University of Wisconsin-Extension

GEOLOGICAL AND NATURAL HISTORY SURVEY
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LAND USE AND THE GEOLOGIC AND HYDROLOGIC ENVIRONMENT IN BURKE TOWNSHIP, DANE COUNTY, WISCONSIN

by

P.G. Olcott

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March, 1974

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PREFACE

M.E. Ostrom

Land Use and the Geologic and Hydrologic Environment in Burke Township, Dane County, Wis.

by Perry G. Olcott

INTRODUCTION

Purpose & Scope

The purpose of this paper is threefold: to demonstrate to land owners, planners, and managers the need and use of geologic, soils, topographic, and hydrologic information in land management; to present a comprehensive assessment of land use suitability based on geologic, soils, topographic, and hydrologic information, for Burke Township; and to serve as an example for county-wide environmental geology studies of the Wisconsin Geological and Natural History Survey.

The report includes geologic, soils, topographic, and hydrologic information taken from recent, detailed county-wide maps prepared by the Wisconsin Geological and Natural History Survey, U.S. Geological Survey, and USDA Soil Conservation Service. This report, limited in scope to one township in the county, demonstrates the methods of approach used to translate basic physical data into land use suitability.

Location

Burke Township is located immediately north and east of Lake Mendota in the northeastern part of Dane County. It essentially spans the area between the cities of Madison and Sun Prairie. It is approximately 36 square miles in area and is described in the Federal System of Land Subdivision as Township 8 North, Range 10 East (Figure 1).

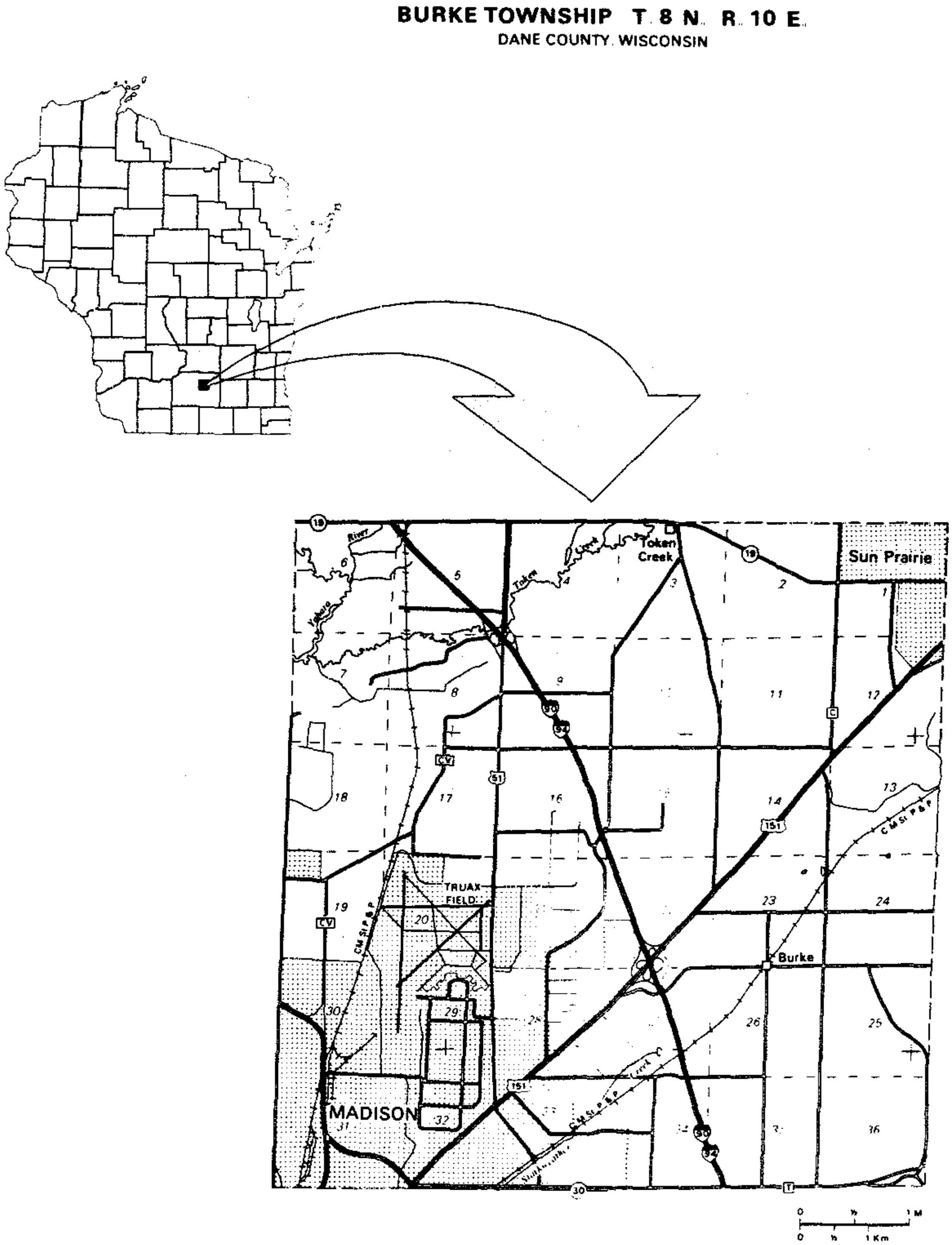


Figure 1 Location of Burke township

Method of Approach

The application of geology to land use planning and the method of approach herein described are not new but have been used successfully and with wide acceptance for the past decade in many areas of the country. Books and reports by Flawn (1970), Leggett (1970), Frye (1967), Gross (1970), Green and Bograd (1973), and the Geological Survey of Alabama (1971) are a few examples describing the process and its use in land use planning. The method, illustrated in Figure 1, entails 3 successive orders of mapping: 1st Order, which illustrates physical parameters; 2nd Order, which interprets the physical parameters in regard to criteria for specified land uses; and 3rd Order, which shows land suitability for specified uses.

Bedrock and surficial geology, topography, soils, and surface and ground water are the physical framework of the natural environment. Man depends on this framework for building materials, metallic minerals, food and fiber, water supply and many other necessities. A knowledge of these parameters is basic to land use planning. Appropriately then, these basic mappable resources, including land surface topography, drainage, flood potential, glacial deposits, soils, bedrock geology and topography, and the ground-water surface, are the basic data or 1st Order maps on which this method of approach is based (Figure 2).

Resources and engineering properties are shown by 2nd Order maps (Figure 2) which deal with the technical limitations for use or delineation of resources and are derived from one or more of the basic data maps. For example, the 2nd Order dolomite reserves map is derived from the 1st Order bedrock geology and the thickness of overburden maps. These 2nd Order maps will be most useful to the engineer, geologist, soil scientist, and other technical people. They also form an aggregate of detailed physical framework information that is the basis for the 3rd Order maps.

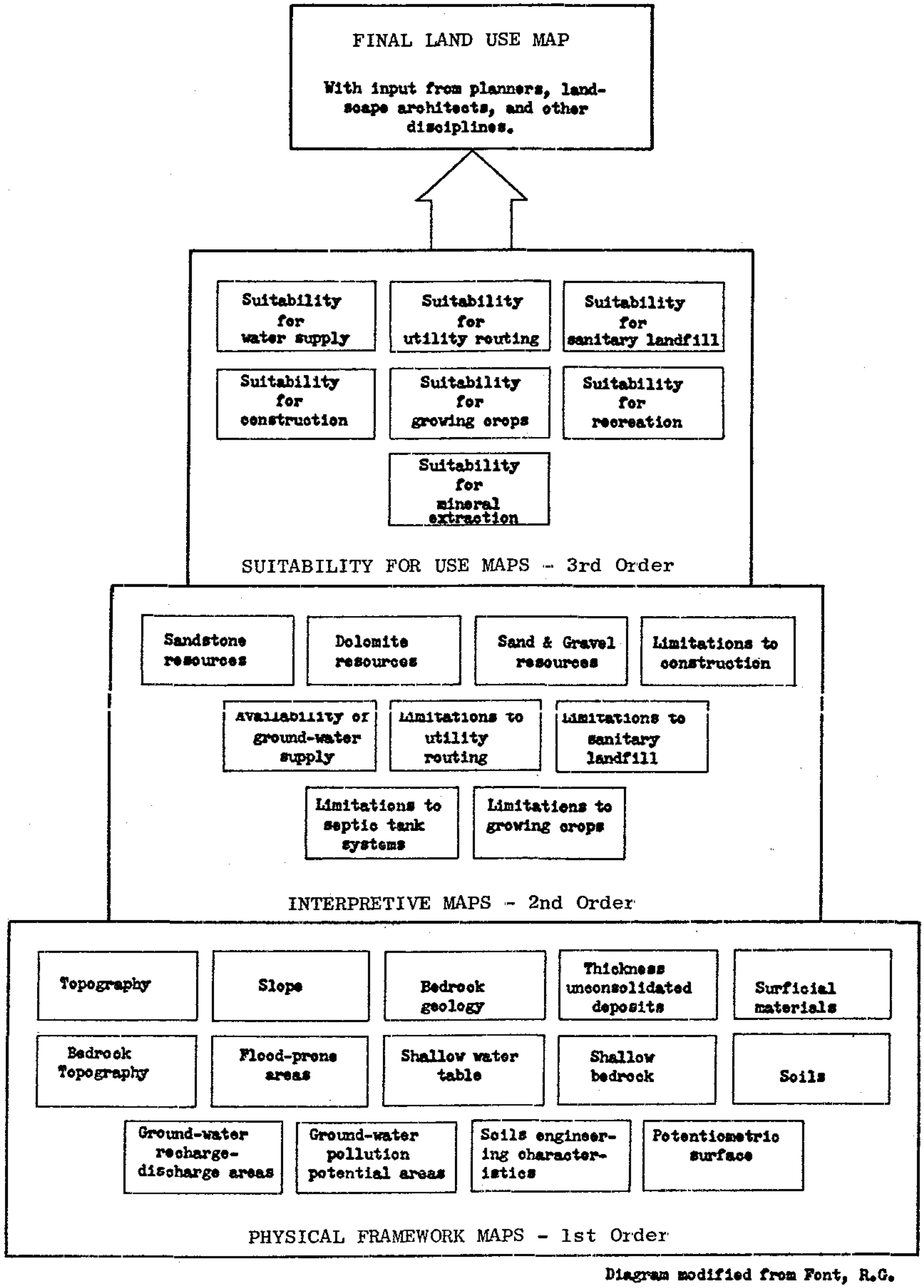


Figure 2.--Diagram of the method of approach to environmental geology.

The 3rd Order maps are designed to show by three colors--red, yellow, and green-- suggested land use based on the 1st and 2nd Order information. The colors are analogous to the traffic stop light with green (go) being the best area(s) or those with the fewest limitations for the particular use designated, yellow (caution) indicating some limitations, and red (stop) designating severe limitations or the poorest area for the particular land use. These maps are intended for the county, city, or township official, the interested layman, and/or others concerned with land use decisions.

As mentioned, this report concentrates on the physical framework which is only a part of final land use planning. Cultural features, zoning regulations, municipal boundaries, transportation patterns and many other aspects of planning have been ignored for two reasons: (1) it is not within the Wisconsin Geological and Natural History Survey's expertise or responsibility to examine these parameters, and (2) it is expected that land planners and managers, city officials, and others, will evaluate present as well as future zoning and other land related activities in the light of the material herein presented. Thus, 4th Order maps, representing final land use maps based on complete data on all planning aspects, should be drawn by the land planner and manager.

The maps presented in this report are accurate consistent with available data and are based on a large number of data points. However, local inaccuracies are inherent in these as in most maps because they represent extrapolation and interpretation of the data points. Thus, the maps can be considered as a basic guide to land use but any development should be preceeded by a detailed site study to ascertain actual conditions.

Acknowledgements

The invaluable advice and assistance by Professor F.D. Hole, Wisconsin Geological and Natural History Survey and the University of Wisconsin Soils Department, and Mr. Carl Glocker, U.S.D.A., Soil Conservation Service in preparation of soils information for this report and for Dane County maps is gratefully acknowledged. Thanks are due to staff members and student employees of the Survey for drafting and compilation of maps and review of the report. Acknowledgement is also made of the valuable critiques given by Messrs. C.L.R. Holt, Jr., William Drescher, and Gerth Hendrickson of the U.S. Geological Survey.

THE PHYSICAL FRAMEWORK - 1ST ORDER

Geology, soils, topography, and hydrology form the setting or physical framework of the natural environment. They are defined by mapping surface and bedrock topography and geology, soils, and the water table and form the basic data required for intelligent land use. These basic data are the subject of the 1st Order maps.

The physical framework of Burke Township is the result of geologic processes, both erosional and depositional, that have been shaping the earth's surface since the planet was formed. The greater part of this long geologic history, an estimated 3.4 billion years, is embraced by the Precambrian Era, a time when there were repeated episodes during which whole sequences of rocks were deposited as sediments, uplifted into mountains, metamorphosed and intruded by granite bodies and eventually eroded down to a relatively smooth but uneven surface. These Precambrian rocks underlie Burke Township at depths ranging up to 800 feet or more and form the base upon which sedimentary rocks of the Cambrian and Ordovician periods of the Paleozoic era were deposited.

The Paleozoic Era began about 600 million years ago with the advance of the sea over the Precambrian erosion surface. This advance marked the beginning of the Cambrian Period of geologic time during which there was at least one more advance and retreat. The cambrian Period lasted 160 million years. There were at least 3 more advances and retreats during the 90 million years of the Ordovician Period which followed. Rivers draining the land area to the north carried sand, silt, and clay into these ancient seas where they were deposited to form our present sandstones and shales. Animals and plants living in the sea deposited calcium carbonate and built reefs to form rocks which are now dolomite--a magnesium-rich limestone. As these rocks were exposed to erosion during the retreat of the seas, uneven erosion surfaces were left which were subsequently covered by sand, silt, clay, and lime during the next advance of the sea. These old erosion surfaces, referred to as unconformities, are preserved in the rock record.

The last seas to invade this area probably retreated during the Silurian Period, about 300 million years ago. From that time up to about a million years ago, the area was probably subjected to additional episodes of erosion and deposition. However, erosion dominated and removed much of the upper layers of rock and impressed a deeply entrenched drainage system on the bedrock surface similar to the topography of the present driftless area of southwestern Dane County.

The last major episode of the land-forming processes started about a million years ago with the advent of continental glaciation. Glaciers invaded the area from the northeast, smoothing off hill tops and depositing unsorted rock debris (till) beneath the ice. As the glacial ice retreated, meltwater laden with sediments drained through the valleys and deposited layers of silt, sand, and gravel. In low-lying areas where drainage was temporarily blocked, lakes formed and entrapped the finer grained sands and silts carried by the meltwaters.

The final retreat of glacial ice in the vicinity of Burke Township occurred about 14,000 years ago. The barren landscape was devoid of vegetation and wind-borne silt drifted over the area. As vegetation became established the land surface stabilized. Since the time of their deposition the glacial and wind blown sediments have been subject to weathering through chemical and mechanical processes which has produced the soil layer that now covers the area.

This heritage of over 4 billion years of geologic history created the physical framework of Burke Township as it exists today. The basement rocks of the township are igneous and metamorphic granite, schist, quartizte and other crystalline rock types. The surface of these Precambrian rocks, which is about 800 feet below land surface, dips gently to the east. Cambrian rocks consisting primarily of sandstones with some shale and dolomite overlie the Precambrian surface and conform to the dip of that surface. Ordovician rocks rest on the Cambrian rocks. They are composed of 2 dolomite units with a sandstone, the St. Peter

Sandstone, sandwiched between them. The St. Peter rests on a principal unconformity or ancient erosion surface and is therefore variable in thickness.

The upper surface of the Cambrian and Ordovician sedimentary rocks, the bedrock surface, is deeply eroded with more than 550 feet difference in elevation between the deepest valley and highest hilltop. Unconsolidated glacial and alluvial deposits, up to 350' thick, have filled the bedrock valleys. But these deposits form only a thin veneer, generally less than 50 feet thick, over the bedrock highs. Thus, the bedrock surface is closely reflected in the land surface topography. This bedrock surface profoundly affects land use in the township because it largely controls drainage, flood prone areas, wetlands, depth to water table, availability of mineral resources, depth to bedrock, land slope, soils, and other parameters.

The unconsolidated deposits greatly influence productivity of the land because they, together with small areas of shallow bedrock, are the parent materials of the soils of the township and their character is reflected in the soils. The unconsolidated glacial deposits are also the source for sand and gravel which is an important economic resource of the township.

The sedimentary bedrock and glacial deposits together form the container in which the hydrologic systems of Burke Township operates. They are the reservoir for ground-water that receives its input from precipitation and discharges its excess to streams and wetlands. This reservoir represents the water supply for municipal, industrial, domestic, and farm use in the township.

The physical framework of Burke Township is defined in the following discussion as a basis for the land use planning process. The physical framework of Burke Township is defined in the following discussion as a basis for the land use planning process. A description of the land surface topography, including land slope, sets the stage for the discussion because it is the most visable and predominant factor affecting land use. Subsequent sections deal with bedrock and surficial geology, soils, and hydrology which, although less visable than topography, also have a pronounced influence on land use.

Land Surface Topography

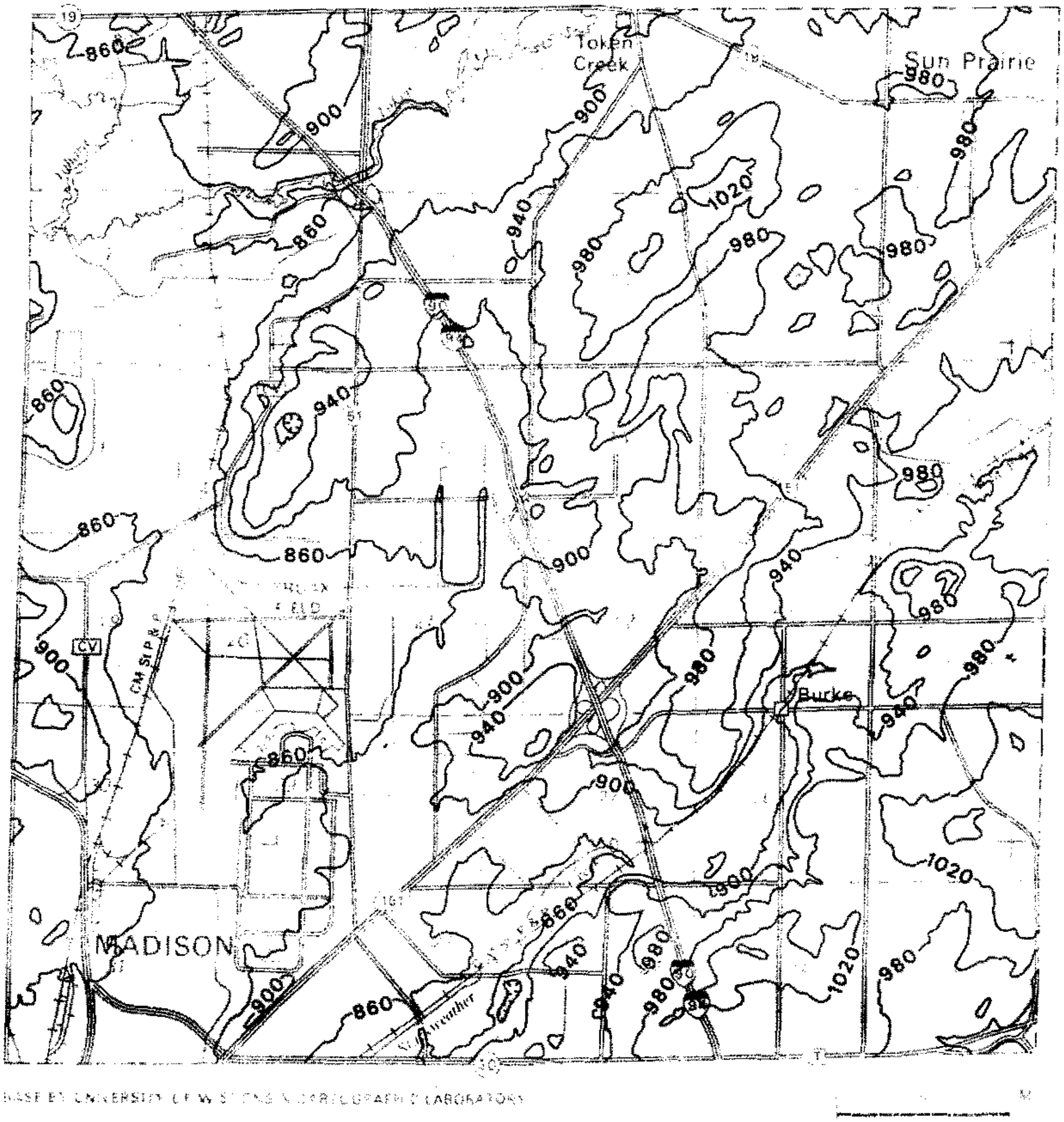
The topography of Burke Township (Figure 3) reflects the underlying deeply eroded sedimentary bedrock surface that has been greatly modified by glacial deposition. Thick deposits of glacial debris nearly fill bedrock valleys to form broad, flat low-lying areas containing wetlands and streams. The dolomite bedrock highlands are covered by only a thin veneer of glacial debris and underlie the topographically high areas of Burke Township. The topography of the township has been only slightly modified by man.

