PHYSIOGRAPHIC PATTERNS IN MENOMINEE COUNTY, MICHIGAN

Thesis for the Degree of M. A.
MICHIGAN STATE UNIVERSITY

Wayne T. Strand

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ABSTRACT

Wayne T. Strand

The surface configuration of Michigan can be attributed almost in its entirety to Pleistocene glaciation and subsequent fluvial activity. A great number and variety of landforms and landform patterns are the results of glacial and fluvioglacial deposition and erosion. In order to appreciate the significance of the various landforming processes, the aspects of the individual form as well as the general areal physiography must be examined.

The traditional method of landform classification in which individual relief features are categorized according to their origin fails many times to adequately describe the complexity of the surface configuration. Similarly, the division of an area into physiographic regions entirely on a genetic basis does not allow for terrain variations within a region. Too large a degree of generalization may lead one to overlook smaller landform units which are giving a unique character to particular portions of a large area.

This study is an attempt to describe the complexity of the physiography of Menominee County, Michigan, and to show the relationships that exist between individual landform components. The nature of the terrain allows delineation of the County into both morphographic and morphogenetic regions which, in most cases, have similar boundaries. Certain glacial, fluvioglacial, and lacustrine processes have formed distinct landform patterns.

The elements which create regional variations in the surface configuration are slope, local relief, drainage patterns, and material composition. By analyzing the areal distribution of variations in each element, the extent of the different forms of morphogenesis can be recognized.

The component characteristics of each region can be seen only through large scale mapping. Type sites (small areas within each landform type which represent the terrain of each region) are used to show the topographic details of each homogeneous landform unit.

There are many morphogenetic problems which exist in the County. The evolution of many landforms is not yet understood (e.g. eskers, drumlins) and the post-glacial history of the region has not been determined. Three of these problems are discussed in the last chapter of the thesis so that some light might be shed on both the evolution of individual landforms and the post-glacial erosion of the region.

PHYSIOGRAPHIC PATTERNS IN MENOMINEE COUNTY, MICHIGAN

by

Wayne T. Strand

A THESIS

Submitted to Michigan State University in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Department of Geography

1963

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I am deeply indebted to Dr. Dieter Brunnschweiler, chairman of my thesis committee, for his guidance and help in the writing of this thesis. Dr. Brunnschweiler's enthusiasm in geomorphology motivated me to work with continuous interest on the physiography of Menominee County.

I am also indebted to Mr. Robert Frost, Chief of the Photo Interpretation Division, USA CRREL, who suggested that I attend graduate school. I would also like to thank my wife, who made graduate school financially possible.

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CHAPTER I

INTRODUCTION

In spite of the wide variety of interesting features, the physiography of Michigan is a neglected field of study. The previous geomorphic investigations are primarily of the Southern Peninsula and concerned with the genetic aspects of the surface configuration. Consequently, little is known of the physiography of the Northern Peninsula.

Personal observation of the many landform types in Menominee County led to the selection of this area for my thesis. Although there have been some previous geomorphic studies of the County, they were primarily designed to analyze the characteristics of certain types of glacially formed features. The large-scale physiographic aspects of the County have not been described.

Statement of Problem - This study is an attempt to delineate landform regions on the basis of descriptive (morphographic) and quantitative (morphometric) methods. The main objective is the typification of homogeneous landform units within the County by means of detailed descriptions of small areas. The areas or type sites selected for the detailed analysis were those that best express the characteristics of the regions.

In order to delineate homogeneous landform units, the major physical characteristics of the topography must be examined. These components (form, material, structure, and drainage) vary greatly in different areas and form distinct patterns in the surface configuration. There is a close relationship between the boundary locations of the aforementioned characteristics which allows an accurate delineation of the terrain into landform

types. These boundaries coincide closely with those which have been established for the different morphogenetic regions (Martin, 1957).

Landform types are usually classified according to mode of origin (e.g. fluviatile, glacial, solutional). The division of Menominee County into landform types is in essence such a classification. However, within each homogeneous terrain unit there are a number of smaller features which have a different origin than that of the predominant landform type. This study is therefore designed to show, through the description of regional type sites, the complex of features which may be found in a landform region.

Techniques - The morphographic and morphometric information used in this study was derived primarily from four sources. The quantitative data of the surface configuration were derived from examination of the topographic quadrangles of the County (Plate XXII). The large scale of the quandrangles (1:24,000) allowed a detailed investigation. Accuracy of the maps is very high because of the photogrammetric method used in the compilation of the data and the recent date of publication (1962).

The landform patterns are most conspicuous on the aerial photo mosaics. Individual aerial photographs which best expressed the character of the landform regions were selected to be used as examples for the type site studies.

The soil map, although highly generalized, was used for investigating the areal distribution of soil types. The composition of parent material in the different regions could be interpreted from the soil types. The drainage and swamp patterns were also derived from the soil map.

Field investigations were carried out in the summer of 1962. The purpose of the field work was to examine details of the surface configuration that could not be seen on the aerial photos or topographic

quadrangles. Individual features that could not be recognized by any other method were checked by field studies. Traverses of the County were made to study glacial drift color and composition. Ground and aerial photographs were taken to illustrate the structure and form of individual landform features.

Previous Studies - The most important geomorphic studies of the south-central part of the Northern Peninsula are by Israel C. Russell (1907) and Walter A. Ver Wiebe (1926). Russell described the surface geology of parts of Menominee, Dickinson, and Iron Counties. A major part of his text is devoted to the discussion of glacial landforms. The form and structure of the various glacially formed features are described and conclusions concerning the mode of formation are made. Russell also describes the color and texture of the drift in the different landforms. He was the first to record the presence of red till in Menominee County.

Ver Wiebe studied individual landform features in Menominee County. He was concerned primarily with the structure and genesis of the various landforms and cited examples in his discussion. Dimensions of individual structures were included as well as the distribution and number of the various features. Ver Wiebe located his examples by the township and range method, thus enabling possible further field checks.

Other studies of limited scope have been done in the south-central part of the Northern Peninsula. Goldthwait (1907) made reference to the location and elevation of the major abandoned beach ridge systems in the southern part of the County. Leverett and Taylor (1915) briefly described the lacustrine landforms and major lake fluctuations in the Northern Peninsula. The Department of Agriculture (1925) published a soil map with an accompanying text of Menominee County. Leverett (1929) described

the location and genesis of lacustrine formations of the Northern Peninsula. Martin (1957) mapped the distribution of landform types in the state. However, none of these studies integrate all of the elements forming the surface configuration and therefore do not fully describe the physiography.

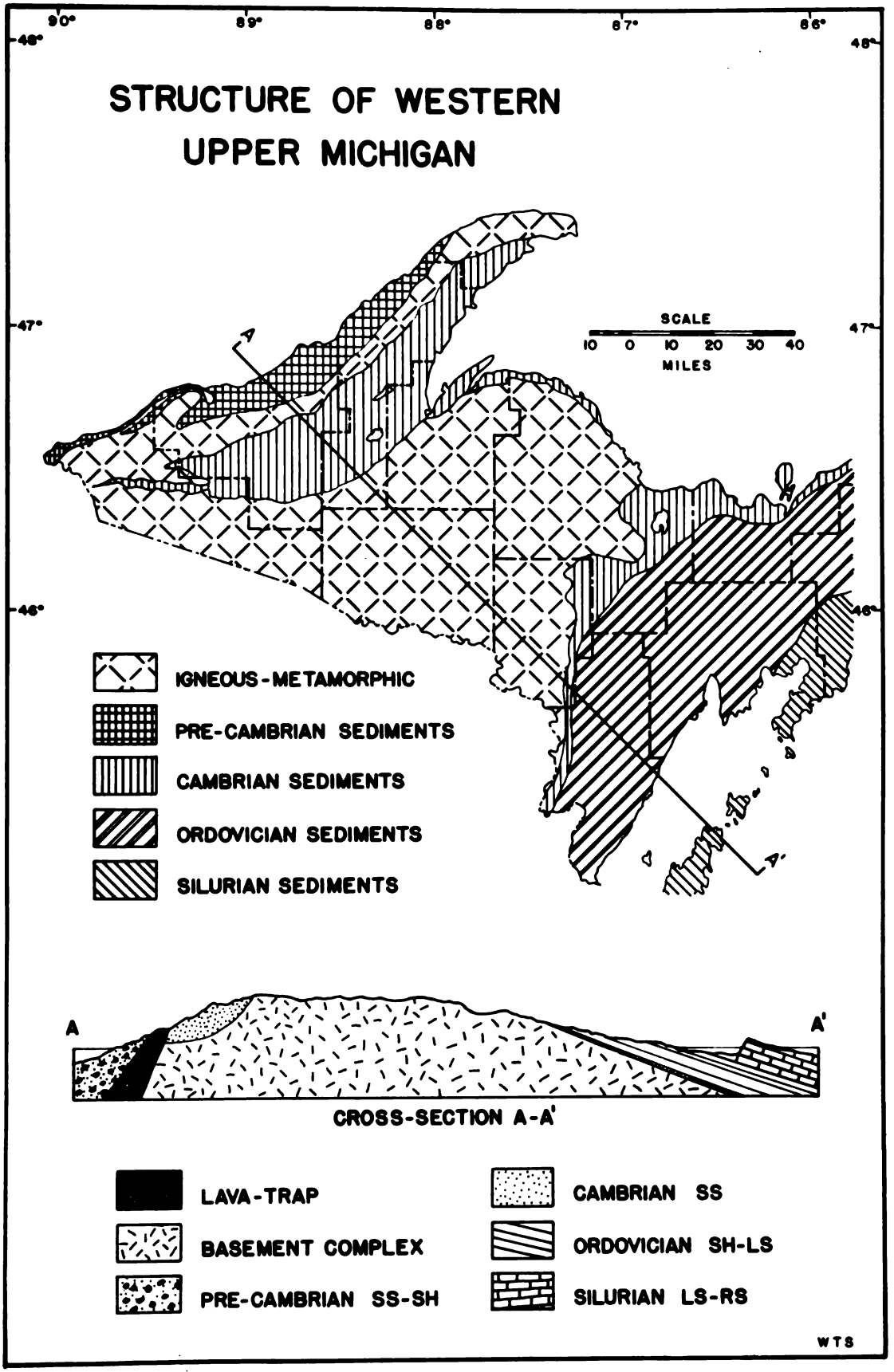
CHAPTER II

MAJOR MORPHOLOGIC CHARACTERISTICS

Structure - There are two types of structure in Menominee County (Plate I). The extreme western part of the County contains an igneous and a metamorphic complex. The central and eastern parts are underlain by a series of sedimentary strata.

The structural arrangement has an important bearing on the surface configuration of the County. A more or less uniformly inclined surface has been formed from the resistant igneous and metamorphic complex in the west on the slope of the sedimentary strata towards the center of the Michigan Basin in the east (Plate II). Structural influence is evident in the orientation of the topography. The major landform features in the central and eastern parts of the County form a linear pattern oriented in a northeast-southwest direction.

The linear topography of the County is primarily caused by the strike and dip orientation of the sedimentary strata. The varying resistance of the strata to erosive processes has formed a series of cuestas along the strike of the structure. These cuestas and their intervening lowlands form a series of topographic highs and lows in the area. The major direction of glacial movement was obviously influenced by the strike of the strata resulting in a superimposed linear pattern in the glacial drift. In contrast to the oriented topography of the sedimentary regions, that of the igneous and metamorphic complex exhibits no particular trend.



SOURCE: MICHIGAN GEOLOGICAL SURVEY, 1957

PLATE I

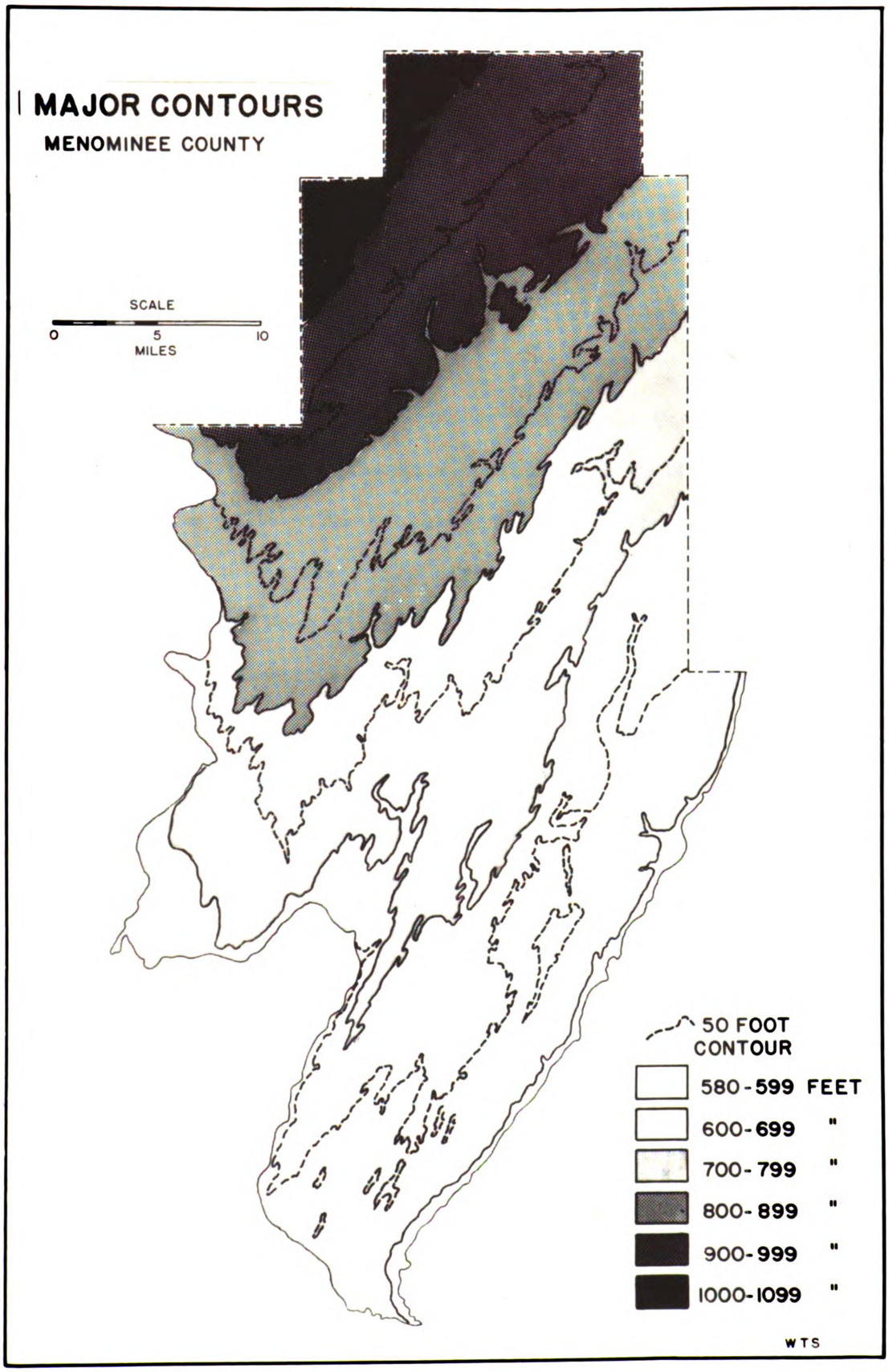

MAJOR CONTOURS
MENOMINEE COUNTY
SCALE
0
5
10
MILES
50 FOOT CONTOUR
580-599 FEET
600-699 "
700-799 "
800-899 "
900-999 "
1000-1099 "
WTS

PLATE II

The structure of the County is buried under varying thicknesses of glacial drift. The valley of the Menominee River in the igneous and metamorphic area is marked by numerous outcrops where the drift has been removed. A series of waterfalls and rapids have formed where the river has cut down to the basement complex. The drift cover on the cuestas in the central part of the County is thin and in several places bedrock is exposed. The structure in the eastern part is completely buried by drift and lacustrine sediments.

The most extensive bedrock outcrops are in the Green Bay basin. A cuesta remnant extends from Chambers Island north to Whaleback Shoal in the center of the basin. The Niagara Escarpment, the most prominent cuesta in the region, forms a steep cliff along the eastern shore of Green Bay. This cuesta forms the Door Peninsula of Wisconsin (Plate XIX).

The extent of structural influence on the surface configuration varies in different locations. In the Green Bay basin, the structure is the most important component of the topography. The orientation of the major terrain features in the central part of the County has been strongly influenced by the structure. There are areas where the surface configuration is not conformal to the structure, however. The orientation of the landforms in the northwestern part of the County is not parallel to the strike of the cuestas. Instead, the trend of the surface features is in more of a westerly direction offset from the strike. The linear pattern of the eastern part of the County, although parallel to the sedimentary strike, was formed by lacustrine processes rather than as a result of structural control.

Glacial Landforms - Most of the topography of the County is formed from unconsolidated glacial and fluvioglacial material. The material was

deposited during the various substages of the Wisconsin glaciation. Evidence of the three preceding glaciations (Nebraskan, Kansan, and Illinoian) has not been discovered. The major physical characteristics of the County are therefore directly associated only with the processes which were active during and after the Wisconsin glaciation.

Menominee County was covered by the Green Bay lobe of the glacier (Plate III). The direction of major ice movement was parallel to the axis of the Green Bay basin. The orientation of the glacial landforms in the central and eastern parts of the County indicates that they were formed by ice movement which was parallel with the Green Bay axis. In the western part, however, the major topographic features give evidence that they were formed under marginal spreading of the ice.

Most of the surface configuration is composed of ice-contact features. The central part of the County contains conspicuously formed till deposits. The northern half of the region is characterized by a drumlin field whereas the southern half is marked by low parallel hills in the form of a till plain. The predominant glacial features in the western part of the County are recessional moraines which were formed during phases of ice stagnation. Another small recessional moraine is located in the southeastern part of the County.

Fluvioglacial features are numerous and widespread (Plate IV). Eskers are found in all but the extreme eastern part of the County. They are superimposed on every type of glacially formed feature. The eskers vary greatly in size and structure (Ver Wiebe, 1926). Most of the systems are oriented across the trend of the glacial landforms and consequently are often interrupted.

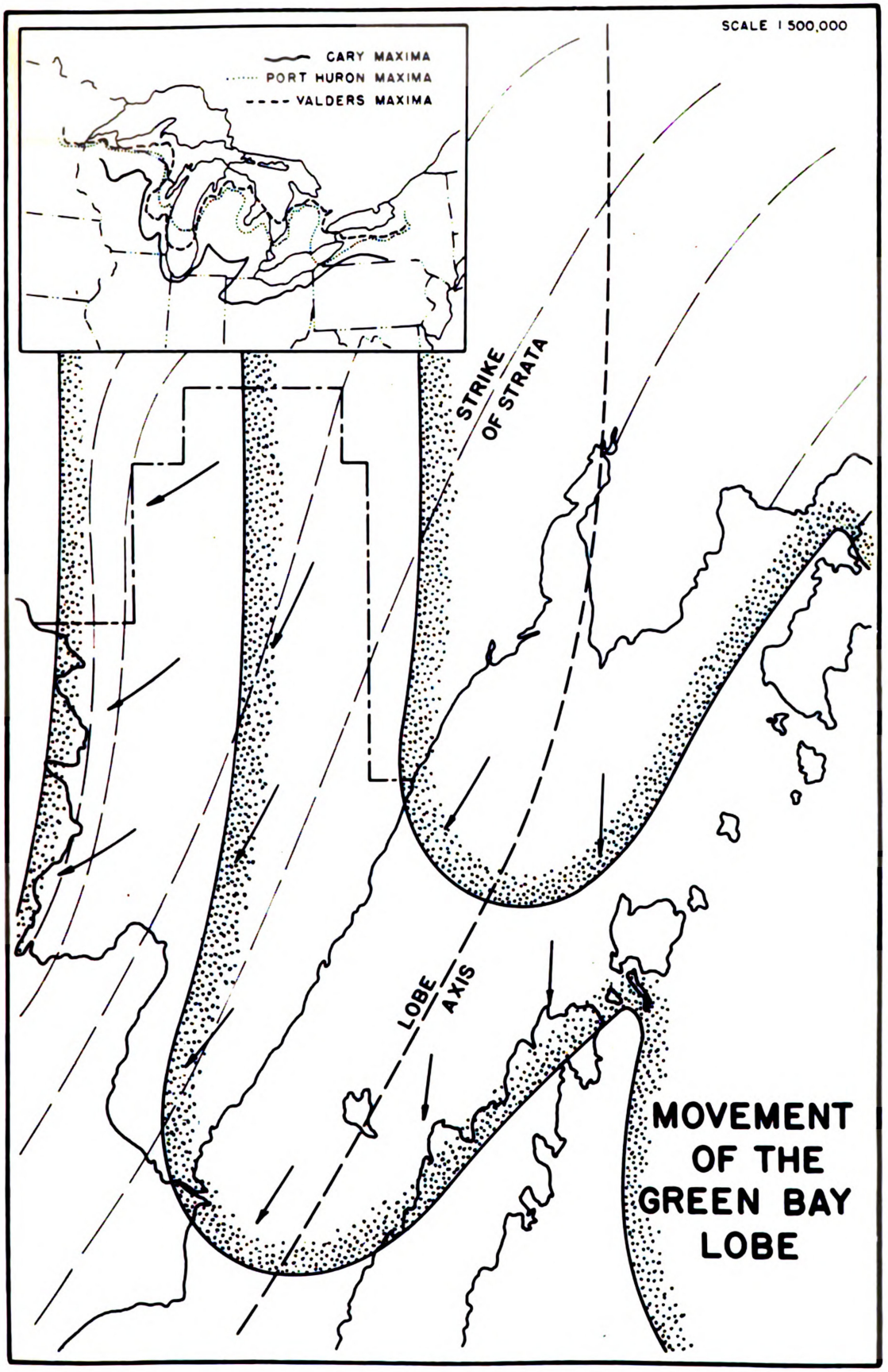

SCALE 1 500,000
CARY MAXIMA
PORT HURON MAXIMA
VALDERS MAXIMA
STRIKE OF STRATA
LOBE AXIS
MOVEMENT OF THE GREEN BAY LOBE

PLATE III

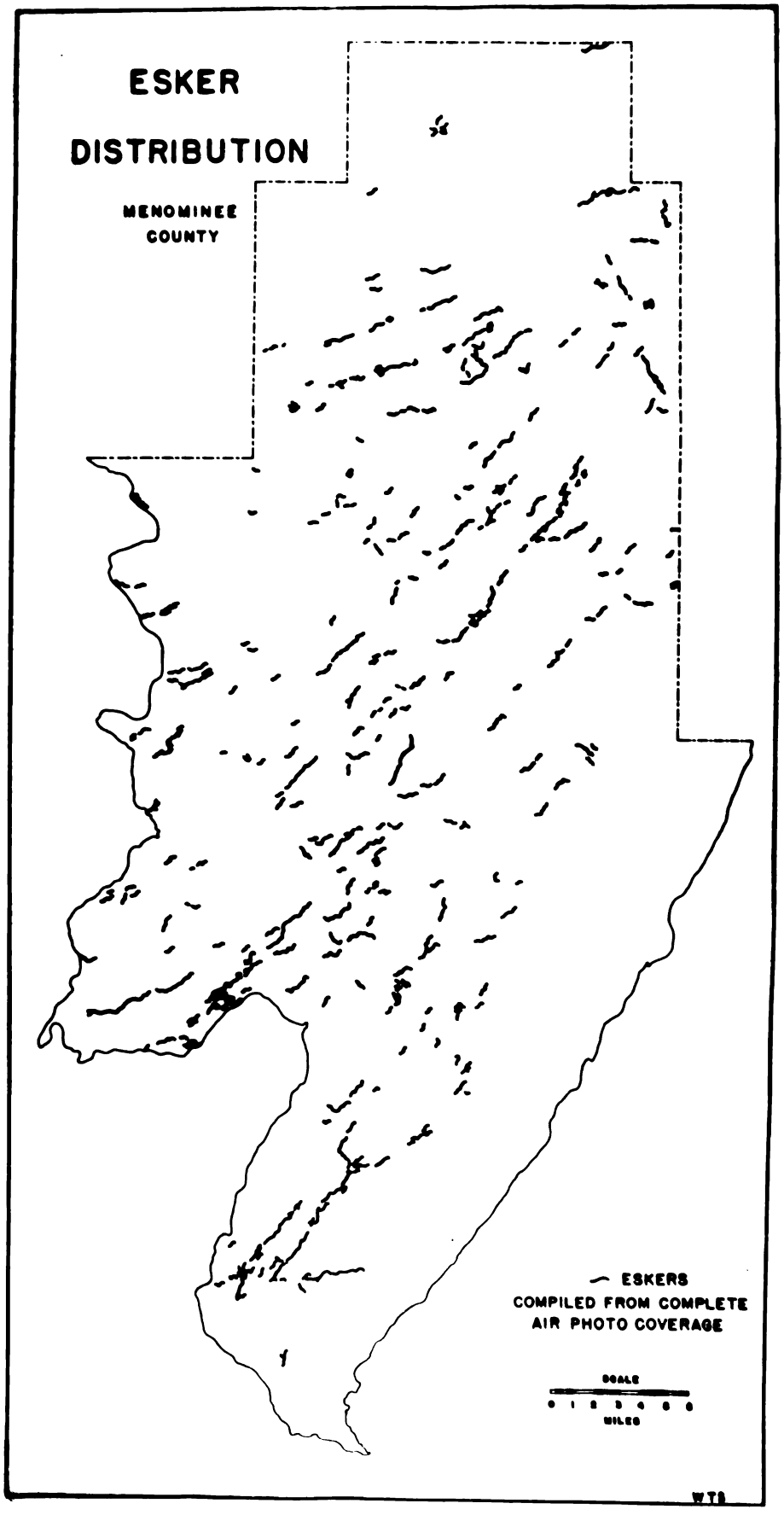

ESKER
DISTRIBUTION
MENOMINEE
COUNTY
ESKERS
COMPILED FROM COMPLETE
AIR PHOTO COVERAGE
SCALE
0 1 2 3 4 5 6
MILES
WTB

PLATE IV

Fluvioglacial plains are occupying the depressions in the glacial drift. Those in the drumlin field and the recessional moraines are limited in size whereas the fluvioglacial plains in the southern part of the County adjacent to the moraines are large. All of the fluvioglacial landforms were formed by meltwater during the last recession of the glacier.

