

PHYSICAL COMPONENTS OF THE
ENVIRONMENT AT THE MUIRFIELD
SITE, OHIO

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Prepared for

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INTRODUCTION

Muirfield Ltd. intends to build a planned residential community northwest of Columbus, in Dublin, Ohio on a 1,360-acre tract of land. The tract is situated on the Delaware-Franklin County line east of the Scioto River in the valley of Deer Run (Figure 1). The purpose of this report is to present information related to the topography, geology, soils, climate and water quality of the Muirfield Site in such a way that it will be useful to planners and developers.

The site has considerable natural beauty and it is important that many factors be considered before construction begins. The soils which have formed from various geologic materials and the plant life which it supports are of primary importance. A balance between the scenic splendor and homesite development is essential to the success of this venture. This balance will become easier to achieve as we become more aware of the interrelationship of the components of the environment. This report is submitted as an attempt to further this awareness.

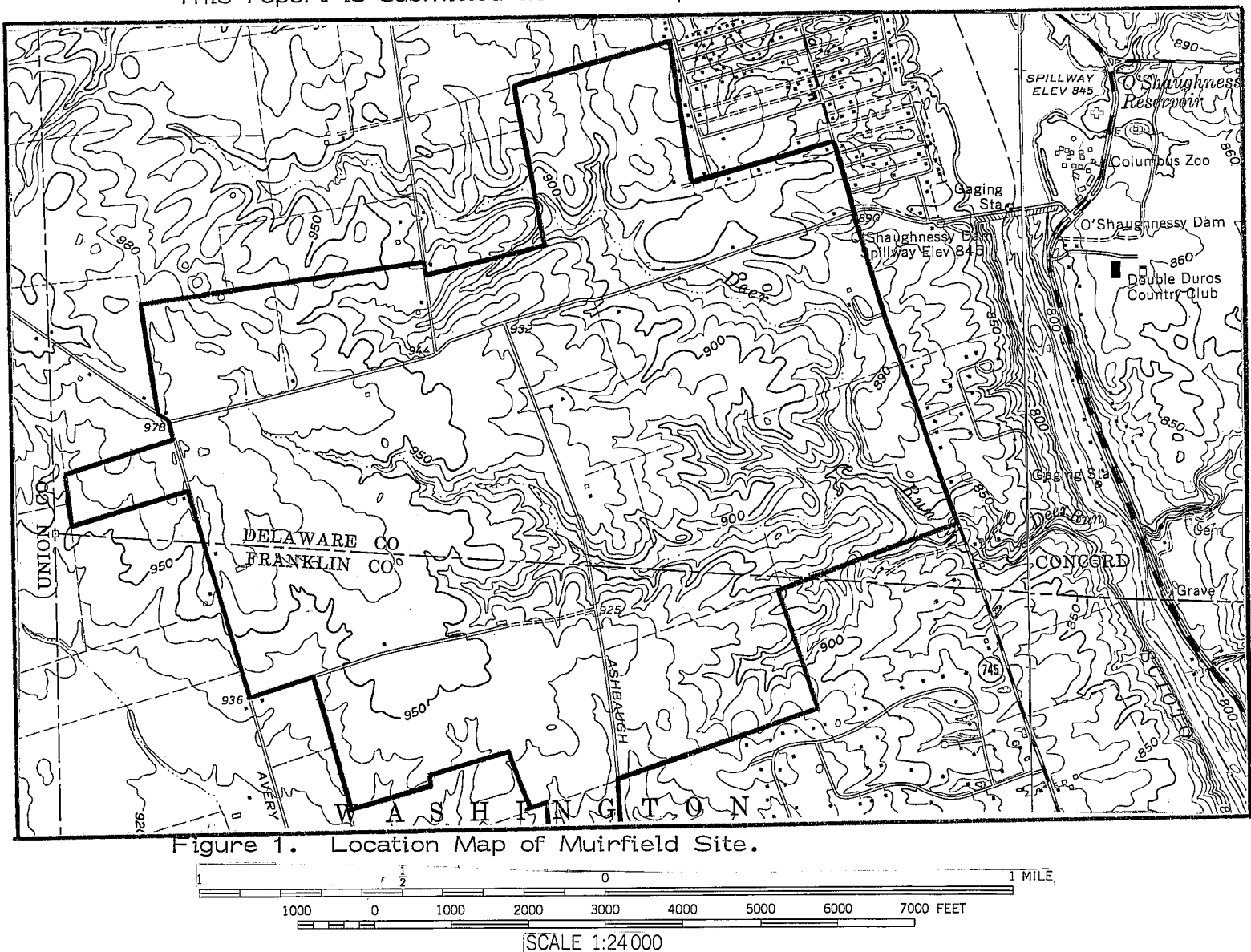


Figure 1. Location Map of Muirfield Site.

TOPOGRAPHY

The Muirfield Site is situated in central Ohio and embraces parts of southwestern Delaware and northwestern Franklin Counties. The site is in the Central Lowlands physiography province and lies entirely within the Till Plains. The plain derives its name from the fairly thick glacial deposits (till) which covers the bedrock in this part of the State.

The Muirfield Site occupies a gently rolling portion of this plain which has been moderately dissected by Deer Run, a tributary to the Scioto River. Nowhere on the site has this stream cut deeply enough into the till to expose the underlying limestone bedrock. Several hundred feet east of the boundary where Deer Run plunges into the Scioto River gorge, the bed of the stream is in rock.