Prominent topographic features of the township are the broad lowland and marsh area in the western 1/3 to 1/2 of the area and the rolling to steep topography in the eastern part. Land surface elevations range from slightly below 860 feet above mean sea level (MSL) in the lowland in the northwestern part to slightly above 1060 feet above MSL in the highlands of the southeastern part of the township. Total relief is about 200 feet.

There is a general lineation of surface features in the township, observable on many of the maps, which have a northeast-southwest trend. The lineation was produced by continental glaciers which streamlined many of the surface features and aligned deposits in the direction of ice movement. The pattern is emphasized to some extent by buried bedrock valleys that are similarly oriented.

Slope

Implicit in the topographic map of Burke Township is land slope, a critical factor in land use planning. Land slopes of the township have been extracted from the soils and topographic maps and are mapped in units of 0-6, 6-12, 12-20, and greater than 20 percent slope (Figure 4). The broad flat lowland and marsh area in the western part of the township shows on the slope map as having less

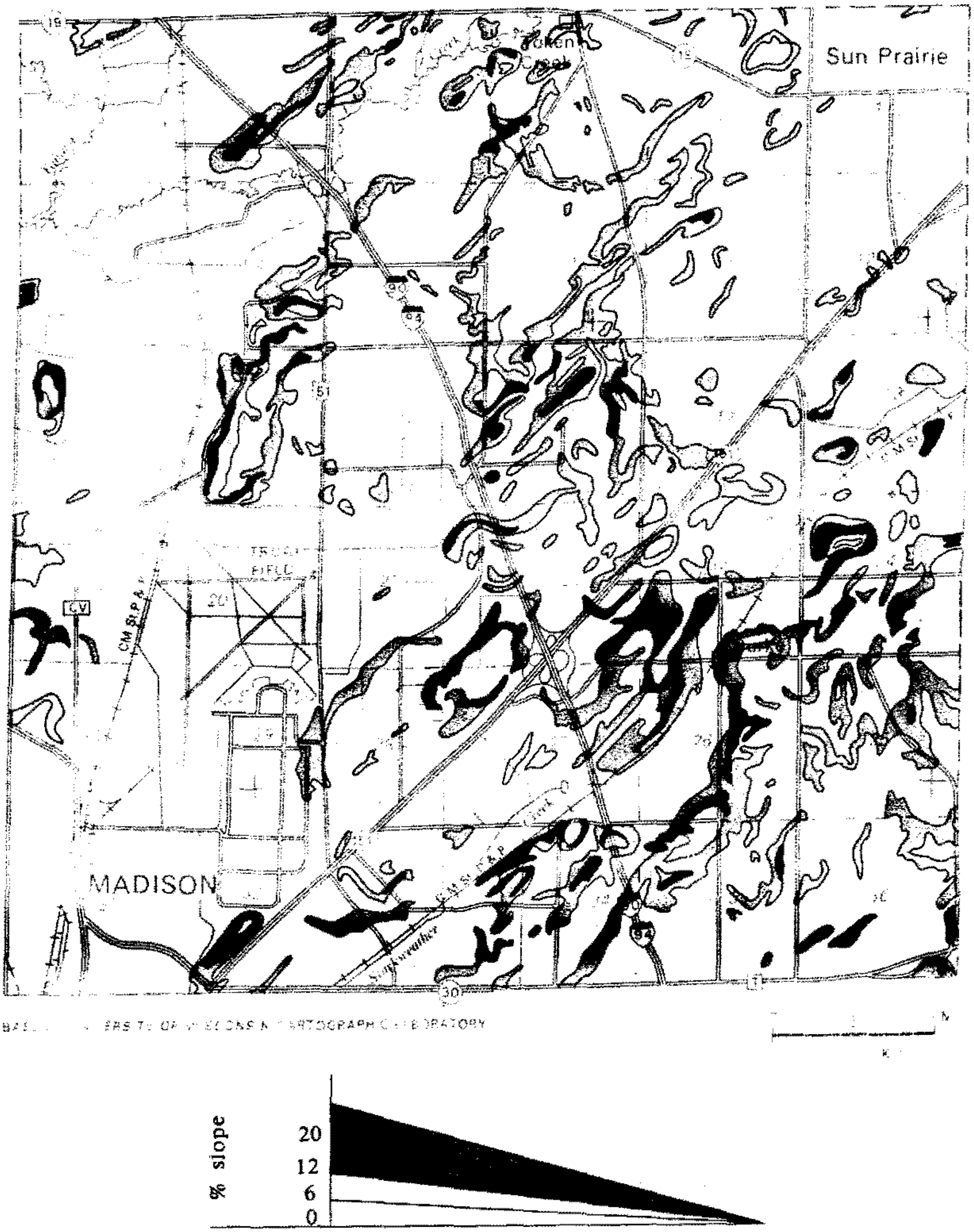


900

Line of equal elevation of the land-surface in feet above Mean Sea Level. Contour interval 40 feet.

Source: USGS 15 min topographic maps Madison and Sun Prairie quadrangles

Figure 3 Land-surface topography



Source: USDA SCS Advanced field sheets

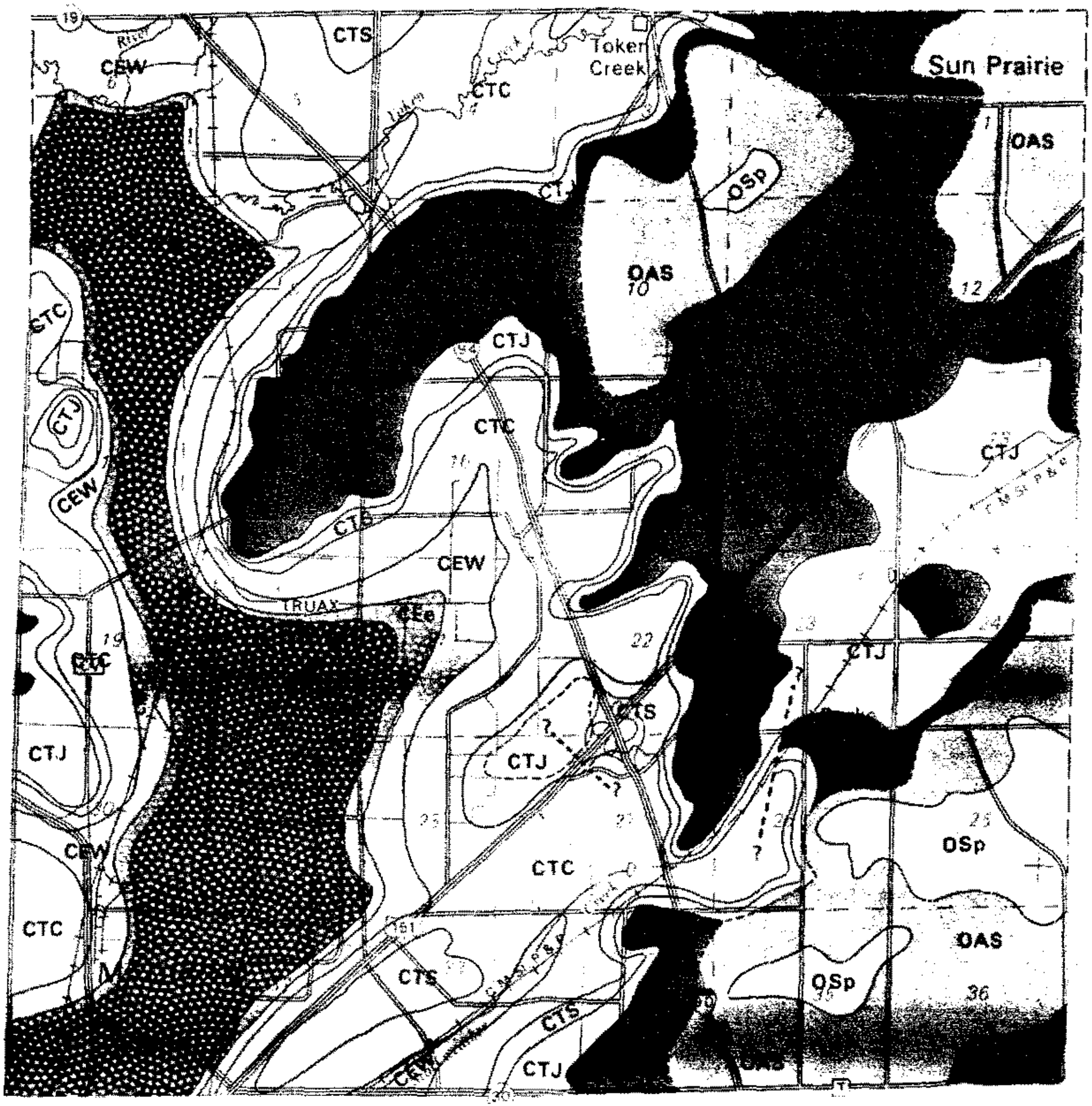
Figure 4 Land slope

than 6 percent slope. For the most part slope is probably less than 2 percent over much of this area. Slopes of less than 6 and from 6 to 12 percent dominate most of the township with the higher slopes occurring mainly in the uplands. The minor areas of 12 to 20 and over 20 percent slope occur mainly in areas of very shallow bedrock in the uplands.

Bedrock Geology

The bedrock of Burke Township consists of an alternating sequence of essentially flat-lying, thick layers of sandstone and dolomite up to 800 feet in thickness which rests on the ancient Precambrian crystalline rock surface. The distribution of these rocks, shown on the bedrock geology map (Figure 5), is the result of deep erosion of the flat-lying rocks. The uplands generally represent the most erosion-resistant, as well as the youngest rock; in this case the Sinnipee Group and Prairie du Chien Group dolomite units. The deep bedrock valley on the western side of the township exposes successively older formations of the more easily-erodable Cambrian sandstones. The deep valley has cut into the Mt. Simon Sandstone, the lowermost and oldest sedimentary bedrock formation.

The St. Peter Sandstone, which underlies the Sinnipee Group and overlies the Prairie du Chien Group of dolomites, rests on an ancient erosion surface with considerable relief that existed prior to deposition of the sandstone. Thus, the thickness of the sandstone varies inversely with the thickness of the Prairie du Chien Group and one unit may be present to the exclusion of the other. For example, in the southeastern part of the township (Section 26), the Prairie du Chien is missing and the St. Peter Sandstone rests on the Jordan Sandstone. This inconsistency makes the areal extent of the St. Peter Sandstone difficult to map in the subsurface. Consequently, the contact is dashed on the map indicating that it is an approximation.



Geologic contact

Assumed geologic contact

Fault

Ordovician	OSp	Platteville Fm (*dolomite*)
Ordovician	OAS	St Peter Fm (*sandstone*)
Ordovician	OP	Prairie du Chien Gp (*dolomite*)
Cambrian	CTJ	Jordan Fm (*sandstone*)
Cambrian	CTS	St Lawrence Fm (*dolomite*)
Cambrian	CTC	Tunnel City Gp (*sandstone*)
Cambrian	CEW	Wonewoc Fm (*sandstone*)
Cambrian	CEe	Eau Claire Fm (*sandstone*)
Cambrian	CEM	Mt Simon Fm (*sandstone*)

Fm – Formation Gp – Group

Source: P Olcott 1973

Figure 5 Bedrock geology

Two small bedrock faults, rock fractures along which movement has occurred, were mapped in the township from outcrop exposures. They appear to be oriented nearly vertical with only small displacement. They could not be traced in subsurface mapping but may be related to faulting south of the township.

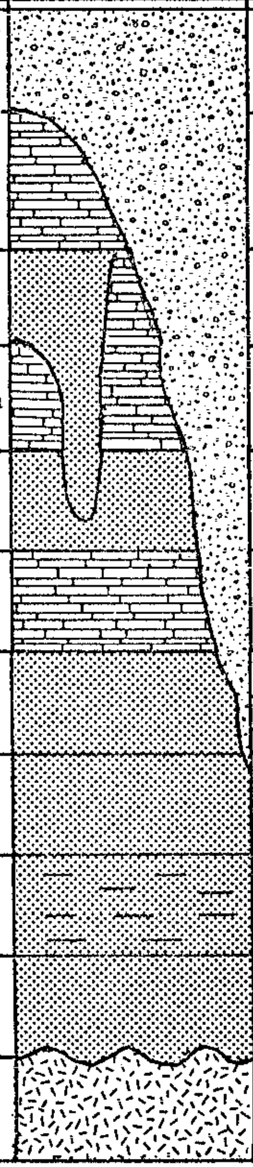
Movement along faults is the cause of most earthquakes. Faults indicate a present or past regional stress on the rocks. When rocks adjust to stress by fracturing, earthquakes occur as movement takes place along the fracture. These small mapped faults are not active but indicate a past adjustment to stress. They are not a significant geologic hazard.

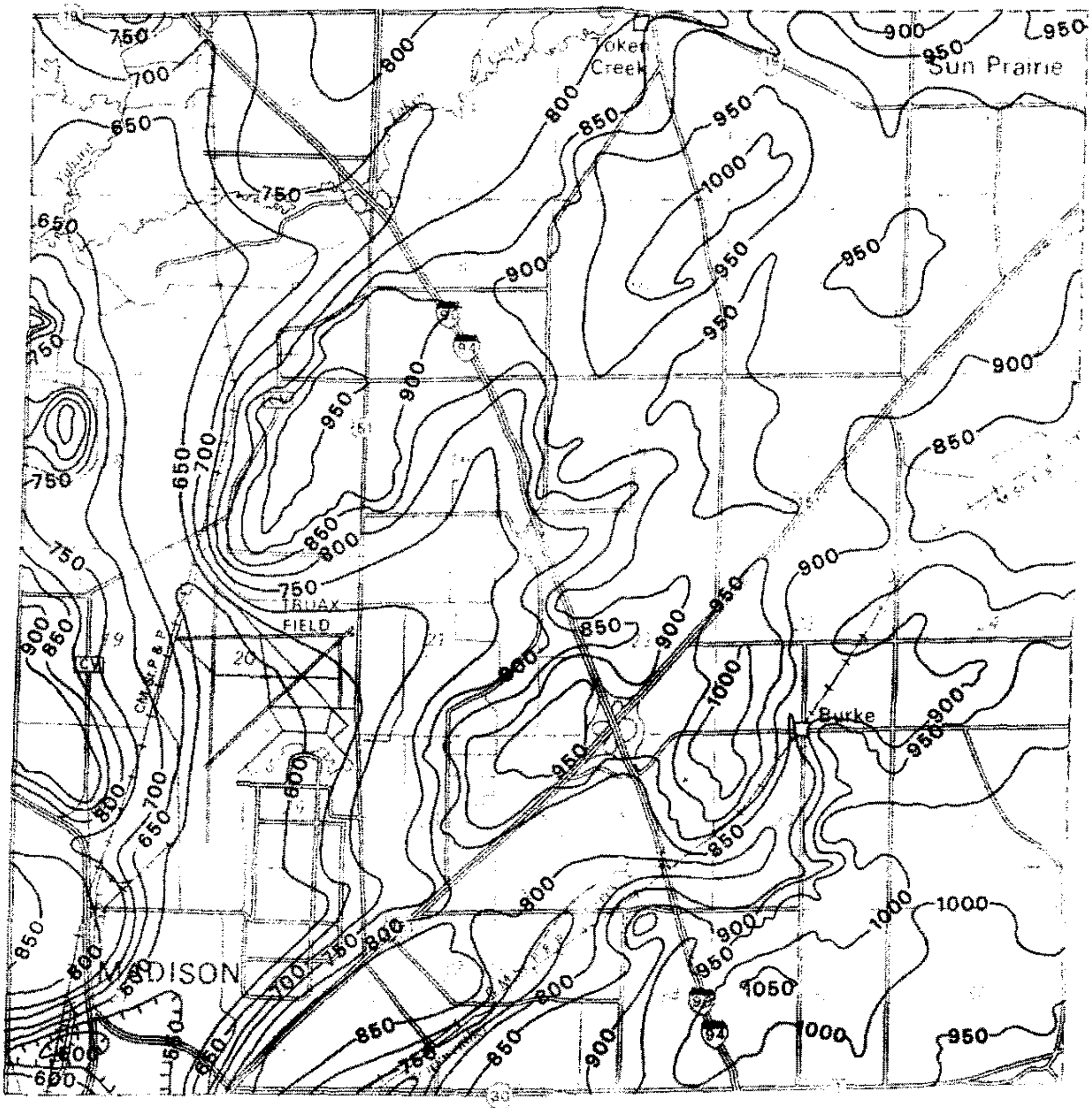
The age, stratigraphic or vertical position, lithology or rock description, approximate range in thickness, and potential economic uses of the bedrock units in the township are shown in Table 1. Except for water supply, listing of potential economic uses of rocks in the township is confined to the units above the St. Lawrence Formation because of their accessability. Both the Jordan and St. Peter sandstone units have potential as a source of industrial sand but are not presently being mined. The Prairie du Chien and Sinnipee Group dolomite units have potential for aggregate, building stone, agricultural lime and riprap, however, the Prairie du Chien Group is generally superior to the Sinnipee for most of these purposes. Both of the dolomite units are presently being mined.

