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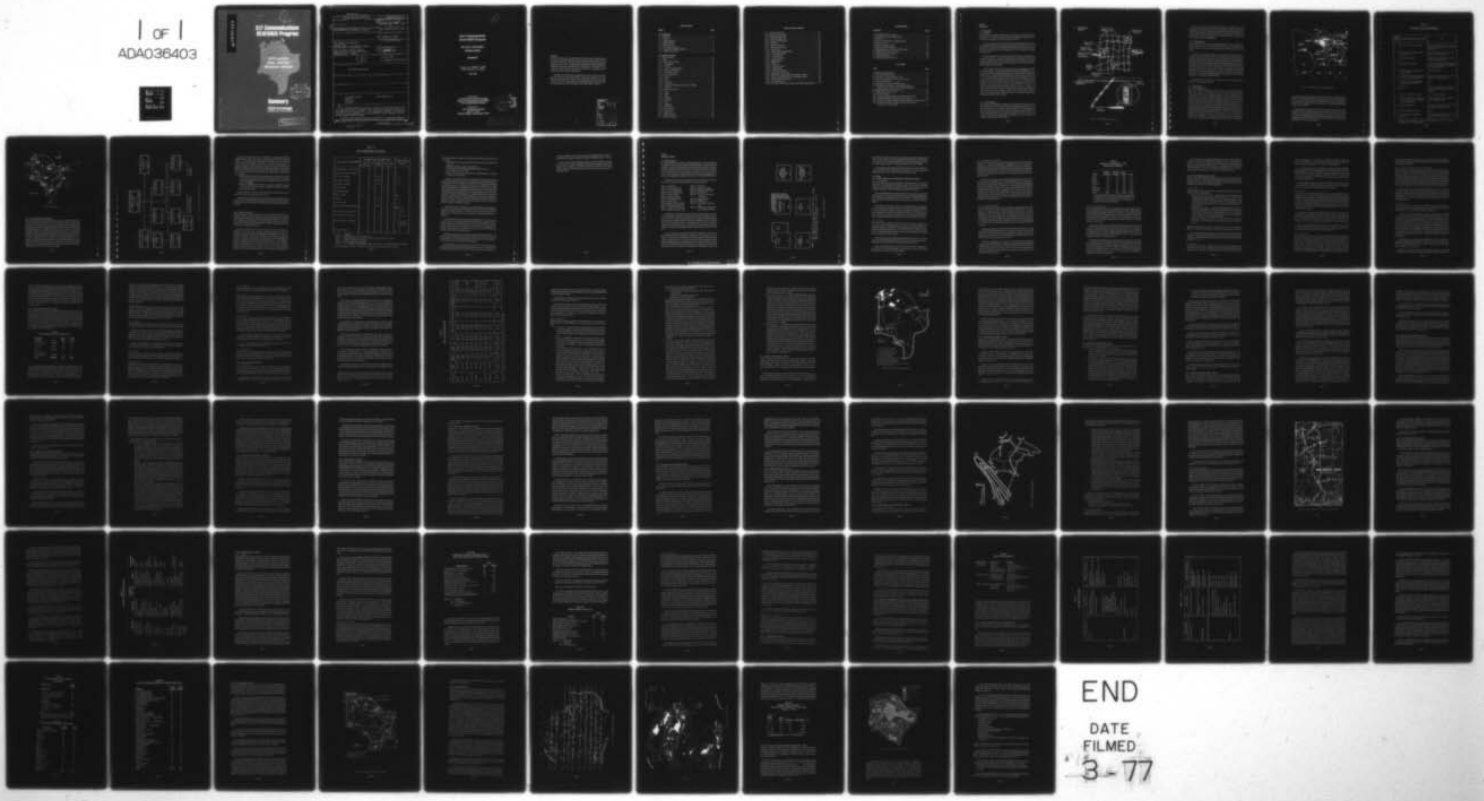

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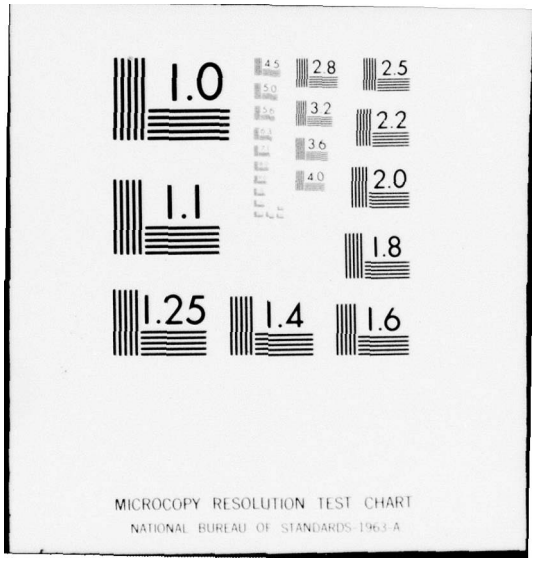
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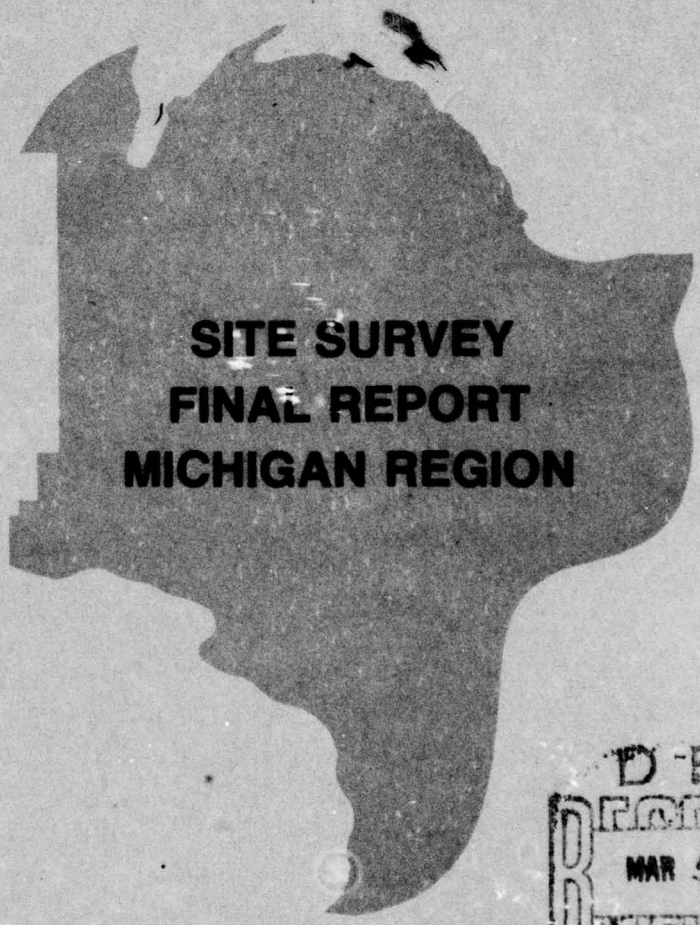

SITE SURVEY FINAL REPORT MICHIGAN REGION

Summary

GTE SYLVANIA INCORPORATED
COMMUNICATION SYSTEMS DIVISION

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This report presents the results of a survey of a specified area in the west central portion of Michigan's Upper Peninsula conducted for the Navy's ELF Communications Project Office. The information collected is of the type necessary for the preparation of an Environmental Impact Statement relative to the proposed Seafarer System.

The entire Site Survey Final Report consists of 27 separately bound volumes. This summary volume provides an overview of the significant results.

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ELF Communications
SEAFARER Program

Site Survey Final Report

Michigan Region

Summary

Contract No. N00039-75-C-0309
CDRL Sequence No. B006

July 1976

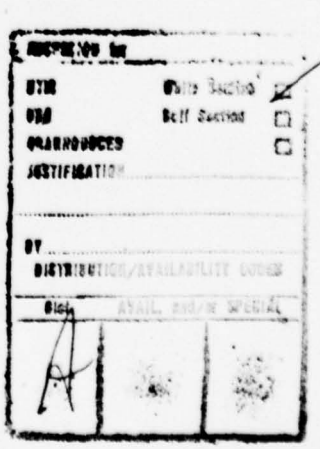
Prepared for:
Naval Electronic Systems Command
Special Communications Project Office
ELF Communications Division

Prepared by:
GTE Sylvania Incorporated
189 "B" Street
Needham Heights, Massachusetts 02194

Foreword

The purpose of this report is to present the results of a survey of a specified area in the west-central portion of Michigan's Upper Peninsula conducted in late 1975 and early 1976 for the Navy's ELF Communications Project Office. This material is intended for use by others, principally those responsible for engineering the SEAFARER system and for preparing the Environmental Impact Statement. For this reason, this report presents no conclusions, but rather is a compilation of the information required by those other groups.

Throughout the field work and during the many contacts since then, all members of the team were impressed with the cooperation extended by the many Michigan officials and private citizens. The people whom we met, almost without exception, were interested in helping us gain factual information and in learning all they could about the system. We express our heartfelt thanks to them all.



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Section 1
Introduction

1.1 Background

1.1.1 General

In February 1975, following a competetive procurement process, the Navy selected GTE Sylvania to be the prime system contractor for design and development of the Extremely Low Frequency (ELF) communication system.

Systems operating in this frequency band have not been employed in the past because of their cost and because the attributes that make them attractive (*i.e.*, deep penetration of sea water, low atmospheric attenuation and relative freedom from atmospheric disturbances) have been required by few users other than strategic deterrent forces.

Looking to the future, the Navy has determined the need for a communication system located in the U.S., capable of sending messages essentially world wide and achieving communications that are relatively free of constraints on submarine speed and depth. ELF systems satisfy these requirements to a much greater degree than any other known technique.

In late February 1975, the Navy was directed by the governing council of the *World Wide Military Command Communications System* (WWMCCS—a communications policy-making and operations group in the Department of Defense) to develop an ELF system called SEAFARER for possible location in the Western U.S. where the Government owns or controls extensive areas of land. This system consists, in concept, of a transmitter control center (TCC), a few randomly-located, above-ground transmitter stations (TS), a transmitting antenna made up of an irregular criss-cross pattern of buried cables grounded at each end, and submarine-mounted receiving components (antenna, receiver, etc.). Figure 1 is a line drawing of this system concept. The number of antenna lines and transmitter stations may vary from one design to another. Only the transmitter complex is addressed in this report since design of the receiver is completely independent of the location chosen for the transmitter.

1.1.2 Western Regions

The Western sites designated for study were in Nevada and New Mexico, specifically the Nellis Air Force Range and White Sands Missile Range/Fort Bliss complex. The Nevada site is a multi-use range at which Air Force fighter pilots are trained and where the Energy Research and Development Agency (ERDA) conducts underground nuclear tests and other experiments. The New Mexico site consists of Army missile training ranges at Fort Bliss, and tri-service missile test and pilot training ranges at White Sands.

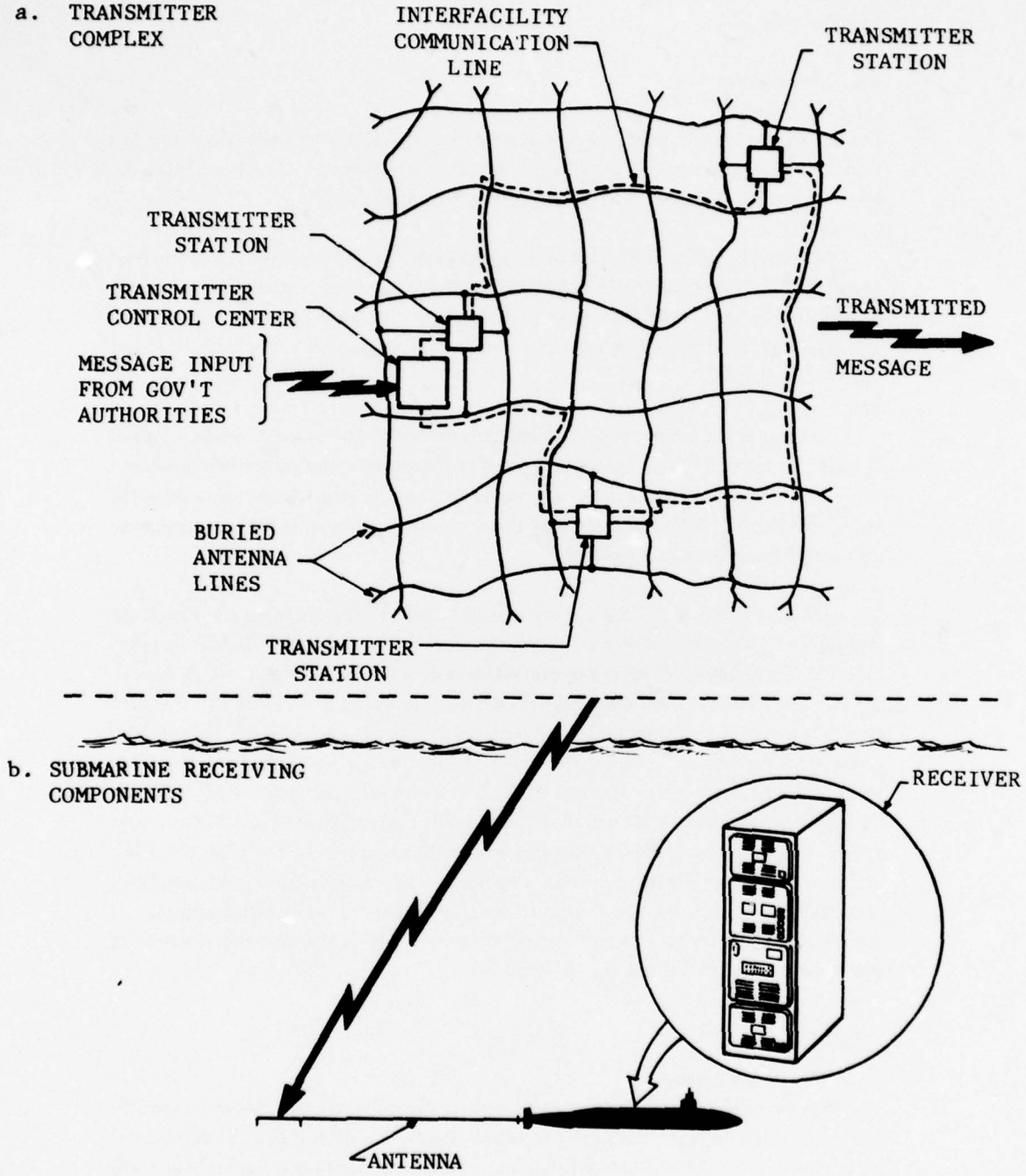


Figure 1 – SEAFARER System Concept

The Navy did not have the detailed information on the natural, social, and engineering characteristics of these new sites needed to complete the designs, estimate their costs, and prepare an Environmental Impact Statement (EIS). To overcome this problem, a task entitled Site Survey was added to the GTE Sylvania contract that required the gathering of 23 categories of data, ranging from socioeconomic factors through geology.

1.1.3 Michigan Region

During the summer of 1975, Governor William Milliken created a task force to conduct a preliminary review of SEAFARER and this group recommended that the DoD be invited to have an Environmental Impact Statement prepared on the project.

The task force submitted its report in August; and in September, Governor Milliken invited the Director of Defense Telecommunications and Command & Control Systems (DTACCS) to prepare an EIS, specifically reserving until later an invitation to proceed with project construction. Discussions were then held between the Michigan Environmental Review Board (MERB) and the Navy to reach agreement on the content of the EIS. Although much data had been acquired in the 1973-74 site survey, some of it was out of date. It was also necessary to study additional subjects in order to prepare a site-adapted system design—a prerequisite to the EIS. A new survey was found to be necessary. Details of the study were sufficiently resolved with the MERB by the end of October that a site survey of the UP was able to commence in mid-November.

Figure 2 illustrates the survey area in relation to the rest of the UP and the upper Great Lakes region in general.

1.2 Scope of Survey

1.2.1 Contractual Direction

When the Governor's invitation was received, the Navy's ELF Communications Project Office (PME 117-21) modified GTE Sylvania's Statement of Work to include the requirement for a Michigan Site Survey. It was stipulated that the SANGUINE survey report prepared by EDAW in 1974 was to be reviewed for currency and that only newer or different categories of data were to be collected. Table I lists the specified data categories. Guidelines, both verbal and written, were provided to delineate the study area and minimize the effects of day-to-day activities in the UP. For example, no entry for observations or measurements were to be made on privately owned land or in Experimental Forests, and urban areas were excluded. Data on utilities services, pipeline systems, telephone networks, fences, and industrial electronic instrumentation (Table I - items 2, 3, 4, 8, and 10) were specified to be provided by the Navy as an output of another contract. To accomplish the "Public Inputs" data requirement (Table I, item 7), the Michigan office of Environmental Review (OER) requested project literature from the Navy

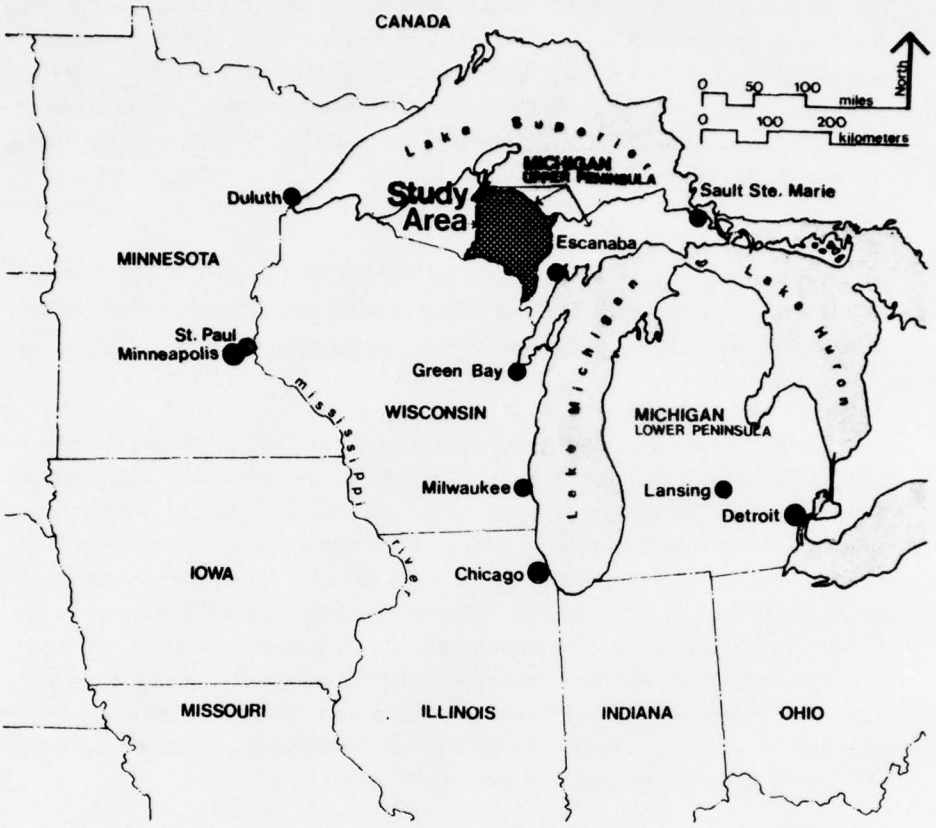


Figure 2 – The Study Area in the Upper Midwest

to be located in libraries and Department of National Resources (DNR) offices in the UP, plus the OER headquarters in Lansing. Figure 3 is a more detailed map of the area surveyed. It is the same as that studied in 1973 and 1974, except that its western limit is the edge of the Ottawa National Forest; Gogebic and Ontonagon Counties were excluded.

Responsibility for supervision of the GTE Sylvania site survey work was delegated to the Naval Facilities Engineering Command (NAVFAC PC-6) which assigned a two-man field team to that task. They were stationed at K.I. Sawyer Air Force Base (SAFB) near Marquette while field data collection was under way. They scheduled appointments with Federal, State, and local agencies, and made other arrangements for Site Survey personnel.

TABLE I

SPECIFIED DATA REQUIREMENTS

DATA ITEM NO.	ENVIRONMENT/DESIGN DATA ITEM	USE
1	Electrical Power Systems	EIS; System Design; Test Site Design & Construction; Initial Mitigation
2	*Utilities Services (Water, Gas, POL)	EIS; System Design; Test Site Design & Construction
3	*Pipeline Systems	EIS; Identification of First Order Avoidance Area
4	*Telephone Systems	EIS; System Design; Determination of Avoidance Area/Mitigation Requirements
5	Conductivity (Surface and Deep Earth)	System Design
6	Construction/Cable Emplacement Unit Cost Factors	EIS; System Design; Test Site Design & Construction
7	Public Inputs (SEAFARER Information Office)	EIS
8	*Fences	EIS; Determination of Avoidance Area/Mitigation Requirements
9	Existing Rights of Way	EIS; System Design
10	*Electrically or Electronically Operated Industrial Instrumentation	EIS; System Design; Mitigation Requirements
11	Land Ownership	EIS; System Design; Test Site Design & Construction
12	Socioeconomic Factors	EIS
13	First Order Avoidance Areas	EIS; System Design; Test Site Design & Construction

*Mapping only required - Data and descriptive narratives to be supplied by the Government.

