
	Henley Community Spring	Spring	D	15	53	-
	Hillsville U.D.	Manchester	By Manchester	700	2,058	-
	Manchester	Little Duck River	ACSFDL Fl	2,600	7,644	1.04
	Summitville Trailer Court	Well	D	20	150	0

TABLE D-1. COMMUNITY WATER SUPPLY SYSTEMS IN DEKALB AND SURROUNDING COUNTIES (Continued)

County	System	Source	Treatment [b]	DeKalb and Adjacent Counties		
				Direct Connections	Direct Population Served	Capacity (mgd) [c]
Coffee	Tullahoma	Spring	CSFDL Fl	5,596	16,542	2.48
	Univ. of Tennessee Space Institute	Woods Reservoir	CSFD	1	150	0.16
Jackson	FL & CT Water Coop	Gainesboro	By Gainesboro	122	334	-
	Gainesboro	Cumberland River	CSFD Fl	530	1,468	0.34
Putnam	Algood	Springs (2), Well	CSFD Fl	805	2,383	0.29
	Bankham U.D.	Cookeville	By Cookeville	565	1,672	-
	Baxter	Cookeville	By Cookeville	850	2,516	-
	Cookeville	Center Hill Lake	CSFDL Fl	5,777	17,100	7.5
	Cookeville Boat Dock Road U.D.	Cookeville	By Cookeville	640	1,894	-
	Double Springs U.D.	Cookeville	By Cookeville	520	1,539	-
	Dry Valley U.D.	Cookeville	By Cookeville	230	672	-

TABLE D-1. COMMUNITY WATER SUPPLY SYSTEMS IN DEKALB AND SURROUNDING COUNTIES (Continued)

County	System	Source	Treatment [b]	DeKalb and Adjacent Counties: Direct Connections	Direct Population Served	Capacity (mgd) [c]
Putnam	Falling Water U.D.	Cookeville	By Cookeville	320	947	-
	Monterey	Impoundment	ACSFD	914	2,705	0.35
	Old Gainesboro Road U.D.	Cookeville	By Cookeville	440	1,302	-
Smith	Carthage	Cumberland River	CSFDL	847	2,312	0.61
	Cordell Hull U.D.	Carthage	By Carthage	293	800	-
	I-40 Rest Area	Caney Fork River	CSFD	10	2,000	0.03
	Smith U.D.	Caney Fork River	CSFD Fl	812	2,215	1.04
	Twenty-Five U.D.	Carthage	By Carthage	229	625	-
Warren	Centertown, U.D.	McMinnville	By McMinnville	694	1,978	-
	Irving College U.D.	McMinnville	By McMinnville	503	1,443	-
	Lower Collins U.D.	McMinnville	By McMinnville	783	2,232	-

TABLE D-1. COMMUNITY WATER SUPPLY SYSTEMS IN DEKALB AND SURROUNDING COUNTIES (Continued)

County	System	Source	Treatment [b]	DeKalb and Adjacent Counties		
				Direct Connections	Direct Population Served	Capacity (mgd) [c]
Warren	McMinnville	Barren Fork	CSFDL Fl P	4,667	13,300	3.51
	North Warren U.D.	McMinnville	By McMinnville	710	2,023	-
	Viola U.D.	McMinnville	By McMinnville	474	1,351	-
	West Warren U.D.	McMinnville	By McMinnville	358	1,020	-
White	Bon De Croft U.D.	Firestone Lake	CSFD	242	704	0.32
	DeWhite U.D.	Sparta	By Sparta	800	2,320	-
	O'Connor U.D.	Sparta	By Sparta	842	2,442	-
	Quebeck-Walling U.D.	Sparta	By Sparta	528	1,531	-
	Sparta	Calfkiller Creek	CSFDL Fl	2,717	8,184	3.81
Wilson	Belinda City Service Co.	Cumberland U.D. (Davidson Co.)	By Cumberland U.D.	150	430	-
	Camp Boxwell	Cumberland River	CSFD	22	450	0.14
	Easter Seal Camp	Spencer Creek	CSFD	12	130	0.02
	Gladeville U.D.	Lebanon	By Lebanon	866	2,485	-
	LaGuardo U.D.	Lebanon	By Lebanon	300	897	-

TABLE D-1. COMMUNITY WATER SUPPLY SYSTEMS IN DEKALB AND SURROUNDING COUNTIES (Continued)

				DeKalb and Adjacent Counties		
County	System	Source	Treatment [b]	Direct Connections	Direct Population Served	Capacity (mgd) [c]
Wilson	Lebanon	Cumberland River	CSFD Fl	5,267	15,166	6.20
	Spring Creek Water Coop	Lebanon	By Lebanon	278	773	-
	Watertown	Wells (2)	F_z DP Fl	537	1,541	0.13
	West Wilson U.D.	Cumberland River	CSFDL Fl	3,500	10,045	0.87
Van Buren	Fall Creek Falls U.D.	Taft Youth Center (Bledsoe Co.)	By Taft Youth Center	320	960	-
	Spencer	Impoundment	CSFDP Fl	789	2,367	0.21

[a] Source: State of Tennessee [1977]

[b] Treatment Symbols:
- A - Aeration
- C - Coagulation
- S - Sedimentation
- F - Filtration
- D - Disinfection
- Fl - Fluoridation
- L - Lime
- P - Phosphates
- F_z - Zeolite Softening

[c] mgd - Million gallons per day.

TABLE D-2. QUALITY OF WATER, COMMUNITY SUPPLY SYSTEMS OF DEKALB AND SURROUNDING COUNTIES

Constituent	Maximum Permitted/ Recommended mg/l [a]	DeKalb Co. Smithville [b]	Coffee Co. Manchester [c]	Jackson Co. Gainsboro Raw Water [d]	Putnam Co. Cookeville [e]	Smith Co. Smith U.D. Raw Water [f]	Smith Co. Carthage Raw Water [g]	Warren Co. McMinnville [h]	White Co. Sparta [i]	Wilson Co. Belinda [j]	Wilson Co. Lebanon
Arsenic	0.05	0.002-[l]	0.002-	0.001-	0.001-	0.001	0.020	0.002	0.002-	0.005-	0.005-
Barium	1.0	0.03	0.031	0.02	0.01	0.020	0.030	0.02	0.01	0.03	0.02
Cadmium	0.01	0.001-	0.001-	0.001	0.001-	0.001	0.001	0.001-	0.002	0.001-	0.001-
Chloride	250	5.2	2.0	4.0	6.0	7.0	6.0	5.6	4.0	5.9	7.25
Chromium, hexavalent	0.05	0.01-	0.01-		0.001-			0.01-	0.01-	0.01-	0.01-
Copper	1.0	0.008	0.042	0.008	0.004	0.043	0.008	0.015	0.004	0.024	0.008
Cyanide	0.01	0.003-	0.003-		0.01-			0.003-	0.003-	0.003-	0.003-
Iron	0.3	0.025	0.625	1.400	0.11	0.9	0.200	0.02	0.036	0.029	0.014
Lead	0.05	0.01-	0.02-	0.005-	0.001	0.01	0.005-	0.01-	0.01-	0.01-	0.01-
Manganese	0.05	0.003-	0.029	0.047	0.004	0.037	0.023	0.004	0.003-	0.005	0.003-
Mercury	0.002	0.001-	0.001-	0.0003	0.001-	0.050	0.0002-	0.001-	0.001-	0.001-	0.001
MBAS [k]	0.5	0.02-	0.02	0.03-	0.002	0.03-	0.02	0.03	0.02-	0.02-	0.02-
Nitrate (as NO3)	45	0.47	0.01		0.48			0.93	0.47	0.11	0.22
Phenol	0.001	0.001-	0.001-		0.001-			0.001	0.001-	0.001-	0.001-
Selenium	0.01	0.001-	0.004	0.001-	0.001-	0.001-		0.002-	0.001-	0.002	0.001
Silver	0.05	0.001-	0.001-	0.001-	0.0001-	0.001-	0.001-	0.001-	0.001-	0.001-	0.001-
Sulfate	250	30.4	8.6	22	9.0	24	10	23.3	19.3	24.4	28.5
Total Dissolved Solids	500	150.0	114		109			135	128.0	127	110
Zinc	5.0	0.004	0.028	0.063	0.01	0.022	0.014	0.085	0.032	0.280	0.390
Fluoride		0.86		0.08		0.55	0.1		0.82		

[a] U.S. EPA, National Primary/Secondary Drinking Water Standards.
[b] Environmental Science and Engineering Corp., June 14, 1977.
[c] Environmental Science and Engineering Corp., Sept. 9, 1974.
[d] Tennessee Dept. of Health, Division of Water Quality Control, June, 1977.
[e] Stewart Laboratories, Inc., December 8, 1977.
[f] Tennessee Dept. of Public Health, Division of Water Quality Control, July, 1974
[g] Tennessee Dept. of Public Health, Division of Water Quality Control, April, 1977.
[h] Environmental Science and Engineering Corp., February 19, 1976.
[i] Environmental Science and Engineering Corp., June 3, 1977.
[j] Environmental Science and Engineering Corp., Sept. 9, 1976. Representative of Cumberland, U.D., Davidson Co.
[k] Environmental Science and Engineering Corp., Sept. 3, 1976.
[l] Minus (-) sign indicates "less than".

APPENDIX E

BIOLOGICAL RESOURCE DATA

SECTION E-1

VEGETATION OF REGIONAL STUDY AREA

Table E-1-a. Principal Taxa of Oak-Hickory Forest Community

Dominants	
Bitternut hickory	*Carya cordiformis*
Shagbark hickory	*Carya ovata*
White oak	*Quercus alba*
Red oak	*Quercus rubra*
Black oak	*Quercus velutina*
Other Components	
Pignut hickory	*Carya glabra*
Black hickory	*Carya texana*
Mockernut hickory	*Carya tomentosa*
White ash	*Fraxinus americane*
Black walnut	*Juglans nigra*
Black cherry	*Prunus serotina*
Chinquapin oak	*Quercus muhlenbergii*
Southern red oak	*Quercus falcata*
Overcup oak	*Quercus lyrata*
Blackjack oak	*Quercus marilandica*
Shumard oak	*Quercus shumardii*
Post oak	*Quercus stellata*
American basswood	*Tilia americana*

Table E-1-b. Principal Taxa of The Mixed Mesophytic Forest Community

Dominants

Sugar maple	*Acer saccharum*
Yellow buckeye	*Aesculus octandra*
Beech	*Fagus grandifolia*
Tuliptree	*Liriodendron tulipifera*
White oak	*Quercus alba*
Red oak	*Quercus rubra*
Basswood	*Tilia heterophylla*

Other Components

Black maple	*Acer nigrum*
Striped maple	*Acer pennsylvanicum*
Red maple	*Acer rubrum*
Downy Serviceberry	*Amelanchier arborea*
Yellow birch	*Betula allegheniensis*
Black birch	*Betula lenta*
American hornbean	*Carpinus caroliniana*
Bitternut hickory	*Carya cordiformis*
Pignut hickory	*Carya glabra*
Shagbark hickory	*Carya ovata*
Eastern redbud	*Cercis canadensis*
Flowering dogwood	*Cornus florida*
White ash	*Fraxinus americana*
Silverbells	*Halesia carolina* var. *monticola*
American holly	*Ilex opaca*
Black walnut	*Juglans nigra*
Cucumbertree	*Magnolia acuminata*
Fraser magnolia	*Magnolia fraseri*
Bigleaf magnolia	*Magnolia macrophylla*
Umbrella magnolia	*Magnolia tripetala*
Eastern hop hornbeam	*Ostrya virginiana*
Sourwood	*Oxydendrum arboreum*
Black cherry	*Prunus serotina*
American basswood	*Tilia americana*
Eastern hemlock	*Tsuga canadensis*