The only parts of the County that are not characterized by glacially formed features are the eastern part and the Menominee River valley. The surface configuration of the eastern region has been formed by wave erosion and deposition during the various stages of lake levels. The topography of the lacustrine plains consists of a broad, flat plain with superimposed parallel ridges and scattered dune formations. The river valley is marked by fluvially eroded and deposited features.

Hydrographic Pattern - Menominee County has a poorly integrated drainage pattern (Plate V). Although there are a number of streams that penetrate the County, there are many areas which are characterized by interior drainage. Most of the depressions in the recessional moraines and the drumlin field are collecting basins for run-off waters from the surrounding slopes. The distribution of landforms greatly restricts the development of a well-integrated pattern. Most stream gradients are low and consequently the waters do not have enough power to cut through the uplands and are confined to the depressions.

There are two major drainage networks in the County. The larger of the two, that of the Menominee River, drains most of the western part of the County. This system is fed by a series of tributary streams which penetrate the County in a northeasterly direction. The other network is that of Cedar River which drains the northeastern section. The pattern

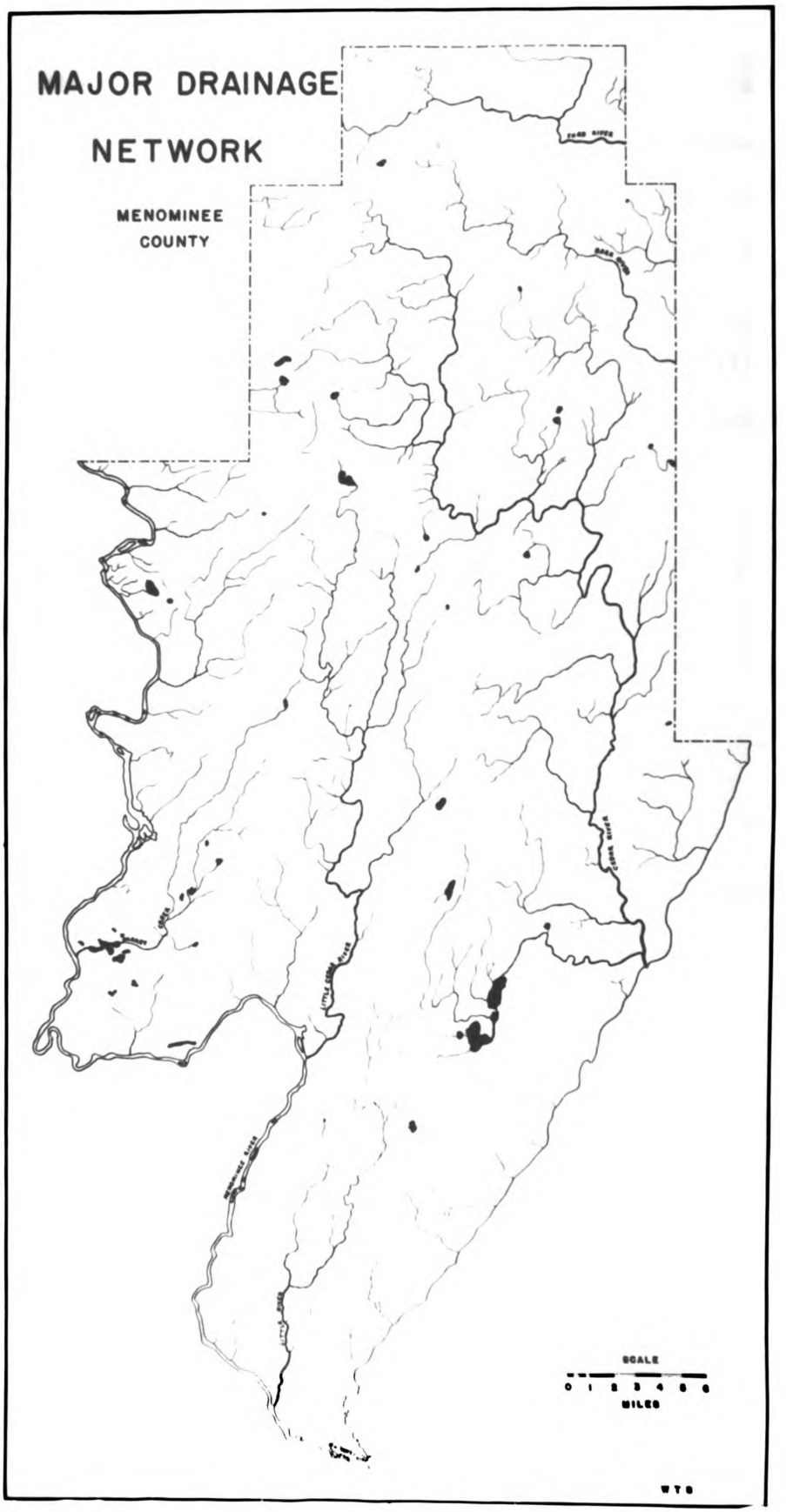

MAJOR DRAINAGE
NETWORK
MENOMINEE
COUNTY
SCALE
0 1 2 3 4 5 6
MILES
WTS

PLATE V

formed by this stream reflects the degree of structural influence in the drainage. The southeastern part of the County is drained by a series of small streams which enter directly into Green Bay. These streams, unlike the others, are oriented in a northwest-southeast direction following the regional slope which is perpendicular to the shoreline.

The drainage systems of the County are obviously very young. With the exception of the Menominee River, all have poorly-defined valleys. The strong structural control of the drainage has resulted in many areas of interior drainage and a large number of swamps.

APPROXIMATE WATERSHED AREAS
OF THE LARGER STREAMS

Cedar River	380	square miles
Little Cedar River	170	" "
Bark River	75	" "
Little River	75	" "
Ford River	70	" "
Other Streams	225	" "

Surface Drainage - Drainage throughout the County is generally poor. The depressions which are fed by interior drainage are predominantly swampy. Most of the streams have gradients too low to satisfactorily drain their watersheds.

The poor drainage conditions have resulted in a high amount of land occupied by swamps and a generally high water table (Plate VI). The swamps form distinct patterns in the various landform regions of the County (Plate VII). Three factors were found to influence the patterns. The shape and size of the depressions which contain the swamps are directly related to the type of relief features in each region. The level of the water table controls the base elevation at which the swamps can form. The type of drainage (exterior or interior) determines the quantity of water which is available for swamp formation.

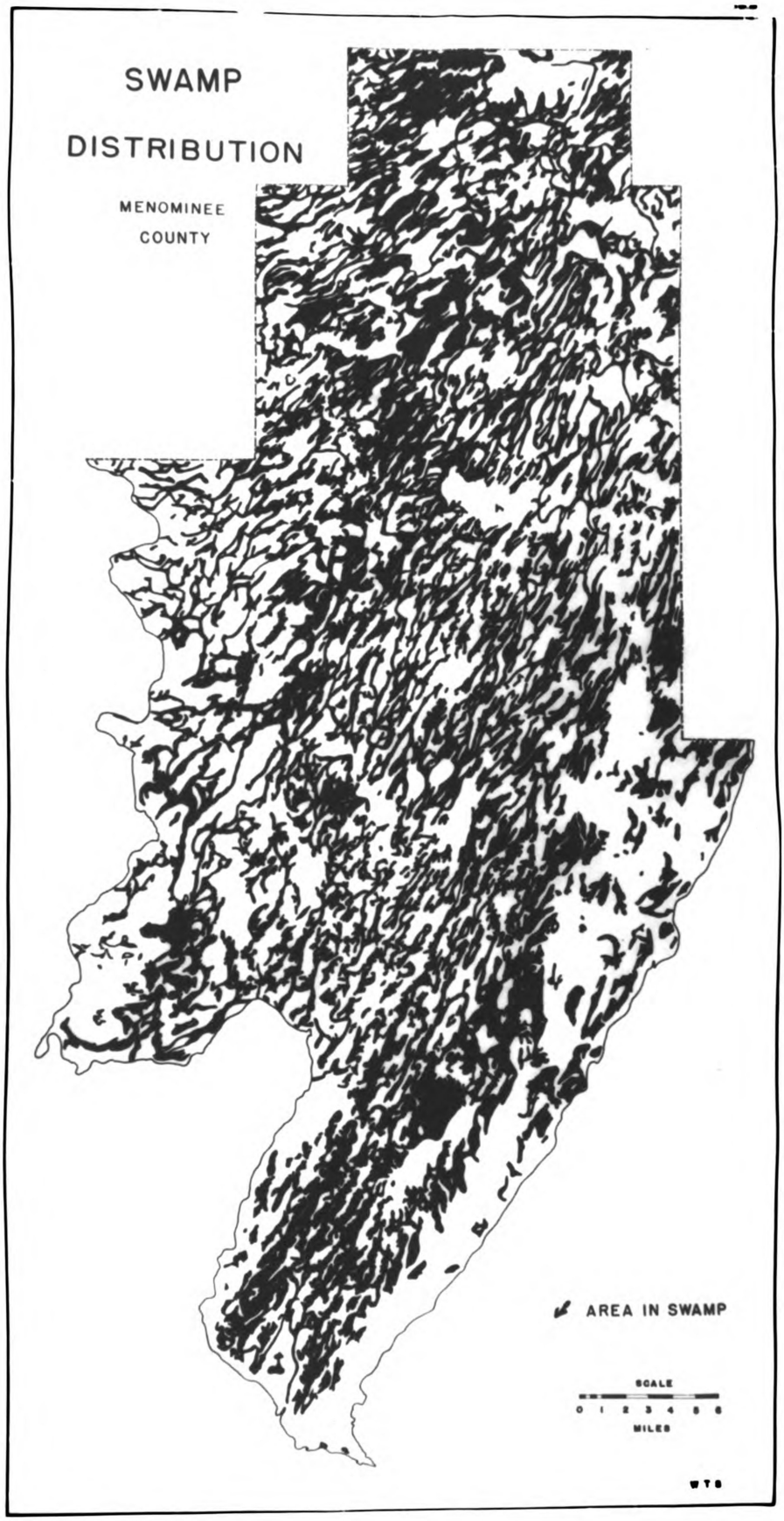
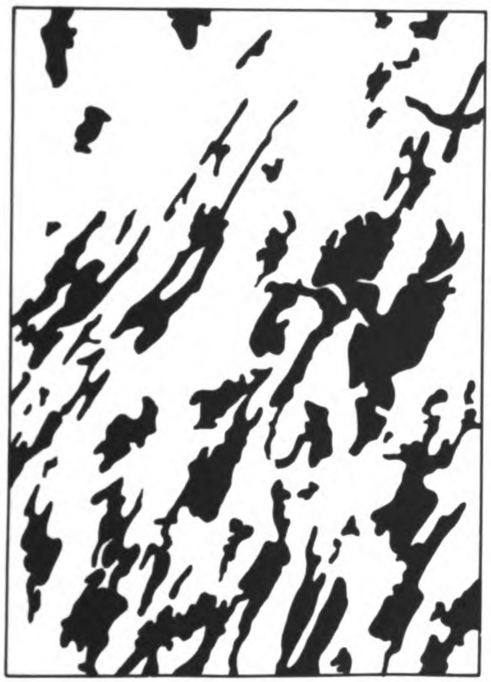

SWAMP
DISTRIBUTION
MENOMINEE
COUNTY
AREA IN SWAMP
SCALE
0 1 2 3 4 5 6
MILES
WTS

PLATE VI

MORAINIC REGION

LACUSTRINE PLAINS REGION



DRUMLIN REGION

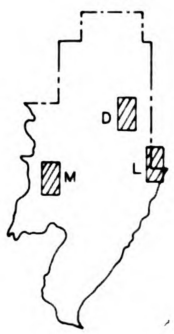
SWAMP PATTERNS

MENOMINEE COUNTY

SCALE

0 6000 12000

FEET



WTS

PLATE VII

Swamp patterns, therefore, are good indicators of certain aspects of the surface configuration. The swamp pattern in the morainic area indicates that the terrain is non-oriented. The majority of the depressions are isolated and vary greatly in size and shape. The swamp pattern of the lacustrine plains has been formed primarily in linear depressions parallel to the shoreline. The size of the swamps indicates that much of the area is flat whereas the shape of the swamps implies that the depressions are contained by linear, parallel uplands. The pattern in the drumlin field reflects a linear arrangement of the major topographic features. Most of the swamps are isolated which indicates that they are located in areas of interior drainage.

Pedologic Aspects - Soils are intimately related to geomorphic genesis and other physical characteristics of the landform. They reflect mode of origin, groundwater conditions, degree of erosion, slope characteristics, and geologic age. A distinct relationship exists between the soils series of the County and particular aspects of the terrain (U.S. Department of Agriculture, S.C.S., 1925).

SOIL SERIES	GEOMORPHIC RELATIONSHIP
Bergland Eastport Alpena	lacustrine plains
Ewen	stream alluvium
Grayling	fluvioglacial outwash
Longrie	limestone within 3 feet of surface
Menominee	deposited by wind or water
Wallace	sand dunes

The effects of drainage on soil development in the County are significant and numerous. Rifle and Greenwood Peat are the two most important organic soils in the County. They occupy approximately 33% of the total land area. The organic soils are widely distributed (Plate VI). The younger ones in the eastern part of the County support a vegetational cover of leatherleaf whereas the older organic soils in the central and western parts possess a thick forest cover.

The poorly drained mineral soils are located primarily along the swamp borders. Their typical profile consists of an organic layer less than one foot thick, a gray layer, a fine-textured layer with brown and yellow mottling, and a water-logged substratum. They are represented by the Bergland, Saugatuck, and Granby series.

The well drained soils are associated with the uplands of the County. The most extensive series is Onaway which is found throughout the central and western regions. The texture of the Onaway is a fine sandy loam in the western part of the County where it has developed from a coarse-grained parent material. A loam texture has developed from the clay till in the central region. Other well drained soils are the Rodman, Longrie, Roselawn, and Emmet series.

CHAPTER III

DISTRIBUTION OF LANDFORM TYPES

The terrain patterns which are seen on the air photo mosaics and soil map are reflected by various landform types. A landform type, for the purpose of this study, may be defined as an area on the earth's surface created by natural processes in such a way that it may be described and recognized in terms of typical features wherever it may occur, and which, when identified, will provide dependable information concerning its structure, composition, and form (after Lueder, 1959).

The surface configuration of Menominee County has been formed primarily by glacial, fluvioglacial, and lacustrine processes. The results of these processes formed distinct associations of landforms. The major characteristics of the terrain, structure, composition, and form, vary with the mode of formation, and thereby cause different landform types. On this basis, the landform types of the County can be designated as morphogenetic regions.

In order to classify the surface configuration of the County into morphographic types, the measurable characteristics of the terrain must be examined. Slope, local relief, and material are the most important parameters which are used in this study for landform classification. Slope elements form horizontal as well as vertical dimensions of the topography. Local relief, which may be defined as the difference in elevation within a unit area, is an important indicator of vertical

terrain differences. Two distinct regions of high local relief exist in the County (Plate VIII). Material variations indicate differences in deposition. On the basis of these criteria, the County has been classified into five landform types (Plate IX):

Moraine Hill Lands
Till Plains (Ground Moraine)
Oriented Morainic Hill Lands (Drumlin Field)
Valley Trains (Fluvioglacial Plains and Valleys)
Lacustrine Plains (Lake Plains)

Several of the landform types occur in more than one area. There are three regions which have been classified as moraine hill lands. Although the local relief varies, form, structure, and material composition of these areas are similar. The mode of formation of the three regions is basically the same, therefore the moraine hill lands are homogeneous in genesis as well as in morphometric and morphographic qualities.

Only the major fluvioglacial features are classified as landform types. Most of the fluvioglacial valleys and plains are limited in size and occur entirely within other landform types. Consequently, they are considered as extraneous features of the other regions. However, there are three fluvioglacial plains in the southern part of the County large enough to be considered as special landform types.

Most of the landform types have one dominant characteristic that differentiates them from all others. Fluvioglacial plains are recognized by the stratification of fine sorted material. Moraine hill lands can be identified by the poor sorting of material and the presence of non-oriented hills. Till plains are characterized by poor material sorting and low, undulating hills. Oriented moraine hill lands are recognized by the form and distribution of individual hills, and lacustrine plains generally contain long, parallel abandoned beach ridges.

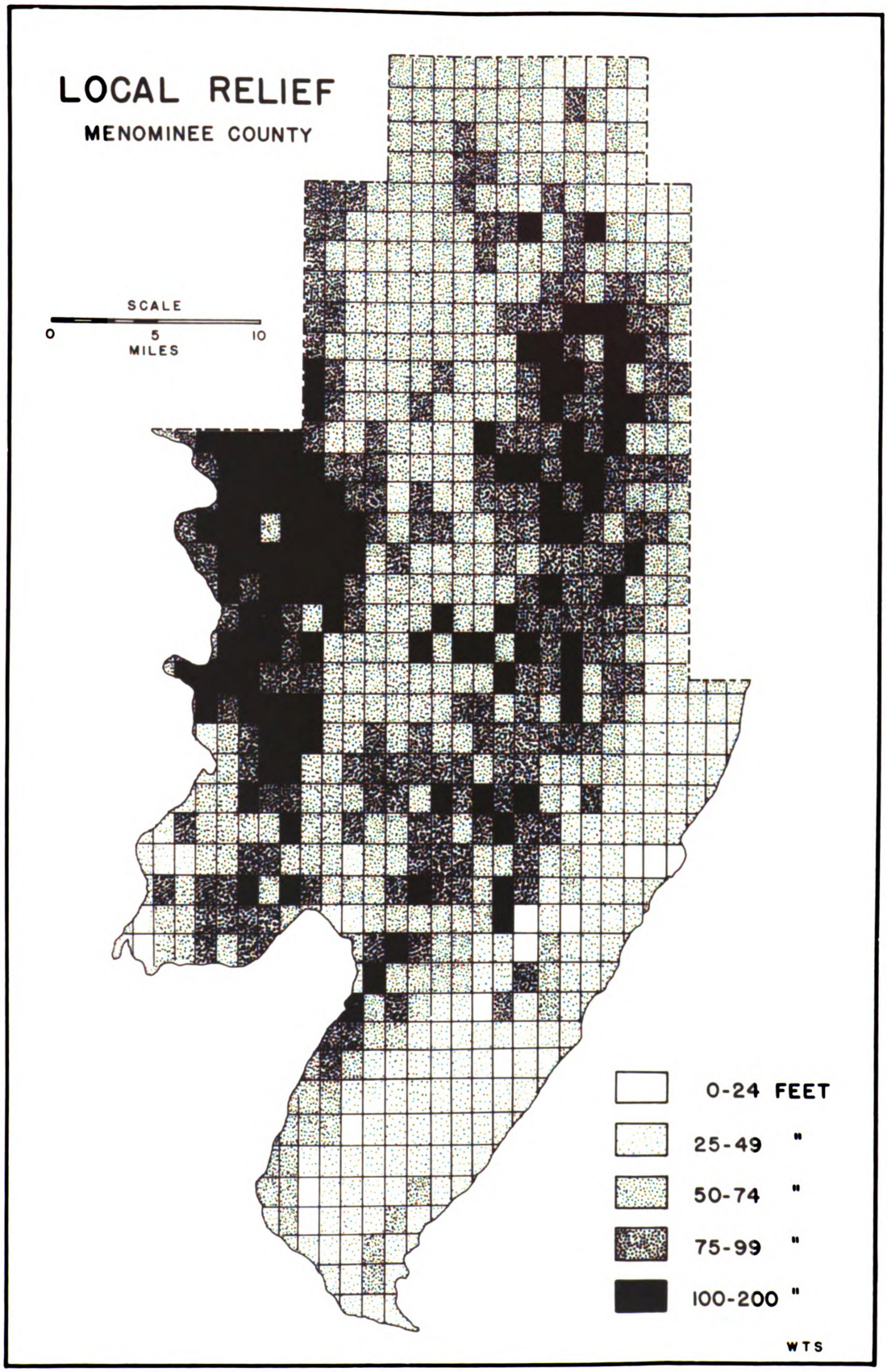

LOCAL RELIEF
MENOMINEE COUNTY
SCALE
0
5
10
MILES
0-24 FEET
25-49 "
50-74 "
75-99 "
100-200 "
WTS

PLATE VIII

Although each landform type is primarily the result of a particular process, it should be noted that these regions may also contain features of different genesis. Eolian forces have reworked the surface material in many areas, thereby altering the original surface configuration. Eskers, kames, and other forms of fluvioglacial outwash occur in all regions except the lacustrine plains. These features which are superimposed upon the original glacial topography are locally dominant. Only large scale mapping can bring out the individuality of these features.

Boundary Problems - The landform type boundaries that are shown on Plate IX are only approximate. In most cases, boundaries between the regions are not clearly marked. Instead, the peripheral parts of the various landform types increase in extraneous characteristics which are not associated with the "modal" character of the regions. Consequently, an area exists between the regions where characteristics of the landform types merge. An example of a transitional region is the area between the Ingalls fluvioglacial plain and the drumlin field. Individual drumlins, although more infrequent and smaller than in the central part of the drumlin field, have been partially buried by fluvioglacial outwash. An exact boundary is difficult to locate. It could be placed in the part of the drumlin field where the outwash begins, or in that part of the fluvioglacial plain where the drumlins cease to exist. It seems logical that the boundary be placed in the center of the transitional area.

