LAND USE AND THE GEOLOGIC AND HYDROLOGIC ENVIRONMENT IN PARTS OF MIDDLETON, VERONA, MADISON, AND FITCHBURG TOWNSHIPS, DANE COUNTY, WISCONSIN.

by

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Table of Contents

List of Illustrations

List of Tables

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INTRODUCTION

Purpose and Scope

The purpose of this paper is to demonstrate to landowners, planners, and managers the need and use of geologic, soils, topographic, and hydrologic information in land development and management and to present a comprehensive assessment of land use suitability, based on these physical parameters for the project area. The project is in support of a land-use demonstration study conducted by the University of Wisconsin Department of Landscape Architecture and Environmental Awareness Center under a grant from the University of Wisconsin Foundation.

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 U.S. Department of Agriculture, Soil Conservation Service. This report, limited in scope to approximately 65 square miles covering parts of 4 townships, demonstrates the method of approach used to translate basic physical data into land use suitability.

Location

The project area is located west and south of the City of Middleton extending southward to the village of Verona. It is roughly bordered on the north by U.S. Highway 14 and the Chicago, Milwaukee, St. Paul and Pacific Railroad right-of-way, on the south by U.S. Highway 151 and the Chicago and

Northwestern Railroad right-of-way, on the west by the west border of the townships of Middleton and Verona, and on the east by the West Beltline Highway (U.S. Highways 12 & 18).

The area covers parts of Middleton, Verona, Madison, and Fitchburg Townships and is in the west-central part of Dane County.

Method of Approach

The application of geology and hydrology 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.

The method, illustrated in Figure 1, entails 3 successive orders of mapping: 1st Order, which illustrates physical parameters; 2nd Order, which interpretes the physical parameters in regard to criteria for specified land uses; and 3rd Order, which show land suitability for the specified uses.

Bedrock and surficial geology, soils, topography, and surface and ground water make up 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 therefore basic to land use planning. Appropriately then, these basic mappable resources, including landsurface and bedrock topography, drainage, flood potential, distribution and thickness of glacial deposits, soils, bedrock geology, and the ground water surface, are the basic data or 1st Order maps on which this method of approach is based (Figure 1).

Resource and engineering properties are shown by 2nd Order maps (Figure 1) which deal with the technical limitations for land use or delineation of resources and are derived from one or more of the basic data or 1st Order maps. For example, the 2nd Order dolomite resources map is derived from the 1st Order bedrock geology and the thickness of overburden maps. These 2nd Order

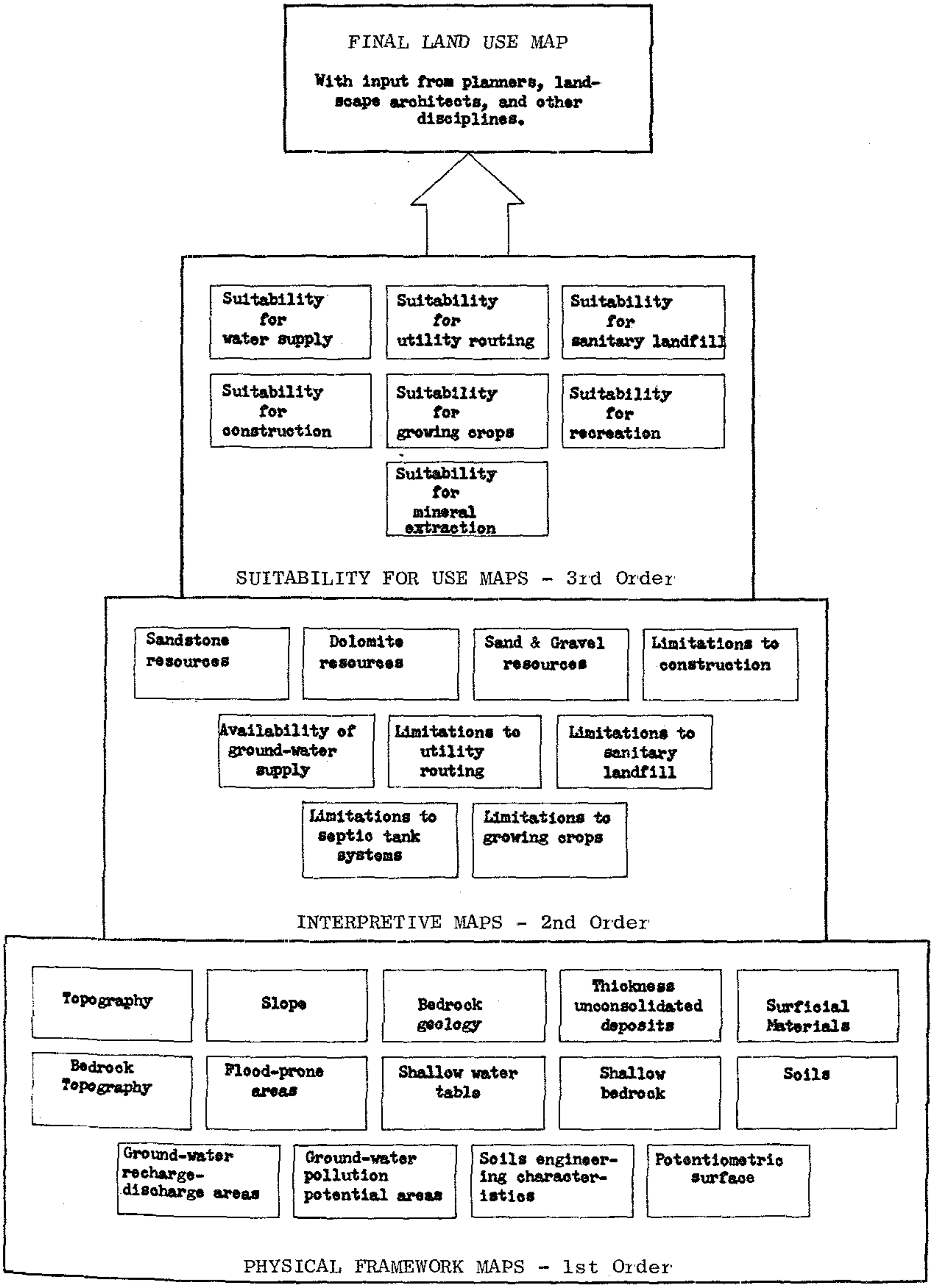

Diagram modified from Font, R. G.

Figure 1.--Diagram of the method of approach to environmental geology.

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.

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 of the project area which is only a part of 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, county, city, and township 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 should 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

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Thanks are due to Professor F.D. Hole, Wisconsin Geological and Natural History Survey and the University of Wisconsin Department of Soils, and Mr. Carl Glocker, U.S.G.S., Soil Conservation Service for their advice and help in preparation of soils information for this report and for Dane County maps.

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 thus form the b basic data required for intelligent land use. These basic data are the subject of the 1st Order maps.

The physical framework of the area 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 the project area at depths ranging up to 1150 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 diminished 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, melt-water 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 area occurred about 14,000 years ago. The barren landscape was devoid of vegetation and windborn silt drifted over the area after the retreat of the ice. As vegetation became established the land surface stabilized. Since the time of this 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 the project area as it exists today. The basement rocks of the township are igneous and metamorphic, granite, schist, quartzite and other crystalline rock types. The surface of these Precambrian rocks, which is about 1000 feet below land usrface, dips gently to the south and west. 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 feet thick have filled the bedrock valleys, but 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. The 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 system of the area 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 the project area is defined in the following discussion as a basis for the land use planning process. A description of the land usrface topography, including land slope, sets the stage for the discussion because it is the most visible and predominant factor affecting land use. Subsequent sections deal with bedrock and surficial geology, soils, and hydrology which, although less visible than topography, also have a pronounced influence on land use.

Land Surface Topography

The topography of the project area is the result of geologic processes, both erosional and depositional, working on the earth surface throughout geologic time. It has been only slightly modified by man. The topography of the area is shown in Figure 2 which is the basemap for each of the succeeding map illustrations.

The area is divided into 2 distinct topographic provinces by the northwest-shotheast oriented ridge in the southwestern sector. This ridge is part of the Johnstown Moraine which marks the southwestern-most extent in the area of Wisconsin glaciation. North and east of the moraine the land surface is rolling to hilly where glacial deposits have filled valleys in the deeply eroded bedrock surface and form a thin veneer over bedrock highlands. South and west of the moraine the rugged topography of the driftless area with the deep, steep-sided and narrow valleys between prominant highlands forms the land usrface.