Table E-1-c. Principal Taxa of The Appalachian Oak Forest Community

Dominants	
White oak	Quercus alba
Red oak	Quercus rubra
Other Components	
Red maple	Acer rubrum
Sugar maple	Acer saccharum
Black birch	Betula lenta
Bitternut hickory	Carya cordiformis
Pignut hickory	Carya glabra
Mockernut hickory	Carya tomentosa
American beech	Fagus grandifolia
Tuliptree	Liriodendron tulipifera
Scarlet oak	Quercus coccinea
Chinquapin oak	Quercus muhlenbergii
Chestnut oak	Quercus prinus
Black oak	Quercus velutina
Eastern hemlock	Tsuga canadensis

Table E-1-d. Principal Taxa of The Oak-Hickory-Pine Forest Community

Dominants

Hickory	*Carya* spp.
Shortleaf pine	*Pinus echinata*
Loblolly pine	*Pinus taeda*
White oak	*Quercus alba*
Post oak	*Quercus stellata*

Other Components

Bitternut hickory	*Carya cordiformis*
Pignut hickory	*Carya glabra*
Shagbark hickory	*Carya ovata*
Mockernut hickory	*Carya tomentosa*
Flowering dogwood	*Cornus florida*
Common persimmon	*Diospyros virginiana*
Sweet gum	*Liquidambar styraciflua*
Tuliptree	*Liriodendron tulipifera*
Black tupelo	*Nyssa sylvatica*
Virginia pine	*Pinus virginiana*
Scarlet oak	*Quercus coccinea*
Southern red oak	*Quercus falcata*
Blackjack oak	*Quercus marilandica*
Chestnut oak	*Quercus prinus*
Northern red oak	*Quercus rubra*
Shumard oak	*Quercus shumardii*
Black oak	*Quercus velutina*

Table E-1-e. Principal Taxa of the Cedar Glades Community

Dominants

Hackberry	*Celtis laevigata*
Red cedar	*Juniperus virginiana*
Poverty grass	*Sporobolus vaginiflorus*
Winged elm	*Ulmus alata*

Other Components

Big bluestem	*Andropogon gerardi*
Little bluestem	*Andropogon scorparius*
Sandwort	*Arenaria patula*
	Aristida longispica
Side-oats grama	*Bouteloua curtipendula*
Gum bumelia	*Bumelia lanuginosa*
Pignut hickory	*Carya glabra*
Georgia hackberry	*Celtis tenuifolia*
Eastern redbud	*Cercis canadensis*
Hairy lipfern	*Cheilanthes lanosa*
Prairie tea	*Croton monanthogynus*
	Forestiera ligustrina
	Leavenworthia spp.
Purple prairie-clover	*Petalostemum purpureum*
Scurf-pea	*Psoralea* spp.
Blackjack oak	*Quercus marilandica*
Chinquapin oak	*Quercus muhlenbergii*
Black oak	*Quercus velutina*
Fragrant sumac	*Rhus aromatica*
Rock moss	*Sedum pulchellium*
Coralberry	*Symphoricorpus orbiculatus*

Table E-1-f. Principal Taxa of The Bluestem Prairie Community

Common name	Scientific name
Dominants	
Big bluestem	Andropogon gerardi
Little bluestem	Andropogon scorparius
Switchgrass	Panicum virgatum
Indian grass	Sorghastrum nutans
Other Components	
Wild aster	Aster ericoides
Cream wild indigo	Baptisia leucantha
	Baptisia leucophaea
Fleabane	Erigeron strigosus
Bedstraw	Galium obtusum
Blazing star	Liatris scariosa
	Panicum scribnerianum
Prairie phlox	Phlox pilosa
Prairie coneflower	Ratibida pinnata
Rosin-weed	Silphium laciniatum
Tall goldenrod	Solidago altissima
Goldenrod	Solidago missouriensis

SECTION E-2

VEGETATION OF DEKALB COUNTY

Table E-2-a. Principal Taxa of The Mixed Mesophytic Forest on the Lower and Middle Slopes of the Caney Fork River Gorge and Tributary Gorges - Undissected Eastern Highland Rim (Vegetational Region I-a-1)

Large Trees	
Sugar maple	Acer saccharum
Basswood	Tilia heterophylla
Box elder	Acer negundo
Sweet buckeye	Aesculus octandra
Bitternut	Carya cordiformis
Tuliptree	Liriodendron tulipifera
Beech	Fagus grandifolia
White ash	Fraxinus americana
Cucumbertree	Magnolia acuminata
Chestnut oak	Quercus prinus
Yellowwood	Cladrastis lutea
Butternut	Juglans cinerea
Northern red oak	Quercus rubra var. borealis
Sycamore	Platanus occidentalis
American elm	Ulmus americana
Heaven tree	Ailanthus altissima
Blue beech	Carpinus caroliniana
Sweet gum	Liquidambar styraciflua
Empress tree	Paulownia tomentosa
Black locust	Robinia pseudo-acacia
Red maple	Acer rubrum
Black walnut	Juglans nigra
White oak	Quercus alba
Pignut	Carya glabra
Sweet hickory	Carya ovalis
Red mulberry	Morus rubra
Wild black cherry	Prunus serotina
Umbrella tree	Magnolia tripetala
Shrubs and Small Trees	
Dogwood	Cornus florida
Hop hornbeam	Ostrya virginiana
Blue beech	Carpinus caroliniana
Hydrangea	Hydrangea arborescens
Paw-paw	Asimina triloba

Large Trees (Continued)

Spicebush	*Lindera benzoin*
Bladdernut	*Staphylea trifolia*
Poison ivy	*Rhus radicans*
Round-leaved dogwood	*Cornus rugosa*
Summer grape	*Vitis aestivalis*
Alder	*Alnus serrulata*
Privet	*Ligustrum sinense*
Virginia creeper	*Parthenocissus quinquefolia*
Ninebark	*Physocarpus opulifolius*
Strawberry bush	*Euonymous americanus*
Crossvine	*Bignonia capreolata*
Pinkster	*Rhododendron nudiflorum*
Mountain camellia	*Stewartia ovata*
Mountain laurel	*Kalmia latifolia*

Herbs and Ferns

Goldenrod	*Solidago flexicaulis*
Christmas fern	*Polystichum acrostichoides*
Stinging nettle	*Urtica dioica*
Leafcup	*Polymnia canadensis*
Waterleaf	*Hydrophyllum* sp.
Maidenhair fern	*Adiantum pedatum*
Jewelweed	*Impatiens pallida*
Wild yam	*Dioscorea villosa*
Wild yam	*Dioscorea quaternata*
Foamflower	*Tiarella cordifolia*
Wild ginger	*Asarum canadense*
False goatsbeard	*Astilbe biternata*
Sedges	*Carex* spp.
Bulblet fern	*Cystopteris bulbifera*
	Nemophila microcalyx
Bellwort	*Uvularia pudica*
Lady's thumb	*Polygonum persicaria*
Large-flowered trillium	*Trillium grandiflorum*
Early meadow-rue	*Thalictrum dioicum*
Doll's eyes	*Actaea pachypoda*
Thimbleweed	*Anemone virginiana*
Rue anemone	*Anemonella thalictroides*
Dragon root	*Arisaema dracontium*
Jack-in-the-pulpit	*Arisaema triphyllum*
Mouse-ear chickweed	*Cerastium nutans*
Toothwort	*Dentaria laciniata*
Cut-leaved toothwort	*Dentaria multifida*
Dutchman's breeches	*Dicentra cucullaria*
Shooting star	*Dodecatheon meadia*
Trout lily	*Erythronium americanum*
White snakeroot	*Eupatorium rugosum*
Sweet-scented bedstraw	*Galium triflorum*
Avens	*Geum canadense*
Spotted touch-me-not	*Impatiens capensis*

Herbs and Ferns (Continued)

Dwarf crested iris	Iris cristata
Twinleaf	Jeffersonia diphylla
Great lobelia	Lobelia siphilitica
Indian-pipe	Monotropa uniflora
Yellow oxalis	Oxalis stricta
Purple oxalis	Oxalis violacea
Ginseng	Panax quinquefolia
Phacelia	Phacelia bipinnatifida
Blue phlox	Phlox divaricata
Pokeweed	Phytolacca americana
May apple	Podophyllum peltatum
Bloodroot	Sanguinaria canadensis
Early saxifrage	Saxifrage virginiensis
False Solomon's seal	Smilacina racemosa
Solomon's seal	Polygonatum biflorum
Spotted trillium	Trillium cuneatum
Reflexed trillium	Trillium recurvatum
Violets	Viola spp.
Woodfern	Woodsia obtusa
Fragile fern	Cystopteris fragilis
Allegheny spurge	Pachysandra procumbens
Resurrection fern	Polypodium polypodioides
Bracken	Pteridium aquilinum
Blackstem spleenwort	Asplenium resiliens
Walking fern	Camptosorus rhizophyllus
Cinnamon fern	Osmunda cinnamomea
Rattlesnake fern	Botrychium virginianum

Table E-2-b. Principal Taxa of the Oak-Hickory-Hardwood Association on the Upper Slopes and Crests of the Caney Fork River Gorge and Tributary Gorges - Undissected Eastern Highland Rim (Vegetational Region I-a-2)

Large Trees

Black oak	Quercus velutina
Post oak	Quercus stellata
White oak	Quercus alba
Southern red oak	Quercus falcata
Scarlet oak	Quercus coccinea
Chestnut oak	Quercus prinus
Shagbark hickory	Carya ovata
Sweet hickory	Carya ovalis
Pignut	Carya glabra
Mockernut	Carya tomentosa
Black gum	Nyssa sylvatica
Sassafras	Sassafras albidum
Red maple	Acer rubrum
Sugarberry	Celtis occidentalis
Sourwood	Oxydendrum arboreum

Shrubs and Small Trees

Dogwood	Cornus florida
Huckleberry	Vaccinium stamineum
Highbush huckleberry	Vaccinium arboreum
Pinkster	Rhododendron nudiflorum
Maple-leaved haw	Viburnum acerifolium
Graybark grape	Vitis cinerea
Poison ivy	Rhus radicans
Carolina buckthorn	Rhamnus caroliniana
Mountain laurel	Kalmia latifolia

Herbs

Agrimony	Agrimonia pubescens
Agrimony	Agrimonia rostellata
St. Andrew's cross	Ascyrum hypericoides
Asters	Aster spp.
Wintergreen	Chimaphila maculata
Blue waxweed	Cuphea petiolata
Cut-leaved toothwort	Dentaria laciniata
Fireweed	Erechitites hieracifolia
	Glecoma hederacea
Liverleaf	Hepatica americana
	Houstonia purpurea
Twinleaf	Jeffersonia diphylla
Lespedeza	Lespedeza repens
Scorpion grass	Myosotis macrosperma
Pennywort	Obolaria virginica

<u>Herbs</u> (Continued)

May apple	*Podophyllum peltatum*
Crowfoot	*Ranunculus allegheniensis*
Crowfoot	*Ranunculus micranthus*
Bloodroot	*Sanguinaria canadensis*
Early saxifrage	*Saxifraga virginiensis*
Pink crowfoot	*Sedum pulchellum*
Goldenrod	*Solidago gigantea*
Goldenrod	*Solidago ulmifolia*
Celandine poppy	*Stylophorum diphyllum*
Lopseed	*Tovara virginiana*
Spotted trillium	*Trillium cuneatum*
Large-flowered trillium	*Trillium grandiflorum*

Table E-2-c. Principal Taxa of the Tuliptree-Sweet Gum-White Ash Association on Drastically Disturbed Sites in The Caney Fork River Gorge and Tributary Gorges - Undissected Eastern Highland Rim (Vegetational Region I-a-3)

