A LAND SUITABILITY STUDY FOR LAKEWOOD TOWNSHIP IN ST. LOUIS COUNTY, MINNESOTA

A PLAN B PAPER

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Introduction

Town and rural planning is now generally accepted as a vital public service, and the responsible units of government seem to pay a good deal of attention to the implementation of environmental policy. Geological data are beginning to be recognized as essential information in the planning and development of cities, rural communities, or any other engineering projects. All planning should be concerned with the optimum use of land, yet recognize at the same time its physical limitations so that development of any region may best meet the needs of people and the ecological requirements of the environment. The proper use of land can be achieved only if the nature of the ground and subsurface conditions is known with certainty. It is for this reason why geology must take a major position in the planning process, the legal framework of which has changed so rapidly with the recent introduction of environmental legislation.

In order to ensure meaningful communication and to establish a useful relationship with other professional experts during all phases of the planning process, the geologist must present the physical data in a way conducive to the multidisciplinary nature of regional planning. The traditional geologic map, for instance, is not a useful medium of communication, for it is often ineffective in terms of planning needs. Stratigraphic units generally reflect only time-rock elements, establishing relative geologic age and defining mineralogic and biologic variations, regardless of engineering properties. Furthermore, the traditional geologic map shows bedrock without regard for the thickness and nature of overburden.

Thus the development of special format maps has become necessary and indeed they are used widely as either single map or multiple map sheets. The map units are chosen on the basis of their observed or inferred engineering and physical properties. In this way, confusing or extraneous data are eliminated, and the planners have only the information which is necessary and important for the solution of their specific problems.

Although a wide range of automated graphical data display systems are now available, geologists will have to become members of the multidisciplinary planning teams if the controlling factors and probable results of alternative courses of action are going to be weighed and analyzed skillfully.

Purpose and Scope

The purpose of this paper is to provide opportunity for a practical exercise in regional planning. It must be emphasized that this paper is a report rather than an original planning contribution. Fieldwork other than four reconnaissance trips was not undertaken. Instead, data compilation has been achieved through personal consultation of local planning offices and governmental agencies as well as literature research. However, content and format (including graphical representation) are the result of the writer's work and judgement.

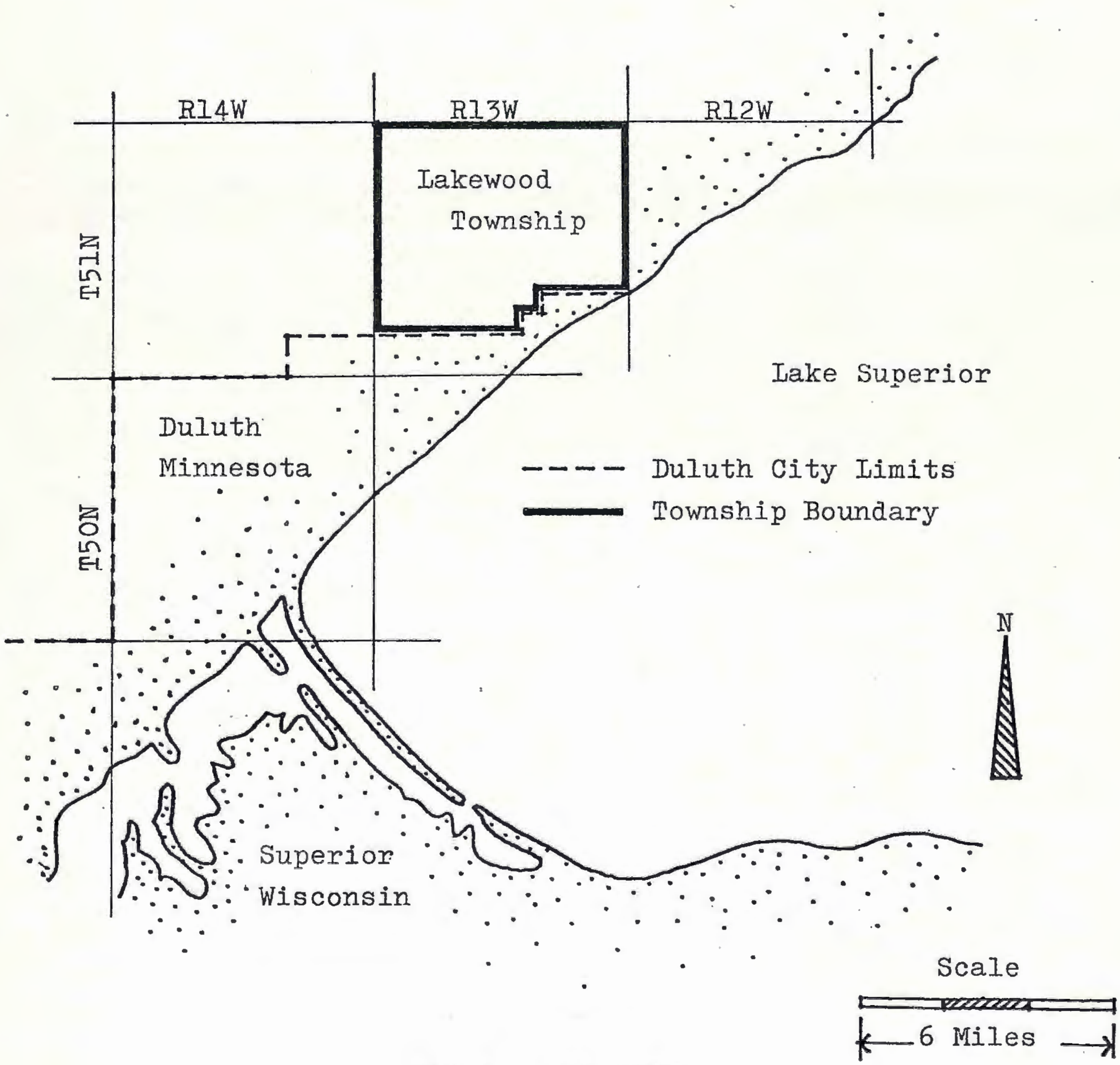
This report is primarily a survey of the physical characteristics of Lakewood Township, and is supposed to circumscribe the capabilities and sensitivities of the land as defined by its natural features. In this context it is an actual land suitability study for the purpose of suburban residential development, or any other development for that matter.

Acknowledgements

It is the wish of the writer to acknowledge the advice and guidance rendered by Professor John C. Green from the Geology Department at the UMD. Also, special thanks are due to several individuals of the following offices and agencies in Duluth: Arrowhead Regional Development Commission, Western Lake Superior Sanitary District, St. Louis County Health Department, Minnesota Department of Natural Resources, and Anderson Drilling Company of Duluth.

Location

The geographical location of Lakewood Township is T51N, R13W. It is situated along the northeastern city limits of Duluth, Minnesota, and comprises an area of approximately 28 square miles.



MAP 1 - LOCATION

Climate

The climate of the region is continental and is considerably modified by the presence of Lake Superior. However, temperature modifications are minimized rapidly away from the lake, so that areas behind the bluffs are less affected by the influence of the lake. Temperature extremes are mitigated along the shore by several degrees. The following data give a few yearly climatological averages for the Duluth area in the 1941-1970 period:*

Temperature	38.5°F
Highest in Aug. 1961	95.0°F
Lowest in Jan. 1972	-39.0°F
Precipitation	28.37 in
Snowfall	55 in
Prevailing wind	WNW

Thunderstorms are the principal source of rain during the active vegetative period. Severe storms such as tornados and ice storms, however, are infrequent.(9) Several feet of snow may accumulate at the end of winter where temperature affects the runoff patterns. Gradual melting allows the water to enter the soil and subsoil, and

*The above data have been obtained from the U.S. Department of Commerce, with the help of Prof. T.W. Chamberlin, Dept. of Geog., UMD.

replenishing possible aquifers. Sudden thaws, on the other hand, cause rapid runoff and result in a swelling of the rivers.

Regional Geology

Lakewood Township lies in the Lake Superior Basin, and its geology is therefore determined by the history of the Precambrian Era which can be divided into three sequences, each of which is marked by a major unconformity.[7,p.3]

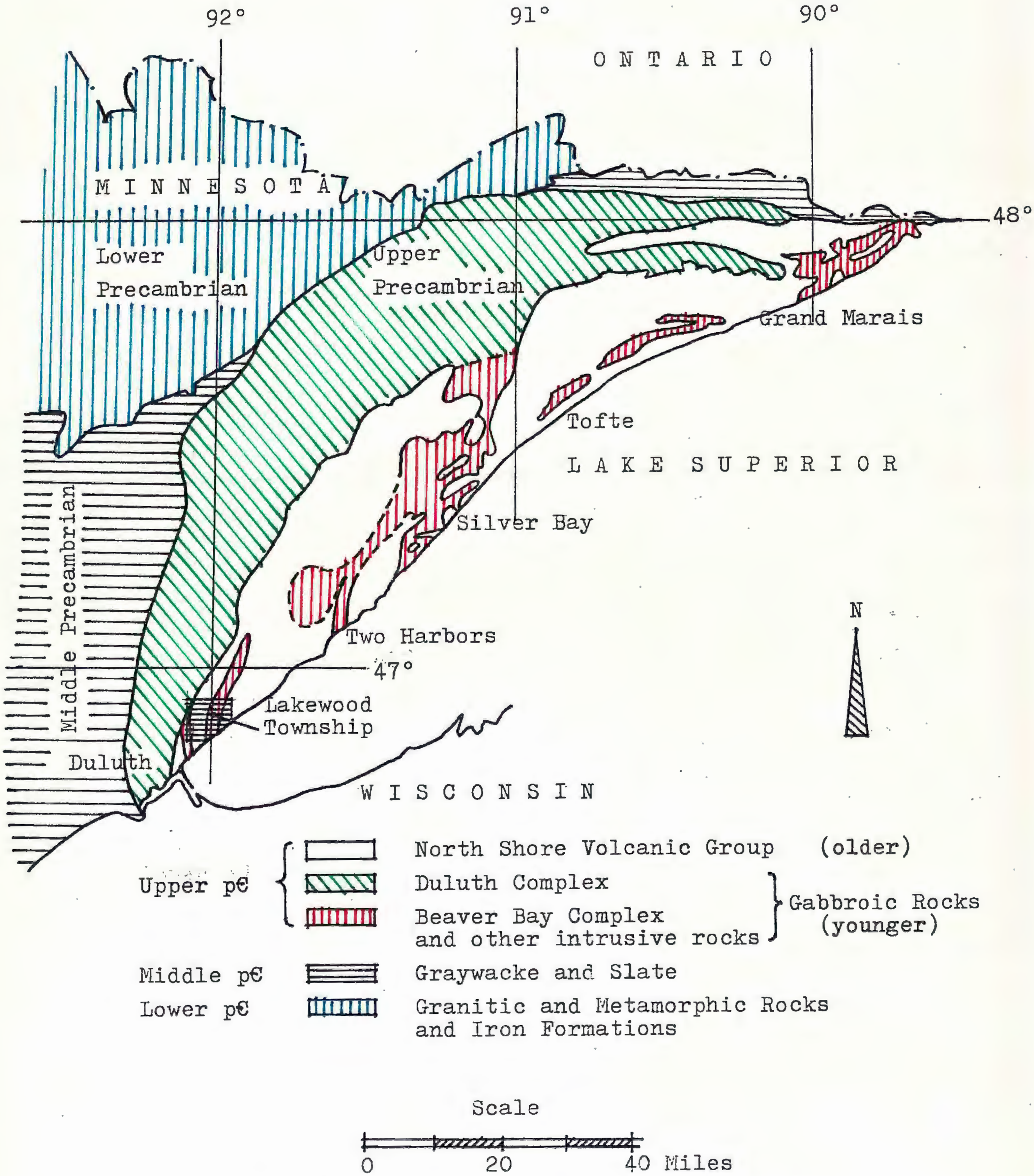
During the Algoman orogeny the Early Precambrian rocks in northern Minnesota underwent folding and faulting, and various types of granitic and syenitic rocks were emplaced. (see Map 2, p.9)