A prominant broad east-west oriented valley along the northern boarder is the surface expression of a deep bedrock valley which is partially filled with glacial material. The lowest land surface elevation of the project area, approximately 880 feet above MSL (Mean Sea Level), is located in this valley along Pleasant Branch Creek (NE$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 11, T.7N., R.8E.). The highest elevation of the area, about 1240 feet above MSL, is located on the Johnstown Moraine (NE$\frac{1}{4}$, SW$\frac{1}{4}$, Sec.30, T.7N., R.8E.). Total relief of the area is therefore about 360 feet. Elevations of the highlands are not significantly different on either side of the moraine. However, they generally diminish to the northeast.

The project area straddles the topographic divide between the Yahara River drainage to the north and east, the Black Earth Creek drainage to the west, and the Sugar River drainage to the south and west. The divide as well as the topograph of the whole project area is strongly controlled by the topography on the bedrock surface.

Slope

Implicit in the topographic map of the area is land slope, a critical factor in land-use planning. Landslopes have been extracted from soils and topographic maps and are presented in Figure 3 in units of 0-2, 2-6, 6-12, 12-20, and over 20 percent slope.

An estimated 50 to 60 percent of the project area has landslopes of 6 percent or less. These shallow slopes occur mainly in valley or lowland areas and, for the most part, represent the level surface of glacial and aluvial fill in buried bedrock valleys. Slopes of 2 percent or less are common and also occur in these low areas, especially in the larger valleys.

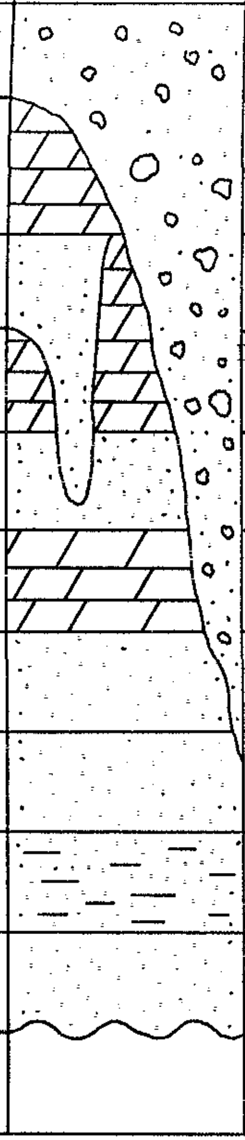
Slopes of from 6 to 12 and 12 to 20 percent include an estimated 35 to 40 percent of the project area and occur mainly on bedrock controlled highland areas and along the terminal moraine. The steepest slopes, over 20 percent, include only a small part of the area and are found mainly along the terminal moraine and along the steep, bedrock-controlled valley walls.

Bedrock Geology

The bedrock of the project area consists of an alternating sequence of essentially flat-lying, thick layers of sandstone and dolomite up to 1150 feet in thickness which rests on the ancient Precambrian crystalline rock surface. The distribution of these rocks, shown on the bedrock geology map (Figure 4), is the result of deep erosion of the flat-lying formations. The uplands generally are formed by the most erosion-resistant as well as the youngest rock; in this case the Sinnipee Group and Prairie du Chien Group, both of which consist of dolomite (a magnesium rich limestone). The deeper bedrock valleys expose successively older formations of the more easily eroded Cambrian sandstones. The deep east-west oriented valley on the northern boarder has been cut into the Mt. Simon Sandstone on the eastern end, the lowermost and oldest sedimentary bedrock formation.

The St. Peter Sandstone, which underlies the Sinnipee Group and overlies the Prairie du Chien Group, rests on an ancient erosion surface with considerable relief that existed prior to deposition of the sandstone. Thus, the base of the sandstone is very irregular in elevation and the thickness of the sandstone varies inversely with the thickness of the Prairie du Chien Group to the extent that one unit may be present to the exclusion of the other. For example, in sections 14 and 15 (T.6N., R.8E.) (Figure 4) the Prairie du Chien is missing and the St. Peter Sandstone rests on the Jordan Sandstone. Conversely, in section 5 (T.6N., R.8E.) the St. Peter Sandstone is very thin and the Prairie du Chien Group is dominant. This inconsistency makes the areal extent of the St. Peter Sandstone difficult to map in the subsurface. Consequently, the lower contact is dashed on the map to indicate that it is an approximation.

The age, stratigraphic or vertical position, lithology or rock description, approximate range in thickness, and potential economic uses of the bedrock units

Geologic Time	Formation or Group	Column	Rock Type	Approximate Range in Thickness (Feet)	Potential Economic Uses
Pleistocene	Glacial & Recent deposits		Clay, silt, sand, gravel and boulders; sand and gravel; sand; muck and peat.	0 - 370	Aggregate; fill material; domestic water supply; peat.
	erosion surface				
Ordovician	Sinnipee Group		Dolomite, medium- to thin-bedded, fossiliferous, thin clay parting in some horizons, some chert.	0 - 100	Good to poor grade aggregate and building stone; agricultural lime.
	St. Peter		Sandstone, medium- to fine-grained, medium- to thick-bedded.	0 - 225	Industrial sand; domestic water supply where saturated; sand for construction and fill.
	erosion surface				
	Prairie du Chien		Dolomite, thick- to thin-bedded, cherty, minor thin clay partings, algal.	0 - 170	Excellent aggregate and building stone; agricultural; riprap.
Cambrian	Jordan		Sandstone, medium- to fine-grained, thin- to thick-bedded.	0 - 35	Industrial sand; domestic water supply where saturated; sand for construction and fill.
	St. Lawrence		Dolomite, silty, medium- to thin-bedded and siltstone, dolomite, thin-bedded.	0 - 40	Attractive building stone.
	Tunnel City		Sandstone, very fine- to medium-grained, glauconitic.	0 - 105	None.
	Wonewoc		Sandstone, medium- to fine-grained, medium- and thick-bedded.	0 - 130	Domestic, municipal, and industrial water supply.
	Eau Claire		Sandstone, fine-grained, dolomitic, and shale, dolomitic.	0 - 30	None.
	Mt. Simon		Sandstone, coarse- to fine-grained; some silt and clay layers.	400 - 490	Principal aquifer for municipal and industrial water supply.
	erosion surface				
Precambrian			Granite, quartzite, and other igneous and metamorphic rock types.	Unknown	None.

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 Sandstones have potential as a source of industrial sand. The St. Peter is being mined in the project area for use as a fill sand, primarily as a subcoarse for concrete. The Jordan Sandstone is not mined in the project area. The Prairie du Chien and Sinnipee 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 or have been quarried in the project area.

Bedrock Topography and Thickness of Unconsolidated Deposits

The bedrock topographic map, Figure 5, was prepared from well logs, outcrops, and surficial topography. The ancient, deeply-incised drainage pattern is apparent on the map with the ancient Yahara valley on the north and the several long narrow tributaries to the ancient Sugar River system to the south. Thus, the bedrock highlands in the central part of the area formed the divide between these ancient river systems as it does in the modern drainage of the present system.

Bedrock topography, the features and relative elevation on the surface of the bedrock in the project area, is the primary controlling factor on the physical setting of the area. The bedrock surface, shown on Figure 5, has a total relief of approximately 500 feet that is only partially masked by unconsolidated glacial sediments. Thus, high areas on the bedrock surface, such as several areas in excess of 1150 above MSL (Secs. 7, 27, 28, and 34, T.7N., R.8E.), form highlands on the land surface while bedrock valleys underlie broad flat lowlands. The bedrock controlled highland areas have the steepest slope, 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 valley areas formed over bedrock valleys, are characterized by shallow depth to water table and contain the present drainage and principal wetlands. These lowland areas are most subject to flooding, have the lowest slopes, tend to contain water-laid glacial deposits, including sand and gravel, and soils tend to be lighter and poorly drained.

The thickness of unconsolidated deposits in the project area, Figure 6, is also strongly influenced by bedrock topography. 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 on the eastern end of the broad buried valley on the northern boarder of the area and are generally 150 to 200 feet thick in the other buried valleys in the area covered by glacial materials. Unconsolidated alluvium is 50 to 100 feet thick in the driftless area valley in the southwest corner and probably reaches 150 feet in thickness at the southern boarder. The bedrock highlands of the area generally have only a thin veneer of glacial deposits usually less than 50 feet thick. The terminal moraine, which for the most part rests on bedrock highland, is also generally less than 50 feet in thickness.

Unconsolidated Surfical Deposits

Unconsolidated surficial deposits in the project area, shown in Figure 7, 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, which was further verified in the field, shows the distribution of glacial and other surficial deposits in the area. The lithology and some of the engineering characteristics of the mapped units are tabulated in Table 2.