In a few instances, the boundaries are clearly marked. Wave erosion has cut a series of cliffs in the hills of the southeast moraine forming a distinct boundary between the lacustrine plains and the moraine region. The Menominee River valley has been cut into the western side of the

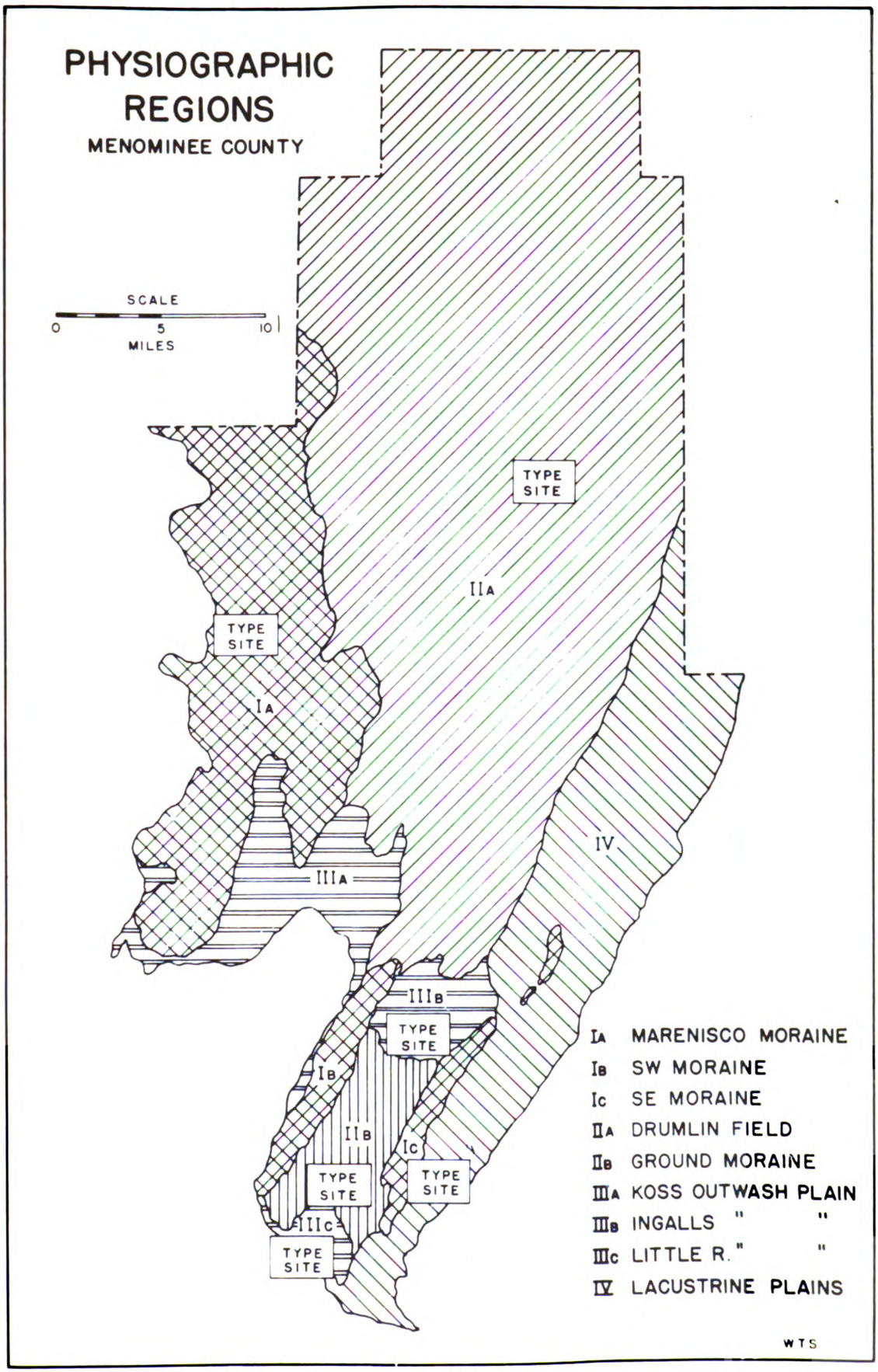

PHYSIOGRAPHIC REGIONS
MENOMINEE COUNTY
SCALE
0 5 10
MILES
TYPE SITE
IIA
TYPE SITE
IA
IIIA
IV
IIIB
TYPE SITE
IB
IIB
IC
TYPE SITE
TYPE SITE
IIIC
TYPE SITE
IA MARENISCO MORAINE
IB SW MORAINE
IC SE MORAINE
IIA DRUMLIN FIELD
IIB GROUND MORAINE
IIIA KOSS OUTWASH PLAIN
IIIB INGALLS " "
IIIC LITTLE R." "
IV LACUSTRINE PLAINS
WTS

PLATE IX

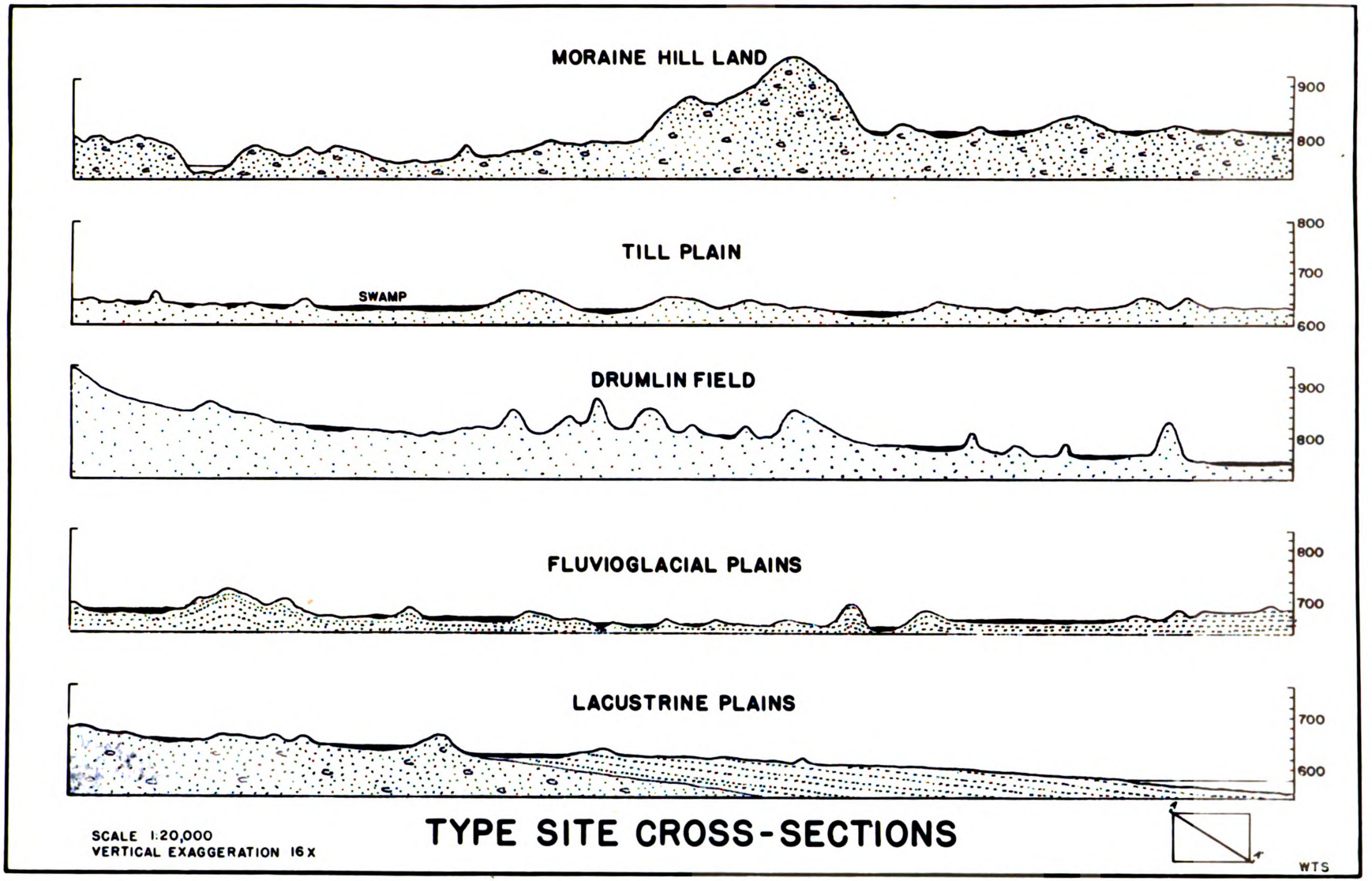

MORAINE HILL LAND
900
800
TILL PLAIN
SWAMP
800
700
600
DRUMLIN FIELD
900
800
FLUVIOGLACIAL PLAINS
800
700
LACUSTRINE PLAINS
700
600
SCALE 1:20,000
VERTICAL EXAGGERATION 16X
TYPE SITE CROSS-SECTIONS
WTS

PLATE X

southwest moraine thereby clearly marking the western boundary of the moraine. Clearly marked boundaries are the exception rather than the rule, however.

Extent of Type Regions - Many of the landform types in the County are only portions of much larger systems. The Marenisco Moraine system is over 200 miles long, the eastern part of which is located in Menominee County. The central part of the County is only a part of a much larger till plain which extends as far north as Lake Superior. The lacustrine plains region of Menominee County is only a small segment of the western Lake Michigan lacustrine plains.

Landform types which occur exclusively in Menominee County are the southwest and southeast moraines and the Koss, Ingalls, and Little River fluvioglacial plains. These regions occupy only a small part of the total surface configuration.

CHAPTER IV

MORAINE HILL LANDS

There are three separate moraine systems in Menominee County. They mark the positions of ice stagnation during the recessional stages of the Green Bay lobe. Two of the systems are confined entirely to the County whereas the third is a much larger system which extends over a distance of 200 miles. The extreme eastern part of this moraine lies within the borders of the County.

In spite of the different locations of the three moraine hill lands, they all possess similar characteristics.

1. They are all oriented in a northeast-southwest direction parallel to the present shoreline. The orientation indicates the glacier receded along the axis of the Green Bay basin rather than in a northerly direction.

2. The surface configuration of the three systems has a definite trend in the major relief features. The hills are elongated and oriented in a northeast-southwest direction.

3. Fluvioglacial deposits are widespread between the moraine uplands in each of the regions.

4. The material composition of the moraines is essentially the same. The only difference is the higher percentage of clay in the southeast system. The soil which has developed from the parent material has been classified as the Onaway series.

5. The moraines have poorly developed drainage systems. Swamps have formed in both areas of interior drainage and along stream courses.

The southeast moraine is located along the lacustrine plains in the southern part of the County. The surface configuration is characterized by a series of elongated hills and interlying lowlands which are oriented in the typical northeast-southwest direction. The hills are interrupted in many places and have the appearance of a linear series of moderately sloping knobs. The slopes are marked by many broad, shallow gullies. The local relief of the region varies between 40 and 60 feet.

A large number of the lowland areas within the system are occupied by swamps. Many of the depressions in the center of the region are basins of interior drainage. The drainage network is developed only in the exterior sections of the moraine.

The moraine is composed of a till with a high clay content. Erratics of various size and rock type are scattered throughout the till. The compact texture of the material restricts the rate of permeability and consequently a series of gullies have developed on the steeper slopes.

The southwest moraine is located along the valley of the Menominee River in the southern part of the County. The boundary on the west side of the moraine is marked by a steep slope which has been formed by the river widening its valley. The uplands on the eastern side of the moraine grade into more gentle relief of the fluvioglacial plains and the ground moraine region.

The surface configuration of the region is similar to that of the southeast moraine. The hills have a definite orientation and are separated by interlying lowlands. Swamps have formed in most of the

Figure 1. Surface Form of the Southeast Moraine. The surface configuration of this region is characteristic of the southeast and southwest moraines.

Figure 2. A Large Erratic in a Morainic Area. This calcareous erratic is much larger than most of the rocks which are found in the till.

FIGURE 1

FIGURE 2

lowlands as a result of poor drainage. The only drainage system in the region is a series of short, intermittent streams which drain the western slopes of the moraine.

The principal difference between the southeast and southwest moraines is that of material composition. The southwest moraine is composed of fine-textured sands. The high permeability of the sand has restricted the formation of gullies. Instead, areas in which the vegetational cover has been removed have undergone eolian erosion. Shallow blowouts have formed on many of the hill crests.

The different soil textures of the two regions are reflected in two different types of vegetation which have developed. The soils with a high percentage of clay have a higher porosity than the sandy materials and consequently support a growth of hardwoods. The sandy areas support the growth of conifers in rather open stands.

The Marenisco hill land is the largest moraine system in the County. It is located in the central and northwestern parts of the County along the Menominee River. The local relief of this system is much greater than that of the other regions. Variances in height exceed 180 feet within a horizontal distance of one-half mile in places. The surface configuration consists of the more typical "knob and kettle" form which is characteristic of recessional moraines.

The drainage conditions are similar to those in the other moraines. Large parts of the system's inner portions do not have a surfacial drainage network and consequently depressions serve as collecting basins for local run-off. Swamps have formed in most of these depressions. The drainage system, where it does exist, is poorly developed and consists primarily

of a trunk stream with one or two tributaries. Many of the streams have an intermittent flow regime.

The fact that the Marenisco system is the larger and better developed moraine has led to its selection for the type site analysis. The area which has been selected is representative of most of the characteristics associated with the morainic regions of the County.

Type Site Analysis (Figure 3, Plate XI) The original surface configuration which was formed by glacial deposition has been strongly dissected by late-glacial erosion. A series of spillway valleys have been cut through the moraine which divide the region into a number of hill tracts.

The morainic uplands are characterized by broad, moderately-sloping hills upon which steeply-sloping, symmetrical knobs are located. The slopes of the hills are generally uniform and not marked by any major irregularities. The only exceptions occur in the areas where spillway valleys have been eroded into the side of a hill and at the break points at the bases of the knobs. In these cases, the slopes are generally much steeper. The knobs are the most prominent relief formers in the region. Many attain heights of over 100 feet above the crests of the broader uplands.

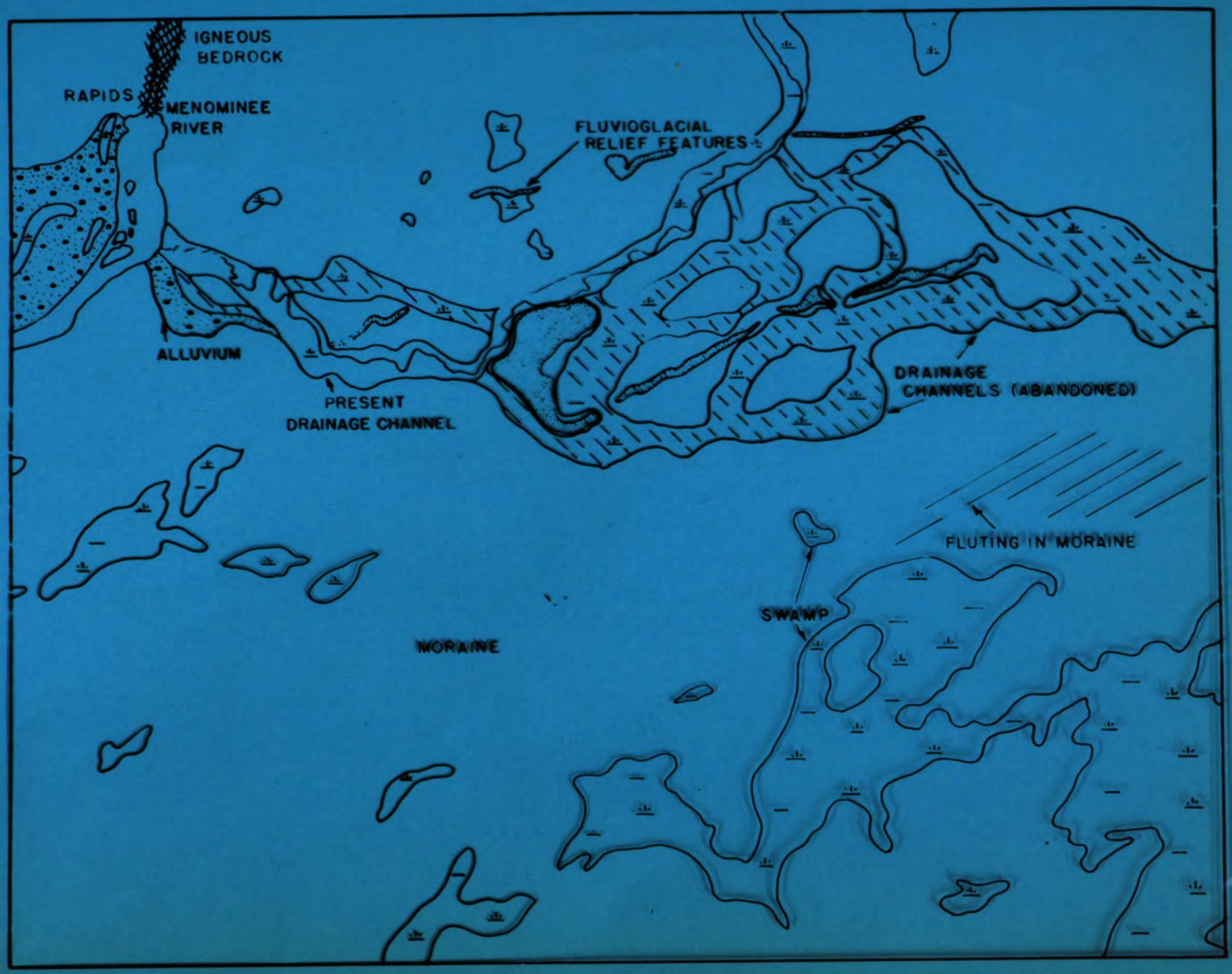
Small valleys have been cut into the sides of the uplands, most of which are oriented in a northeast-southwest direction. These valleys have been formed by intermittent rather than permanent streams.

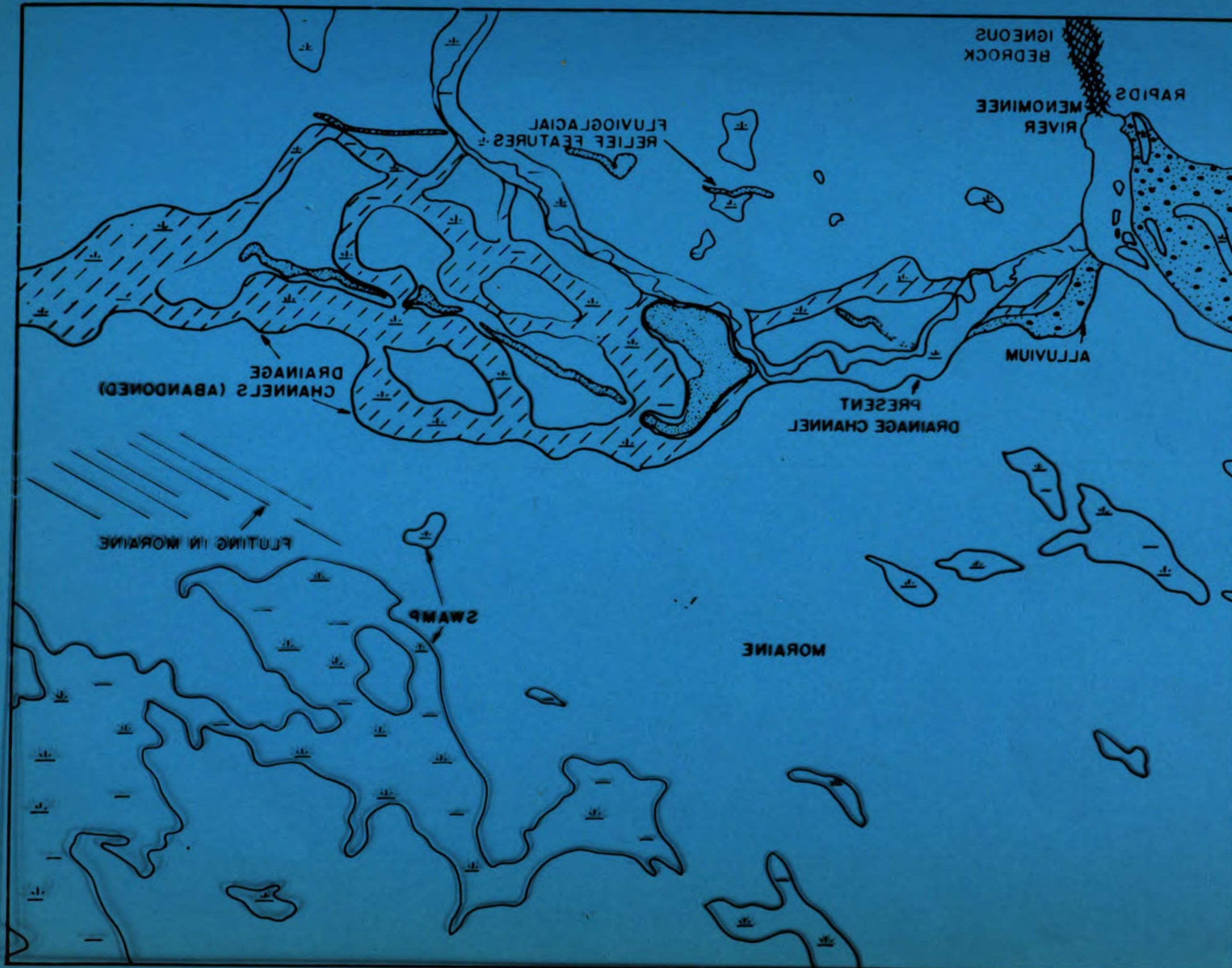
Many of the smaller hills are elongated and resemble drumlins. The major axes of the hills are parallel to the orientation of the drumlins which are located to the east. On many of the hills there exists a series of long, parallel grooves which have a trend similar to that of the drumlins. These grooves (fluting) are formed by erosional activity of the ice (Flint, 1957).

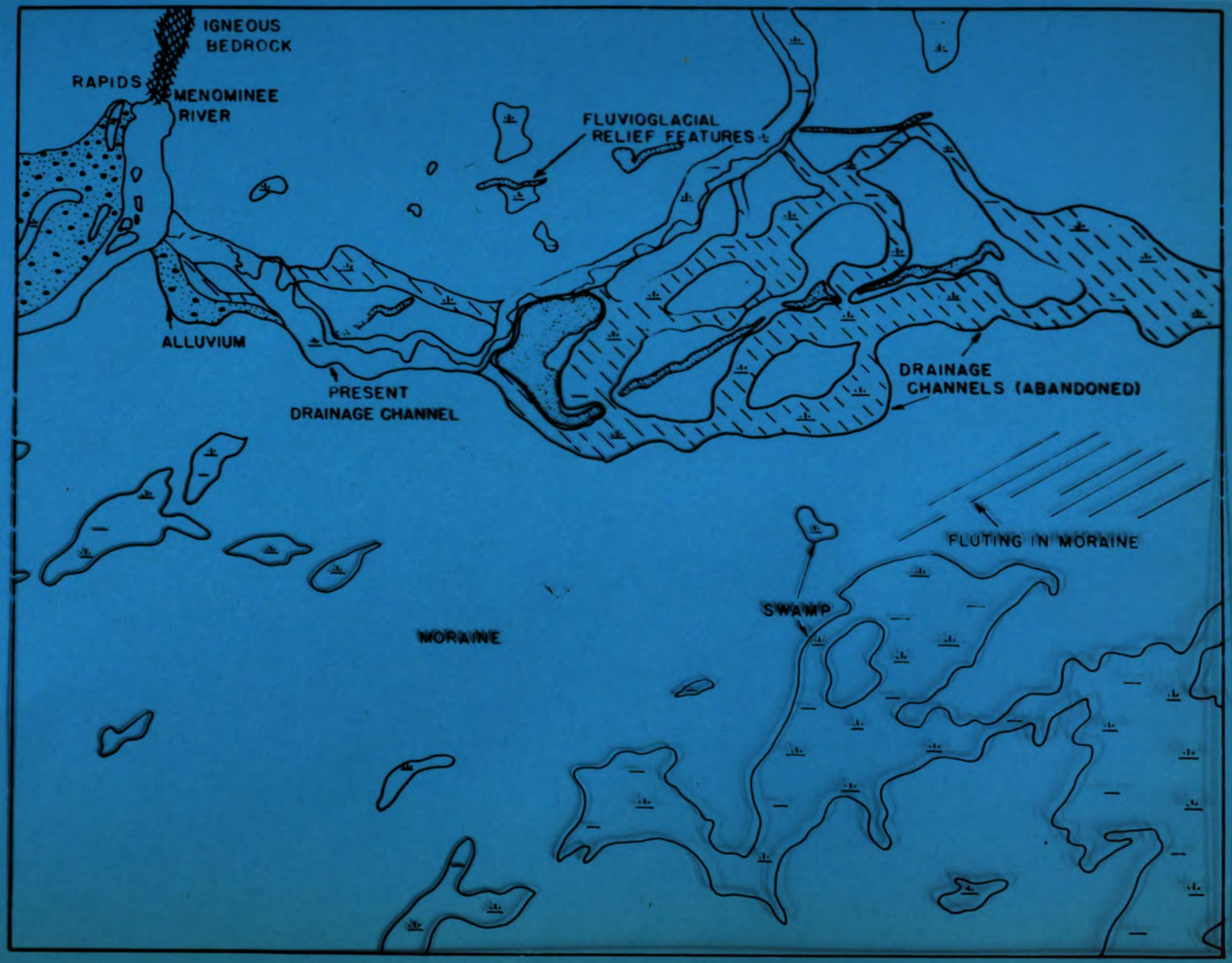
A series of valleys, ranging between one-eighth to one-quarter mile in width, cut through the moraine in an east-west direction. The valley in the northern part of the type site extends across the present valley of the Menominee River. It is cut into the moraine and the underlying crystalline rock on its west side. The gradient of the valley floor is directed eastward which indicates that the direction of flow in the spillway valley was from west to east.