<u>Bedrock Topography and Thickness of Unconsolidated Deposits</u>

The bedrock topographic map, Figure ~~5~~ 6, was prepared from well logs, outcrops, and surficial topography. The most prominent feature is the deeply incised north-south trending valley on the western side of the township which contains the lowest bedrock elevation of about 500 feet above MSL in Section 31. The remainder of the western 2/3 of the area is well dissected by the an ancient tributary system to the deep valley. Several smaller eastward draining valleys underlie the eastern 1/3 of the township. The bedrock highlands formed

Table 1. Rock Units and Their Potential Economic Uses

Geologic Time	Formation or Group	Column	Rock Type	Approximate Range in Thickness (Feet)	Potential Economic Uses
Pleistocene	Glacial & Recent deposits **erosion surface**		Clay, silt, sand, gravel and boulders; sand and gravel; sand; muck and peat.	0 - 370	Aggregate; fill material; domestic water supply; peat.
Ordovician	Platteville		Dolomite, medium- to thin-bedded, fossiliferous, thin clay partings in some horizons.	0 - 30	Good to poor grade aggregate and building stone; agricultural lime.
Ordovician	St. Peter **erosion surface**		Sandstone, medium- to fine-grained, medium- to thick-bedded.	0 - 125	Industrial sand; domestic water supply where saturated; sand for construction and fill.
Ordovician	Prairie du Chien		Dolomite, thick- to thin-bedded, cherty, minor thin clay partings, algal.	0 - 125	Excellent aggregate and building stone; agricultural, riprap.
Cambrian	Jordan		Sandstone, medium- to fine-grained, thin- to thick-bedded.	0 - 45	Industrial sand; domestic water supply where saturated; sand for construction and fill.
Cambrian	St. Lawrence		Dolomite, silty, medium- to thin-bedded and siltstone, dolomite, thin-bedded.	0 - 30	Attractive building stone.
Cambrian	Tunnel City		Sandstone, very fine- to medium- grained, glauconitic.	0 - 105	None.
Cambrian	Wonewoc		Sandstone, medium- to fine-grained, medium- and thick-bedded.	0 - 130	Domestic, municipal, and industrial wate supply.
Cambrian	Eau Claire		Sandstone, fine-grained, dolomitic, and shale, dolomitic.	0 - 30	None
Cambrian	Mt. Simon **erosion surface**		Sandstone, coarse- to fine-grained; some silt and clay layers.	400 - 490	Principal aquifer for municipal and industrial water supply.
Precambrian			Granite, quartzite, and other igneous and metamorphic rock types.		Unknown.



BASE: UNIVERSITY OF WISCONSIN CARTOGRAPHIC LABORATORY

——— 700 ———

Line of equal elevation of the bedrock surface in feet above Mean Sea Level. Contour interval 50 feet.

Source: P. Olcott, 1973

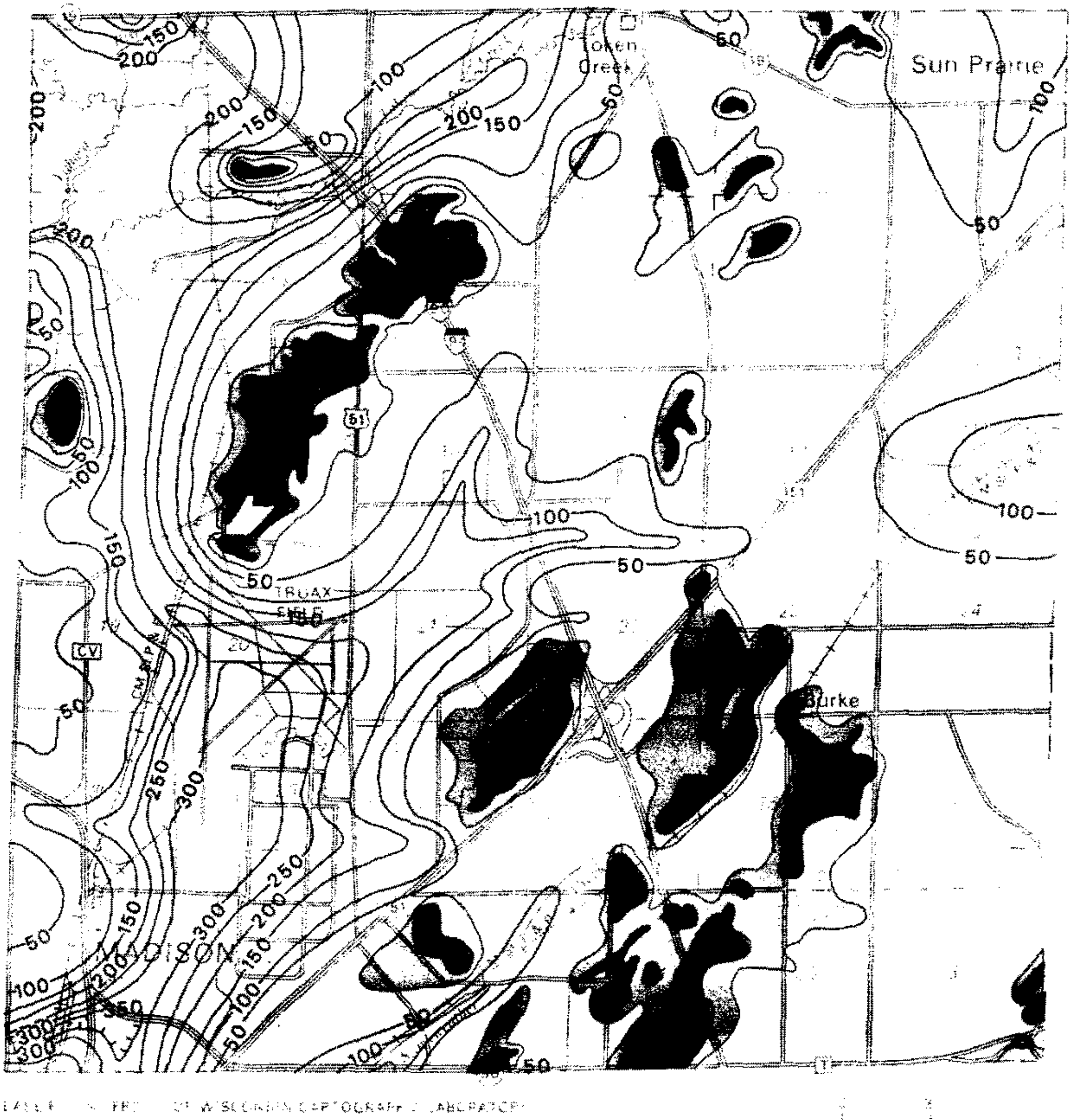
Figure 6. Bedrock topography.

a divide between these two valley systems in the ancient preglacial drainage as they do with the present drainage.

Bedrock topography, the features and relative elevations on the bedrock surface of Burke Township, is one of the primary controlling factors on the physical setting of the area.

The very uneven bedrock surface was formed by erosion prior to deposition of glacial materials. It has a total relief of about 550 feet that is only partially masked by glacial deposits which filled in the valleys by as much as 350 feet. Thus, high areas on the bedrock surface, such as the maximum 1050 feet above mean sea level (MSL) bedrock high in Section 35 (Figure ~~5~~ 6), form highlands on the land surface while bedrock valleys underlie broad flat lowlands on the land surface. The bedrock controlled highland areas of the township have the steepest slopes, the shallowest bedrock, and the greatest depth to water table. They contain dolomite mineral reserves and tend to be covered with glacial till on which the heaviest and best drained soils occur. The broad flat valleys formed over bedrock valleys are characterized by shallow depth to water table and contain the present drainage, marshes, areas subject to flooding, lowest slopes, water-laid glacial deposits including sand and gravel, and soils which tend to be lighter and poorly drained.

The thickness of unconsolidated deposits in the township (Figure ~~6~~ 7) is also correlated to the bedrock surface. The thickest unconsolidated deposits are found in, and nearly fill, the bedrock valleys. The deposits range up to a maximum of about 350 feet in thickness in the deep bedrock valley on the western side and are generally 200 to 300 feet in the deeper parts of the valley. Thicknesses of 100 feet or more are present in the smaller tributary bedrock valleys and in small buried valleys in the northeastern and eastern parts of the township. The bedrock highland areas of the township generally have less than 50 feet of unconsolidated materials and the highest bedrock ridges, con-



Areas where bedrock is 5 feet or less from land-surface
(Modified from USDA, SCS advanced field sheets)

Approximate areas where bedrock is 10 feet or less from land-surface

——100——

Line of equal thickness of unconsolidated materials
Contour interval 50 feet

Source: P Olcott 1973

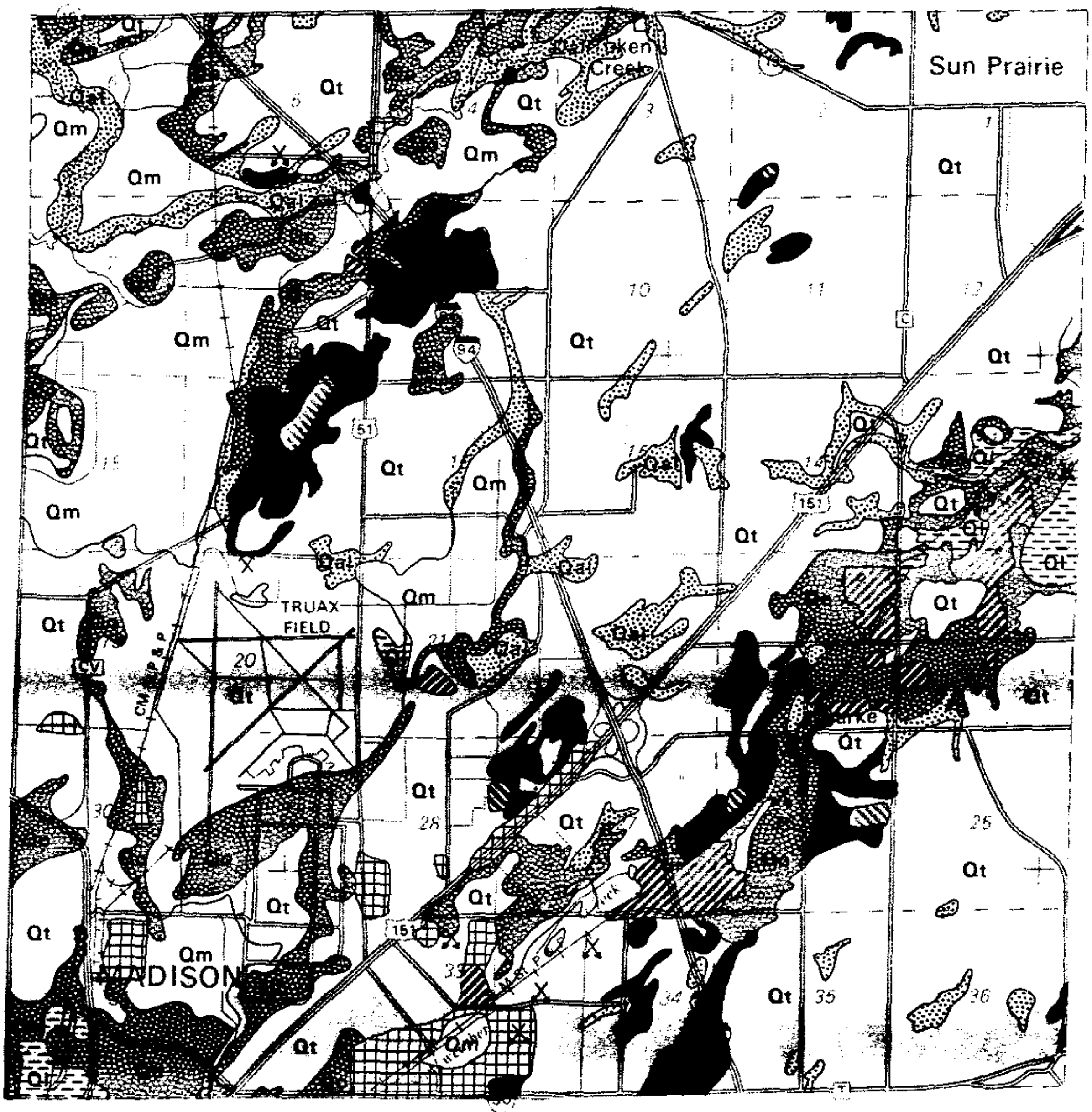
Figure 7 Thickness of unconsolidated materials and areas of shallow bedrock sisting largely of dolomite have a covering of less than 10 feet of unconsolidated materials (Figure 7).

Unconsolidated Surficial Deposits

Unconsolidated surficial deposits in Burke Township shown in Figure 8, include the glacial, alluvial, and loess or wind blown deposits between the land surface and the bedrock surface. These deposits along with very shallow bedrock, are the "parent materials", or the material on which the soils have developed through the weathering process. The map was drawn from recent soils mapping by the USDA, Soil Conservation Service by classifying the parent materials or C horizon of the soils types into glacial till, outwash, alluvium, lacustrine, marsh deposits, and bedrock. The resulting map (Figure 8) shows the distribution of glacial and other surficial deposits in the township. The lithology and some of the engineering characteristics of the mapped units are tabulated in Table 2.

The map shows that an estimated 60 percent of Burke Township is covered by till, an ice-laid deposit of nonstratified and unsorted materials ranging in grain size from clay and silt to boulders. Till is most prevalent in the upland areas of the township. It may also be present at depth in the buried valleys. Small isolated areas of alluvium, lacustrine, and marsh deposits surrounded by till on the map are probably also underlain by till.

Outwash, a stratified and sorted, water-laid glacial deposit consisting largely of sand and sand and gravel, is generally present along the broad drainageways formed by the drift filled bedrock valleys. During glacial stagnation or melting, these natural drainageways channeled meltwater laden with sand and gravel released from the melting ice, to the deep Yahara Valley southwest of the township. The sand and gravel was deposited along the drainageways where stream gradients, and therefore water velocity, decreased. The southwest-trending outwash deposit in the southwestern one-quarter of the township, that



Qt	Glacial till – ground and hilly moraine, clay, silt, sand, gravel, and boulders, unsorted and unstratified
Qal	Alluvium – valley bottom and flood plain deposits, mainly silt and sand, sorted and stratified
Ql	Lacustrine deposits – mainly silt and fine sand
	Made land, landfills, dumps, etc.
Qo	Glacial outwash – outwash plains, terraces, deltas, and ice contact deposits, mainly silt, sand, and gravel, sorted and stratified
Qm	Marsh – lowland drainageway and small depression deposits, organic peat and muck, some inorganic materials
	Bedrock – dolomite and sandstone
	Gravel pit
	Quarry

Modified from USDA SCS Advanced field sheets

Figure 8. Surficial materials

Table 2. Engineering Characteristics of the Parent Materials (C horizon) of Soils

Parent Material	Soils Classification		Permeability in inches/hour	Shrink-Swell Potential	Bearing Value (tons/sq. ft.)	Frost Hazard
	Unified +	AASHO ±				
Glacial Till	SM CL	A-2 A-4 A-6	2.0-6.3 .63-2.5*	Low	2-3 1-2*	Low High*
Outwash	GM CL ML SP SM GP	A-1 A-2 A-3	6.3-20	Low	1.0-5	Low
Alluvium	CL ML	A-4 A-6 A-7	.63-2.0	Low	1.0-1.5	High
Lacustrine	CL	A-6	.05-.2	Moderate	1-2	High

* Lowlying wet soils

\+ Unified classification system used by the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation.

± American Association of State Highway Officials classification.

Soils engineering data obtained from USDA Soil Conservation Service (1969).

has been a major source of gravel, is an example of such a drainage channel. Isolated outwash deposits in the deep buried bedrock channel on the western side indicates the presence of similar channel deposits. However, well logs show a large percentage of fine grained lacustrine deposits in this valley interspersed with the sand and gravel. This valley probably intermittently ponded meltwater during most of the glacial melt period accounting for the thick deposits of fine grained lake sediments. The many small outwash deposits in the northern part of the deep valley, in and surrounding the large marsh, indicate outwash may underlie the marsh deposits. However, test holes are necessary to determine the character of these underlying unconsolidated sediments.

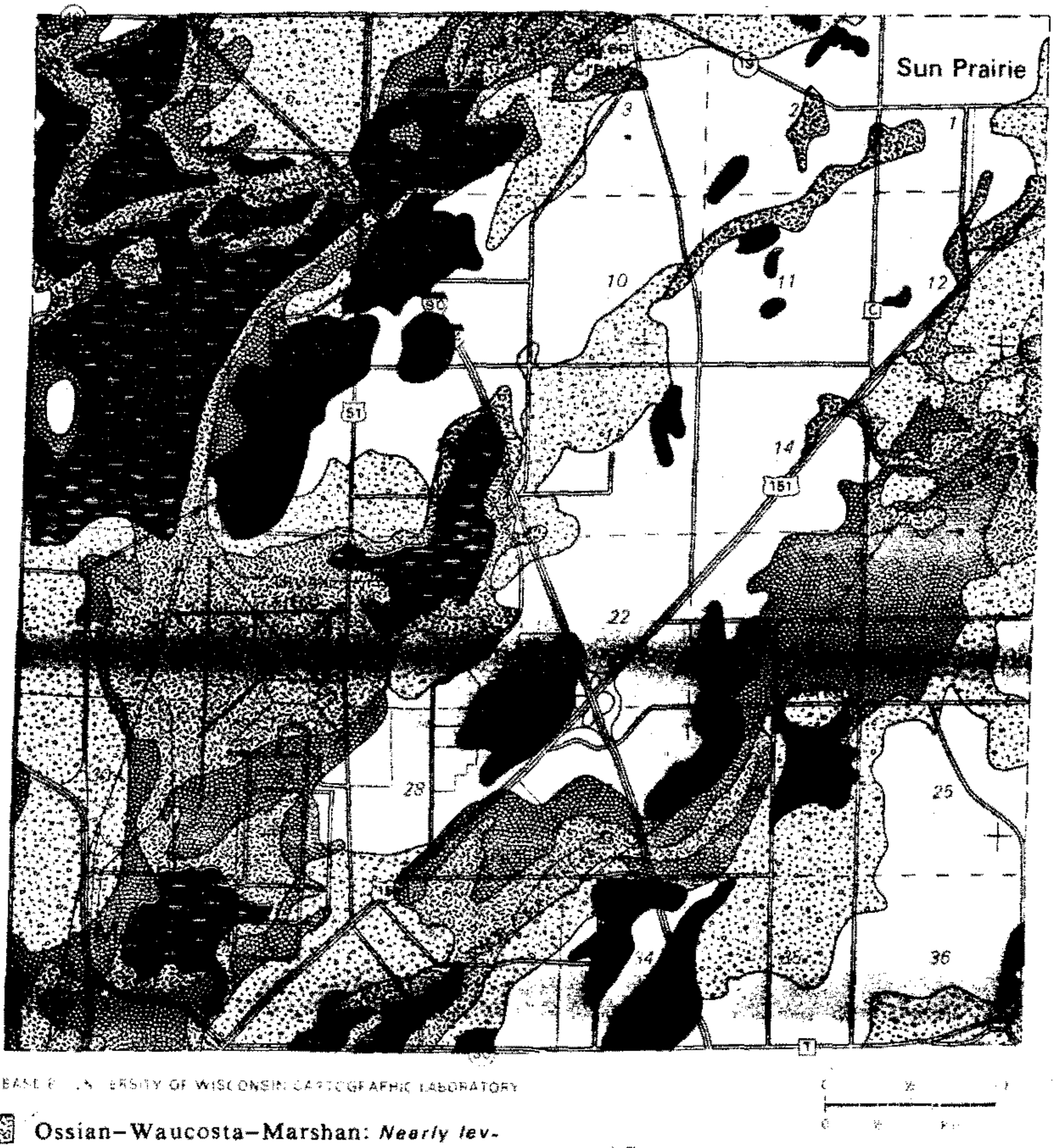
According to soils data alluvium, marsh, and lacustrine deposits are mostly fine grained materials. They have been carried into drainageways and depressions mainly by water but also by wind. Alluvium is most common along present stream drainages. Marsh deposits contain large amounts of organic material or peat along with silt. Lacustrine deposits represent fine-grained materials carried into ephemeral or temporary lakes during and after glacial stagnation.