The Middle Precambrian, for the most part, consists of clastic rocks and interstratified iron-formations. In northern Minnesota, these strata (Animikie Group) unconformably overlie Lower Precambrian rocks and are slightly deformed. These sedimentary rocks are inferred to cover a large part of northern Minnesota, but exposures are limited to relatively few areas.(7, p.5)

The Lake Precambrian events in Minnesota are assigned to Keweenawan time, which was divided into three segments - Early, Middle, and Late. However, this traditional three-fold subdivision, based largely on rock-stratigraphic units, is currently being re-evaluated, pending adoption of a new time-stratigraphic classification. The Lower Keweenawan contains a substantial thickness of igneous rocks that differ from Middle Keweenawan rocks in lithology and metamorphic grade as well as in magnetic properties.(7, p.5) The Middle Keweenawan (1.1 to 1.2 b.y. old) contains the North Shore Volcanic Group (upper part, according to Green), the Duluth Complex, and the lesser Beaver Bay Complex and other diabase intrusives.(7, p.11) The Middle and Upper Keweenawan boundary has been placed at the contact between dominantly clastic strata (above) and volcanic rocks (beneath), which are found in the subsurface of eastern Minnesota. Northeast of Duluth, however, the Late Keweenawan has left no rock record and could therefore not be dated.(7, p.5)

MAP 2 - REGIONAL BEDROCK

Geologic Map of Northeastern Minnesota



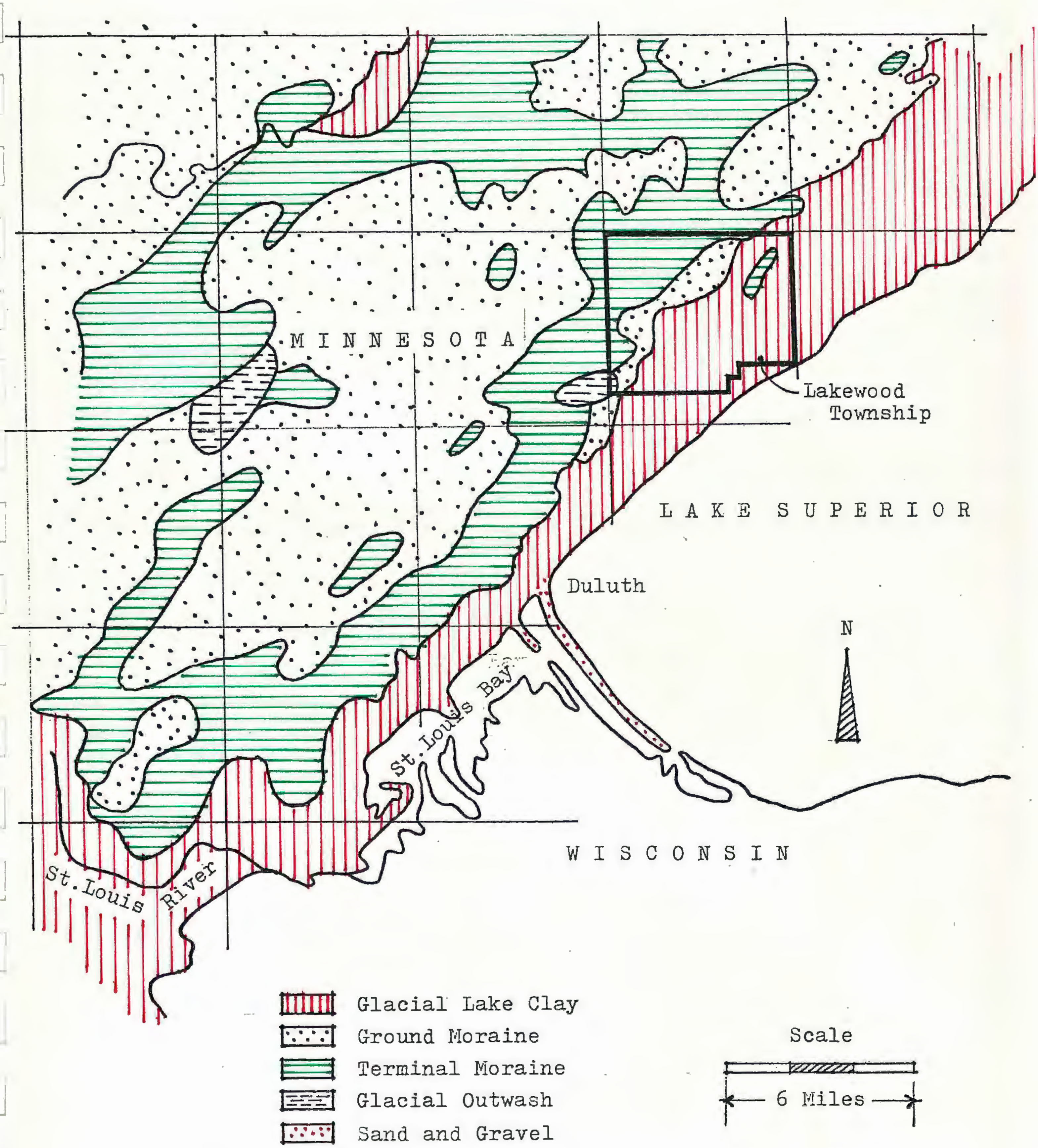
Source: Sims and Morey, 1972; Geology of Minnesota: A Centennial Volume. p. 332.

The lavas that comprise the North Shore Volcanic Group are dominantly basaltic in composition but include substantial volumes of intermediate and felsic rocks. Major lava types are olivine-tholeiite, quartz tholeiite, andesite, trachyandesite, intermediate quartz latite, and rhyolite.[7] These flows are tilted gently southeastward toward Lake Superior. The total thickness of these lava flows in the Duluth area is between 23,000 and 25,000 feet, and the dip is generally 20 degrees.[8] The flow trends are complicated locally by intrusions and faulting. Many large dikes, sills, plugs, and irregular bodies of the different diabase intrusives penetrate the lavas, breaking them into segments and producing faults. Most of these faults, however, are thought to have small displacements, are transverse, have steep dips, and lack preferred direction of displacement. They are seen only along the lakeshore or in streambeds, and cannot be traced laterally for any distance.[7]

The largest mafic intrusion in northeastern Minnesota is the Duluth Complex; it is also one of the largest in the world. It is about 150 miles long and consists of several anorthositic, gabbroic, and granitic intrusions emplaced along a major unconformity between Lower and Middle Precambrian metamorphic and igneous rocks and Keweenawan lava flows. It is a very complex intrusive body with an average thickness of about 14,500 feet.[8]

The North Shore has no Phanerozoic record except Pleistocene deposits. There were several glaciations, but the last extensive invasion was the Superior lobe of late Wisconsin time. The scouring and deposition of drift by the Superior lobe practically obliterated evidences of earlier glaciations.[8] When the glaciers retreated, large glacial lakes (Lake Duluth, Lake Algonquin, Lake Nipissing) were formed. The waters of Lake Duluth (the earliest glacial lake) filled the present basin of Lake Superior and extended inland up to 5 miles from the present shore, reaching an elevation of 1135 ft. or 533 ft. above the present level of the lake.[8,p.72] Beaches of glacial Lake Duluth and successively later glacial lakes extend along the entire North Shore area. Beach ridges consist of gravelly deposits occurring at various levels and mark the different stages of glacial lakes.[9] The overburden now covering the

MAP 3 - GLACIAL DEPOSITS OF DULUTH METRO AREA

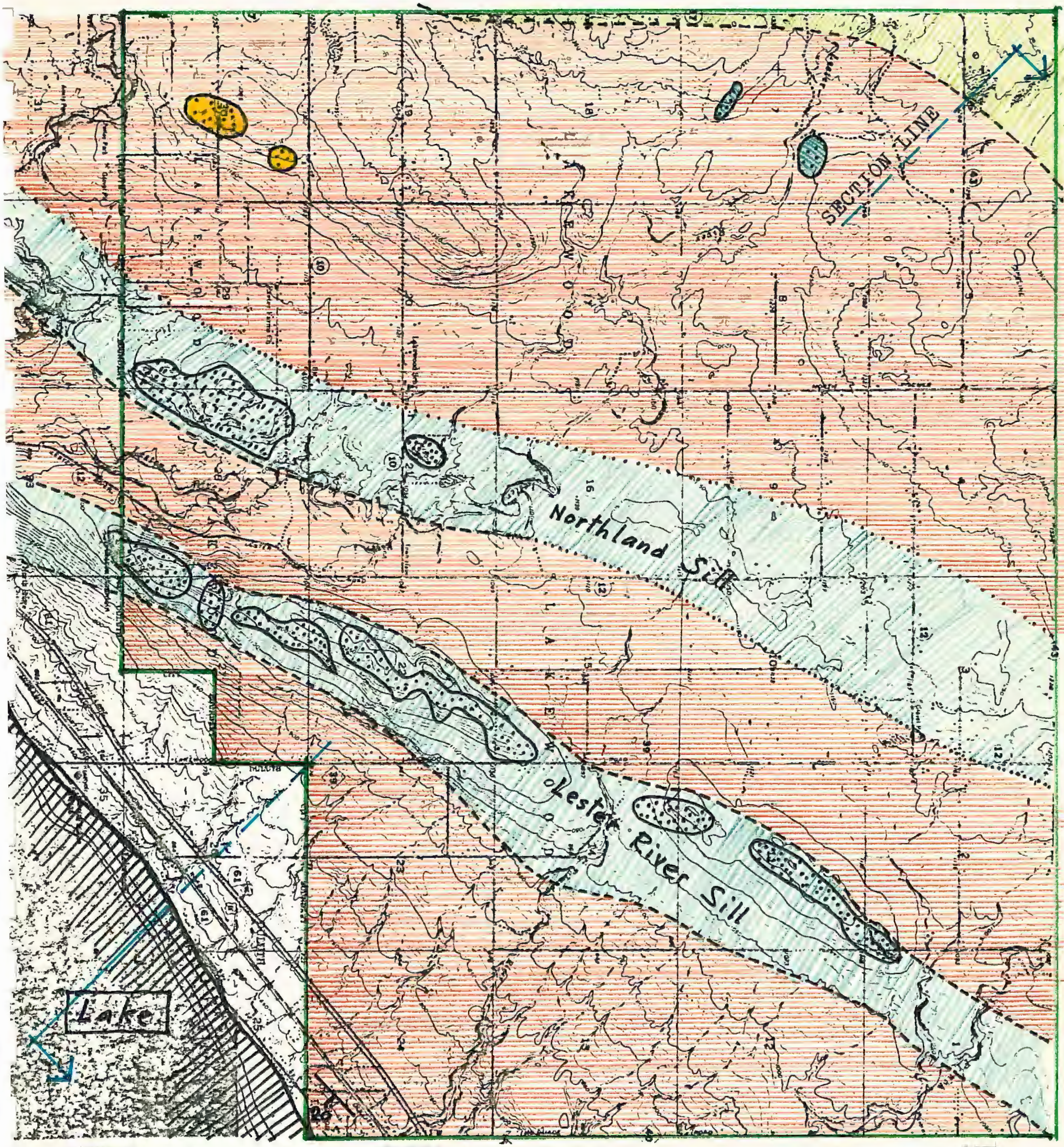


After G.M. Schwartz, 1949, The Geology of the Duluth Metropolitan Area, Plate 14 bedrock of the area is thus typically glacial lake deposits, terminal moraine, and ground moraine material. The local distribution of these glacial deposits is shown on map 3.

Geology of Lakewood Township

Map 4 shows the bedrock conditions of Lakewood, and it can be seen that most of the bedrock is lava flows of the North Shore Volcanic Group. The most abundant general type of lava is olivine basalt of several varieties. Another widespread one is a mottled variety called ophite or olivine tholeite.[7, p.302] They contain a few sporatic interflow sediments, principally red, cross-bedded sandstone beds which are only a few inches thick. Conglomerates are rare.[7, p.301] The North Shore Volcanic Group has generally a low porosity and permeability, but it is moderately fractured and has joints large enough to hold considerable amounts of water.