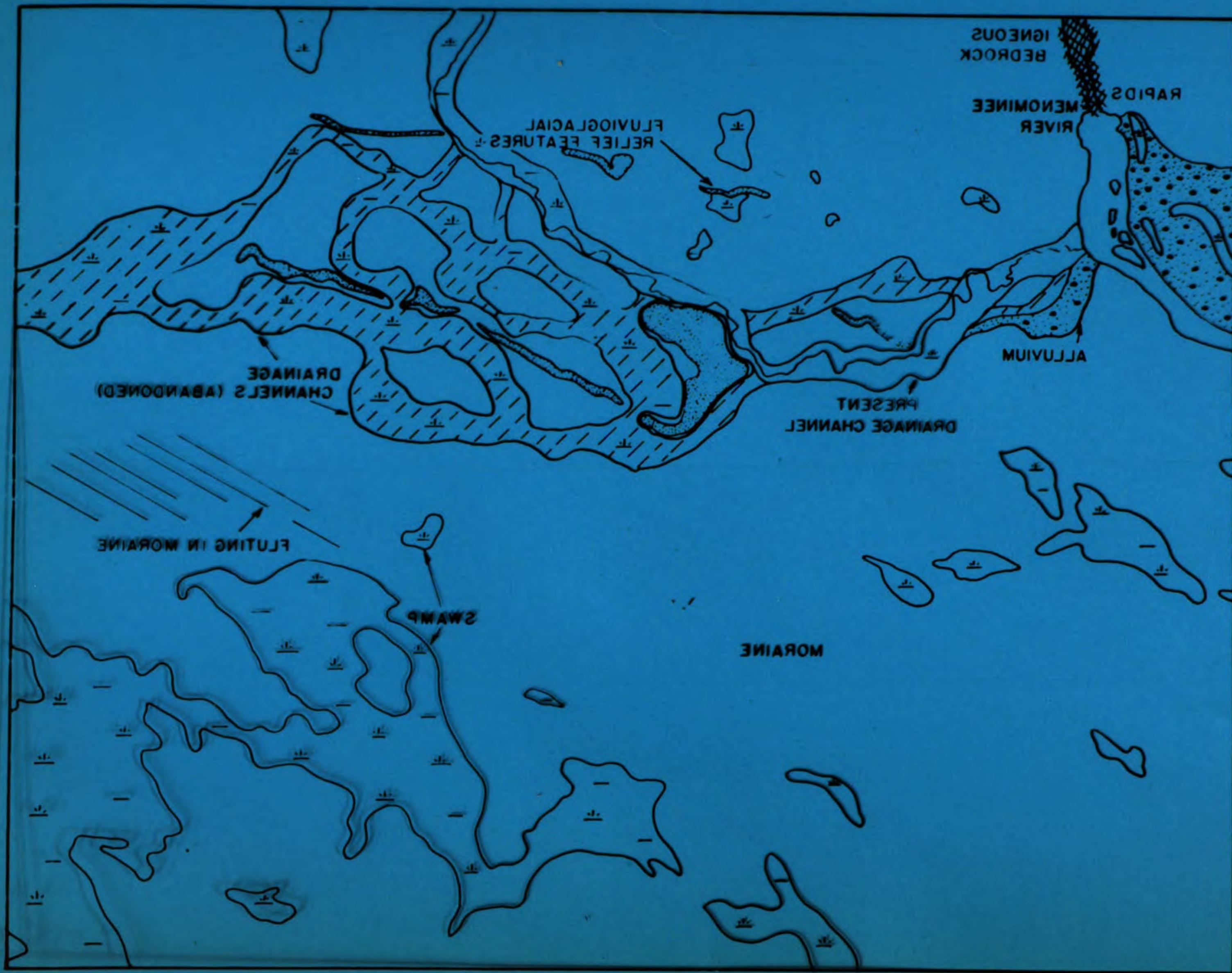
The form of the valley varies in different areas. The narrow valleys generally have steep sides whereas the wider ones contain a series of channels and a poorly developed floodplain. Small, underfit streams presently occupy parts of the spillway valleys. These streams form the major part of the moraine's drainage network.

The present course of the Menominee River has developed along the western part of the moraine. Many hills have been truncated forming steep valley walls. The river valley in the type site area is narrow with no evidence of floodplain development. A series of rapids have been formed in the channel where the river has cut down into the underlying crystalline rock.


IGNEOUS BEDROCK
RAPIDS
MENOMINEE RIVER
FLUVIOGLACIAL RELIEF FEATURES
ALLUVIUM
PRESENT DRAINAGE CHANNEL
DRAINAGE CHANNELS (ABANDONED)
FLUTING IN MORAINE
SWAMP
MORAINE


IGNEOUS
BEDROCK
RAPIDS
MENOMINEE
RIVER
FLUVIOGLACIAL
RELIEF FEATURES
ALLUVIUM
DRAINAGE
CHANNELS (ABANDONED)
PRESENT
DRAINAGE CHANNEL
FLUTING IN MORAINE
SWAMP
MORAINE


IGNEOUS BEDROCK
RAPIDS
MENOMINEE RIVER
FLUVIOGLACIAL RELIEF FEATURES
ALLUVIUM
PRESENT DRAINAGE CHANNEL
DRAINAGE CHANNELS (ABANDONED)
FLUTING IN MORAINE
SWAMP
MORAINE


IGNEOUS
BEDROCK
RAPIDS
MENOMINEE
RIVER
FLUVIOGLACIAL
RELIEF FEATURES
ALLUVIUM
PRESENT
DRAINAGE CHANNEL
DRAINAGE
CHANNELS (ABANDONED)
FLUTING IN MORAINE
SWAMP
MORAINE


8-16-39-10:61
MA-2000-5-VB 8-17
Adams Aerial Survey Corp. Lansing, Mich.

FIGURE 3

There are several fluvioglacial deposits in the type site area. A kame deposit occupies the central part of the spillway valley. The kame has a crescent shape and is slightly over thirty feet in height. Two esker systems have been formed, one in the spillway valley and the other on the northern valley wall. These fluvioglacial deposits mark the termination of glacial activity in the area.

Sections of the lowlands adjacent to the valleys possess a veneer of alluvial material. A delta has been formed at the junction of the spillway valley and the west side of the Menominee River. Alluvial material also exists in the spillway valley where a floodplain has been developed.

Most of the deeper depressions have originated as pit lakes and are now covered by swamps. Kettles and swales in the morainic uplands are also occupied by swamps as are the abandoned channels of the valleys. Most of the swamps in the uplands are isolated features and vary greatly in size and shape, whereas the valley swamps form an interconnecting linear pattern.

CHAPTER V

THE TILL PLAIN REGION (GROUND MORAINE)

The till plain region forms a narrow, rectangular-shaped lowland between the southeast and southwest moraine systems. The north and south boundaries of the region are formed by fluvioglacial plains.

The till plain is the southern part of a much larger ground moraine system which extends through the center of the County in a north-south direction. Many of the characteristics of the drumlin field, which is located in the central part of the ground moraine system, can also be found in the till plain region.

The surface configuration has a definite northeast-southwest orientation, similar to that of the drumlins. The elongated, parallel till plain uplands form a linear pattern of islands in a large network of swamps. The majority of the esker systems in the till plain have a northeast-southwest trend.

The material composition of the ground moraine uplands is similar to that of the drumlin field. The uplands are composed of a clayey till with a large number of cobbles. The diameter of the cobbles ranges between one and four inches. Large erratics are uncommon in the ground moraine. The material possesses a distinct red hue which may be related to the deposition with the Valders Advance (Chapter IX).

The till plain is poorly drained. The drainage system is composed of one stream which extends the length of the region. Small tributaries branch out from the trunk stream and drain sections of the peripheral

Figure 4. Deflation in the Till Plain. In parts of the till plain there exists a veneer of eolian sand. The sand has not been deposited in dune formations but instead has been formed into low, gently undulating hills. Vegetation has anchored most of the sand but in places where cultural activities have disturbed the plant cover, recent eolian erosion has taken place.

Figure 5. Oblique View of the Till Plain. The better drained uplands of the till plain are used for agricultural purposes. The rock piles throughout the fields are evidence of the stoniness of the till. The forest cover occurs primarily in the swampy areas.

FIGURE 4

FIGURE 5

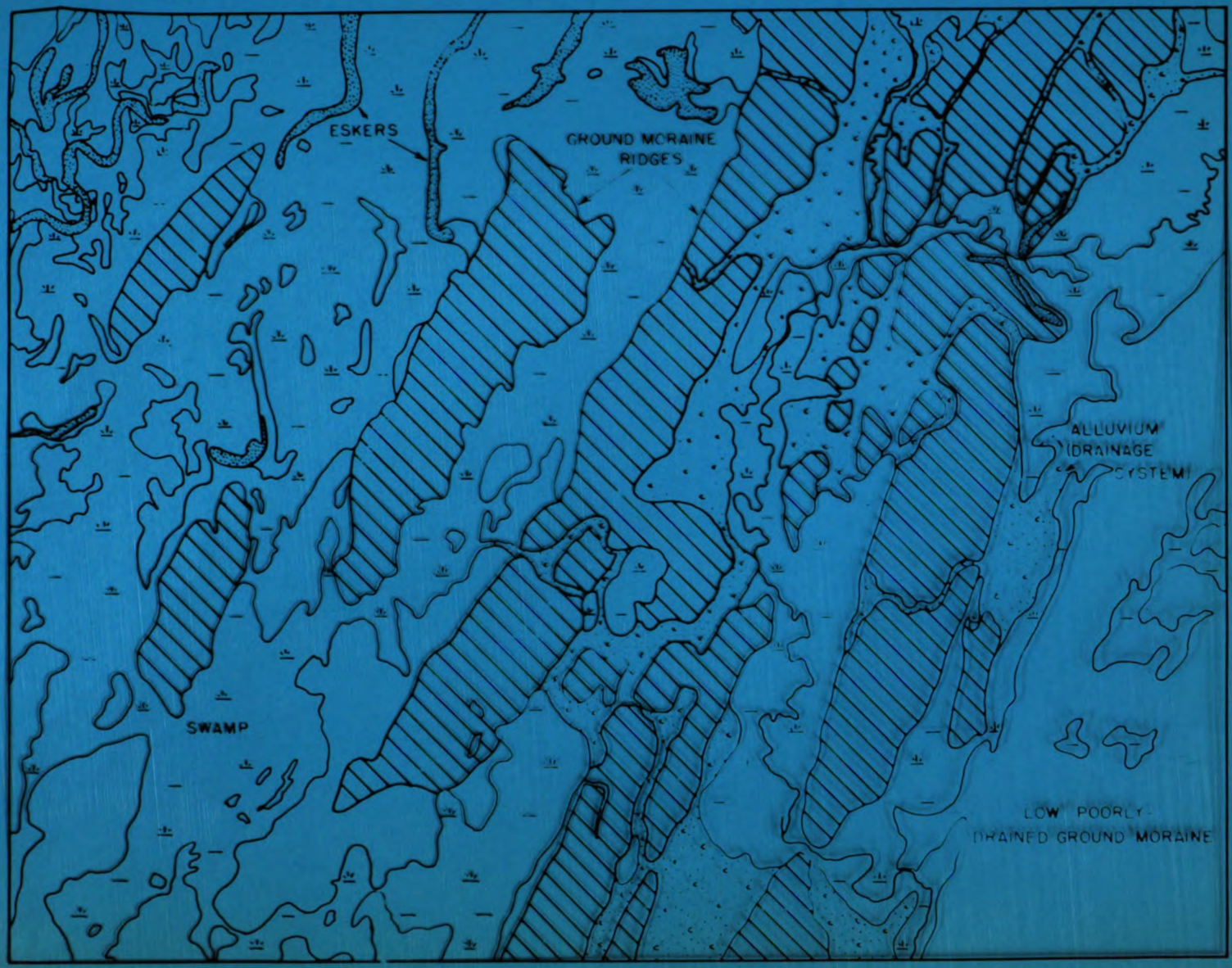
areas of the till plain. The presence of the morainic regions on either side of the till plain is one of the prime causes of the large amount of land which is occupied by swamp. A large percentage of the water which originates in the morainic regions does not reach the drainage system of the till plain and consequently is contained in the lowland areas where it supports swamp formation.

There are many eskers located throughout the till plain. Two large systems have been formed parallel to one another in the central and northern sections of the region. These two eskers are approximately eight miles long and are oriented in a northeast-southwest direction. Another large sinuous ridge is located in the central part of the till plain. This feature, unlike the other two, is oriented in an east-west direction. All three terminate in approximately the same area. There are many smaller esker systems, most of which are located in the northern half of the till plain.

Eolian forces have deposited a mantle of fine-grained sands over the glacial till in the northern and western sections of the till plain. The surface configuration of the sand areas is characterized by a flat to gently rolling terrain. The high permeability of the sand has caused a different type of vegetation to develop than in the other sections. In places where the coniferous cover has been disturbed, blowouts have been formed. The source region of the sand is the fluvioglacial plains and the moraine regions which surround the till plain.

Type Site Analysis (Figure 6, Plate XII) The major relief forming phenomena of the till plain are the elongated hills which form a linear pattern in the topography. The hills are 1000 to 2000 feet wide and rise approximately 40 feet above the plane of the swamps.

The ground moraine uplands have been severely dissected. The low permeability of the till encourages surface run-off rather than percolation, and consequently the hill slopes are marked by a series of gullies.


ESKERS
GROUND MORAINE RIDGES
ALLUVIUM (DRAINAGE SYSTEM)
SWAMP
LOW POORLY DRAINED GROUND MORAINE


GROUND MORAINE
RIDGES
ESKERS
ALLUVIUM
(DRAINAGE SYSTEM)
SWAMP
LOW POORLY
DRAINED GROUND MORAINE

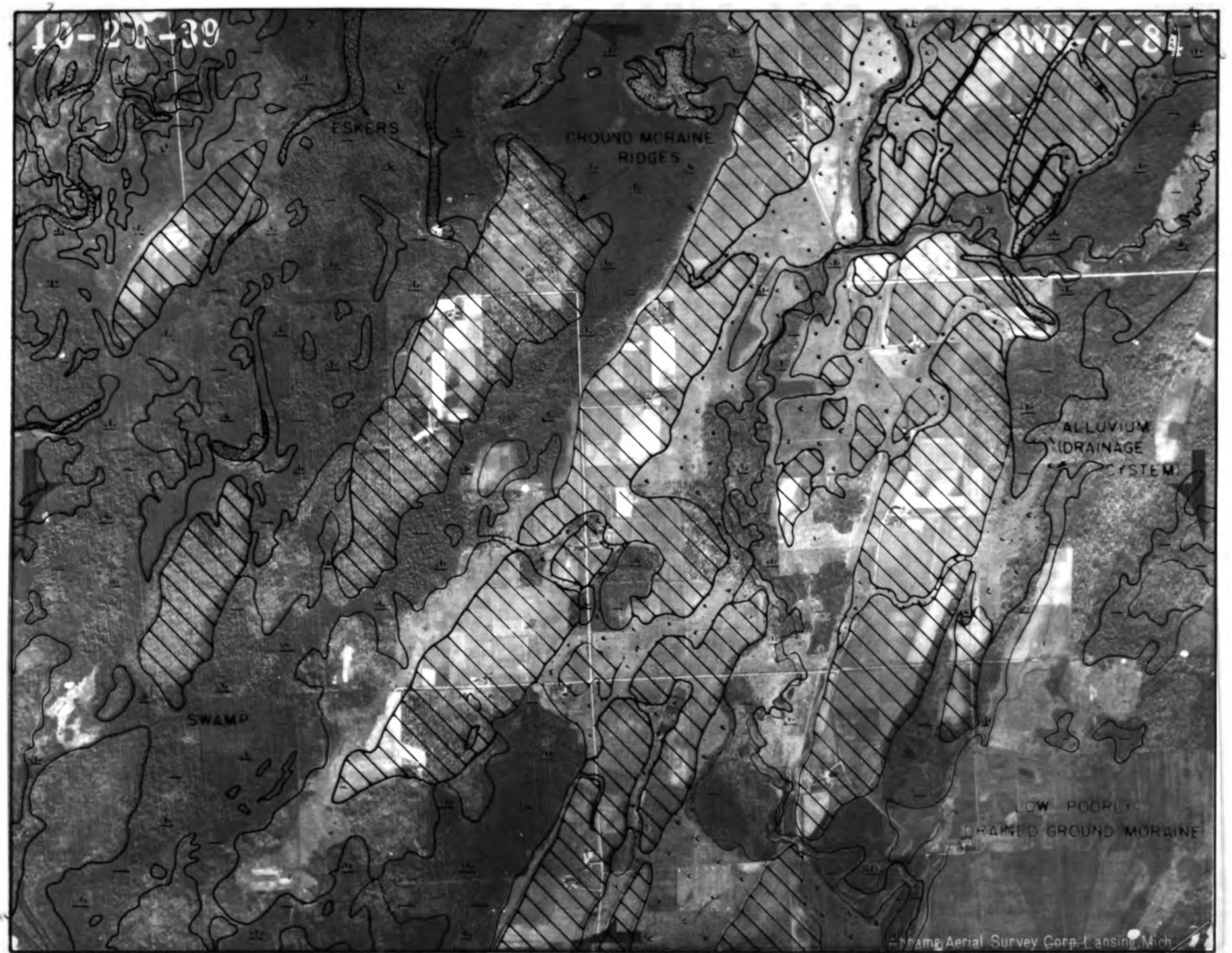
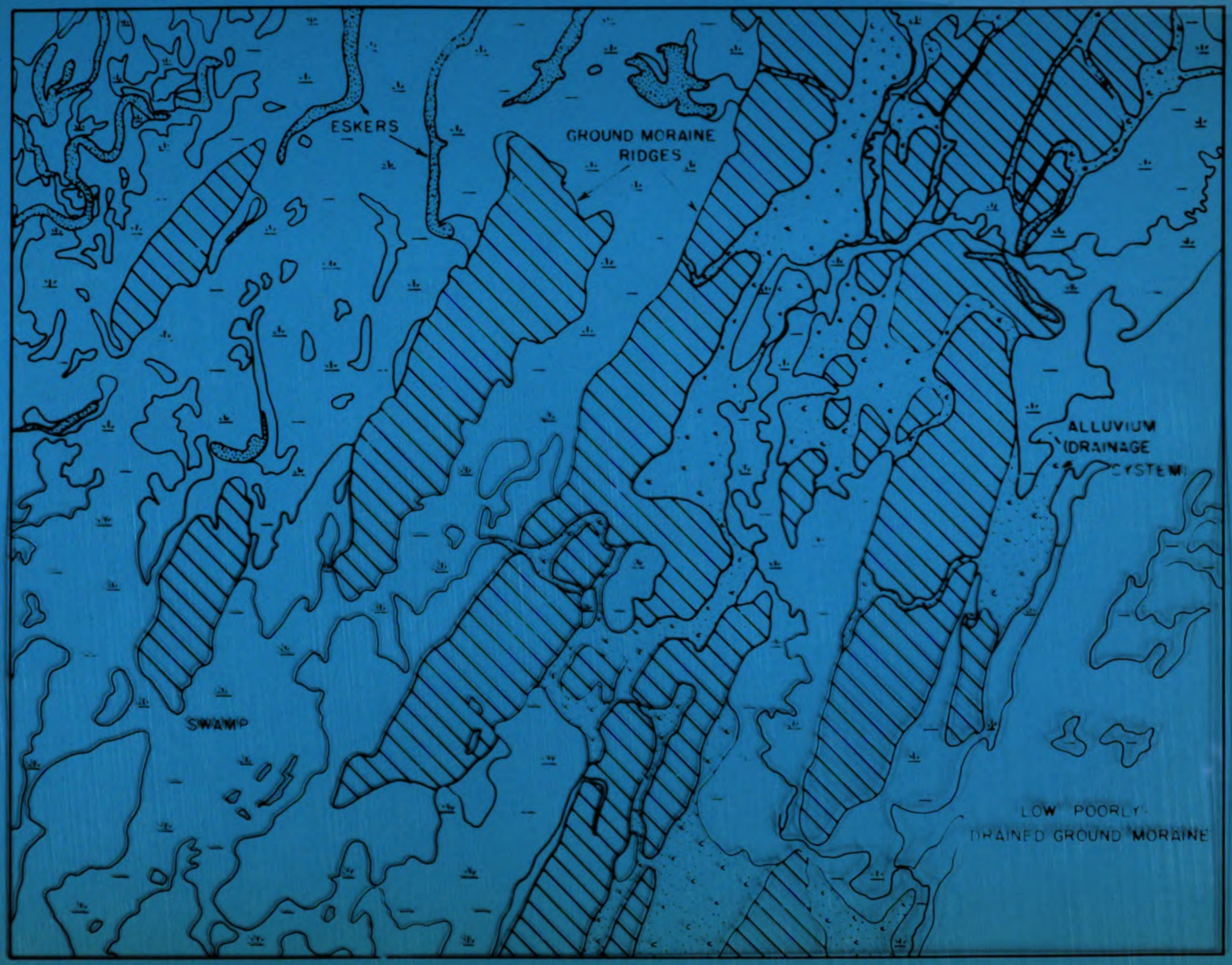
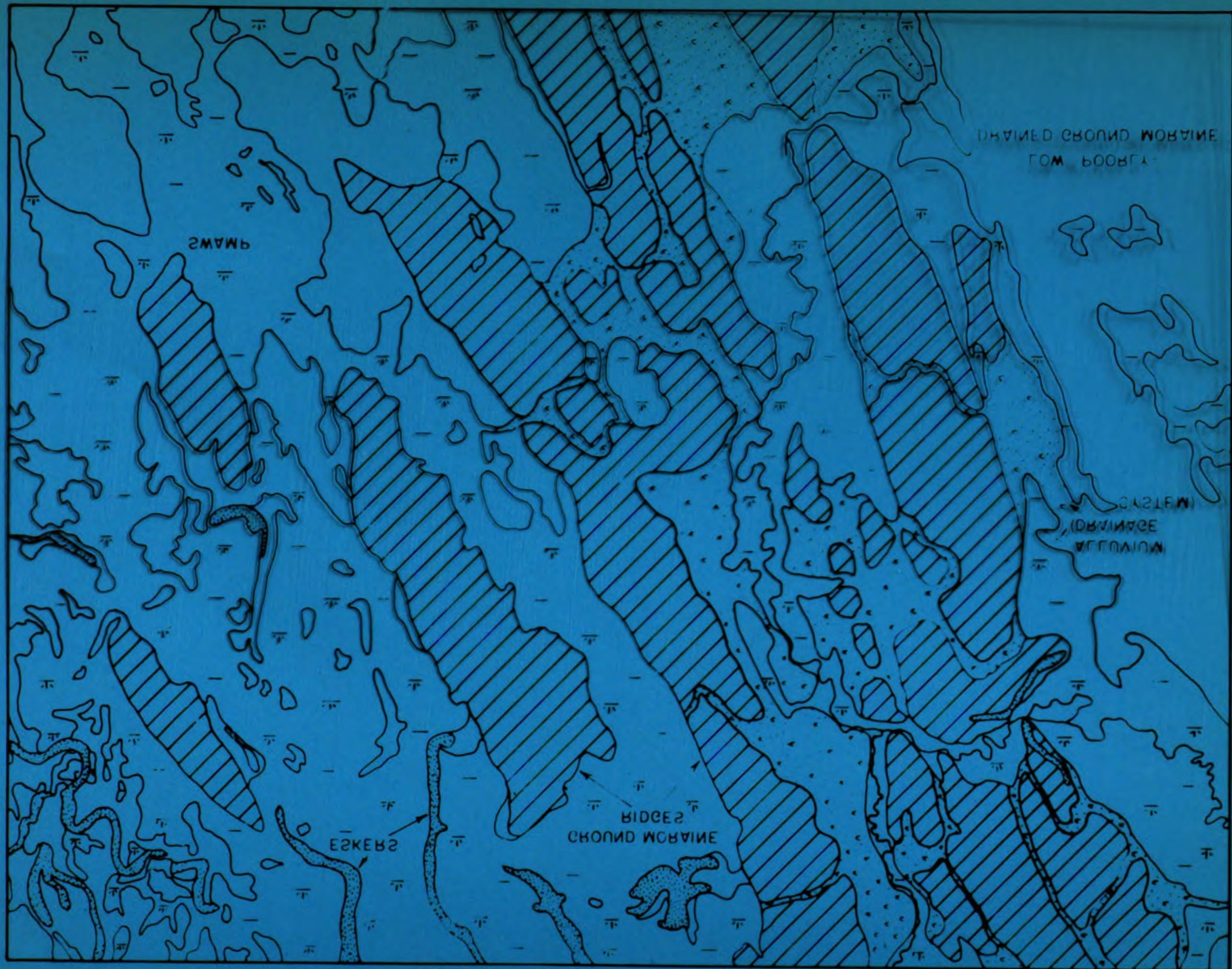

ESKERS
GROUND MORAINE RIDGES
ALLUVIUM DRAINAGE SYSTEM
SWAMP
LOW POORLY DRAINED GROUND MORAINE
Fairchild Aerial Survey Corp. Lansing, Mich.