Made land includes active and inactive quarries and gravel pits, fill, areas stripped for development, and dumps or sanitary landfills.

Soils

Soils of Burke Township are shown in Figure ~~8~~ 9 which is a generalized soil association map taken from an unpublished map of Dane County in the files of the U.S. Department of Agriculture, Soil Conservation Service. The soils map essentially represents the upper 5 feet of the earth surface.

The soils of the township for the most part are the product of weathering of loess or wind blown silt over glacial deposits and shallow bedrock. Their character is largely a result of the materials on which they formed as well as depth to water table, topography and other factors such as climate. Because



BASE BY UNIVERSITY OF WISCONSIN CARTOGRAPHIC LABORATORY

Ossian–Waucosta–Marshan: *Nearly level to gently sloping, poorly drained soils, in lowlands, marsh borders, drainage ways and depressions*

Houghton, muck–Houghton, mucky peat–Palms, muck: *Nearly level to gently sloping, poorly drained muck and mucky peat soils in lowlands, drainage ways, and depressions*

Plano, gravelly substratum–Elburn, gravelly substratum: *Nearly level to sloping, well to poorly drained soils in silt, sand and gravel*

St. Charles–McHenry–Lapeer: *Nearly level through sloping, well drained soils in silt and sandy loam till*

Plano–Ringwood–Griswold: *Nearly level through sloping, well drained soils in silt and sandy loam till*

Batavia, gravelly substratum–Dresden–Virgil, gravelly substratum: *Nearly level through very steeply sloping, well through poorly drained soils in silt, sand, and gravel*

Rockton–Whalon–Dunbarton: *Nearly level to very steeply sloping, well drained soils with bedrock at 4 feet or less from surface*

Source: Unpublished map in the files of the USDA Soil Conservation Service

Figure 9 Soil Association

glacial deposition, depth to water table, and topography were strongly influenced by bedrock topography, this influence is also reflected in the soils.

The soils of the bedrock uplands of the township are chiefly the St. Charles-McHenry-Lapier and Plano-Ringwood-Griswold soil associations (figure 8) consisting of well-drained silt and sandy loams developed on glacial till. In the lowland formed over the buried bedrock valley on the western side of the township the Houghton muck-Houghton mucky peat-Palms much and Ossian-Waucosta-Marshan soil associations predominate (figure 8). They are nearly level to gently sloping poorly drained soils in marshes and marsh boarders, small depressions, and drainageways where water table is near to the land surface. The Batavia, gravelly substratum-Dresden-Virgil, gravelly substratum and the Plano, gravelly substratum-Elburn, gravelly substratum soil associations (figure 8) are found on the glacial outwash deposits in the township along the glacial drainageways. The bedrock outcrop areas in the highlands have the Rockton-Whalan-Dunbarton association (figure 8), well drained soils with bedrock at less than four feet from the land surface.

Permeability, shrink-swell potential, bearing value and frost hazard properties of the upper and middle layers (A & B horizons) of the soils (U.S.D.A. Soil Conservation Service, 1969) throughout the township, except in the marsh areas, are remarkably similar. The soil forming processes have not been strongly impressed on this area and the soils strongly reflect original deposition during and after glaciation. For the most part, the A and B soil horizons are weekly developed in wind blown loess or silt. Thus, the properties of these upper horizons are similar. Muck and peat soils represent recent accumulations largely of organic materials giving rise to properties different from the loessial soils.

The loessial soils have permeabilities in the range of .63 to 2.0 inches per hour and bearing values of 1.0 to 2.0 tons per square foot. Shrink swell potential is low to moderate and frost hazard moderate to high. Permeabilities of the muck and peat marsh soils are in the range of 2.0-6.3 inches per hour and bearing values are very low.

Hydrology

Surface Water

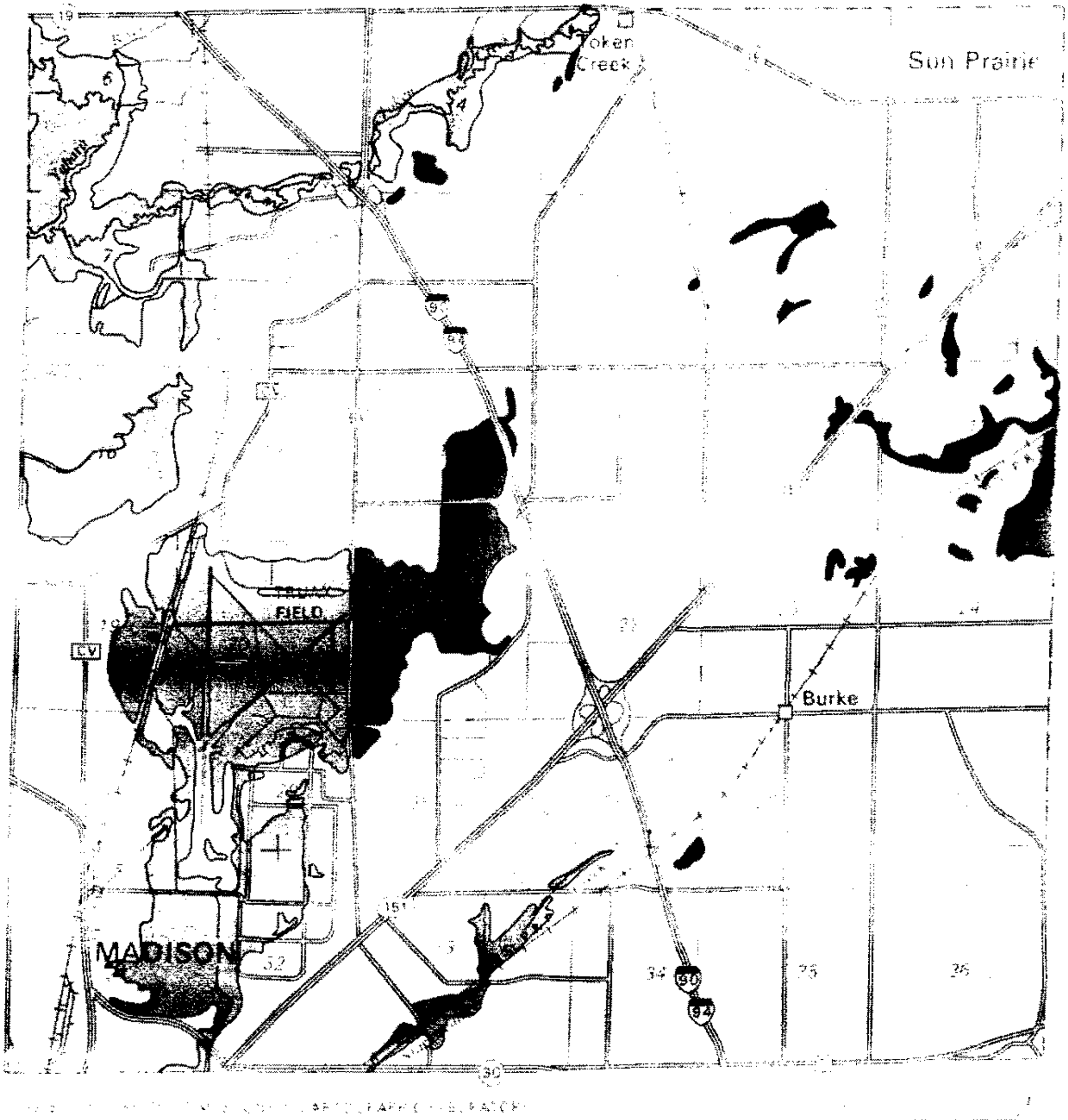
Burke Township is in the Yahara River Basin. It is drained in the northern and western areas by the upper Yahara River and its tributary, Token Creek, which empty into Lake Mendota. Starkweather Creek, a tributary of Lake Monona, drains the southwestern quarter of the township. The eastern and southeastern area is drained by Door and Koshkonong creeks which empty into Lakes Kegonsa and Koshkonong, respectively. The extensive wetland in the northwestern corner, several smaller wetlands, (Figure ~~7~~ 8) and a few man-made ponds are the only other surface-water features in the township.

Marshes, low wet ground usually supporting wetland vegetation, presently cover an estimated 1/8 of the area of the township. The largest marsh is adjacent to and drained by the Yahara River and its tributary Token Creek in the northwestern quarter of the township. Smaller marshes in the central and southwestern parts are associated with Starkweather Creek. Marsh areas of the township have been reduced largely through drainage ditches expecially in the west-central and southwest according to a comparison of the 1904 Madison quadrangle, U.S. Geological Survey Topographic map and the 1959 Madison quadrangle. Truax Field partially occupies a drained area. Some small reduction in marsh areas as well as flow of streams may also have been produced through the slight lowering of ground water levels through municipal and industrial pumping in the adjacent Madison area.

Surface water as a potential source of supply for irrigation, cooling, fish rearing, and other purposes is confined mainly to Token Creek and the Yahara River. Only incomplete streamflow data is available for the township. Low flow gaging stations on Token Creek (SW$\frac{1}{4}$, section 4, at Highway 51: station is south of township) and the Yahara River (NE$\frac{1}{4}$, section 30, T.9N., R.10E., 2.3 mi. south of DeForest: Station is north of township) indicate the 7-day low flow that occurs on the average of once in 2 years is 11 and 3.1 cfs (cubic feet per second) on Token Creek and the Yahara River, respectively (Gebert, 1971). The relatively high low flow of Token Creek, especially, assures a consistent water supply from that stream even during very low flow conditions. It also indicates the presence of extensive permeable deposits, probably sand and gravel, in the stream basin.

Flooding in Burke Township is not a serious problem. Areas that will be inundated during the 100 year flood (the flood discharge that has an average frequency of occurrence of once every 100 years) in the township are outlined in Figure 9. Most flooding will occur in the wetlands and lowlying areas. Except for Truax Field, there has been little development in the flood prone areas. Thus, the 100 year flood should cause little damage in the township.

Flood discharge figures for Token Creek at Highway 51 for the period 1961 through 1968 are given by Conger, 1971. Peak discharge for Token Creek during that period was 488 cfs in February 1966. The regional flood or that flood that can be expected to occur once in 100 years on Starkweather Creek at the confluence of the East and West Branches (sec. 5, T.7N., R.10E., about $\frac{1}{2}$ mile south of the township) is 600 cfs (Lawrence and Holmstrom, 1972). Urbanization in Starkweather Creek basin including storm sewers, paving, roof tops, and channelization generally has had the effect to increase flood peaks and decrease the length of runoff time for flood peaks (Lawrence & Holmstrom, 1972).



Flood-prone areas for the 100-year flood from U S Geological Survey, Open file report (Lawrence and Holmstrom, 1972)

Flood-prone areas for the 100-year flood interpreted from airphotos and topographic maps by the U. S Geological Survey

Source: U S Geological Survey in cooperation with the City of Madison, Dane County Regional Planning Commission, and the Wisconsin Dept of Natural Resources, and unpublished maps by the U S Geological Survey

Figure 10 Flood-prone areas for the 100-year flood

Surface water and ground water are directly related in the township, as elsewhere in the county. Except for short term overland runoff to the streams and marshes from storm events and snowmelt, streamflow and marshes are maintained by water from the ground water reservoir. Thus, these surface water features represent ground-water discharge areas where water is moving upward and/or horizontally out of the ground water reservoir into the streams and marshes.

Ground Water

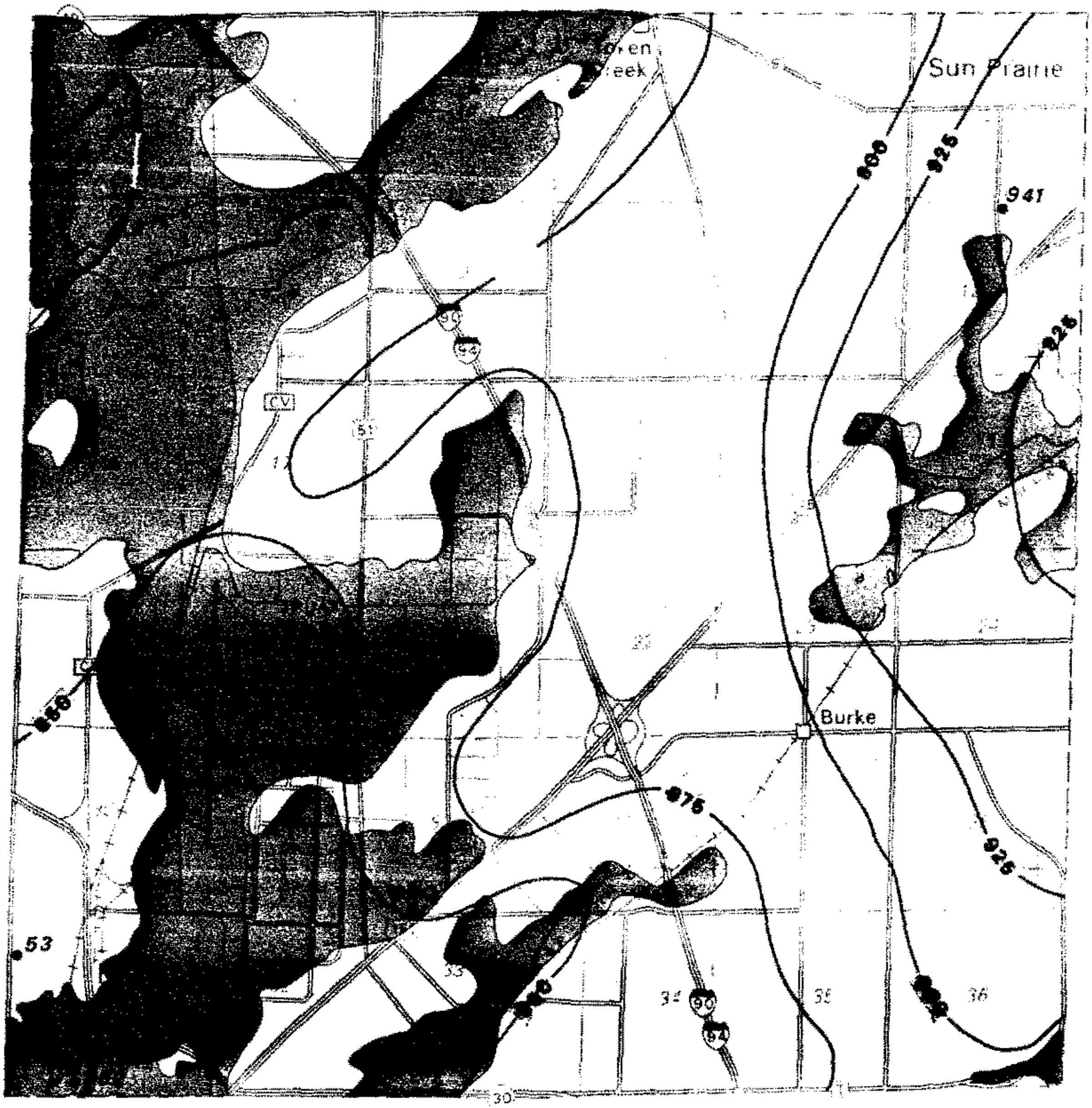
The ground-water reservoir is defined as the water-saturated zone between the water table and the top of the underlying Precambrian crystalline rock surface which includes both the consolidated Cambrian and Ordovician rocks and the unconsolidated glacial and alluvial materials. Because the height of the water table varies in response to seasonal, climatic, and man-made changes in recharge and discharge, the thickness of the reservoir (and therefore the amount of water in storage) varies to a small extent but it generally ranges from about 875 to 900 feet across the township. This vast reservoir of water is a readily available and relatively cheap source of water supply for municipal, industrial, commercial, domestic, and farm uses.

The source of ground water in the township is from precipitation that falls on the land surface in the township and its immediate area. About 6 inches of the average 30 inches of precipitation that falls annually in the area, soaks into the ground and eventually reaches the ground water reservoir (Cline, 1965). This recharge occurs everywhere in the township except in the discharge areas (Figure 12). The water enters the reservoir and moves under the influence of gravity to the discharge areas where it again emerges at the surface to be carried off as streamflow or evaporated. Pumping of wells intercepts the water before it is discharged to streams and, in several urbanized areas, the water is directed out of the township by the municipal sewerage system. Ground-water pumping thus tends to diminish streamflow in the township.

The approximate water table elevation in the township is defined on Figure 10 by contours. As indicated, the water table is an irregular surface which is controlled largely by topography, rates of recharge and discharge, pumping wells, and permeability of the rock formations. The water table tends to be a subdued replica of the land surface topography. It is very shallow in the low-lying areas of drainage and marshes as shown by the mapped areas of less than 10 feet to water table (Figure ~~10~~ 11). The water table in the highlands of the township is deeper, ranging up to 140 feet or more in areas of the highest land surface elevations (Figures ~~2~~ 3 and ~~13~~ 14).

Ground water movement in the township is down the gradient indicated by the water table map (Figure ~~10~~ 11) and approximately perpendicular to the contour lines of the map. Most of the ground water in the township is moving westward to the Yahara River, Token Creek, and Starkweather Creek. A small part on the eastern side of the township is moving eastward and southward toward Door and Koshkonong Creeks.

Adequate ground-water supplies for most uses are available in the township from three aquifers or water bearing rock units, namely, the unconsolidated glacial materials aquifer and two sedimentary bedrock aquifers. The bedrock aquifer is subdivided into a shallow and deep aquifer at the base of the Tunnel City Formation (Table 1 and Figure ~~4~~ 5). Because most large wells in and around the township are cased through the Tunnel City Formation and the upper bedrock formations are slightly less permeable than the lower formations, the lower bedrock aquifer has a lower water level or hydraulic head than the upper aquifer. It receives its recharge through the upper aquifer and especially through the glacial aquifer in the deep bedrock valleys (McCleod, open file report). Discharge from the deep aquifer is through pumping of wells in and around the township. The shallow bedrock aquifer and the glacial aquifer have similar water levels



—— 875 ——

Line of equal elevation of watertable above Mean Sea Level

Areas where watertable lies 10 feet or less below land-surface

• 23

High capacity wells

Numeral is WG&NHS well number

Source: Watertable contours from unpublished map in the files of the U S Geological Survey

Figure 11 Contours on the watertable and areas of shallow groundwater and act as a single hydraulic unit. Both receive recharge from the surface and discharge to streams but the shallow bedrock, where it is overlain by the drift aquifer, may receive recharge, and discharge water through, the glacial drift to streams.

The deep bedrock aquifer in the township will yield 1500 to 2000 gallons per minute (gpm) to properly constructed wells. Smaller wells in the glacial aquifer and shallow bedrock aquifer will probably yield 10 to 20 gpm with little difficulty.