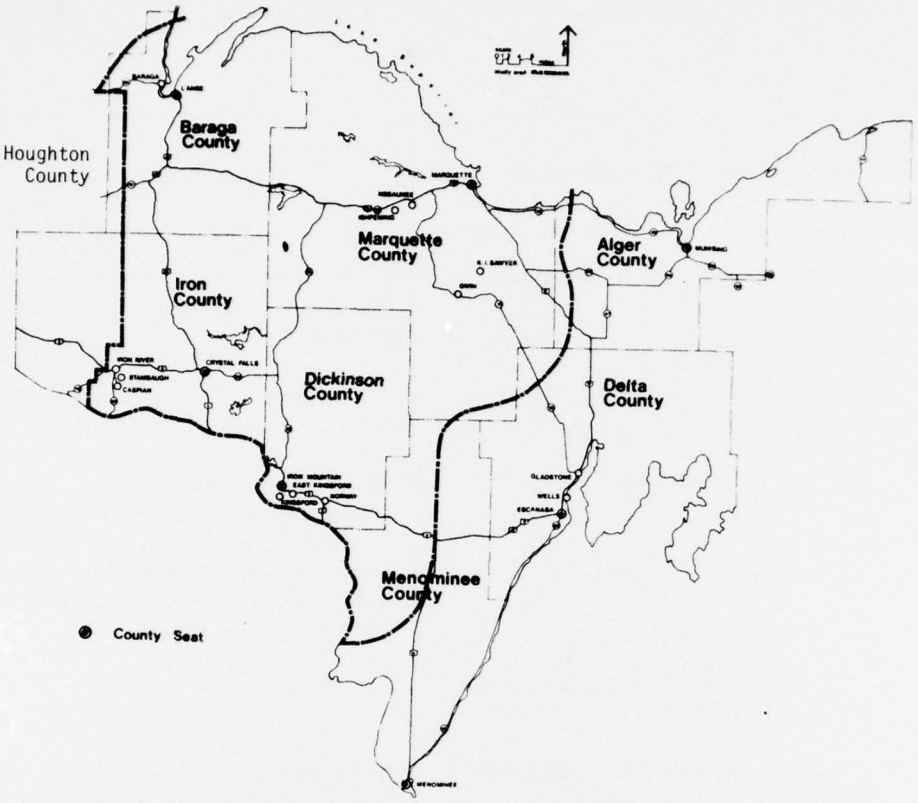


Figure 3 – Study Area

1.2.2 Organization and Responsibilities

The team assembled to conduct the Michigan survey evolved from the one that performed the Western Regions work and is illustrated in Figure 4. George Bradshaw and James Barron of GTE Sylvania continued in their familiar task-management roles, and David Macklin again planned and directed the conductivity measurement program. In addition, Erwin Day acted as Sylvania's on-site data coordinator during the active field data collection period. He was stationed in Marquette. Thomas Crabtree performed the K.I. Sawyer Air Force Base interface study—the equivalent of the Western Regions mission compatibility study. Since no public information program was conducted, no Info Office Manager was appointed. Russell Hall consulted with the Navy on informational literature. Carmen DiNardo was added to the team to perform a function not required in the Western Regions—that of contacting corporate land managers to obtain permission to enter their properties for observations and measurements.

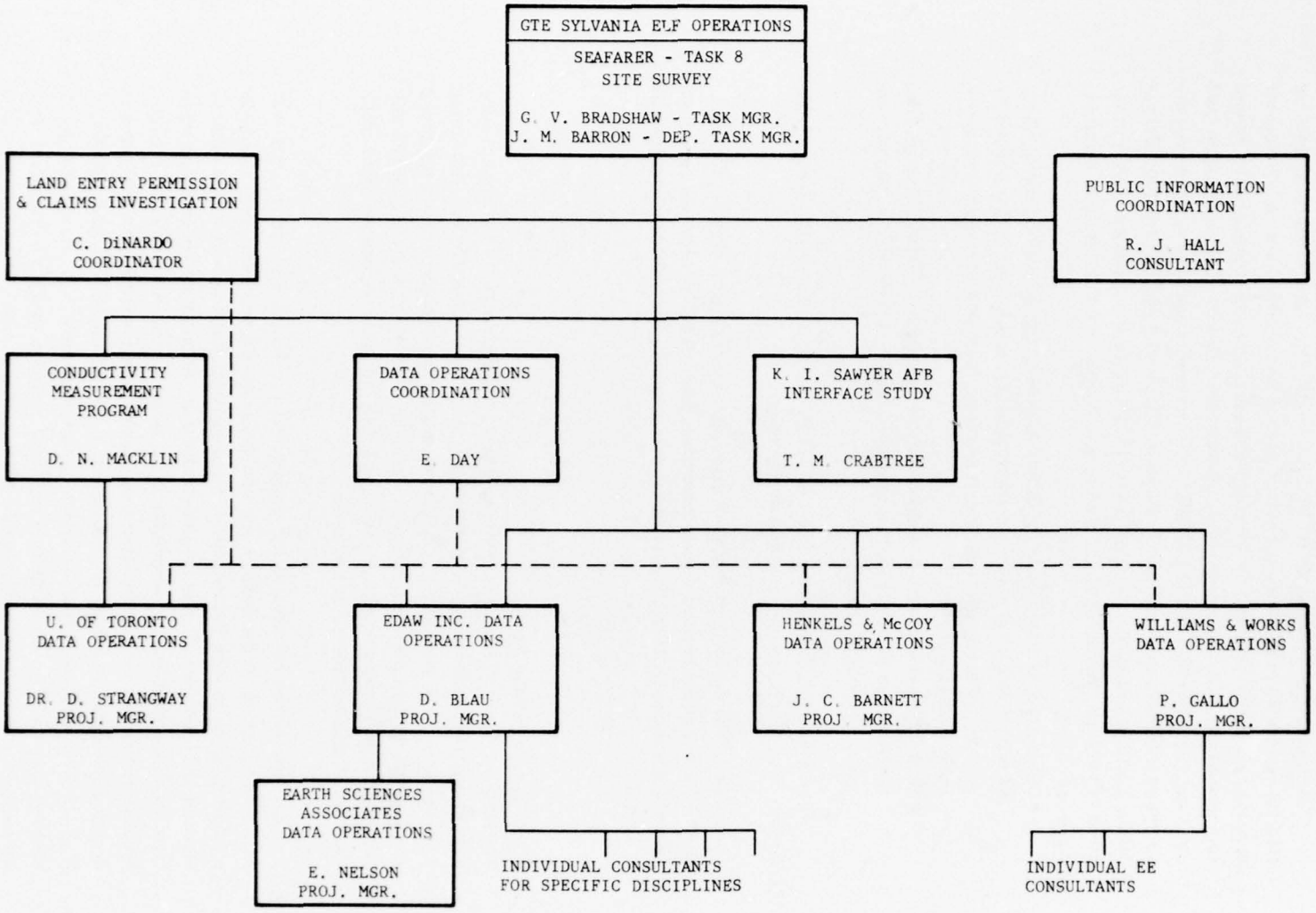


Figure 4 – Site Survey Organization–Michigan Region

The University of Toronto (U of T), EDAW, Inc., and Henkels & McCoy (H&M) performed in the same capacities as they had during the Western Regions survey; *i.e.*, earth conductivity measurements and analyses, natural science and socioeconomic data collection, and antenna cost factors data acquisition and analysis, respectively. The EDAW field work was performed by personnel from the company's Minneapolis and San Francisco offices, and H&M's by their Detroit office. Earth Sciences Associates (ESA) of Palo Alto again supported EDAW in the areas of geology, mineralogy, and hydrology. New subcontractor team members were as follows:

- Williams & Works (W&W) of Grand Rapids, assigned to conduct the study of the UP electrical power generation and distribution network - assisted by two electrical engineering consultants from Michigan Technical University (MTU) in Houghton.
- A number of Michigan-based consultants engaged by EDAW for specific assistance in the noise and air quality, vegetation and wildlife, and history and archaeology studies.

In addition, the Navy contracted with IIT Research Institute (IITRI) to provide certain data which are incorporated in this report.

Table II lists the responsibilities of these team members for directing the work, as well as for meeting specific data requirements listed in Table I. The last column of Table II lists the parts of the final report in which results of the detailed studies will be found.

1.2.3 Conduct of the Survey

The field portion of the survey commenced on 13 November 1975 when the advance members of the team arrived in Marquette to make local arrangements. A meeting was held with the State Police at Division Headquarters in Negaunee to explain the survey and point out that the field crews would be working in the eight-county study area during the coming weeks. Banking and Post Office arrangements and a truck lease were also completed at this time.

Because of the lateness of the season and the delays that snow cover was expected to cause in the field work, the conductivity program was begun immediately, even though the two-week Michigan deer hunting seasons was due to start on 15 November. A plan for the conductivity program had been prepared in October that called for measurements to be taken by the Audio Magnetotelluric method at 106 locations in the study-area depicted in Figure 3. This technique is described in detail in Part 4 of this report, *Earth Conductivity Data*. Briefly, it involves stretching 100-foot wires in four directions from a center point and lightly staking their ends to the ground. A sensitive receiver at the central point then measures signals from distant thunderstorms, and a computer later interprets the

TABLE II

TASK RESPONSIBILITY MATRIX

FUNCTION/DATA REQUIREMENT	ORGANIZATIONAL RESPONSIBILITY					FINAL REPORT PART* & BOOK NUMBER
	GTE SYLVANIA	U of T	EDAW/ ESA	H&M	W&W	
Program Mgmt. & Direction	x					1
Electrical Power Systems					x	4
Utilities Systems			x**			2 - 8
Pipeline Systems			x**			2 - 8
Telephone Systems			x**			2 - 8
Conductivity	x	x				5
Antenna Factors				x		3
Public Inputs	x					N/A
Fences			x**			2 - 8
Existing ROWs			x			2 - 21
Industrial Instrumentation			x**			N/A Received.
Land Use/Value/Ownership			x			2 - 4,5,6
Socioeconomic Factors			x			2 - 2,3,7,17, 20
Natural Science Factors			x			2 - 9,10,11, 12,13,14, 15,16,18, 19
Avoidance Areas			x			2 - 21

* Part 1 - Summary
Part 2 - Environmental and Design Data
Part 3 - Antenna Construction Cost Factors and Installation Plan
Part 4 - Power Distribution Network
Part 5 - Earth Conductivity Data
Part 6 - K. I. Sawyer AFB SEAFARER Support Potential and Operational Interfaces

** Data provided by Navy. Mapping and reporting only provided by EDAW.

results and calculates conductivity. These points had been selected on the basis of five criteria:

- Coincidence with representative points previously measured by MTU and the Navy.
- Relatively uniform coverage of the study area.
- Examination of the full range of geologic substructure types.
- Accessibility via roads or trails.
- Exclusion of no points on private land or in experimental forests—minimum number on corporate land.

The first few days of measurements were planned for points on State lands, and blanket permission for access to those was obtained from the appropriate agencies in Lansing by NAVFAC (LCDR G. D. Luzum). Permission to make measurements on corporate property was obtained by GTE Sylvania. Fortunately, few weather delays were encountered, permitting the three-man crew to work almost continuously until finished, with a short holiday break at Christmas. The crew traveled in four-wheel drive, leased vehicles and was occasionally joined by one of the U of T geologists. The field work in Michigan was completed on 16 January, and the crew then moved to Wisconsin for a week of calibration and validation measurements at the Navy ELF facility at Clam Lake. The raw data were then taken to Toronto for reduction, analysis, comparison with Western Region and previous Wisconsin results, mapping, and eventual reporting.

During the week of 17 November, a two-man GTE Sylvania team visited K.I. Sawyer Air Force Base to attend briefing sessions arranged by the NAVFAC personnel with representatives of most base activities. In that short period 17 interviews were conducted, and a set of some 40 civil engineering drawings were obtained.

The EDAW/ESA field work also commenced during the week of 17 November when interviews were conducted with numerous State agencies and departments in Lansing, followed in succeeding weeks by interviews with UP Federal, regional, county, and city agencies and corporations. That work was completed in mid-December although numerous telephone contacts were necessary in the following months as the reports were being prepared.

The H&M team started its work by interviewing unions and contractors, and deferred work in the field until close of the deer hunting season. Observations and measurements were made either along public roads or at the points where permission had been granted for conductivity measurements.

The W&W effort was started during the week of 24 November and involved identifying and meeting with the six power companies and co-ops serving the study area. This work involved interviews in Wisconsin as well as the UP, since one of the

two largest suppliers in the study area (Wisconsin-Michigan Power Company) is headquartered in Appleton, Wisconsin. Interviews continued into late February.

At the conclusion of the field data collection, work then shifted to the offices and laboratories of all the team members. That effort consisted of intensive data analysis, review, mapping, coordination between team members, and writing, which culminated in this report. The results of that work are summarized in the following section.

Section 2
Summary of Results

2.1 Report Structure

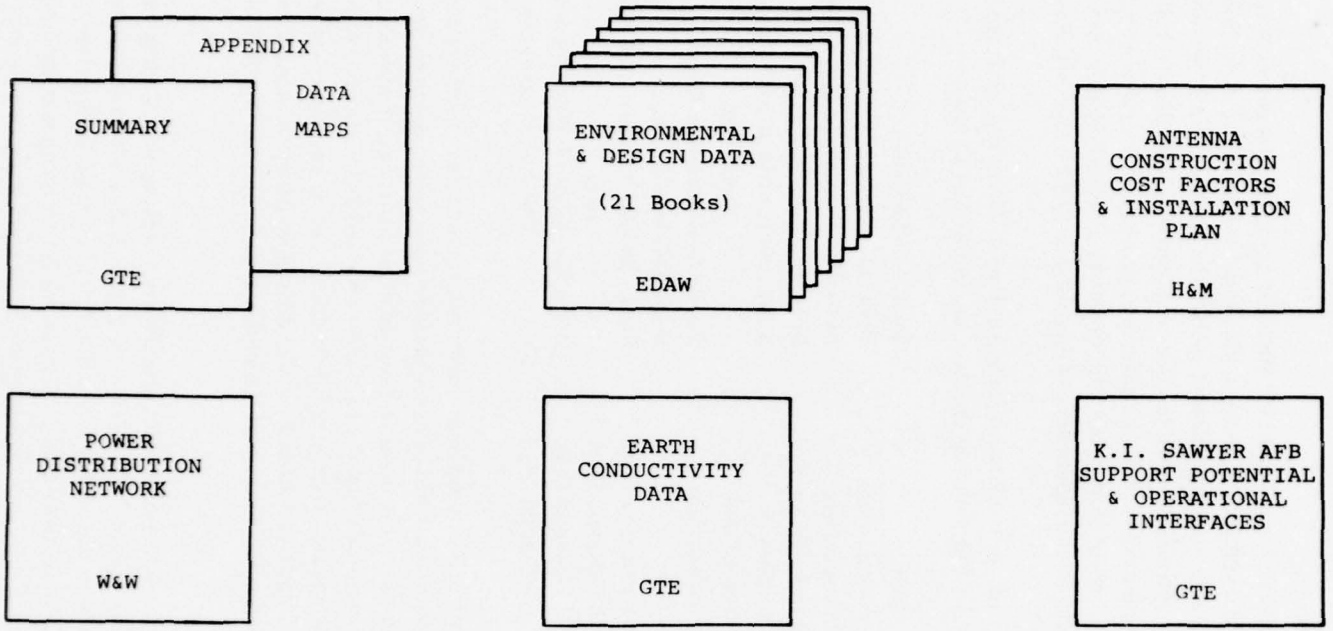
The entire Site Survey Final Report for Michigan comprises six parts consisting of 27 separately-bound volumes or books as illustrated in Figure 5. This section of this book (Part 1) contains a condensation of each of the other parts and presents their principal findings and conclusions, but does not contain all the details, validation, or lists of information sources. Its purpose is to provide an overview in sufficient depth to make the reader conversant with the study area and the principal survey results, and to highlight the significance of these results to the SEAFARER project.

The majority of the work is presented in Part 2, *Environmental and Design Data*. The 21 books that make up that part are entitled as follows:

Book 1—Introduction
Book 2—Socioeconomic Data
Book 3—Governmental Data
Book 4—Land Ownership Data
Book 5—Land Use Data
Book 6—Market Value Data
Book 7—Transportation Data
Book 8—Utilities Data
Book 9—Mineral Extraction Data
Book 10—Bedrock Geologic Data
Book 11—Surficial Geologic Data
Book 12—Slope and Terrain Data
Book 13—Soil Data
Book 14—Surface Water Data
Book 15—Subsurface Water Data
Book 16—Climatic Data
Book 17—Cultural and Recreational Data
Book 18—Vegetation Data
Book 19—Wildlife Data
Book 20—Air Quality and Noise Data
Book 21—Right-of-Way Opportunities and Avoidance Features

Although many of the books treat similar subjects and therefore have considerable common material, each has been prepared to stand alone, making it unnecessary for the reader to refer to another book. In many instances, the books contain new material not available when the 1974 report was published. In others, the 1974 material has been updated with new information, and in yet others—where the material was still found to be current —only editorial revisions were made to delete reference to Gogebic and Ontonagon Counties which lie outside the 1975-76 study area.

No new information was sought specifically for Houghton County because such a small portion (about 7400 acres—see Figure 3) lies within the study area boundary and because the probable location of the manned Transmitter Control Center is some distance away at K.I. Sawyer Air Force Base, making it unlikely that SEAFARER will have any significant social or economic effects in that region of the UP. Where Houghton County information was available in conjunction with that of other counties, or where the 1974 material was still judged to be valid, it has



LEGEND: GTE = GTE Sylvania, Communication Systems Division, Needham
EDAW = EDAW, Inc., San Francisco
H&M = Henkels & McCoy, Inc., Blue Bell, PA & Detroit
W&W = Williams & Works, Grand Rapids

Figure 5 – Report Structure

been included. Conversely, new data were sought and are reported for Alger and Delta Counties because, while only small portions of them also lie within the study area, they are much closer to the probable TCC location and may therefore experience some social, economic, or transportation effects from SEAFARER.

The colored data maps from the individual books of Part 2 are also included in a separate appendix to this volume. Map notes that refer to the text apply to the appropriate book of Part 2 rather than to this Summary volume.

2.2 Results

2.2.1 Socioeconomic Factors (No data map is provided for this subject.)

2.2.1.1 Demography

Since 1950, the study area has experienced a very gradual increase in resident population. Official projections for 1980 and 1990 show that this trend should accelerate, except for Alger and Baraga Counties which are expected to lose population through the 1970's and then pick up again in the 1980's.

Major population centers in and around the study area normally provide a full range of goods and services to both the resident and tourist/transient populations. Over 40 percent of the inhabitants reside in towns, cities, or villages with populations of 1,000 or less; and most counties are classified "rural" by the U.S. Census Bureau.

The population of the seven counties is over 99 percent white. All age groups are expected to increase between the years 1975 and 1990, except the 60 to 74 group. In Iron and Dickinson Counties, a growing community of retired persons is reflected in higher than average county median age statistics. In contrast, there has been a decline in the number of persons under 11 years throughout the counties. This may negatively impact the available labor force in the next 10 to 20 years.

2.2.1.2 Housing

In 1970 the vacancy-available rate for the study area was about 2.5 percent, but one-fourth of all existing housing units are presently considered by officials to be physically inadequate to the needs of the resident population. There has been a continued decline in household size since 1970; however, with slight but steady increases in population and the number of current substandard units, the demand for new housing will continue to exist.

The average persons per dwelling unit throughout the study area is 3.17. About 10 percent of all husband-wife families are over 65 years of age. About 11 percent of all families have incomes below the federally-defined poverty level.

About one-third of the housing constructed in the central UP is attributable to public efforts. Private housing production is not likely to meet expected 1980 household demand without government subsidies.

2.2.1.3 Economic Characteristics

The economy of the UP has historically been dependent on exploitation of natural resources, i.e., mining and lumbering. In Marquette County, iron mining was responsible for over 19 percent of labor and proprietor income in 1973, and production is increasing at the present. The wholesale and retail trade industry is important to all counties, particularly so to counties with a relatively large tourist business. Except in Iron County, contract construction is not a major study-area producer of personal income.

In 1975, the seven-county average annual unemployment rate rose to over 11 percent of the total civilian labor force. Total employment has been increasing, but not as fast as the increase in the labor force. It is to be remembered that Houghton County is not included in these considerations, so that the employment figures do not reflect the present condition of the copper mining industry there. Greatest yearly fluctuations in the percent unemployed occur in those counties that are dependent on few industries for employment and where industries are subject to seasonal demand, as in tourism and construction. Per capita personal income levels remain below those of the State as a whole, and welfare payments account for a large share of governmental costs.