FIGURE 6


ESKERS
GROUND MORAINE RIDGES
ALLUVIUM (DRAINAGE SYSTEM)
SWAMP
LOW POORLY DRAINED GROUND MORAINE



LOW POORLY DRAINED GROUND MORAINE
ALLUVIUM (DRAINAGE SYSTEM)
SWAMP
GROUND MORAINE RIDGES
ESKERS

FIGURE 6

The gullies are generally broad and shallow and form an intricate drainage network. They form a rectangular pattern as they are oriented parallel and at right angles to the trend of the hills. Many of the larger gully systems which are located in depressions between the uplands mark the locations of former stream channels. These gullies contain alluvial deposits which have a braided pattern.

The valley of the master stream in the eastern part of the type site is marked by a braided alluvium pattern and a narrow, sinuous swamp. The alluvium was deposited during the functioning of a late-glacial discharge stream which often changed its channel. The abandoned channel courses wind through parts of the uplands and form a series of small ground moraine "islands" and are marked by curvilinear depressions which appear as dark gray areas on the photograph.

The area adjacent to the stream channel is characterized by a series of small, sedge-covered islands. The low stream gradient has caused a number of small meanders to form. The meanders cause periodic local flooding in the swamp area.

The fluvioglacial features are located entirely in the northern part of the type site. Most of these features are in the form of small esker segments. Two short eskers are located on the ground moraine uplands in the eastern section of the type site whereas the remainder are situated in the swamplands in the western section.

Most of the esker formations are small and seldom exceed 10 feet in height. In the northwest corner of the type site, three short eskers connect and terminate as a single feature. An irregularly-shaped fluvioglacial deposit is located in the north-central part of the type site. This deposit resembles the form of a kame rather than that of an esker.

The drainage of the type site is very poor. The eskers and ground moraine uplands are the only parts of the region which have satisfactory drainage. The soils of the ground moraine which are adjacent to the swamplands are characterized by mottling and waterlogged substrata in their horizons.

CHAPTER VI

ORIENTED GROUND MORAINE REGION

The largest and most diverse landform type region is that of the oriented moraine hill land. The drumlin field is morphographically and morphogenetically the most interesting complex of landforms in the County.

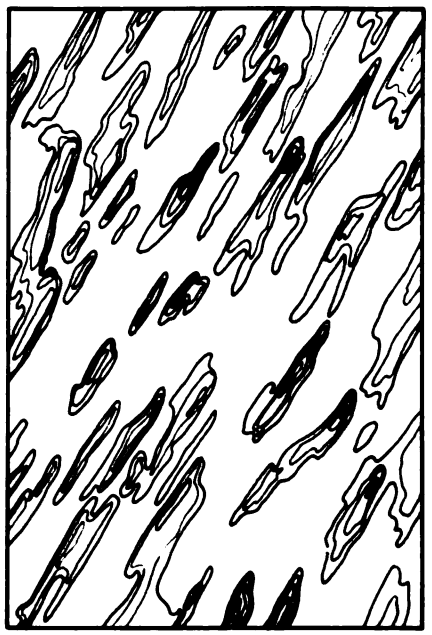
Drumlin fields are not common in Michigan. The Menominee drumlin field is the only one in the Northern Peninsula and there are two in the northern part of the Southern Peninsula. They are located in the Traverse Bay and Cheboygan areas (Melhorn, 1956). The drumlins in the Southern Peninsula are small in comparison to those in Menominee County. In the Traverse Bay region, they vary from one-eighth to one mile in length and range between 40 to 70 feet in height. Those in the Cheboygan area vary from one-eighth to one-half miles in length and range between 20 to 50 feet in height. The drumlins in Menominee County range up to one and one-half miles in length and exceed 130 feet in height.

The three drumlin fields have several characteristics in common. They are all located on sedimentary rock which has a distinct regional dip. Drumlin cores are composed of pre-Valders drift and have a surface plastering of Valders till.

Regional Aspects of the Menominee Drumlin Field - The oriented morainic hill lands of the County extend over 44 miles along a northeast-southwest axis. The width of the region averages approximately 12 miles.

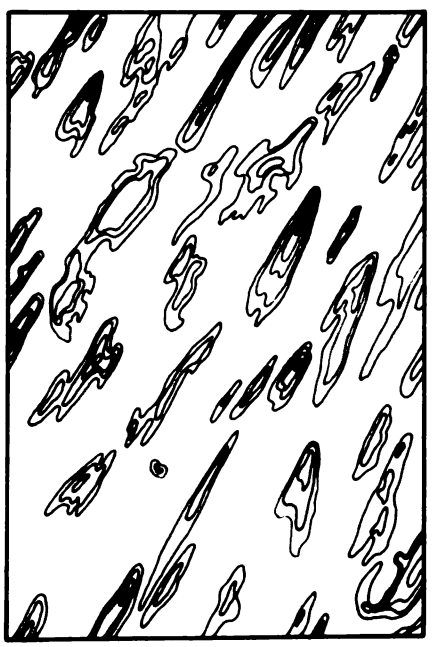
AREA A

NUMBER OF DRUMLINS	61
MEAN LENGTH OF DRUMLINS	3060'
MEAN HEIGHT OF DRUMLINS	48.5'



AREA B

NUMBER OF DRUMLINS	50
MEAN LENGTH OF DRUMLINS	4680'
MEAN HEIGHT OF DRUMLINS	64.5'



AREA C

NUMBER OF DRUMLINS	46
MEAN LENGTH OF DRUMLINS	3960'
MEAN HEIGHT OF DRUMLINS	67'

DRUMLIN DISTRIBUTION

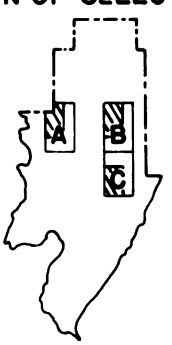
MENOMINEE COUNTY

CONTOUR INTERVAL
30 FEET

SCALE

0 6000 12000 FEET

LOCATION OF SELECTED AREAS



WTS

PLATE XIII

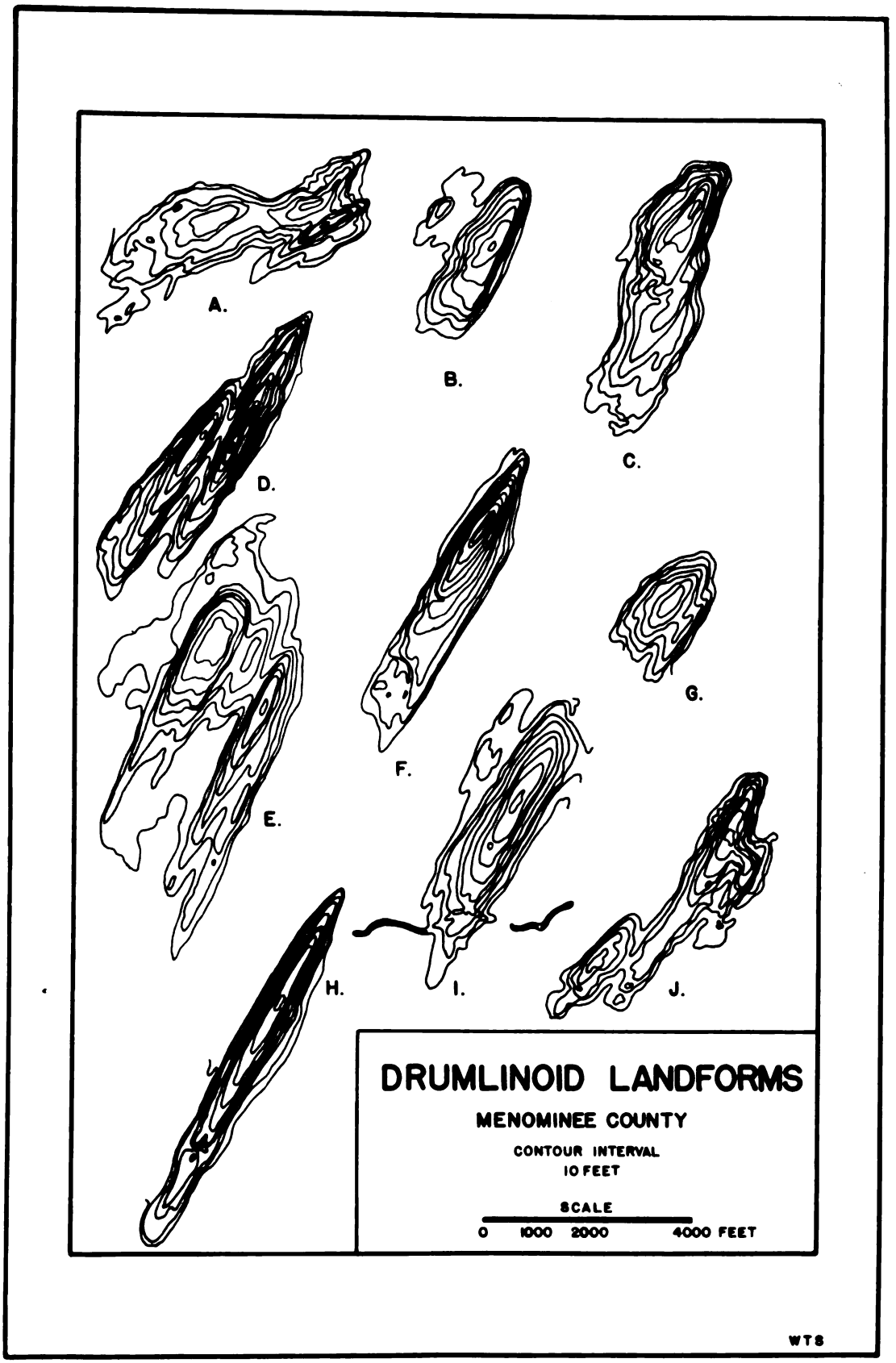

A.
B.
C.
D.
E.
F.
G.
H.
I.
J.
DRUMLINOID LANDFORMS
MENOMINEE COUNTY
CONTOUR INTERVAL
10 FEET
SCALE
0 1000 2000 4000 FEET
WTS

PLATE XIV

Figure 7. An Undissected Drumlin. This drumlin has moderately sloping, convex sides and a broad, flat crest. The forest cover, which is a deterrent to gullying, has only recently been removed. A small swamp has formed in the low, inter-drumlin area due to the absence of exterior drainage.

Figure 8. A Narrow, Steeply Sloping Drumlin. This feature has a narrow crest and steeply sloping convex slopes on which a series of incipient gullies have developed. The profile of this type of drumlin is characterized by an even, gently rounded crest. The lowland in the foreground, although not in swamp, has a very high water table which restricts its agricultural use.

FIGURE 7

FIGURE 8

Figure 9. Material Composition of the Oriented Morainic Hill Lands. The till consists of a sandy clay matrix with a large number of cobbles. The cobbles generally range between one to six inches in diameter.

Figure 10. Gully Development in the Clay Till Along a Road-cut. Gullies develop quickly in areas where the vegetational cover has been removed. The finer particles are washed away leaving behind a very stony slope.

FIGURE 9

FIGURE 10

Figure 11. A Typical Esker in the Drumlin Field. The sinuous form of the ridge is partially obliterated by the dense forest cover. The height of the esker can be visualized from the size of the trees in the background. The high porosity of the material within the eskers allows a different type of vegetation to grow than in the surrounding areas.

Figure 12. Stratified Sands and Gravels of a Stream in the Drumlin Region. The valleys of the larger streams in the drumlin field contain large deposits of stratified sands and gravels. These sediments indicate that there have been frequent changes in the stream courses. The shifting of stream courses is also evident in the organic layer approximately one foot below the present surface.

FIGURE 11

FIGURE 12

The drumlins in the eastern part of the field are higher and occupy a larger percentage of land than in any other section (Plate XIII).

The peripheral parts of the drumlin field are marked by a decrease in drumlin size and an increase in number. The regional boundaries of the north, west, and south sides are not abrupt, instead they tend to blend into the peripheral parts of the surrounding type regions. On the eastern side, however, the wave-cut cliffs form a distinct boundary between the drumlin field and the lacustrine plains. Many drumlins along this boundary have been totally or partially destroyed by wave action of the former, higher lake levels.

There is a gradual shift in drumlin orientation from the eastern to the western portion of the field. The axes of the drumlins in the eastern section trend along an azimuth of 34 degrees. The orientation gradually shifts to a more westerly direction in the extreme western part of the field where the axes have an azimuth of 70 degrees, or a change of 36 degrees over a distance of 12 miles.

The drumlins have a wide variety of shapes (Plate XIV). Many appear as long, narrow ridges whereas others are more symmetrical. Other drumlims appear as groups superimposed on pediments. The pediments are broad, intermediate uplands composed of till. Where drumlins join one another, they form a complex series of slopes. The hills which possess the more typical drumlin form (tapering off of the profile in the direction of ice movement and the blunt end at the stoss side) usually appear as individual features.

Type Site Analysis (Figure 13, Plate XV) The drumlin field is composed of three principle kinds of landforms: glacial, fluvioglacial and fluvial. The post-glacial processes have altered the original form of the glacial deposits and thereby have created a complex topography. Consequently, in order to show the actual surface configuration of a


DRUMLIN
BASE
ARCHES
PRESENT
STREAM
VALLEY
DRUMLINS
(STEEP
SIDE)
ESKERS
SWAMPS
ABANDONED
STREAM CHANNEL


DRUMLIN
BASE
ARCHES
PRESENT
STREAM
VALLEY
DRUMLINS
(STEEP
SIDE)
ESKERS
SWAMPS
ABANDONED
STREAM CHANNEL

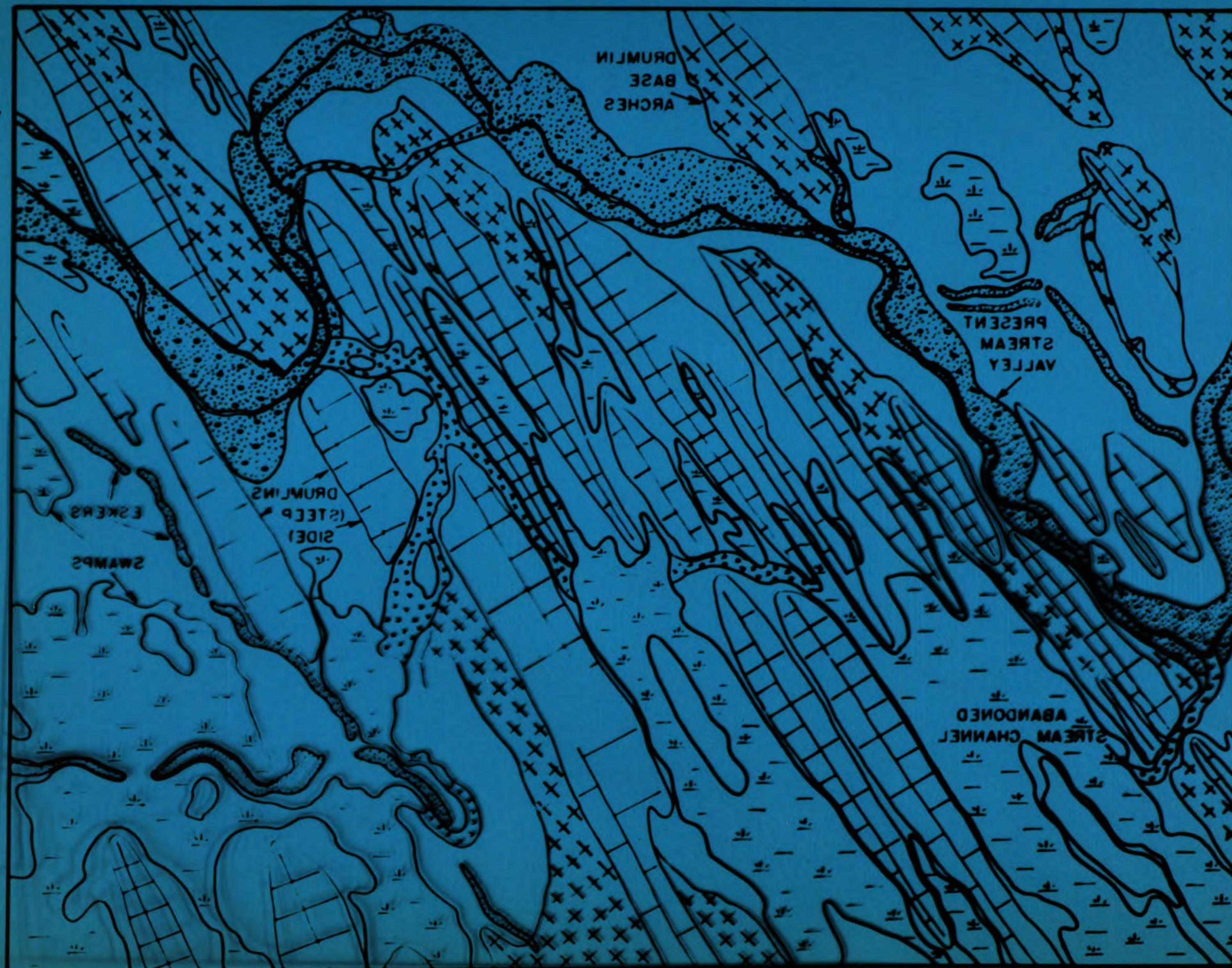

DRUMLIN BASE ARCHES
PRESENT STREAM VALLEY
DRUMLINS (STEEP SIDE)
ESKERS
SWAMPS
ABANDONED STREAM CHANNEL

FIGURE 13

drumlinized region, the various features superimposed on the drumlin area must be considered as important characteristics of the region.

Glacial Features - The material of the oriented morainic hill lands is composed of a clay till with a large number of cobbles. The cobbles are generally well rounded and vary from one to six inches in diameter. Large sedimentary erratics, although uncommon, are scattered throughout the drift.

The slopes of the glacial topography can be classified into three categories: flat to gently sloping lowlands, gently to moderately sloping drumlin pediments, and steeply sloping drumlins. The breaks in slope between these three categories are sharp in some places while in others they are hard to locate.

The flat to gently sloping lowlands constitute a platform upon which the drumlin pediments and drumlins are located. The lowlands have a successive increase in absolute elevation in a northwesterly direction as the result of the underlying rock structure (Plate II). The lowlands have undergone the most extensive alteration by post-glacial processes. Almost all of the fluvially formed features are confined to the inter-drumlin areas.

In the northern part of the type site, the inter-drumlin areas are small and moderately dissected whereas in the southern part they are broad and flat. An important factor which caused dissection in the northern part and not in the southern section is the relationship of the local elevation to the base level of the drainage network. In the north, the lowlands are at an elevation above the level of the primary stream channel and therefore the tributary streams are able to entrench themselves. In the south, however, the broad lowlands do not have an adequate gradient to the principal stream channel and consequently extensive swamps have developed.

The drumlin pediments are intermediate uplands which generally form a base upon which the drumlins are located. They are not all associated with drumlins, however, as in places the drumlins rise directly above the lowlands. Gullies have been formed on the slopes of the pediments due to the low permeability of the till.

The drumlins have been formed in a variety of shapes and sizes. In the central part of the type site, they are long and narrow whereas in the western part they are more blunt. The drumlin profiles vary greatly. In most cases, the highest point of the crest is located towards the stoss end. In others, however, the maximum height is reached at the center of the profile and in some cases at the lee end. Drumlin cross-sections have many forms. The slopes vary from concave to convex and in some cases both types can be found on one drumlin. Many drumlins have a steep slope on one side and a gentle slope on the other. The steep slope can occur on either side.

The drumlins occur as individuals or as interconnected groups. Those that are in groups are commonly superimposed on pediments. There is not any pattern of drumlin density. In the central part of the site, drumlins occur within several hundred feet of one another whereas in the southern and northern areas they are separated by lowlands several thousand feet wide.

Fluvioglacial Features - Effects of fluvioglacial erosion and deposition are evident throughout the drumlin field. Trenches have been cut at right angles through many of the drumlin crests. It can be inferred that these trenches were cut by meltwater streams which were superimposed on the drumlins during the retreat of the glacier.

The most common of the fluvioglacial landforms are the eskers. They are generally located on the drumlin pediments and in the lowlands. Materially, they consist of stratified sands and gravels or boulders.

The eskers vary greatly in size. The larger ones, which exceed heights of 40 feet, form systems which extend for several miles. The smaller eskers, which range between 10 to 20 feet in height, are short, usually not exceeding several thousand feet in length.

The most common esker cross-section is that of steep sides with the height approximately equal to the basal width. The profiles are often interrupted, thereby forming a series of esker segments. Individual segments begin and terminate abruptly rather than gradually tapering off. The larger systems have a greater number of segments due to their superimposition over a more diverse terrain.

In plane view the esker profiles are very irregular. They are all sinuous and in places may suddenly turn at right angles to their major trend. In a few cases, two eskers join and form one system. Almost all of the systems are oriented in a northeast-southwest direction. Those that are situated on drumlin pediments generally follow the trend of the pediment. The eskers that are located in the lowlands are more apt to diverge from the orientation of the other landforms.

The eskers in the type site area are both isolated and segments of much larger systems. Those in the southeastern part are the terminal segments of long eskers whereas those in the northwest section originate and terminate within the site area. The terminal point of the esker which extends along the trend of the drumlin pediment is in the form of a small kame. In the northwestern part of the site, an esker is oriented perpendicular to the axis of the drumlin. It extends up the slope of the drumlin pediment and terminated against the side of the drumlin.

Esker-Drumlin Relationships - There are several instances in the oriented moraine hill lands where eskers cross over drumlins. In the southwest corner of Section 17, T.38 N., R.25 W., an esker has been superimposed on a drumlin. The esker is flat and low at the drumlin crest but on either side has the steep-sided ridge form (Ver Wiebe, 1926). There are cases where esker streams have eroded trenches through drumlins, thereby connecting the eskers on either side. In the southeast corner of Section 12, T.36 N., R.26 W., an esker has cut a channel 15 feet deep and 25 to 40 feet wide through a drumlin. On the northwest side of the drumlin, there is a poorly-defined esker whereas on the southeast side there is a large amount of stratified sand and gravel in the form of an alluvial fan.

The occurrence of eskers on drumlin pediments and in cases crossing over drumlin crests indicates that the eskers were formed either within or upon the ice and superimposed on the glacial topography or else created as continuous delta deposits that were formed during the retreat of the glacier. The trenches which cut through drumlin crests are evidence of fluvial activity at elevations high above the present base level. The occurrence of trenches at different elevations tends to indicate that the fluvioglacial erosion and deposition was caused by

superimposition of the meltwater streams upon the glacial terrain rather than in the form of delta formations with adjacent glacial lakes. If glacial lakes existed in the area there should be some evidence of terracing in the drumlin slopes.

Fluvial Features - Effects of fluvial activity are evident in a number of different forms. A trellis drainage system was formed as a result of structural control. Streams tend to wind around drumlins rather than cut through them. The trunk stream in the type site area is contained to the inter-drumlin lowlands in the west and central parts but has cut through a drumlin pediment in the eastern part. The channel at this point is marked by steep cliffs. The first order tributaries enter the trunk stream at right angles. The trend of these streams, unlike that of the trunk stream, is parallel to the orientation of the drumlins. Second order tributaries which are located on the drumlin slopes join the first order tributaries at right angles. The tributary streams are generally intermittent. The steepest stream gradients occur where channels have been cut perpendicular to the drumlin axis.