Unconsolidated glacial deposits in Burke Township will yield only small amounts of water to wells in some areas. In the highland areas of the township, the glacial deposits are generally thin, unsaturated, and consist of till deposits with low permeabilities. The lowland areas, especially in the deep buried bedrock valley area, do contain saturated sand and gravel layers that will yield adequate water for domestic wells. However, these deposits are scattered both vertically and horizontally through till and lacustrine deposits with low permeability and can be located only by drilling. Large yields could be obtained from thick saturated sand and gravel deposits if they are present. The glacial drift aquifer is not extensively used in the township at present.

The bedrock aquifer is the source for municipal and industrial water supply in Burke Township and the adjacent Madison area. The extensive pumping of this aquifer has created a regional lowering of ground-water levels in the area. Although this lowering in water levels is not presently a problem, improper spacing or excessive pumping of future wells may cause excessive water level drawdowns in the township.

In recognition of theneed for ground water management in the Madison Metropolitan area, both an analog and digital computer models of the aquifer system were constructed, the former by the Wisconsin Geological & Natural History Survey in cooperation with the U.S. Geological Survey and the City of Madison

Water Utility and the latter by the state and federal surveys. These models show the effects of present and historical pumping and will show the effect on the aquifer of any additional well or wells installed in the future at any location. The models will provide very valuable management tools to assure optimum development of the aquifer including Burke Township. The model studies are summarized in three reports presently in progress (Gonthier, report in progress; McCleod, open file report and report in progress).

Present water use in the township includes 6 high capacity wells which in 1970 produced an average 9.45 million gallons per day from the deep bedrock aquifer (Gonthier, report in progress). Individual well pumpage is tabulated in Table 3. In addition, a large number of domestic and stock wells provide water from the shallow bedrock aquifer.

Table 3. Pumpage from Sandstone Aquifer, 1970

WG & NHS Well Number	Owner and Well Description	Pumpage (1970) in Million Gallons/Day
53	City of Madison, Unit Well #7	1.68
930	City of Madison, Unit Well #15	3.08
74	Oscar Mayer & Co., Well #2	
75	Oscar Mayer & Co., Well #3	4.42 (Three Well Total)
892	Oscar Mayer & Co., Well #4	
941	City of Sun Prairie, Well #5	.27
		9.45

Water in both the bedrock and unconsolidated glacial aquifers in Burke Township is very hard and may have a high iron content locally but generally it is of good quality. Water in both aquifers is of about the same quality (Cline, 1965, p. 51) with calcium, magnesium, and bicarbonate as the principal constituents.

Several chemical analyses from two Madison city wells and an analysis from a Sun Prairie municipal well located in the township are shown in Table 4. The analyses are considered representative for ground water in the township. Successive analyses in Madison City wells numbers 7 and 15 (Table 4) indicate very little change in water quality with time and continued pumping.

Iron and hardness are troublesome constituents in ground water of the township but both can be relatively easily and cheaply treated for and neither of the constituents are deleterious to human or animal health. Hardness of 300 to 400 milligrams per liter (mg/l) is everywhere present in ground water of the township. Iron in excess of .3 mg/l, a concentration that will cause staining and iron deposition in plumbing, is present in many areas of the township which is not readily definable because of its erratic occurrence.

Ground water is being discharged to all streams and marsh areas of Burke Township as indicated on Figure 11. Thus, the lowlying areas, and particularly the buried bedrock valley areas, are groundwater discharge zones. All of the remaining area of the township can be considered a recharge area for ground water (Figure ~~11~~ 12).

Recharge to the ground-water reservoir is from precipitation. Recharge can only take place if the soil is sufficiently wetted and excess moisture is available. Thus, the principal period of recharge is during the spring snowmelt and periods of rainfall on unfrozen ground when the soil is saturated, evapotranspiration is low, and abundant water is available. Recharge can occur during summer storms depending on soil moisture conditions. However, evapotranspiration is high during this period which tends to reduce dramatically the amount of recharge to the water table. Recharge occurs in the fall after the killing frost when evapotranspiration is again low. In the winter precipitation is stored on the land surface in the form of snow and ice and little or no recharge takes place.

Table 4. Chemical Analyses of Water from Deep Bedrock Wells

WG & NHS Well Number	Owner and Well Designation	Date	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrite (NO_2)	Nitrate (NO_3)	Dissolved Solids	Hardness as $CaCO_3$ (Total Ca & Mg)	pH
53	City of Madison Well #7	*12/ 4/44	.4	.0	70	42	---	398	11	9.0	.1	---	---	344	350	7.2
		* 4/30/52	---	---	68	38	---	390	14	2.7	---	---	---	---	328	7.6
		* 2/ 2/61	.5	.0	70	36	---	388	14	.0	.0	.0	.0	328	318	7.3
		6/23/66	.65	.03	73	40	3.4	388	22	1.8	.2	.0	.4	---	351	7.4
		3/10/71	---	---	62	46	4	400	24	2.0	.7	---	.2	362	344	7.6
930	City of Madison Well #15	10/27/64	.18	.05	80	41	---	387	16	9	0.1	.036	7.8	432	368	7.5
		8/31/67	.03	.03	66	32	2.0	346	2.0	.5	.1	.01	1.8	298	296	7.3
		3/10/71	---	---	60	39	4.0	376	14	4.0	.2	---	---	---	312	7.6
941	City of Sun Prairie Well #5	8/29/67	.04	.04	66	35	3.2	342	7	2.5	.2	---	2.8	342	306	7.4

* From Cline, 1965

All values in milligrams per liter except pH.

Areas of best ground-water recharge potential – underlain by outwash sand and gravel with permeabilities of 6 3 to 20 0 inches per hour Permeability of overlying loess and silt about .63 to 2 .0 inches per hour	Areas of moderate recharge potential – underlain by glacial till, lacustrine silts and clays, and bedrock with permeabilities of 05 to 2 0 inches per hour Permeability of overlying loess and silt about 63 to 2 0 per hour
Principal ground-water discharge areas	Areas with the greatest potential for ground-water polution – underlain by very shallow, fractured bedrock and very permeable sand and gravel

Source: P Olcott 1973

Figure 12. Ground-Water recharge and discharge areas and areas with greatest potential for ground-water pollution

Land slope is another parameter affecting recharge, especially the steep slopes which accelerate overland runoff and therefore reduce the amount of water available for recharge. Slopes of 12% or more are present but include only a small area of Burke Township (Figure 4) and do not seriously diminish recharge. Broad areas of relatively flat land both in the uplands and in the valleys outside of the discharge areas are available for recharge in the township.

The permeability of surficial materials is a primary consideration in ground water recharge as the water must move into any through these materials. Soils information indicates that much of the recharge area is covered with from 2 to 4 feet of loess and, locally, alluvium with modest permeabilities of from .63 to 2.0 inches per hour (Table 2 and USDA Soil Conservation Service, 1969). Glacial till, lacustrine deposits and bedrock with permeabilities of from .05 to 2.0 inches per hour underlie the loess in much of the recharge area (Figure 8). The sand and gravel underlying loess in the areas outlined on the map has moderate to extremely high permeabilities ranging from 6.3 to 20 inches per hour. These areas and especially gravel pits where the loess has been removed are the best areas for recharge in the township. However, considerable recharge also occurs through the materials of lower permeability.

Ground water pollution potential is not an extensive problem in Burke Township because a large part of the area is covered by loess and glacial till both of which have only moderate permeabilities. Also, in much of the recharge area the water table is relatively deep, which allows time and an opportunity for oxidation and degradation of pollutants before they enter the aquifer. If pollutants such as the highly mobile nitrates and chlorides, do reach the water table, they are greatly diluted by the ground water. Discharge areas of the township (Figure 12) are not a threat to ground-water purity because emerging ground water prevents pollutants from entering the aquifer.

Several areas of the township where ground water pollution may be a hazard are outlined on the map, Figure ~~11~~ 12. These are areas of highly permeable sand and gravel and areas of exposed or shallow bedrock where pollution from the land can readily enter the aquifer. Areas of permeable sand and gravel adjacent to ground-water discharge zones have not been included because pollutants entering these gravel bodies will be discharged in a very short time to the adjacent streams and marshes.

Data is not available to adequately document the extent of pollutants in ground water in the township. However, regional information (Cotter, et. al., 1969) shows no extensive pollution of shallow aquifers. Water from several individual domestic wells in the area surrounding the township show slightly higher nitrate content than normal, indicating pollution, but this can usually be traced to faulty construction or well location adjacent to a barnyard or other pollution source. The well code, administered by the Wisconsin Department of Natural Resources, requires adequate well construction and has been a major influence in minimizing pollution of private water-supply wells.

Shallow dolomite bedrock, where recharge moves only through joints and fractures with little filtration, is highly susceptible to contamination. Shallow sandstones also commonly are fractured and easily contaminated from the land surface and they are therefore included in the mapped areas subject to pollution (Figure ~~11~~ 12).

INTERPRETIVE MAPS--2ND ORDER

Engineering Characteristics

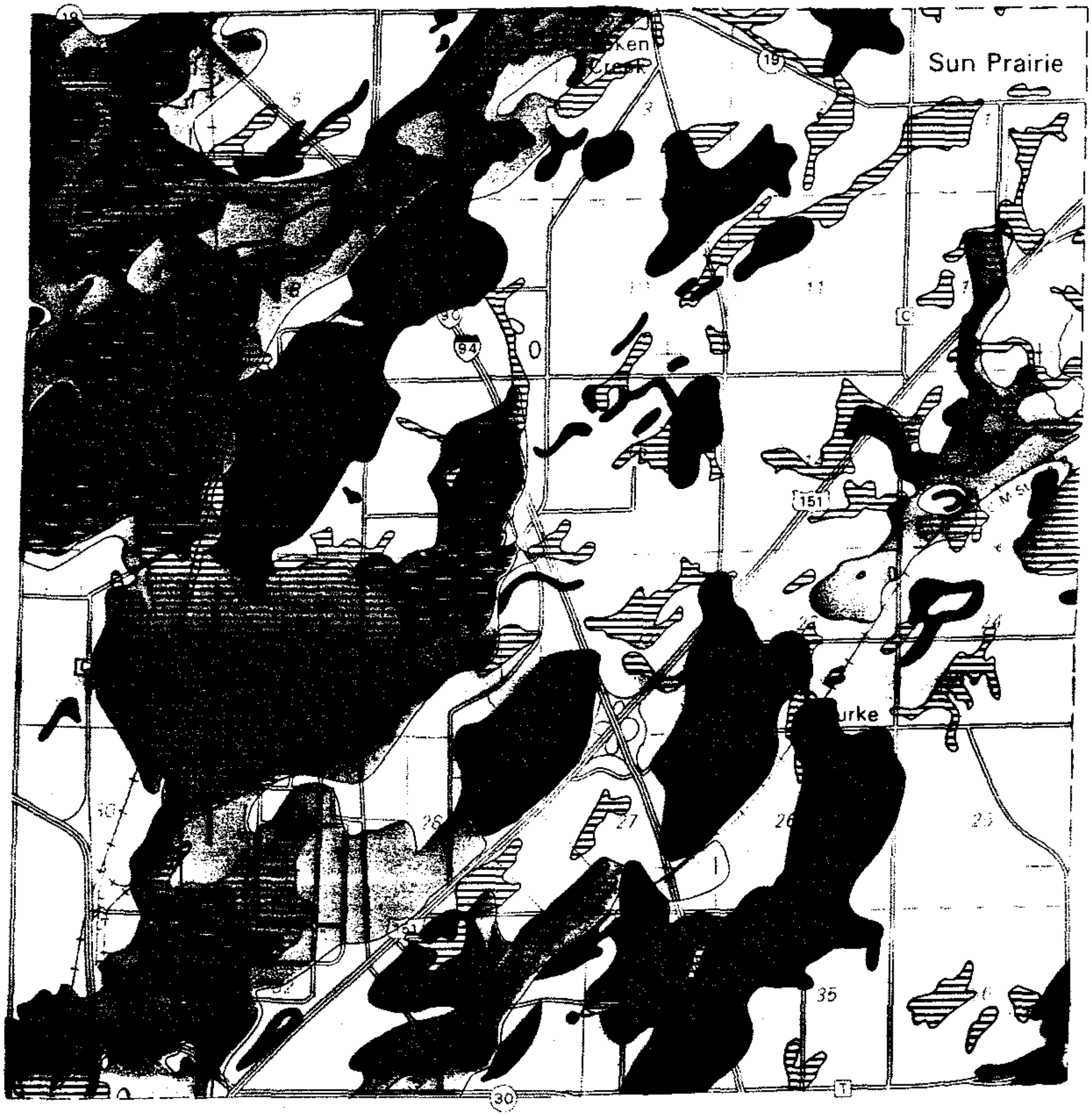
Second Order interpretive maps are designed to point out areas best suited to development, that is, the construction of roads and buildings and other developments; routing of utility lines such as sewer, water, and electrical lines; sanitary landfill sites; and to some extent locating septic tank sewerage systems. They also delineate potential mineral resources and source of water supply of the township as well as limitation for growing crops. The maps are derived from information presented in the 1st Order physical data maps, each being compiled from one or more of the 1st Order maps.

Criteria for land use suitability for construction of roads and buildings, routing of utility lines, sanitary landfill and septic tanks are all similar. Shallow water table and bedrock inhibit excavation and present a potential groundwater pollution hazard. Flooding is universally a problem and unstable and low bearing strength of soils along with shallow water table in marshes and lacustrine, alluvial, and wet till areas is detrimental to most development. The best areas for development are generally acceptable for each of the proposed uses. Because of the similarity of criteria the engineering and development factors have been assembled on one map, Figure 13.

The 2nd Order maps point out engineering and/or economic limitation which may or may not preclude specific areas for a specific use. An engineering or management judgement must be made for any development in a zone that has such limitations. These maps are intended to inform the developer that limitations exist and that they should be considered in planning for a development.

Development Factors

The lowlying areas of the township, especially in the area of the deep buried bedrock valley, present the greatest limitations to development. These areas have a high water table and extensive marshes with unstable peat and muck, each of which presents a limitation to development. A large part of the area where water table is less than 10 feet from land surface is subject to flooding during the 100 year flood (Figure 10). In much of the lowlying areas and in



BASE BY UNIVERSITY OF WISCONSIN CARTOGRAPHIC LABORATORY

Areas best suited to development

- Watertable and bedrock greater than 10 feet below land-surface, slope less than 12%, bearing capacity 1 to 5 tons per square foot, and frost hazard and shrink-swell potential low

Natural limitations

- Marsh, muck, and peat, watertable at or near the land-surface
- Bedrock at or within 10 feet of land-surface
- Land-slope in excess of 12 percent
- Watertable at or within 10 feet of land-surface marsh, flood prone areas, and several small areas of shallow bedrock
- Lacustrine and alluvial deposits, and wet till areas with some limitations to construction—bearing capacities range from 1 to 2 tons per square foot, shrink-swell potential is low to moderate, and frost heave potential is high

Source: P Olcott 1973

Figure 13 Factors affecting land-use for construction of buildings and structures, utility routing, sanitary landfill, and septic tank sewerage systems.

closed depressions in the uplands, lacustrine, alluvial, and wet till deposits have relatively low bearing capacities and may be subject to frost heave.

Limitations to development in the highland areas of the township are generally confined to shallow bedrock and steep slopes. Slopes exceeding 12%, and in some cases 20%, occur in several areas of the township (Figure ~~8~~ 4) and are generally associated with bedrock highs. Steep slopes are detrimental or costly to nearly any construction, landfill, septic sewerage system, or other development. Shallow bedrock, also associated with bedrock highs (Figure ~~6~~ 7), inhibits excavation for foundations, trenching or setting poles for utility routing, and road construction and presents a potential ground-water pollution hazard to septic systems and landfills.

The best areas for development are generally in the moderate elevations of the township. Glacial till and some outwash underlie these areas. Bedrock is greater than 10 feet in depth which will accommodate most excavations for road building, foundations, and utility lines. Adequate depth to water table and bedrock provides safe areas for septic tanks and sanitary landfills and flooding is not a problem.

Water Supply

An adequate supply of good quality water for municipal, industrial, domestic, and farm uses is readily available in Burke Township mainly from bedrock aquifers and in some areas from unconsolidated glacial aquifers. Existing high capacity wells in the township tap the bedrock aquifer and in some cases fully penetrate to Precambrian crystalline rocks at a depth of about 800 feet. Yields of these wells are in excess of 1500 gallons per minute both in the areas of bedrock uplands and in the deep buried bedrock valley where pumpage induces recharge from thick overlying deposits of glacial drift. Caving sandstone in several deep wells has been a problem in the township but in most cases this problem was solved by construction design and extensive development of the wells. Because of the ease of obtaining high capacity wells, suitability for this use has not been mapped. However, the bedrock geology (Figure ~~4~~ 5) and thickness of unconsolidated materials (Figure ~~6~~ 7) map should be useful for high capacity well design.

Of more critical concern, perhaps, is the ease of construction of low capacity domestic and farm wells and, especially, identification of areas where well costs will be the least. Adequate ground water is available for domestic wells from the bedrock aquifer throughout the township and is available from the unconsolidated glacial deposits in areas where they are thick, sufficiently permeable, and saturated. Thus the two maps (Figures ~~13~~ 14 and ~~14~~ 15) concerned with development of domestic water supply are related to cost of construction rather than availability of water.

The highest water-yielding saturated units of the bedrock aquifer within much of domestic wells of the township are the Jordon and Wonewoc Sandstones (Table 1). However, because the Jordon is missing or not saturated in parts of the township and the Wonewoc is missing or lies at excessive depths in parts of the township, the Prairie du Chien dolomite and the Tunnel City Sandstone may be the principal rocks penetrated. These rock units generally yield only small quantities of water but the 5 to 10 gallons per minute required for domestic or farm use can probably be obtained from properly constructed wells.

Construction of bedrock wells require casing from the land surface to, or a short distance into the bedrock. Since casing is an expensive item in well construction, well costs will be least in areas with thin unconsolidated deposits because casing length can be kept to a minimum.[1] The map in Figure ~~13~~ 14

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[1] The state well code, administered by the Wisconsin Department of Natural Resources, requires certain minimum casing requirements to insure against surface contaminants entering the well.

outlines areas where unconsolidated materials are from 0 to 50, 50 to 100, and over 100 feet in thickness. The highland areas, mainly in the eastern 2/3 of the township, have the thinest unconsolidated materials. Very thick unconsolidated deposits, up to 350 feet (Figure 7) occur in the deep buried bedrock valley on the western side of the township. The 50 to 100 feet thickness of unconsolidated deposits occur on the boarder of this and other small buried valleys in the township.

Another principal factor in costs is well depth. A well generally will be drilled an adequate depth below water table to assure a supply, depending on water-yielding capability of the rocks. Thus, a minimum depth to the water table will help minimize the total depth that a well must be drilled. The depth to water table from the land surface in Burke Township is shown in Figure 14. Maximum depths of up to 140 feet occur in the highlands in the western 2/3 of the township. Water level is very shallow in and on the edges of the buried bedrock valleys and intermediate depths between these extremes occur in the remainder of the area.