2.2.1.4 Resource Productivity

Iron ore mining and beneficiation is the dominant factor in the mining industry in the study area. Occurrences of other metallic minerals, including gold, silver, lead, copper, zinc, and uranium, have been documented; but no mine is currently producing ore from any of these deposits. The larger deposits, however, may constitute resources that could prove to be economically extractable in the next several decades. By the year 2000, it is anticipated that all iron ore will come from lower-grade taconite deposits. The Lake Superior district will become the principal U.S. source of this ore, and mining will continue to be a major industry within the study area.

Agricultural production is of only minor significance in the study area, except for portions of southeastern Menominee County, and to a much lesser extent, the southeastern portion of Delta County. Forest land and products represent a significant resource in the study area. Table III summarizes land productivity by value and county for each major product area in 1974.

The future of agriculture in the study area is projected to remain stable in response to local market demands. Additional product development possibilities include maple syrup, cold climate vegetables and specialty fruit orchards in the western midsection of Baraga County. The future of forest related products is projected to gradually increase through time, notably in the specialty areas of hardwoods and panel products.

Table III
Summary of Land Productivity — 1974
(Annual Values in Millions $)

County	Mineral Production	Agriculture Products	Forest Related*	Total
Alger	0.1	1.1	20.0	21.1
Baraga	0.1	0.6	30.0	30.7
Delta	0.2	2.4	25.0	27.6
Dickinson	37.4	1.2	25.0	63.6
Iron	6.6	0.6	45.0	52.2
Marquette	172.3	0.5	50.0	222.8
Menominee	0.1	8.8	25.0	33.9
Total	**216.8**	**15.2**	**220.0**	**452.0**

* Includes estimated values for forest products, all commercial recreational uses, and intangible (non-quantifiable) factors associated with various non-commercial recreational, wilderness, and conservation functions.

2.2.1.5 Community Services

The complete range of medical services normally found in major urban areas does not exist within the study area. Medical doctors number .80 per 1,000 population, less than half the 1974 national average of 1.533. However, each county is served by at least one hospital, with 50 percent of the total study area bed count found in the three Marquette County hospitals; ambulance service is furnished by 23 organizations that provide reasonably comprehensive coverage in all but the most rural sections of each county.

The public school facilities vary significantly throughout the region in terms of size and enrollment, ranging from a single one-room school house to a complex of schools operating under one system. Most pupil/classroom ratios are currently at the optimum level, and a stable to slightly declining enrollment is expected to the year 1980. Vocational training is limited primarily to the few courses provided through the region's four-year high schools.

The equipment available for fire suppression varies, with smaller cities having less equipment and correspondingly lower annual operating budgets. Cooperation for fire protection between local governments is widespread to make up for low personnel and equipment inventories. In addition, fire fighting resources are available to local settlements from K.I. Sawyer Air Force Base and the Michigan Department of Natural Resources. The U.S. Forest Service has fire fighting responsibilities on National Forest lands.

Police protection is provided by the Michigan State Police, county sheriffs, city and, to a lesser degree, township police. Typically, the size of individual police agencies is small, and a great deal of reliance is placed upon the State Police for protection and surveillance outside urban areas. Additionally, the 8th District State Police Headquarters, located near Negaunee in Marquette County, maintains a crime laboratory available for use by local governmental police units.

2.2.2 Governmental Data (Refer to Map 1.)

Federal, State, and local governmental bodies and agencies working within the study area result in a complex pattern of jurisdiction, control and responsibility. The functions of the various governmental bodies of particular interest to SEAFARER are described in the following paragraphs.

2.2.2.1 Federal

Within the study area there are three U.S. Government departments with activities of direct interest to SEAFARER:

- *Department of Interior* — The L'Anse Indian Reservation in Baraga County is held for the ownership and residence of the L'Anse, Vieux Sert, and Ontonagon bands of the Chippewa Nation under the jurisdiction of the Bureau of Indian Affairs, Great Lakes Agency. Federal regulations enable the tribal council to grant rights-of-way subject to approval by the Secretary of the Interior.
- *Department of Agriculture* — The Milwaukee Regional Office of the Forest Service (a division of the USDA) has responsibility for the two UP National Forests, Ottawa and Hiawatha. Although both forests lie outside the study area, the Forest Service provides administration for the two experimental forests within the area, McCormick and Dukes.
- *Department of Defense* — The U.S. Air Force operates K.I. Sawyer Air Force Base—a fully-equipped, strategic bomber installation south of Marquette.

Other Federal agencies that extend to the local level, such as FAA, FBI, IRS, HEW, etc., are of course, present in the UP, but are not discussed in this report.

The two regional planning commissions in the UP that are empowered by both Federal and State legislation and administered by the Economic Development Administration of the Department of Commerce are discussed later under a special category (see 2.2.2.6).

2.2.2.2 State

In addition to State statutes relating to local governmental establishment and control, the State exercises its jurisdiction and powers through departments and commissions. As represented through their many respective commissions and

boards, the Departments of Commerce, Agriculture, Education, Natural Resources, State Highways, and others, exercise strong influence within the study area concerning existing land use, conservation, and development.

It is the Department of Natural Resources (DNR) and the State Highway Department that are of the most immediate interest to SEAFARER. The former provides guidelines and issues permits for constructing rights-of-way across State Forest land. It also monitors industrial activities for compliance with air- and water-quality regulations. The latter controls use of rights-of-way associated with State-maintained highways.

Future changes at the State and local level will most likely result in the creation of special districts to preserve natural features and scenic amenities, define land-use policy, and promote methods to bolster the UP economy.

2.2.2.3 County

Each county has its own legal personality. However, as an agent for the State, it is required to carry out certain State programs. The conduct of elections, the enforcement of State criminal laws, the registering of property deeds, issuing of birth certificates, and the administration of justice are some of the functions conducted by county government on behalf of the State. The basic powers of the county include the responsibility to purchase real estate for county use, borrow money for service projects, make contracts for those projects, and perform acts necessary to safeguard county property.

In addition to their legislative and judicial powers, counties were extended the right in 1943 to create zoning commissions. Today all counties within the study area have active planning commissions; and Baraga, Delta, and two townships in Marquette County have been recently zoned. As of January 1976, 65 percent of the study area was covered by some form of zoning—either county, township, or city.

The county highway departments issue permits for construction of utilities on their rights-of-way and also for transportation of over-weight construction machinery, both of which are governed by seasonal considerations.

2.2.2.4 Townships

Each township is governed by a four-member township board whose principal powers are to secure taxes, create debt, issue by-laws and orders regulating township affairs, and acquire and hold real and personal property for public use. In recent years, township governments have had to meet increasing demands for public services and utilities. Consequently, the legislature has given townships broad powers to provide for water supply, storm and sanitary sewers, planning ordinances, and public health controls. Most ordinances can be adopted by resolution of the township board followed by media publication and subsequent entry into

the township ordinance book. Exceptions are zoning ordinances and amendments which must be preceded by public hearings before the township zoning commission or coordinating committee.

2.2.2.5 Incorporated Settlements - Cities and Villages

Within the study area, fourteen urbanized regions have been incorporated into cities. All of these cities have adopted home rule provisions of the constitution which free them to devise forms of government and exercise powers of self-government under locally prepared charters that are adopted by referendum. A city, having seceded from a township, must assume the basic State-required duties as well as provide its own services. In addition to assessing property and collecting taxes for county and school district purposes, the city also becomes solely responsible for registering voters and conducting all elections within its boundaries.

There are only four incorporated villages within the study area: L'Anse and Baraga of Baraga County, and Alpha and Mineral Hills of Iron County. The incorporated village, unlike the city, participates in township affairs. The township retains the power to levy taxes for school districts and administer county, state, and national elections. Townships and villages frequently cooperate to provide combined public utilities.

2.2.2.6 Planning

The Western and Central Upper Peninsula Planning and Development Regions, created in the late 1960's through public act, are an example of special governmental considerations given to regionally planning the environment.

The Western Upper Peninsula Planning and Development Region (WUPPDR) is a six-county planning and economic development district empowered by the Public Works and Economic Development Act of 1965 and administered by the Economic Development Administration (EDA), of the U.S. Department of Commerce. The organization was fostered by the Michigan Department of Commerce under the auspices of the EDA and brought into being by the Boards of Commissioners of Baraga, Gogebic, Houghton, Iron, Keweenaw, and Ontonagon Counties. Total representation on the WUPPDR is unlimited, but the apportionment must remain equal for each county represented, with membership open to any unit of government choosing to participate. WUPPDR employs a full-time staff of professional planners.

Performing functions similar to those of WUPPDR, the Central Upper Peninsula Planning and Development Region (CUPPAD) was organized in 1968 by public officials and interested citizes from six counties—Alger, Delta, Dickinson, Marquette, Menominee and Schoolcraft.

Future directions for the UP, as indicated through the major goals of WUPPDR and CUPPAD, is to increase employment opportunities, expand the quantity and

quality of community facilities, improve local and regional transportation systems, encourage community development and the implementation of planning and land-use regulations, promote the development and wise utilization of natural resources, and coordinate project funding with local governmental units. Zoning Board Supervisors require that the expenditure of public funds for roads, services, and other public improvements (including the activities of State and Federal agencies) be restricted by and conform to the purposes of each ordinance. All other property uses are considered prohibited except those that the Boards of Supervisors, by resolution, may determine to be consistent with purposes established for the respective districts.

2.2.3 Land Ownership Data (Refer to Map 2.)

Of the study area's approximate 2.9 million acres (including water bodies), approximately .6 million is owned by the Federal and State governments, State ownership predominating with approximately 95 percent of that total. This land, under the Commercial Forest Act, is specifically designated for public use and is not available on the open market. Of the remaining 2.3 million acres, 45 percent is owned by large corporations whose properties are of substantial size (1,000 acres or more), and are also not for sale on the open market, except for large acreages at high prices per acre. Individual owners hold approximately one million acres of land. See Table IV for a summary of land ownership data.

Table IV
Land Ownership Areas and Percent Total Area

Ownership Categories	Acres	Square Miles	Percent of Total
Federal & State	600,000	938	20.7
Corporate	1,035,000	1,618	35.7
Private	1,000,000	1,562	34.5
Miscellaneous & Unaccounted for	265,000	414	9.1
Total	**2,900,000**	**4,532**	**100.0**

The information on land ownership was obtained from individual county plat books and identifies 40-acre minimum parcels. All data collected for the plat books by their publishers were gathered from official public records at the county courthouses. As the cycle of land sales and purchases is a continual process, it is impossible to guarantee with total accuracy the ownership information as of any specific given date. A review, however, of the new plat books of Menominee,

Marquette, Dickinson, Iron, and Houghton Counties (published after the completion of the Land Ownership Report at the end of 1973) reveals that an overwhelming majority of all recent land sales were the result of private landholders selling to other private individuals. The average amount of land sold by individuals to either corporations or governments has been less than one percent and in small tracts averaging less than one hundred acres. For these reasons the Ownership Data Map prepared in 1973 and used as the basis for Map 2 can still be considered reliable, as can the county-by-county land area and ownership information contained in the following subsections.

2.2.3.1 Alger

Approximately 10,000 acres of Alger County, along its western boundary, is in the study area. The State of Michigan owns well over 50 percent of this area. This publicly-owned land is basically contained within the Menominee and Escanaba River State Forests. Slightly more than half the remaining property is owned by private individuals, with the balance owned by corporations, the largest of which are the Mead Corporation and Cleveland Cliffs Iron Company.

2.2.3.2 Baraga

Baraga is almost entirely within the study area (532,000 of 592,402 total acres), and is second to Marquette County in the amount of land under corporate ownership.

Much of the County is under State Government ownership, principally the Baraga State Forest. There are also substantial corporate holdings in the eastern and central sections. Most of these corporate lands are owned by firms such as American Can Company, Ford Motor Company, Kimberly Clark Corporation, Mead Corporation, and North Woods Paper Products, Inc.

There is one substantial area of privately-owned land in the northwestern section of the County. However, most land that is privately owned does not appear in large sections on the map, but is well distributed.

2.2.3.3 Delta

There are 10,240 acres of Delta County in the study area. Eighty percent of the land is privately owned. Ten percent is owned by the Kimberly Clark Corporation. The rest is publicly-owned State property, principally the Menominee State Forest.

2.2.3.4 Dickinson

The entire County of Dickinson, or 488,320 acres, is included in the study area. The southern sections, near the population/residential/commercial centers of Iron Mountain and Kingsford, are largely privately owned. The northern section of the County is substantially government-owned land, primarily the Sturgeon River State Forest. The central sections of the County have a general mixture of all three categories, with the vast majority of corporate land owned by the Keweenaw Land Association, the Kimberly Clark Corporation, and Inland Steel.

2.2.3.5 Houghton

Of the approximately 7,360 acres of Houghton County within the study area, the majority is under private ownership with some scattered corporate holdings.

2.2.3.6 Iron

Approximately 60 percent or 468,096 acres of Iron County lie within the study area. The majority of the northern half of the area is owned by corporations such as American Can Company, Celote Corporation, Inland Steel, U.S. Steel, Michland, Inc., and Wisconsin-Michigan Power Company. The southern part of the area, located in and about the population centers of Iron River and Stanbaugh, is predominately under private ownership. This area is not only a residential and commercial center, but a growing recreational area with a high demand for recreation/residential property.

2.2.3.7 Marquette

With 1,210,920 acres, Marquette is the second largest county in the continental U.S. All but about 10,000 acres in the southeastern corner are within the study area. The major portion is owned by such corporations as Cleveland Cliffs Iron Company, Ford Motor Company, Kimberly Clark Corporation, Inland Steel, and U.S. Steel. It also contains the Escanaba River and Michigamme State Forests. The southern and southwestern sections are largely under government ownership while the central and northwestern sections are largely owned by corporations.

The Huron Mountain Club owns much of the western part of the County's Lake Superior shoreline. Much of the shoreline near Marquette is owned by individuals who have homesites or recreational property on the lake.

The area within 30 miles of the City of Marquette contains one of the heaviest concentrations of privately-owned land in the UP.

2.2.3.8 Menominee

Of the 230,400 acres in Menominee County within the study area, most of the land at the southern tip is privately owned. The central and northern areas are owned largely by corporations such as Kimberly Clark and U.S. Steel. The publicly-owned land consists primarily of the Menominee State Forest.

2.2.4 Land Use Data (Refer to Map 3.)

2.2.4.1 General Uses

Land use patterns in any region are shaped by the character and distribution of natural resources, climate, terrain, watercourses, overland transportation means, and geographic relationships to markets and major political boundaries. All of these factors have influenced land use in the UP from the earliest days to the present.

French missionaries and fur traders were the first Eurpoeans to arrive. Furs commanded high prices and animals were abundant. Copper discoveries of the

early 19th Century generated a mineral boom which expanded rapidly with iron discoveries in what are now Marquette, Iron, Dickinson, and Gogebic Counties. Towns sprang up wherever major copper and iron deposits were located. The mining companies, needing labor, provided transportation to the region for immigrants.

Because timber was needed in quantity for charcoal to refine ore and to support mine-shaft walls, the Michigan logging industry was born. Large-scale lumbering followed, which also led to the formation of new towns. By the early 1900's, the lumbermen began to move on, selling depleted forest lands to immigrant farmers or allowing the land to revert to the State as tax delinquent. Large open-pit iron mines in Minnesota began to outproduce the shaft mines of the UP; and after World War I, copper mining began to decline. Although some industrial development occurred through the years on a limited basis, it was the tourist and vacation industry which helped stabilize the waning economy.

Farm products have been exported only during periods of high consumer demand rather than on a continual basis, as the harsh climate gives a competitive advantage to the farm lands of the lower Midwest. Also the remote location of the region has placed it at a disadvantage in terms of accessibility for and to larger U.S. population centers and markets.

Table V lists the acreage by county devoted to the major land-use categories as compiled in 1972. In this table, entire counties are included.* The largest category of land use in the study area is forest land, capable of commercial production and accounting for approximately five million acres or 85.9 percent of the total area. A large percentage of commercial forest land is in State and Federal ownership, with large tracts open to the public for hiking, fishing, hunting, and camping.

The next largest land use in the study area is agriculture, which accounts for a little less than a half million acres or 7.7 percent of the land area. However, it has been noted that approximately 16 percent of land classified as agricultural in 1963 had slipped into inactive use by 1970. Land held by retired farmers is often sold to part-time farmers or those looking for recreational or retirement homes, further fragmenting agricultural land ownership.

Following agricultural land use is public recreational land use. While land areas publicly owned and used primarily for recreation consume over 24,000 acres in the

*Because the data sources were not sufficiently detailed to permit segregation of land-use distribution within the study area boundary, the acreage listed in Table V, as well as other acreages cited in this narrative, encompasses county land extending beyond the study area boundary. The relative percentage figures, however, are just as valid for portions within the study area as they are for the complete eight-county region.

TABLE V

LAND USE DISTRIBUTION

COUNTIES	TOTAL AREA	INLAND WATER	LAND SURFACE	FOREST	AGRICULTURE	TRANSPORTATION	PUBLIC* RECREATION	URBAN	OTHER
Alger	597,760	18,880 3.2%	578,880 96.8%	535,900 89.7%	25,146 4.2%	8,498 1.4%	1,496 .3%	2,146 .4%	5,694 1.0%
Baraga	592,402	15,488 2.6%	576,914 97.4%	535,100 90.3%	24,952 4.1%	7,152 1.2%	6,995 1.2%	2,715 .5%	-
Delta	769,280	16,320 2.0%	752,960 97.9%	623,900 81.1%	101,542 13.2%	11,558 1.5%	2,756 .4%	7,925 1.0%	5,279 .7%
Dickinson	510,236	3,712 .8%	506,524 99.3%	447,700 87.7%	39,749 7.8%	8,936 1.8%	300 .1%	9,839 1.9%	-
Houghton	670,080	19,200 2.9%	650,880 97.0%	560,800 83.7%	45,906 6.9%	12,111 1.8%	1,357 .2%	14,553 2.2%	16,153 2.4%
Iron	780,160	30,720 2.9%	749,440 96.1%	696,100 89.2%	27,283 3.5%	9,281 1.2%	3,731 .5%	2,858 .4%	10,187 1.3%
Marquette	1,210,920	41,000 3.4%	1,169,920 96.6%	1,097,100 90.4%	27,393 2.3%	18,023 1.5%	6,032 .5%	14,793 1.2%	6,579 .5%
Menominee	698,874	3,904 .6%	694,970 99.4%	513,300 73.4%	162,239 23.2%	13,593 1.9%	2,327 .3%	3,511 .5%	-
TOTAL	5,829,712 100%	149,224 2.6%	5,690,488 97.4%	5,009,900 85.9%	454,210 7.7%	89,152 1.5%	24,994 .5%	58,340 1.0	43,892 .8%

*Detailed information on privately-owned recreation areas is not available.

study area, commercial forests, as well as State forest lands, are open to hunting, fishing, hiking, canoeing and camping, adding tens of thousands of additional acres for those seeking recreation.

The mining industry holds large acreages of land within the study area, but less than 2 percent is devoted to surface use.

Owing to the area-wide characteristics of fragmented property ownership and widely separated population centers, land devoted to public highways, roads, railroads, and airports is high in comparison to urban land uses. These transportation uses account for 89,215 acres or 1.5 percent of total land area, while urban land—including city and village streets—accounts for 58,340 acres or approximately 1 percent of the land area.

2.2.4.2 Special Uses

Within the general land-use categories described above are a few subcategories of particular interest to SEAFARER because of their potential effect on antenna siting.

a. *Cemeteries* — There are some 47 cemeteries in the study area. Public and private burial grounds are registered with the Department of Commerce Cemetery Commission, and all construction easements through a cemetery are prohibited unless successfully appealed to the Commission directors.

b. *Prisons* — In Marquette County there is a State prison complex consisting of three sites: the main facility, a farm, and an honor camp. Rights-of-way across prison lands are granted only when they are of benefit to the facility itself. Appeals are made to the Michigan Department of Corrections.

c. *Upper Peninsula Experimental Forest* — This experimental forest consists of over 5,000 acres located at Dukes in Marquette County, approximately 20 miles southeast of the City of Marquette. The tract was given National Forest status in 1935 and is maintained by the Forest Service. With the exception of 320 acres of the original forest, which is handled under cooperative agreement with the Cleveland Cliffs Iron Company, timber in the forest is cut and sold under National Forest timber sales procedures in cooperation with the Upper Michigan National Forests. The experimental forest is well provided with main hauling roads, either through existing State highways, County roads, or roads constructed by the Forest Service. In addition, a system of low standard logging roads makes the area very accessible for harvesting the timber crop.

d. *Sturgeon River Watershed* — This is an 83,980-acre tract located in the central portion of Dickinson County. A watershed work plan has been jointly prepared by the Dickinson Soil Conservation District, the Dickinson County Road Commission, and the East Branch of the Sturgeon

River Water Users Association. The plan calls for three reservoir structures to be built for the following purposes:

- Flood prevention to protect agricultural lands and transportation facilities.
- Irrigation of local potato and oat crops.
- Provisions for general recreation.