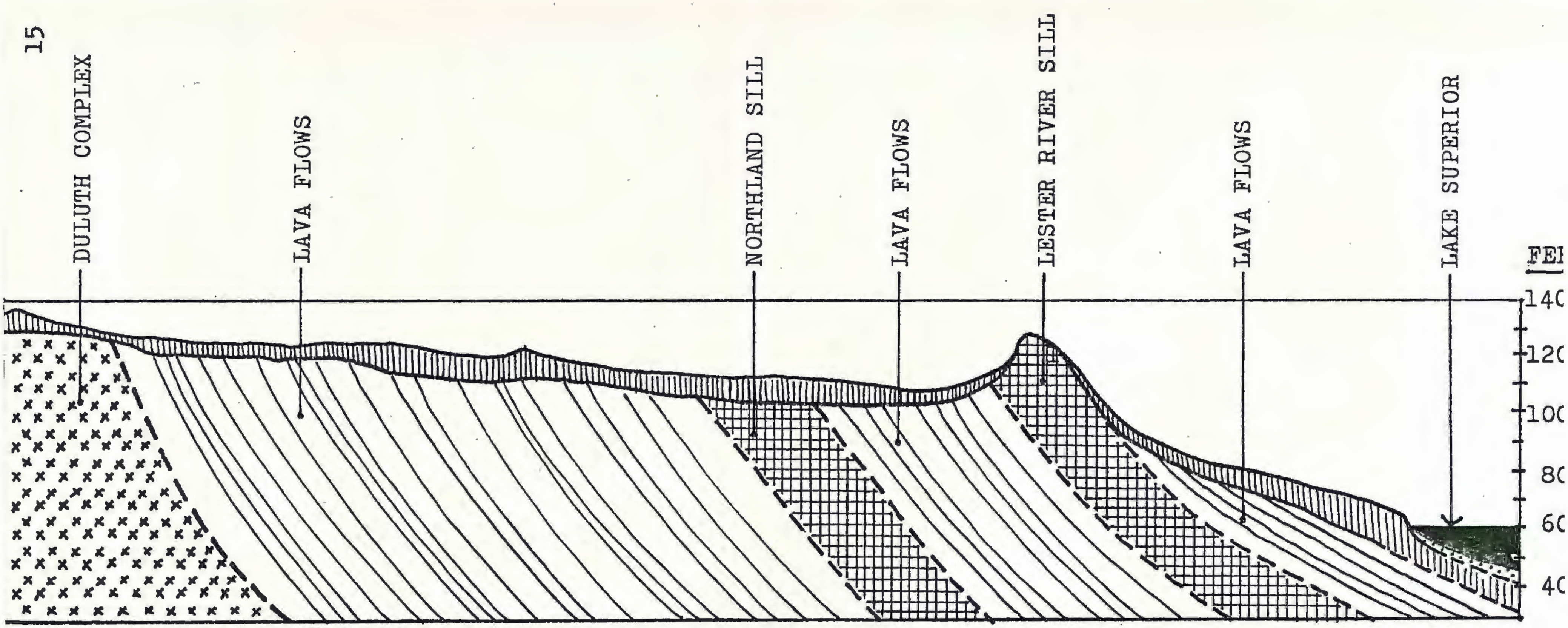
In the northwestern corner of the township there is a contact of the Duluth Complex and, typically, this area has a gabbroic-troctolitic bedrock with inclusions of hornfels.



Duluth Complex
Lava Flows
Diabase
Diabase Outcrop
Granite Outcrop
Township Boundary

Scale
1 Mile
North

After G.M. Schwartz, 1949,



Pleistocene

Recent lake deposits

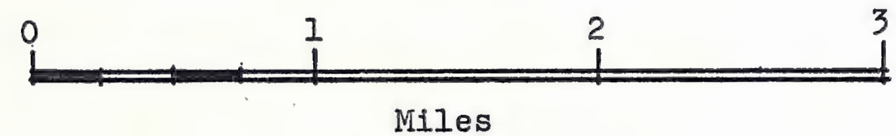
Glacial deposits

Late Precambrian

Lavas ranging in composition from olivine basalt to quartz latite and local rhyolite, containing interbeds of conglomerate and related clastic rocks.

Anorthositic gabbro

Mafic intrusive rocks (diabase)



GEOLOGIC CROSS-SECTION THROUGH LAKEWOOD TOWNSHIP

From Lake Superior to northwest
(see Map 4 on page 14 for line of section).
Dips of formations not to scale.

There are two diabase sills running through the area: the Northland Sill and the Lester River Sill. They form ridges approximately at right angles to the general slope of the surface. The Lester River Sill, approximately 1,000 feet thick, extends from the shore of the Lake to the northeast corner of the township, creating a divide between the east and west portion. At places the ridge of the Lester River Sill rises 200 feet above the lake plain of glacial Lake Duluth, and it shows extensive outcrops of massive and resistant diabase,[8] in addition to irregular zones of felsic and intermediate differentiates. (7, p.327) The Northland Sill, on the other hand, is exposed only in the southern part of the township and consists of medium0grained, massive, black diabase.[8]

The overburden consists primarily of Lake deposits from glacial Lake Duluth and of glacial till (see Map 5). The northwestern part of the township, apparently constituting part of the Highland moraine, is a terminal moraine which reaches a thickness of almost 100 feet (see Map 5). In general, the moraine is composed of bouldery material with more or less fine material intermixed. As a geomorphic feature the moraine is irregularly developed and it is difficult to trace a continuous belt. Furthermore, it merges imperceptibly into areas of glacial drift with less relief and rolling topography referred to as till plains or ground moraine.[8,p.73]

A belt of ground moraine (not necessarily continuous) extends from Sec. 3 southwest to Sec. 30. In general it is gently rolling with abundant boulders in the soil which locally are concentrated at the surface. However, the soil of the ground moraine has sufficient clay with sand and gravel to make for satisfactory cultivation.[8] As a rule, till associated with ground moraine is generally much thinner than that in end moraine. It is composed of basal deposits and sediments melted out during ice retreat.

The main rock types found in the till are Keweenawan flows and associated intrusive rocks, and granite.[8] The source of this material is the bedrock formations of the Superior basin, whereas the granite had most likely been transported from Canada, northeast of Lake Superior.[8,p.79]

East of the ground moraine mentioned before, the area is a lake plain with the rock ridges of the Lester River Sill and the Northland Sill, along which there are well-defined beaches and even sea cliffs.(8) These features were formed especially during low stages of glacial Lake Duluth and, by inference, such ancient beaches must be found in sections 11, 22, 27, and 28 of the township (see Map 6). Thus more than half of Lakewood Township is covered with glacial Lake Duluth sediments and therefore no morainal deposits are exposed in this area except in natural and artificial cuts and banks. Morainal deposits which may have existed are buried by glacial lake clays. The thickness of the clay deposits has not been established for this report. However, it could be assessed by drill probes or by observation along the shore of Lake Superior and eroded river valleys of the streams in the area.

Known as Superior clay, (G.M. Schwartz, 1949) the material is a red clay soil that varies from clay to silt. Other soil types are loam, sandy loam, and sand. The red clay not well suited for agriculture, is a heavy soil which is compact and has the ability to absorb water and become plastic so that swelling could be a problem. The red color is confined to the upper few feet and passes into gray below, where oxidation has not been active (Schwartz, 1949).

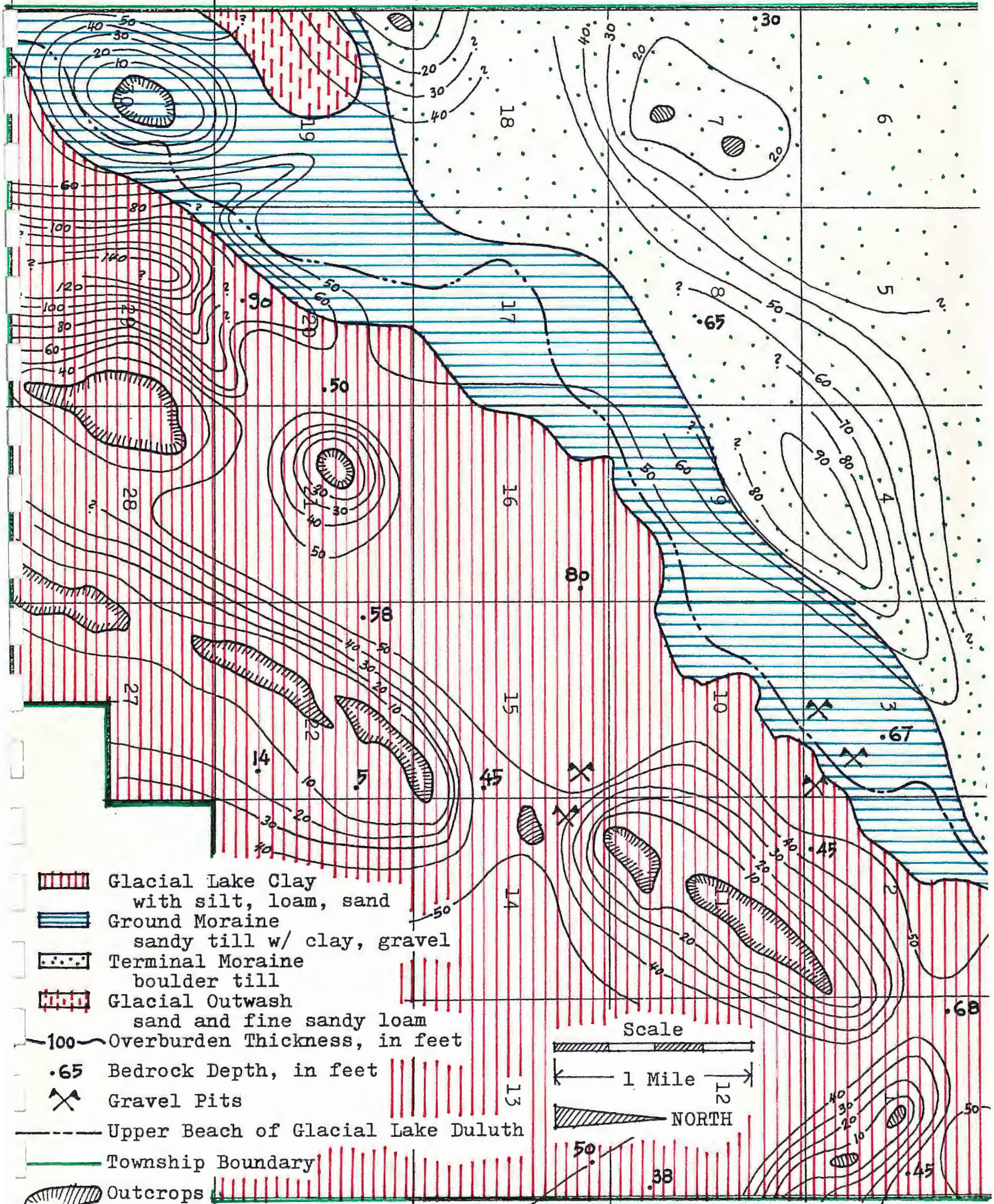
The lake plain and the moraine areas of Lakewood Township are cut by the valleys of the Lester, Talmadge, and French rivers. The lower portions of these rivers cut down to the underlying rock, whereas farther upstream they flow over a boulder bed in the lake plain or the moraine.

Map 5 shows the spatial relationships between the different glacial deposits as well as the thickness of overburden.

As far as economic geology is concerned, sand and gravel have been profitably mined for years, and several gravel pits (most of them abandoned) are located in Lakewood (see Map 5). Sand and gravel could possibly be obtained from the deposits all along the upper beach of glacial Lake Duluth (see Map 5), particularly in the northern part of the township (G.M. Schwartz, 1949) because streams pouring into the glacial lake apparently built up alluvial fan deposits or deltas.(8, p.72) Despite a separate field trip, the writer did not succeed in actually locating alluvial fans. It is conceivable that some of these deposits have already been exploited, evidence for which might be found in the abandoned gravel pits. In general, however, gravel accumulations in this area are difficult to spot, for they are obscured by relatively heavy vegetation covers.

In addition to sand and gravel there might be a possibility to extract clay for the production of brick. The area to be considered would most likely be the one east of the Lester River Sill. According to Schwartz (1949) there are places similar to Wrenshall within the Lake Duluth depositional area that could be opened up for economic purposes. The material in the Wrenshall area is varved and is richer in clay (90%), whereas that in the Lakewood area has only about 70% clay and is not distinctly varved; but' other than that the two clays should be quite similar (personal communication with Mr. R. Lewis, SCS, Duluth).