A suitable domestic or farm water supply can be obtained from unconsolidated deposits in the township where they are saturated, reasonably thick and sufficiently permeable (Figure 15). The permeable deposits are sand and sand and gravel which are generally associated with glacial outwash. Thick, saturated outwash deposits occur in the deep buried bedrock valley on the western side of the township and in the outwash belt in the southeastern quarter as shown in Figure 15. Thin till deposits of low permeability in the highlands generally are not suitable for use as a source of water.

The nature of the unconsolidated deposits in the buried bedrock valley is not well known but well logs do indicate the presence of some buried sand and sand and gravel. The fact that these deposits are very thick and saturated to within 10 feet or less of the land surface and the presence of outwash in

Areas where the watertable is at 10 feet or less from the land-surface

——— 125 ———

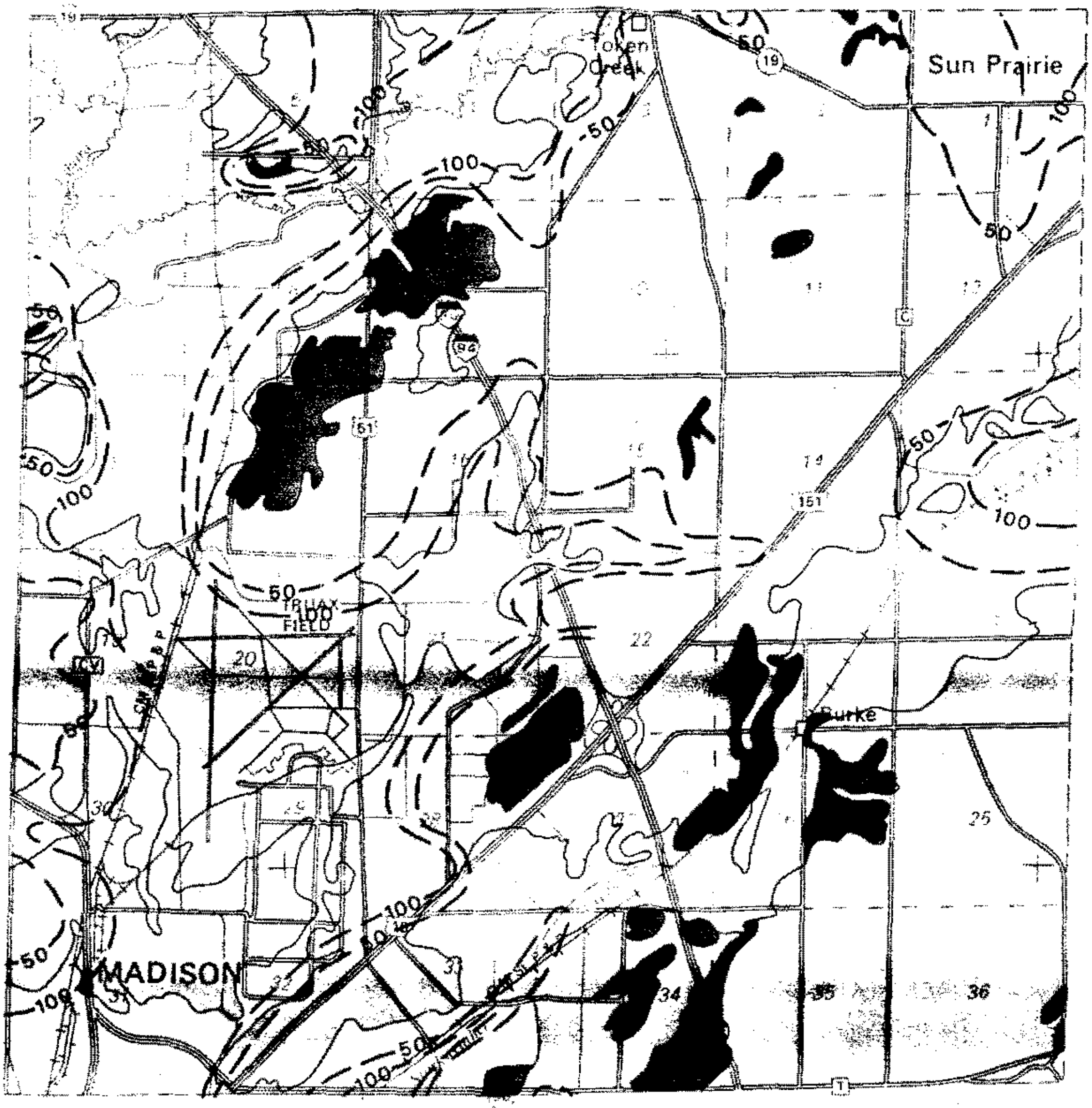
Contours showing approximate depth to water-table from land-surface
contour interval 25 feet

— — — 50 — — —
— — — 100 — — —

Contours showing thickness of unconsolidated materials that require well casing depths of less 50 feet, 50 to 100 feet, and more than 100 feet

Source: P Olcott 1973

Figure 14. Factors affecting development of domestic water-supply wells tapping the bedrock aquifer



Areas of permeable surficial deposits with the best potential for obtaining a water supply—water-table is within 25 feet of landsurface in most of this area

Areas with bedrock at or near landsurface—glacial drift aquifer is missing and/or unsaturated in this area

Areas of surficial deposits with low permeability with a poor potential for obtaining a water supply

Contours showing where glacial deposits are less than 50 feet, from 50 to 100 feet, and greater than 100 feet in thickness

Source: P. Olcott, 1973

Figure 15 Factors affecting development of domestic water-supply wells tapping the glacial drift aquifer.

the northern half of the valley indicates that these deposits will yield adequate water for domestic or farm supply in many places.

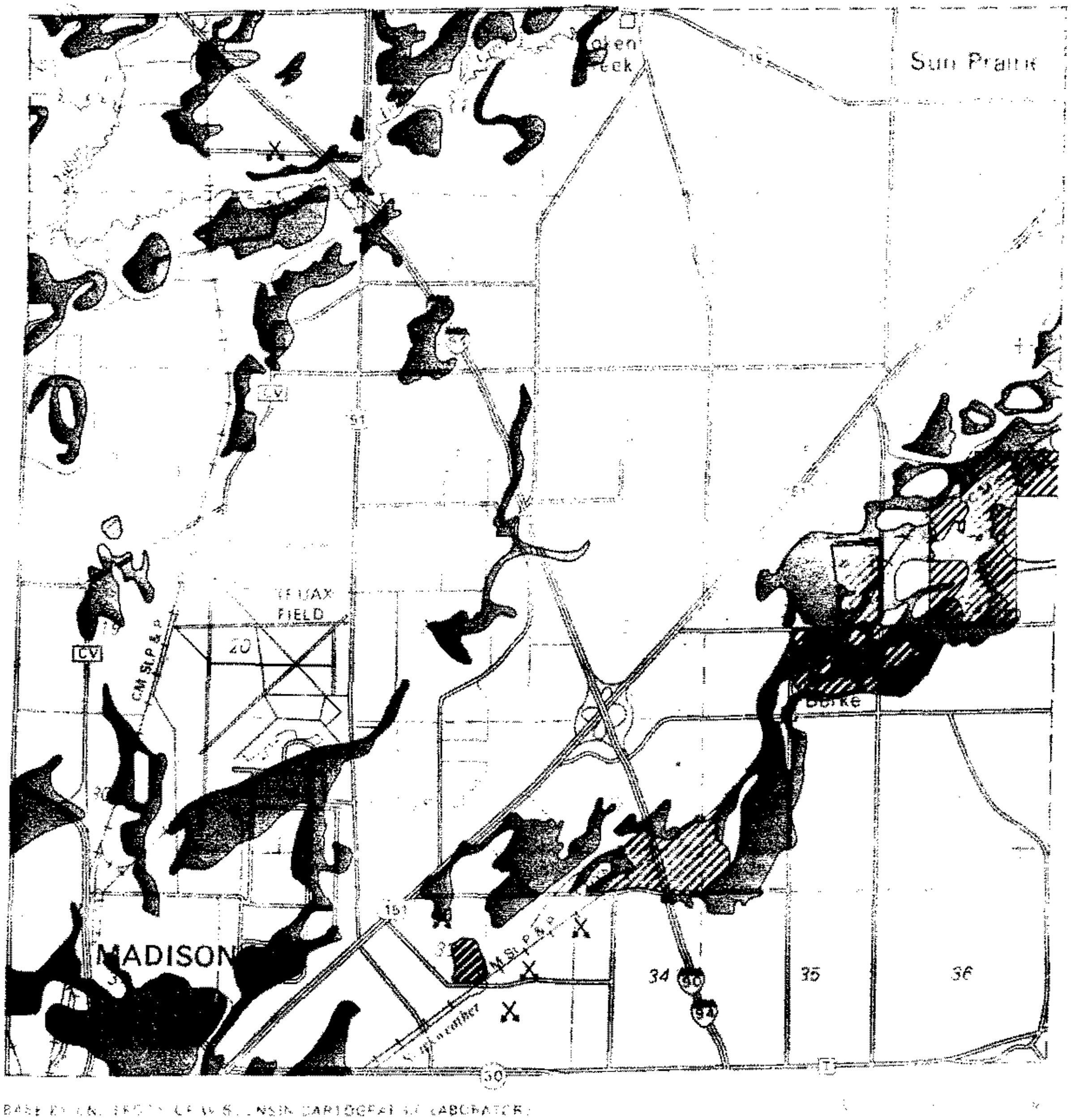
Mineral Resources

Mineral Resources of the township are limited to construction materials and silica sand. Dolomite (a magnesium rich limestone) and silica sand can be obtained from bedrock formations and sand and gravel is obtained from unconsolidated glacial deposits. There may also be some possibility for peat in marsh areas. The aggregate and building stone quarried in the township are of vital importance to the growing Madison metropolitan area for construction of roads, housing, industrial, commercial, and municipal buildings, and many other uses. The value of sand and gravel and stone produced in Dane County, including Burke Township, in 1971 was $3,814,000 (Broderick, 1974).

Because sand and gravel and stone are high bulk, low value commodities, transportation is an important economic factor in their use. Burke Township is located in close proximity to Madison, the principal market. Thus, its sand and gravel and stone deposits will continue to be important resources to the growing Madison area.

Sand and Gravel

Sand and gravel deposits, in general, occur in the lowlying parts of the township in the areas of the buried bedrock valleys. These valleys were channelways for meltwaters that carried sand and gravel washed out of glaciers. The numerous deposits of outwash sands and gravels on the western side of the township (Figure ~~15~~ 16) occur in the deep buried bedrock valley and may extend below the water table in this lowlying area. Available logs of wells in the deep valley fill do not, however, indicate any shallow, large, or extensive gravel deposits in the southern half of this buried valley.



Areas with potential as a source of well sorted sand and gravel

Areas zoned for mineral extraction by the Dane County Zoning Board

Existing sand and gravel pit

Source: U S D A SCS Advanced field sheets

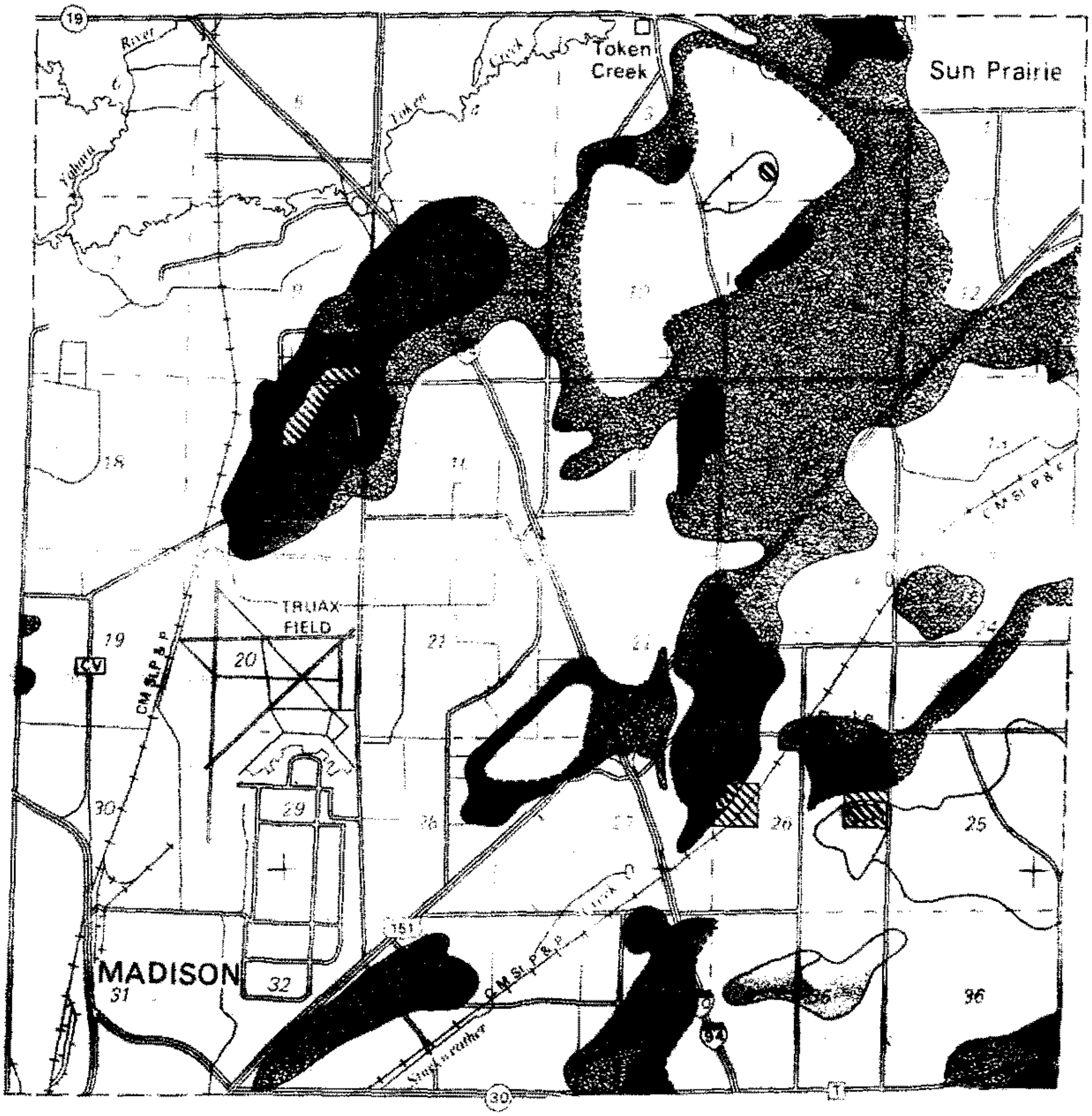
Figure 16 Areas with potential for sand and gravel

Sand and gravel has been extensively mined in Burke Township especially along the northeast-southwest trending outwash deposit in the eastern and southcentral part of the township (Figure 16). Existing pits are shown on the map along with outwash deposits delineated by soils parent materials information. It is beyond the scope of this project to provide a detailed analysis of each of the sand and gravel deposits in the township. Thus, the areas shown should be considered as having above average potential to contain deposits of sand and gravel, and therefore, as target areas for future exploration.

The usable sand and gravel deposits of the township could be identified and preserved through zoning to assure recovery of the resource before land development precludes use. Present zoning for mineral extraction by the Dane County Zoning Board is shown on the map (Figure 16). It is generally confined to areas of existing pits. Considerable additional work is needed to define the usable sand and gravel resources of the township.

Dolomite

Dolomite resources of Burke Township are present in three different units: the Sinnipee Group, the Prairie du Chien dolomites, and the St. Lawrence Formation. The approximate maximum thickness, lithology and potential use are tabulated in Table 5. The areal distribution of the 3 formations where they have less than 10 feet of overburden and from 10 to 50 feet of overburden are shown on the map, Figure 17. Dolomite reserves, especially the Sinnipee Group and Prairie du Chien dolomites, are located in highland areas of the township.



BASE BY UNIVERSITY OF WISCONSIN CARTOGRAPHIC LABORATORY

Platteville Formation

- Areas with less than 10 feet of overburden
- Areas with 10 to 50 feet of overburden

Prairie du Chien Group

- Areas with less than 10 feet of overburden
- Areas with 10 to 50 feet of overburden

St. Lawrence Formation

- Areas with less than 10 feet of overburden
- Areas with 10 to 50 feet of overburden

- Areas zoned for mineral extraction by the Dane County Zoning Board
- Inferred contact
- Existing quarry

Source: P. Olcott 1973

Figure 17 Areas with potential for shallow dolomite deposits

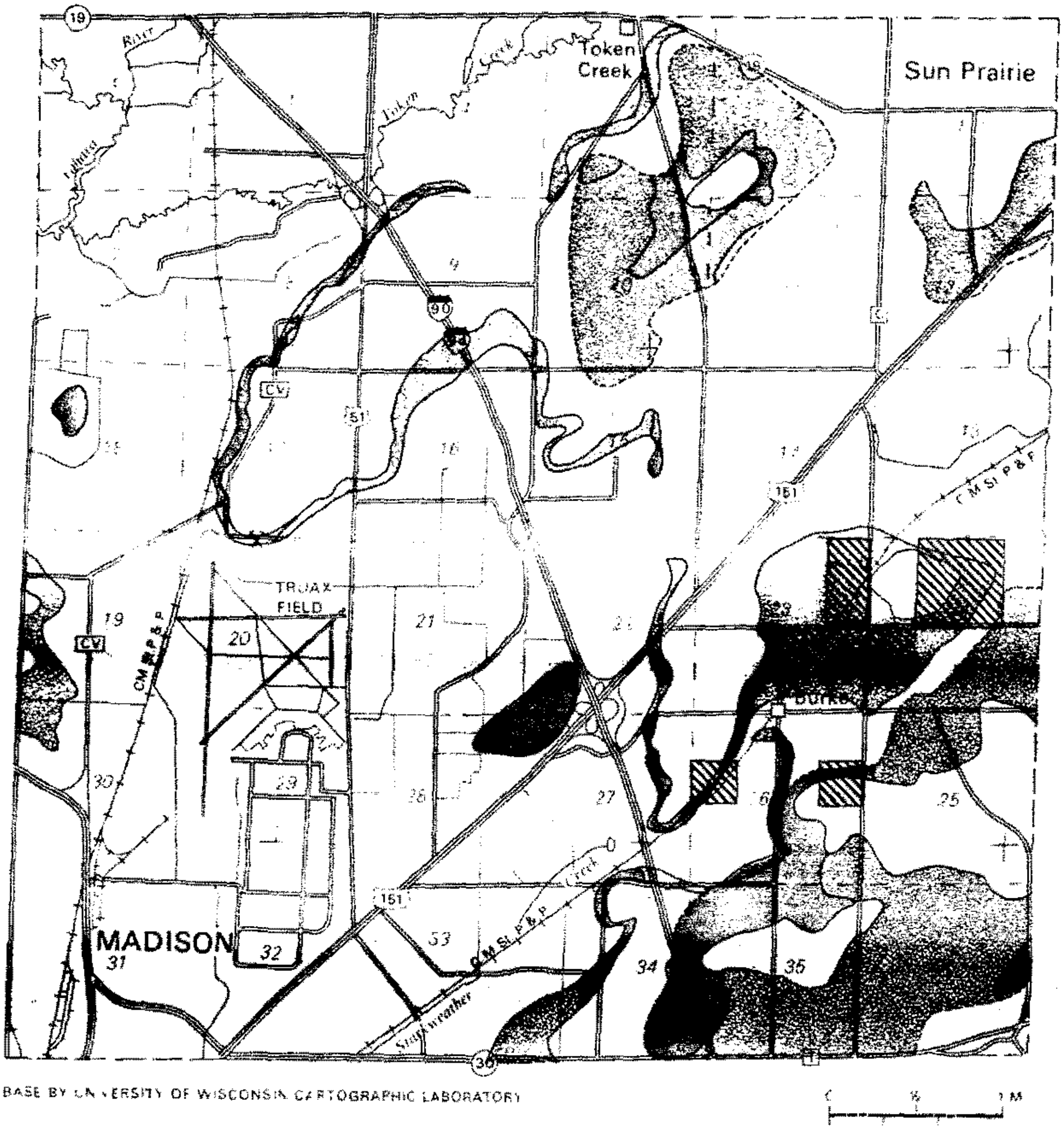
Table 5. Characteristics and Present or Potential Uses of Dolomite

Formation	Approximate Max. Thickness (feet)		
Sinnipee Group	25	Dolomite, medium to thin bedded, fossiliferous, thin clay partings in some horizons, some chert.	Good to poor grade aggregate and building stone; aglime.
Prairie du Chien Dolomite	75	Dolomite, algal, massive to thin bedded, cherty, minor thin clay layers.	Excellent aggregate and building stone; aglime; rip-rap.
St. Lawrence Formation	25	Dolomite, medium to thin bedded, silty, glauconitic.	Attractive building stone.