The map (Figure 7) shows that an estimated 45 percent of the project area 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 and is generally less than 50 feet thick. It may also be present at depth in some of 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 in the project area along the broad drainageways formed by the drift filled bedrock valleys and covers an estimated 25 percent of the project area. During glacial stagnation or melting, these natural drainageways channeled meltwater laden with sand and gravel released from the melting ice to the Yahara and Sugar Rivers and Black Earth Creek. The sand and gravel was deposited along the drainageways where stream gradients, and therefore water velocity, decreased. Outwash was carried and deposited west of the terminal moraine in Badger Mill Creek and Sugar River valleys in the southern part of the area and secs. 5, 8, and 9, T.6N., R.8E. This latter deposit was undoubtedly carried through a breach in the moraine near the center of sec. 5 which is visible on the present topography (Figure 7).

According to soils data, alluvium, marsh, and lacustrine deposits are mainly fine grained clay, silts, and sand. They have been carried into drainage

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

Parent Material	Soils classification Unified+	AASHO±	Permeability in inches/hour	Shrink-swell Potential	Bearing value (Tons/sq. ft.)	Frost hazard
Glacial Till	SM	A-2 A-4	2.0-6.3	Low	2.0-3.0	Low
Outwash	GP-GM SM CL-ML SP	A-1 A-4 A-6 A-3	6.3-20	Low	2.0-5.0	Low
Alluvium	CL ML PT	A-7 A-4	.63-2.0	Low	1.0-1.5	High
Lacustrine	SP SM	A-3	.63-2.5	Moderate	1.0-2.5	High

\+ Unified classification system used by the U.S. Army Corp 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).

ways and depressions mainly by water but also by wind. Alluvium is common along present perennial and intermittent stream drainages in the drift covered area and is the principal deposit along drainage ways in the driftless area.

Marsh deposits contain organic material or peat along with silt. These deposits have developed in undrained or poorly drained low-land areas and depressions with a high watertable. They cover only an estimated 5 percent of the project area.

Lacustrine deposits represent fine grained materials carried into ephemeral or temporary lakes during and after glacial stagnation. The principal lacustrine depositis in the northeast corner of the area (Figure 7) and is a part of "Glacial Lake Middleton," (Alden, 1918, p. 26). Glacial Lake Middleton was a large ephemeral lake formed in the lowlands to the west of Lake Mendota from glacial meltwaters when the Mendota Lake basin and the Yahara drainage was still blocked by ice. Lacustrine deposits also occur in the low-lying Dunns Marsh and the University of Wisconsin Arboretum in the eastern part of the area and in other small low-lying areas.

The made land category on Figure 7 includes active and inactive quarries and gravel pits, filled or stripped areas, dumps, and landfill sites.

Soils

Soils of the area are shown in Figure 8 which is a compilation of information from advanced field sheets prepared by the U.S. Dept. of Agriculture, Soil Conservation Service. The soils map essentially represents the upper 5 feet of the earth surface.

The soils 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 slope, and other factors such as climate. Because glacial deposition, depth to water table, and topography are strongly influenced by bedrock topography, this influence is also reflected in the soils.

The soils types of the upland areas are predominantly the McHenry, Ringwood, Lapeer, and St. Charles silt loams and theOctagon silt loam, sandy loam substratum phase. These soils consist of well-drained silt and sandy loams developed on glacial till with discontinuance loess cover. Outwash and ice-contact gravelly deposit with discontinuance loess cover in the upland drainage-ways as well as the deep bedrock valleys have well-drained silt loam soils. Predominant soil type include the Batavia silt loam gravelly substratum phase; Dresden silt loam, silty variant; Kendall silt loam, gravelly substratum phase; Plano silt loam, gravelly substratum phase; and the Elburn silt loam, gravelly substratum phase.

There are nearly level to gently sloping poor to moderately-well drained soils, consisting chiefly of the Troxel, Radford, Otter (Sawmill), and Washtenaw silt loams, developed on alluvium along stream floodplains and in the upland drainageways. Poor to moderately well drained soils on the lacustrine deposits in the north and northeastern parts of the area and in small depressed areas and marsh borders are largely the Ossian, thin solum variant, and Grays silt loan and the Kibbi sandy loam. The poorly drained Palms Muck, Houghton Muck, Waubesa Muck and Houghton Peaty Muck predominate in the few wetland or marsh areas.

Silt and sandy loam soils developed on dolomite and sandstone bedrock in the southwestern driftless part of the area and throughout the uplands of the area include a number of soil types. The Derinda, Dodgeville, Rockton, and Whalen silt loams and the Elk Mound sandy loam soils are predominant. They are found on moderate to steep slopes and are generally well drained 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 area except in the marsh areas, are remarkably similar. The soil forming processes have not been strongly impressed on this area and the soils mainly reflect materials deposited during and after glaciation. For the post part, the A and B soil horizons are weakly developed in wind blown loess or silt. Thus, the properties of these upper horizons are similar. Muck and peat soils represent accumulations largely of organic materials that impart 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

The project area straddles the divide between 3 river systems. Most of the southern half of the area is drained by the Sugar River and its tributaries including Badger Mill Creek, that are part of the Rock River system. The northeastern part is drained by Pheasant Branch Creek and other minor drainage which is tributary to the Yahara River, also part of the Rock River system. The northwestern part is drained by Black Earth Creek and other small drainages that are tributary to the Wisconsin River. Numerous small natural and man-made ponds, such as Morse Pond, and several small marshes are the only other surface water features of the area.

Marshes, low wet ground usually supporting wetland vegetation, presently cover only a small part of the area. The principal marshes occur in the deep buried bedrock valley area in the northern part (Figure 7) in association with the lacustrine deposits and in the flood plain of the Sugar River in the southwest. Dunns Marsh (Sec. 5, T.6N., R.9E.) and the several others in the area occur in small depressions. Comparison of U.S. Geological Survey topographic maps for 1904 and 1959 indicate very little reduction of marsh area by drainage. Some small reduction in marsh areas as well as flow of streams may have been produced in the area through the slight lowering of ground-water levels through municipal and industrial pumping in the adjacent Madison area. (McCleod, report in progress).

Surface water as a potential source of supply for irrigation, cooling, fish rearing, and other purposes is confined mainly to the Sugar River, Badger Mill Creek and Black Earth Creek. Only incomplete streamflow data is available as no gaging stations are located in the area. However, a U.S. Geological Survey low-flow gaging station is located on the Sugar River about 2 miles south of the project area (SE$\frac{1}{4}$, sec. 33, T.6N., R.8E.). Data from this gage indicate that the minimum 7 day flow of the river will on the average, drop to 12 cfs. (cubic feet per second) once in 2 years (Gebert, 1971). Thus, the sustained flow of the sugar in the project area should be reasonably high and usable as a source of water supply. A stream gage on Black Earth Creek several miles downstream from the project area also indicates a high base flow for that stream. This is to be expected because of the thick outwash deposits in that stream basin (Figure 7).

Flooding in the area is not a severe 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) are outlined in Figure 9. Most flooding will occur in the Sugar River valley, along Black Earth Creek, and along the Pheasant Branch Creek. The small depression wetlands and ponds are also subject to minor flooding. Because there has been little development in the flood-prone areas, the 100-year flood should cause little damage in the project area.

Streams and marshes in the project area are directly related to ground water 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.

Many small ponds occur in the area that differ both in origin and hydrology. Naturally occuring ponds in the lowlying areas and marsh areas, such as Dunns Marsh (Sec. 5, T.6N., R.9E.), are fed by ground water discharging from the shallow aquifer. Similarly, many undrained man-made ponds in the lowlying areas resulting mainly from the excavation of sand and gravel to some depth below the water table such as those near Verona (Sec.22, T.6N., R.8E.), discharge ground water by evaporation. A third pond category is the naturally occurring kettle hole ponds in and behind the terminal moraine in the uplands area, such as Morse Pond (Sec. 3, T.6N., R.8E.) and small ponds in the area immediately to the south (Secs. 9, 10, and 16. T.6N., R.8E.). These ponds are probably perched slightly above the water table and obtain most of their water from overland runoff or very shallow ground-water flow systems in the immediate pond area. Because they are above the water table, water will tend to move downward from the ponds to recharge the aquifer. However, this movement should be very slow and the ponds do not constitute a significant source of recharge to the aquifer.

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 and includes both consolidated and unconsolidated sedimentary rock formations. 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 800 to 1100 feet across the area. 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 area is from precipitation that falls on the land surface in the immediate vicinity. About 6 inches of the average 30 inches of precipitation that falls annually, 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 where the water table is at or above the land surface (Figure 11). The water percolates downward to the water table and then moves laterally under the influence of gravity to a discharge area where it again emerges at the surface to be evaporated or carried off as streamflow. Pumping of wells intercepts ground water on its path to discharge areas. In the sewered areas of Madison and Middleton this water is directed out of the township by the Metropolitan sewerage system and thus represents a loss to local streamflow. The Verona sewerage system and the county home sewerage system at Verona both discharge the water back to Badger Mill Creek with very little loss.

The approximate water table elevation in the area 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. The water table in the highlands is deeper, ranging up to 250 feet or more in areas of the highest land surface elevations (Figures 2 and 13).