Operation and maintenance of all dam structures will be the responsibility of the Dickinson County Road Commission. Recreational functions will be the responsibility of the Michigan Department of Conservation. Construction and filling are now essentially complete.

e. *Cyrus H. McCormick Experimental Forest* — In 1901, Cyrus McCormick, son of the inventor of the McCormick reaper, and attorney Cyrus Bentley began buying land in western Marquette and eastern Baraga Counties. Eventually they controlled over 17,000 acres (much of which had been previously logged), containing 16 lakes, numerous streams, and a variety of game animals. McCormick's heirs left the property to the care of the U.S. Forest Service. To keep the land in a wilderness condition, Ottawa National Forest officials, in early 1970, announced a set of rigid regulations for the McCormick tract. Overnight camping was banned; and all horses, motorcycles, cars, snowmobiles, carts and motorboats were prohibited. The value of the McCormick Experimental Forest to increasing research interests depends to a large degree on its isolation and relative lack of use. There is good road access to only one corner of the 17,000-acre tract, where only casual use by fishermen and hunters is permitted.

f. *K.I. Sawyer Air Force Base (SAFB)* — The site of SAFB was acquired by the County of Marquette in 1940 for the purpose of constructing a new county airport. However, construction of the airport did not begin until 1945, and was not completed until 1949. On 1 January 1955, a 99-year lease was signed by the United States Government and Marquette County. Through this lease, the U.S. Government acquired K.I. Sawyer County Airport as the site for the construction of K.I. Sawyer Air Force Base which now covers approximately 5,200 acres. SAFB is divided into eight land use categories: airfields, cantonment and operations, family housing, munitions storage and handling, recreation, sanitary fill, schools, and clearance easements. Thirty-seven percent, or 1,938 acres of the Base area is devoted to airfield. The existing runway system consists of a 300-foot wide by 12,300-foot long runway, and a 75-foot wide taxiway, with 50-foot bituminous shoulders on each side. Within all eight use categories, there are a total of 890 buildings, 41 miles of paved roads, and two miles of railroad. SAFB provides 883,026 square feet of administrative and industrial space, 1,693 family housing units, and quarters for 1,421 single airmen and officers. Total base population is approximately 10,000, with 4,200 military personnel, 450 civilian employees, and 5,350

dependents. A later section of this volume (Section 2.2.24), as well as a separate book (Part 6), deals with the possible integration of SEAFARER with the on-going operation of SAFB.

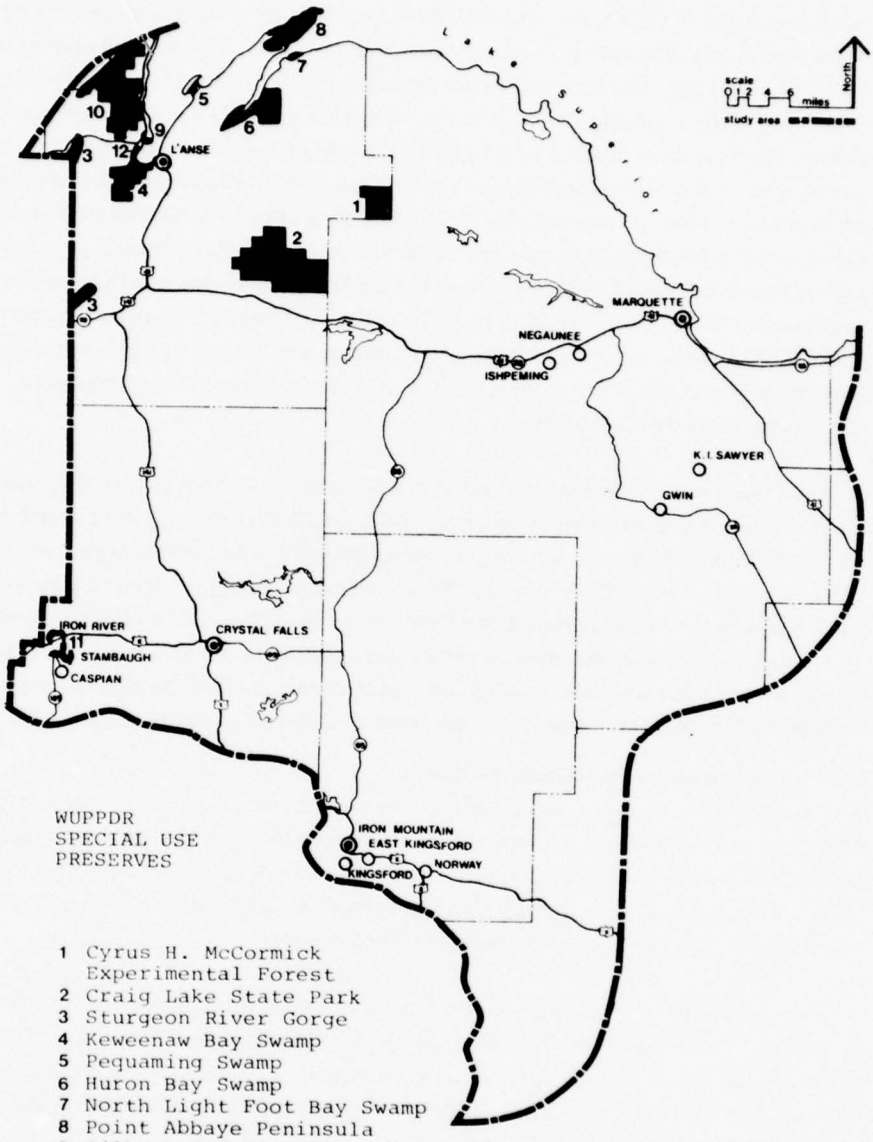
g. *Proposed Preserve Areas* — In 1973 WUPPDR completed an environmental land-use plan for the six counties under its jurisdiction. Implementation will be largely the responsibility of the local county planning and zoning commissions. One aspect of the plan is the identification of twelve special-use preserve areas (see Figure 6). These areas are intended for the following uses: wildlife management, open space, wilderness-like areas and passive recreation areas. Secondary uses would be allowed only after approval by the managing entity. These tentative special-use preserves are the McCormick tract, Craig Lake State Park, Sturgeon Gorge Area, Keweenaw Bay Swamp, Pequaming Swamp, Huron Bay Swamp, North Lightfoot Bay, Shoreline, Point Abbaye Peninsula, Baraga Green Belt, Ojibway Red Pine Stand, Sturgeon Sloughs, and Iron River Urban Open Space Systems. No such lands have been identified for the counties under the jurisdiction of CUPPAD.

h. *Huron Mountains* — These mountains are located along a 22-mile stretch of Lake Superior's south shore in the north central portion of the study area and occupy nearly 100,000 acres. They sweep up from a low, level plain that borders on the lake and rise to over 1,000 feet. The coast line along the plain varies from precipitous cliffs to sand beaches with low, broken sandstone formations completing the lake-shore physiography. Remnants of old mature forests exist over portions of the mountain region, although elsewhere logging has altered the forest communities. A significant portion of the Huron Mountains is owned by the Huron Mountain Club and used as a vacation site by member families who have preserved the natural character of the landscape. This area is considered by the DNR to have high wilderness potential. In the event the land becomes available, every attempt will be made by the State to purchase it, then designate it a wilderness area.

2.2.5 Market Value Data (Refer to Map 4.)

Land values discussed in this Summary and the separate Market Value Data volume are the maximum prices in today's economy that a willing buyer would pay and a willing seller would accept if neither were under abnormal pressure. The analysis represents a collective opinion by knowledgeable real estate brokers, government officials (i.e., tax equalization officers), and local real estate appraisers.

Rural land values do not vary significantly in the UP for the following reasons. First, approximately 0.6 million of the 2.9 million acres is owned by Federal and State Governments and is not for sale on the open market, but is available for public use under the Commercial Forest Act. Of the remaining 2.3 million acres, 45



1 Cyrus H. McCormick Experimental Forest
2 Craig Lake State Park
3 Sturgeon River Gorge
4 Keweenaw Bay Swamp
5 Pequaming Swamp
6 Huron Bay Swamp
7 North Light Foot Bay Swamp
8 Point Abbaye Peninsula
9 Ojibway Red Pine Stand
10 Sturgeon River Slough
11 Iron River Urban Open Space Systems
12 Baraga Green Belt

Figure 6 – Special Use Preserve Areas

percent consists of sizable properties (1,000 acres or more) owned by large corporations. For practical purposes, because asking prices are so high and the minimum parcels are so large, this land is also not available for sale. Second, approximately 80 percent of the available land is in forest, which is a consistent market factor: the density of forest areas limits accessibility to the land and also the type and scope of its use, and—hence—its value. Finally the land remains frozen for about half a year, which limits not only its accessibility and use, but its productivity and profit; thus its value is correspondingly limited. For these reasons, agricultural land is generally valued between $75 and $100 per acre, but is declining in price where the land is of poor quality or has been over-worked. Although the lowest rural per-acre prices begin at $45 and rise as high as $350 in a few more accessible and valuable areas, for more than 70 percent of the study area, the average price per acre in a parcel of 40 acres is between $90 and $100.

The most expensive land in the UP can be found in its two largest urbanized areas (Marquette-Ishpeming-Negaunee and Iron Mountain-Kingsford), and in areas bordering the Great Lakes, major rivers, and highways. Land in the urbanized areas is valued from $125 to over $1,000 an acre, depending on accessibility and subdivision potential, and Great Lake frontage is valued from $75 to $200 per foot. In southern Dickinson and Iron Counties, land speculation and turnover is high, which drives prices upwards. Furthermore, in this area, much of the land is used for recreational living, and demand is increasing as the supply dwindles.

2.2.6 Transportation Data (Refer to Map 5.)

The study area's transportation system is more limited than that of the rest of Michigan and the national average due to its remote location in relation to major population and market centers. This is particularly true of passenger facilities; but, on the other hand, excellent deep-water port facilities are available, primarily for the movement of raw materials and industrial products.

Marquette and Presque Isle are the only active deep draft harbors in the study area. The vast majority of their business is the shipping and receiving of bulk commodities—iron ore, coal, and petroleum products. Escanaba on Lake Michigan (and outside the study area) has modern docking/loading facilities and handles significant amounts of ore.

There are six railroad companies presently operating in the study area. These lines mainly transport bulk commodities to and from the ports of Presque Isle and Marquette, which are inside the study area, and to Escanaba, which is to the south. The highest concentration of railroad activity is in the iron mining district around Ishpeming. No regular passenger service is provided by rail anywhere in the study area.

One east-west (U.S. 2) and one north-south (U.S. 41) major highway serve the area, although neither is multi-lane. U.S. 2 enters the UP from lower Michigan via

the Mackinac Bridge, well to the east, and passes through the lower portion of the study area continuing on to Duluth and eventually the Pacific Coast. U.S. 41 originates at Copper Harbor just north of the study area, passes through Houghton, L'Anse, Marquette, Escanaba, and Menominee en route to Green Bay, Chicago, and eventually Miami. Except for a short stretch of I-76 connecting the Mackinac Bridge with Saulte Ste. Marie and Canada, there are no interstate highways in the UP. Gravel and unsurfaced, two-lane roads compose a large percentage of the highway system. These and the large number of logging trails are of particular interest to SEAFARER in that they offer the promise of siting large portions of the antenna without further effect on the natural setting. Further discussion of this subject is contained in Section 2.2.20 and Book 21 of Part 2, *Right-of-Way Opportunities and Avoidance Data*.

Air transportation in the UP is limited. Two commercial airports located in Marquette and Iron Mountain are within the study area boundary. Three other commercial airports in Houghton, Escanaba, and Menominee are close enough to service parts of the study area. Scheduled commercial flights originating from these airports are basically feeder links, connecting with Green Bay to the south, and then west to Duluth and Minneapolis, south to Milwaukee and Chicago, or south-east to Grand Rapids and Detroit. A small commuter airline servicing Houghton and Marquette offers some connection to lower Michigan and Detroit. The study area has three general airports (publicly-owned airports without scheduled passenger service), while two other such airports outside the boundary also provide similar service. These all have limited capacities that are not expected to increase significantly in the future.

2.2.7 Utility Systems Data (Refer to Map 6.)

Information concerning the location and characteristics of utilities in the UP is of particular interest to SEAFARER for several reasons:

a. Since electrical power for the system will be drawn from commercial sources, knowledge of the location and capacity of existing and planned facilities is necessary to permit the system designers to locate the transmitters most economically.

b. Unbalanced or open-wire lines of the type employed for single-phase power drops and older telephone systems may pickup induced voltage from the SEAFARER antenna if they are close to and run parallel with it for considerable distance. The same is true of any long, ungrounded conductors such as fences and pipelines. Information is required on the location and characteristics of these long electrical conductors, both within the study area and for a short distance outside it, in order to plan for and estimate the cost of eliminating or avoiding potential interference by techniques that have already been developed. Where the cost of this corrective action (known as mitigation) is judged to be too high, the antenna will be routed to avoid the conductors.

c. Balanced, multi-phase power lines and balanced telephone circuits are not subject to interference from SEAFARER. Therefore, where rights-of-way for these systems already exist, they offer opportunities for siting antenna lines without requiring additional property.

Six electric power companies and co-ops serve the study area, not including smaller municipal light and power companies. The two largest are Wisconsin-Michigan Power Company (WM) and Upper Peninsula Power Company (UPP). Together, they generate approximately 484 MW (90 percent) of the electrical energy presently used within the study area. Marquette Board of Light and Power also has a generating capacity of 57.2 MW, bringing the total to 541.2 MW. The remaining three companies purchase their electrical energy for resale from WM or UPP. It is estimated that there are approximately 5400 miles of transmission and distribution lines in the study area, not including the countless short lines or drops less than 300 feet in length.

The study area telephone system has 37 central offices, approximately 800 route-miles of open-wire line, and 2,200 sheath-miles of telephone cable. Service is provided by two nation-wide systems (Bell and GTE) and four local companies.

Several of the area's major metal pipelines (ranging in size from 2-inch to 36-inch diameters) transport petroleum products and natural gas, with a total of approximately 550 miles of pipeline within the study area.

The six commercial railroads of the study area have a total track length of approximately 750 miles. Five of these are freight lines, with a variety of communication systems along their routes, while the sixth is a seasonal excursion carrier with no communication lines.

Fences are most numerous in agricultural regions within the study area. They are usually three- or four-strand barbed wire, in lengths of a few hundred to a few thousand feet. The most substantial fences are associated with institutions and mining operations. In addition, many sections of highway are equipped with steel guard rails or cables up to 1,000 feet long.

Other long conductors in the study area include utility lines and tracks in active mines, utility lines at SAFB, coaxial cable for TV signal distribution, and the steel cables of ski lifts.

2.2.8 Mineral Extraction Data (Refer to Map 7.)

There is a direct relationship between mineral deposits and geologic conditions. The distribution and character of mineral deposits are governed by bedrock geology or, in the case of sand and gravel deposits, placer gold, etc., by surficial geologic conditions. The concentration of valuable minerals in specific locations within the

earth's crust is the result of certain types of geologic processes, such as the intrusion of igneous rocks, unique sedimentary conditions, regional metamorphism, etc. Consequently, a definite relationship exists between various types of minerals and the host rock (or environment) in which they are likely to be found. For example, in the UP, copper, molybdenum, lead, zinc, gold, and silver deposits are generally associated with greenstone belts, whereas the iron formations occur within the Middle Precambrian sedimentary rocks.

The location of mines within the study area is an obvious indication of the locations of some of the deposits, but is also dependent on other factors. The thickness of glacial deposits has a great influence on the potential for discovery of minerals present in the bedrock, and—after discovery—on the economics of extraction. Exposed mineral concentrations are obviously more easily located than those buried beneath appreciable thicknesses of glacial cover. Even where modern geophysical exploration methods have indicated that mineral concentrations may be present at depth, the costs of drilling through overburden to prove out reserves can be prohibitive. Equally important may be the cost of stripping off the glacial deposits to get at the ore.

Ground water conditions also have a significant influence on the feasibility of developing and operating both open pit and underground mines. Where large flows of water enter the workings, the cost penalties associated with pumping may be sufficient to make the operation uneconomical.

Iron ore mining and beneficiation is the major industry in the study area. Six of the seven major iron producing districts of Michigan having historic or current production are located within the defined area. Occurrences of other metallic minerals—including gold, silver, lead, copper, zinc, and uranium—have been documented; but no mine is currently producing ore from any of these deposits. However, the larger ones may constitute resources that may be economically extractable in the next several decades.

Cumulative production of iron ore from the more than 200 historic iron mines in the region exceeds 750,000,000 tons. Six mines are currently producing iron ore in the study area, and construction and development work is scheduled to begin on a seventh iron mine in 1976. Total production from the district's mines in 1974 amounted to 11,500,000 long tons of iron ore pellets and direct-shipping ore, having a total value of $214,000,000. The current capacity of these iron mines is approximately 17,000,000 long tons of pellets and ore, and the anticipated capacity of existing and planned facilities for 1985 is about 30,000,000 long tons. Iron production will undoubtedly continue for several decades, and there is considerable potential for increased output from the mining of the lower-grade deposits and the reworking of old waste dumps as new beneficiation processes are developed. A problem related to iron mining is the subsidence of the ground surface in areas

underlain by active and inactive underground mines. Although the trend today is away from underground mines and toward deeper open pits, many inactive underground mines do exist in the study area. In a few areas, the caving-in of old underground workings is affecting developed areas. Portions of Negaunee are affected by this problem, which has necessitated the closing of some streets.

Numerous deposits of sand and gravel as well as other non-metallic minerals exist throughout the study area, but they generally have not been of major economic significance because of low demand.

The Keweenaw Peninsula, a region having considerable historic copper production, lies to the north of the study area. Consequently, copper mining is not treated in this report.

Additional exploratory work, directed at finding currently unrecognized metallic mineral deposits, undoubtedly will be conducted in the future. These programs will include both conventional geologic methods, such as mapping and drilling, as well as geophysical methods that involve the measurement of variations in induced electrical fields or in the earth's magnetic field.

2.2.9 Bedrock Geologic Data (Refer to Map 8.)

Bedrock geology concerns the distribution, thickness, sequence, and types of rock that make up the earth's crust, and is of vital importance to any ELF communication system inasmuch as the length of antenna required is governed by the electrical conductivity of the bedrock. As a general rule, the older the rock types, the lower their conductivity, and therefore the better for ELF communications.

Within the study area, most of the rocks are of Precambrian age (more than 600 million years old). These ancient rocks have been divided into the Archean Series, the Huronian Series, and the Keweenawan Series. The Archean rocks are the oldest group, consisting principally of altered lava flows intruded by granite. The next younger rock series, the Huronian, is largely a thick section of sedimentary rocks that overlap the Archean Series. These sedimentary units have been intruded by basic volcanic rocks. Metamorphic rocks, mainly slates and quarzites, occur elsewhere in the Huronian section which also contains several iron-rich units known as "iron formations." The youngest Precambrian rocks—the Keweenawan Series, found west of the study area—are principally lava flows and conglomerates, although minor units of shale and sandstone exist.

Shallow-dipping Paleozoic sedimentary rocks overlie the Precambrian sequence and crop out in the eastern part of the study area. Here Cambrian and Ordovician sedimentary formations dip gently in a southeasterly direction to form the northwesterly rim of the Michigan Basin. These rocks are mainly sandstones,

dolomites, shales, and limestones. Younger rocks have been almost entirely removed by glaciation. The distribution of bedrock in the study area is shown on the Bedrock Geologic Data Map (Map 8).

The Lower and Middle Precambrian rocks were affected by major episodes of mountain building during the Precambrian period that involved folding, thrust faulting, and metamorphic alteration. Since at least the mid-Paleozoic era (about 350 million years ago), the study area has been tectonically stable, with Pleistocene glaciation being the major factor in modification of the landscape. Hard, bare rock is exposed at the surface in many relatively small areas, but a soil and glacial mantle, ranging from a few feet to a few hundred feet thick, overlies the bedrock throughout most of the study area. This covering is discussed in the next section, Surficial Geologic Data.

The study area is presently geologically stable, with no significant tectonic, volcanic, or seismic activity.

2.2.10 Surficial Geologic Data (Refer to Map 9.)

Surficial geology deals with the composition, distribution, and thickness of soil and rock in the uppermost portion of the earth's crust, all of which have implications to the ease and cost of SEAFARER antenna emplacement.

During the Pleistocene Epoch (which began approximately 2.5 million years ago), glaciers advanced and retreated across the study area at least four times. Each glacial advance was the result of climatic changes, including longer winters with increased snowfall and shorter, cooler summers. Because of these changes, a point was reached at the start of each glacial advance where the snow would no longer melt completely each summer and, consequently, the snow depth began to increase with each passing winter.

With increased depth, snow compacts under its own weight; and, as the pressure increases, it fuses into a solid mass of ice. Still greater pressure causes the ice to become plastic and flow at a slow rate. The combination of movement and high pressure that develops at the base of thick sheets of ice (glaciers) enables them to grind or bulldoze away the soil and rock that they cover.