There are presently 4 quarries in the township, 2 in the Sinnipee and 2 in the Prairie du Chien. One small quarry in the St. Lawrence Formation is now abandoned, graded over, and the site built upon. The St. Lawrence is not as accessible here as in western Dane County and it is less desirable for aggregate than the Sinnipee and Prairie du Chien. Zoning for mineral extraction is presently confined to 3 of the 4 quarry areas (Figure ~~16~~ 17).

Sandstone

Sandstone resources of Burke Township occur in 2 formations, the St. Peter Formation and the Jordan Formation (Figure ~~17~~ 18). The approximate thickness, lithology, and potential economic uses are tabulated in Table 6. Areal distribution with less than 10 feet of overburden and 10 to 50 feet of overburden is shown on the map.



BASE BY UNIVERSITY OF WISCONSIN CARTOGRAPHIC LABORATORY

St. Peter Formation

- Areas with less than 10 feet of overburden
- Areas with 10 to 50 feet of overburden

Jordan Formation

- Areas with less than 10 feet of overburden
- Areas with 10 to 50 feet of overburden

- Areas zoned for mineral extraction by the Dane County Zoning Board
- ------ Inferred contact
- X Existing quarry

Source: P. Olcott, 1973

Figure 18. Areas with potential for shallow sandstone deposits

Sandstone is not quarried in the township at present. One small quarry in the Jordan Formation, now abandoned, is located in the west central part of the township (Figure 18 17).

Table 6. Characteristics and Potential Uses of Sandstone

Formation	Approximate Max. Thickness	Lithology	Potential Economic Uses
St. Peter Sandstone	80	Sandstone, quartz, medium- to fine-grained, silica cement, friable.	Molding sand, filter sand, abrasives.
Jordan Sandstone	40	Sandstone, quartz, medium to very fine grained in lower part, coarse to fine grained in upper part, with some local silica and dolomite cement, friable.	Molding sand; filter sand, abrasives.

The St. Peter Sandstone, which generally occurs in the upland areas, is the most readily available and extensive sandstone formation. It occurs above the water table in most of its area and 2 relatively large areas have less than 10 feet of overburden. The Jordan Formation, for the most part, crops out along valley walls in the township and is overlain by the Prairie du Chien dolomite. However, two small areas with little overburden are present. (Figure 18 17). It also lies above the water table. Grain size and chemical analyses are not available for these bedrock units. Consequently, the mapped units should be considered as target areas for sandstone exploration.

Peat

Peat, useful as a mulch and soil conditioner, is present in the marsh areas of the township (Figure 8 7), however, its extent, extractability, and quality have not been assessed.

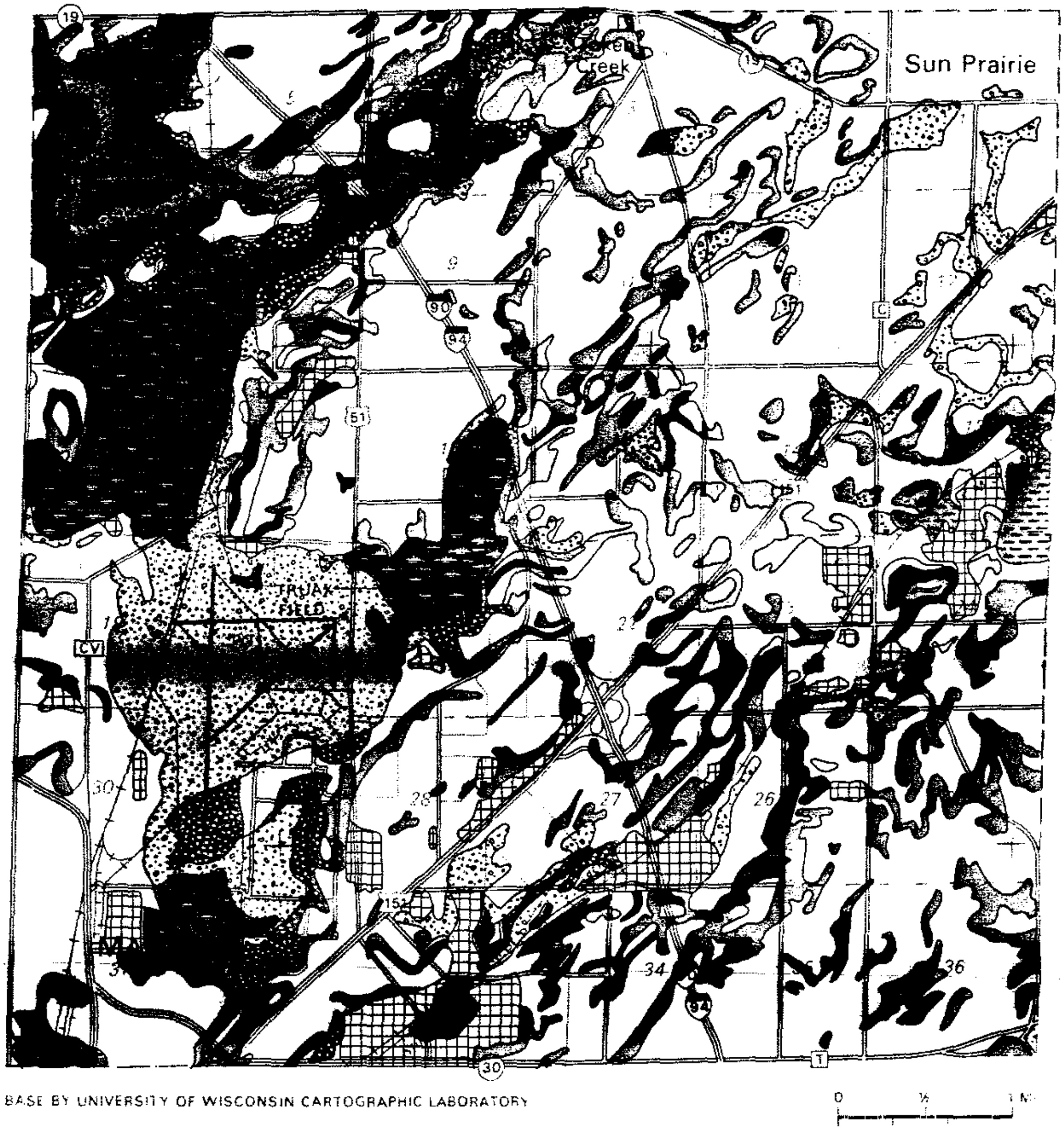
Agriculture

An estimated 80 percent of the land area of Burke Township has only moderate to slight limitations to growing crops (Figure ~~18~~ 19) Silty and sandy loam soils developed on loess and glacial tills, lacustrine deposits, bedrock and outwash cover most of the cropable area. The soils range from nearly flat to steeply sloping and poorly drained to well drained. Slope and wet soils cause moderate limitations to crops in the area.

Slopes range from nearly level to over 20 percent in the cropable area of the township. Because soil slope has an influence on productivity, areas in excess of 6 percent slope are considered to have some limitations to growing crops. Areas in excess of 12 percent slope are considered as poor cropland. The steepest slopes of 12 percent or more occur mainly in the highlands of the township and are often underlain by shallow bedrock. The nearly level soils occur mainly in the broad lowland area underlain by the deep buried bedrock valley.

The nearly level lowland soils in the southwestern quarter of the township and in valley bottoms, drainageways, wetland margins, and small depressions in the remainder of the township tend to be poorly drained because of high water table. These areas are suitable for growing crops except during wet periods when water table may rise near to, or above the ground surface. Much of this area is also subject to flooding (Figure ~~9~~ 10). Thus the wet soil areas have at least moderate limitations to growing crops.

Approximately 20 percent of the township is unsuitable for cropland. This includes the extensive wetland areas, lowland drainageways, and small depressions with muck and peat soils; the numerous pits, quarries and landfills or dumps; and small areas where land slope exceeds 12 percent. The muck and peat soils occur mainly in the western part of the township in the buried bedrock valley area. Pits, quarries, and landfills are spread throughout the township but are concentrated along the outwash belt in the southeastern quarter of the township (Figure ~~7~~ 8).



Best areas for growing crops

Wetlands–lowland drainage ways and small depressions, organic peat and muck, silts and clays, poorly drained

Lacustrine deposits–lowlands and marsh borders, silts, fine sand, and clay, poorly drained

Alluvium–valley bottoms, flood plains, and small depressions, silt and fine sand, poorly drained

Made land–landfills, dumps, sand and gravel pits, and quarries

Lowland outwash– drainage ways and marsh borders, silt, sand, and gravel, poorly drained

Lowland till– lowlands, drainage ways and small depressions, clay, silt, sand, gravel, and boulders, poorly drained

Land slope

6–12 %

12–20 %

over 20 %

Source: P Olcott 1973

Figure 19 Factors affecting the growing of crops

SUITABILITY FOR LAND USE MAPS - 3RD ORDER

Third Order maps summarize land suitability for specific uses in simple three color illustrations from information presented in the 1st and 2nd Order maps. The red, yellow, and green colors, analagous to a traffic signal, show areas with severe limitations, areas with moderate limitations, and areas with few limitations to the specified use. Because these maps were compiled from regional mapping any development should be preceeded by a detailed site study.

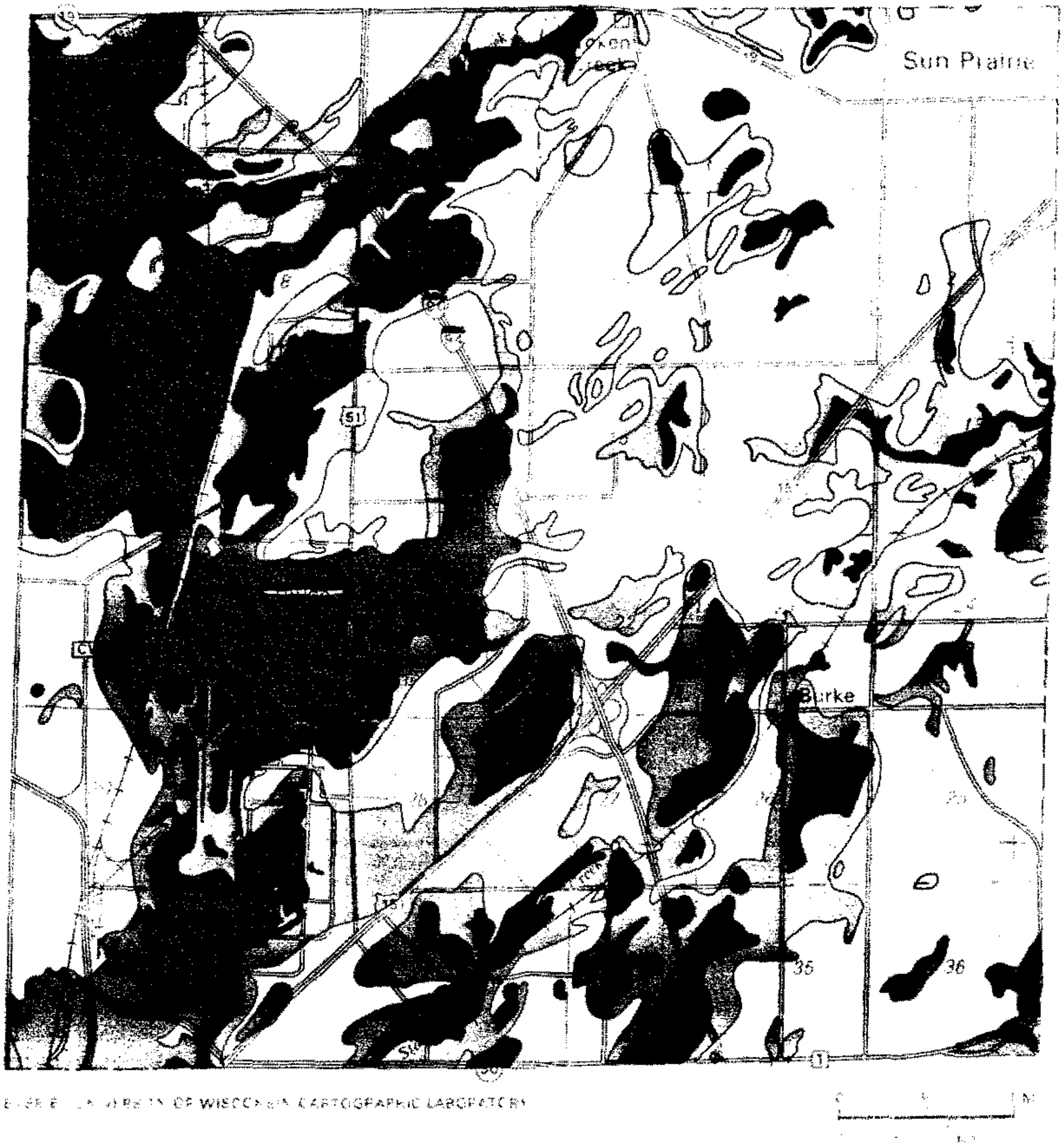
Suitability for Construction Siting

Criteria for construction and road siting include difficulty of excavation, high water table, flood hazard, unstable ground or low bearing capacity, excessive slopes, and frost heave potential. The areas mapped in Figure 19 as having severe limitations are marsh areas with water table at the land surface, potential flood inundation areas and areas where bedrock, generally dolomite, is at or within 5 feet of the land surface. Areas mapped as having moderate limitations include shallow bedrock, shallow water table, slopes in excess of 12%, lacustrine and alluvial deposits with possible low bearing capacities and soils subject to frost heave.

Areas with few limitations for construction of buildings and roads are located chiefly in the flat to rolling areas of the township outside of the flood-prone area and with slopes of less that 12%. These areas are largely underlain by glacial till and/or outwash in excess of 10 feet thick and water table is in excess of 10 feet deep. Bearing capacities range from 1 to 5 tons per square foot and are generally 2 to 3 tons per square foot. Frost heave and shrink swell potential of the soils parent materials are low.

Suitability for Utility Routing

Utility routing, including buried sewer, water, electrical, telephone, and gas lines and above surface electrical and telephone lines, are subject to criteria similar to building and road construction and the same map (Figure ~~19~~ 20)



Areas best suited – bedrock and water table greater than 10 feet from land-surface, slopes less than 12 %, low frost hazard, and moderate to high bearing capacities

Areas moderately suited – including one or more of the following; bedrock and/ or watertable within 10 feet or less of the land-surface, slopes in excess of 12 %, moderate to high frost hazard, and low bearing capacities

Areas poorly suited – including one or more of the following; bedrock within 5 feet of land-surface, marsh areas, water-table at or near land-surface, very low bearing capacities, and flood-prone areas

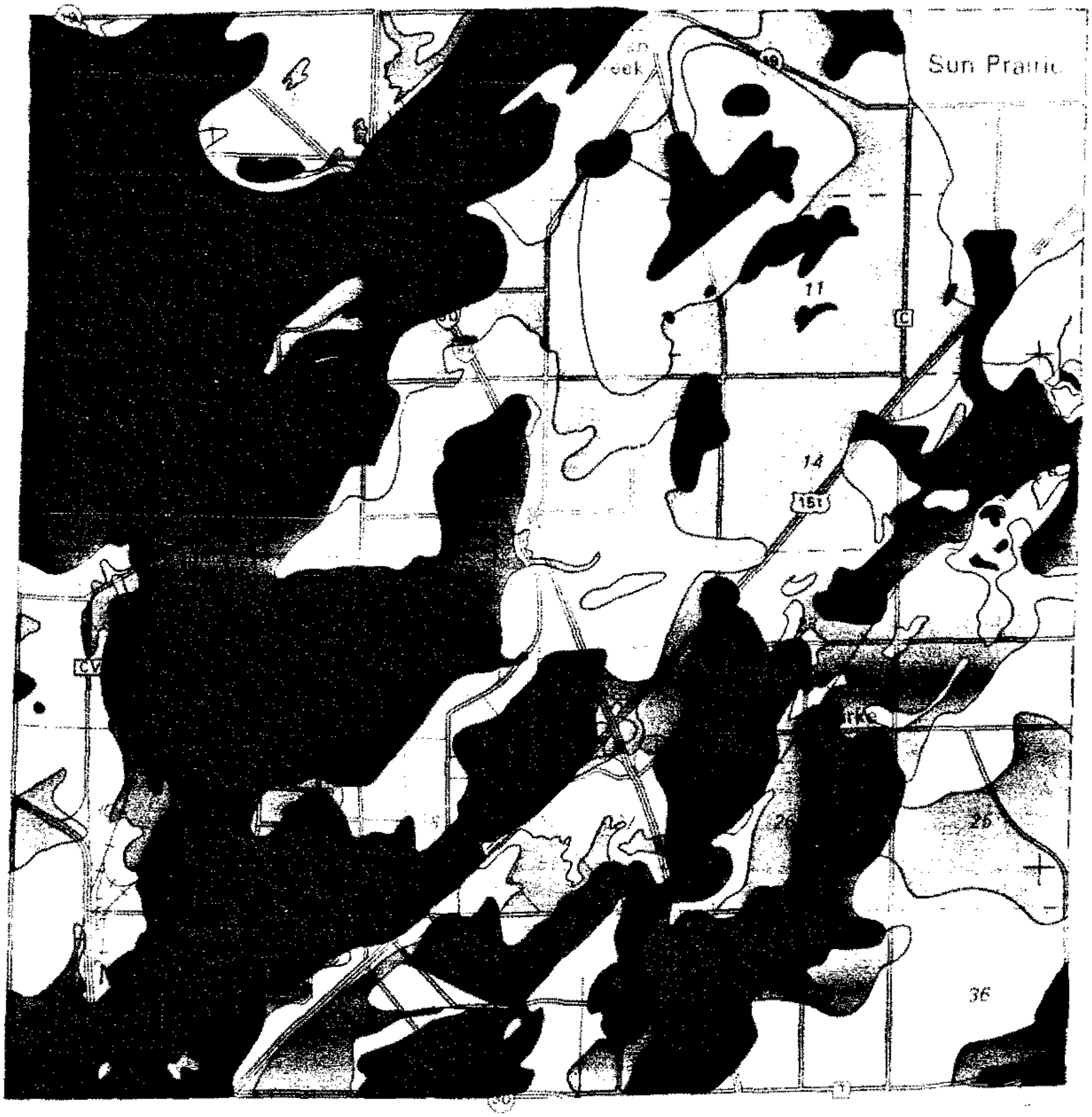
Source: P. Olcott 1973

Figure 20 Suitability for utility routing and construction of roads, buildings, and structures can be used for either consideration. Excavation difficulty, especially near surface bedrock, is of primary consideration in trenching and drilling holes for supporting utility poles. Steep slopes, shallow water table, and wetland areas are all considered as limiting factors to utility routing. Frost heave and shrink swell potential is a hazard to supporting utility poles.