Ground-water movement in the area is down the hydraulic gradient indicated by the water table map (Figure 10) and approximately perpendicular to the contour lines of the map. The ground-water divide between the Sugar River system and the Yahara River system transects the central part of the project area, bisecting the closed 975 foot contour in a northwesterly-southeasterly direction (Figure 10). Ground water to the south of the divide moves toward and discharges to the Sugar River and Badger Mill Creek. Ground water moves northward from the divide to the Pheasant Branch and Black Earth Creeks. Another north-south trending divide crosses the deep valley in the northern part of the area and separates drainage to the Pheasant Branch and Black Earth Creeks (Figure 10).

Adequate ground-water supplies for most uses are available in the area 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). Because most large wells in and around the project area are cased from the surface through the Tunnel City Formation and the upper bedrock units are slightly less permeable than the lower units, 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 wells in and around the project area. The shallow bedrock aquifer and the glacial aquifer have similar water levels and act as a single hydraulic unit. Both receive recharge from the surface and discharge to streams, marshes, and wells but the shallow bedrock, where it is overlain by the drift aquifer, receives recharge, and discharges water through the glacial drift.

Pumpage in the Madison area from the deep aquifer has lowered water levels in that aquifer in and for a considerable distance around Madison including the project area (McCleod, open-file report). McCleod has shown that water levels in the deep aquifer were lowered 20 or more feet in the central and eastern parts of the project area, by 1970. This water-level decline has in turn lowered water levels in the upper aquifer up to about 10 feet in the eastern part of the project area. The effect of these lowered water levels is to shift the ground-water divide southwestward and induce ground-water to move northeastward to the Madison area that normally would have discharged to the Sugar River. This trend will continue in the future as pumpage in the Madison area increases (McCleod, open-file report in progress). However, adequate water is and will continue to be available in the project area for most uses and with proper management of the aquifer in the Madison area there is little danger of depleting the supply.

In recognition of the need 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 and 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. Digital models were constructed for both the upper and lower bedrock aquifers. 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 for any location. The models will provide very valuable management tools to assure optimum development of the aquifers in the Madison area, including the project area. The model studies are summarized in three reports presently in progress. (Gonthier, report in progress; McCleod, open-file report and report in progress).

The deep aquifer in the project area will yield 1500 to 2000 gallons per minute (gpm) to properly constructed wells. Smaller wells in the upper aquifer will probably yield 10 to 20 gmp with little difficulty.

Unconsolidated deposits in the project area will yield moderate to large amounts of water to wells where they are thick, saturated, and sufficiently permeable. Unconsolidated deposits in the bedrock valley on the north and the Sugar River Valley on the south have the best potential for yielding reasonably large amounts of water, possibly up to 500 gpm. The best yields can be obtained from the unconsolidated deposits if layers of coarse sand and/or gravel can be located. Small yields for domestic purposes can probably be obtained in much of the two valley areas. Elsewhere in the project area, such as the uplands, the glacial deposits are thin, unsaturated, and/or consist of till deposits with low permeability and yield little water. There may be some possibility for obtaining domestic supply in the upland valley where saturated outwash deposits are present. The unconsolidated glacial aquifer is not extensively used in the area at present.

Present water use in the project area includes 7 municipal wells and an institutional well which in 1970 produced an average 4.59 million gallons per day from the deep bedrock aquifer (Gonthier, report in progress). Individual well pumpage is tabulated in Table 3 and well locations are shown in Figure 10. In addition to the high capacity wells, a large number of domestic and stock wells provide water mainly from the shallow bedrock aquifer.

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

Chemical analyses from Madison, Middleton, and Verona municipal wells, two private wells, a town of Fitchburg well and the County Hospital well which are located in the project area are shown in Table 4. The analyses are considered representative of ground water in the area for the upper and lower bedrock and glacial drift aquifers. The table shows the similarity of chemical quality of water in each of the aquifers. Successive analyses in each of several wells shows little change through time with pumping. All constituents are within recommended drinking water standards (U.S. Public Health Service, 1962) except iron and manganese which exceeds the recommended concentration of .3 milligrams per liter (Mg/l) and .05 Mg/l, respectively, in several of

Table 3. Principal Pumpage from the Bedrock Aquifer, 1970

WG&NHS Well Number	Owner and Well Description	Pumpage (1970) Million Gallons/day
30	Dane County Hospital	0.10
96	City of Madison, Well #10	0.72
111	City of Madison, Well #12	1.55
947	City of Madison, Well #16	1.49
56	City of Middleton, Well #2	0.11
119	City of Middleton, Well #3	0.35
82	Village of Verona, Well #1	0.04
316	Village of Verona, Well #2	0.18
	Total	4.59

the wells (Table 4). High iron and manganese concentrations occur in both the bedrock and glacial aquifers in and adjacent to the buried bedrock valley in the northern part of the project area, especially in the Middleton area. Although iron and manganese and hardness are troublesome constituents in ground water of the area, they can be relatively easily and cheaply treated for and they are not deleterious to human or animal health.

resentative Chemical Analyses of Ground Water

Date of ample	Iron & Manganese (Fe & Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrite (NO_2)	Nitrate (NO_3)	Dissolved Solids	Hardness as $CaCO_3$	pH
4/62	.05	70	35	---	---	354	42	4.0	.0	---	---	354	320	7.3
/19/66	.10	68	33	2.5	---	352	11	2.1	.1	---	1.6	314	308	7.5
/13/63	.14	67	34	---	---	356	55.0	1.0	---	---	1.6	---	306	7.5
/31/62	.13	62	35	---	---	359	55.0	.5	.0	---	1.0	302	298	7.3
/29/45	.00	63	38	---	---	351	4.5	7.0	.1	---	---	290	310	7.5
/19/66	.06	69	32	2.5	---	344	11	2.2	.1	---	2.1	314	306	7.5
/13/63	.04	66	34	---	---	339	10	3.0	---	---	2.2	---	304	7.4
/27/62	.08	66	30	---	---	346	---	---	---	---	---	---	298	7.4
/31/62	.08	63	35	---	---	349	12	1.5	.0	---	2.5	310	302	7.1
/29/45	.00	71	40	---	---	339	38	8.0	.1	---	---	340	340	7.4
/16/62	2.23	66	---	---	---	373	6.5	.0	---	---	.0	---	304	---
/13/62	2.40	---	---	---	---	388	---	---	---	---	.1	---	---	7.2
/31/62	2.04	64	34	---	---	373	2.0	.0	.2	---	.0	306	298	7.0
/28/60	.96	---	---	---	---	---	---	.0	---	---	---	---	311	---
7/19/66	.06	68	35	2.2	---	364	11	.3	.1	---	.4	292	298	7.6
9/ 7/66	.69	67	34	---	---	361	9.0	.0	---	---	.0	---	308	---
7/ 1/64	---	65	---	---	---	353	---	---	---	---	---	304	302	7.5
6/23/66	.28	71	34	1.9	---	354	77.0	.6	.1	---	.4	330	317	7.4
2/ 2/61	.25	60	30	---	---	351	77.5	.0	.2	---	.0	---	298	7.4
6/23/66	.06	61	33	1.9	---	327	6.0	.3	.4	---	.4	294	289	7.4
8/ 1/61	.06	60	32	2.2	1.0	335	10	1.0	---	---	.2	286	281	7.6
4/27/61	.06	59	34	---	---	325	.7	.0	.0	---	.2	282	272	7.4
4/20/60	2.10	---	---	---	---	366	36	2.0	.1	---	.5	---	330	7.9
4/ 9/58	.04	79	46	---	---	344	58	16	.1	---	---	424	368	7.6
4/10 58	.10	71	40	3.0	1.5	366	18	4.5	.1	---	---	348	328	7.6
6/20/66	.06	61	33	2.8	---	317	88.0	2.3	.2	---	15	336	291	7.5
12/29/44	.00	62	30	---	---	339	33.2	4.5	.1	---	---	288	305	7.3
1/ 1/35	.00	---	---	---	---	351	.0	5.0	---	---	7.0	293	318	---
2/17/67	.10	60	37	2.5	---	344	77.0	2.0	.2	---	7.5	308	302	7.4
10/12/65	.24	64	30	---	---	334	99.0	3.0	.1	---	15	298	284	7.3
4/ 1/59	.04	59	41	1.5	2.6	367	13.0	1.0	.1	---	---	354	310	7.5
8/04/66	.06	80	35	3.4	---	362	26	8.5	---	---	4.3	418	344	7.6