During the peak periods of glaciation, the thickness of the glaciers covering the UP is estimated to have been in excess of one mile. These enormous sheets of moving ice removed great thicknesses of rock that once covered the area, and profoundly modified the landscape.

In the UP, although there were several glacial stages during Pleistocene times, the deposits left by the earlier ice sheets have been totally obliterated. All glacial deposits present in the study area are products of the last glaciation, the Wisconsin

Ice Age. During this glacial advance, ice fanned out from the Laurentian Highlands, east of Hudson Bay, and advanced south as far as Ohio, Indiana, and central Illinois. Along with removing earlier glacial deposits, the Wisconsin ice sheets removed more of the existing bedrock, and with their melting—approximately 10,000 to 11,000 years ago—left behind an irregular bedrock surface covered by a mantle of unconsolidated debris which varies in thickness from a few feet in some places to several hundred feet in others, with isolated areas of protruding bedrock. Because most of these materials were transported and deposited by glacial ice, they are poorly sorted, containing sizes ranging from clay particles to boulders.

Glacial deposits are of four principal types and are of interest here because of their implications to antenna emplacement.

a. *Till* — Till is deposited directly by and underneath a glacier without subsequent reworking by meltwater from the glacier. It consists of a heterogeneous mixture of soil material and rock fragments ranging in size from bits of clay to boulders a few feet in diameter. It does not possess any characteristics of a water-lain sediment, such as size sorting, stratification, or absence of fine particles. Till is one of the most widespread surface deposits in the Great Lakes Region. Local areas of bouldery till may present problems in cable plowing operations and require pre-ripping.

b. *Moraine* — One of the most prominent of continental glacial features is the unique hilly terrain left after the galcier's retreat. These systems of hills, called moraines, are traceable for miles across the landscape. They originate at a stabilized front of an active glacier, where the forward movement of ice equals the melting rate. In such a situation, large quantities of ground-up rock material melt out of the ice and are deposited in ridges parallel to the ice front that are called end moraines. End moraines form long, relatively continuous hills that are tens to hundreds of feet high. Isolated areas of the UP where bouldery materials are concentrated present excavation problems.

c. *Drumlin* — A drumlin is a low, smoothly rounded, elongated, oval hill or mound of compact glacial till. Drumlins are built up under the ice, or carved out of older moraines by the readvancing ice, and shaped by its flow. Their long axes are oriented in the direction of ice movement, and they are generally 10 to 100 feet high and less than one-half mile long. Drumlins are sometimes found in groups of hundreds of aligned oval hills.

d. *Outwash* — As the name implies, this type of deposit is literally washed out beyond the glacial front by meltwater. It is characteristically coarsely grained, fairly well sorted, and relatively free of fine particles. Variations in grain size, from place to place, are great, however; and the particle sizes present may range from boulders to sand. Very coarse sediments were generally deposited near the ice front; finer sands and silts were laid down further out on the outwash plain.

All UP glacial deposits are geologically young and have been subjected to the processes of erosion and weathering for only a relatively short period of time. Consequently, stream drainage patterns and soil profiles are still developing.

The Surficial Geologic Data Map (Map 9) was prepared by compiling existing maps and data pertaining to surficial conditions in the study area, including maps showing glacial deposits and the location and size of rock outcrops, drilling logs of water wells and soil borings, etc. The existing maps varied greatly in the area covered, scale, and level of detail. Where detailed data were available, such as depth to bedrock from water-well logs, the information is shown on the map. Finally, previously unmapped bedrock outcrops and adjustments to contacts between surficial units were added by limited interpretation of small-scale color aerial photographs in portions of the study area where coverage was available. The map provides useful and reliable information on the location of bedrock outcrops and the areal extent of surficial deposits. It also provides general, but somewhat less reliable information, on the thickness of the glacial deposits.

2.2.11 Slope and Terrain Data (Refer to Map 10.)

Unlike the plains states and even the majority of the surrounding Great Lakes Region, the UP comprises dramatic shifts in topography. The land forms visually describe its geologic history. The most ancient rocks of North America, part of the Laurentian Shield, appear at the surface toward the west end of the area, but the eastern portion is buried under old sea beds of sand. Together, the topological character, geologic history, soils, and topographic orientation divide the UP into two major parts. The significant division is generally along the eastern edge of Marquette County and the western boundary of Menominee County. This is also approximately the eastern boundary of the study area.

The study area and the land farther to the west are quite rocky and either mountainous or rolling. Great Lakes frontage occurs on Lake Superior from L'Anse in Baraga County, east to Marquette, and on into Alger County. This area contrasts with the eastern half of the UP, which is typified by level to rolling topography.

Of the three mountain masses in the UP, only the Hurons are within the study area. This mass is located in the northeastern section of Marquette County. Two other mountain areas, the Porcupines and Brockways, are located to the northwest of the study area. The Huron Mountains have a lake/knob topography of high, rocky, tree-covered crests with many lakes between them. It is in the Huron Mountains that the steepest terrain in the study area occurs. The vast majority of the range has slopes over 20 percent, with large areas over 45 percent.

Much of Baraga County has areas of slope in the 20- to 45-percent range. Another dominant characteristic of this County is the hummocky terrain which is

characteristic of glacial moraines. These systems of hills are traceable for miles across the landscape, their slopes ranging from 10 to 20 percent.

The land along the eastern portion of the study area boundary is flat, with only small isolated areas having slopes steeper than 10 percent. These lands consist mostly of glacial till and alluvium deposits, with some glacial outwash. Menominee County, in the south east of the study area, forms a special territory of its own. It is made up of drumlins, old sea beds, and some rolling terrain associated with end moraines. This is the only section within the study area where drumlins are found.

The Slope and Terrain Data Map (Map 10) was prepared by interpreting quadrant maps published by the U.S. Geological Survey (USGS). Without a field survey made by the SEAFARER study team to compare USGS map features with actual terrain, it is possible that specific geographic locations may not have exactly the terrain features shown on the USGS maps. However, terrain types shown on Map 8 are typical of the area in which they are located; no detail variation will affect antenna siting, since special aerial photos will be made of proposed antenna corridors before precise routes are chosen.

2.2.12 Soil Data (Refer to Map 11.)

The Soil Data Map, a compilation of data from existing sources that are also unchecked by a field survey, and its relationship to the Surficial and Bedrock Geologic Maps prepared during this study, must be kept in mind during its use. The areal distribution of soil associations is shown essentially as mapped by the Soil Conservation Service of the U.S. Department of Agriculture. Although the information presented is very general, the Soil Data Map provides useful information about the approximate thickness and type of soil present in a general area (but not necessarily at a precise location).

In the UP, the near-surface soils have formed as a result of the in-place decomposition of glacially-deposited parent material. The thickness of the soil horizons is only a few inches to a few feet, and in most areas they grade downward into glacial deposits of till, moraine, outwash, or into lacustrine (lake) deposits. Soil and glacial deposits are absent on the many knobs and ledges where hard, ringing rock crops out at the surface. Alluvial soil deposits (water-transported deposits not associated with glacial-related processes) are found locally within narrow, rock stream-bed areas, and are generally only a few feet thick.

There is a direct relationship between the type of soil present and the underlying parent material. Soils overlying outwash deposits are predominantly sand or sandy loam at the surface, grading downward to sand and gravel. Soils which have formed over clay-rich glacial till and lacustrine deposits consist of silty loam to loamy clay, and are generally thicker than the soils overlying outwash. Thick, mucky peat soils overlie organic deposits.

The predominant soil types present in the study area are sandy and silty loams, and loamy sands.

2.2.13 Surface Water Data (Refer to Map 13.)

Surface water is the water flowing or impounded on the surface of the land, and includes rivers, streams, lakes, ponds, and reservoirs. The source of surface water is precipitation that falls within an area and either enters the system directly as runnoff, or infiltrates the ground and indirectly becomes surface flow when it subsequently emerges as springs and seeps. A scan of maps of the Upper Great Lakes Region leads to the conclusion that there is less surface water, particularly lakes, in the study area than further to the west in the UP, as well as in neighboring Wisconsin and lower Minnesota. However, both perennial and intermittent streams exist within the study area. These two types of streams and their relative sizes are indicated on the Surface Water Data Map (Map 12). The surface waters of the study area have important industrial, municipial, and domestic uses that include supplying water for municipalities, power generation, mining, and recreation.

Lake Superior borders part of the study area to the north; Lake Michigan lies just beyond the area's southeastern edge. Inland water bodies are found throughout and represent about 2 percent of the total surface area. Most of these are natural lakes and ponds, the majority of which are less than 20 acres in size. The large number of natural water bodies is the result of glaciation. In many places, natural basins now exist where the ice gouged out bedrock or deposited glacial debris so that closed depressions were formed. Lakes and ponds are also found in depressions on topographically low, deposit-covered areas where the drainage is young and inefficient.

The principal drainage in the study area is either north to Lake Superior or southeast toward Lake Michigan. Important rivers flowing into Lake Superior are the Yellow Dog, Huron, Silver, and Sturgeon. The Paint, Sturgeon (a second Sturgeon River, not to be confused with the one in Baraga County mentioned in the previous sentence), and the Michigamme Rivers flow south or southeast into the Brule/Menominee River bordering the south-central edge of the study area. The Menominee River empties into Lake Michigan at Menominee. The Escanaba and Ford Rivers flow generally southeast, and empty into Lake Michigan at Escanaba and Ford River, respectively.

In parts of the study area, especially where Precambrian bedrock is at or near the surface, the drainage net is highly developed and efficient. This results in "flashy" stream behavior, streams rising quickly after a period of heavy rainfall, with high peak flows, and then subsiding rapidly. In most of the area, however, drainage is poorly developed. These areas are characterized by numerous ponds, lakes, and swamps. There are often thick and extensive deposits of permeable glacial overburden; and during rainy periods, much of the rain infiltrates the ground instead of running off. The presence of significant numbers of surface water bodies

allows temporary storage of surface runoff. These factors combine to produce a stream-flow behavior characterized by relatively gradual rises in streams, moderate peak flows, and then gradual declines in stream flow. In such areas, the base flow of streams during rainless periods is sustained by ground water that infiltrates the glacial overburden and then emerges as springs and seeps that feed the streams. Thus, these areas with poorly developed drainage do not usually exhibit "flashy" stream behavior, but instead tend to have a relatively uniform flow.

Many USGS stream-gauging stations are located in the study area, and their numerous stream-flow records are available. High flows in UP streams and rivers are usually the result of spring snowmelt or a combination of rain and snowmelt. High-intensity rainfall may also cause infrequent summer flooding. On 29 July 1949, for example, five inches of precipitation were measured in about two hours at Ishpeming; however, across the study area, the average annual precipitation is a modest 30 to 32 inches. The record floods of the spring of 1960 were the result of both rain and snowmelt. On a smaller scale, ice damming is another potential flood hazard. During the spring breakup, ice blocks may become wedged in the stream channel, causing local flooding.

The quality of water in the streams is generally good. The Precambrian bedrock and overlying glacial deposits in the central part of the study area yield very little soluble material to the streams, so that the total dissolved solids content of most streams is low—probably no more than about 200 ppm even under low flow conditions. During periods of high flow, the concentrations of various ions in streams tend to decrease due to dilution. The Paleozoic rocks around the periphery of the study area contribute more dissolved materials to the streams. Limestones, in particular, can cause the surface waters to be somewhat hard because they contribute calcium and magnesium to streams flowing over them.

The predominant uses of man-made reservoirs in the study area are agriculture, municipal water supplies, hydroelectric power generation, and recreation. Some of the larger reservoirs include Lake Michigamme (4,212 acres) and Dead River Storage Basin (2,704 acres) in Marquette County, and Peavy Pond (2,763 acres) in Iron County. All are used for hydroelectric power generation. A new reservoir is Greenwood (about 1,400 acres) on the Escanaba River in Marquette County. This reservoir, completed in September 1973, was constructed by the Cleveland Cliffs Iron Company to supplement other impoundments that supply water for iron ore processing. The new Sturgeon River Watershed Project, now nearing completion in Dickinson County, consists of three man-made lakes constructed for flood control, irrigation, and recreation purposes.

Surface water in the study area has two principal industrial uses—power generation and, in the iron industry, mining and beneficiation. Except for possible slight changes to its temperature, use of surface water for hydroelectric power

generation has essentially no effect on its quality. The iron industry uses vast amounts of water in the mining and processing of ore. After most of the suspended sediment is removed in settling ponds, the water is eventually put back into the streams. Water used in beneficiation processes and returned to streams has increased dissolved solids, turbidity, and sediments. These conditions are reduced by dilution downstream, however, and do not appear to adversely affect aquatic life forms.

It is unlikely that significant changes to the surface water regime of the study area will occur in the foreseeable future, except that existing or future recreational/housing developments near lakes and streams might cause rapidly deteriorating surface water quality due to the acceleration of erosion and siltation by grading operations, and to inefficient or faulty waste-disposal systems. It is obvious that any construction activity near streams and other water bodies can accelerate erosion and siltation, and cause pollution; but the implication of these effects to SEAFARER is that, in order to minimize its impact on the water quality, construction activities (especially at antenna-stream crossings) must comply with the procedures required by the Michigan Department of Natural Resources' *Rules and Regulations Concerning Inland Lakes and Streams Act* (see Appendix D, Book 14).

2.2.14 Subsurface Water Data (Refer to Map 13.)

Little interaction between SEAFARER and the UP subsurface water reserve is anticipated. The few widely separated transmitter stations (TS) planned do not need to be water-cooled, although operational cost would be marginally lower if they were. Furthermore, only modest amounts of water would be required even if that cooling method were ultimately chosen. Potable and sanitary water supplies will be required only for the operation and maintenance crews. After construction is complete, no effect on the water table is expected.

The Subsurface Water Data Map (Map 13) shows the locations of representative wells within the study area, depth to water at these locations, and the quality of water present.

The amount of subsurface water that can be extracted by wells within the study area varies greatly. Wells extract water both from bedrock aquifers and from glacial deposits that exist at the surface throughout most of the area. Moderate yields (a few tens of gallons per minute) are generally available from wells penetrating the Paleozoic sandstones and limestones at the southeast and northwest margins of the study area, but the older Precambrian crystalline rocks underlying the central portions of the area are generally so dense and impermeable that they yield only very small amounts of water. Consequently, near-surface glacial deposits may be the only available sources of ground water within areas of Precambrian bedrock. The most promising areas for ground water development appear to be areas of

stratified glacial outwash along major streams where yields of several hundred gallons per minute are possible from the fairly coarse and uniform sands and gravels. Least promising are the areas where dense Precambrian bedrock crops out at the ground surface or where the glacial deposits are thin and/or clayey, and yields of just a few gallons per minute are difficult.

The water table is near the ground surface (0 to 10, 20, or 30 feet) in much of the area, and water will be encountered in most excavations deeper than 10 feet. In some areas, however, depth to water is variable, ranging from a few feet in valleys underlain by glacial deposits to over 100 feet in upland areas underlain by bedrock. There does not appear to have been any long-term rise or fall in ground water levels within most of the study area, although some local areas have probably experienced a lowering of the water table due to the large-scale pumping operations of mining activities.

The quality of the ground water throughout the study area is generally good. The only two minor water-quality problems frequently encountered are hardness and excessive iron concentrations, both of which can usually be alleviated by standard water treatment methods. Some of the deeper (300 to 400 foot) wells in bedrock produce water that is somewhat salty (250 to 400 ppm chloride). In addition, there is some possibility of the bacterial contamination of shallow aquifers by surface pollution sources, particularly within areas underlain by the Paleozoic limestone aquifers at the eastern and southeastern edges of the study area.

2.2.15 Climatic Data (Refer to Map 14.)

The study area has a temperate continental climate categorized by meteorologists as the "cool summer type." Summer temperatures are relatively uniform, but winter temperatures exhibit wide diurnal and seasonal variation. There are three major features which affect the winter climate: polar outbreak highs moving south out of Canada, deep cyclonic storms moving north out of Texas, and proximity to the Great Lakes.

Polar outbreak highs are usually preceded by mild, warm fronts which bring rain or snow. After these fronts move through the area, winds shift from southwest to north and initiate a rapid drop in temperature as the polar high advances southward. This temperature drop is referred to as a cold wave and is typical of the winters of a continental climate. Cold waves end when deep cyclonic storms, orginating in Texas move northward bringing with them warmer temperatures and rain or snow. The climate of this region is also modified somewhat by the Great Lakes. In the fall, the lakes decrease the severity of the first cold winds from the north by warming them slighty. They also increase the moisture content of the north winds, thus increasing the snowfall in the area.

The summer temperatures are less controlled by storms and exhibit a greater regularity. Two major elements control the summer weather: hot waves and cold-

front thunderstorms. Hot waves are a response to long-continued advection of tropical air masses by south winds. Eastward advancing cold-front thunderstorms end the hot waves, shifting the winds from the south to the northwest and bringing cooler temperatures.

The principal climatic and climate-induced factors of significance to SEAFARER are snowfall and depth of frost. Snowfall records have been maintained for many years in the UP, and this parameter is plotted on the detailed data map (Map 14).

Depth of freezing of the soil, on the other hand, is quite variable, depending not only on temperature, but also on the insulating properties of ground cover, as well as moisture content and thermal conductivity of the different soil types. The maximum depth of frost in the study area averages 5 feet, but can range to as deep as 8 feet in bare ground.

Annual mean low temperatures for the December through March period range from 20° to 1.3°F, and annual mean highs for the period are between 38.7° and 22.5°. The record low temperature for the area is -46°, recorded in February 1951, in Houghton County. Average high temperatures for July and August are 75.6° and 74°, respectively; and the lows for these months are 57.6° and 57.5°, respectively. The highest temperature was 102°, recorded in Marquette in August 1947.

In Marquette the average for the first freezing temperature of autumn is October 20. The mean annual freeze-free period varies over the study area from more than 120 days along the Lake Surperior shoreline, to less than 60 days in the west central part.

Precipitation in the area ranges from less than 30 inches to more than 32 inches annually, and is evenly distributed throughout the year (see Figure 7). With this even distribution of precipitation, there is no definite wet or dry season. However, the summer rainfall is often intense and of short duration.

Snowfall may occur in the study area from September until May. The mean accumulated snow depth at Marquette for each of these months is from 0 to 25 inches, with a monthly maximum of 52.6 inches. Average annual snowfall for the study area ranges from 120 inches in the northeastern part to 60 inches in the southern tip. In Marquette the greatest snowfall on record is 189.1 inches during the winter of 1890-1891. The least winter snowfall on record is 53.4 inches for the 1940-1941 season.