Large Trees

Sweet gum	*Liquidambar styraciflua*
Tuliptree	*Liriodendron tulipifera*
White ash	*Fraxinus americana*
Box elder	*Acer negundo*
Red maple	*Acer rubrum*
Sugarberry	*Celtis occidentalis*
Heaven tree	*Ailanthus altissima*
Butternut	*Juglans cinerea*
Sycamore	*Platanus occidentalis*
Cottonwood	*Populus deltoides*
Wild black cherry	*Prunus serotina*
Black locust	*Robinia pseudo-acacia*
Slippery elm	*Ulmus rubra*
Winged elm	*Ulmus alata*
Empress tree	*Paulownia tomentosa*
Honey locust	*Gleditsia triacanthos*

Shrubs and Small Trees

Dogwood	*Cornus florida*
Alder	*Alnus serrulata*
Crossvine	*Bignonia capreolata*
Japanese honeysuckle	*Loniceria japonica*
Staghorn sumac	*Rhus typhina*
Buckbush	*Symphoricarpus orbiculatus*
Indigo bush	*Amorpha fruticosa*

Herbs and Ferns

Ragweed	*Ambrosia artemisiifolia*
	Ammania coccinea
Ebony spleenwort	*Asplenium platyneuron*
Asters	*Aster* spp.
Spanish needles	*Bidens* sp.
Rattlesnake fern	*Botyrichium virginianum*
Bird's rape	*Brassica rapa*
Bitter cress	*Cardamine hirsuta*
Sedges	*Carex* spp.
Wild senna	*Cassia hebecarpa*
Sensitive plant	*Cassia nictitans*
Golden aster	*Chrysopsis camporum*
Thistle	*Cirsium altissimum*
Dayflower	*Commelina communis*
	Cuscuta grovonii

Herbs and Ferns (Continued)

Hound's tongue	*Cynoglossum virginianum*
Tickseed	*Desmodium nudiflorum*
Tickseed	*Desmodium pauciflorum*
Buttonweed	*Diodia virginiana*
Elephant's foot	*Elephantopus carolinianus*
Fireweed	*Erechitites hieracifolia*
Ageratum	*Eupatorium coelestinum*
Flowering spurge	*Euphorbia corollata*
Spurge	*Euphorbia dentata*
Bedstraw	*Galium aparine*
Bedstraw	*Galium triflorum*
Pennyroyal	*Hedeoma pulegioides*
	Helenium flexosum
Wild barley	*Hordeum pusillum*
St. John's wort	*Hypericum punctatum*
Morning glory	*Ipomoea pandurata*
Lespedeza	*Lespedeza cuneatum*
Frogbit	*Lippia lanceolata*
Lobelia	*Lobelia inflata*
	Lycopus rubellus
Yellow oxalis	*Oxalis stricta*
Lady's thumb	*Polygonum convolvulus*
Smartweed	*Polygonum pennsylvanium*
White lettuce	*Prenanthes alba*
Self heal	*Prunella vulgaris*
Kudzu	*Pueraria lobata*
Golden ragwort	*Senecio* spp.
Hedge mustard	*Sisyrinchium angustifolium*
Horse nettle	*Solanum carolinense*
Goldenrod	*Solidago* spp.
Ladies' tresses	*Spiranthes ovalis*
Hop clover	*Trifolium dubium*
Red-top	*Triodia flava*
Sea oats	*Uniola latifolia*
Stinging nettle	*Urtica dioica*
Mullein	*Verbascum thaspus*
Goatweed	*Verbesina occidentalis*
Frostweed	*Verbesina virginica*
Ironweed	*Vernonia altissima*
Nimble will	*Muhlenbergia schreberi*

Table E-2-d. Principal Taxa of the Mixed Hardwood Forests in the High Valleys - Undissected Eastern Highland Rim (Vegetational Region I-b)

Large Trees

Shortleaf	Pinus echinata
White oak	Quercus alba
Black oak	Quercus velutina
Shagbark hickory	Carya ovata
Mockernut	Carya tomentosa
Beech	Fagus grandifolia
Sugar maple	Acer saccharum
Basswood	Tilia heterophylla
Southern red oak	Quercus falcata
Scarlet oak	Quercus coccinea
Cucumbertree	Magnolia acuminata
May apple	Podophyllum peltatum
Sweet gum	Liquidambar styraciflua
Tuliptree	Liriodendron tulipifera
White ash	Fraxinus americana
Box elder	Acer negundo
Red maple	Acer rubrum
Sugarberry	Celtis occidentalis
Heaven tree	Ailanthus altissima
Butternut	Juglans cinerea
Sycamore	Platanus occidentalis
Cottonwood	Populus deltoides
Wild black cherry	Prunus serotina
Black locust	Robinia pseudo-acacia
Slippery elm	Ulmus rubra
Winged elm	Ulmus alata
Empress tree	Paulownia tomentosa
Honey locust	Gleditsia triacanthos

Shrubs and Small Trees

Dogwood	Cornus florida
Alder	Alnus serrulata
Crossvine	Bignonia capreolata
Japanese honeysuckle	Loniceria japonica
Staghorn sumac	Rhus typhina
Buckbush	Symphoricarpus orbiculatus
Indigo bush	Amorpha fruticosa

Herbs and Ferns

Ragweed	Ambrosia artemisiifolia
	Ammania coccinea
Ebony spleenwort	Asplenium platyneuron
Asters	Aster spp.

Herbs and Ferns (Continued)

Spanish needles	Bidens sp.
Rattlesnake fern	Botyrichium virginianum
Bird's rape	Brassica rapa
Bitter cress	Cardamine hirsuta
Sedges	Carex spp.
Wild senna	Cassia hebecarpa
Sensitive plant	Cassia nictitans
Golden aster	Chrysopsis camporum
Thistle	Cirsium altissimum
Dayflower	Commelina communis
	Cuscuta grovonii
Hound's tongue	Cynoglossum virginianum
Tickseed	Desmodium nudiflorum
Tickseed	Desmodium pauciflorum
Buttonweed	Diodia virginiana
Elephant's foot	Elephantopus carolinianus
Fireweed	Erechitites hieracifolia
Ageratum	Eupatorium coelestinum
Flowering spurge	Euphorbia corollata
Spurge	Euphorbia dentata
Bedstraw	Galium aparine
Bedstraw	Galium triflorum
Pennyroyal	Hedeoma pulegioides
	Helenium flexosum
Wild barley	Hordeum pusillum
St. John's wort	Hypericum punctatum
Morning glory	Ipomoea pandurata
Lespedeza	Lespedeza cuneatum
Frogbit	Lippia lanceolata
Lobelia	Lobelia inflata
	Lycopus rubellus
Yellow oxalis	Oxalis stricta
Lady's thumb	Polygonum convolvulus
Smartweed	Polygonum pennsylvanium
White lettuce	Prenanthes alba
Self heal	Prunella vulgaris
Kudzu	Pueraria lobata
Golden ragwort	Senecio spp.
Hedge mustard	Sisyrinchium angustifolium
Horse nettle	Solanum carolinense
Goldenrod	Solidago spp.
Ladies' tresses	Spiranthes ovalis
Hop clover	Trifolium dubium
Red-top	Triodia flava
Sea oats	Uniola latifolia
Stinging nettle	Urtica dioica
Mullein	Verbascum thaspus
Goatweed	Verbesina occidentalis
Frostweed	Verbesina virginica
Ironweed	Vernonia altissima
Nimble will	Muhlenbergia schreberi
Spotted trillium	Trillium cuneatum
Wild ginger	Asarum ruthii
Woodfern	Woodsia obtusa

Table E-2-e. Principal Taxa of the Fields, Pastures, Pine Stands, Oak-Tuliptree Woods in the Tablelands - Undissected Eastern Highland Rim (Vegetational Region I-c)

Large Trees

Scrub pine	Pinus virginiana
Loblolly pine	Pinus taeda planted
Sugarberry	Celtis occidentalis
Tuliptree	Liriodendron tulipifera
Post oak	Quercus stellata
Scrub oak	Quercus marilandica
Winged elm	Ulmus alata
Osage orange	Maclura pomifera
Heaven tree	Ailanthus altissima
Mockernut	Carya tomentosa
Honey locust	Gleditsia triacanthos
Black walnut	Juglans nigra
Red mulberry	Morus rubra
Sassafras	Sassafras albidum
Persimmon	Diospyros virginiana
Red maple	Acer rubrum
Shortleaf pine	Pinus echinata

Shrubs and Small Trees

Buckbush	Symphoricarpus orbiculatus
Cow itch	Campsis radicans
Staghorn sumac	Rhus typhina
Shining sumac	Rhus copallina
Japanese honeysuckle	Lonicera japonica
Plum	Prunus angustifolia
Blackberries and dewberries	Rubus spp.
Sawbrier	Smilax glauca
Elderberry	Sambucus canadensis
	Ampelopsis cordata

Herbs

Cultivated fescue grasses	Festuca spp.
Broomsage	Andropogon virginicus
Crab grass	Digitaria sanguinaria
Bermuda grass	Cynodon dactylon
Red-top	Diodia teres
Cinquefoil	Potentilla canadensis
Lespedeza	Lespedeza striata
Ragwort	Senecio spp.
Ragweed	Ambrosia artemisiifolia
Daisy fleabane	Erigeron strigosus
Showy fleabane	Erigeron pulchellus
Cheat	Bromus cathartica
Bitterweed	Helenium amarum
Frostweed	Helenium autumnale

Herbs (Continued)

Queen Anne's lace	*Daucus carota*
Ruellia	*Ruellia cilliosa*
Asters	*Aster* spp.
Goldenrods	*Solidago* spp.
Sweet clover	*Melilotus alba*
Wild onion	*Allium* spp.
Wild false garlic	*Nothoscordum bivalve*
Herb robin	*Geranium carolinianum*
Buckhorn	*Plantago lanceolata*
Ox-eye daisy	*Chrysanthemum leucanthemum*
Pokeweed	*Phytolacca americana*
Rush	*Juncus effusus*
Henbit	*Lamium amplexicaule*
Dandelion	*Taraxicum officinale*
Jimsonweed	*Datura stamineum*
Dog fennel	*Anthemis cotula*
Evening primrose	*Oenothera* spp.
May apple	*Podophyllum peltatum*
Spotted trillium	*Trillium cuneatum*
Foxtail	*Setaria glauca*
Silvery spleenwort	*Athyrium thelypterioides*

Table E-2-f. Principal Taxa of the Willow Oak-Sweet Gum-Red Maple Swamps in the Tableland - Undissected Eastern Highland Rim (Vegetational Region I-d)

Note: These swamps are generally surrounded by taxa listed in Tables E-2-c and E-2-d as characteristic of high valleys. Towards the edge of the swamps there is a noticeable increase of white oak (*Quercus alba*), beech (*Fagus grandifolia*), sweet gum (*Liquidambar styraciflua*), and red maple (*Acer rubrum*).