MAP 5 - UNCONSOLIDATED GLACIAL DEPOSITS



Information by WLSSD and Reference 16 (J.C. Green, 1977)

Soils

The characteristics of the different soil types in a development area should always be a prime consideration. Soil limitations and their effects on various construction elements must be known in order to plan for sound development. The general soil map is intended to give a rough idea of the soils within an area, delineating the location of large tracts of land that are representative for certain kinds of soils. Soil is the top few feet of material which has developed on the unconsolidated Pleistocene deposits already described in the foregoing section. Map 6 is a general soil map, and the soils in any one delineation ordinarily differ in slope, depth, drainage, and other characteristics that affect their use and management.

Within Lakewood Township there are five general soil types recognized and each one will be briefly described. All of the following information has been obtained from the U.S. Soil Conservation Service and is contained in the pertinent soil survey interpretation sheets. The official SCS designations for the different soil series have been abandoned because they were found to be too cumbersome.

Soil designations as used in this paper	Soil designations as used by SCS
A	1A, 48B; 1B, 48A
B	2A, 3B; 2B, 3A
C	4A, 43B, 44B; 4B, 58B
D	9A, 40A; 9B, 40B; 9C, 10C
E	P

Type A consists of poorly to moderately well drained soils formed in lacustrine deposits on uplands. Native vegetation is forest. The surface layer is dark reddish-brown silty clay about 6 inches thick. The subsoil is reddish brown clay with a very slow permeability. The available water capacity (for use by plants) is moderate and organic matter content is low.

Limitations for Selected Uses in Soil Type A

Septic Tank Fields	Severe	Very slow permeability
Excavations (shallow)	Severe	Poor workability
Dwellings with Basement	Severe	High shrink-swell potential
Sanitary Landfill	Severe	Poor trafficability and workability
Local Roads and Streets	Severe	Low bearing strength
Corrosivity:		
steel	Moderate	
concrete	Low	
Frost Action	Moderate	
Flooding	None	
Shrink-swell Potential	High	

Type B consists of nearly level to rolling, poorly to moderately well drained soils formed in loam or clay loam till. These soils are on ground moraine and lake plain material. Native vegetation is forest. The surface layer is very dark gray silt loam, about 4 inches thick. The subsurface layer is dark gray and gray silt loam and very fine sandy loam, about 11 inches thick. The subsoil is dark reddish brown, firm loam about 53 inches thick. The underlying material is dark reddish brown loam. Permeability is low, and the available water capacity (for use by plants) is high. Organic matter content is low.

Limitations for Selected Uses in Soil Type B

Septic Tank Fields	Severe	Slow permeability
Excavations (shallow)	Slight Moderate Severe	0 - 6 percent slopes 6 -12 percent slopes over 12 percent slopes
Dwellings with Basement	Slight Moderate Severe	0 - 6 percent slopes 6 -12 percent slopes over 12 percent slopes
Sanitary Landfill	Slight Moderate	0 -12 percent slopes 12-25 percent slopes
Local Roads and Streets	Severe	High susceptibility to frost action
Corrosivity: steel concrete	 Moderate Moderate	
Frost Action	Severe	
Flooding	None	
Shrink-swell Potential	Low	

Type C consists of nearly level to steep, well and moderately well drained soils formed in sandy loam till. These soils are on terminal moraines. Native vegetation is forest. The surface layer is very dark brown silt loam, about 2 inches thick. The subsoil is dark brown, very friable, fine sandy loam about 14 inches thick in the upper part. The lower part is reddish brown, firm sandy loam, about 44 inches thick. The underlying material is reddish brown fine sandy loam. Permeability is moderately slow. The available water capacity and organic matter content are low. These soils have very dense lower subsoils and underlying material. Cobbles are common throughout the profile.

Limitations for Selected Uses in Soil Type C

Septic Tank Fields	Severe	Moderately slow permeability
Excavations (shallow)	Slight	Occasional large boulders
	Moderate	6-12 percent slopes
	Severe	over 12 percent slopes
Dwellings with Basement	Slight	
	Moderate	6-12 percent slopes
	Severe	over 12 percent slopes
Sanitary Landfill	Slight	0-12 percent slopes; coarse fragments are common; difficult to dig when dry.
	Moderate	12-25 percent slopes
Local Roads and Streets	Severe	High susceptibility to frost heave
Corrosivity:		
steel	Moderate	
concrete	Moderate	
Frost Action	Severe	
Flooding	None	
Shrink-swell Potential	Low	

Type D consists of steeply sloping, well drained soils, formed in 20 to 40 inches of dark brown medium acid, gravelly sandy loam that is underlain by bedrock of basaltic composition (Diabase). Surface stones typically occupy less than 5 percent of surface, whereas subsurface coarse fragment content typically is 25 percent. Slopes range from 5 to 35 percent and over. Most areas are in forest.

Limitations for Selected Uses in Soil Type D

Septic Tank Fields	Severe	Bedrock at 20 to 40 inches; hilly terrain
Excavations (shallow)	Severe	Same as above
Dwellings with Basement	Severe	" " "
Sanitary Landfill	Severe	" " "
Local Roads and Streets	Severe	" " "
Corrosivity:		
steel	Low	
concrete	Mod.-Severe	
Frost Action	Slight	
Flooding	None	
Shrink-swell Potential	Low	

Type E consists of moderately deep organic soils, known as peat, and occurs in bogs on level terrain. These soils are made of black and dark reddish brown, moderately to highly decomposed organic materials. Permeability is slow and frost action high. The overall soil limitations for engineering purposes are severe.

Explanatory Notes on Soils

The following is a summary of the detailed descriptions of soil limitation criteria found in a special appendix to the soil interpretation sheets of the U.S. Soil Conservation Service, and a preliminary report on "Geology for Planning on the Sonoma County Coast" by M.E. Huffman, 1972.

Septic tank absorption fields: Evaluated is usually the material from a depth of 1½ to 6 feet. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties affecting absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects difficulty of layout and construction, but also erosion, lateral seepage, and downslope flow of effluent.

Shallow excavations are those that require digging to a depth of less than 6 feet (as for pipelines, sewer lines, power transmission lines, some basements). Desirable soil properties are good workability, gentle slopes, absence of rock outcrops, and freedom from flooding.

Dwellings: Features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement. Soil properties that affect support capacity are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential.

Sanitary Landfill areas are subject to heavy vehicular traffic. Soil properties affecting suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The ratings apply only to a depth of about 6 feet, and limitation ratings of slight or moderate may therefore not be valid for greater depths. But regardless of ratings, every site should be investigated before it is selected.

Corrosivity for steel is commonly based on resistance to flow of electrical current, total acidity, soil drainage, soil texture and conductivity of saturation extract. Corrosion of steel results mainly from electron migration in a soil-metal system where an electrical potential exists.

Corrosivity for concrete is related to the amount of sulfates, soil texture and acidity. Concrete conduits are calcareous and therefore highly susceptible to corrosion in acid soils, especially where there are seasonal or perennial high water tables.

Shrink-swell potential represents the difference in the volume of a given weight of soil when dry and when moist. Soils containing a high percent of montmorillonitic clay or peat have a high S-W potential, whereas sandy soils or soils mainly consisting of illitic clay have a moderate or low one.

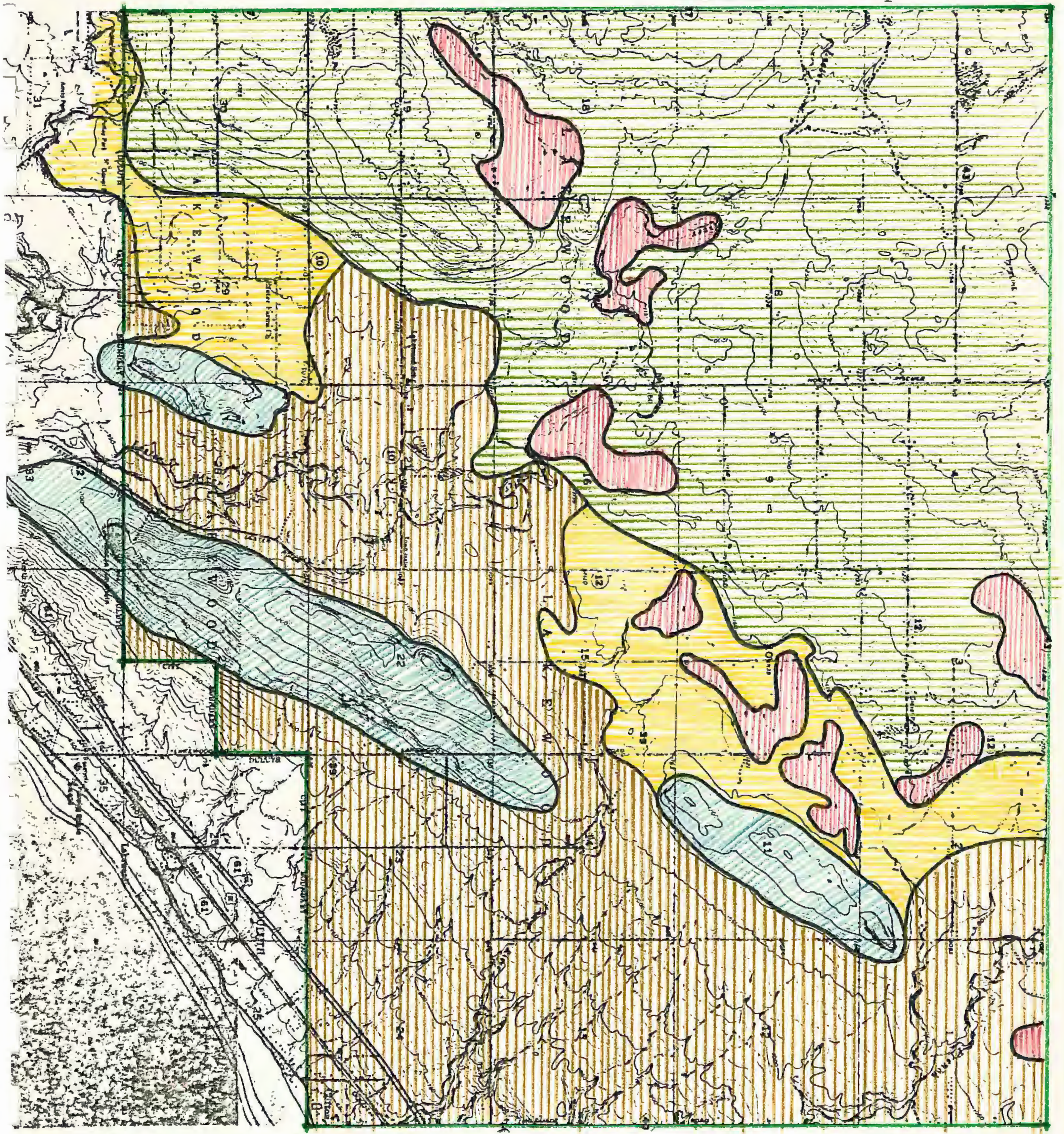
<u>Limitation ratings</u> are slight, moderate, and severe. Slight soil limitation is the rating given to soils that have properties favorable for the stated use. Moderate is the rating given to soils that have properties moderately favorable for the stated use. This degree of limitation can be overcome or modified by special planning, design or maintenance. Severe is the rating for soils with one or more properties unfavorable for the stated use, such as steep slopes, bedrock near surface, flooding hazard, high shrink-swell potential, a.o. This degree of limitation generally requires major soil reclamation, special design, or intensive maintenance.