2.2.16 Cultural and Recreational Data (Refer to Map 15.)

2.2.16.1 Archaeological Data

The sequence of man's cultural development within the Great Lakes Region is generally known where archaeological investigation has taken place. However,

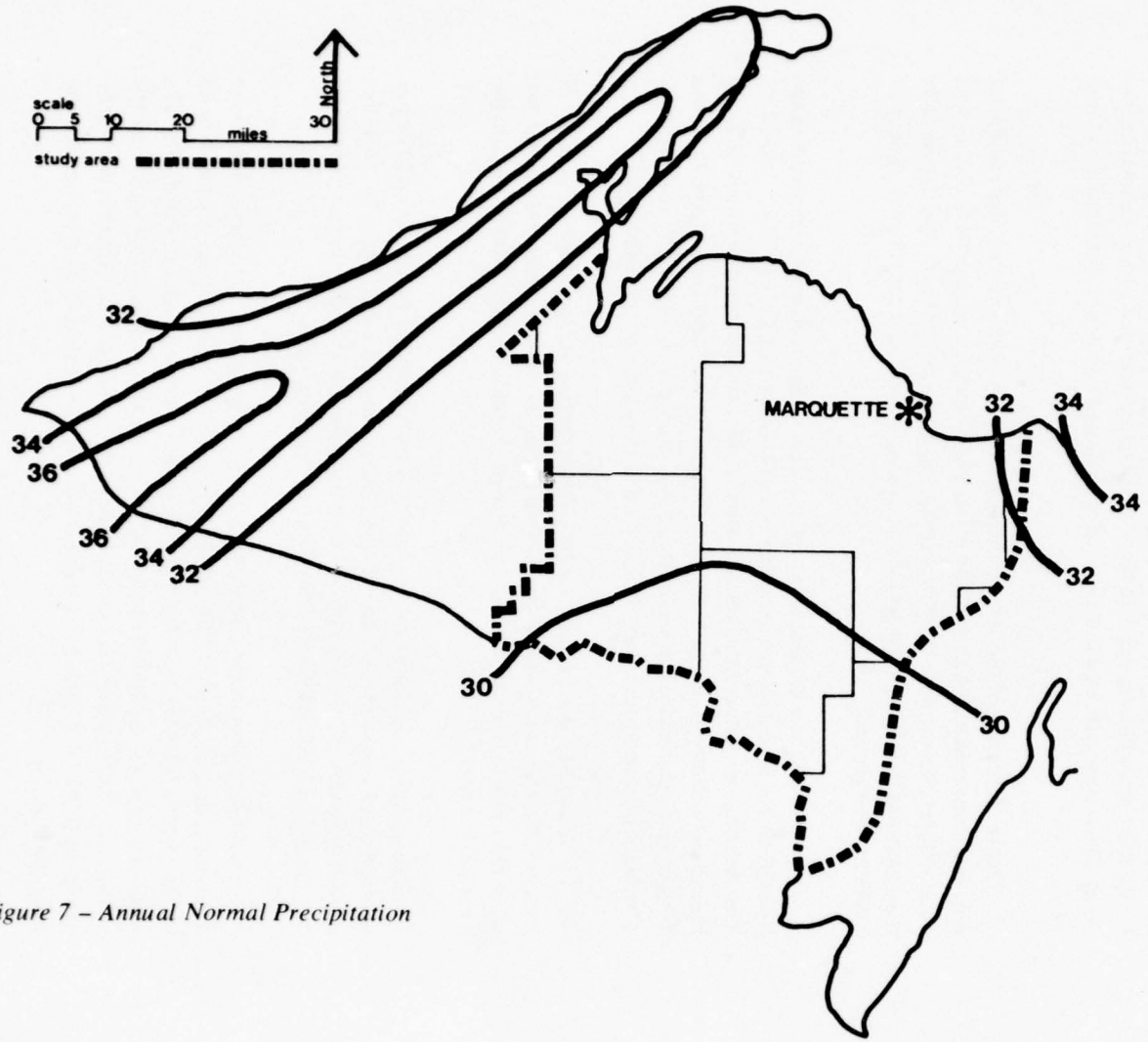


Figure 7 – Annual Normal Precipitation

many gaps remain in the knowledge of Upper Peninsula prehistory. What follows is a very abbreviated summary of several of the known archaeological periods and their important developments.

a. *Paleo-Indian through Late Archaic Periods* — The first well-defined regional cultural complex is that of the Paleo-Indians who are thought to have subsisted on large mammals. Although the earlier of these nomadic groups appear to have been restricted to the southern Lower Peninsula between 11,000 and 9,000 BC, research suggests that later groups dating from 9,000 to 7,000 BC may have occupied the western UP. The milder climate in Menominee County may have encouraged a substantial population during the Late Archaic Period, as evidenced by artifacts recovered along the Menominee River; however, many archaeological sites predating 3,500 BC may exist in unexpected locations because ancient environmental conditions were very different from those of today.
b. *Early Woodland Period* — Recent studies indicate that between 3,500 and 2,000 BC seasonal and environmental conditions similar to those of the present contributed to the development of a pattern of winter population concentration and summer dispersal.
c. *Middle Woodland Period* — Dating roughly between 300 BC and 400 AD, the Middle Woodland Period marks the appearance of the first pottery in the western UP that can be definitely associated with a recognized culture. Characterized by certain pottery styles, the Middle Woodland groups in the north are thought to have concentrated in large fishing villages along lake shores during the summer months. The remains of winter camps may also be present within the study area—sites smaller in size, possibly scattered throughout the interior as a result of population dispersal necessary for survivial by hunting.
d. *Late Woodland Period* - The Late Woodland Period lasted from about 400 AD until the Indian cultures were drastically altered by European contact during the 17th and 18th Centuries. A number of sites of this period have been found in the western UP on the Lake Superior shore and along the Menominee River.

Although archaeological sites may be found anywhere in the study area due to patterns of seasonal dispersal and—prior to 3,500 BC—to a climate that differed greatly from that of the present, the following seem to have the greatest potential for new archaeologic discovery:

- All shorelines along Lake Superior.
- All inland lakes, especially in the lake areas of Iron County.
- Along all streams and rivers, especially the Menominee system.

2.2.16.2 Historical Data

An understanding of the UP's more recent historical character is gained through study of its natural resources. Furs, copper, iron, and an abundance of timber have

made the area what it is today. In the early 17th Century, the UP became the first area of Michigan to be visited by Europeans, and for over one hundred years its shores and interior trails were traversed by French missionaries and fur traders. In 1761 the British succeeded the French, their Hudson Bay Company greatly expanding the regional fur trade. Later, 18th Century American frontiersmen continued the trade and, in the process of exploration, discovered large deposits of copper and iron. By the mid-1800's the lure of this material wealth brought to the UP the first great mineral rush in North America. Waves of immigrants from northern and western Europe came initially to work the mines, and soon thereafter to harvest the forest. Their diverse national heritages enriched the regions's cultural base, adding to the substantial contributions of the Indians, fur traders, and explorers; and Michigan's economy began to prosper as the timber and ore reached the industrial marketplace.

By the end of World War I, the UP had lost its economic vitality. Exploitation of the natural resource base, coupled with industrial competition from areas more accessible to regional population centers, had reduced the mines, and pulpwood cutting had replaced the logging of virgin pine forests.

The historical implications of the past have not vanished, but still exist in the buildings, structures, sites, and industrial remains of past significant events.

2.2.16.3 Recreational Data

Upper Peninsula planning documents point out that projected further development of recreational lands within the UP will increase the flow of tourists into the regions while at the same time providing added leisure activities for the resident population. Highway improvement programs will allow persons from distant areas to reach the region in less time, thus making it accessible to greater numbers of people. The UP's remote location, however, will help retain its wilderness character.

The large holdings of State and Federal public lands are open to hunting, fishing, hiking, camping, canoeing and other recreational uses. Figure 8 is a snowmobile trail map prepared by the DNR to aid winter activities and is indicative of the state of recreational development of State Forests.

The UP is unique in that resident populations are not expected to increase significantly in comparison with that of the rest of the State, but there are projected increases in recreational use. These increases will be due primarily to use by Lower Peninsula residents and out-of-state visitors. Both the public and private sectors have plans for additional campsites in the region.

At the present the DNR is studying possible new state parks within the study area. There are four areas that are considered suitable: the Slate River Falls area, land around Roland Lake, Mt. Curwood (the highest point in Michigan), and an area northeast of Mt. Curwood.

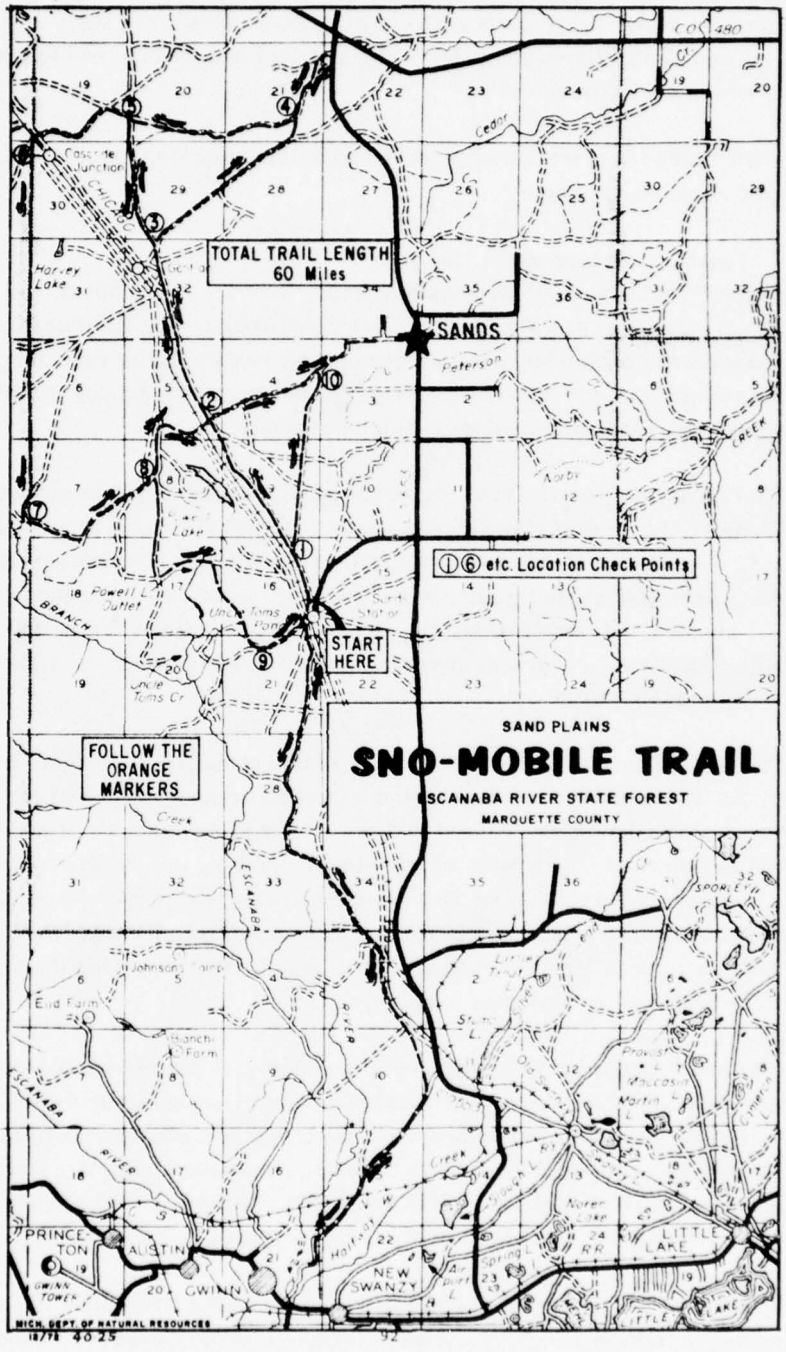


Figure 8 – Michigan State Forest Recreation Development

A distinctive feature of Michigan's Natural Rivers Act is the provision for protecting rivers and their tributaries by zoning restrictions imposed by local governments on the use of lands adjacent to streams. Within the study area the Sturgeon and Fence Rivers are under study; and the Paint, Huron, and Escanaba Rivers are proposed for study.

There are no rivers in the study area that are being studied for possible National Wild and Scenic River status.

2.2.17 Vegetation Data (Refer to Map 16.)

Vegetation is influenced by both natural and human factors. Climate and soil patterns resulting from past glacial activity are the most significant natural factors in vegetation determination. Since the settlement of the study area, the vegetation has undergone major changes resulting from logging and clearing for agriculture, and to a lesser degree, changes caused by mining operations.

The classification used in Map 16 groups vegetation according to dominance of crown cover. The primary classification represents 50 to 95 percent ground space covered by the dominant vegetative unit, with secondary classification representing 5 to 49 percent of ground space covered. Vegetative units comprise the following: (C) conifers, (H) hardwoods, (S) shrubs, (G) grasses and forbs, and (W) wetlands. Other classes of ground cover recognized are (A) agriculture, (U) urban-industrial, and (R) rock.

The study area was once the site of many large stands of White Pine. In the 1840's and 1850's, commercial logging and lumbering began, and by 1905 the area had been so heavily cut and burned that few saw-log timber stands of pine and hardwoods remained. The lumber and saw-timber industry was closely related to the mining industry of the region. The mines used timber for props, and wood for charcoal production played an important part in the manufacturing of pig iron. Well over 800,000 acres of land were cleared from 1860 to 1925 to provide the timber necessary to keep the iron furnaces burning.

Pine is still being logged, but will never regain its previous individual tree size and abundance. The area is now covered primarily by stands of hardwood, but these second-growth hardwoods are not as valuable to the lumber industry as were the original forests. Many areas are now dominated by an Aspen-Birch association with a Balsam Fir-White Spruce understory. As long as fire is excluded from their areas, the White Pine stands may eventually be replaced by hardwoods.

With the virtual exclusion of extensive wild fire in the study area, the more shade-tolerant trees like Sugar Maple will eventually succeed less tolerant species like Aspen and Birch. Most of the Aspen-Birch areas, however, will be succeeded by Spruce-Fir associations before the climax Sugar Maple woodlands.

Vegetation is significantly related to climate. The interior regions of the study area are subjected to colder weather, which shortens the growing season. Local water availability has the most effect on species compositon. Willow and Alder prefer the moist areas near streams and rivers; Red Pine prefers sandy plains and dry gravelly ridges; and Sugar Maple prefers moist, rich soils in valleys and uplands, and moist, rocky slopes.

The effect of glacial activity on the vegetation of the region is evident. Lowlands, carved by glacial action, are occupied by swamps, bogs, marshes, and fens, with mixed hardwood and hardwood-conifer types occupying the uplands.

Wildlife is highly dependent on the forests. The deer, for example, seek forest edges, the amount and type of which are important determining factors in game production. Openings in the forest provide food sources for deer, while adjacent forests act as protective cover. In winter deer tend to herd in areas (yards) which provide shelter and readily-available browse. The importance of White Cedar swamps as deer yards is due to the ability of the Cedar to provide these two important needs. While White Cedar deer yards are not present throughout the UP, Cedar is the nucleus of such yards where it is numerous.

Managing the Northern White Cedar because of its value as winter cover is a joint effort of district foresters and biologists. Some of the problems associated with this management include overbrowsing by both the Whitetailed Deer and the Snowshoe Hare, sensitivity to fluctuating water tables, and an extremely low germination rate. White Cedar is a slow-growing tree having a rotation age between 120 and 160 years. Seed production normally begins when the trees are 20 to 30 years old, but maximum production is best after 75 years.

Because of a shallow root system, any change in water table can result in mortality. Such changes are often the result of improper road construction and trenching. Improper trenching has been found to raise the water table on the upslope side, killing trees as far back as one-half mile.

A few endangered and threatened plant species are found in the study area. Endangered species are defined by the Smithsonian Institution as "those species of plants in danger of extinction throughout all or a significant portion of their ranges," and threatened species as "those species of plants that are likely to become endangered within the foreseeable future throughout all or a significant portion of their ranges."

The Smithsonian lists one endangered and two threatened species as occurring in the study area. The State of Michigan has compiled species lists of its own that include 16 endangered and 195 threatened species, of which two and 17, respectively, occur in the study area counties. Table VI is a compilation of information from both the Smithsonian and Michigan lists.

Table VI
Endangered and Threatened Plant Species

Latin Name	Common Name	Designated by		Habitat	Known Location (County)
		Smith.	Mich.		
Agropyron dasystachym	This grass has no common name.		T	Sand dunes & lake shores.	Menominee
Allium schoenaprasum	Chives, Ciboulette, Brulotte.		T	Stream banks, rock crevices.	Baraga
Arenaria macrophylla	Sandwort.		T	No information.	
Calamagrostis lacustrus	Reed-Bentgrass.		T	Lake shores, rock crevices.	Baraga
Calypso bulbosa	This herb of the orchid family has no common name.		T	Moist conifer woods, or conifer-hardwoods.	Marquette
Carex atratiformus	This sedge has no common name.		T	Wooded edges, rock outcrops.	Marquette
Carex synchnocephala	Same as above.		T	River bottoms, lake shores.	Menominee
Cyripedium arietinum	Ram's-Head Lady-Slipper.	T	T	Dunes-conifer swamps.	Marquette, Menominee
Disporum hookeri	This fairy bells specie has no common name.		T	Woodlands.	Iron
Gentiana linearis	Closed Gentian.		T	No information.	Baraga, Marquette
Gymnocarpium heterosporum	This lichen has no common name.	T		Cool, rocky woods, limestone cliffs and ledges.	Marquette
Iris lacustris	This iris has no common name.		T	Moist sands, gravel, limestone crevices.	Menominee
Juncus stygius	This rush has no common name.		T	Peat bog.	Marquette
Myriophyllum farewellii	No common name.		T	No information.	
Opuntia fragilis	Fragile Prickly Pear.		E	No information.	
Orchis rotundifolia	Small Round-Leafed Orchis.		T	Conifer bogs.	Marquette, Dickinson
Oryzopsis canadensis	This mountain rice specie has no common name.		T	Sandy openings in Jack Pine and White Spruce.	Baraga, Marquette
Pinguicula vulgaris	Common Butterwort.		T	No information.	
Trisetum spicatum	This grass has no common name.		T	Rock crevices and shores.	Marquette
Woodsia abbeae	This fern has no common name.	E	E	Rock crevices and ledges.	Marquette

T — Threatened
E — Endangered

2.2.18 Wildlife Data (Refer to Map 17.)

2.2.18.1 General

Animals differ in their ranges of tolerance to a number of parameters, particularly to the degree they can continue to live in close proximity with man. Some species are restricted to specific habitats; and when these are removed or altered to any substantial degree, the animals disappear with them. When one type of habitat is destroyed, though, a new one is created. This may bring an entirely different specie or complex of species into the area, and those that are preadapted to the new habitat may occupy it and flourish.

Nearly all of the UP was once covered by a climax forest of hardwood interspersed with several important preclimax conifer forests. These pristine conditions were dramatically altered with the advent of the logging era. Wildfires were probably never uncommon on the UP; but because of the mosaic-like distribution of vegetation cover and soil types, they were also never very extensive. Large-scale clearcutting destroyed this natural pattern of firebreaks and allowed numerous large fires to sweep across the Peninsula between 1920 and 1927, so that the changes wrought by the axe were intensified by the flame. Some animal species of the deep, unbroken woods like the pine marten, fisher, and cougar disappeared completely, whereas species like the coyote flourished with the extension of man into the forest. Others like the wolf and lynx were able to retreat before the timber cutter to the most inaccessible habitats possible, where a few remnant populations exist today. Some species suffered serious depletion because they were valued for fur and meat or were reviled for their depredations. The elk is an extirpated species well adapted to a variety of habitats, but is too easily hunted and is not compatible with human activity. The same is also true of the moose.

An opposite situation was created for many species associated with the earlier successional stages of vegetation development. The creation of large, unbroken openings favored the Whitetailed Deer, Ruffed Grouse, and Sharp-Tailed Grouse.

Animals that may have originally been entirely absent from the regions, like the opposum and fox squirrel, moved to fill newly established niches. In the late 1930's, a major effort was made to reforest large areas of the UP. This, together with better fire control, has led to a reversion to a more climax type vegetation and a loss of habitat for animals of the early and middle successional states. Thus, in response to a fluctuating environment, there is an ever-continuing fluctuation in animal types.

In some respects there have been changes and fluctuations in aquatic habitats that are as encompassing as those occurring on the land. The inland sport fishery of the UP has changed relatively little; fishing quality remains good, and fishing pressures are probably below that which the area could suppport. However, for Lake Superior and Lake Michigan, an opposite sitation existed until a few years ago, for the fishing quality of these large lakes declined drastically between 1940 and

1965. In 1966, the Great Lakes Fishery Commission and the Michigan DNR began a major effort at rehabilitation with the introduction of salmonid species into the Lakes.

Thirty years ago, Lakes Michigan and Superior supported a well-balanced and highly productive fish population. Commercial fishermen annually caught 15 million pounds of lake trout alone. This fishery was upset by successive invasions of the sea lamprey and the alewife. A selective lamprey poison was developed in the late 1950's. This, together with a lake trout restocking program, permitted partial reattainment of a balanced fishery in both lakes. The abundance of the alewife required more than the restoration of lake trout, so the DNR introduced young coho salmon in the Lakes' tributary waters in 1966 followed by chinook salmon a year later.

The future status of the mammals and birds of the UP, particularly economically important species like deer and grouse, depends almost entirely upon the extent man is willing to indefinitely arrest the process of secondary forest succession, or selectively direct and control its progress. Under natural succession alone, the area can expect to experience a continued loss of open or semi-open habitats with a possible return to prominence of some of the climax species of undisturbed woodland and forest. Some species like the cougar and the caribou are probably gone forever, but others may make a comeback if they are reintroduced and given protection.

There is less certainty about the sport fishery in the UP. Its continued growth and importance will depend, in part, upon the continued success of the salmon program which, in turn, will depend on overcoming other threats. Persistent pesticides are an immediate danger, and a longer-term danger is that the overenrichment of Great Lakes waters by phosphates and other nutrients will lead to accelerated eutrophication. Coho and other salmonid species may have difficulty surviving under eutrophic conditions. Finally there is the uncertainty about the contined availability of a highly abundant forage fish. It is possible that the coho, chinook, and lake trout, which have prospered since the decline of the lamprey, will succeed too well in reducing the alewife population.

2.2.18.2 Protected Species

Table VII lists twelve species of mammals currently inhabiting the study area whose population status is under scrutiny by Federal or State biologists. Six species (those identified with an asterisk in Table VII) have been afforded complete protection by the DNR. The timber wolf population in the UP is now estimated to be less than 50 individuals that are scattered throughout the more remote areas. Despite legal protection given the moose in 1899, it has continued to decline, with only 25 to 50 animals still remaining in the UP. There are less than half this number in the study area. An attempt to bolster the population by introducing 71 Isle Royale Moose in the mid-1930's was unsuccessful.