Willow oak	*Quercus phellos*
Black willow	*Salix nigra*
Shortleaf pine	*Pinus echinata*
Sweet gum	*Liquidambar styraciflua*
Red maple	*Acer rubrum*
Sugar maple	*Acer saccharum*
Wild black cherry	*Prunus serotina*
Tassel-white	*Itea virginica*
Buttonbush	*Cephalanthus occidentalis*
Holly	*Ilex opaca*
Sourwood	*Oxydendrum arboreum*
Sawbriers	*Smilax* spp.
Cattail	*Typha latifolia*
Bulrush	*Scirpus* sp.
Hackberry	*Celtis missippiensis*
Christmas fern	*Polystichum acrostichoides*
Virginia chain-fern	*Woodwardia virginica*
Sensitive fern	*Onoclea sensibilis*
Cinnamon fern	*Osmunda cinnamomea*
White ash	*Fraxinus americana*
Bitternut	*Carya cordiformis*
Narrowleaf spleenwort	*Athyrium pycnocarpon*
Royal fern	*Osmunda regalis*
	Eleocharis equisetoides

Table E-2-g. Principal Taxa of the Chestnut Oak-Oaks-Hickories-Hardwoods Association on the Rim Spurs - Undissected Eastern Highland Rim, and the Hill Crests - Dissected Eastern Highland Rim (Vegetational Regions I-e and II-e)

Chestnut oak	*Quercus prinus* L. [a]
White Oak	*Quercus alba*
Tuliptree	*Liriodendron tulipifera*
Black oak	*Quercus velutina*
Post oak	*Quercus stellata*
Scarlet oak	*Quercus coccinea*
Black locust	*Robinia pseudo-acacia*
Wild black cherry	*Prunus serotina*
Red maple	*Acer rubrum*
Short-leaf pine	*Pinus echinata* [b]
Sweet hickory	*Carya ovalis*
Beech	*Fagus grandifolia*
Black gum	*Nyssa sylvatica*
Sugar maple	*Acer saccharum*
Highbush huckleberry	*Vaccinium arboreum*
Asters	*Aster* spp.
Birdfoot violet	*Viola pedata*
Ebony spleenwort	*Asplenium platyneuron*
Elephant's foot	*Elephantopus carolinianus*
Hawkweed	*Hieracium venosum*
Pussy toes	*Antennaria plantaginifolia*
Bracken	*Pteridium aquilinum*

[a] Predominant, especially on Rim Spurs.
[b] Rare or absent on Hill Crests of the Dissected Rim.

Table E-2-h. Principal Taxa of the Mixed Hydrophytic Hardwoods Association in the Alluvial and Flood Plains - Dissected Eastern Highland Rim and Outer Central Basin (Vegetational Regions II-f and III)

Silver maple	Acer saccharinum
Box elder	Acer negundo
Cottonwood	Populus deltoides
Black willow	Salix nigra
River birch	Betula deltoides
Sweet gum	Liquidambar styraciflua
Sycamore	Platanus occidentalis
Swamp privet	Forestiera acuminata
Giant ragweed	Ambrosia trifida
Cocklebur	Xanthium sp.
Johnson grass	Sorghum halepense
Buttonbush	Cephalanthus occidentalis
Cane	Arundinaria gigantea
American elm	Ulmus americana

Table E-2-i. Principal Taxa of the Mississippi Hackberry - Red Cedar-White Ash-Broomsage Association in the Outer Central Basin (Vegetational Region III)

Red cedar	*Juniperus virginia*
Black walnut	*Juglans nigra*
Chinquapin oak	*Quercus muhlenbergii*
White oak	*Quercus alba*
Post oak	*Quercus stellata*
White ash	*Fraxinus americana*
Blue ash	*Fraxinus quadrangulata*
Wafer tree	*Ptelea trifolia*
Dogwood	*Cornus florida*
Shagbark hickory	*Carya ovata*
Pignut	*Carya glabra*
Aromatic sumac	*Rhus canadensis*
Glade privet	*Forestiera ligustrinia*
Buckbush	*Symphoricarpus orbiculatus*
Shumard oak	*Quercus shumardii*
Mockernut	*Carya tomentosa*
Hackberry	*Celtis missippiensis*
Sugarberry	*Celtis occidentalis*
Rock elm	*Ulmus thomasi*
Winged elm	*Ulmus alata*
American elm	*Ulmus americana*
Honey locust	*Gleditsia triacanthos*
Sawbriers	*Smilax* spp.
Elderberry	*Sambucus canadensis*
	Ampelopsis cordata
Black haw	*Viburnum rufidulum*
Grayback grape	*Vitis cinerea*
Osage orange	*Maclura pomifera*
Carolina buckthorn	*Rhamnus caroliniana*
Redbud	*Cercis canadensis*
Persimmon	*Diospyros virginiana*
Prickly pear	*Opuntia rafinesquii*
Broomsage	*Andropogon virginicus*
Lespedeza	*Lespedeza striata*
Virgin's bower	*Clematis virginiana*
Sugar maple	*Acer saccharum*
Tuliptree	*Liriodendron tulipifera*
Beech	*Fagus americana*
Hairy lip-fern	*Cheilanthes lanosa*
Alabama lip-fern	*Cheilanthes alabamiensis*
Sawbrier	*Smilax bona-nox*
Ragweed	*Ambrosia artemisiifolia*
Bitterweed	*Helenium amarum*

Table E-2-j. Notes on the Occurrence and Distribution of Tennessee-Native Evergreen Conifers Known to Occur in or near DeKalb County

Shortleaf pine (Pinus echinata). Occurs sparsely throughout the Undissected Eastern Highland Rim. Occasionally forms considerable clumps.

White pine (Pinus strobus). Not known to occur naturally. Occasionally planted.

Loblolly pine (Pinus taeda). Not known to occur naturally. Planted to a considerable extent on the Undissected Rim.

Scrub pine (Pinus virginiana). Scattered throughout the Undissected Rim.

Hemlock (Tsuga canadensis). Not known from DeKalb County, but probably occurs sparsely in upper reaches of Caney Fork River. Known to occur close by in Putnam and White Counties.

Red cedar (Juniperus virginiana). Occurs throughout the county--local colonies on limestone outcrops in the Undissected Rim. Extensive stands of all ages on old pastures in the Dissected Rim and the Central Basin. The most abundant woody taxon in the latter two areas.

Arbor vitae (Thuja occidentalis). Not known to occur in DeKalb County, but does occur naturally at Window Cliffs in Putnam County.

Table E-2-i. Principal Taxa of the Mississippi Hackberry - Red Cedar-White Ash-Broomsage Association in the Outer Central Basin (Vegetational Region III)

Red cedar	*Juniperus virginia*
Black walnut	*Juglans nigra*
Chinquapin oak	*Quercus muhlenbergii*
White oak	*Quercus alba*
Post oak	*Quercus stellata*
White ash	*Fraxinus americana*
Blue ash	*Fraxinus quadrangulata*
Wafer tree	*Ptelea trifolia*
Dogwood	*Cornus florida*
Shagbark hickory	*Carya ovata*
Pignut	*Carya glabra*
Aromatic sumac	*Rhus canadensis*
Glade privet	*Forestiera ligustrinia*
Buckbush	*Symphoricarpus orbiculatus*
Shumard oak	*Quercus shumardii*
Mockernut	*Carya tomentosa*
Hackberry	*Celtis missippiensis*
Sugarberry	*Celtis occidentalis*
Rock elm	*Ulmus thomasi*
Winged elm	*Ulmus alata*
American elm	*Ulmus americana*
Honey locust	*Gleditsia triacanthos*
Sawbriers	*Smilax* spp.
Elderberry	*Sambucus canadensis*
	Ampelopsis cordata
Black haw	*Viburnum rufidulum*
Grayback grape	*Vitis cinerea*
Osage orange	*Maclura pomifera*
Carolina buckthorn	*Rhamnus caroliniana*
Redbud	*Cercis canadensis*
Persimmon	*Diospyros virginiana*
Prickly pear	*Opuntia rafinesquii*
Broomsage	*Andropogon virginicus*
Lespedeza	*Lespedeza striata*
Virgin's bower	*Clematis virginiana*
Sugar maple	*Acer saccharum*
Tuliptree	*Liriodendron tulipifera*
Beech	*Fagus americana*
Hairy lip-fern	*Cheilanthes lanosa*
Alabama lip-fern	*Cheilanthes alabamiensis*
Sawbrier	*Smilax bona-nox*
Ragweed	*Ambrosia artemisiifolia*
Bitterweed	*Helenium amarum*

Table E-2-j. Notes on the Occurrence and Distribution of Tennessee-Native Evergreen Conifers Known to Occur in or near DeKalb County

Shortleaf pine (*Pinus echinata*). Occurs sparsely throughout the Undissected Eastern Highland Rim. Occasionally forms considerable clumps.

White pine (*Pinus strobus*). Not known to occur naturally. Occasionally planted.

Loblolly pine (*Pinus taeda*). Not known to occur naturally. Planted to a considerable extent on the Undissected Rim.

Scrub pine (*Pinus virginiana*). Scattered throughout the Undissected Rim.

Hemlock (*Tsuga canadensis*). Not known from DeKalb County, but probably occurs sparsely in upper reaches of Caney Fork River. Known to occur close by in Putnam and White Counties.

Red cedar (*Juniperus virginiana*). Occurs throughout the county--local colonies on limestone outcrops in the Undissected Rim. Extensive stands of all ages on old pastures in the Dissected Rim and the Central Basin. The most abundant woody taxon in the latter two areas.

Arbor vitae (*Thuja occidentalis*). Not known to occur in DeKalb County, but does occur naturally at Window Cliffs in Putnam County.

Table E-2-k. Representative Species List of the Vascular Flora of DeKalb County, with Emphasis on the Vicinity of Center Hill Reservoir

Ophioglossaceae	
Rattlesnake Fern	Botrychium virginianum
Pteridaceae	
Maidenhair fern	Adiantum pedatum
Alabama lip-fern	Cheilanthes alabamensis
Hairy lip-fern	Cheilanthes lanosa
Purple cliffbrake	Pellaea atropurpurea
Bracken	Pteridium aquilinum
Selaginellaceae	
Spikemoss	Selaginella apoda
Osmundaceae	
Royal fern	Osmunda regalis
Cinnamon fern	Osmunda cinnamomea
Aspidiaceae	
Narrowleafed spleenwort	Athyrium pycnocarpon
Silvery spleenwort	Athyrium thelypterioides
Fragile fern	Cystopteris fragilis var. protrusa
Fragile fern	Cystopteris fragilis var. mackayii
Bulblet fern	Cystopteris bulbifera
Marsh-fern	Dryopteris thelypteris
New York fern	Dryopteris noveboracensis
Beech fern	Dryopteris hexagonaptera
Sensitive fern	Onoclea sensibilis
Christmas fern	Polystichum acrostichoides
Broadbeech fern	Theloypteris hexagonoptera
Blunt-lobed woodsia	Woodsia obtusa
Blechnaceae	
Virginia chain-fern	Woodwardia virginica
Aspleniaceae	
Mountain spleenwort	Asplenium montanum
Ebony spleenwort	Asplenium platyneuron
Walking fern	Asplenium rhizophyllum
Spleenwort	Asplenium sp.
Blackstem spleenwort	Asplenium resiliens
Polypodiaceae	
Resurrection fern	Polypodium polypodioides
Pinaceae	
Loblolly pine (planted only)	Pinus taeda
Shortleaf pine	Pinus echinata
Scrub pine	Pinus virginiana
White pine (planted only)	Pinus strobus

Typhaceae	
Cattail	*Typha latifolia*
Cupressaceae	
Red cedar	*Juniperus virginiana*
Poaceae	
Bent grass	*Agrostis* spp.
Little bluestem	*Andropogon scoparius*
Broomsage	*Andropogon virginicus*
	Aristida dichotoma
Cane	*Arundinaria gigantea*
Brome grass	*Bromus* sp
Brome grass	*Bromus techorum*
Bermuda grass	*Cynodon dactylon*
Orchard grass	*Dactylis glomerata*
	Danthonia spicata
Crab grass	*Digitaria sanguinalis*
Goose grass	*Eleusine indica*
Wild rye	*Elymus virginicus*
Beard grass	*Erianthus alopecuroides*
Fescue	*Festuca elatior*
Barley	*Hordeum pusillum*
Barley	*Hordeum* sp.
Rye grass	*Lolium perenne*
Melic grass	*Melica mutica*
Panic grasses	*Panicum* sp.
Dallas grass	*Paspalum dilatatum*
	Paspalum boscianum
Timothy	*Phleum pratense*
Grass	*Phyllostachys aurea*
Annual bluegrass	*Poa annua*
	Poa chapmaniana
	Poa compressa
Kentucky bluegrass	*Poa pratensis*
Cheat	*Setaria glauca*
Cheat	*Setaria viridis*
Johnson grass	*Sorghum halepense*
Purple top	*Triodia flava*
Grass	*Uniola latifolia*
Cyperaceae	
Sedge	*Carex grayi*
Sedge	*Carex* spp.
Sedge	*Cyperus* spp.
	Cyperus tenuifolius
	Eleocharis quadrangulata
	Eleocharis equisetoides
	Eleocharis obtusa
Bulrushes	*Scirpus* spp.
Araceae	
Green dragon	*Arisaema dracontium*
Jack-in-the-pulpit	*Arisaema triphyllum*