Table 4. Representative Chemical Analyses o

WG & NHS & USGS Well Number	Owner & [illegible] Designation	Aquifer	Date of Sample	Iron & Manganese (Fe & Mn)	Calcium (Ca)	Magnesium (Mg)	
6/8/14-30	Dane County Hospital	Lower Bedrock	6/04/62	.05	70	35	-
7/8/11-56	City of Middleton	Lower Bedrock	7/19/66	.10	68	33	2
			6/13/63	.14	67	34	-
			1/31/62	.13	62	35	-
			1/29/45	.00	63	38	-
7/08/11-119	City of Middleton	Lower Bedrock	7/19/66	.06	69	32	2
			6/13/63	.04	66	34	-
			2/27/62	.08	66	30	-
			1/31/62	.08	63	35	-
7/8/11-339	City of Middleton	Upper Bedrock	1/29/45	0.00	71	40	-
7/8/2-698	City of Middleton	Upper and Lower Bedrock	10/16/62	2.23	66	---	-
			2/13/62	2.40	---	---	-
			1/31/62	2.04	64	34	-
			11/28/60	.96	---	---	-
7/8/12-921	City of Middleton	Lower Bedrock	7/19/66	.06	68	35	2
			9/ 7/66	.69	67	34	-
			7/ 1/64	---	65	---	-
7/9/32-96	City of Madison	Upper and Lower Bedrock	6/23/66	.28	71	34	1
			2/ 2/61	.25	60	30	-
7/9/30-144	City of Madison	Lower Bedrock	6/23/66	.06	61	33	1
			8/ 1/61	.06	60	32	2
			4/27/61	.06	59	34	-
7/8/1-214	A.J. Meyer	Glacial Drift	4/20/60	2.10	---	---	-
7/8/7-272	Sunnyside Farm	Glacial Drift	4/ 9/58	.04	79	46	-
7/8/17-275	Raymond Kubista	Upper Bedrock	4/10 58	.10	71	40	[illegible]
6/8/15-82	Village of Verona	Lower Bedrock	6/20/66	.06	61	33	[illegible]
			12/29/44	.00	62	30	-
			1/ 1/35	.00	---	---	-
6/8/22-316	Village of Verona	Lower Bedrock	2/17/67	.10	60	37	[illegible]
			10/12/65	.24	64	30	-
			4/ 1/59	.04	59	41	1
6/9/5-882	Fitchburg Sanitary District #2	Lower Bedrock	8/04/66	.06	80	35	[illegible]

Source: Holt and Skinner, 1973

Ground-water is being discharged to the Sugar River and Badger Mill, Pheasant Branch, and Black Earth creeks to several wetlands associated with these streams and to several small depression wetlands such as Dunn's Marsh in the project area (Figure 11). Thus, the lowlying stream valleys and depressions, particularly in the buried bedrock valley areas, are ground-water discharge zones. All of the remaining area of the township can be considered a recharge area for ground-water (Figure 11).

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.

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 percent or more are present in the area but include only a small part (Figure 3) 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 project area.

The permeability of surficial materials is a primary consideration in ground water recharge as the water must move into and 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 low to moderate permeabilities of from .05 to 2.0 inches per hour underlie the loess in much of the recharge area (Figure 7). The sand and gravel of glacial outwash deposits 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 project area. However, considerable recharge also occurs through the materials of lower permeability.

Ground-water pollution potential is not presently an extensive problem in the project area because a large part of the area is covered by loess, glacial till, alluvium and lacustrine deposits which have only moderate permeabilities and because land development has been relatively small. 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 entering the ground-water reservoir. If pollutants, such as the highly mobil nitrates and chlorides, do reach the water table, they are greatly diluted by the ground-water. Discharge areas (Figure 11) are not a threat to ground-water purity because emerging ground-water prevents pollutants from entering the aquifer.

A number of relatively large areas which have the highest potential for ground-water pollution are outlined on the map, Figure 11. These are areas where fractured dolomite bedrock occurs at or near the land surface and where permeable sand and gravel deposits overlie dolomite bedrock. Because water moves through joints and fractures in dolomite with little filtration, any pollutant entering the dolomite can move rapidly over long distances with little attenuation.

Data is not available to adequately document the extent of existing pollutants in ground water in the project area. However, regional information (Cotter, et.al., 1969) and Hindall and Borman, in press) shows no extensive pollution of shallow aquifers. Water from several individual domestic wells in the area 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.

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 sewerage, water, and electrical lines; sanitary land fill sites; and to some extent locating septic tank sewerage systems. They also delineate potential mineral resources and source of water supply of the area as well as limitations 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 ground-water 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 12.

The 2nd Order maps point out engineering and/or economic limitations which may or may not preclude specific areas for a specific use. An engineering or management judgment 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 valley areas of the project area, especially in the Sugar and Badger Mill Creek valleys and the deep buried bedrock valley in the northern part, present the greatest limitations to development (Figure 12). These areas have a shallow water table, contain the flood-prone areas (Figure 9), as well as marshes with unstable peat and muck soils, each of which presents a limitation to development. In much of the lowlying areas and in 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 upland areas are generally confined to shallow bedrock and steep slopes. Slopes exceeding 12 percent, and in some cases 20 percent, occur in numerous parts of the area (Figure 3) and are generally associated with bedrock highs, bedrock controlled valley walls and the terminal moraine. Steep slopes are detrimental or costly to nearly any construction, landfill, septic sewerage system, road, or other development. Shallow bedrock occurring in the southwestern part of the area, along the deep valley in the north, and in scattered patches in the remainder of the area (Figure 12) inhibits excavation for foundations, trenching or setting poles for utility routing, and road construction and presents a pollution hazard to septic tanks and landfills.

The best areas for development are generally in the moderate to higher elevations of the township. Well-drained glacial till and outwash with moderate to high bearing capacities underlie these areas. Bedrock is deep enough to accommodate most excavations for road building, foundations, and utility lines. Adequate depth to water table and bedrock provides safe areas for septic tank sewerage systems 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 the project area mainly from the bedrock aquifer and in some areas from the unconsolidated glacial aquifer. Existing high capacity wells in the area tap the bedrock aquifer and in some cases fully penetrate to Precambrian crystalline rocks at a depth of up to 1150 feet. Yields of these wells are in excess of 1500 gallons per minute (gpm) both in areas of bedrock uplands and in the valleys areas. Because of the relative ease of obtaining high capacity wells in the area, suitability for this use has not been mapped. However, the bedrock geology map (Figure 4), thickness of unconsolidated materials map (Figure 6), and the piezometric map (Figure 10) 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 costs will be the least. Adequate ground water is available for domestic wells from the bedrock aquifer throughout the project area and is available from the unconsolidated glacial deposits in areas where they are thick, sufficiently permeable and saturated. Thus, the two maps (Figures 13 and 14) concerned with development of domestic and farm water supply are related to costs of well construction rather than availability of ground water.

The best water-yielding saturated units of the bedrock aquifer in the project area are the Wonewoc and Jordan Sandstones (Table 1 and Figure 4). The St.Peter Sandstone would also produce high yields but in most of the area this unit occurs above the water table and is not saturated. Because the Jordan is missing or not saturated in parts of the area and the Wonewoc lies at excessive depths or is missing in some areas, the Prairie du Chien Group dolomite and the Tunnel City Sandstone (Table 1 and Figure 4) 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 and stock use can probably be obtained from properly constructed wells.

Construction of bedrock wells requires casing from the land surface to, or a short distance into bedrock. Since casing is an expensive item in well construction, well costs will be least in areas with thin unconcolidated deposits because casing length can be kept to a minimu.[1] The map in Figure 13 outlines areas where unconsolidated materials are from 0 to 50, 50 to 100, and over 100 feet in thickness. The highlands throughout the project area have the thinnest unconsolidated materials of less than 50 feet. The thickest unconsolidated deposits, over 100 feet, occur in the buried bedrock valleys with a maximum of 350 feet in the northeast corner of the area (Figure 6). The intermediate 50 to 100 feet thickness of unconsolidated material occurs on the border and tributary areas of the deep valleys.

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 the 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 approximate depth to water table from the land surface in the project area is shown in Figure 13. Maximum depths of 200 to 250 feet occur in the highlands in the northwestern quarter of the area. The water level is very shallow in the buried bedrock valley areas and intermediate depth between there extremes occur in the remainder of the area.

A suitable domestic or farm water supply can be obtained from unconsolidated deposits in the areas where they are saturated, reasonably thick, and sufficiently permeable (Figure 14). Such wells are also less expensive to construct than bedrock wells in such areas. The permeable deposits are sand and sand and gravel which are generally associated with glacial outwash. Thick, saturated outwash deposits occur in the buried valley in the northern part of the area, along

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

Badger Mill Creek valley and the southern part of the Sugar River valley (Figure 14) which are probably suitable for well development in many places. Other outwash deposits (Figure 14) will probably also yield water to wells, however, these deposits at higher elevations in the central part of the project area may not be saturated. Thin till deposits (Figure 14) of low permeability in the highlands generally are not suitable for use as a source of water.