Table VII
Endangered, Threatened, or Reintroduced Species, or
Species Whose Status Has Not Yet Been Determined

Mammal Species	Status	
	USDI	MDNR
*Eastern timber wolf (*Canis lupus lycaon*)	E	E
*Canada lynx (*Lynx c. canadensis*)	SU	SU
*Marten (*Martes a. americana*)	SU	T
*Fisher (*Martes p. pennanti*)	SU	RI
*Moose (*Alces alces americana*)	—	SU
Gray fox (*Urocyon cinereoargenteus*)	—	SU
*Southern bog lemming (*Synaptomeys cooperi*)	—	T
Pigmy shrew (*Microsorex hoyi*)	—	SU
Thompson's pigmy shrew (*Microsorex thompsoni*)	—	SU
Arctic shrew (*Sorex arcticus*)	—	SU
Water shrew (*Sorex paustris*)	—	SU
Eastern pipistrelle (*Pipistrellus subflavus*)	—	SU

*Completely protected under Michigan DNR law.

Legend: E — Endangered
RI — Reintroduced
SU — Status Undertermined
T — Threatened

Three species of birds found in the study area are considered endangered by the DNR: the Peregrine Falcon, an occasional visitor; the American Osprey and the northern Bald Eagle, both of which nest in the study area.

Although Peregrine Falcons are not known to nest in the study area, they do pass through in early spring (March or April) while migrating to their known breeding grounds in northern Canada, or in the fall to their southern ranges. However, should a nest of this falcon be observed, the same regulations would apply as for Bald Eagle and Osprey nests: the DNR prohibits snowmobiles, timber harvest, construction, and other human activities which could disturb the nesting raptors, from approaching within one mile to one-half mile of the nest. This exclusion is enforced only during the nesting period that runs from January to August.

The Osprey is migratory. A few individuals begin arriving at nesting sites in mid-March. Eagles may nest as early as 1 March. Although not considered by local authorities to be migratory, the Bald Eagle is generally absent from the nest sites from mid-December until March. The Wildlife Data Map (Map 17) shows known nest sites in the fall and spring of 1972 and 1973. Not all are currently occupied. If a nest is not destroyed beyond repair during the winter, there is a high probability that the same pair will occupy it again the succeeding spring.

The Greater Sandhill Crane is an extremely sensitive bird and will abandon its nest if there is human activity in a nearby area. There are an estimated 500 to 600 birds on the UP, and only recently have they started to expand their nesting range into the eastern edge of the study area.

Seven other bird species are designated threatened by the DNR and are listed in Table VIII. None of these birds species is currently listed by the USDI.

There are no endangered reptile species in the study area.

The USDI has classified one fish specie within the study area as rare — the Lake Sturgeon. Its population has been reduced indirectly by commercial fishing; and dams that have blocked its run up rivers to spawning areas, plus predation by the lamprey, have kept the population depressed. In the study area there is a resident population above the first dam in the Menominee River. Some sturgeon also run up the Sturgeon River from Lake Superior to just below Pricket Dam.

Table VIII
Endangered Birds in the Study Area

Species	Status	
	USDI	MDNR
Peregrin falcon (*Falco peregrinus*)	E	E(OV)
Double-crested cormorant (*Phalacrocorax auritus*)	—	T
Cooper's hawk (*Accipiter cooperii*)	—	T
Red-shouldered hawk (*Buteo lineatus*)	—	T
Marsh hawk (*Circus cyaneus*)	—	T
Osprey (*Pandion haliaetus*)	—	T
Bald eagle (*Haliaeetus leucocephalus*)	E	T
Piping plover (*Charadrius melodus*)	—	T(OV)
Loggerhead shrike (*Lanius ludovicianus*)	—	T
Barn owl (*Tyto alba*)	—	T

Legend: E — Endangered
T — Threatened
OV — Occasional Visitor

2.2.18.3 Game Species

The Whitetailed Deer is the most important game specie in the UP in terms of dollar investment by the sportsman and dollar income to the local resident. But in recent years populations have been declining significantly. Large winter die-offs are becoming common, oasically because the abundant natural browse resulting from heavy logging 40 or 50 years ago has grown out of the deers' reach, while understory vegetation has become much more sparse as the second-growth forest matures.

Deer compound their own problem, particularly during the critical winter months, by congregating in yards. The location of some yards will shift over time; but unless there are significant changes in the type of land use in or near a yard, they will continue to be utilized by deer for many years. The Wildlife Data Map shows all the known deer yards. Ordinarily deer will begin to move into the yards between mid-November and mid-December, and are completely yarded by 1 January. Spring breakup normally occurs in early April. In summer, the deer range as far as 20 to 25 miles from the winter yards.

In 1970, the DNR was given the authority by the Natural Resources Commission to manage all of the State Forest land in order to produce not only timber but wildlife. One of the first concerns of the DNR has been to bring as many yards as possible under intensive management. Their program calls for rehabilitating those yards presently supporting sizeable populations of deer before attempting to restore vacant ranges. To do this, they are (1) cutting noncommercial timber to open up stands for increased understory growth, (2) contracting for winter logging so that slash become available to the deer, and (3) purchasing private land adjacent to deer yards in hope of reducing deer population densities within the yard.

The Black Bear provides the only other big-game hunting in the UP. In terms of the number of hunters who go after bear, it has become an increasingly important specie over the last ten years, with the average annual kill ranging between 550 to 850 animals. Small-game mammal hunting is provided by the Red Squirrel, Gray Squirrel, Snowshoe Hare, and the Eastern Cottontail.

A number of grouse species are found in the UP, of which the most popular and widely hunted upland game bird is the Ruffed Grouse. To increase the game-bird population, the Black Grouse, a specie native to northern Europe and central Asia, was introduced in Dickinson County in 1974. The Sharp-Tailed Grouse, native to Wisconsin, reached a population and distribution peak in the 1930's, but by the mid-1950's was declining as reforested areas became too dense for a suitable habitat. The hunting of one specie, the Spruce Grouse, often associated with Jack Pine bog areas has been discontinued because of its considerably reduced numbers.

The Woodcock and Jacksnipe both flourish on the UP, but only the Woodcock is popular with hunters. Since Federal regulations were revised in 1968, permitting a

lengthening of the Woodcock season so it would coincide with the Ruffed Grouse season, hunter kill has increased each year. In 1972 it was nearly three time what it was in 1968 with no apparent ill effects on the population as a whole. The Rail, Coot, and Common Gallinule provide limited hunting, but they rank low on the list of important game species.

None of the remaining resident game birds provide significant hunting in the study area, and of the turkey and pheasant, both introductions to Menominee County, only the pheasant is in sufficient numbers to permit limited hunting.

According to the USFS and the DNR, the annual waterfowl kill is considerably below the potential for the area; and both organizations have, therefore, started a program of waterfowl development projects designed to entice more birds and more hunters into the region.

The UP lies within the area where the western edge of the Atlantic flyway (migratory route) overlaps the Mississippi flyway. Two western corridors of the Atlantic flyway cross the UP from northwest to southeast. This is a general route taken by diving ducks such as the Canvasbacks, Redheads, and Scaups that come from the great interior breeding grounds of Canada. The Mississippi flyway provides most of the other waterfowl that cross the UP. Most of the dabbling ducks use it regularly, and even the Brant and the European Widgeon find their ways into the study area occasionally. This flyway also accommodates three separate populations of Canada Geese whose concentrations are heavy. An estimated 25,000 to 75,000 birds use the western corridor, and another 75,000 to 100,000 make use of the eastern corridor.

In addition to the migratory individuals coming from breeding grounds far to the north, 12 to 15 species of waterfowl are known to nest locally.

2.2.18.4 Other Considerations

Wildlife species which could conceivably attack the underground cable are very few, but an accidental encounter by an individual of a specie with the cable is possible. Such an encounter by a woodchuck (which usually digs its den only four to five feet deep) could occur. Other animals which enlarge and utilize woodchuck dens and, therefore, could also encounter the cable include coyote, fox, skunk, and Black Bear. The limited research in this field has shown that gnawing mammals, such as gophers, will not avoid cable, but will, in fact, chew on it. Inquiries to Michigan Bell Telephone Comapny revealed no additional problem animals.

2.2.19 Air Quality and Noise Data

Data on the quality of the air and on the generation of man-made noise for the study area is limited. Of the six parameters used to describe air quality, those monitored within the study area are well below required levels, and there has never been a

recorded ambient violation. All air pollution control is derived from Federal legislation termed the "Clean Air Act." All regulation and enforcement of air quality controls is under the authority of the DNR. There are a number of point sources of air pollution in the study area, predominantly paper mills, industrial boilers, mines, and ore processing plants. In general, point sources are located near the more populated areas.

There are two types of noise pollution, on-site and ambient noise. On-site noise is legally controlled by the Federal Occupational Health and Safety Act (OSHA) and administered by the Michigan Department of Public Health. The enactment of policies to control ambient noise, by authority of the Federal Noise Control Act of 1972, is the responsibility of the Environmental Protection Agency, but primary responsibility for the enforcement of noise controls rests with State and local governments. Ambient noise pollution is not considered a serious problem in the study area. There are no monitoring stations or mobile units checking noise quality.

The major areas of the Noise Control Act that apply to major construction projects include nonoccupational noise, interstate truck traffic noise, and air compressor noise. There are no noise restrictions or regulations regarding vehicles moving on highways and roads in the State.

2.2.20 Right-of-Way Opportunities and Avoidance Features (Refer to Maps 18 and 19.)
This section discusses right-of-way (ROW) opportunities and avoidance features that have been found to occur within the study area. ROW opportunties are defined as all existing rights-of-way that have potential for use as a SEAFARER antenna routing, such as roads, trails, transmission lines, telephone lines and abandoned railroads. Avoidance features are those areas—such as incorporated settlements, lakes, and unique natural areas—that have been excluded from consideration for antenna siting.

In terms of SEAFARER system siting, ROW opportunities and avoidance features represent the two extremes of the spectrum with all other data factors falling somewhere between. Further definition of constraint levels by data category will be the subject of a follow-on phase of work.

ROW opportunities have been identified to minimize both engineering and environmental costs in siting; avoidance features have been identified to minimize social, environmental and mitigation costs.

ROW opportunities are shown on Map 18. The information has been extracted directly from the Transportation Data Map (Map 5) and the Utilities Data Map (Map 6). Table IX lists each type of feature located on the map.

Avoidance features are shown on Map 19. It depicts those features designated by the Navy in specifications and guidelines to represent the highest level of

Table IX
Rights-of-Way Opportunities

Data Category	Data Factor	Minimizes
Transportation	Highways	Construction cost
	Paved roads	Operation & Maintenance cost
	Gravel roads & trails	Biological cost
	Abandoned railroads	Social cost
Utilities, Electrical	Transmission lines	Construction cost
	Distribution lines	Operation & maintenance cost
	Underground cables	Biological cost
		Social cost
Utilities, Telephone	Underground cables	Construction cost
	Aerial cables	Operation & maintenance cost
	Open wires	Biological cost
		Social cost

constraint. They are, therefore, excluded entirely from consideration for SEAFARER system siting. Table X lists the features shown on the map. A number of the avoidance features, such as cemeteries, quarries, nesting sites, and historic sites, have been shown on the map as point data since the scale of mapping does not permit individual site configurations. Many other environmental characteristics represent constraints to system siting (such as dense vegetation, steep topography, exposed bedrock, etc.), but none has been classified as absolute avoidance. Each data category will be assessed in terms of the level of constraint it represents and will then be used in the siting analysis as part of a subsequent phase of work.

2.2.21 Antenna Construction Factors and Installation Plan

This study was performed by subcontractor Henkels & McCoy, Inc. (H&M), and the details of their work are reported in a separate volume (Part 3) bearing this same title.

To form a baseline for the cost modeling studies, GTE Syvlania provided H&M with typical antenna layouts of 1350 linear miles, taken from an early system engineering report. It must be understood that this layout was for baseline study only and does not represent the final antenna configuration. That determination is to be made later in consideration of all the data acquired during the survey and other factors as well. Unit costs derived during the H&M study will be employed to estimate the installation cost of the antenna configuration finally selected.

TABLE X

AVOIDANCE FEATURES

DATA CATEGORY	DATA FACTOR	REASONS FOR AVOIDING
Land Use	Corporate boundaries Urban and rural settlements (U-1, U-2, U-3, R-1, R-2)	Mitigation cost Operation and maintenance cost Social cost
	Planned developments	Mitigation cost Operation and maintenance cost Social cost
	Special Preserve Areas Sturgeon Gorge Keweenaw Bay Swamp Pequaming Swamp Huron Bay Swamp Light Foot Bay Swamp Point Abbaye Peninsula Sturgeon Sloughs	Biological cost Social cost
	Cemetaries	Social cost
	Prison facilities	Social cost
Transportation	Railroads (operational)	Mitigation cost
	Airports	Mitigation cost Social cost
	Harbors	Social cost
Utilities	Pipelines	Mitigation cost

TABLE X (Cont.)

DATA CATEGORY	DATA FACTOR	REASONS FOR AVOIDING
Mineral Extraction	Mines (active and inactive)	Construction cost Mitigation cost Social cost
	Quarries and pits (active and inactive)	Construction cost Social cost
Surface Water	Lakes and reservoirs	Construction cost Social cost
Cultural and Recreational	McCormick Experimental Forest	Biological cost Social cost
	Park sites with campgrounds	Social cost
	Small parks and picnic areas	Social cost
	Recorded view points	Social cost
	Ski areas	Social cost
	Historic sites	Social cost
	Archaeological sites	Social cost
Wildlife	Nesting sites	Biological cost Social cost
	Wildlife flooding areas	Biological cost Social cost

The cable will be placed in the ground by employing conventional techniques. The probable burial depth will be 6 feet in soil and 2½ feet in bedrock. The basic and least cost method involves the vibratory plow and will be employed wherever conditions permit. All areas where cable is to be emplaced by plowing will require pre-ripping. The power to pull the plow at 6-foot depth through rocky soil and tree roots is excessive without pre-ripping. Wherever bedrock outcroppings cannot be avoided, drilling and blasting will be necessary. Machine and hand trenching will be required at points where underground utility lines (power, telephone, pipelines, etc.) must be crossed. To pass the cable under railroads and major highways, horizontal boring will be employed and conduit installed. Where highway regulations permit, roads will be crossed by plowing or trenching followed by approved restoration of the surface.

Due to the nature of the terrain in the UP, there exist numerous wet, swampy areas that vary in size from small streams to bogs a few miles in width and length. While these areas will be avoided as much as possible in the antenna routing, some crossings, nevertheless, may be required.

The first of these conditions is stream crossings. Most streams can be crossed by plowing. This method is preferred by the Michigan DNR as it minimizes any disturbance to the natural condition of the stream and its banks. The second method, used for deeper waterways, requires the use of a trailer plow. This machine can be winched across the stream by a machine on the bank and the cable plowed into the stream bed. The trailer plow can operate in deeper water than the conventional plow and still place the cable at the required depth. There may be some water crossings too deep for any of the methods described here. In this event, a trench will be dug across the bottom of the area using a drag bucket or clam shell. Another method of crossing streams or other obstacles when highway or railroad bridges are present is to install conduit on the bridge structures and pull the cable through the conduit.

The bogs constitute a major portion of the wet areas, and three different methods will be used to install cable in them. The first method is to plow the cable in the same manner as in dry areas. Although slower progress will be made in the bogs, some of them have bottoms hard enough to support construction equipment. Only one or two feet of water covers much of these sections. Second, where the bottom is not so shallow or firm, a corduroy road will be built using the logs left from the ROW clearing. Equipment will then be run on this road which will be removed when construction is complete. Third, some areas are expected to be nearly inaccessible except in the late winter when the bogs are frozen. A small amount of cable will, necessarily, have to be installed during winter. A trench approximately six inches wide will be cut with a rock saw through the ice and frozen earth and a trailer plow used to place the cable at its proper depth. No technical data presently exists on the load-bearing and other properties of the UP bogs under winter conditions. If that

type of information becomes available later, some modification or refinement of this installation plan may be required.

Because of the delicate nature of the environment in the bogs, as well as the difficulties of working in them, extra planning will be required to minimize the amount of equipment, number of trips through, and overall disruption of the area. ROW width will be kept to 15 feet wherever possible. Special care will be taken to eliminate the disposal of any construction material or the spillage of fuel. Restoration will be made where possible. All wet areas are to be entered, worked in, and restored in accordance with the rules and regulations of the Inland Lakes and Streams Act of 1972, Act 346. Permits are required by that Act for construction on bottomland.

The antenna will be installed along existing roads or trails, or in cross-country rights-of-way (either existing in the form of present utilities routes, or new). Within each of these basic categories a variety of conditions will be encountered. The most difficult of these conditions and the most expensive in terms of antenna construction are bogs or swamps and the areas where bedrock lies less than 6 feet below the surface.

A nominal ROW width of 25 feet is considered adequate for most of the work areas. However, wider areas of 50 feet, spaced approximately every 1000 feet, may be required for equipment movement and parking, while in many areas a narrower ROW of perhaps 15 feet may be sufficient. Such a latter case would be short sections between roads where it is not necessary to run equipment long distances up and down the ROW. Cable installation along roads are to be made as close as possible to the edge of the road ROW. When it is necessary to place cable close to the road pavement, rubber-wheeled equipment will be used to minimize damage to the road surface.

Table XI summarizes the extent of each type of emplacement environment associated with the typical baseline antenna.

It is estimated that about ¾ of the total manpower for antenna construction can be obtained from the northern Michigan/UP regions. The types of manpower and numbers required for the installation of the 1350-mile baseline antenna are listed in Table XII. Some classifications of manpower from the contractor's own staff will be utilized regardless of local availabilty. If the construction contractor (to be selected by competitive bidding) turns out to be headquartered in the UP, then nearly 100 percent of the construction manpower will be local.

The types of equipment required are listed in Table XIII, along with the anticipated quantities and avilability of this equipment in the study area. The totals include back-up equipment.

Table XI
Anticipated Baseline Antenna Construction Environments*

Category/Type	Length (Miles)
Existing Roads	
a. PLOW — away from pavement	705
b. PLOW — alongside pavement	87
c. DRILL/BLAST — bedrock	28
d. TRENCH	20
Cross Country	
a. PLOW — dry areas	418
b. PLOW/SAW — bogs/streams	60
c. DRILL/BLAST — bedrock	27
d. TRENCH	5
Total	**1350**

*1350 miles of antenna were selected as a baseline system considering possible conductivity values. The final system may vary from this length after taking all design factors into account.

Table XII
Labor Requirements for Baseline Antenna System

Classification	Total Required	Local Hire
Administration & Supervision	28	16
Foreman	90	45
Operator	165	70
Journeyman	37	30
Tree Trimmer	50	50
Driver	78	78
Laborer	190	190
Blaster	9	9
Driller	42	42
Mechanic	10	4
Mechanic Helper	6	6
Welder	5	3
Welder Helper	2	2
Watchman	30	30
Surveyor	18	10
Surveyor Assistant	27	20
Engineer	2	—
Assistant Engineer	2	—
Draftsman	2	2
Total	**793**	**607**

Table XIII

Construction Equipment Requirements for Baseline Antenna System

Equipment	Total Required	Locally Available
D-9 with Blade & Plow	35	2
D-7 with Blade & Winch	16	4
D-6 with Blade & Winch	25	4
Austin-Western 501 Super-Grader with Plow	8	3
Caterpillar 980 Front-End Loader	7	4
Case 580 Backhoe	29	8
Lubrication Truck	8	2
Fuel Truck	8	2
Welding Truck	4	4
Tow Truck	2	2
Air Compressor 600 CFM	45	8
Air Compressor 105 CFM	15	15
Pick-Up Truck ¾ Ton — 4-Wheel Drive	25	15
Stake Truck 4 Ton	14	5
Stake Truck 1-½ Ton — 4-Wheel Drive	27	5
Concrete Saw	5	3
Crew Cab Truck — 4-Wheel Drive	102	20
Wagon Drill	45	5
Low Boy with Tractor	35	15
Cable Trailer	2	2
Diesel 18 Yd. Terex Dump	18	10
Fork Lift 2000#	2	2
Automobile	8	—
Conduit Pushing Equipment	4	4
Crane Pettibone Model 30, 18 Ton	1	1
Tag-A-Long Trailer	8	8
Light Dump	4	4
Pumps Diesel 4"	11	5
Chipper V-8	24	10
Case 850 Excavator	11	5
Farm Tractor	9	9
Chain Saw	118	50
Rock Saw Trencher	3	1
Trailer	18	10
Tractor & Trailor	2	2
Trailer Plow	4	—
Total	**702**	**249**

2.2.22 Power Distribution Network

As part of the Michigan Site Survey program, subcontractor Williams & Works of Grand Rapids performed a comprehensive inventory of the electrical power generation and distribution systems in the study area. The details of that study are contained in a separate volume (Part 4) of this overall report. The essential data are also incorporated in the Utilities Data book of the EDAW section of this report.

Six power companies and cooperatives that provide electrical service to the study area were studied in detail. In addition, there are several small city and town light and public works departments that were not studied, since they do not provide service outside their urban areas, and such areas were excluded from the present survey. Of the six major companies, two—Upper Peninsula Power Company (UPP) and Wisconsin—Michigan Power Company (WM)—generate and distribute 90 percent of the 541 MW of power consumed in the study area. All locally-generated power originates in either hydroelectric or fossil fuel plants; there are no nuclear plants in the study area.