Commelinaceae	
Dayflower	Commelina communis
Spiderwort	Tradescantia virginiana
Juncaceae	
	Juncus effusus
	Juncus tenuis
Woodrush	Luzula campestris
Liliaceae	
Wild onion	Allium canadense
Wild onion	Allium vineale
Asparagus	Asparagus officinalis
Wild false garlic	Disporum lanuginosum
Dog-toothed violet	Erythronium americanum
	Medeola virginiana
Wild false garlic	Nothoscordum bivalve
Star of Bethlehem	Ornithogalum umbellatum
Solomon's seal	Polygonatum biflorum
Bullbrier greenbrier	Smilax bona-nox
Common greenbrier	Smilax rotundifolia
Bristly greenbrier	Smilax hispida
Sawbrier	Smilax glauca
False Solomon's seal	Smilacina racemosa
	Trillium grandiflorum
Wake robin	Trillium erectum
Spotted trillium	Trillium cuneatum
Recurved trillium	Trillium recurvatum
	Uvalaria sessifolia
Dioscoreaceae	
Wild yam	Dioscorea villosa
Iridaceae	
Dwarf iris	Iris cristata
Blue-eyed grass	Sisyrinchium angustifolium
Amaryllidaceae	
Yellow star-grass	Hypoxis hirsuta
Orchidaceae	
Coral root	Corallorhiza maculata
Rattlesnake plantain	Goodyera pubescens
Adder's mouth	Malaxis uniflora
Ladies' tresses	Spiranthes cernua
Cranefly orchid	Tipularia discolor
Salicaceae	
Cottonwood	Populus deltoides
Black willow	Salix nigra

Juglandaceae

Bitternut hickory	Carya cordiformis
Pignut hickory	Carya glabra
Shagbark hickory	Carya ovata
Hickory	Carya ovalis
Mockernut hickory	Carya tomentosa
Glade hickory	Carya carolinae-septentrionalis
Kingnut	Carya laciniosa
Butternut	Juglans cinerea
Black Walnut	Juglans nigra

Betulaceae

Tag alder	Alnus serrulata
River birch	Betula nigra
Ironwood	Carpinus caroliniana
Hop Hornbeam	Ostrya virginiana

Fagaceae

Chestnut	Castanea dentata
Chinquapin	Castanea pumila
Beech	Fagus grandifolia
White Oak	Quercus alba
Southern red oak	Quercus falcata
Black Jack oak	Quercus marilandica
Yellow chestnut oak	Quercus muehlenbergii
Rock chestnut oak	Quercus prinus
Red oak	Quercus rubra
Post Oak	Quercus stellata
Black Oak	Quercus velutina
Shumard Oak	Quercus shumardii
Scarlet oak	Quercus coccinea
Willow Oak	Quercus phellos

Ulmaceae

Mississippi hackberry	Celtis laevigata
Hackberry	Celtis occidenalis var. georgiana
Winged elm	Ulmus alata
American elm	Ulmus americana
Slippery elm	Ulmus rubra
Rock elm	Ulmus thomasi

Moraceae

Paper mulberry	Broussonetia papyritera
Osage orange	Maclura pomifera
Red mulberry	Morus rubra

Urticaceae

False nettle	Boehmeria cylindrica
Stinging nettle	Urtica dioica

Loranthaceae

Mistletoe	Phoradendron flavescens

Aristolochiaceae	
Birthwort	Aristolochia serpentaria
Wild ginger	Asarum canadense
Heartleaf	Hexastylis ruthii
Polygonaceae	
Climbing buckwheat	Ploygonum scandens
Climbing buckwheat	Ploygonum convolvulus
Lady's thumb	Ploygonum pensylvanicum
Yellow dock or yellow sorrel	Rumex crispus
Dock	Rumex hastatulus
Jumpseed	Tovara virginiana
Phytolaccaceae	
Poke	Phytolacca americana
Chenopodiaceae	
Lamb's quarters	Chenopodium album
Amaranthaceae	
Spiny pigweed	Amaranthus spinosus
Pigweed	Amaranthus hybridus
Aizoaceae	
Carpetweed	Mullugo verticillata
Portulacaceae	
Spring beauty	Claytonia virginica
Spring beauty	Claytonia caroliniana
Caryophyllaceae	
Mouse-eared chickweed	Cerastium nutans
Pink	Dianthus armeria
	Holosteum umbellatum
	Lychnis alba
Bouncing bet	Saponaria officinalis
Fire pink	Silene virginica
Chickweed	Stellaria media
Giant chickweed	Stellaria pubera
Ranunculaceae	
Bayberry	Actaea pachypoda
Thimbleweed	Anemone virginiana
Rue anemone	Anemonella thalictroides
Columbine	Aquilegia canadensis
Leather flower	Clematis crispa
Virgin's bower	Clematis virginiana
Dwarf larkspur	Delphinium tricorne
Liverleaf	Hepatica acutiloba
Liverleaf	Hepatica americana
Buttercup	Ranunculus arvensis
Rock crowfoot	Ranunculus allegheniensis
Rock crowfoot	Ranunculus micranthus
	Ranunculus abortivus
	Ranunculus recurvatus
	Ranunculus hispidus
Meadow rue	Thalictrum sp.
	Trantvetteria carolinensis

Berberidaceae	
Blue cohosh	*Caulophyllum thalictroides*
Twinleaf	*Jeffersonia diphylla*
May-apple	*Podophyllum peltatum*
Menispermaceae	
Coralbeads	*Cocculus carolinus*
Magnoliaceae	
Tulip tree	*Liriodendron tulipifera*
Cucumber tree	*Magnolia acuminata*
Umbrella tree	*Magnolia tripetala*
Annonaceae	
Pawpaw	*Asimina triloba*
Lauraceae	
Spicebush	*Lindera benzoin*
Sassafras	*Sassafras albidum*
Papaveraceae	
Bloodroot	*Sanguinaria canadensis*
Fumariaceae	
Squirrel corn	*Corydalis flavula*
Dutchman's breeches	*Dicentra cucullaria*
Brassicaeae	
Turnip	*Brassica campestris*
Shepherd's purse	*Capsella bursa-pastoris*
Toothwort	*Cardamine diphylla*
Bittercress	*Cardamine hirsuta*
Toothwort	*Dentaria laciniata*
Toothwort	*Dentaria multifida*
Toothwort	*Dentaria diphylla*
Whitlow-grass	*Draba verna*
Peppergrass	*Lepidium virginicum*
Hedge mustard	*Sisymbrium officinalis*
Crassulaceae	
Stonecrop	*Sedum pulchellum*
Saxifragaceae	
	Astilbe biternata
Alum root	*Heuchera americana*
Alum root	*Heuchera villosa*
Hydrangea	*Hydrangea arborescens*
False willow	*Itea virginica*
Miterwort	*Mitella diphylla*
Mock orange	*Philadelphus inodorus*
axifrage	*Saxifraga virginiensis*
Foamflower	*Tiarella cordifolia*

Hamamelidaceae	
Witch-hazel	*Hamamelis virginiana*
Sweet gum	*Liquidambar styraciflua*
Platanaceae	
Sycamore	*Platanus occidentalis*
Rosaceae	
Cocklebur or tall agrimony	*Agrimonia gryposepala*
Cocklebur	*Agrimonia pubescens*
Cocklebur	*Agrimonia rostellata*
Serviceberry	*Amelanchier arborea*
Hawthorne	*Crataegus crus-galli*
Mock strawberry	*Duchesna indica*
White avens	*Geum canadense*
Rough avens	*Geum virginianum*
Indian physic	*Gillenia stipulata*
Ninebark	*Physocarpus opulifolius*
Five fingers	*Potentilla canadensis*
	Potentilla recta
Black cherry	*Prunus serotina*
Plum	*Prunus angustifolia*
Prairie rose	*Rosa setigera*
Blackberry	*Rubus betulifolius*
	Rubus sp.
Black raspberry	*Rubus occidentalis*
Hardhack	*Spiraea tomentosa*
Fabaceae	
Mimosa	*Albizia julibrissin*
	Amorpha fructicosa
Wild senna	*Cassia marilandica*
Wild sensitive plant	*Cassia nictitans*
Sicklepod	*Cassia obtusifolia*
Redbud	*Cercis canadensis*
Yellow wood	*Cladrastis lutea*
Showy tick trefoil	*Desmodium canescens*
Showy beggar's tick	*Desmodium nudiflorum*
	Desmodium pauciflorum
Tickseed	*Desmodium glutinosum*
Honey locust	*Gleditsia triacanthos*
Lespedeza	*Lespedeza cuneata*
Lespedeza	*Lespedeza striata*
Korean lespedeza	*Lespedeza stipulacea*
Black medic	*Medicago lupulina*
White sweet clover	*Melilotus alba*
Yellow sweet clover	*Melilotus officinalis*
Kudzu	*Pueraria lobata*
Black locust	*Robinia pseudoacacia*
Clammy locust	*Robinia viscosa*
Sensitive brier	*Schrankia microphylla*

Fabaceae	
Hop Clover	Trifolium agrarium
Red Clover	Trifolium pratense
White Clover	Trifolium repens
Clover	Trifolium sp.
	Trifolium cuneatum
Carolina vetch	Vicia caroliniana
Geraniaceae	
Wild geranium	Geranium maculatum
Herb robin	Geranium dissectum
	Geranium carolinianum
Rutaceae	
Hop tree	Ptelea trifoliata
Oxalidaceae	
Wood-sorrel	Oxalis stricta
Violet wood-sorrel	Oxalis violacea
Simaroubaceae	
Tree-of-Heaven	Ailanthus altissima
Euphorbiaceae	
Three-seeded Mercury	Acalypha virginica
Three-seeded Mercury	Acalypha gracilens
Three-seeded Mercury	Acalypha ostryaefolia
Goatweed	Croton monanthogynus
	Croton capitatus
Flowering Spurge	Euphorbia corollata
Poinsettia	Euphorbia dentata
	Euphorbia mercurialina
Spurge	Euphorbia maculata
Anacardiaceae	
Fragrant sumac	Rhus aromatica
Dwarf sumac	Rhus copallina
Common sumac	Rhus glabra
Poison Ivy	Rhus radicans
Staghorn sumac	Rhus typhina
Aquifoliaceae	
American holly	Ilex opaca
Winterberry	Ilex verticillata
Celastraceae	
Strawberry bush	Euonymus americanus
Staphylaeceae	
Bladdernut	Staphylea trifolia
Buxaceae	
Pachysandra	Pachysandra procumbens

Aceraceae	
Box Elder	Acer negundo
Red Maple	Acer rubrum
Sugar Maple	Acer saccharum
Silver Maple	Acer saccharinum
Hippocastanaceae	
Buckeye	Aesculus octandra
Balsaminaceae	
Touch-me-not	Impatiens pallida
Spotted jewelweed	Impatiens capensis
Rhamnaceae	
New Jersey tea	Ceanothus americanus
Buckthorn	Rhamnus caroliniana
Vitaceae	
	Ampelopsis cordata
Virginia creeper	Parthenocissus quinquefolia
Summer grape	Vitis aestivalis
Muscadine	Vitis rotundifolia
Pigeon grape	Vitis cinera
Hypericaceae	
St. Andrew's Cross	Ascyrum hypericoides
Spotted St. Johnswort	Hypericum punctatum
St. Johnswort	Hypericum sp.
Malvaceae	
Butter mold	Abutilon theophrastii
Theaceae	
Mountain camellia	Stuartia ovata
Violaceae	
Green violet	Hybanthus concolor
Three-lobed violet	Viola triloba
Wild pansy	Viola rafinesquii
Birdfoot violet	Viola pedata
	Viola papilionacea
	Viola primulifolia
	Viola hastata
	Viola eriocarpa
	Viola canadensis
	Viola walteri
Passifloraceae	
Passion flower	Passiflora incarnata
Passion flower	Passiflora lutea
Cactaceae	
Prickly-pear	Opuntia compressa