An abandoned stream channel exists south of the present channel. Like that of the present drainage system, the channel is marked by a braided arrangement of stratified sands and gravels. The abandoned channel is much narrower than the present course which indicates that it did not function for as long a time as that of the active channel.

A large percentage of the lowlands in the southern part of the site is occupied by swamps. Stream gradients are too low to adquately drain these areas. North of the present channel, however, drainage is much better and consequently the swamps are not widespread.

CHAPTER VII

FLUVIOGLACIAL PLAINS REGIONS

Evidence of past fluvioglacial activity is widespread throughout Menominee County. Meltwater streams have produced large numbers of small features such as eskers, kames, and spillway valleys.

In areas of large scale fluvioglacial activity, plains consisting of outwash material were formed. There are many of these outwash features throughout the County although most of them are small and must be considered as special features of the other landform types. There are three fluvioglacial plains which are large enough to be considered as separate landform types, however. They are the Koss, Little River, and Ingalls fluvioglacial plains. Even though they are areally separated, they all possess a set of similar characteristics.

1. They are characterized by a flat to gently rolling terrain which has not undergone any severe post-glacial erosion.

2. The three regions are poorly drained and have a large percentage of their area occupied by swamplands.

3. The stratified sediments consist of varying textures of sands and gravels, all of which have a distinct red tint.

4. They all possess some of the characteristics of the bordering glacially formed regions.

The Koss fluvioglacial plain is located along the west-central boundary of the drumlin field. Although the drumlins are farther apart and smaller than in the center of the field, they are prominent enough

to form a distinct pattern in the outwash plain. The fluvial sediments were deposited in the lowlands between the drumlins and consequently the larger drumlins which were not buried by the outwash rise above the general level of the plain. The largest number of drumlin outliers is located in the eastern section of the Koss plain. They gradually decrease in both size and number towards the west.

Little Cedar River extends through the central part of the region. The flatness of the terrain and the base level given by the Menominee River system have resulted in a poorly developed drainage network. The channel of the Little Cedar River meanders greatly which further indicates poor drainage conditions. Consequently, a large percentage of the plain is covered by swamps. The isolated drumlins which are scattered throughout the region comprise the largest percentage of the better drained lands.

The Little River fluvioglacial plain is a small, delta-shaped region located at the junction of the Little and Menominee rivers. This plain has been formed on the southern part of the ground moraine region and consequently the basic characteristics of the ground moraine are also found in the outwash area. Low, elongated hills oriented in a northeast-southwest direction rise above the level of the stratified sediments. Although the hills occupy only a small percentage of the total area of the region, they nevertheless form a distinct pattern in the surface configuration.

Little River is the only drainage system in the region. A low stream gradient has deterred run-off and consequently the stream is sluggish and meanders aimlessly. Most of the area adjacent to the

Figure 14. Cross-section of a Delta-kame. A wide variety of grain size is found in the stratification of the formation. The fine-grained light and dark layers are clays whereas the coarser materials are finely washed sands and gravels. The clay layers vary in thickness from lenses to several feet. The tilting and warping of the stratification indicates that slumping has occurred.

Figure 15. A Section of the Delta-kame Where Slumping has not Occurred. The material is composed primarily of sands and gravels. The tilting of the stratification indicates that this part of the delta-kame was deposited directly on the underlying ground moraine. The knobby surface configuration of the formation is shown in the extreme left side of the photograph.

FIGURE 14

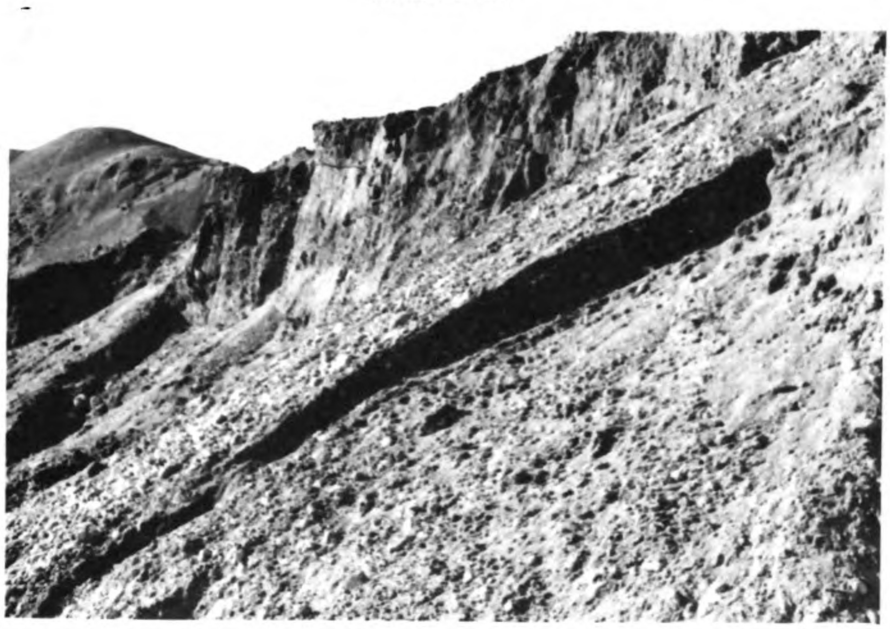


FIGURE 15

channels is periodically flooded. Swamps have formed on most of the level areas; the only places which are adequately drained are the elongated hills of the ground moraine.

The Ingalls fluvioglacial plain forms a natural divide between the southern end of the drumlin field and the northern part of the ground moraine region. In the northern part of the plain drumlin outliers rise above the surface of the outwash. The drumlins diminish in number and size towards the center of the plain and grade into the low, elongated hills which are characteristic of the till plain.

The drainage of the Ingalls outwash plain is better than that in either the Koss or Little River plains. There are many areas which have sufficient surface and subsurface drainage to prohibit swamp formation. The area is more accessible for analysis and it was, therefore, selected to be used as the type site area.

Type Site Analysis (Figure 16, Plate XVI) The surface configuration of the type site area is composed of four kinds of features. The flat to gently undulating surface of the fluvioglacial sediments forms the base above and below which the other landforms are located.

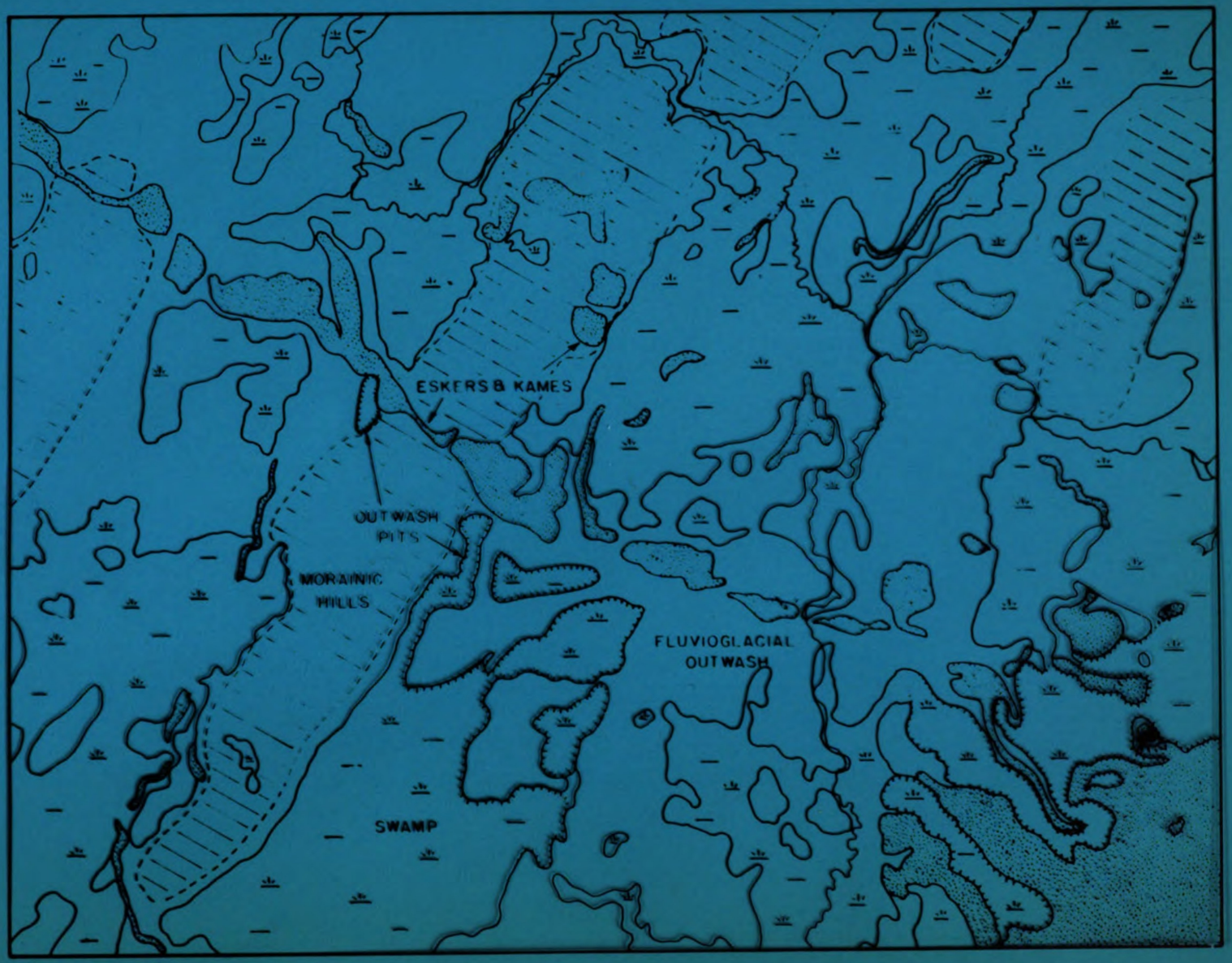
There are two distinct patterns in the fluvioglacial plain. In the northern part of the type site the outwash has been deposited without any great irregularities. The sediments form a smooth, undulating terrain marked only by an intricate series of channels. The channel pattern reflects material differences rather than relief variations. The areas of finer-grained material contain a higher percentage of water than do the coarse-grained gravels and therefore accentuate the pattern on the photograph.

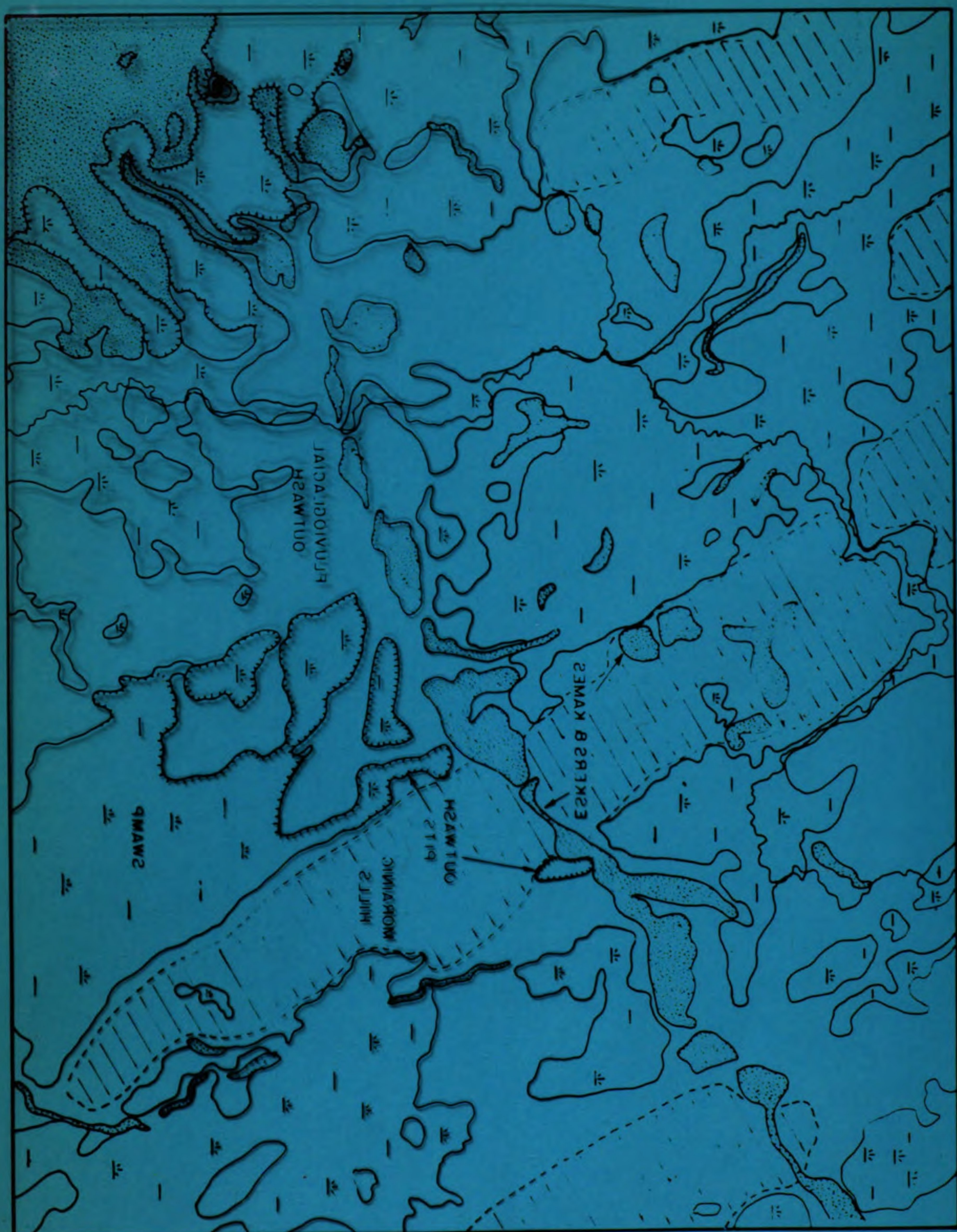
In the southern section of the type site the fluvioglacial material is marked by a hummocky surface configuration. An intricate series of short, interrupted channels form a linear system oriented in an east-west direction. The local relief of the hummocky topography is slight, never in excess of 10 feet. The depressions have a dark-gray tone on the aerial photo, the result of swamp formation.

The elongated, ground moraine hills cross the type site in a northeast-southwest direction. They vary between 1,000 and 2,500 feet in width and seldom exceed 20 feet in height. The crests of the hills are well rounded and flanked by gently sloping sides. Small gullies have formed on the sides of the hills. Thin deposits of fluvioglacial material are located on various parts of the hills (as on the ground moraine arch in the south-central section of the type site).


ESKERS & KAMES
OUTWASH PITS
MORAINIC HILLS
FLUVIOGLACIAL OUTWASH
SWAMP


ESKERS & KAMES
OUTWASH PITS
MORAINIC HILLS
FLUVIOGLACIAL OUTWASH
SWAMP


ESKERS & KAMES
OUTWASH PITS
MORAINIC HILLS
FLUVIOGLACIAL OUTWASH
SWAMP



FLUVIOGLACIAL
OUTWASH
ESKERS & KAMES
OUTWASH
PITS
MORAINIC
HILLS
SWAMP

FIGURE 16

A large number of fluvioglacially formed features rise above the level of the outwash plain. A high, interrupted ridge extends across the type site in a northwest-southeast direction. This particular feature is a delta-kame which continued to form during the recession of the ice-front. In the northwestern part of the type site, the delta-kame attains a height of 80 feet whereas in the southeastern part the system has greater horizontal rather than vertical dimensions.

There are several distributaries that diverge from the trend of the delta-kame. In the eastern part of the site the distributary is broad and flat whereas in the central section another distributary has the typical esker form of steep sides and a narrow crest. The latter distributary bifurcates at its terminal point.

There are many smaller, irregularly-shaped kame deposits, most of which are located on the north side of the delta-kame. These deposits are situated both in the outwash areas and on the morainic hills. The kames are randomly scattered throughout the area and do not form any type of linear pattern. Heights of the deposits vary between 20 and 50 feet.

The irregular shapes of many of the kame formations are the result of slumping. The stratification of the sediments is often greatly disrupted which indicates that parts of the kames were originally formed as ice contact features.

Eskers are located throughout the type site. The eskers are often interrupted and appear as a series of short segments. They have steep sides and narrow crests as do those in the other landform type regions. However, all of the eskers in the type site are small and seldom exceed 10 to 15 feet in height. The common orientation of the sinuous ridges is northeast-southwest.

The outwash material is marked in many places by irregularly shaped, steep sided depressions, most of which are adjacent to the delta-kame system. It can be inferred that these depressions mark the locations of former stagnant ice blocks around which the fluvioglacial sediments were deposited. After the ice blocks melted, their indentations in the surrounding material formed the existing depressions.

The smaller depressions generally are completely surrounded by steep sides whereas the larger ones often have one section, usually away from the source region of the sediments, level with the plane of the outwash. The depth of the pits seldom exceeds 10 feet. Subsequent swamp formation has modified the depth, thereby distorting the actual dimensions of the depressions.

The drainage of the type site is poor. Most of the lowland areas have become basins for organic accumulation. The larger depressions are connected by a series of small, sluggish streams. Stream gradients are very low, however, and the channels are marked by many small meanders. There are two types of swamps. The more shallow, broader ones support a dense forest growth whereas the deeper swamps generally contain a growth of sedges or leatherleaf. The better drained areas include the eskers, kames, and ground moraine hills.

The Ingalls fluvioglacial plain was formed during the last recession of the ice sheet. The large delta-kame indicates that a body of water was dammed by the ice and surrounding uplands. The channel system in the till plain region indicates that the lake drained to the south. The

sediments adjacent to the delta-kame were deposited by the same forces that formed the delta-kame. A gradual slope extends up to the steep slopes of the system. In the areas not adjacent to the delta-kame, the outwash was deposited perpendicular to the ice front. The channel systems in the outwash show that the meltwater streams were oriented in an east-west direction.

CHAPTER VIII

THE LACUSTRINE PLAINS

The lacustrine plains region of Menominee County occupy a strip of land two to five miles wide along the present shoreline of Green Bay. The plains are narrowest at the southern end of the County due to a lesser degree of crustal rebound than in the north and the presence of a morainic system which prevented the westward expansion of the water during the higher lake stages.

The form of the lacustrine plains is not homogeneous in the area as a whole. In the southern section the abandoned beach ridges are poorly developed and the major relief features have been formed by eolian activity. The swamps are generally shallow and small.

The central part of the lacustrine plain is characterized by two dominant abandoned beach ridge systems and broad, intervening lowlands. The Algonquin and Nipissing beach ridge systems are the major relief features. The Algonquin beach is located along the western boundary of the plains whereas the Nipissing system is close to the present beach. A step-type topography has been formed below the position of the Algonquin system by a series of small, poorly-developed abandoned beach ridges. These small ridges have primarily been formed in areas where bays existed. Eolian activity in this section has not produced any large dune formations.

The northern part of the lacustrine plains is the widest and has undergone the most extensive uplift. The higher lake levels which were

reached during the Algonquin time spread into the eastern part of the drumlin field. Many partially eroded drumlins exist in the western part of this section.

The Algonquin and Nipissing beach ridge systems are best developed in this area. The only interruptions in the beach ridges occur where streams have cut through them. In many places the abandoned beach ridges rise 20 feet above the surrounding terrain.

There are many dune formations in the northern part of the plains. A large dune field is located along the valley of Cedar River. Individual dunes have crescentic shapes with the tails pointing in a northerly direction. Many of the dunes have elevations in excess of 40 feet.

Most of the broad lowland areas are poorly drained and consequently much of the region is occupied by swamp. The more shallow, smaller swamps, most of which are located east of the Algonquin beach ridge, support a dense growth of coniferous trees. The swamps west of the Algonquin system are much larger and deeper. Small lakes exist in parts of these swamps. Most of the vegetational cover is composed of sedges and leatherleaf shrubs. Small islands within the swamps support a growth of coniferous trees.

The Present Shoreline - The only irregularities in the present shoreline are in the form of small points and bays. The points are composed of glacial erratics from which the matrix has been removed. The points have complementary embayments on one side, generally the south, in which silts and muds have accumulated.

Figure 17. Cross-section of a Dune. The regular foreset bedding which is characteristic of dunes is well visible. The height of the dune is approximately 15 feet whereas the length is over one-half mile.

Figure 18. Cross-section of an Abandoned Beach Ridge. The composition of the stratification indicates that the lake level was fluctuating during the formation of the ridge. This section of the beach ridge is unique as most abandoned beach ridges are composed primarily of sands.

FIGURE 17

FIGURE 18

Figure 19. Vegetation Types of one of the Larger Swamps of the Lacustrine Plains. The poorly-drained lowlands behind the abandoned beach ridges are characterized by two types of vegetation. The larger, more open swamps support a growth of leatherleaf and sedges. Areas of open water are found in this type of swamp.

Figure 20. Oblique View of the Swamp in the Above Photograph. The open channel marks the position of the main stream. Small islands of trees mark the locations of areas where inorganic materials rise above the water level.

FIGURE 19

FIGURE 20

The only conspicuous deltas have been formed at the mouths of the larger drainage systems. The Menominee delta has an irregular shape with most of the alluvium located on the south side of the channel. The Cedar River delta is more poorly developed. Most of the sediments have been carried south by wave and current action.

The floor of the Green Bay basin slopes gradually towards the center of the bay as a result of the sedimentary rock structure (Chapter IX). The bottom topography adjacent to the shoreline is composed of a series of sand bars and interlying rock strips. In the areas where off-shore bars are high enough to destroy most of the wave action, lagoons have formed. They are characterized by shallow water and bottom accumulations of muds. Many of the lagoons have a dense growth of reeds and rushes.

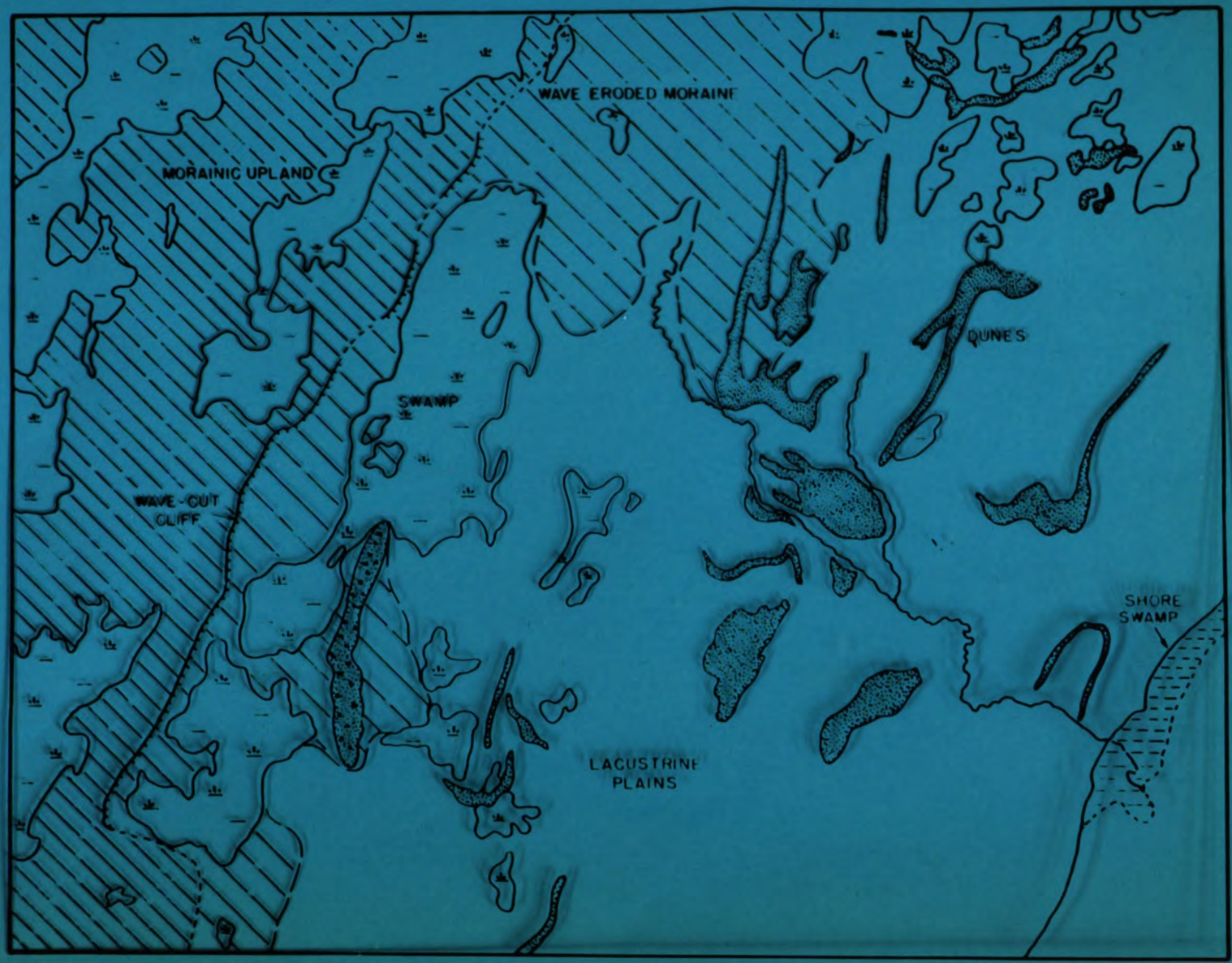
Type Site Analysis (Figure 21, Plate XVII) The most characteristic feature of the lacustrine plains is the flatness of the terrain. The regional gradient of the type site, which slopes from west to east, can be divided into two parts. Below the 620 foot contour, an even slope of approximately 20 feet per mile exists. The uniformity of the slope is broken only in those places where streams exist and where dunes and portions of abandoned beach ridges have been formed.