Suitability for Sanitary Land Fill

Hydrologic and geologic criteria for solid waste management by a land disposal operation is specified in the Wisconsin Administrative code, chapter NR 151 which sets forth conditions for solid waste management. The code specifies that land disposal operations are prohibited within 1,000 feet of any navigable lake, pond, or flowage and within 300 feet of a navigable river and/or above the flood plain. It goes on to state in general terms that it is prohibited in an area where, "...solid waste or leachings therefrom have a detrimental effect on surface water" and in areas where "...leaching from solid waste may have a detrimental effect on ground water quality." Solid waste disposal is also prohibited by the code within wetlands. Specific depths to water table or bedrock, type of bedrock, ground water movement, and other specific criteria are assessed on an individual basis by the Department of Natural Resources under the generalized statements of the code.

Criteria used in compiling the map (Figure ~~20~~ 21) relate to the code and generally conform to standards used by the Department in issuing permits for landfills. However, proximity to surface water has not been considered. The areas mapped as having severe limitations for landfill include areas where water table is less than 10 feet in depth, wetlands, flood inundation areas, and areas where bedrock is less than 100 feet from the land surface. The map unit with moderate limitations for landfill is based on areas underlain by highly permeable sand and gravel and fractured dolomite bedrock having from 10 to 50 feet of overburden. In areas mapped as having few limitations



BASE: UNIVERSITY OF WISCONSIN CARTOGRAPHIC LABORATORY

Areas best suited–bedrock greater than 10 feet and dolomite bedrock greater than 50 feet from land-surface, water table greater than 10 feet from land-surface, unconsolidated deposits with moderate to low permeability and not subject to flooding

Areas moderately suited–highly permeable unconsolidated deposits and/or fractured dolomite bedrock at depths of 10 to 50 feet from land-surface

Areas poorly suited –bedrock or water table at less than 10 feet from land-surface and/or subject to occasional flooding

Source: P Olcott 1973

Figure 21. Suitability for sanitary landfill

for landfill, bedrock and water table is greater than 10 feet from land surface, unconsolidated glacial material consists of till with relatively low permeabilities, and bedrock consists largely of sandstone.

It should be emphasized that any proposed land fill site will require a detailed site study. The map should be helpful in pointing out target areas for land fill sites.

Suitability for Mineral Extraction

Available mineral resources in Burke Township presently mined or with a potential for future mining include sand and gravel, dolomite, and sandstone. Areas suitable for extraction of these minerals are showin in Figure ~~21~~ 22. Areas of highest potential for mineral extraction are the surficial glacial outwash deposits where sand and gravel is most likely to occur, and areas where dolomite and sandstone bedrock formations occur within 10 feet of the land surface. Areas where dolomite and sandstone occur at 10 to 50 feet from the land surface also offers some potential for extraction of these materials although somewhat less than the shallower bedrock and the surficial outwash areas. In the remainder of the township mineral extraction is unlikely because of the lack of any sizeable sand and gravel deposits, thick overburden, and high water table.

Suitability for Water Supply

Areas best suited to drilling a well in bedrock occur where land surface elevations are intermediate between the highlands and lowlands of the township (Figure ~~22~~ 23). In the highlands, depths to water table are excessive, wells must be drilled to relatively great depths, pumping costs are high, and extra piping in the well increases cost of construction. However, drift thickness is less in the highland areas and well casing costs are consequently lower. In the lowlands, the thickness of unconsolidated glacial material is great, up to 350 feet in the deep buried bedrock valley. Thus, well depths and casing length

BASE BY UNIVERSITY OF WISCONSIN CARTOGRAPHIC LABORATORY

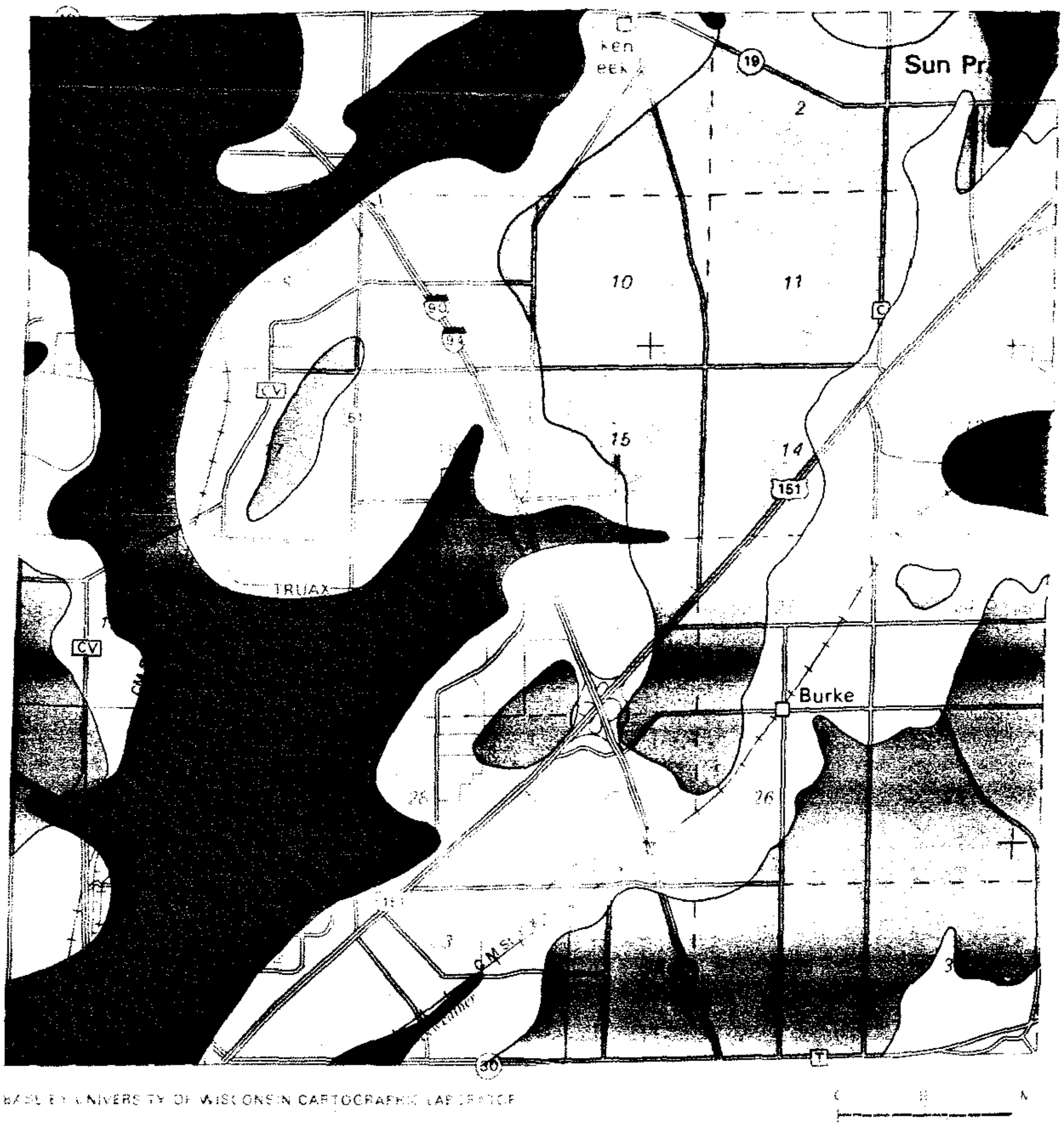
Areas best suited – dolomite, sandstone, and sand and gravel occur at or near the land-surface

Areas moderately suited – dolomite and sandstone occur at depths ranging from 10 to 50 feet from the land surface

Areas poorly suited – dolomite, sandstone, and/or sand and gravel is not present or occurs at excessive depths

Source: P Olcott 1973

Figure 22 Suitability for mineral extraction



Areas best suited—less than 100 feet of casing required and water level will stand less than 50 feet below land-surface in completed well

Areas moderately suited—water level will stand more than 50 feet from land-surface in completed well but less than 100 feet of casing required

Areas poorly suited—more than 100 feet of casing required but water level will stand less than 50 feet from land-surface in completed well

Source: P Olcott 1973

Figure 23 Suitability for developing a domestic water supply from the bedrock aquifer for bedrock wells are large although the depths to water are small and therefore pumping costs and equipment required is smaller than in the highlands. The best areas, therefore, are in the intermediate elevation zone where well depths, casing, and depth to water are moderate.

Unconsolidated glacial materials are either too thin, unsaturated, or not sufficiently permeable to develop wells in much of the township except in the buried bedrock valley areas (Figures 24 and 6). In the deep buried valley on the western side of the township well logs indicate the presence of scattered permeable sand and gravel layers and lenses that will probably yield adequate amounts of water for domestic supply. However much of the valley is filled with clayey and silty glacial materials of low permeability that will yield only small amounts of water. If the buried sand and gravel layers can be penetrated, an adequate domestic supply can be developed.

Ground water in Burke Township is of the calcium magnesium bicarbonate type. It is hard and iron may be a problem in some areas but generally it is of excellent quality. Chemical analyses from Madison unit wells #7 and #15, located in the township, are tabulated in Table 4 and are representative of ground water in the township.

Suitability for Cropland

An estimated 2/3 of the land area of Burke Township is suitable for growing crops with only slight to moderate limitations (Figure 25). Natural limitations are the muck and mucky peat soils with high water table of the wetland areas, flood-prone areas, poorly drained depressions and drainageways, and small areas of very steep slopes in the uplands. Manmade limitations include the rather extensive mined areas of the township, roadways and several dump and land fill sites.

The areas best suited to cropland are on the St. Charles-McHenry-Lapeer and Plano-Ringwood-Griswold soil associations which are well-drained soils in silt and sandy loam till on less than 6 percent slope. Well to poorly drained

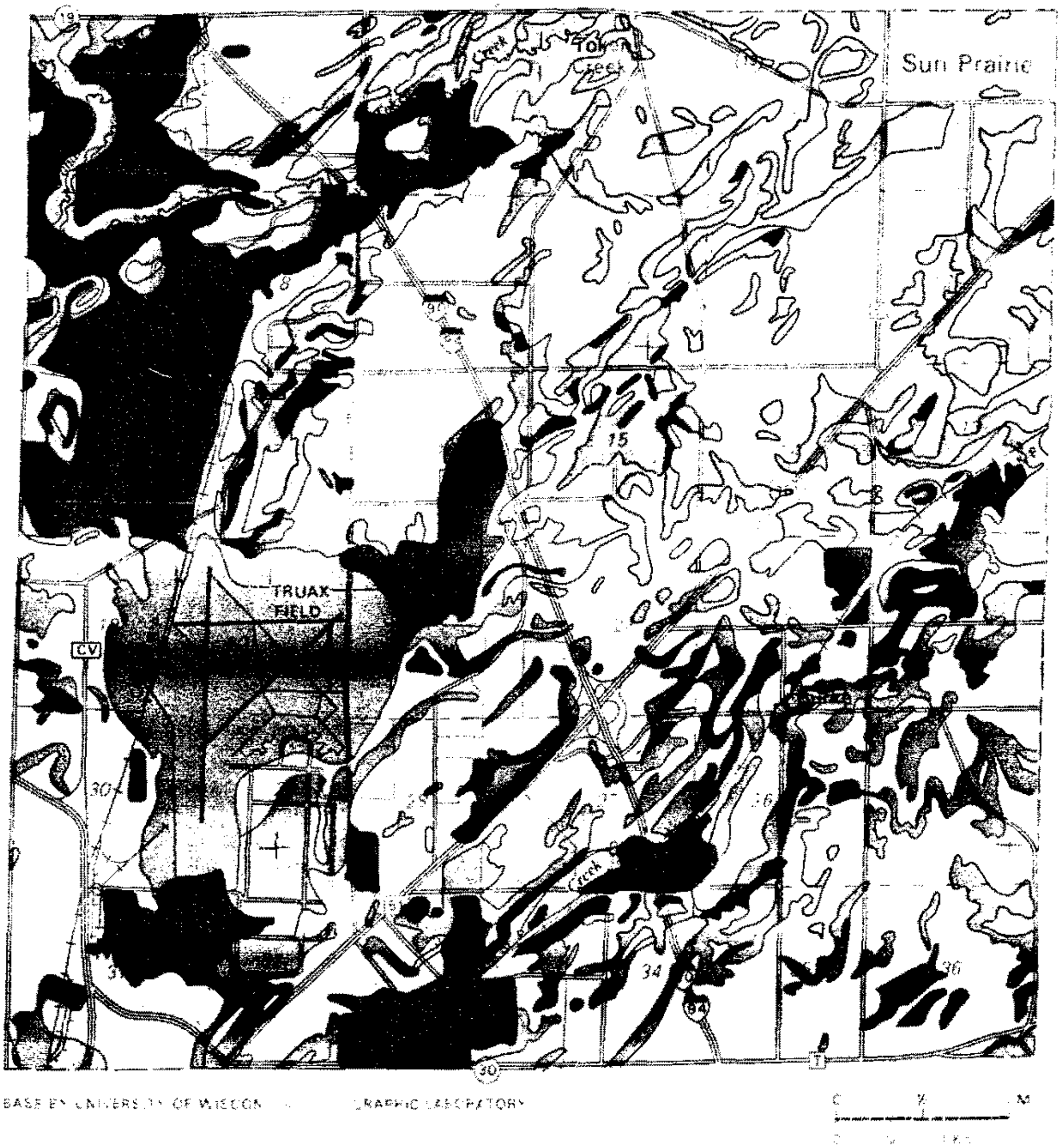
Areas best suited–aquifer exceeds 50 feet in thickness in areas with permeable surficial deposits

Areas moderately suited – aquifer is less than 50 feet in thickness in areas with permeable surficial deposits or aquifer exceeds 50 feet in thickness in areas with surficial deposits of low permeability

Areas poorly suited–aquifer is less than 50 feet in thickness in areas with surficial deposits of low permeability

Source: P Olcott 1973

Figure 24: Suitability for developing a domestic water supply from unconsolidated glacial deposits



BASE BY UNIVERSITY OF WISCONSIN ... GRAPHIC LABORATORY

Areas best suited—less than 6 % slope, level through gently sloping well drained soils in silty and sandy loam till and outwash. Some areas with bedrock at 4 feet or less from land-surface

Areas moderately suited—includes one or more of the following: slope between 6 and 12 %, high water-table, some areas subject to flooding, poorly drained soils in lowlands, marsh borders, drainageways, and depressions

Areas poorly suited—includes one or more of the following: pits, quarries, and landfills, slope exceeds 12 %, poorly drained muck and peat soils in drainageways, wetlands, and depressions

Source: P. Olcott 1973

Figure 25 Suitability for cropland

soils in silt and sand and gravel of the Batavia-Dresden-Virgil and Plano-Elburn associations where slopes are less than 6 percent are included in this category.

Areas with moderate limitations to the growing of crops include slopes of from 6 to 12 percent and the Ossian-Waucasta-Marshan poorly drained soils in lowlands, marsh borders, drainageways, and depressions. Some of these soils have water table near to the land surface and may be subject to periodic flooding.

Recreational Development

Recreation potential in Burke Township has not been mapped. It is restricted to land-based rather than water-based recreational pursuits except for a minor warm-water fishery in the Yahara River and Token Creek and the hunting of water fowl and nature appreciation activities in the wetlands. There is space for hunting upland birds and game usually associated with an agricultural area as well as hiking, cross country skiing, and snowmobiling.

The extensive sand and gravel pits in the township have potential for future public parks and recreational areas. Sand and gravel has been mined to within a few feet of the water table over broad areas in the southeastern part of the township. Rehabilitation of one or more of these pits for a public park could feature lagoon or small lake areas by dredging the sand and gravel from below the water table. Appropriate rehabilitation and landscaping methods could make very attractive recreational parks of the mined out areas.

SUMMARY AND CONSLUSIONS

Optimum land management, in both the public and private sector, is logically based on a thorough knowledge of the physical characteristics of the land resource. Physical characteristics are shown by 1st Order maps which are the basic data of the land use planning procedure and which indicate bedrock and surficial geology, soils, topography, drainage, and water information. With the basic maps and a list of engineering criteria for specific land uses, 2nd Order maps are constructed to show suitability for specific land uses. Simplified 3rd Order maps are drawn from the 2nd Order maps to show areas best suited, areas with some limitations, and areas unsuited for the specific land use. These simplified 3rd Order maps are intended as the earth science input to the land use planning process. They should be combined with cultural and other data by the planner to arrive at a final comprehensive land use plan.

The bedrock topography of Burke Township is the predominant influence on the physical character of the area. The bedrock topography, which is the result of deep erosion of dolomite-capped sandstone bedrock, is prominantly reflected in the land surface topography through a veneer of unconsolidated glacial deposits. The dominant feature on the bedrock surface, a buried bedrock valley filled with up to 350 feet of glacial sediment, extends north-south along the west side of the township and forms a broad flat lowland. In the lowland, the water table is near the land surface and marsh areas are present. The area is partially subject to flood inundation. Soils tend to be wet or mucky and peaty and outwash deposits of sand and gravel as well as lacustrine deposits tend to be concentrated in this area.

The uplands of the township are formed on erosion resistant dolomite bedrock covered by from 0 to 50 feet of glacial till. The steepest land slopes occur in the uplands and dolomite reserves for aggregate and building stone are present.

The water table is deep and the uplands form a principal recharge area for the ground water reservoir. Soils are generally well drained and are developed in sandy loam till.

Ground-water supply is available throughout the township from the bedrock aquifer for municipal, industrial, domestic and farm supply. Small supplies may also be available from buried sand and gravel deposits in the buried bedrock valley area. Ground water quality generally is good but the water is hard and iron may be troublesome in some areas.

Sand and gravel, dolomite, and silica sand resources are available in the township. Extensive mining of sand and gravel and dolomite is in progress. The township should continue to be an important source for these minerals because of its proximity to the growing Madison area.

The best areas for mineral resources, construction of buildings and roads, utility routing and sanitary land fill sites tend to be concentrated in the upland areas of the township. The best areas for agriculture also occur in the uplands area as opposed to the lowest lying land where wet soils and marsh areas are limiting factors. Mined areas and areas of steep slopes also limit agriculture.

Recreation is largely confined to non-water related sports because of the lack of lakes or large streams. Large marsh areas are suitable for hunting and esthetic pursuits and much of the upland area provides opportunities for hiking, snowmobiling, and cross-country skiing. Reclamation of abandoned sand and gravel pits could provide good sites for public parks.

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