Lythraceae	
	Ammannia coccinea
Waxweeds	*Cuphea petiolata*
Araliaceae	
Ginseng	*Panax quinquefolium*
Thymelaeaceae	
Leatherwood	*Dirca palustris*
Onagraceae	
	Circaea lutetiana
Evening primrose	*Oenothera biennis*
	Oenothera laciniata
	Oenothera speciosa
Apiaceae	
Wild chervil	*Chaerophyllum tainturieri*
Honewort	*Cryptotaenia canadensis*
Queen Anne's lace	*Daucus carota*
Pepper and salt	*Erigenia bulbosa*
Snakeroot	*Sanicula canadensis*
	Sanicula gregaria
Sticktight	*Torilis arvensis*
Nyssaceae	
Black gum	*Nyssa sylvatica*
Cornaceae	
Flowering dogwood	*Cornus florida*
Red-panicle dogwood	*Cornus racemosa*
Alternate leaf dogwood	*Cornus alternifolia*
Ericaceae	
Spotted wintergreen	*Chimaphila maculata*
Mountain laurel	*Kalmia latifolia*
Indian pipe	*Monotropa uniflora*
Sourwood	*Oxydendrum arboreum*
Flame azalea	*Rhododendron calendulaceum*
Pinkster	*Rhododendron nudiflorum*
Highbush blueberry	*Vaccinium arboreum*
Primulaceae	
Shooting star	*Dodecatheon meadia*
	Lysimachia tonsa
Ebenaceae	
Persimmon	*Diospyros virginiana*
Sapotaceae	
Southern buckthorn	*Bumelia lycioides*

Oleaceae	
Fringe-tree	Chionanthus virginicus
Glade privet	Forestiera ligustrina
White ash	Fraxinus americana
Blue ash	Fraxinus quadrangulata
Privet	Ligustrum sinense
Loganiaceae	
Indian pink	Spigelia marilandica
Gentianaceae	
Pennywort	Obolaria virginiana
	Swertia carolinensis
Apocynaceae	
Indian hemp	Apocynum cannabinum
Dogbane	Apocynum
Grave ivy	Vinca minor
Asclepiadaceae	
Common milkweed	Asclepias syriaca
Convolvulaceae	
Bindwind	Convolvulus arvensis
Compact dodder	Cuscuta compacta
Lovevine	Cuscuta gronovii
Ivy leaf morning glory	Ipomoea hederacea
Wild potato vine	Ipomoca pandurata
Polemoniaceae	
Blue phlox	Phlox divaricata
	Phlox amoena
Spotted phlox	Phlox maculata
Jacob's ladder	Polemonium reptans
Hydrophyllaceae	
	Nemophila microcalyx
Phacelia	Phacelia bipinnatifida
	Phacelia purshii
Boraginaceae	
Wild comfrey	Cynoglossum virginianum
Turnsole	Heliotropium indicum
Forget-me-not	Myosotis macrosperma
Verbenaceae	
Fog fruit	Lippia lanceolata
Hoary vervain	Verbena stricta
	Verbena urticifolia
	Verbena simplex
Phrymaceae	
Lopseed	Phyrma leptostachya

Lamiaceae

	Glecoma hederacea
Pennyroyal	Hedeoma pulegioides
Henbit	Lamium amplexicaule
	Lycopus rubellus
	Monarda fistulosa
Catnip	Nepeta cataria
Self heal	Prunella vulgaris
Mountain mint	Pycnanthemum tenuifolium
Sage	Salvia lyrata
	Satureja calamintha
Skullcap	Scutellaria integrifolia
Wood-mint	Teucrium canadense

Solanaceae

Jimsonweed	Datura stramonium
Horse nettle	Solanum carolinense

Scrophulariaceae

Downy false-foxglove	Aureolaria virginica
Indian cigar	Catalpa speciosa
Monkey flower	Mimulus ringens
Empress tree	Paulownia tomentosa
Lousewort	Pedicularis canadensis
Beard tongue	Penstemon digitalis
Woolly mullein	Verbascum thapsus
Moth mullein	Verbascum blattaria
	Veronica peregrina
	Veronica arvensis

Bignoniaceae

Cross vine	Bignonia capreolata
Trumpet vine	Campsis radicans

Orobanchaceae

Beech-drops	Epifagus virginiana

Acanthaceae

Ruellia	Ruellia caroliniensis
Ruellia	Ruellia humilis

Plantaginaceae

English plantain	Plantago lanceolata
Plantain	Plantago major
Plantain	Plantago rugelii

Rubiaceae

Button bush	Cephalanthus occidentalis
Button weed	Diodia virginiana
Cleavers	Galium aparina
White wild licorice	Galium circaezans
Yellow Bedstraw	Galium lanceolatum

Rubiaceae	
Bedstraw	Galium pilosum
Fragrant bedstraw	Galium trifolium
Bluets	Houstonia caerulea
Bluet	Houstonia longifolia
Summer bluet	Houstonia purpurea
Partridge berry	Mitchella repens
Caprifoliaceae	
Honeysuckle	Lonicera japonica
Coral honeysuckle	Lonicera sempervirens
Elderberry	Sambucus canadensis
Coral-berry	Symphoricarpos orbiculatus
Mapleleaf viburnum	Viburnum acerifolium
Rusty blackhaw	Viburnum rufidulum
Campanulaceae	
Bellflower	Campanula americana
Cardinal flower	Lobelia cardinalis
Indian tobacco	Lobelia inflata
Great lobelia	Lobelia siphilitica
Venus' looking glass	Specularia perfoliata
Asteraceae	
Yarrow	Achillea millefolium
Ragweed	Ambrosia artemisiifolia
Dog fennel	Anthemis cotula
Pussy toes	Antennaria solitaria
	Antennaria plantaginifolia
	Artemisia vulgaris
Aster	Aster spp.
Spanish needles	Bidens bipinnata
Beggar ticks	Bidens cernus
Thistle	Carduus altissimus
Muck thistle	Carduus nutans
Ox-eye daisy	Chrysanthemum leucanthemum
Prairie golden aster	Chrysopsis camporum
Chicory	Cichorium intybus
	Coreopsis major
Elephant's foot	Elephantopus carolinianus
Fireweed	Erechtites hieracifolia
Daisy fleabane	Erigeron annuus
Daisy fleabane	Erigeron philadelphicus
Fleabane	Erigeron spp.
	Erigeron pulchellus
Horsetail weed	Erigeron canadensis
Mistflower	Eupatorium coelestinum
Joe Pye weed	Eupatorium purpureum
	Eupatorium album
White snakeroot	Eupatorium rugosum

Asteraceae

Cud-weed	Gnaphalium purpureum
Rabbit tobacco	Gnaphalium obtusifolium
Sneezeweed	Helenium autumnale
Bitterweed	Helenium amarum
Sneeze-weed	Helenium flexuosum
Sunflower	Helianthus divaricatus
Jerusalem artichoke	Helianthus tuberosa
Hawkweed	Hieracim venosum
Dwarf dandelion	Krigia biflora
	Kuhnia eupatorioides
Wild lettuce	Lactuca canadensis
Lettuce	Lactuca spp.
Blazing star	Liatris spicata
Bear's foot	Polymnia uvedalia
White lettuce	Prenanthes alba
False dandelion	Pyrrhopappus carolinianus
	Rudbeckia laciniata
Black-eyed Susan	Rudbeckia hirta
	Rudbeckia triloba
Ragwort	Senecio smallii
Ragwort	Senecio spp.
Goldenrod	Solidago caesia
Late goldenrod	Solidago gigantea
	Solidago juncea
	Solidago rugosa
Elm-leaved goldenrod	Solidago ulmifolia
Sow thistle	Sonchus asper
Common dandelion	Taraxacum officinale
	Verbesina alternifolia
Crownbeard	Verbesina occidentalis
	Verbesina virginica
Ironweed	Vernonia altissima
Cocklebur	Xanthium strumarium

SECTION E-3
WILDLIFE OF DEKALB COUNTY

Table E-3-a. Representative Mammals of DeKalb County

Opossums	
Virginia Opossum	*Didelphis marsupialis*
Shrews and Moles	
Smoky Shrew	*Sorex fumeus*
Short-tailed Shrew	*Blarina brevicauda*
Least Shrew	*Cryptotis parva*
Southeastern Shrew	*Sorex longirostris*
Eastern Mole	*Scalopus aquaticus*
Bats	
Little Brown Myotis	*Myotis lucifugus*
Gray Myotis	*Myotis grisescens*
Keen's Myotis	*Myotis keenii*
Indiana Myotis	*Myotis sodalis*
Silver-haired Bat	*Lasionycteris noctivagans*
Eastern Pipistrelle	*Pipistrellus subflavus*
Big Brown Bat	*Eptesicus fuscus*
Red Bat	*Lasiurus borealis*
Hoary Bat	*Lasiurus cinereus*
Evening Bat	*Nycticeius humeralis*
Rafinesque's Big-eared Bat	*Plecotus rafinesquii*
Hares and Rabbits	
Eastern Cottontail	*Sylvilagus floridanus*
Rodents	
Eastern Chipmunk	*Tamias striatus*
Woodchuck	*Marmota monax*
Eastern Gray Squirrel	*Sciurus carolinensis*
Eastern Fox Squirrel	*Sciurus niger*
Southern flying squirrel	*Glaucomys volans*
Beaver	*Castor canadensis*
Rice Rat	*Oryzomys palustris*
Eastern Harvest Mouse	*Reithrodontomys humulis*
White-footed Mouse	*Peromyscus leucopus*
Cotton Mouse	*Peromyscus gossypinus*
Golden Mouse	*Ochrotomys nuttalli*
Meadow Jumping Mouse	*Zapus hudsonius*

Rodents (continued)

Eastern Wood Rat	*Neotoma floridana*
Hispid Cotton Rat	*Sigmodon hispidus*
Meadow Vole	*Microtus pennsylvanicus*
Prairie Vole	*Microtus ochrogaster*
Pine Vole	*Microtus pinetorum*
Muskrat	*Ondatra zibethica*
Southern Bog Lemming	*Synaptomys cooperi*
Black Rat	*Rattus rattus*
Norway Rat	*Rattus norvegicus*
House Mouse	*Mus musculus*

Carnivores

Red Fox	*Vulpes fulva*
Gray Fox	*Urocyon cinereoargenteus*
Raccoon	*Procyon lotor*
Longtail Weasel	*Mustela frenata*
Mink	*Mustela vison*
Eastern Spotted Skunk	*Spilogale putorius*
Striped Skunk	*Mephitis mephitis*
Bobcat	*Lynx rufus*

Ungulates

White-tailed Deer	*Odocoileus virginianus*

Table E-3-b. Representative Birds of DeKalb County

Loons

Common Loon	*Gavia immer*		T	

Grebes

Horned Grebe	*Podiceps auritus*		T	
Pied-billed Grebe	*Podilymbus podiceps*		R	

Pelicans and Allies

Double-crested Cormorant	*Phalacrocorax auritus*		T	

Herons and Allies

Great Blue Heron	*Ardea herodias*		R	
Green Heron	*Butorides virescens*		R	
Little Blue Heron	*Florida caerulea*		T	(u)
Cattle Egret	*Bubulcus ibis*		T	(u)
Common Egret	*Casmerodius albus*		T	(u)
Snowy Egret	*Egretta thula*	T	(r)	
Black-crowned Night Heron	*Nycticorax nycticorax*		T	
Yellow-crowned Night Heron	*Nyctanassa violacea*		T	
Least Bittern	*Ixobrychus exilis*		S	
American Bittern	*Botaurus lentiginosus*		T	