Mineral Resources

Mineral resources of the project area 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 can be obtained from unconsolidated glacial deposits. There may be some possibility of a commercial peat deposit in wetland areas but because of the small areas of wetland and the low demand for the product peat has not been considered in this analysis. The aggregate and building stone quarried in the project area are of vital importance to the growing Madison Metropolitan area for construction of roads and housing; industrial, commercial, and municipal buildings; and many other uses. The value of sand and gravel and stone produced in Dane County, including the project area, 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. The project area 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

The best sand and gravel deposits, in general, occur in the lowlying parts of the area in the buried bedrock valleys. These valleys were channelways for meltwaters that carried sand and gravel washed out of glaciers. These outwash deposits, shown in Figure 15, are located in the Badger Mill Creek Valley, the deep valley on the north, in the lower Sugar River valley, south and west of the terminal moraine of the glacier and in several other areas in both the drift covered and driftless areas. The outwash deposits have the highest potential for well sorted, clean gravel and are the areas most likely to contain gravel suitable for coarse aggregate (Mickelson, report in progress).

Ice-contact stratified drift deposits are also shown on the map (Figure 15). These are water-laid stratified materials deposited adjacent to glacial ice margins. The ice-contact deposits exhibit abrupt changes in grain size and are not as consistent or uniform as the outwash deposits. They may, however, contain both sand and well sorted gravel and are a potential source of sand and gravel (Mickelson, report in progress).

Sand and gravel has been extensively mined in the project area mainly in the outwash deposits but also in the ice-contact deposits (Figure 15). Existing pits are shown on the map. It is beyond the scope of this project to provide a detailed analysis of each of the sand and gravel deposits. Thus, the areas shown should be considered as having above average potential to contain commercial deposits of sand and gravel and are 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 15). It is generally confined to existing pits. Considerable additional work is needed to define the usable sand and gravel resources of the area.

Dolomite

Dolomite resources of the project area are present in 3 different units: the Sinnipee Group, the Prairie du Chien Group, and the St. Lawrence Formation. The approximate maximum thickness, rock type, and potential uses are tabulated by formation in Table 5. The areal distribution of the 3 formations where they have less than 10 feet of unconsolidated overburden and from 10 to 50 feet of unconsolidated overburden are shown on Figure 16. Dolomite reserves are located in the highland and bedrock valley walls of the area.

Table 5. Characteristics and Present or Potential Uses of Dolomite

Formation	Approximate Maximum Thickness (feet)	Rock Type	Potential Economic Use
Sinnipee Group	100	Dolomite, medium to thin bedded, fossiliferous, thin clay partings in some horizons, some chert.	Good to poor grade aggregate and building stone; agricultural lime.
Prairie du Chien Group	170	Dolomite, algal, medium to thin bedded cherty, minor clay layers.	Excellent aggregate and building stone; agricultural lime; rip-rap.
St. Lawrence Formation	40	Dolomite, medium to thin bedded, silty, glauconitic.	Attractive moderately good building stone, best for interior use.

There are presently 8 dolomite quarries in the project area, 2 in the Prairie du Chien and 6 in the Sinnipee. The St. Lawrence Formation is not mined in the area. It is not as accessable 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 the 8 quarry sites and their immediate area (Figure 16).

Sandstone

Sandstone resources of the area occur in 2 formations, the St. Peter Formation and the Jordan Formation (Figure 17). The approximate maximum thickness, lithology, and potential economic uses of the sandstone formations 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 (Figure 17).

The St. Peter Sandstone is presently mined from 3 quarries in the eastern part of the area where the Sinnipee Group is also mined for dolomite. The Jordan Formation is not mined in the area. Zoning for mineral extraction largely includes the areas presently being used for sandstone extraction.

Table 6. Characteristics and Potential Uses of Sandstone

Formation	Approximate Maximum Thickness (feet)	Lithology	Potential Economic Uses
St. Peter Sandstone	225	Sandstone, quartz, medium to fine-grained dolomite cement, friable.	Molding sand, filter sand, mortar, plaster and cement sand, fill, abrasives.
Jordan Sandstone	35	Sandstone, quartz medium- to fine-grained in lower part, coarse- to fine-grained in upper part, dolomite cement, friable.	Molding sand, filter sand, mortar, plaster and cement sand, fill, abrasives.

The St. Peter Sandstone, which generally occurs in the uplands and valley sides, is the most readily available and extensive sandstone formation. It occurs above the water table in most of its area. An extensive area having less than 10 feet of overburden occurs in the southwestern part and several small areas occur in the southeastern part of the project area (Figure 17). A considerable part of the St. Peter Sandstone, especially in the central part of the area (Figure 17 and 4), is covered by the Sinnipee Group dolomite. Mining of the

St. Peter Sandstone in quarries where the dolomite is removed has extended the value and usefulness of the quarry site in several operations, as mentioned. This practice should be considered in existing and new quarries where geologic and market conditions are favorable.

The Jordan Formation, for the most part, crops out along the deep valley walls. Although the formation is not saturated at the outcrop and areas with little unconsolidated overburden occur in the project area, the overlying Prairie du Chien dolomite limits access to very small areas. The Jordan Sandstone also could be mined in quarries where the Prairie du Chien dolomite is removed.

Grain size, sorting, and chemical analyses are not available for the sandstone units. Consequently, the mapped units should be considered as target areas in exploration for commercial sandstone deposits.

Peat

Peat, useful as a mulch and soil conditioner, is present in only small wetlands of the project area (Figure 7). Although, its extent, extractability and quality have not been assessed, peat resources appear to be extremely limited in the area.

Agriculture

An estimated 80% of the project area has only moderate to slight limitations to growing crops as shown in Figure 18. Silty and sandy loam soils developed on loess and glacial tills, lacustrine deposits, outwash and bedrock cover most of the map area. The soils range from nearly flat to moderately sloping and poorly drained to well drained. Slope and wet soils impose moderate limitations to crops in about 45 percent of the area while an estimated 35% has only slight limitations to growing crops.

Slopes range from nearly level to over 20 percent in the project area. Because slope has an influence on productivity of soils, 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 with severe limitations. The steepest slopes of over 12 percent occur mainly in the highlands of the project area and are often underlain by shallow bedrock. Slopes over 20 percent occur mainly on the terminal moraine in the southwestern part and on the valley walls of the deep valley in the northern part of the area (Figure 18). Nearly level soils occur mainly in the broad low land areas underlain by the buried bedrock valleys.

The nearly level lowland soils in the buried valley areas and in valley bottoms, drainageways, wetland margins, and small depressions in the remainder of the area, tend to be poorly drained because of high water table (Figure 18 and 10). These soils are suitable for growing crops except during wet periods when the water table may rise near to or above the ground surface. Some of this area is also subject to flooding (Figure 9). Thus, the wet soils areas have at least moderate limitations to growing crops.

Approximately 20 percent of the project area is unsuitable for cropland. This includes the small areas of wetland and lakes, lowland drainageways, and small depressions with muck and peat soils; the numerous pits, quarries, and landfills or dumps; and areas where land slope exceeds 12 percent.

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, analogous to a traffic signal, show areas with severe limitations, areas with moderate limitations, and areas with few limitations to the specified use. The maps are intended for land use planning purposes as a summary of geologic, hydrologic, soils, and topographic considerations in land use which, when combined with social, cultural, esthetic, and other considerations, will lead to a comprehensive land use plan for the area.

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 than 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 (Table 2). 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) can be used for either consideration. Excavation difficulty, especially near shallow 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 geologicacriteria 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, 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 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 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 the project area presently mined or with a potential for future mining include sand and gravel, dolomite, and sandstone, Areas suitable for extraction of minerals are shown in Figure 21. Areas of highest potential for mineral extraction are the surficial glacial outwash and ice-contact 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 area mineral extraction is unlikely because of the lack of any sizeable sand and gravel deposits, thick unconsolidated deposits over bedrock, and/or 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 project area (Figure 22). In the highlands, depths to water table are excessive, wells must be drilled to relatively great depths, pumping costs are high, and excessive piping in the well increases cost of construction. However, drift thickness is least in the highland areas and well casing costs are consequently lower. In the lowlands, the thickness of unconsolidated glacial material is great, up to 300 feet in the deep buried bedrock valleys. Thus, well depths and casing length for bedrock wells are large although the depths to water are small and therefore pumping costs and equipment required is less than in the highlands. The best areas for bedrock wells, 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 project area except in the buried bedrock valley areas (Figure 23). In the deep buried valley on the North and in the Sugar River and Badger Mill Creek valleys 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 some of the valley areas are filled with clayey and silty materials of low low permeability that will yield only small amounts of water. If the buried sand and gravel layers can be tapped, an adequate domestic supply can be developed.