Scale

1 Mile

MAP 6 - SOILS

Information by:
U.S. Soil Conservation Service
Arrowhead Region
General Soils Map 1973



- A, silty clay loam (0-6 in) clay (6-60 in)
- B, silty loam (0-15 in) loam (15-60 in)
- North
- C, loam and fine sandy loam (0-16 in)
- D, gravelly sandy loam (0-28 in)
- E, mucky peat (0-60 in)

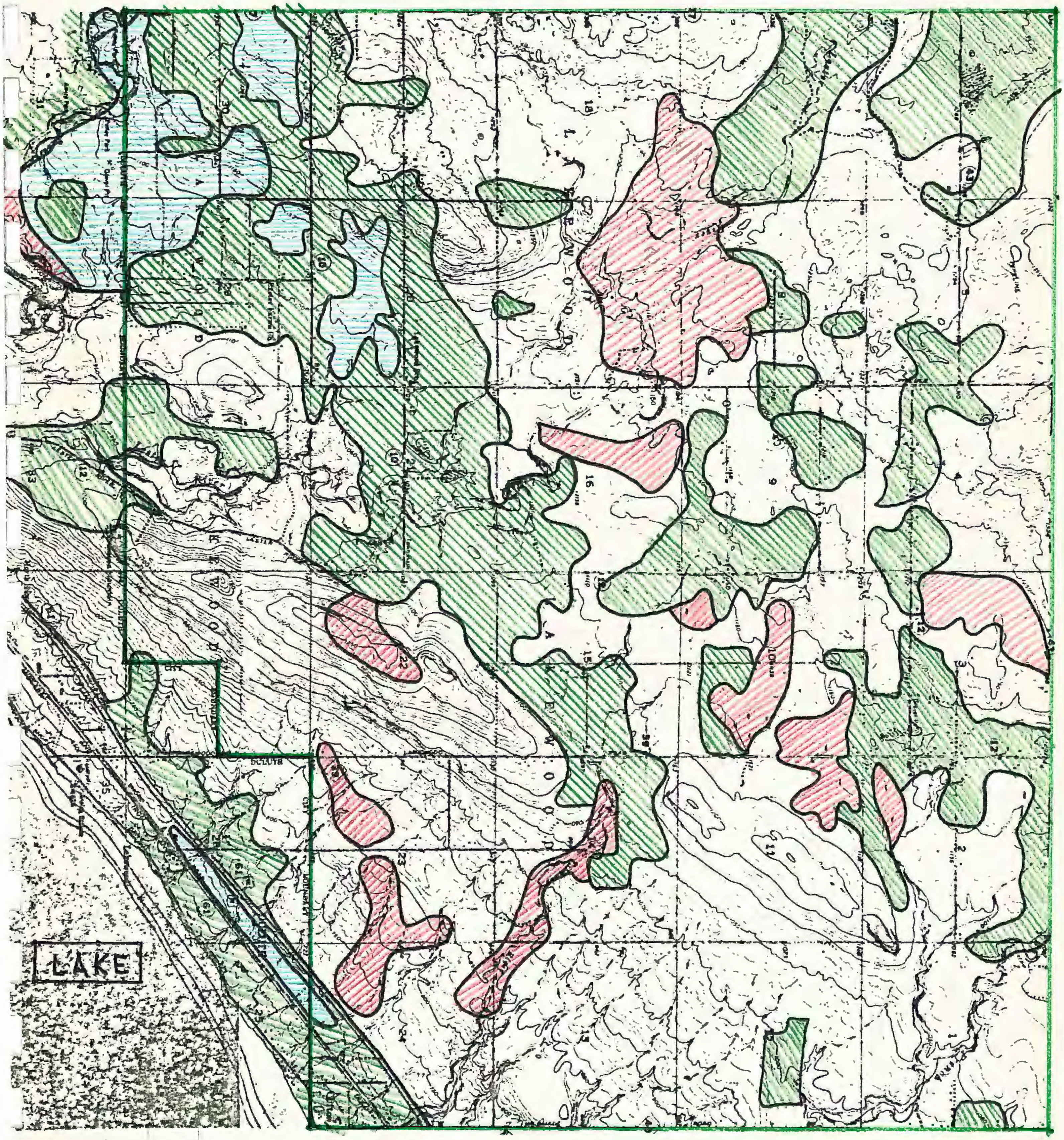
Vegetation

An aerial photography inspection of Lakewood Township shows clearly that the larger part of the area is forested at various densities. During the 1880's extensive logging operations removed the large stands of strees which covered the whole Lakewood. After large areas of the land had been cleared, several farms were established, some of which are still in operation.

More than 80 percent of the township's area is classified as undeveloped open space and most of it is heavily covered with underbrush. The main forest cover is provided by birch and poplar (aspen), mixed with scattered stands of spruce and fir. About 1,000 acres, which is less than 6 percent of the total area, is taken by agriculture which uses the acreage for grazing land and for growing feed crops, such as hay (information by WLSSD). The major portion of this type of land use is in the central and northwest sections of the township where topography and soils are suitable for such practice. Map 7 shows in a very general way, distribution and type of forest cover as well as the major nonforested areas.

MAP 7 - VEGETATION

Information by ARDC



Aspen - Birch

Aspen - Birch, surrounded by other forest types

Spruce - Fir

Nonforest

Township Boundary

Scale

1 Mile

North

Topography

The topographic characteristics of the township are shown on maps 8 and 9 which are photographic reductions of a standard 1:24000 USGS map (quadrangles: Arnold, French River, Lakewood, Duluth; 7.5 minute topographic series). Elevations in the area range from a low of 602 feet at Lake Superior to a high of 1430 feet in the western part (Section 18). Geomorphologically, Lakewood can be divided into four areas:

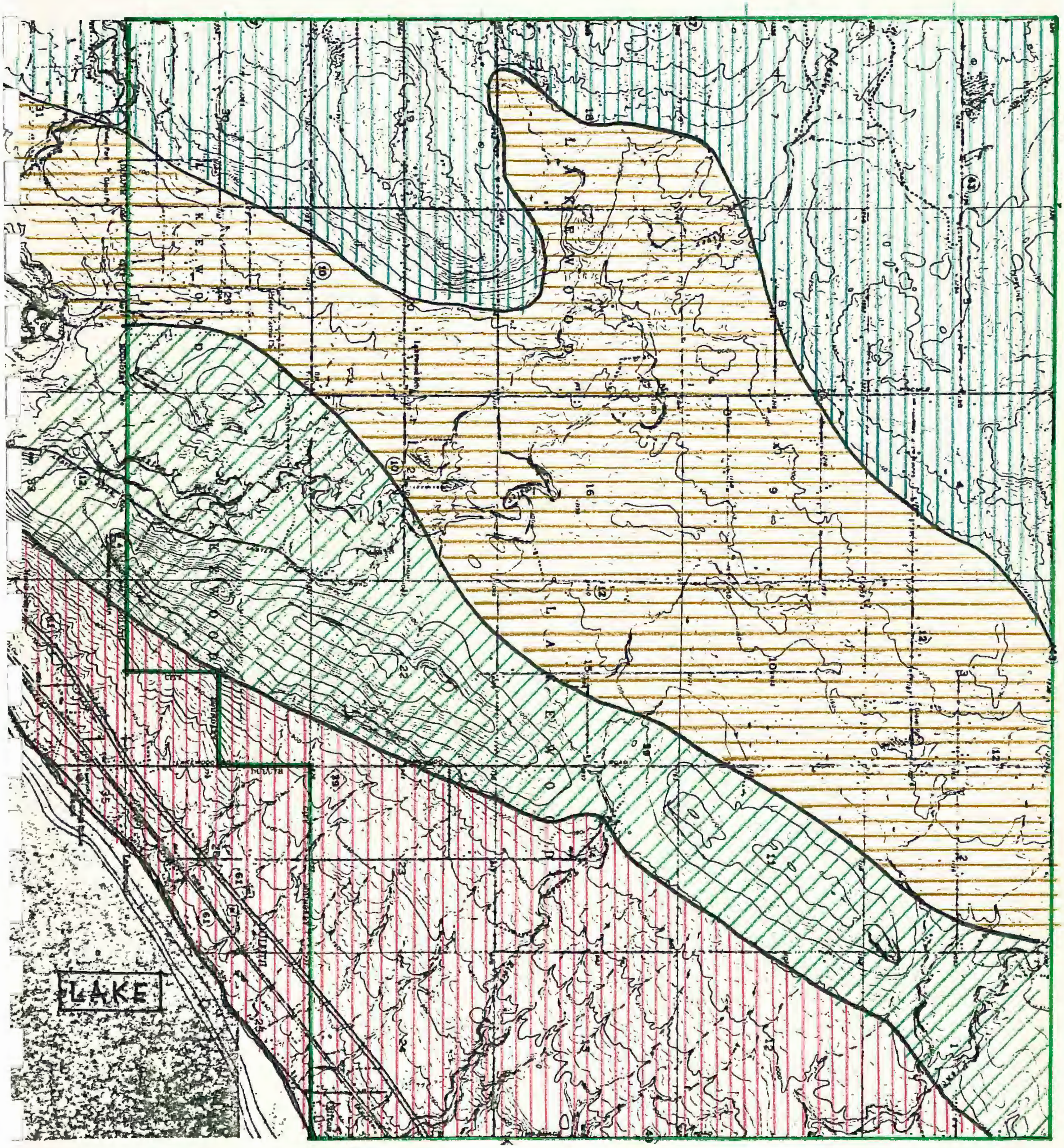
The even and regular lake plain east of the Lester River Sill, gently sloping toward Lake Superior.

The conspicuous ridges of the Lester River Sill and the Northland Sill, both of which show extensive outcrops and in places relatively steep hillsides.

The central area, more or less parallel to the ridges, may be described as a gently rolling landscape with scattered bogs.

The Highland area in the west and northwest, characterized by irregular, hummocky terrain with hills of more than 200 feet relief and a few swamps in isolated surface depressions.

MAP 8 - PHYSIOGRAPHIC AREAS IN LAKEWOOD



Lake Plain (gentle slopes)

Mid Section (rolling)

Ridges
(moderate to steep slopes)

Highland (hummocky)

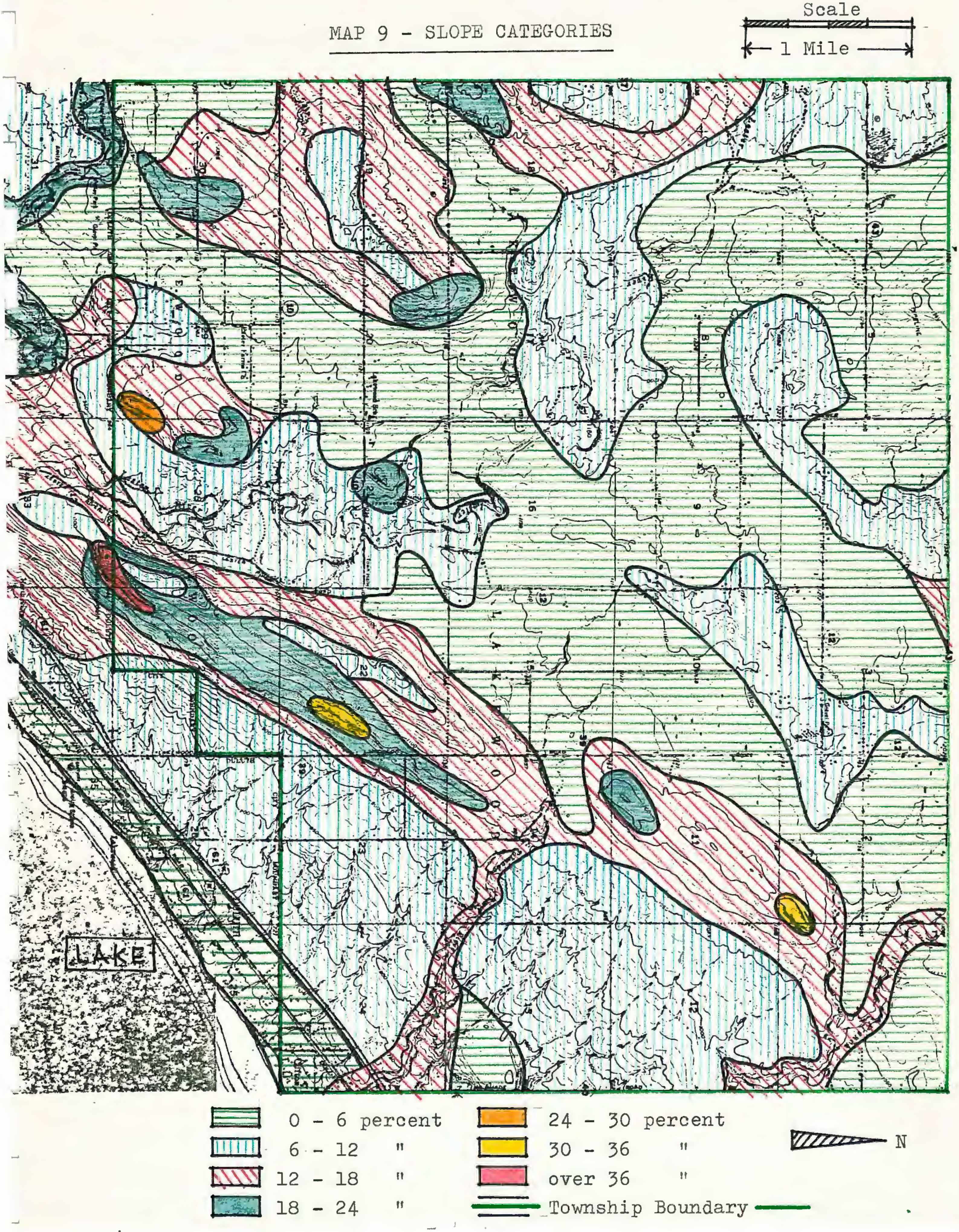
Scale

North

Map 8 shows these four different pysiographic areas. They are transected and drained by the Lester, Talmadge, and French rivers which cut deep gorges with steep embankments as they flow into Lake Superior. Steep hills and erodible soils apparently constitute an ever present erosion problem. For reasons of topographic analysis the writer of this paper produced map 9 in order to categorize the township into several selected slope classes, based on contour densities of the standard USGS topographic map.