Waterfowl

Whistling Swan	*Olor columbianus*		T	
Canada Goose	*Branta canadensis*		T	
Blue Goose	*Chen caerulescens*		T	
Snow Goose	*Chen hyperborea*		T	
Mallard	*Anas platyrhynchos*		T	
Black Duck	*Anas rubripes*		T	
Gadwall	*Anas strepera*		T	
Pintail	*Anas acuta*		T	
Green-winged Teal	*Anas carolinensis*		T	
Blue-winged Teal	*Anas discors*		T	
American Widgeon	*Mareca americana*		T	
Shoveler	*Spatula clypeata*		T	
Wood Duck	*Aix sponsa*		R	
Redhead	*Aythya americana*		T	
Ring-necked Duck	*Aythya collaris*		T	
Canvasback	*Aythya valisineria*		T	
Greater Scaup	*Aythya marila*		T	
Lesser Scaup	*Aythya affinis*		T	
Common Goldeneye	*Bucephala clangula*		T	
Bufflehead	*Bucephala albeola*		T	

Waterfowl (continued)

Oldsquaw	Clangula hyemalis	T	(r)
White-Winged Scoter	Melanitta deglandi	T	(r)
Surf Scoter	Melanitta perspicillata	T	(r)
Ruddy Duck	Oxyura jamaicensis	T	
Hooded Merganser	Lophodytes cucullatus	T	
Common Merganser	Mergus merganser	T	(r)
Red-breasted Merganser	Mergus serrator	T	(r)

Vultures, Hawks and Falcons

Turkey Vulture	Cathartes aura	R	
Black Vulture	Coragyps atratus	R	
Goshawk	Accipiter gentilis	T	(r)
Sharp-skinned Hawk	Accipiter striatus	R	
Cooper's Hawk	Accipiter cooperii	R	
Red-Tailed Hawk	Buteo jamaicensis	R	
Red-shouldered Hawk	Buteo lineatus	R	
Broad-winged Hawk	Buteo platypterus	S	
Rough-legged Hawk	Buteo lagopus	T	
Golden Eagle	Aquila chrysaetos	T	(r)
Bald Eagle	Haliaeetus leucocephalus	T	
Marsh Hawk	Circus cyaneus	T	(r)
Osprey	Pandion haliaetus	T	(r)
Pigeon Hawk	Falco columbarius	T	(r)
Sparrow Hawk	Falco sparverius	R	

Gallinaceous Birds

Bobwhite Quail	Colinus virginianus	R	
Wild Turkey	Meleagris gallopavo	R	(r)
Ruffed Grouse	Bonasa umbellus	R	(r)

Cranes and Allies

King Rail	Rallus elegans	T	(r)
Virginia Rail	Rallus limicola	T	(r)
Sora	Porzana carolina	T	(r)
Common Gallinule	Gallinula chloropus	T	(r)
American Coot	Fulica americana	T	
Sandhill Crane	Grus canadensis	T	(r)

Shorebirds, Gulls and Alcids

Semipalmated Plover	Charadrius semipalmatus	T	
Piping Plover	Charadrius melodus	T	(r)
Killdeer	Charadrius vociferus	R	
American Woodcock	Philohela minor	T	
Common Snipe	Capella gallinago	T	
Upland Plover	Bartramia longicauda	T	
Spotted Sandpiper	Actitis macularia	T	

Shorebirds, Gulls and Alcids (continued)

Solitary Sandpiper	*Tringa solitaria*	T	
Willet	*Catoptrophorus semipalmatus*	T	
Least Sandpiper	*Erolia minutilla*	T	
Dunlin	*Erolia alpina*	T	
Short-Billed Dowitcher	*Limnodromus griseus*	T	
Long-Billed Dowitcher	*Limnodromus scolopaceus*	T	
Semipalmated Sandpiper	*Ereunetes pusillus*	T	
Sanderling	*Crocethia alba*	T	
Franklin's Gull	*Larus pipixcan*	T	(r)
Laughing Gull	*Larus atricilla*	T	(r)
Bonaparte's Gull	*Larus philadelphia*	T	
Caspian Tern	*Hydroprogne caspia*	T	(r)
Ring-billed Gull	*Larus delawarensis*	T	
Herring Gull	*Larus argentatus*	T	
Common Tern	*Sterna hirundo*	T	
Least Tern	*Sterna albifrons*	T	(r)
Black Tern	*Chlidonias niger*	T	(r)

Pigeons and Doves

Rock Dove	*Columba livia*	R	
Mourning Dove	*Zenaidura macroura*	R	

Cuckoos

Yellow-billed Cuckoo	*Coccyzus americanus*	S	
Black-billed Cuckoo	*Coccyzus erythropthalmus*	S	

Owls

Barn Owl	*Tyto alba*	R	
Screech Owl	*Otus asio*	R	
Great Horned Owl	*Bubo virginianus*	R	
Barred Owl	*Strix varia*	R	
Long-eared Owl	*Asio otus*	T	(r)
Short-eared Owl	*Asio flammeus*	T	(r)

Kingfishers

Belted Kingfisher	*Megaceryle alcyon*	R	

Woodpeckers

Common Flicker	*Colaptes auratus*	R	
Pileated Woodpecker	*Dryocopus pileatus*	R	
Red-bellied Woodpecker	*Centurus carolinus*	R	
Red-headed Woodpecker	*Melanerpes erythrocephalus*	R	
Yellow-bellied Sapsucker	*Sphyrapicus varius*	T	
Hairy Woodpecker	*Dendrocopos villosus*	R	
Downy Woodpecker	*Dendrocopos pubescens*	R	

Perching Birds

Eastern Kingbird	*Tyrannus tyrannus*	S	
Great Crested Flycatcher	*Myiarchus crinitus*	S	
Eastern Phoebe	*Sayornis phoebe*	S	
Yellow-bellied Flycatcher	*Empidonax flaviventris*	T	
Acadian Flycatcher	*Empidonax virescens*	S	
Traill's Flycatcher	*Empidonax traillii*	T	
Least Flycatcher	*Empidonax minimus*	T	
Eastern Wood Pewee	*Contopus virens*	S	
Olive-sided Flycatcher	*Nuttallornis borealis*	T	
Horned Lark	*Eremophila alpestris*	T	
Tree Swallow	*Iridoprocne bicolor*	T	
Bank Swallow	*Riparia riparia*	S	
Rough-winged Swallow	*Stelgidopteryx ruficollis*	S	
Barn Swallow	*Hirundo rustica*	S	
Cliff Swallow	*Petrochelidon pyrrhonota*	S	
Purple Martin	*Progne subis*	S	
Blue Jay	*Cyanocitta cristata*	R	
Common Crow	*Corvus brachyrhynchos*	R	
Carolina Chickadee	*Parus carolinensis*	R	
Tufted Titmouse	*Parus bicolor*	R	
White-breasted Nuthatch	*Sitta carolinensis*	R	
Red-breasted Nuthatch	*Sitta canadensis*	T	(r)
Brown Creeper	*Certhia familiaris*	T	
House Wren	*Troglodytes aedon*	S	(u)
Winter Wren	*Troglodytes troglodytes*	T	(u)
Bewick's Wren	*Thryomanes bewickii*	S	(u)
Carolina Wren	*Thryothorus ludovicianus*	R	
Long-billed Marsh Wren	*Telmatodytes palustris*	T	(r)
Short-billed Marsh Wren	*Cistothorus platensis*	T	(r)
Mockingbird	*Mimus polyglottos*	R	
Catbird	*Dumetella carolinensis*	S	
Brown Thrasher	*Toxostoma rufum*	S	
Robin	*Turdus migratorius*	R	
Wood Thrush	*Hylocichla mustelina*	S	
Hermit Thrush	*Hylocichla guttata*	T	

Perching Birds (continued)

Swainson's Thrush	*Hylocichla ustulata*	T	
Gray-cheeked Thrush	*Hylocichla minima*	T	(u)
Veery	*Hylocichla fuscescens*	T	(u)
Eastern Bluebird	*Sialia sialis*	R	
Blue-gray Gnatcatcher	*Polioptila caerulea*	S	
Golden-crowned Kinglet	*Regulus satrapa*	T	(u)
Ruby-crowned Kinglet	*Regulus calendula*	T	
Water Pipit	*Anthus spinoletta*	T	(r)
Cedar Waxwing	*Bombycilla cedrorum*	T	(u)
Loggerhead Shrike	*Lanius ludovicianus*	R	
Starling	*Sturnus vulgaris*	R	
White-eyed Vireo	*Vireo griseus*	S	
Yellow-throated Vireo	*Vireo flavifrons*	S	(u)
Solitary Vireo	*Vireo solitarius*	T	(r)
Red-eyed Vireo	*Vireo olivaceus*	S	
Philadelphia Vireo	*Vireo philadelphicus*	T	(u)
Warbling Vireo	*Vireo gilvus*	S	(u)
Black-and-white Warbler	*Miniotitla varia*	S	
Prothonotary Warbler	*Protonotaria citrea*	S	
Swainson's Warbler	*Limnothlypis swainsonii*	S	(r)
Worm-eating Warbler	*Helmitheros varmivorus*	S	
Golden-winged Warbler	*Vermivora chrysoptera*	T	(r)
Blue-winged Warbler	*Vermivora pinus*	S	
Tennessee Warbler	*Vermivora peregrina*	T	
Orange-crowned Warbler	*Vermivora celata*	T	(r)
Nashville Warbler	*Vermivora ruficapilla*	T	
Parula Warbler	*Parula americana*	S	(u)
Yellow Warbler	*Dendroica petechia*	S	
Magnolia Warbler	*Dendroica magnolia*	T	
Cape May Warbler	*Dendroica tigrina*	T	(u)
Black-throated Blue Warbler	*Dendroica caerulescens*	T	(r)
Myrtle Warbler	*Dendroica coronata*	T	
Black-throated Green Warbler	*Dendroica virens*	T	(u)
Cerulean Warbler	*Dendroica cerulea*	S	(u)
Blackburnian Warbler	*Dendroica fusca*	T	(u)
Yellow-throated Warbler	*Dendroica dominica*	S	
Chestnut-sided Warbler	*Dendroica pensylvanica*	T	(u)
Bay-breasted Warbler	*Dendroica castanea*	T	(u)
Blackpoll Warbler	*Dendroica striata*	T	
Pine Warbler	*Dendroica pinus*	T	(u)
Prairie Warbler	*Dendroica discolor*	S	
Palm Warbler	*Dendroica palmarum*	T	
Ovenbird	*Seiurus aurocapillus*	S	(u)
Northern Waterthrush	*Seiurus noveboracensis*	T	(u)
Louisiana Waterthrush	*Seiurus motacilla*	S	
Kentucky Warbler	*Oporornis formosus*	S	
Connecticut Warbler	*Oporornis agilis*	T	(r)
Mourning Warbler	*Oporornis philadelphia*	T	(r)
Yellowthroat	*Geothlypis trichas*	S	
Yellow-breasted Chat	*Icteria virens*	S	
Hooded Warbler	*Wilsonia citrina*	S	(u)

Perching Birds (continued)