Ground water in the area is of the calcium magnesium bicarbonate type. It is hard and iron may be a problem in some places but generally it is of excellent quality. Chemical analyses from public and private wells, located in the project area, are tabulated in Table 4 and are representative of ground water in the township.

Suitability for Cropland

An estimated 80 percent of the land of the project area is suitable for growing crops with only slight to moderate limitations (Figure 24). 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 areas of very steep slopes in the uplands and valley sides. Manmade limitations include the mined areas and dump or land fill sites. Urbanized areas and roadways are also manmade limitations but they have not been considered on the map.

The areas best suited to cropland are predominantly on the St. Charles, McHenry, Lapeer, and Plano, Ringwood, Griswold, soils that include well-drained soils in silt and sandy loam till on less than 6 percent slope. Well to poorly drained soils in silt and sand and gravel of Batavia, Dresden, Virgil and Plano Elburn soils where slopes are less than 6 percent are included in this category.

Areas with moderate limitations to the growing of crops include soils on slopes of from 6 to 12 percent and the Waucosta and Marshan poorly drained soild 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.

Suitability for Recreational Development

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

SUMMARY AND CONCLUSIONS

Optimum land management, in both the public and private sector, is logivally based on a thorough knowledge of the physical characteristics of the land resource. The physical characteristics of the project area 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, sociologic, economic, and other data by the planner to arrive at a final comprehensive land use plan.

The bedrock topography of the project area is the predominant influence on the physical character of the area. The bedrock topography, which is the result of deep erosion of flat-lying interlayered dolomite and sandstone bedrock, is prominantly reflected in the land surface topography through a veneer of unconsolidated glacial deposits. The dominant features on the bedrock surface, buried bedrock valleys in the northern part and underlying Badger Mill Creek in the southeastern part of the area, the deeply entrenched, unglaciated valley of the Sugar River, and the highlands in the central and northern part of the area control the topography of the land surface. The lowlying areas, overlying the bedrock valleys, contain the present drainage, shallow depths to water, flood-prone areas, wet soils and wetlands. Slopes are generally less than 6% and glacial materials are thick and tend to be waterlaid deposits such as outwash and lacustrine deposits. The highlands of the area have slopes ranging from 6 to over 20%, thin glacial deposits mainly of till, shallow depth to bedrock, and contain the dolomite and sandstone reserves of the area. The water table is deep in the highlands and soils are generally well-drained and are developed in loessial silt over sandy loam till.

Ground-water supply is available throughout the project area 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 areas. 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 area. Extensive mining of sand and gravel and dolomite is in progress. The area 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 areas of intermediate elevations. The best areas for agriculture also occur in this 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. Small marsh areas may be suitable for hunting and esthetic pursuits and much of the upland area provides opportunities for hiking, snowmobiling, and cross-country skiing.

REFERENCES CITED

Broderick, G.N., 1974. The Mineral Industry of Wisconsin: in=U.S. Bureau of Mines, Minerals Yearbook, 1972.

Cline, D.R., 1965. Geology and Ground-Water Reserve of Dane County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1779-U.

Cotter, R.D., Hutchinson, R.D., Skinner, E.L., and Wentz, D.A., 1969. Water Resources of Wisconsin - Rock-Fox River Basin: U.S. Geological Survey Hydrologic Investigations Atlas HA-360.

Font, R.G., The Earth, Engineering for its use and non-use: Department of Geology Texas A & M University.

Gebert, W.A., 1971. Low-Flow Frequency of Wisconsin Streams: U.S. Geological Survey Hydrologic Investigations Atlas, HA-390.

Gonthier, J.B., Electric-Analog model of the Sandstone aquifer in the Madison area, Wisconsin: U.S. Geological Survey, report in progress.

Hindall, S.M., and Borman, R.G., Water Resources of Wisconsin - Lower Wisconsin River Basin: U.S. Geological Survey, Open-file report.

Holt, C.L.R., Jr., and SKinner, E.L., 1973. Ground-Water Quality in Wisconsin through 1972: Wis. Geological and Natural History Survey, Information Circular No. 22.

McCleod, R.S., A digital computer model for estimating drawdawns in the Sandstone aquifer in Dane County, Wisconsin: U.S. Geological Survey, Open-file report.

____________, A digital computer model for estimating hydrologic changes in the upper aquifer in Dane County, Wisconsin: U.S. Geological Survey, report in progress.

Mickelson, D.M., 1973. Progress report, Glacial Geology of the Madison Metropolitan Area: Unpublished report in the files of the Wis. Geol. and Natural History Survey.

U.S. Dept. of Agriculture, Soil Conservation Service, 1969. Wisconsin Soils, their properties and uses: U.S. Soil Conservation Service Report.

U.S. Public Health Service, 1962. Drinking Water Standards: U.S. Dept. of Health, Education, and Welfare, Public Health Service, Pub. No. 956.

UWEX UNIVERSITY OF WISCONSIN–EXTENSION

1815 UNIVERSITY AVENUE MADISON, WISCONSIN 53706 608-262-1705

GEOLOGICAL AND NATURAL HISTORY SURVEY
M. E. Ostrom
Director & State Geologist

January 30, 1974

Mr. Robert B. Rennebohm
Executive Director
Univ. of Wisconsin Foundation
337 Wisconsin Center

Dear Mr. Rennebohm:

Enclosed is a copy of the detailed proposal prepared by Mr. P.G. Olcott, staff geologist, describing work to be done by the Geological & Natural History Survey as a cooperator in the Madison/Verona/Cross Plains land use demonstration project. The proposal includes a detailed budget accounting for a total of $15,000.00.

If this proposal and budget meets with your approval please make the funds payable to UW-Extension and route them through Mr. Paul Tierney, Extension Administrative Services, 815 Extension Building. Also, please indicate that the funds are to be applied to the Madison/Verona/Cross Plains Land Use Planning Demonstration Project of the Geological & Natural History Survey.

If you have any questions please call.

Very truly yours,

WISCONSIN GEOLOGICAL SURVEY

M. E. Ostrom

Dr. M.E. Ostrom
State Geologist & Director

MEO:kz

Enc.

cc: M.T. Beatty
C. Baer
P. Tierney

A Proposal To Study The Geologic, Hydrologic, and Soils Factors Critical To Intelligent Land Use and Environmental Planning For An Area At The West Edge Of The Madison Metropolitan District, Dane County, Wisconsin.

by

Perry G. Olcott
Wisconsin Geological & Natural History Survey

Introduction

Geologic, hydrologic, and soil factors are critical to intelligent land use and environmental planning. The purpose of the proposed project is to provide a comprehensive assessment of land use suitability based on these factors in support of a project proposal developed by Professor Phil Lewis, Department of Landscape Architecture and Environmental Awareness Center, UW-Madison.

The project area (Figure 1) is located west of the City of Middleton and is bordered on the north by U.S. Highway 14 and the Chicago, Milwaukee, St. Paul & Pacific Railroad right-of-way, on the south by U.S. Highway 151 and the Chicago and Northwestern Railroad right-of-way, and on the west by the west border of Middleton Township. The area lies adjacent to rapidly expanding Metropolitan Madison and can be expected to experience pressures related to the growth and expansion of residential and commercial developments in the near future. Orderly growth and expansion can be best achieved through comprehensive land use planning which is dependent on a thorough knowledge of the physical setting.