The slope map (map 9) was made by preparing a transparent template in the scale of the USGS topographic map, subdividing a section (1 sq. mi.) into 2½ acre cells. The number of lo-foot-contour-lines falling within one cell were then counted (in a random distribution of squares) and the slopes classified according to the established code (for example: 2 to 3 lines, code II, 6-12 percent slope).

MAP 9 - SLOPE CATEGORIES



Drainage

Lakewood Township is in the Lake Superior Watershed which generally drains southeasterly toward Lake Superior. The township is drained by the Lester River, the Talmadge River, and the French River, all of which have an irregular gradient and are quite different in their length. They have a channel width from 4 to 30 feet, and all have high seepage losses into the fractured lava flows.(10) This seepage loss is actually an important water storage mechanism which becomes significant for the supply of drinking water. The lower portions of the streams cut deep into the underlying bedrock, whereas farther upstream the rivers flow over a boulder bed in the lake plain or glacial moraines.

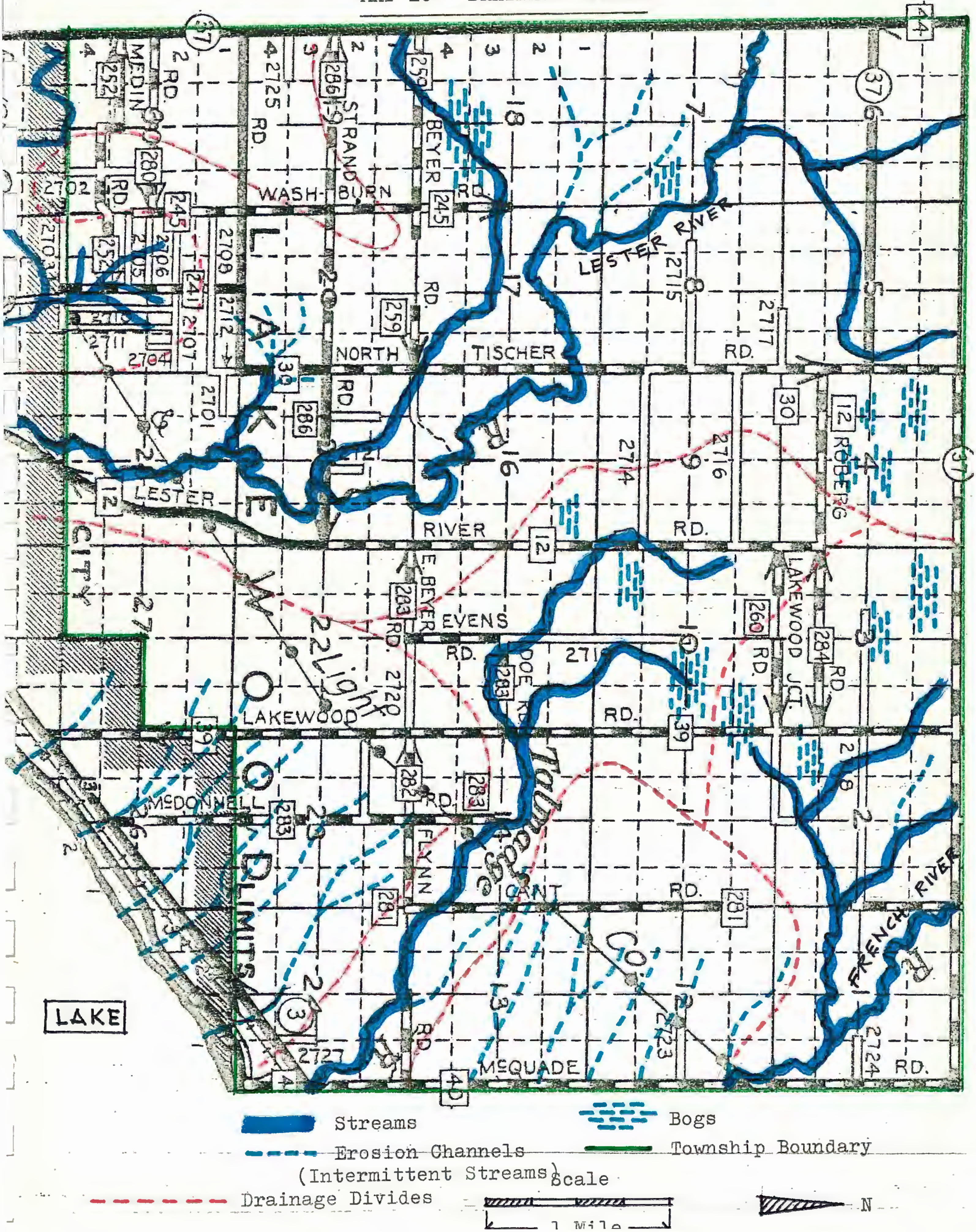
The largest of the three streams is the Lester River which is some 22 miles long and emerges way beyond the township boundary. In its upper reaches it has a gradient of about 16 ft/mi, in the middle parts between 38 and 50 ft/mi, and in the lower run it has a maximum gradient of about 100 ft/mi. Among the three streams the Lester River should have the most sustained flow since it has the largest drainage area (with Eagle Lake and a couple of ponds).

The Talmadge River is the smallest stream in Lakewood, having a length of only about 6.5 miles. The gradient is fairly regular but very steep (average 92 ft/mi) and, as can be seen on map 10, its drainage area is small, so that mean channel flow must be expected to run low. Also, it should be noted that its average gradient is 2.5 times that of the Lester River.

The French River has a length of about 14 miles and irregular, local gradients which vary between 36 ft/mi and 52 ft/mi to 150 ft/mi in the lower reaches, the average being 58 ft/mi. Only a small part of this river is located in Lakewood.

Streamflow is primarily from surface runoff, and the water level in the rivers responds therefore rapidly to seasonal variations in precipitation. Rapid runoff is attributed to the slope of the land, frequent outcroppings, and the generally low permeability of the clay soils on the lake plain. However, during periods of low or deficient precipitation, streamflow is maintained by ground water discharge to the streams and by the gradual

MAP 10 - DRAINAGE SYSTEM



release of water stored in the marshes. The estimated annual increment of ground water discharged to this class of watershed streams is about 2 inches.(10) Map 10 shows the three rivers and the marshes as well as the drainage divides.

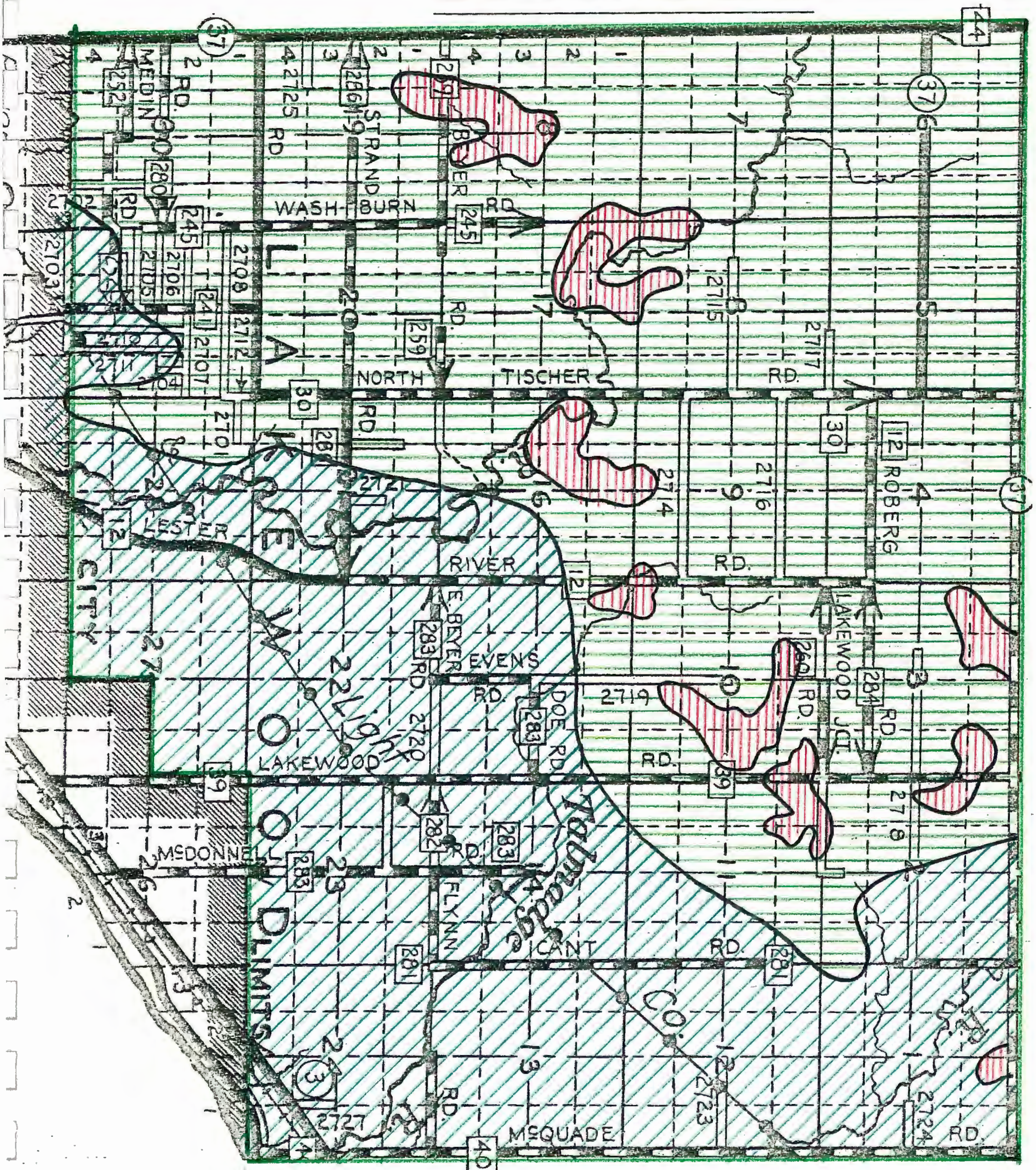
Ground Water

The occurrence of ground water and the abundance of aquifers or water-bearing formations in the region is related primarily to local geologic conditions. The relative abundance or scarcity of ground water is also related to climatic factors such as precipitation and evaporation. Although the precipitation in Lakewood ranges from medium to high and evaporation is low, infiltration and ground water storage are low in the crystalline rocks and thin patches of glacial drift. Ground water supplies generally are obtained from fractures in the bedrock or from sandy lenses in the glacial drift. Large fracture zones in the bedrock and large aquifers in the drift are rare, and accordingly the area is not favorable for developing extensive water supplies.(9)

In the glacial drift, as well as in the bedrock, the direction of ground water movement locally is toward the stream valleys but generally toward Lake Superior. Well records indicate that relatively few water supplies are obtained from the glacial drift and that the lava flows are the best aquifers in the bedrock, although the success of any well appears to be completely unpredictable. The thickness of the glacial deposits varies from 0-100 feet, and the yield of water from sand and gravel lenses is only moderate because the drift is generally too thin and discontinuous to provide adequate water supplies. Thus many home owners have to get their water for domestic use out of great depth from bedrock fractures. Drilling records from Anderson Drilling Company, Duluth, show a well depth range from 45 feet to 435 feet.