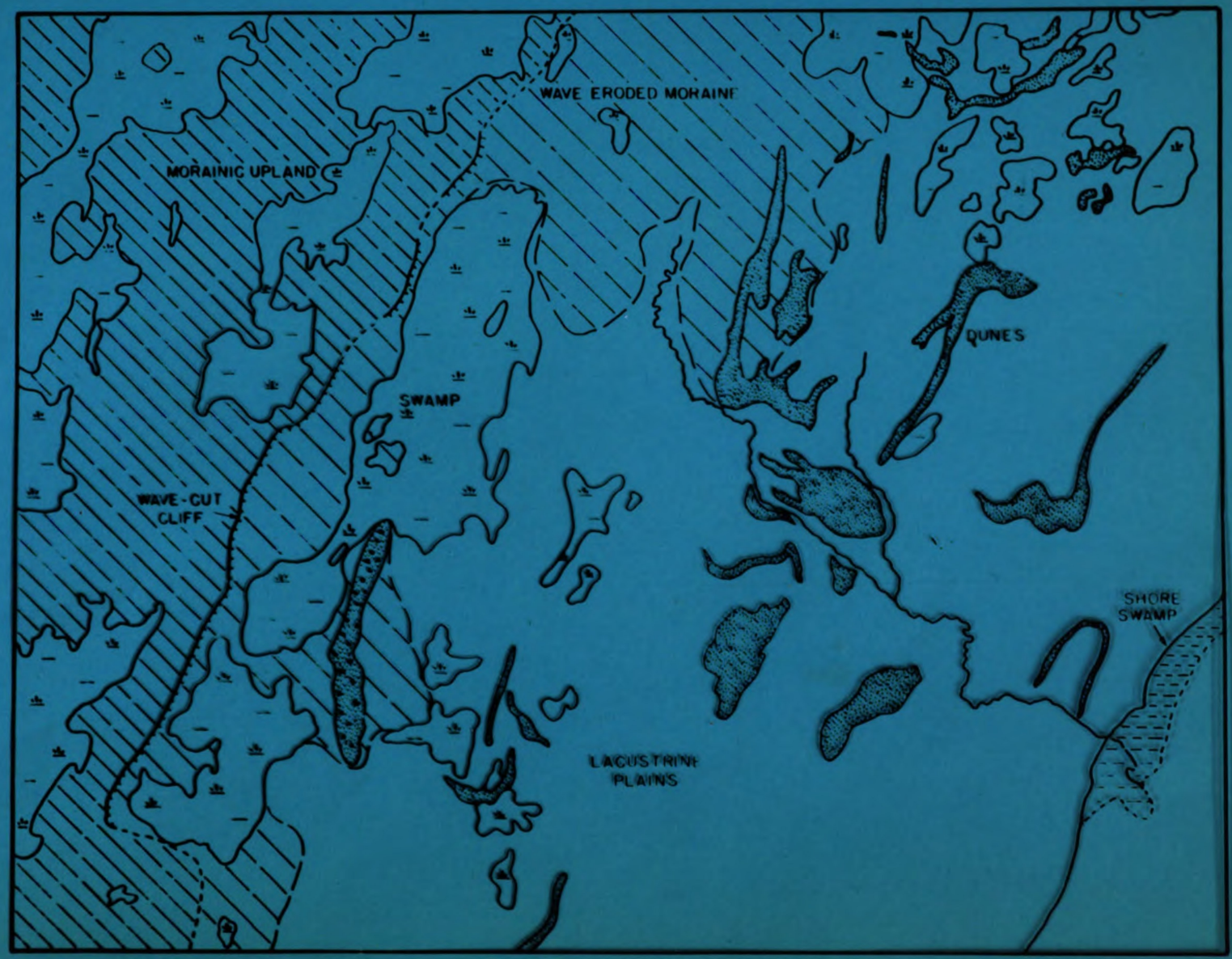
The surface configuration of the area above the 620 foot contour is characterized by a series of parallel, well-rounded hills which are separated by broad lowlands. The hills are remnants of morainic uplands which were modified by wave erosion. The local relief of this section of the lacustrine plains is between 20 and 30 feet.

A series of wave-cut cliffs mark the western boundary of the lacustrine plains. Interruptions occur along the cliffs where the morainic lowlands formed small bays. The wave-cut cliffs are moderately to steeply sloping and are marked by an increase in elevation of approximately 20 feet.

Two types of features have been formed on the plains. Sections of abandoned beach ridges, although poorly developed, exist in both the eastern and western parts of the type site. The abandoned beach ridge in the western part was formed during the Algonquin stage of the Great Lakes. The ridge is composed of stratified sands and gravels which were deposited in a horizontal plane. The northern part of the abandoned beach ridge grades into one of the residual morainic hills.

The Nipissing level of the Great Lakes did not form a continuous beach ridge system in this region. Only a series of small, isolated segments parallel to the present shoreline have been formed. The segments are composed almost entirely of stratified sand.


WAVE ERODED MORAINE
MORAINIC UPLAND
DUNES
SWAMP
WAVE-CUT CLIFF
SHORE SWAMP
LACUSTRINE PLAINS


WAVE ERODED MORAINE
MORAINIC UPLAND
DUNES
SWAMP
WAVE-CUT CLIFF
SHORE SWAMP
LACUSTRINE PLAINS

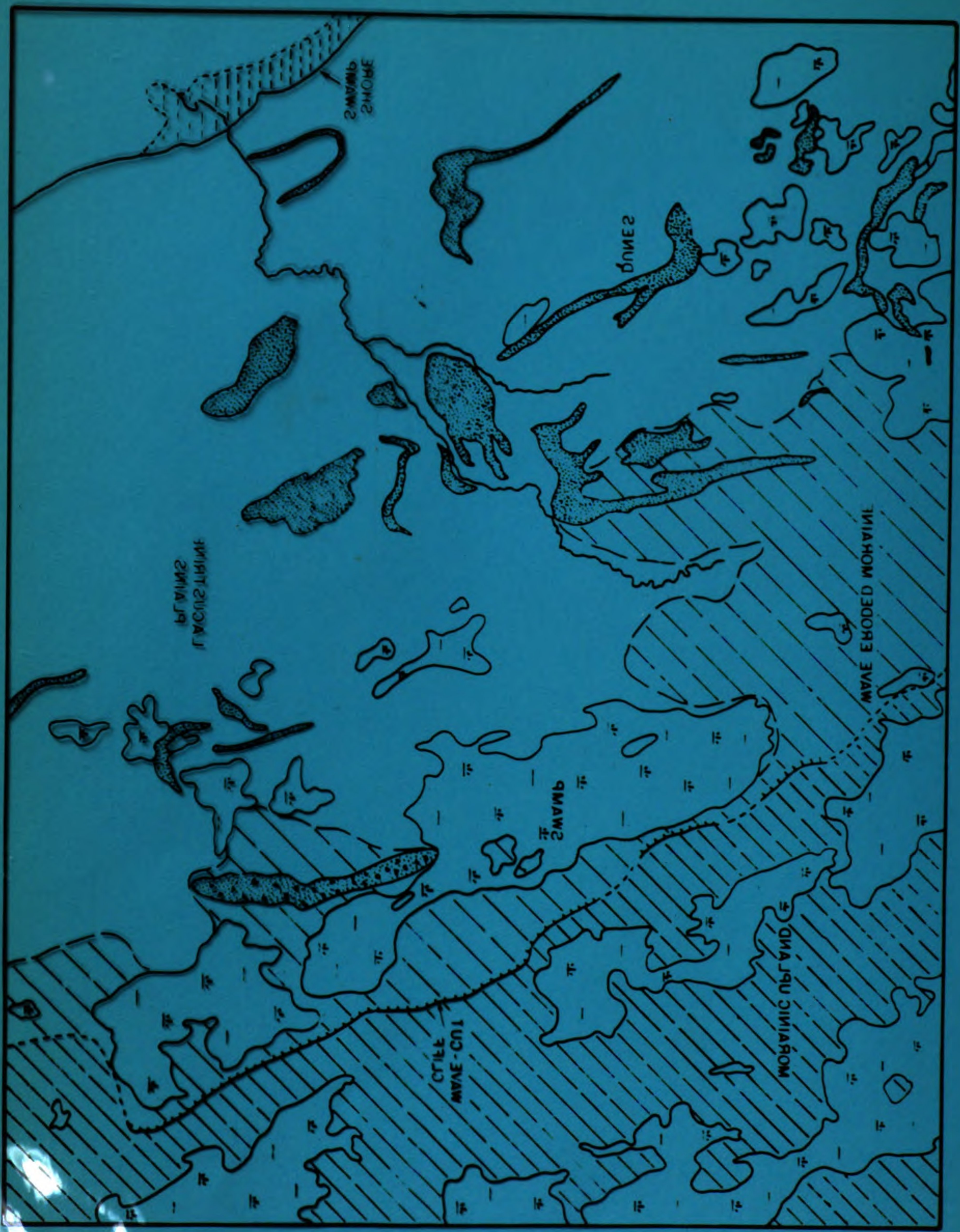

SWAMP SHORE
DUNES
LACUSTRINE PLAINS
SWAMPS
WAVE ERODED MORAINE
WAVE-CUT CLIFF
MORAINIC UPLAND

FIGURE 21

Sand dunes are the most common relief features in the type site area. The dunes have a variety of shapes. Many are linear and parallel to the present shoreline. Fields of dunes have been formed in several places. These areas are characterized by a hummocky surface configuration. Almost all of the dunes have been formed between the 610 and 630 foot contours. Their location is typically between the levels attained by the Algonquin and Nipissing lake levels (See Chapter IX).

The dunes vary greatly in height. Many individual dune formations exceed 30 feet in height whereas the dune fields generally are not in excess of 10 feet above the surrounding terrain. Where the vegetational cover has been disturbed by cultural activity, blowouts have formed on the dune crests.

The lacustrine plains are composed of three principal types of material. The lowland and depression areas have become swamps as a result of poor drainage. The area above the 620 foot contour has many large swamps which have a definite linear pattern whereas the swamps below the 620 foot contour are generally smaller and have more irregular shapes.

The swamps are bordered by poorly drained mineral soils. These soils have also formed in some of the depressions which do not have a true swamp development. An organic layer less than 12 inches thick mantles the waterlogged underlying mineral material. These soils reflect the appearance of a lacustrine floor as they form a "blotchy" pattern in the surface configuration. This may be explained by the intermixing of sand and shallow formations of organic material in the flat, more poorly drained parts of the plains.

The uplands in the western section of the lacustrine plains are composed of till. The eastern sides of the hills have a thin mantle of lacustrine and eolian sand whereas the western sides are generally stony. The flat areas in the eastern part of the plains are composed of coarse sands. The sands are underlain by gravels and clay lenses. The clay restricts the rate of percolation and consequently much of the surface material is constantly waterlogged.

The drainage pattern of the type site area belongs to a single stream. Many of the depressions do not have any exterior drainage but are instead local collecting basins. The stream is fed by local run-off waters and subsurface percolation.

CHAPTER IX

REMARKS ON MORPHOGENETIC PROBLEMS

Menominee County is an excellent site for genetic investigations on glacial and post-glacial terrain evolution. A great variety of Pleistocene relic landforms are distributed over a relatively small area. Post-glacial alterations of the landscape are very much in evidence even though they are definitely of lesser importance than the morphogenesis which took place before and during the Pleistocene.

The genetic problems investigated in the County by former students primarily involve the formation of individual glacial landforms. There have been no studies concerned with the evolution of landform patterns formed by post-glacial processes. The genesis of the present surface configuration, therefore, cannot yet be fully understood.

Out of many problems which exist, three have been selected to shed light on the morphogenesis of the area. They involve the evolution of the landform patterns by both glacial and post-glacial processes.

The Regional Importance of the Wisconsin Glaciation - Most of the unconsolidated material in Menominee County was deposited in the various phases of the Wisconsin glaciation. Drift from the preceding glaciations (Nebraskan, Kansan, Illinoian) has not yet been found in the area.

Twice the County was entirely ice-covered during Wisconsin time. It remained glaciated throughout the first six substages of the Wisconsin glaciation and became first ice-free during the Two Creeks Interstadial when the ice front receded to a position north of Mackinac

Straits (Hough, 1958). The Menominee area remained ice-free until the Valders Advance during which the glacier again pushed south into Wisconsin (Thwaites, 1943). The Valders Advance, recognized as the ultimate substage of the Wisconsin glaciation in the United States, for the last time covered Menominee County.

According to Melhorn (1956), the drift lithology of regions in the Southern Peninsula affected by the Valders Advance reveals that the majority of glacial landforms were created during pre-Valders stages and later modified by the Valders ice. Drumlins in the Traverse Bay and Cheboygan areas contain cores of pre-Valders drift and a thin plastering of Valders drift. Many of the valley trains in these areas are composed of Valders till superimposed on pre-Valders landforms.

The Munsell scale, a standardized color chart for soils, was used by Melhorn to differentiate between the two drifts. Pre-Valders drift is brown (oxidized) or dark blue (unoxidized) with a Munsell range between 10YR 6/3 and 10YR 4/1. The Valders drift is represented by a red color with a Munsell range between 5YR 7/3 and 7.5YR 8/4.

Application of the same technique in Menominee County yielded the result that all samples taken were within the established range for Valders drift. The depth of the Valders till was not determined although road cuts in several drumlins showed the red till at depths of twenty feet.

It can be inferred that the genesis of glacial landforms in Menominee County was similar to that of Valders-affected areas in the Southern Peninsula. Both areas were twice glaciated during Wisconsin time and the same basic landform types exist in both of them. Pending further studies, it

LATE WISCONSIN EVENTS OF THE

LAKE MICHIGAN LOBE

(From Zumberge, 1956)

Years B.P.	Wisconsin Chronology	Lake Stage (elevation above sea level).
		Lake Michigan (581)
2,500		Algoma (595)
3,500	XEROTHERMIC	Nipissing Great Lakes (605)
5,000	NORTH BAY becomes ice free	Lake Chippewa (230)
6,000	GENERAL	Payette and other "Lower Algonquin" lakes of Stanley
	VALDERS	
8,000		
8,500	RETREAT	Lake Algonquin (605)
		Toleston (605)
	VALDERS MAXIMUM	Calumet (620)
11,000	TWO CREEKS INTERSTADIAL	Bowmanville (below 580)
	C Port Huron	Glenwood (640)
	A Lake Border	
	R Tinley	
	Y Valparaiso	

Table 1

may be assumed that the basic glacial topography of the County was formed during pre-Valders glaciations and later covered with a veneer of red drift by the Valders Advance.

Evidence for the Existence of Fluctuating Lake Levels in the Lake Michigan Basin - The level of the Great Lakes has been fluctuating since the Cary substage of the Wisconsin glacier (Table 1). Abandoned beach ridges above the present lake level mark former higher levels. Submerged stream valleys and lake core samples indicate the existence of former lower lake levels. Crustal rebound after the withdrawal of the glacier has differentially raised the abandoned beach ridges. The lacustrine plains of the County and the Green Bay basin contain major evidence for these isostatic movements.

There are two abandoned beach ridge systems on the lacustrine plains that mark positions reached by former high lake levels. The higher one was formed during the Lake Algonquin stage approximately 8,500 years ago (Ver Wiebe, 1926). It is located west of Menominee in the southern part of the County at an elevation of 620 feet, or 40 feet above the present lake level. In the north end of the County, the same beach ridge system is located at an elevation of 670 feet (Plate XVIII). These elevations correspond well with Goldthwait's Lake Algonquin elevations for the eastern shore of Green Bay (1907). The discrepancy in elevation must be attributed to differential crustal rebound.

The lower abandoned beach ridge system was formed during the Nipissing stage of the Great Lakes. This system closely follows the form of the present shoreline although it is located between one-half to two miles inland (Plate XVIII). The lake levels during Algonquin and Nipissing time

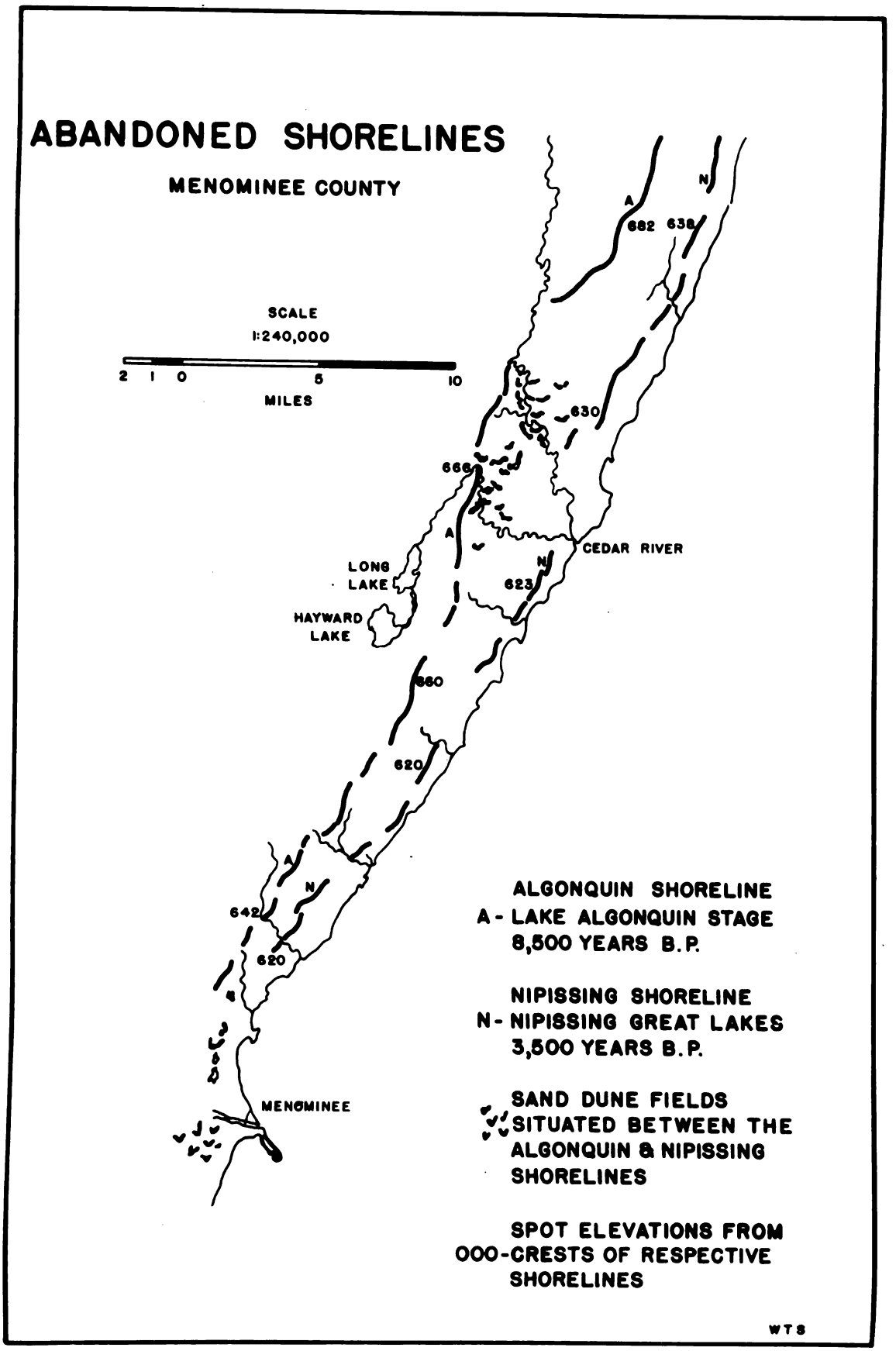

ABANDONED SHORELINES
MENOMINEE COUNTY
SCALE
1:240,000
2 1 0 5 10
MILES
A
N
682
638
630
666
A
CEDAR RIVER
LONG
LAKE
N
623
HAYWARD
LAKE
660
620
A
N
642
620
MENOMINEE
ALGONQUIN SHORELINE
A - LAKE ALGONQUIN STAGE
8,500 YEARS B.P.
NIPISSING SHORELINE
N - NIPISSING GREAT LAKES
3,500 YEARS B.P.
SAND DUNE FIELDS
SITUATED BETWEEN THE
ALGONQUIN & NIPISSING
SHORELINES
SPOT ELEVATIONS FROM
000-CRESTS OF RESPECTIVE
SHORELINES
WTS

PLATE XVIII

were approximately the same in terms of absolute elevation but 5,000 years had elapsed between the two stages (Table 1). Crustal rebound during this interval had raised the Algonquin beach ridge in the northern part of the Great Lakes to increasingly higher elevations in a northern direction above the position reached by the Nipissing Lake level. The Nipissing beach ridge system is at an elevation of 605 feet at the south end of the County but at the north end it has been raised to an elevation of 640 feet (Plate XVIII).

There are other abandoned beach ridges on the lacustrine plains but they are small and discontinuous. They were formed at intervening lake stages between the two major recognized levels.

According to recent investigations, a low water stage called Lake Chippewa (Hough, 1958) occurred between the Algonquin and Nipissing stages of the Great Lakes. Lake Chippewa came into existence when the North Bay channel became ice-free allowing the upper Great Lakes to drain to a low level of 230 feet. The body of water that existed in the Lake Michigan basin during this time is referred to as Lake Chippewa. Drainage continued through the North Bay channel until crustal rebound had elevated the channel sufficiently to terminate flow.

Most of the evidence of the Lake Chippewa stage is found in the lake basins below the present water level. The bottom topography of the Great Lakes has been charted and many of the valleys formed during the Chippewa stage can be traced. A submerged valley connects the Green Bay and Lake Michigan basins. Two valleys were cut in the Green Bay basin, one extending from Washington Island south to Green Bay and the other extending from Washington Island north through Little Bay De Noc

(Plate XIX). A gorge 100 feet deep has been cut through the Niagara Escarpment where the valley enters the Lake Michigan basin.

The north valley is much wider and more deeply entrenched than the south branch indicating that it carried a much greater volume of water. There is evidence that the north branch was a spillway for Lake Duluth during the Chippewa stage. Almost all of the glacial deposits between Rapid River and Munising were carried south by the spillway waters into the Lake Michigan basin. This part of the valley is marked by abandoned channel scars and bedrock outcrops.

The submerged valleys in the Green Bay basin reach a maximum depth of 180 feet below the present lake level, or an elevation of 400 feet. The Lake Chippewa level of 230 feet was far below this mark indicating that the stream gradient was steep enough to allow rapid downcutting. This factor is the principal cause of the deep entrenchment of most of the submerged valleys.

There are many sand dunes located between the Algonquin and Nipissing beach ridges on the lacustrine plains. They were formed after the Algonquin lake level had receded and before the level of the Nipissing Great Lakes was reached. The dunes were formed from lacustrine deposits left exposed to subaerial processes during the low water stage.