The Marquette Board of Light and Power presently has a generating capacity of 57.2 MW and supplies adjacent communities and industries. It also buys power from UPP, and has plans to construct a new 43 MW coal-fired generating plant by 1980.

The Crystal Falls Electric and Water Department extends service to a large rural area west of the city. Their one hydroelectric generating plant is rated at .85 MW and is inadequate for present demands, so the shortage is made up by purchase of power from WM.

The remaining two companies studied (Alger-Delta Cooperative Electrical Association and Ontonagon County Rural Electrification Association) are cooperatives that distribute power purchased from the two major companies.

Figure 9 illustrates the service areas for each company. The study area in this instance is larger than for the other site survey categories, inasmuch as an extra 10 miles on the east and west sides were included to provide data for the mitigation studies being conducted for the Navy under another contract.

The six companies operate almost 5400 route miles of lines, not including short lines and drops less than 300 feet, or distribution lines within urban areas. Transmission (high-power) lines for the two larger companies are on 100 - 110 foot rights-of-way. In the case of UPP, about 10 percent of these are company-owned. The balance are on easements. Nearly all distribution lines (13.8 kV and lower) are on public rights-of-way, with some shared use with telephone and cable-television lines. Marquette Light and Power transmission lines are generally on public road ROW's, with some distribution lines in 20-foot easements on private property.

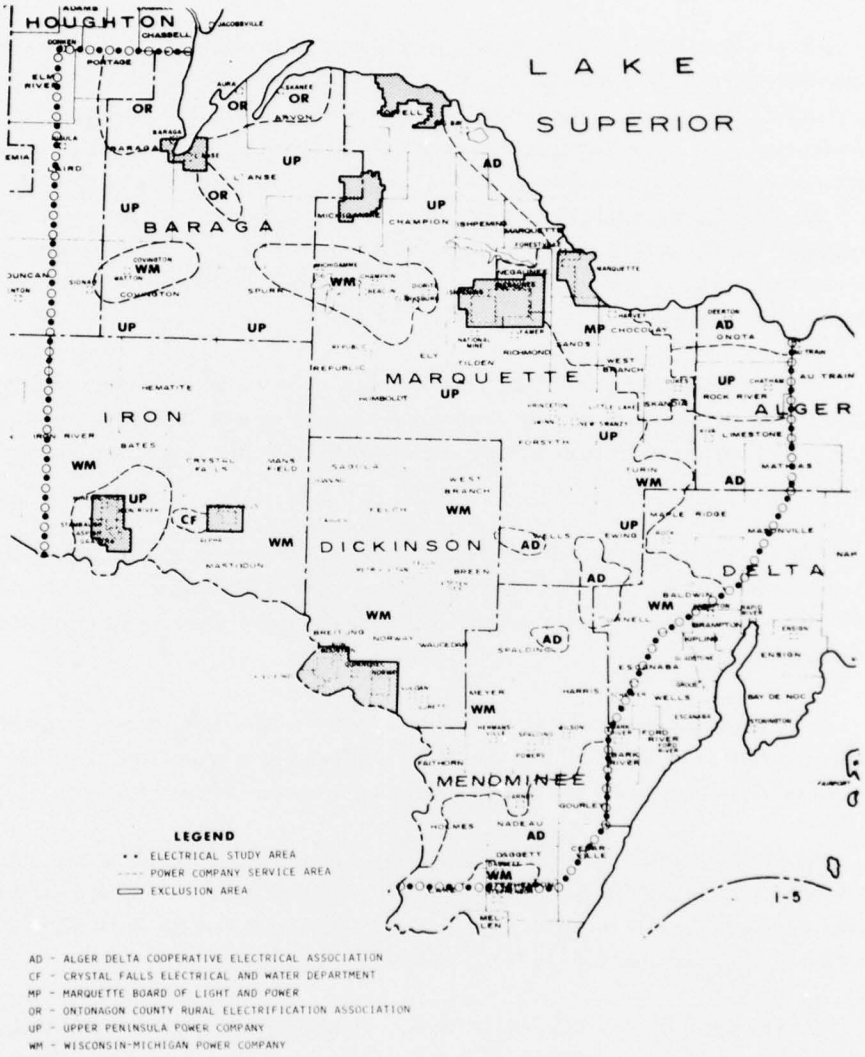


Figure 9 – UP Electrical Power Service Areas

Lines for the two cooperatives are located along roads only one foot off the ROW in easements on private property.

2.2.23 Earth Conductivity

Before this survey, the best available conductivity information on the study area was inferred from geology maps and measurements at less than 30 locations. For this reason, and because of the close relationship between earth conductivity and antenna size (and therefore cost), the site survey included a task for a comprehensive conductivity measurement program similar to that undertaken at the Western candidate sites.

As in the Western regions, the method of measurement was the Audio Magnetotelluric (AMT) technique. In fact, the same instrumentation and personnel were employed to ensure uniformity between the two sets of data, and calibration measurements were again taken at the Wisconsin Test Facility where a large body of data by several measurement methods has been accumulated over the past several years. The AMT method measures the ratio of horizontal electric field at the earth's surface to the orthogonal magnetic field to yield earth resistivities as a function of frequency. The instrumentation consists of a horizontal dipole E-field sensor, a coil H-field sensor, a prewhitening filter box, and a variable frequency analyzer receiver. The receiver integrates the E- and H-field signals and forms the ratio, from which subsurface conductivity is inferred. The signal source is terrestrial spherics (distant lightning discharges). At each measurement location, two 200-foot wire antennas are laid out perpendicular to one another, the termination being a stake inserted no more than 12 inches below the surface. Then orthogonal pairs of measurements are made at each of ten predetermined frequencies over a range of three decades.

In order to select measurement locations, the study area was sectioned into a grid configuration where points were roughly established along lines of latitude spaced approximately six miles apart. Site locations were then evaluated, based on a review of the existing conductivity data base, geology, ownership, and accessibility. Sites located on private property and near population centers were eliminated. Selection criteria were based on access and ownership data, with State-owned property given highest priority. Figure 10 shows the 106 measurement locations, and Figure 11 illustrates the geologic substructure.

In Wisconsin, AMT conductivity measurements were taken at 20 sites along the WTF E/W antenna. Long-wire AMT measurements were also made, utilizing the WTF overhead antenna as the E-field sensor.

The rocks of the central UP region generally exhibit low conductivity, reflecting the presence of massive Precambrian gneisses. To the east, the conductivity increases somewhat, indicating the presence of conductive Cambrian and Ordovician sediments. These patterns are illustrated by the 95 Hz contour map shown in

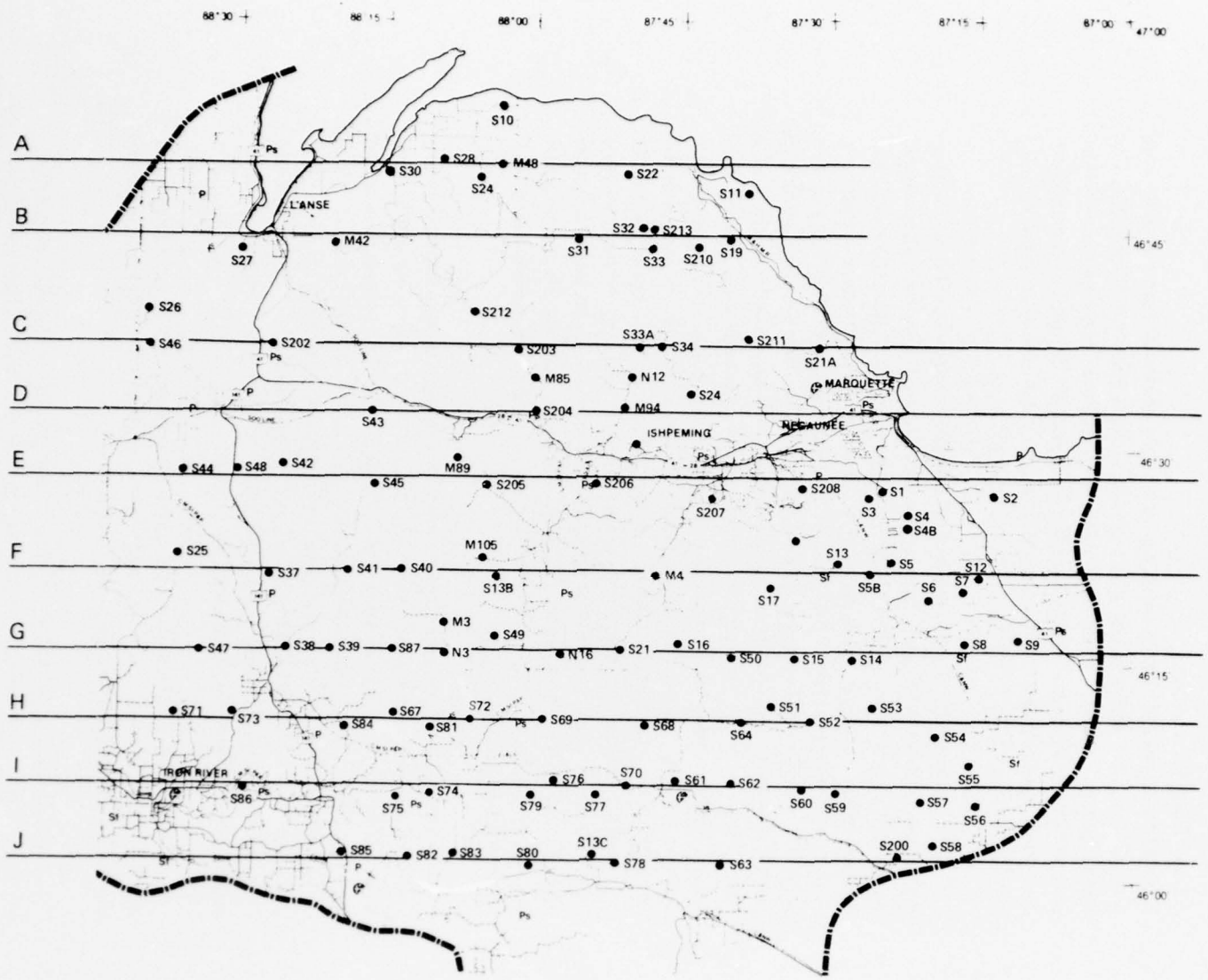


Figure 10 – AMT Measurement Locations

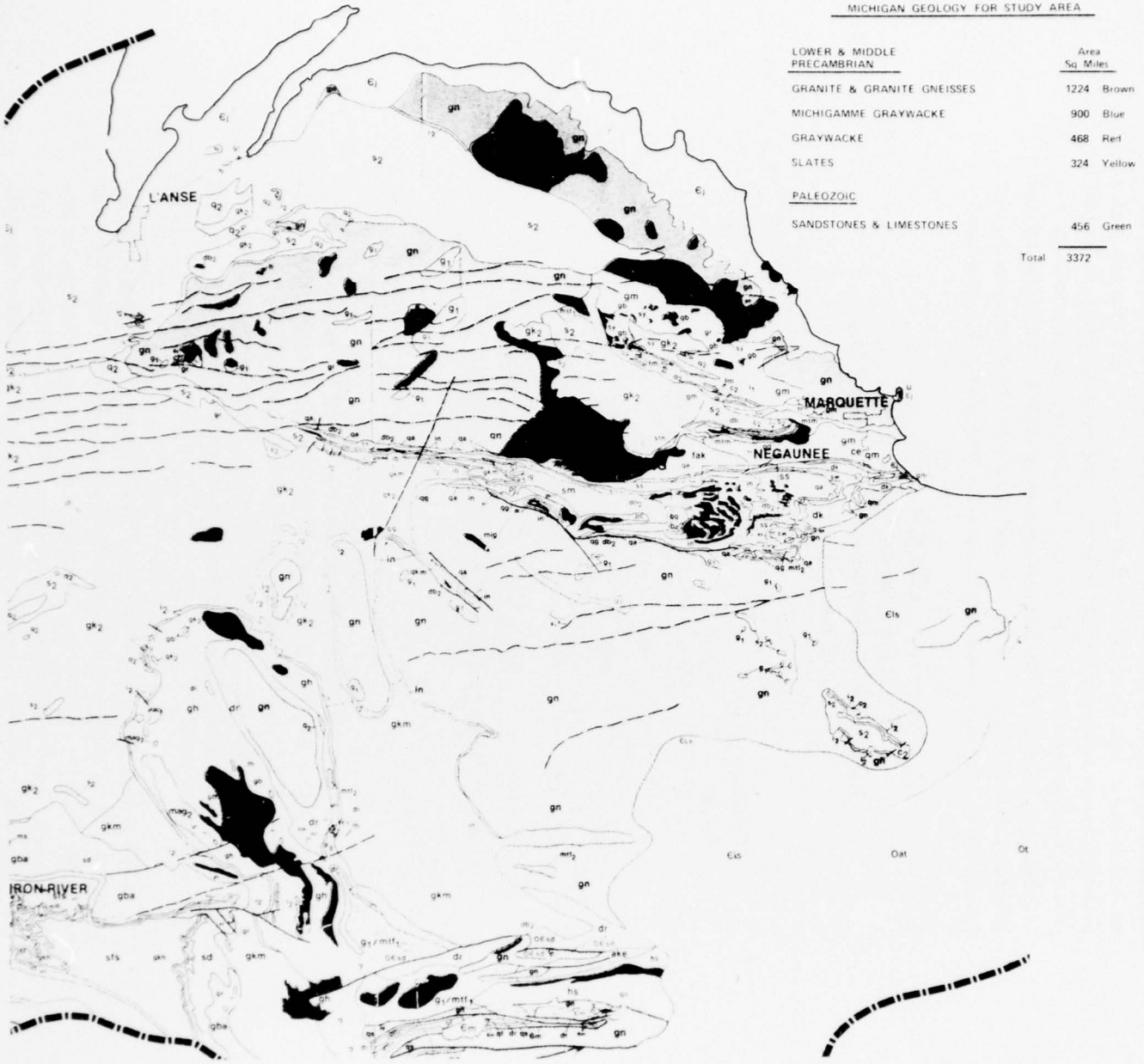


Figure 11 – Geologic Substructure

Figure 12. It is based on averaged, smoothed data for the 106 stations. Table XIV summarizes the results with an area-weighted average conductivity value of 5.06×10^{-4} mhos/meter. This figure is more than twice as high as had been anticipated before the survey was conducted, the difference lying not in the actual conductivity of the rock types, but with the areal extent of the lowest conductivity types. By way of comparison, the equivalent conductivity values for the WTF and the Nevada and New Mexico candidate sites are 2.6×10^{-4} mhos/meter (E/W leg values measured in January 1976), 149×10^{-4} mhos/meter, and 417×10^{-4} mhos/meter, respectively.

Table XIV
Michigan Conductivity Summary
Based on University of Toronto Log ρ Contour Map
(Frequency – 95 Hz)

Contour Ranges $\sigma \times 10^{-4}$	Square Miles	$\overline{\rho}$ Ohm-Meters	$\overline{\sigma}$ MHOS/Meters $\times 10^{-4}$
$\sigma \leq 2.1$	599	10,129	0.987
2.1 – 10	1,479	2,197	4.550
10 – 100	920	435	23.000
$\sigma \leq 100$	431	70	143.000
Area Weighted Average – 5.06×10^{-4} MHOS/Meter			

2.2.24 K.I. Sawyer AFB Support Potential and Operational Interfaces

K.I.Sawyer AFB is an active U. S. Air Force Strategic Air Command (SAC) base located about 20 miles south of Marquette. From the base, the Air Force operates B-52H heavy bombers, KC-135 tankers, F-106 fighter interceptors, and the necessary supporting activities (communications, weather, security, rescue, etc.) for these operational units.

SAFB is of particular interest to SEAFARER, since it offers the potential for collocation on an existing DoD facility. Such co-use, if proven feasible, would reduce SEAFARER's need for new land, and, at the same time, permit operational economies through the shared use of Air Force supporting activities and facilities. For these reasons the site survey included a task to obtain information about the base pertinent to SEAFARER. The results of that effort are contained in a separate volume (Part 6) of this report. Certain information from that volume is also incorporated in both EDAW and W&W material (Parts 2 and 4).

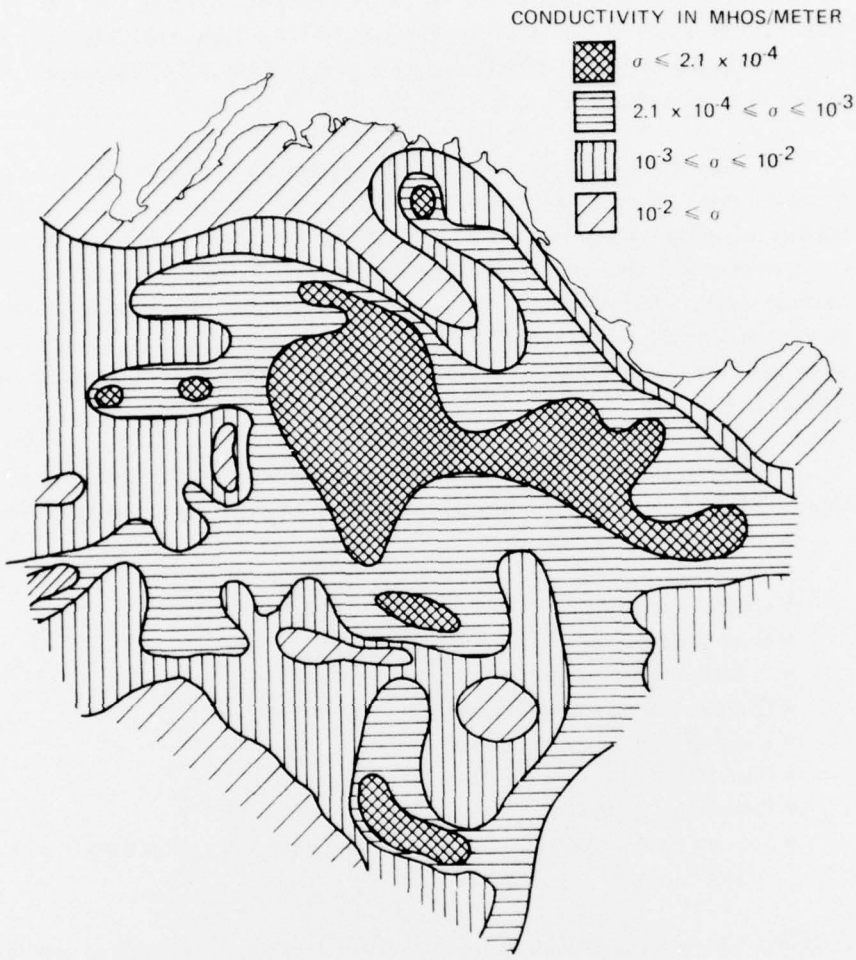


Figure 12 – Conductivity Contours–95 Hz

As noted earlier in this volume (section 2.2.4), SAFB occupies 5,200 acres in Marquette County devoted to eight land-use categories: airfields, cantonment and operations, housing, munitions storage and handling, recreation, sanitary fill, schools, and clearance easements. The dominant features are the 12,300 foot N/S runway, hangers, shops, and operational buildings. There are a total of 890 buildings and 41 miles of paved roads on the base. The total base population, including military dependents and civilian employees, is approximately 10,000 and increasing due to closings of other bases and transfering of their activities and personnel to SAFB.

SAC's 410th Bombardment Wing is the landlord organization. The Wing Commander reports to the 40th Air Division at Wurtsmith AFB, Michigan and thence to the 8th Air Force at Barksdale AFB, Louisiana, and SAC Headquarters at Offutt AFB, Nebraska.

The base civil engineering department maintains drawings of the base and facilities. Prints of about 40 of these that appeared to be directly related to SEAFARER planning were provided by the Chief Engineer and have been employed in the system engineering design effort. On the basis of that information, a tentative location for the SEAFARER transmitter and control building has been selected and coordinated with base personnel. Buried hot water, cold water, and sewage disposal lines service the site, and prime power can readily be run from the base substation.

Of the present base services, it was determined that the following could support SEAFARER either as they now exist or through modification/expanison:

- Electrical power system
- Telephone system
- On-base security
- Base supply
- Vehicle maintenance
- Grounds, building, and equipment maintenance
- Local contract administration
- Commissary
- Disbursing (limited)
- Medical (service personnel and dependents; no civil service employees nor contractors.)

The Navy will need, of course, to provide its own command, operational, administrative, and system service personnel.

Because of the recent influx of new Air Force personnel, waiting lists exist for all on-base housing, and none will be available for SEAFARER personnel unless built or funded by the Navy. There are a number of utilities-equipped sites for private mobile homes, and these can be increased for Navy use.

No direct conflicts between SAFB and SEAFARER operations were found. Two areas that require further study to ensure compatibility are as follows:

- Command communications priorities if shared facilities are employed:
- Possible sensitivity of a few present electronic navigational aids to ELF signals.

The survey team found all personnel to be extremely helpful in providing information and suggesting means for accommodating SEAFARER.