Map 11 gives a very general outline of the ground water distribution in the unconsoliated glacial deposits of Lakewood Township. It does not mean to indicate

MAP 11 - GROUND WATER PATTERNS



More than 5 ft from surface

Less than 5 ft from surface (except on hills)

Near surface (saturated)

Township Boundary

Scale

1 Mile

N

Information by WLSSD

continuous water occurrence at the standard levels shown but rather the likelihood of local occurrence at those levels under proper conditions. In the eastern section of the township, which is covered mostly by glacial lake sediments, the water table is usually more than five feet below the ground surface, whereas the water table in the western part is generally closer to the surface, except on the hills, of course, where the water table stands lower. Typical depths to water table in the hilly parts of this area could not be gathered because only usable water, which is water below 25 feet, is recorded (Anderson Well Drilling, Duluth).

Complete chemical analyses of river water and well water in Lakewood Township could not be obtained for this report. However, water quality conditions of the streams in Lakewood were measured by WLSSD in terms of fecal coliform, ammonia, and dissolved oxygen content. (15, p. 13-14) When compared to the standards for intrastate waters, set by the Minnesota Pollution Control Agency, the Lakewood water samples passed generally within tolerance of permissible deviations. However, the fecal coliform count (warm-blooded animal wastes in the water) throughout the year of 1975 was alarming, for almost half (45 percent) of all samples taken dangerously exceeded the intrastate water quality standards. These violations, recorded by the Western Lake Superior Sanitary District, demonstrate clearly that the marginal soil conditions in Lakewood make septic system leaching fields a serious source of water contamination.

Present Land Use, Zoning and Transportation

Lakewood, at the present time, has a rural character because more than 80 percent of its total area is classified as undeveloped open space. Table 1 shows the generalized existing land use of the township.

TABLE 1 - LAND USE

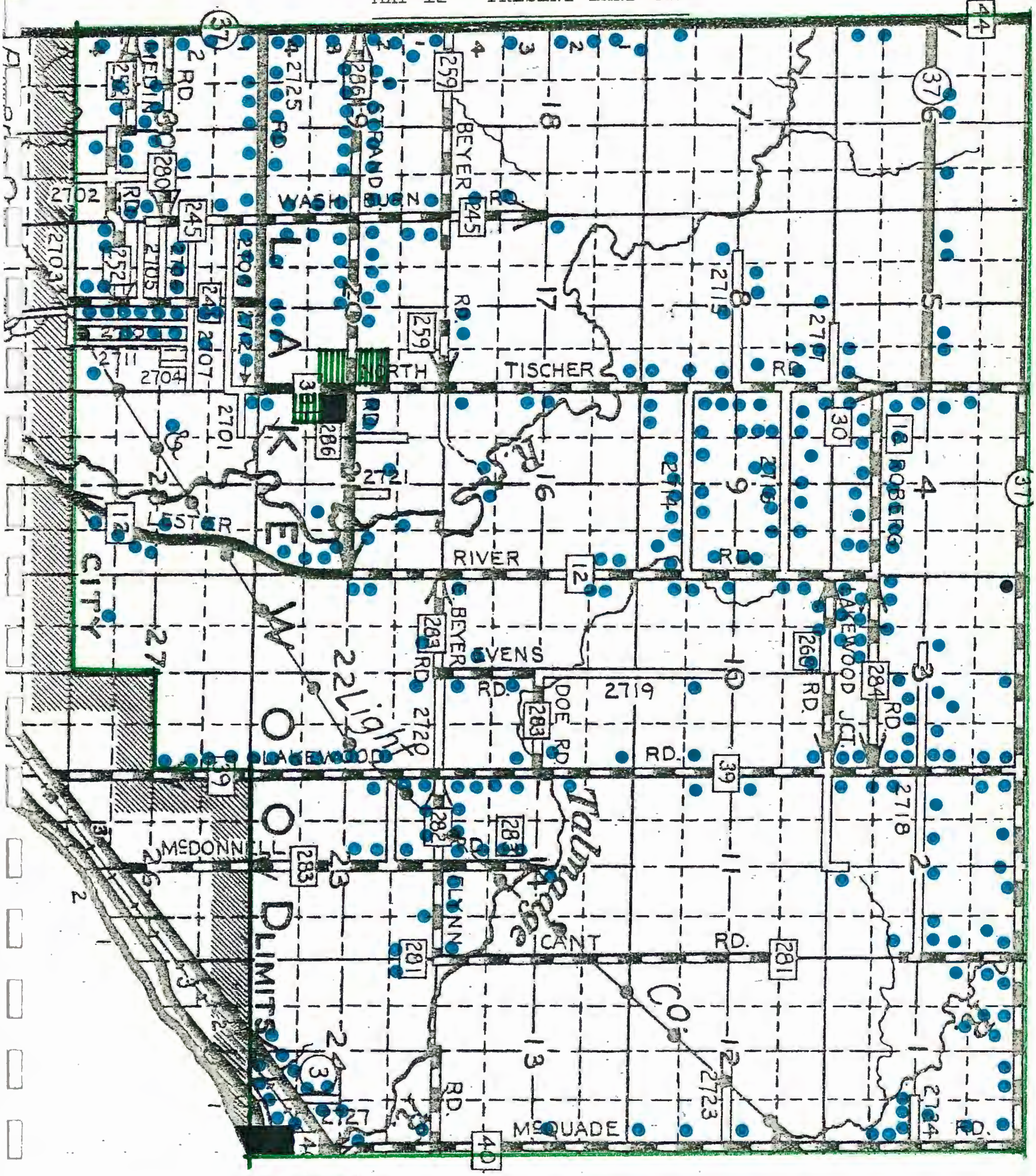
Use	Acres	Percent of total area
Transportation	1,260	7.1
Agriculture	979	5.3
Residential	299	2
Industrial	21	.1
Seasonal	10	.1
Commercial	115	.7
Public or Semi-Public	107	.6
Total Developed Area	2,791	15.9
Undeveloped Open Space	14,849	84
Water Area	20	.1
Total Area	17,660	100.0

Source: Western Lake Superior Sanitary District; Lakewood Township, Inventory and Analysis, 1976.

The largest percentage of developed land is used for transportation, including all of the roads. The portion used for agriculture is in the central and northwest sections of the township where the topography and soils are suitable for such practice. Major concentrations of residential development are in the southwest corner and in the Clifton area. Otherwise, homes are scattered all over the township along the roads. The almost 15,000 acres of open space are both cleared and forest land, most of which is in private ownership (Atlas Plot Book, St. Louis County, South Part, Minnesota 1976). Although this land is not classified as "agricultural", the unforested parts are used by the farmers as grassland in that they contract the hay from the owners. In general, all of this land (84 percent of the township) is speculative land awaiting development.

The transportation system in Lakewood Township is sustained by three classes of roads in addition to U.S. Highway 61. They are County and State Aid Highways (CSAH), County Roads, and Township Roads. The most important ones are the CSAH's, for this network comprises the major circulation routes within the township. The CSAH system has more than 20 miles of bituminous driving surface. The other roads are merely feeder routes to the CSAH system and provide access to residential development. Map 14 illustrates the different roads.

MAP 12 - PRESENT LAND USE



Information by WLSSD

Commercial

Public & Semi-Public

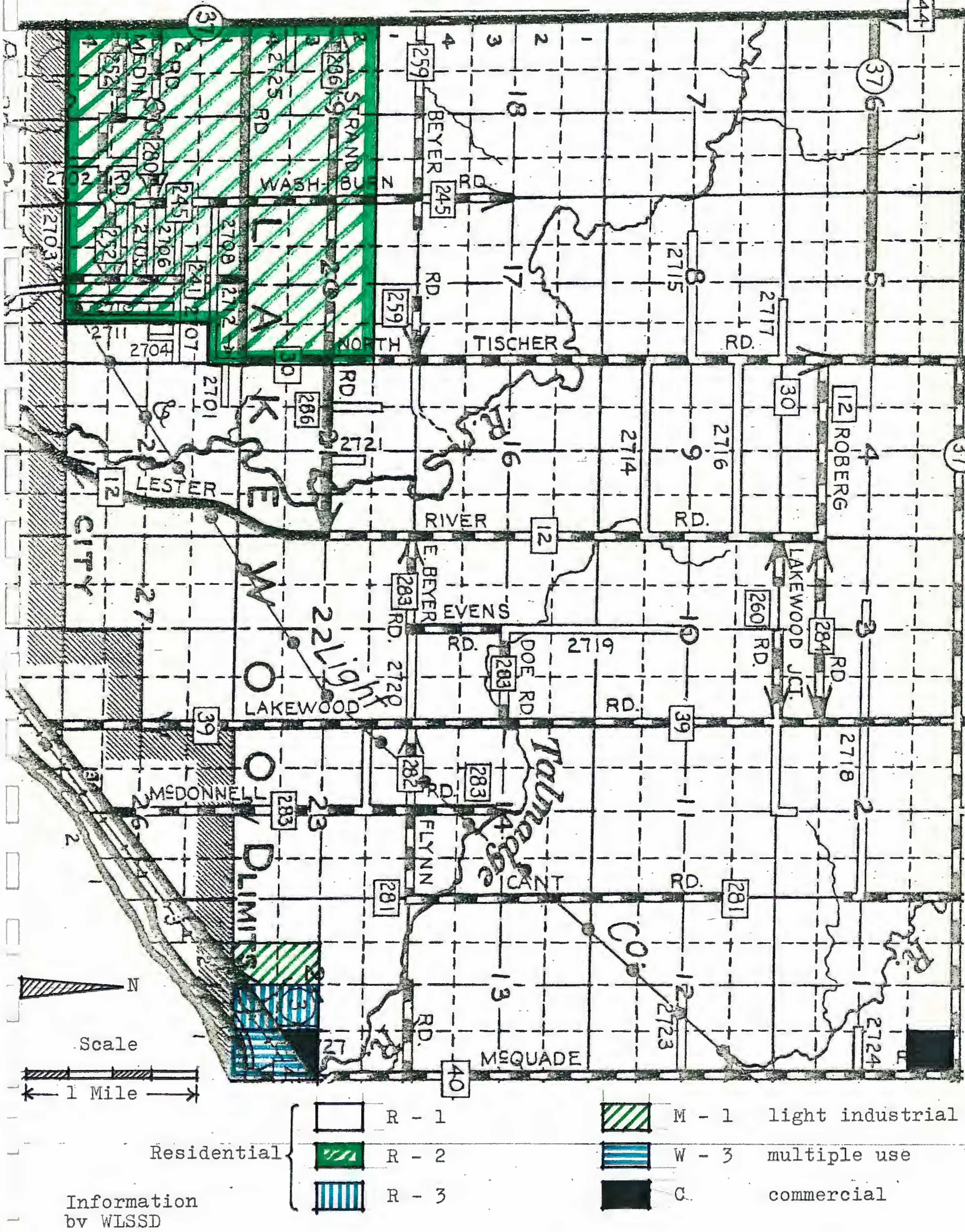
Residential (Dwelling Units)