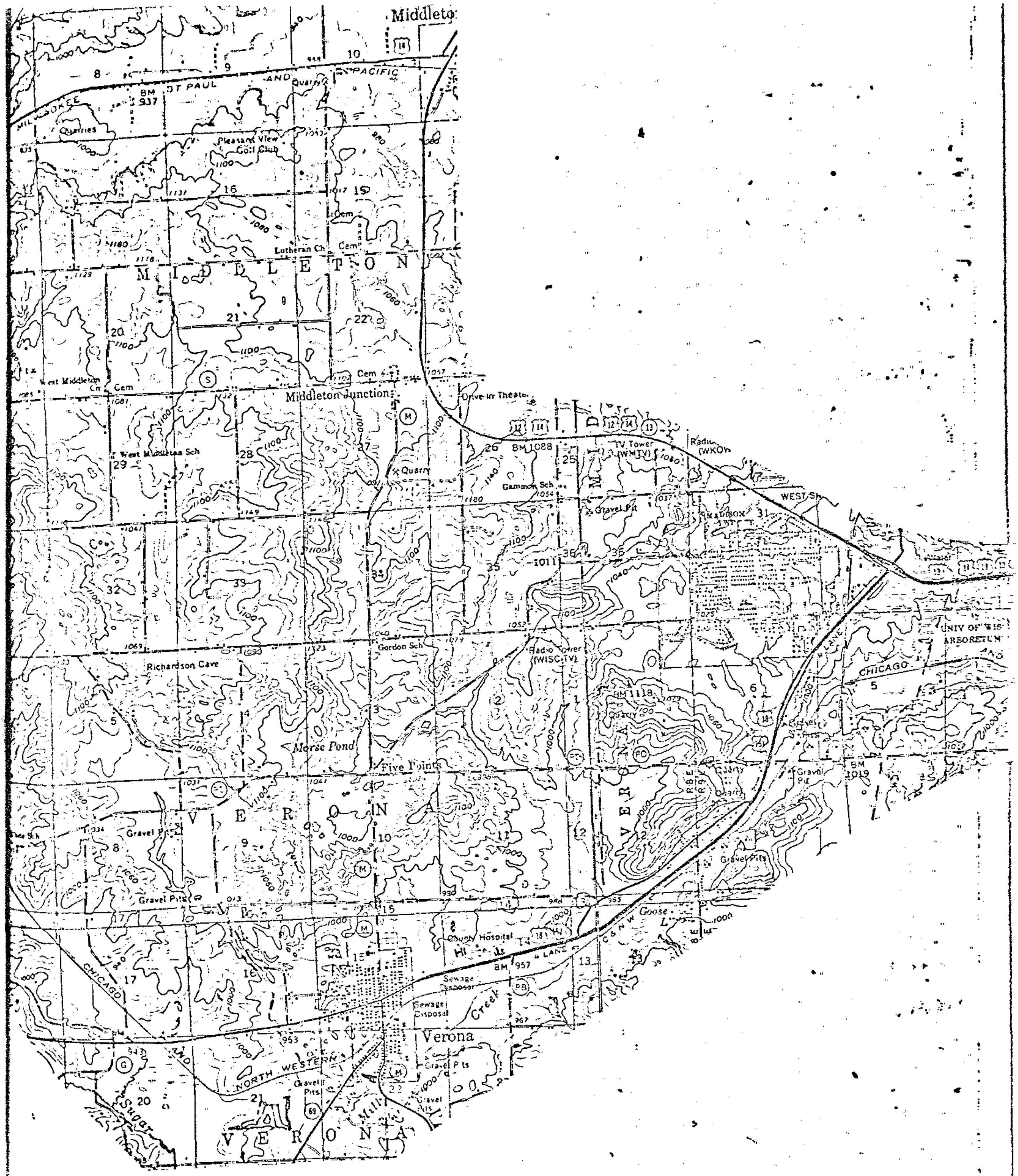
Method of Approach

Recommended land use information for the area will be developed through a technique employed by environmental geologists throughout the country and one being used by the Wisconsin Geological & Natural History Survey in its environmental studies of Dane and Waukesha Counties. The method requires three successive levels of mapping from first order basic information maps through second order interpretive resources and engineering properties maps to third order use suitability maps. Third order maps use 3 colors, namely red, yellow, and green which are analogous to the stop, caution, and go of traffic signals, to indicate land use limitations.

The following proposed outline for a final report to summarize the project is presented below. The outline shows in detail the 3 order map format as well as the mapped information to be prepared during the project. All maps referred to will have a scale of 1:62,500 or approximately 1 inch = 1 mile.

I. INTRODUCTION

- A. Purpose and scope
- B. Location and geography of area
- C. Acknowledgements


Middleto
ST PAUL
AND
PACIFIC
Quarries
Pleasant View Golf Club
Lutheran Ch
Cem
M I D D L E T O N
West Middleton
Middleton Junction
Drive-in Theater
West Middleton Sch
Quarry
Gammon Sch
TV Tower (WMTV)
Gravel Pit
WEST SH
Richardson Cave
Gordon Sch
Radio Tower (WISC-TV)
UNIV OF WIS ARBORETUM
CHICAGO
Morse Pond
Five Points
V E R O N A
Gravel Pits
County Hospital
4 LANE
Sewage Disposal
Creek
Goose
Verona
NORTH WESTERN
Sugar

II. 1ST ORDER BASIC INFORMATION MAPS

A. Topography

1. Map of land surface topography, 40 feet contour interval
2. Map showing land slope, 0-6; 6-12; 12-20; and over 20 percent slope.
3. Discussion of geomorphology, range of relief, highest and lowest areas, and areas of excessive slope.

B. Bedrock

1. Geologic map
   a. With geologic column explaining character and economic uses for each unit
   b. Geologic cross section
   c. Brief discussion

2. Bedrock topography map, 50 feet contour interval
   a. Overprint, 100 feet contours on basement rocks
   b. Brief discussion on geomorphology of bedrock surface

C. Glacial deposits

1. Map of glacial deposits (drawn from soils parent materials)
2. Map of thickness of unconsolidated materials and near surface bedrock, 50 feet contour interval.
3. Brief discussion on character and origin of drift units.

D. Soils association map (from USDA Soil Cons. Service)

1. Brief discussion of units.
2. Selected engineering characteristics of soils, table form.

E. Hydrology

1. Map of piezometric surface (25 feet, contour interval) also show-ing areas where water table is less than 10 feet from land surface.
   a. Location of high capacity wells.
2. Map of drainage, surface water and wetlands.
3. Map of flood inundation areas if available.
4. Discussion of ground-water movement and general hydrologic system.
5. Brief discussion on ground-water availability for water supply (show on maps if practical).
6. Water quality information in table form with brief discussion.

III. 2ND ORDER ENGINEERING PROPERTIES AND RESOURCE POTENTIAL MAPS

A. Map showing construction, sanitary land fill, and septic tank suitability with selected soils engineering properties and discussion.

B. Chart indicating lithologic characteristics of geologic formations and maps to indicate location of existing pits and quarries and areas zoned for mineral extraction. Discussion.

C. Ground-water recharge and discharge areas.

D. Ground-water pollution potential.

E. Discussion and map, if pertinent, on geologic hazards.

IV. 3RD ORDER SUITABILITY FOR USE MAPS

A. Mineral resource potential map

B. Construction siting map

C. Utility routing map

D. Waste disposal map

E. Water supply maps

F. Recreational development map (and/or discussion)

G. Agriculture

V. CONCLUSIONS

VI. SELECTED REFERENCES AND BIBLIOGRAPHY

Information Available

Considerable information on the geology, soils and hydrology of the proposed project area is available in the files of the Wisconsin Geological & Natural History Survey and U.S. Geological Surveys. Most of the 1st Order maps for the entire county are presently being prepared by the State Survey. The hydrology of the county was summarized by Cline in U.S.G.S. Water Supply Paper 1779-U. Reports are in preparation on an analog model and a digital computer model of the sandstone aquifer in the Madison area. These hydrologic studies were carried out under the Wisconsin and U.S. Geological Survey's cooperative water resources program. The Soils of the county have been recently mapped by the U.S.D.A. Soil Conservation Service in cooperation with Dane County. Well log information is available in the files of the State Survey and the Dept. of Natural Resources. Water quality data also is available in the Survey files. The proposed project area is covered by U.S. Geological Survey topographic maps at both 1:62,500 and 1:24,000 scales and a base map, scale 1:62,500 is in preparation by the Wisconsin Geological & Natural History Survey through the UW-Madison Cartographic Laboratory.

Length of Project and Costs

It is anticipated that the project will take 6 months using one full-time professional geologist and part-time student help (one man at 1/3 to ½ time). The final report, following the approximate outline shown above, will be typed with illustrations ready for final drafting. Method of final publication is not determined but could be through the State Survey provided there are sufficient funds for final drafting of illustrations and to offset costs of printing.

The costs of the project, exclusive of publication, are estimated to be $15,000.

BUDGET

SALARIES

Academic

Geologist: Perry G. Olcott, 1/3 time for 6 mo. at $455.55/mo.	$2,733.00	
Fringe Benefits (at 15.21%).	415.00	
	$3,148.00	$3,148.00
Specialist/Geology: Unassigned, full-time for 6 mo. at $800/mo.	$4,800.00	
Fringe Benefits (at 15.21%).	730.00	
	$5,530.00	$5,530.00
Soil Scientist/Soils: Francis D. Hole, 3 weeks at $425.00/week	$1,275.00	
Fringe Benefits (at 15.21%).	194.00	
	$1,469.00	$1,469.00
Specialist/Cartographer: Robert Olmstead 1/8 time for 6 mo. at $136.11/mo.	$ 817.00	
Fringe Benefits	124.00	
	$ 941.00	$ 941.00
Total Academic Salaries		$11,088.00
Student Help		
Cartography, data transfer, and plotting (800 hours at $2.50/hr).	$2,000.00	$2,000.00
Total Student Help Salaries		$2,000.00
Classified		
Secretarial		500.00
Total Classified		$ 500.00
TOTAL SALARIES		$13,588.00
Supplies & Expenses		
Drafting Supplies and field expenses	$1,412.00	$1,412.00
TOTAL BUDGET		$15,000.00