Most of the dunes have barchan shapes, but in many places they are joined and resemble transverse dunes. All have steep southern slopes indicating that they were formed by winds with a prevailing northerly component. It can be inferred that the climate during this time was arid, preventing anchoring of the sand by vegetation.

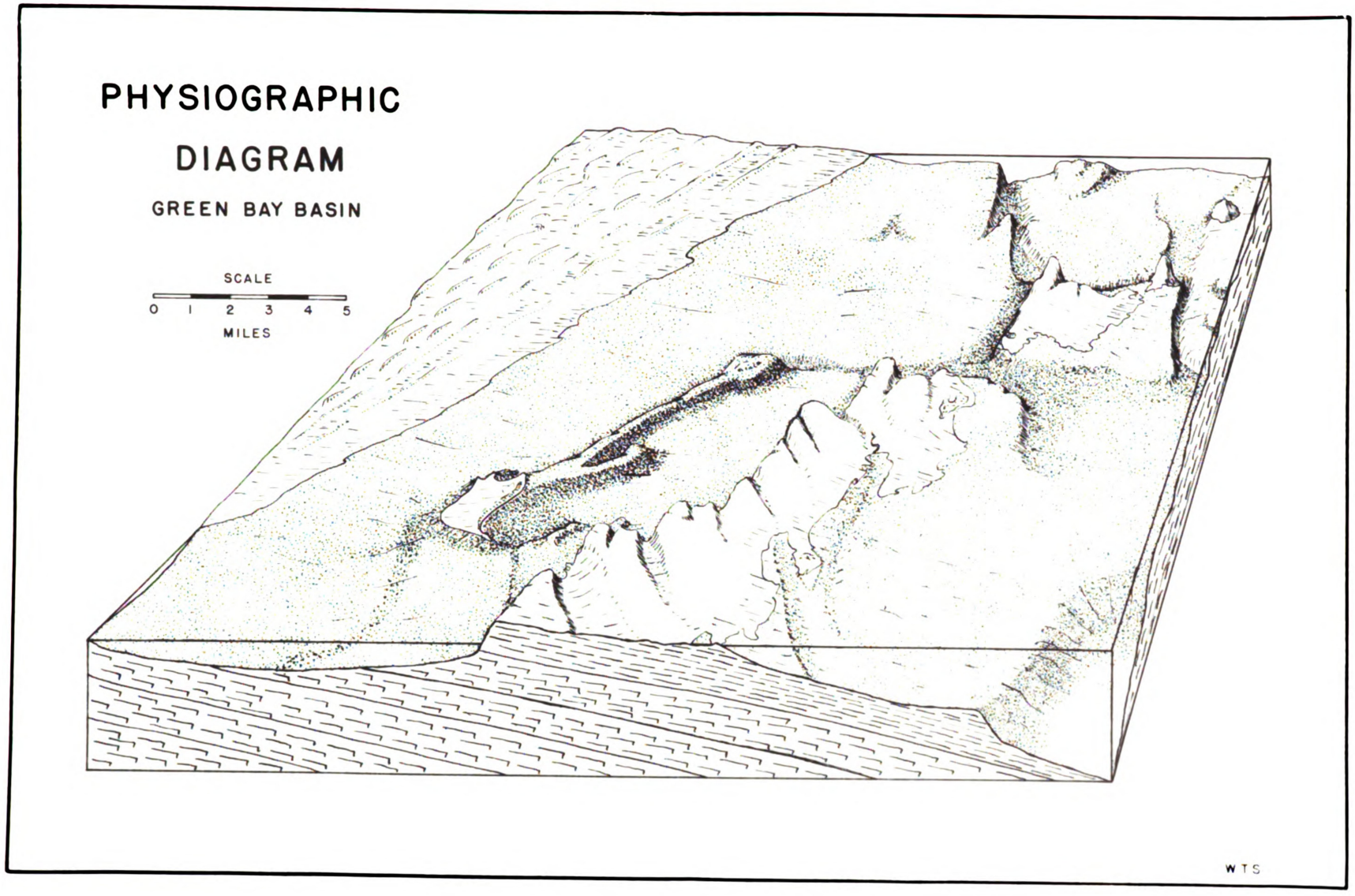

PHYSIOGRAPHIC
DIAGRAM
GREEN BAY BASIN
SCALE
0 1 2 3 4 5
MILES
WTS

PLATE XIX

Evolution of the Menominee River Valley (Figure 22, Plate XX) - The Menominee River valley has been formed by three processes: glacial, erosional, and eolian. Evidence of all three processes is not found throughout the whole valley, however. There are no eolian features in the upper part of the valley. Glacial drift within the valley is limited primarily to the lower part where frequent changes in stream course and lateral erosion have formed the only conspicuous floodplain of the valley. Abandoned channel scars formed by fluvial erosion are the most extensive features. They have been cut in bedrock in the upper valley and in glacial drift in the lower part.

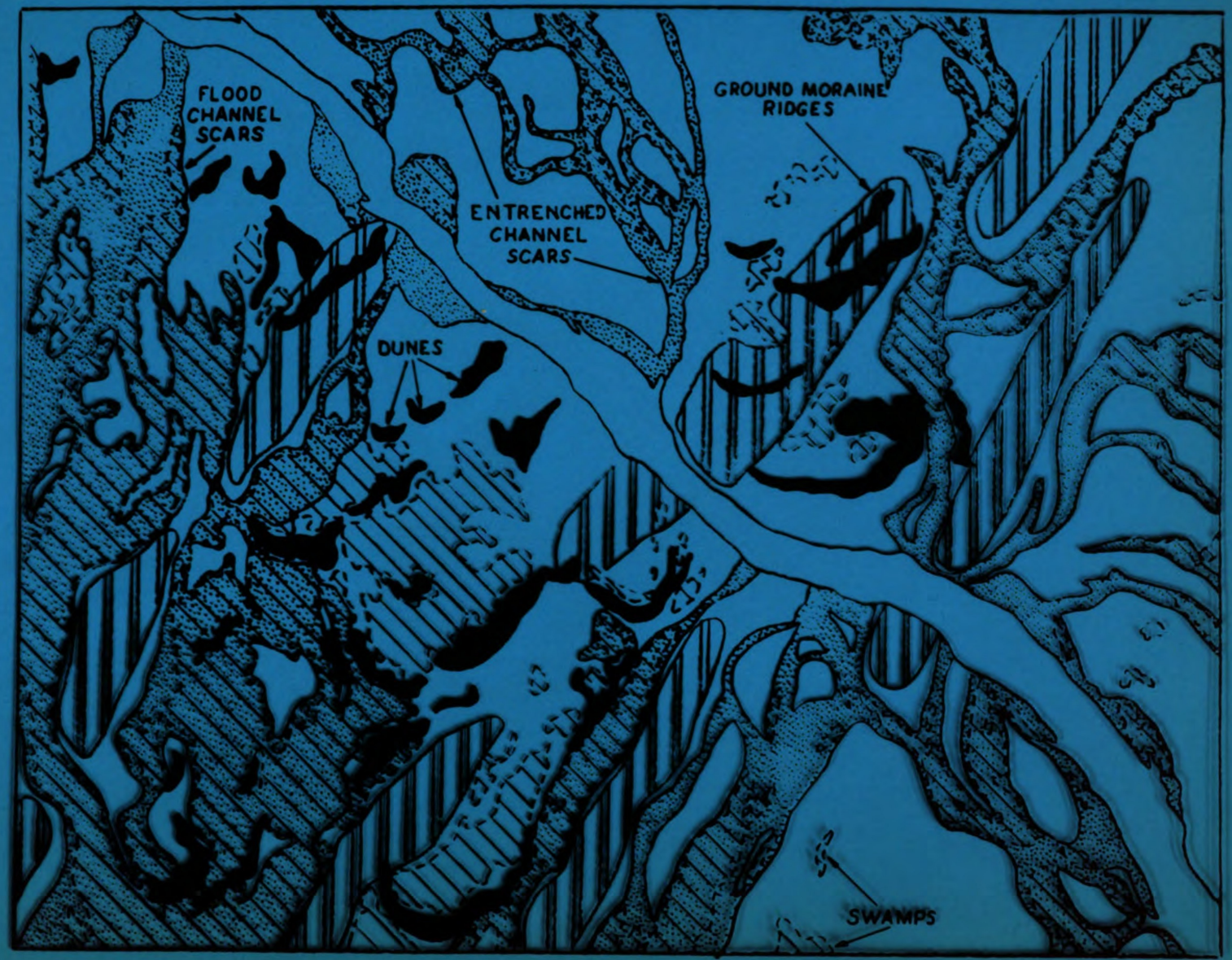
The lower river valley has been cut into an oriented ground moraine. This moraine system is the southern extension of the drumlin field, hence the material and orientation of the two areas are similar. The only exposed parts of the ground moraine are the hill crests. The depressions between the hills have been filled with alluvium and organic accumulations. Most of the hill crests have been strongly dissected by fluvial erosion leaving only irregularly shaped segments as evidence of the ground moraine.

Fluvial erosion has formed two types of patterns in the floodplain. Former stream courses are marked by entrenched channel scars on the north side of the valley. The channel scars vary in width from 200 to 400 feet and form a network of curved swamps with intervening sand islands. The abandoned channel scars are confined to the floodplain and are always connected to the present channel.

There is evidence of a major flood in a veneer of braided alluvium on the south side of the river. The flood waters were not contained in


FLOOD CHANNEL SCARS
ENTRENCHED CHANNEL SCARS
GROUND MORAINE RIDGES
DUNES
SWAMPS


SWAMPS
GROUND MORAINE RIDGES
ENTRENCHED CHANNEL SCARS
DUNES
FLOOD CHANNEL SCARS


FLOOD CHANNEL SCARS
ENTRENCHED CHANNEL SCARS
GROUND MORAINE RIDGES
DUNES
SWAMPS


SWAMPS
GROUND MORAINE
RIDGES
ENTRENCHED
CHANNEL
SCARS
DUNES
FLOOD
CHANNEL
SCARS

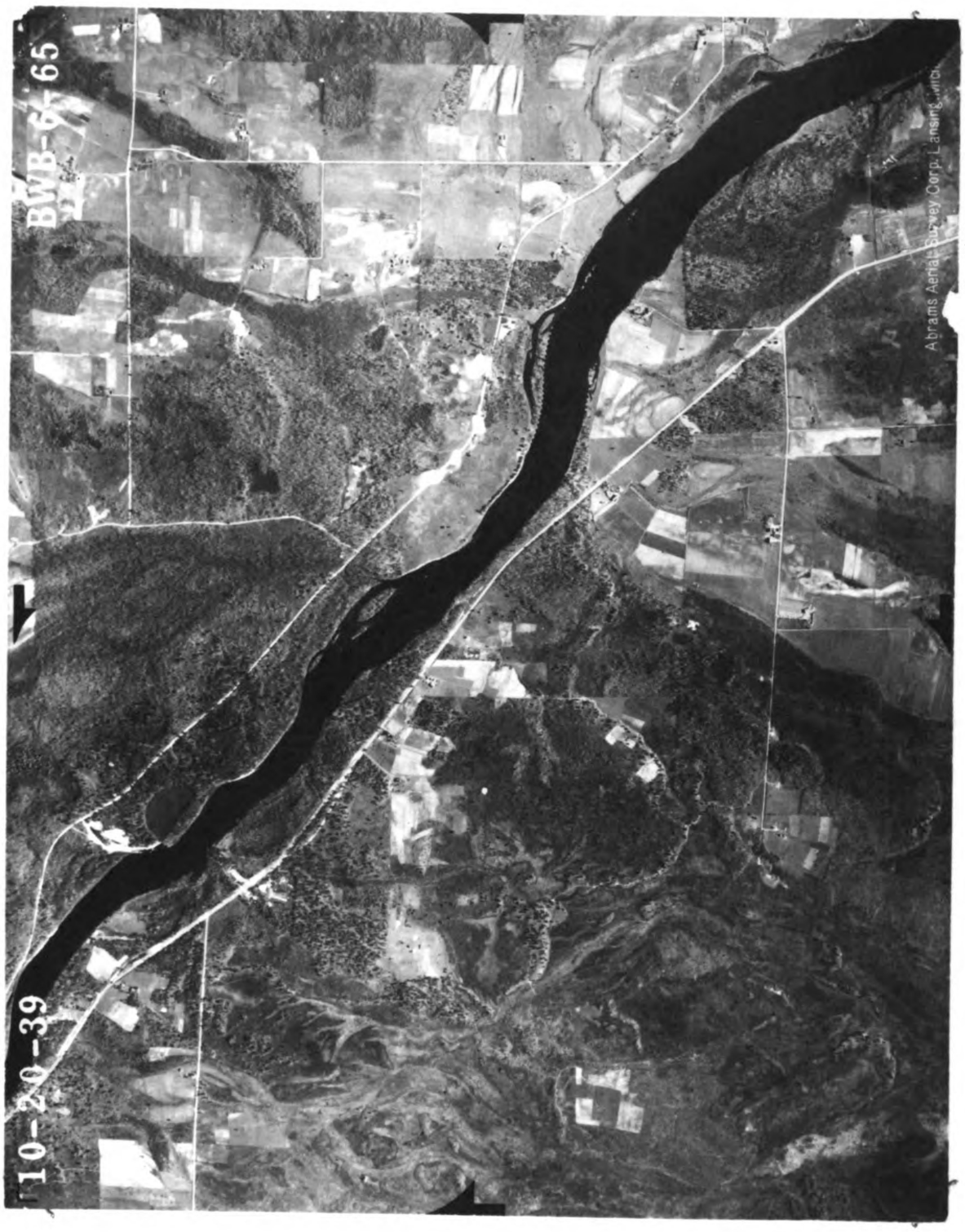


FIGURE 22

the valley but flowed south approximately five miles where they entered into the Peshtigo River system. The flooding action may have occurred during the recession of the glacier when the present valley was not able to contain the large volumes of meltwater.

The pattern formed by the flood waters is primarily reflected in the arrangement of the alluvium. When the waters overflowed from the present channel, the stream velocity dropped sharply causing extensive deposition. The veneer of alluvium which was deposited was reworked by the flood waters into a complex pattern of sand bars and channels. The depressions have become filled with organic accumulations, thereby creating a distinct pattern of material types.

Eolian processes have formed many sand dunes in the Menominee Valley. Most of the dunes are located on the ground moraine hills but a few are on the floodplain terraces. The material of the dunes was derived from the fine-textured sediments of the alluvial plains and the drift sheets. The dune profiles and the orientation are similar to those of the lacustrine plains which indicates that they were formed under comparable climatic conditions.

The chronology of the Menominee Valley evolution is one of the many remaining problems which needs further investigation. It can be assumed that the various fluctuations of lake levels greatly affected the regime of the river. The major tributary valleys of the Menominee system were formed by glacial meltwaters while the glacier was receding from the area. The major activity of the stream at this time was down-cutting to its base level of erosion which was regulated by the lake level in Green Bay. When Lake Chippewa came into existence, the local

base level of the Menominee River was lowered significantly, thereby steepening the river gradient considerably. However, the glacier had receded from the Menominee watershed by this time which greatly reduced the available volume of water. The stream's base level of erosion was raised approximately to its former level during the Nipissing Great Lakes stage. The rise in base level would cause aggradation if the stream volume remained the same, but the climate had become more humid thereby increasing the water volume. Consequently, the post-glacial climatic history of the region needs to be understood before the various phases of valley gorging and filling can be recognized.

APPENDIX

Major Cultural Features

Topographic Coverage

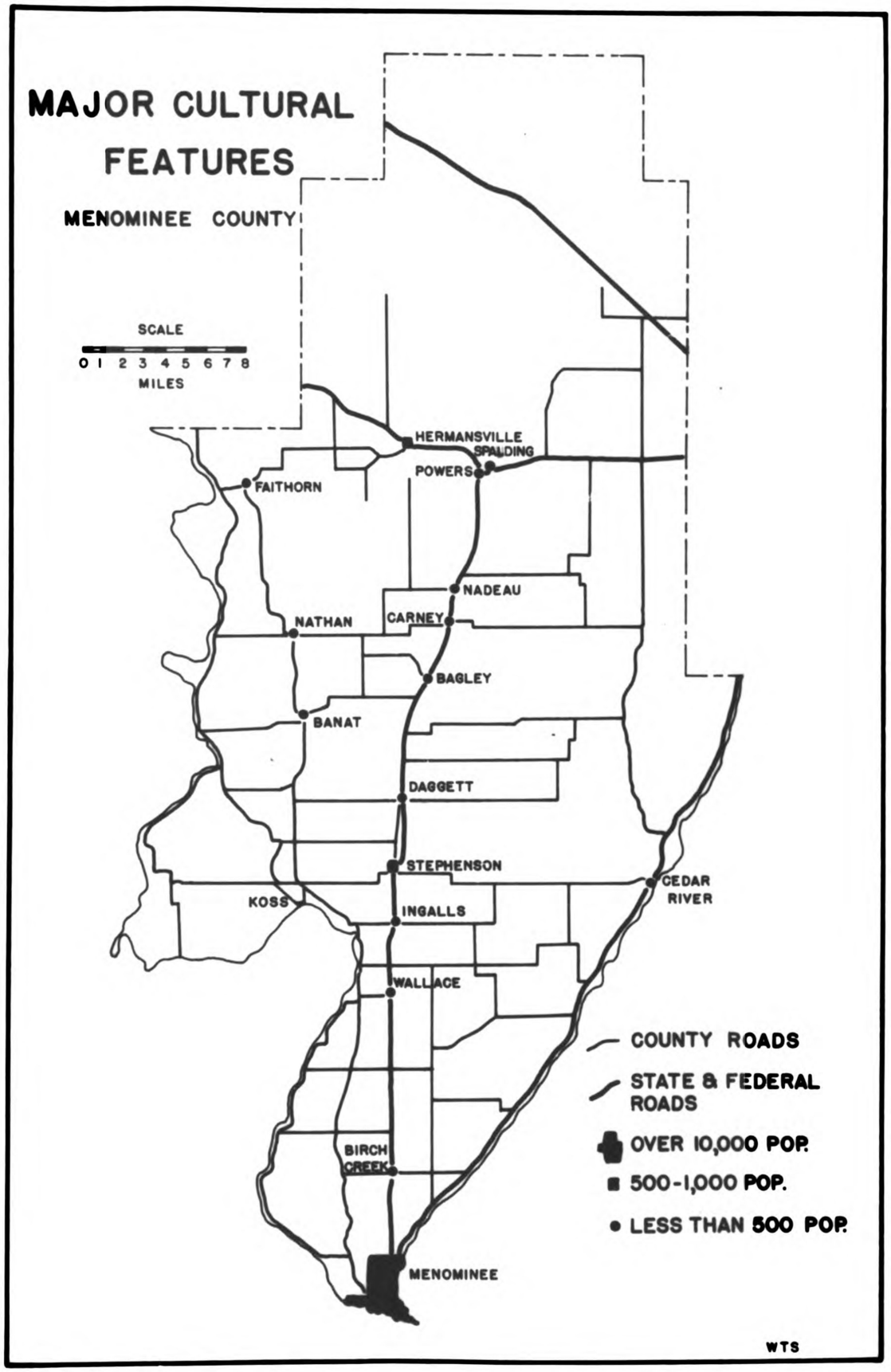

MAJOR CULTURAL FEATURES
MENOMINEE COUNTY
SCALE
0 1 2 3 4 5 6 7 8
MILES
HERMANSVILLE
SPALDING
POWERS
FAITHORN
NADEAU
CARNEY
NATHAN
BAGLEY
BANAT
DAGGETT
STEPHENSON
CEDAR RIVER
KOSS
INGALLS
WALLACE
BIRCH CREEK
MENOMINEE
COUNTY ROADS
STATE & FEDERAL ROADS
OVER 10,000 POP.
500-1,000 POP.
LESS THAN 500 POP.
WTS

PLATE XXI

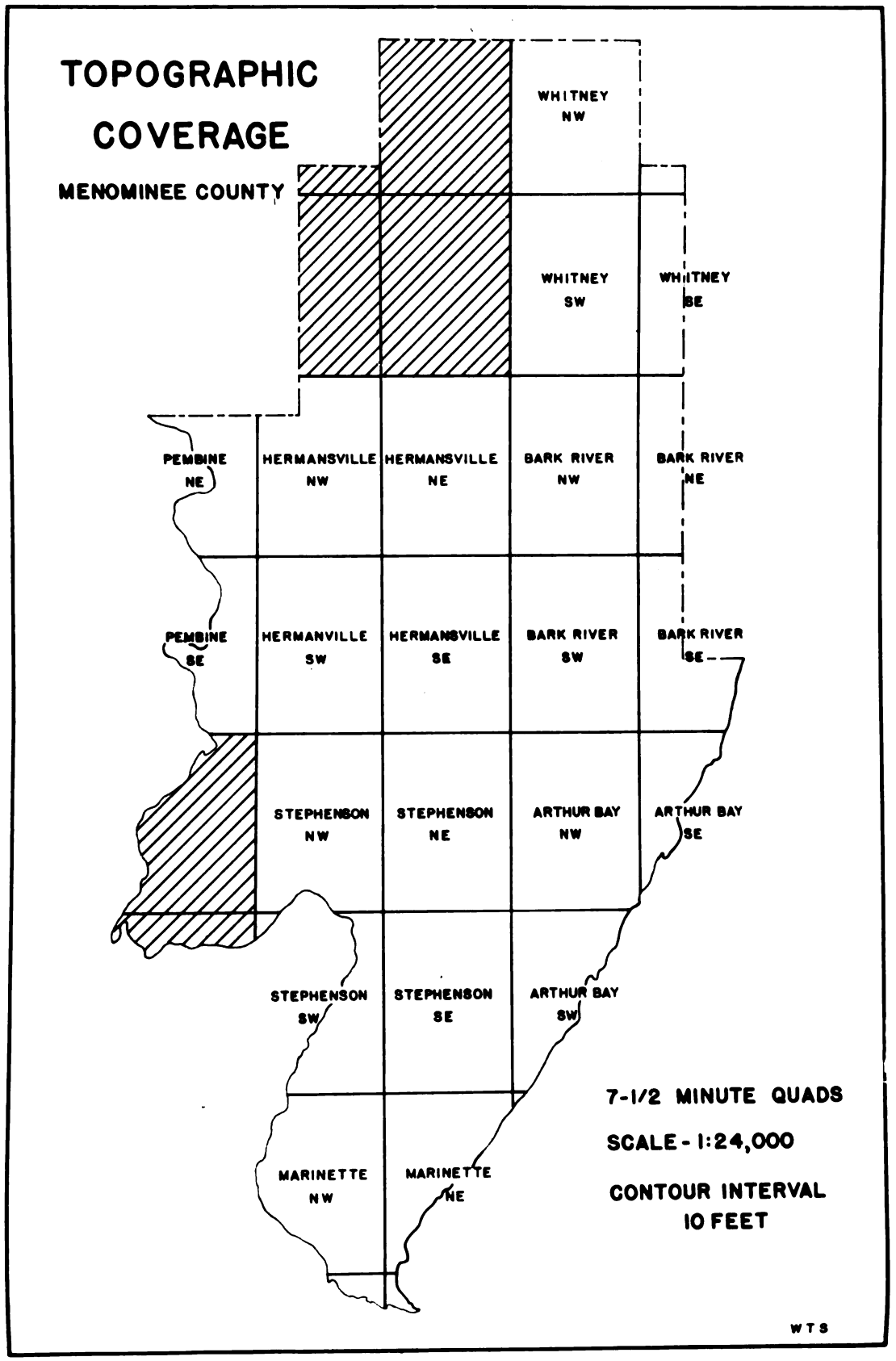

TOPOGRAPHIC
COVERAGE
MENOMINEE COUNTY
WHITNEY NW
WHITNEY SW
WHITNEY SE
PEMBINE NE
HERMANSVILLE NW
HERMANSVILLE NE
BARK RIVER NW
BARK RIVER NE
PEMBINE SE
HERMANVILLE SW
HERMANSVILLE SE
BARK RIVER SW
BARK RIVER SE
STEPHENSON NW
STEPHENSON NE
ARTHUR BAY NW
ARTHUR BAY SE
STEPHENSON SW
STEPHENSON SE
ARTHUR BAY SW
MARINETTE NW
MARINETTE NE
7-1/2 MINUTE QUADS
SCALE - 1:24,000
CONTOUR INTERVAL
10 FEET
WTS

PLATE XXII

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