Scale

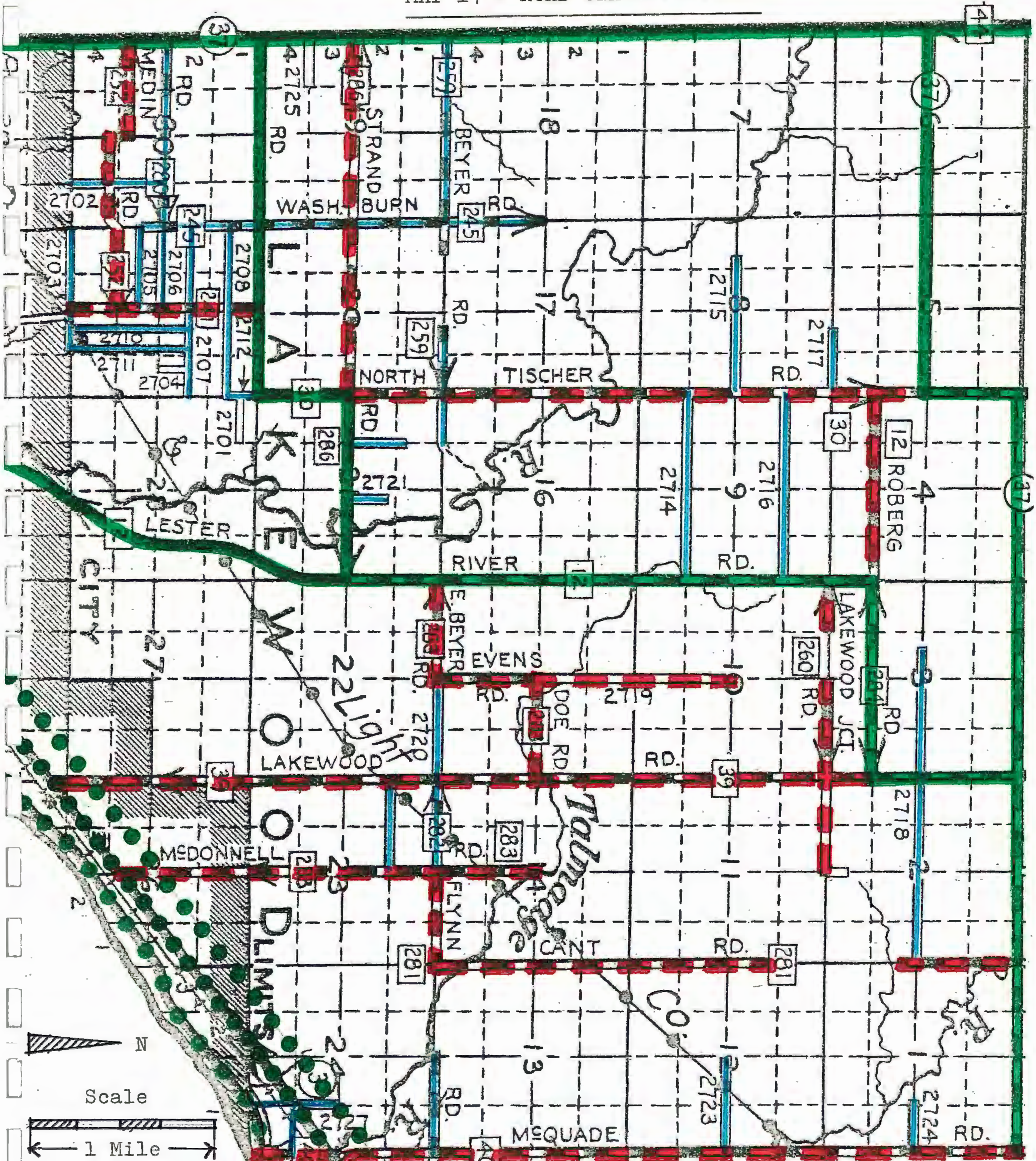
1 Mile

North

MAP 13 - ZONING



MAP 14 - ROAD CLASSIFICATION



U.S. & State Hwys

County & State Aid Hwys

County Roads

Unimproved Roads (Township Roads)

Information by WLSSD

Recommendations

Based on the collected data, the suitability of the land for general development in Lakewood Township has to be designated as critical because the soil/groundwater conditions in extended areas are too sensitive. If the rural character of the township is to be preserved, development should be allowed to occur only within environmental constraints such as soil types, hydrology, forest areas, slope classes, and others. Table 2, for example, shows the relationship between the different slope classes and their practical limitations as to use.

TABLE 2 - SLOPE CLASSES AND THEIR PRACTICAL LIMITATIONS

Uses or Activities	Mapping Categories (percent slope)						
	0-6	6-12	12-18	18-24	24-30	30-36	Over 36
General Recreation	X	X	X	X	X	X	X
Engineered Structures	X	X	X	X	X	X	X
General Urban Uses	X	X	X				
Urban Roads	X	X					
Septic Field Systems	X						
Conventional Housing	X	X	X				
Commercial Centers	X						
Interstate Hwys	X						
Airports	X						
Railroads	X						
Tracked Vehicle Operations	X	X	X	X	X	X	X

(adapted from A.K. Turner and D.M. Coffman, 1973)

Explanation: Every "X" stands for applicability of indicated use.

For all construction projects, geological and engineering advice should be used in evaluating the capabilities and sensitivities of the land at a specific construction site. Characteristics that need to be considered are bearing strength, plasticity, frost-heaving potential, angle of slope, depth to water table, and flood potential. In this context, natural drainage courses are most important environmental resource units and deserve a high degree of attention, for they constitute the natural storm drain system of an area. Rivers and wetlands should be allowed to remain in their natural state as much as possible. Flooding could be a major problem if these natural drainage systems are not integrated into the overall development plans.

The engineering restrictions in areas of possible high water table (less than 5 ft from surface) are considerable, especially with regard to the construction of homes with basement and, even more importantly, septic tank systems. The soil limitations in Lakewood Township related to the use of septic tank systems (and landfills) are probably the most severe. Failure of these systems is common in areas with moderate to high soil limitations such as improper percolation rate, high clay content, and high water table. Unfortunately, these conditions more or less prevail all over Lakewood, and random development should therefore not be encouraged.

The present zoning regulations of Lakewood, in the writer's opinion, are grossly inadequate because the whole township is practically open for residential development (see Map 13). The regulations, which Lakewood adopted from the St. Louis County Zoning Office, are summarized in Table 3.

TABLE 3 - ZONING REGULATIONS

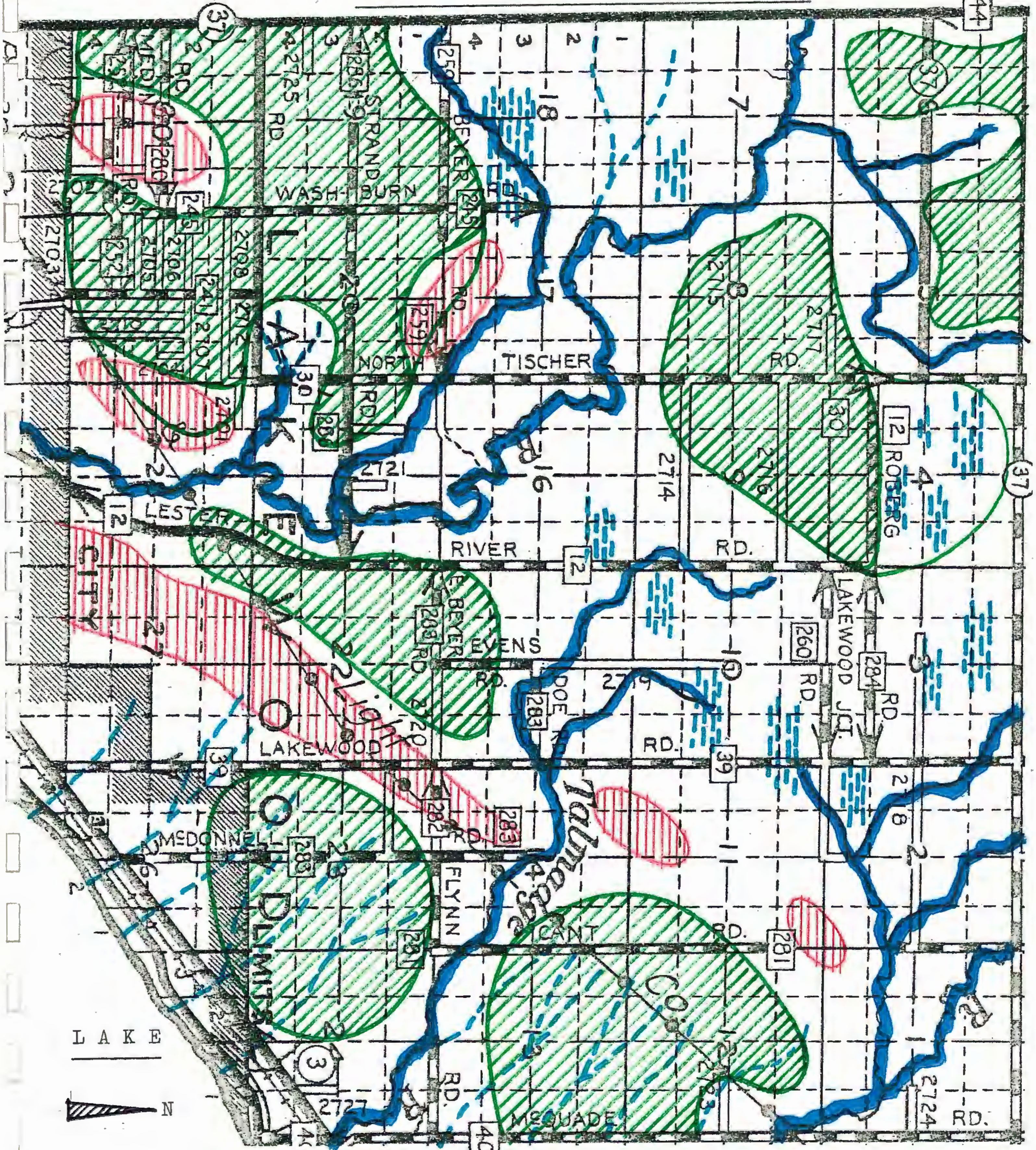
R-1	Single-family residential, including agriculture, forestry and seasonal land use (min. lot size 5 acres).
R-2	A higher density use for single and two-family residences.
R-3	Denser pattern for single and multiple-family residential use (min. lot size 1 acre).
C	Commercial (min. lot size ½ acre).
M-1	Light industrial (min. lot size 1 acre).
M-2	Heavy industrial (min. lot size 1 acre).
O	Open space, game preserves, logging, etc.
W-1	Natural Environment Lakes and Streams (min. lot size 2 acres).
W-2	Recreational development lakes and streams, single family and seasonal homes.
W-3	General development lakes and streams, high density, multiple use area.
W-4	Critical lakes, only conditional use.

Source: Western Lake Superior Sanitary District; Lakewood Township, Inventory and Analysis, 1976.

Minimum lot size restrictions alone are neither sufficient to prevent engineering failures (including G.W. contamination) nor conducive to the ideas of city planning concepts. Because of natural limitations, certain discrete areas in the township should not be used for any construction at all, yet the delineation of the existing roads is such that indiscriminate development is unavoidable. Ideally, those few areas suitable for residential construction should be developed at a high density, whereas the areas of high sensitivity should strictly be kept as open space, for uses compatible with the inherent capabilities of that land; uses such as seasonal recreation, forestry, agriculture, wildlife preserves, etc.

As already mentioned, Lakewood Township has many sensitive areas which are not suitable for development. In addition to the critical relationship between soil and ground water, there are in some areas steep slopes which would require carefully engineered foundations for any kind of building in order to avoid sliding or other structural failures. However, as pointed out before, clusters of higher-density development could conceivably be placed in the least sensitive areas of the township. Such developments, of course, would have to be planned systematically and provide for a sanitary sewer system. Map 15 (the writer's recommendations) tries to localize, in a very general way, the environmentally least sensitive areas. Planning decisions made by individuals, however, are usually biased since the opinions, formed from a combination of factors, are based on subjective interpretation. Despite the availability of physical data, some factors will have to be weighted more important than others. Therefore, land capability studies, which are the first and most important planning parameters, must be produced and completed by a team or teams of individuals who are capable of collecting and analysing all the data necessary in order to make sound judgements and competent recommendations.

MAP 15 - SUITABILITY FOR DEVELOPMENT



Areas more or less suitable for development

Streams

Steep slopes

Erosion channels

Scale

1 Mile

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