Wilson's Warbler	*Wilsonia pusilla*	T	(u)
Canada Warbler	*Wilsonia canadensis*	T	(u)
American Redstart	*Setophaga ruticilla*	S	(u)
House Sparrow	*Passer domesticus*	R	
Bobolink	*Dolichonyx oryzivorus*	T	(r)
Eastern Meadowlark	*Sturnella magna*	R	
Redwinged Blackbird	*Agelaius phoeniceus*	R	
Orchard Oriole	*Icterus spurius*	S	
Baltimore Oriole	*Icterus galbula*	T	(u)
Rusty Blackbird	*Euphagus carolinus*	W	(u)
Brewer's Blackbird	*Euphagus cyanocephalus*	W	
Common Grackle	*Quiscalus quiscula*	R	
Brown-headed Cowbird	*Molothrus ater*	R	
Scarlet Tanager	*Piranga olivacea*	S	
Summer Tanager	*Piranga rubra*	S	
Cardinal	*Richmondena cardinalis*	R	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	T	
Indigo Bunting	*Passerina cyanea*	S	
Dickcissel	*Spiza americana*	S	(u)
Evening Grosbeak	*Hesperiphona vespertina*	T	(u)
Blue Grosbeak	*Guiraca caerulea*	R	(u)
Black-headed Grosbeak	*Pheucticus melanocephalus*	T	(r)
Purple Finch	*Carpodacus purpureus*	T	
Pine Siskin	*Spinus pinus*	T	
American Goldfinch	*Spinus tristis*	T	
Rufous-sided Towhee	*Pipilo erythrophtalmus*	R	
Savannah Sparrow	*Passerculus sandwichensis*	T	
Grasshopper Sparrow	*Ammodramus savannarum*	S	(u)
Le Conte's Sparrow	*Passerherbulus caudacutus*	T	
Henslow's Sparrow	*Passerherbulus henslowii*	T	(r)
Vesper Sparrow	*Pooecetes gramineus*	T	(u)
Lark Sparrow	*Chondestes grammacus*	S	(u)
Bachman's Sparrow	*Aimophila aestivalis*	S	
Dark-eyed Junco	*Junco hyemalis*	T	
Tree Sparrow	*Spizella arborea*	T	
Chipping Sparrow	*Spizella passerina*	S	
Field Sparrow	*Spizella pusilla*	R	
White-crowned Sparrow	*Zonotrichia leucophrys*	T	(u)
White-throated Sparrow	*Zonotrichia albicollis*	T	
Fox Sparrow	*Passerella iliaca*	T	(u)
Lincoln's Sparrow	*Melospiza lincolnii*	T	(u)
Swamp Sparrow	*Melospiza georgiana*	T	
Song Sparrow	*Melospiza melodia*	R	
Lapland Longspur	*Calcarius lapponicus*	T	

KEY

R - Permanent Resident

S - Summer Resident

T - Transient

(r) - Rare in DeKalb County

(u) - Uncommon in DeKalb County

Table E-3-c. Representative Reptiles of DeKalb County

Turtles	
Common Snapping Turtle	Chelydra serpentina serpentina
Stinkpot	Sternotherus odoratus
Stripe-necked Musk Turtle	Sternotherus minor peltifer
Eastern Mud Turtle	Kinosternon subrubrum subrubrum
Eastern Box Turtle	Terrapene carolina carolina
Map Turtle	Graptemys geographica
Ouachita Map Turtle	Graptemys pseudogeographica ouachitensis
Midland Painted Turtle	Chrysemys picta marginata
Cumberland Turtle	Chrysemys scripta troosti
Eastern Spiny Softshell Turtle	Trionyx spiniferus spiniferus
Midland Smooth Softshell Turtle	Trionyx muticus muticus
Lizards	
Northern Fence Lizard	Sceloporus undulatus hyacinthinus
Ground Skink	Leiolopisma laterale
Five-lined Skink	Eumeces fasciatus
Broad-headed Skink	Eumeces laticeps
Six-lined Racerunner	Cnemidophorus sexlineatus
Eastern Slender Glass Lizard	Ophisaurus attenuatus longicaudus
Snakes	
Queen Water Snake	Natrix regina septemvittata
Northern Water Snake	Natrix sipedon sipedon
Midland Brown Snake	Storeria dekayi wrightorum
Northern Red-bellied Snake	Storeria occipitomaculata occipitomaculata
Eastern Garter Snake	Thamnophis sirtalis sirtalis
Eastern Ribbon Snake	Thamnophis sauritus sauritus
Eastern Smooth Earth Snake	Virginia valeriae valeriae
Eastern Hognose Snake	Heterodon platyrhinos
Northern Rinkneck Snake	Diadophis punctatus edwardsi
Midwest Worm Snake	Carphophis amoenus helenae
Southeastern Crowned Snake	Tantilla coronata
Northern Black Racer	Coluber constrictor constrictor
Eastern Rough Green Snake	Opheodrys aestivus aestivus
Black Rat Snake	Elaphe obsoleta obsoleta
Gray Rat Snake	Elaphe obsoleta spiloides
Corn Snake	Elaphe guttata guttata
Northern Pine Snake	Pituophis melanoleucus melanoleucus
Black Kingsnake	Lampropeltis getulus niger
Scarlet Kingsnake	Lampropeltis triangulum elapsoides (r)
Eastern Milksnake	Lampropeltis triangulum triangulum
Red Milksnake	Lampropeltis triangulum syspila

Snakes (continued)

Mole Snake	*Lampropeltis calligaster rhombomaculata*
Northern Scarlet Snake	*Cemophora coccinea copei*
Northern Copperhead	*Agkistrodon contortrix mokason*
Timber Rattlesnake	*Crotalus horridus horridus*

KEY

(r) - Rare in DeKalb County

Table E-3-d. Representative Amphibians of DeKalb County

Salamanders		
Hellbender	*Cryptobranchus alleganiensis alleganiensis*	
Mole Salamander	*Ambystoma talpoideum*	
Marbled Salamander	*Ambystoma opacum*	
Spotted Salamander	*Ambystoma maculatum*	
Eastern Tiger Salamander	*Ambystoma tigrinum tigrinum*	(r)
Red-spotted Newt	*Notophthalmus viridescens viridescens*	
Dusky Salamander	*Desmognathus fuscus*	
Appalachian Seal Salamander	*Desmognathus monticola monticola*	
Zig-zag Salamander	*Plethodon dorsalis dorsalis*	
Slimy Salamander	*Plethodon glutinosus glutinosus*	
Four-toed Salamander	*Hemidactylium scutatum*	(r)
Northern Spring Salamander	*Gyrinophilus porphyriticus porphyriticus*	
Midland Mud Salamander	*Pseudotriton montanus diastictus*	
Northern Red Salamander	*Pseudotriton ruber ruber*	
Northern Two-lined Salamander	*Eurycea bislineata bislineata*	
Long-tailed Salamander	*Eurycea longicauda longicauda*	
Cave Salamander	*Eurycea lucifuga*	
Mudpuppy	*Necturus maculosus maculosus*	
Frogs and Toads		
Eastern Spadefoot	*Scaphiopus holbrooki holbrooki*	
Bullfrog	*Rana catesbeiana*	
Green Frog	*Rana clamitans melanota*	
Southern Leopard Frog	*Rana utricularia*	
Pickerel Frog	*Rana palustris*	
Eastern Narrow-mouthed Toad	*Gastrophryne carolinensis carolinensis*	
American Toad	*Bufo americanus americanus*	
Fowler's Toad	*Bufo woodhousei fowleri*	
Northern Cricket Frog	*Acris crepitans crepitans*	
Northern Spring Peeper	*Hyla crucifer crucifer*	
Eastern Gray Treefrog	*Hyla versicolor versicolor*	
Upland Chorus Frog	*Pseudacris triseriata feriarum*	
Gray Tree Frog	*Hyla chrysoscelis*	

Key

(r) - Rare in DeKalb County

Table E-3-e. Fishes of Center Hill Lake

Rockbass	*Ambloplites rupestris*	
Green Sunfish	*Lepomis cyanellus*	
Warmouth	*Lepomis gulosus*	
Bluegill	*Lepomis macrochirus*	
Longear Sunfish	*Lepomis megalotis*	
Redear Sunfish	*Lepomis microlophus*	
Smallmouth Bass	*Micropterus dolomieui*	
Spotted Bass	*Micropterus punctulatus*	
Largemouth Bass	*Micropterus salmoides*	
White Crappie	*Pomoxis annularis*	
Black Crappie	*Pomoxis nigromaculatus*	
White Bass	*Monrone chrysops*	
Sauger	*Stizostedion canadense*	[a]
Walleye	*Stizostedion vitreum*	
Rainbow Trout	*Salmo gairdneri*	
Black Bullhead	*Ictalurus melas*	[a]
Yellow Bullhead	*Ictalurus natalis*	
Channel Catfish	*Ictalurus punctatus*	
Flathead Catfish	*Pylodictis olivaris*	
Brook Silverside	*Labidesthes sicculus*	
Gizzard Shad	*Dorosoma cepedianum*	
Threadfin Shad	*Dorosoma petenense*	
Stoneroller	*Campostoma anomalum*	
Rosyside Dace	*Clinostomus funduloides*	[b]
Flame Chub	*Hemitremia flamea*	[b]
Silver Chub	*Hybopsis storeriana*	[a]
Orangefin Chub	*Nocomis effusus*	[b]
Golden Shiner	*Notemigonus crysoleucas*	
Rosefin Shiner	*Notropis ardens*	
Emerald Shiner	*Notropis atherinoides*	
Bigeye Shiner	*Notropis boops*	
Central Common Shiner	*Notropis chrysocephalus*	
Whitetail Shiner	*Notropis galacturus*	
Blacknose Shiner	*Notropis heterolepis*	
Rosyface Shiner	*Notropis rubellus*	
Spotfin Shiner	*Notropis spilopterus*	
Telescope Shiner	*Notropis telescopus*	
Steel Color Shiner	*Notropis whipplei*	
Southern Redbelly Dace	*Phoxinus erythrogaster*	[b]
Bluntnose Minnow	*Pimephales notatus*	
Flathead Minnow	*Pimephales promelas*	
Bullhead Minnow	*Pimephales vigilax*	
Blacknose Dace	*Rhinchthys atratulus*	[b]
Creek Chub	*Semotilus atromaculatus*	
Northern Studfish	*Fundulus catenatus*	
Blackstripe Topminnow	*Fundulus notatus*	
Blackspotted Topminnow	*Fundulus olivaceus*	

Cumberland Snubnose Darter	*Etheostoma atripinne*	[b]
Greenside Darter	*Etheostoma blennioides*	[b]
Rainbow Darter	*Etheostoma caeruleum*	
Dirty Darter	*Etheostoma (Catonotus)* sp.	[b]
Fantail Darter	*Etheostoma flabellare*	[b]
Redband Darter	*Etheostoma luteovinctum*	[b]
Orange throat Darter	*Etheostoma spectabile*	[b]
Spottail Darter	*Etheostoma squamiceps*	[b]
Banded Darter	*Etheostoma zonale*	[b]
Logperch	*Percina caprodes*	
American Eel	*Anguilla rostrata*	
Carp	*Cyprinus carpio*	
Quillback Carpsucker	*Carpiodes cyprinus*	
White sucker	*Catostomus commersoni*	
Northern Hogsucker	*Hypentelium nigricans*	
Smallmouth Buffalo	*Ictiobus bubalus*	[a]
Spotted Sucker	*Minytrema melanops*	
Black Redhorse	*Moxostoma duguesnei*	
Golden Redhorse	*Monoxtoma ergthrurum*	
Skipjack herring	*Alosa chrysochloris*	[a]
Mottled Sculpin	*Cottus bairdi*	[b]
Banded Sculpin	*Cottus carolinae*	[b]
Mooneye	*Hiodon tergisus*	
Spotted Gar	*Lepisosteus oculatus*	
Longnose Gar	*Lepisosteus osseus*	
Paddlefish	*Polyodon spathula*	
Drum	*Aplodinotus grunniens*	
Mosquitofish	*Gambusia affinis*	

KEY

[a] Caney Fork River below Dam
[b] Tributaries flowing into Center Hill Reservoir