The total relief of the site is approximately 152 feet. The lowest elevation is 830 feet above sea level in the bed of Deer Run at the Ohio Route 745 highway bridge. The highest point of ground is 982 feet located in the northwest corner of the property. Deer Run possesses a fairly steep-sided, wooded valley over most of its course within the site.

On the surface geology map (Figure 1) one of the most striking features is north-south alinement of the major river valleys of the area. These major water courses are for the most part consequent streams on the till plain, and they date from the last retreat of the glacier from the region. Many lateral minor valleys, such as that of Deer Run, which flows west to east through the Muirfield Site, developed by subsequent streams, join the major valleys, descending as rock gorges. In many of the tributaries of the Scioto River, particularly on the western side, there are waterfalls over ledges of thick-bedded limestone. Hayden Run south of Dublin is a particularly good example of this feature.

Crossing this conspicuous north-south parallelism of major streams in central Ohio is a weaker but equally significant concentric pattern consisting of glacial deposition features. These are a series of recessional or terminal moraines, convex toward the south. One of the largest of these is the Powell Moraine which occupies a position near the border of Delaware and Franklin Counties (Figure 1). This moraine has a rather bold south-facing front and rises 30 to 40 feet above the surrounding till plain. This moraine is strongly developed both east and west of Muirfield but its presence on the site is not dramatic except for its dissection by Deer Run has formed several deep and rather steep ravines. Surrounding the Powell Moraine is a fairly flat to gently rolling plain composed of Wisconsin ground moraine.

GEOLOGY

The geological features of the Muirfield Site are relatively simple with the entire area being covered with a thick mantle of compact, yellow-brown boulder clay or till which is the direct deposit of the ice of a continental glacier. As interpreted from water well and test boring data, the minimum depth to the limestone bedrock in the vicinity of the site is 32 feet at a location 3500 feet south of the intersection of Avery and Brand Roads near the south boundary. The maximum known depth is 165 feet at a point 1500 feet east of Ashbaugh Road in the River Forest development. This great thickness appears to be the result of glacial deposits which have filled a pre-glacial valley. This buried valley may extend to the north northwest where the next deepest rock was found 2000 feet away near the old cemetery on Ashbaugh Road.

The character of the deposits left by the glacier can be seen in the banks of many streams in the area. The till or boulder-clay as the second term indicates, consists of two parts, a clay base or matrix, which makes up to 95% of the whole deposit, and the embedded gravel, pebbles and boulders. The clay is compact, fine-grained, yellowish-brown in color, and on drying breaks into small angular pieces. Where it is unusually thick, particularly if very compact and nearly impermeable to water, the color of the lower part may be blue or gray. This is probably the original color; the yellow color nearer the surface is due to the oxidation of the ferrous compounds of the clay to limonite ($2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$) by downward percolating waters. The layer fragments in the till vary from silt and sand grains to gravel and large blocks several feet in diameter. The boulders often show typical features of ice-worn blocks; they are sub-angular with only the corners and edges rounded off, their sides planed, smoothed, and scratched.

The glacial till deposits of the area are of two types: ground moraine and terminal moraine (Figure 2). The ground moraine was deposited beneath the glacier as it passed over the area. It forms the relatively flat surface north and south of the Muirfield Site and is devoid of transverse linear elements which distinguishes it from a terminal moraine. The ground moraine has an undulating surface marked by gentle sloping swells, sags and basins. There is one terminal moraine in the area, the Powell Moraine (Figure 2). It is a ridgelike accumulation of drift that was built along the front of the glacier. Its topography is primarily constructed in a linear fashion with a higher elevation and is more rugged than the surrounding ground moraine. Most of the Muirfield Site is covered by the Powell Moraine (Stauffer et al, 1911).

The Bedrock underlying the glacial deposits is limestone which was deposited in a Middle Devonian sea approximately 350 million years ago. The Muirfield Site lies near the contact of two limestone formations. East of the site the bedrock is known as the Delaware Limestone and to the west as the Columbus Limestone. These formations are very similar but they do have noticeable differences.

The Columbus strata are massive in bedding, somewhat earthy in appearance, and light gray to light brown in color. Locally chert is present either in definite layers or as scattered nodules. The thickness of this formation is slightly over 100 feet near the site. The limestone beds are very fossiliferous and contain excellent specimens of corals, crinoids, bryozoa, brachiopods, pelecypods, gastropods, cephalopods, trilobites and fish.

One of the best outcrops of the Columbus Limestone in central Ohio is in the deep gorge cut by Deer Run where it enters the Scioto River valley. The cliffs are vertical walls of limestone at places nearly 40 feet in height. Stauffer (1909) reported finding 61 fossil species at this location. At Eversole Run gorge, two miles north of the Delaware County southern line, Stauffer found 145 fossil species in the Columbus Limestone.

The Delaware Limestone varies from thin-bedded to massive. The color ranges from light to very dark bluish-gray. The composition is that of an impure limestone. It has an average thickness of 45 feet (Stout, et al, 1943). The best exposures near Muirfield are in Indian Run and Hayden Run gorges at the Scioto River valley. Here the Delaware Limestone forms the upper 10 to 20 feet of the cliff underlain by the Columbus Limestone. The Delaware is also fossiliferous but not as prolific as the Columbus. Both of these formations have been quarried commercially in Franklin and Delaware Counties and their chemical properties are described in detail by Stout (1941).

LEGEND

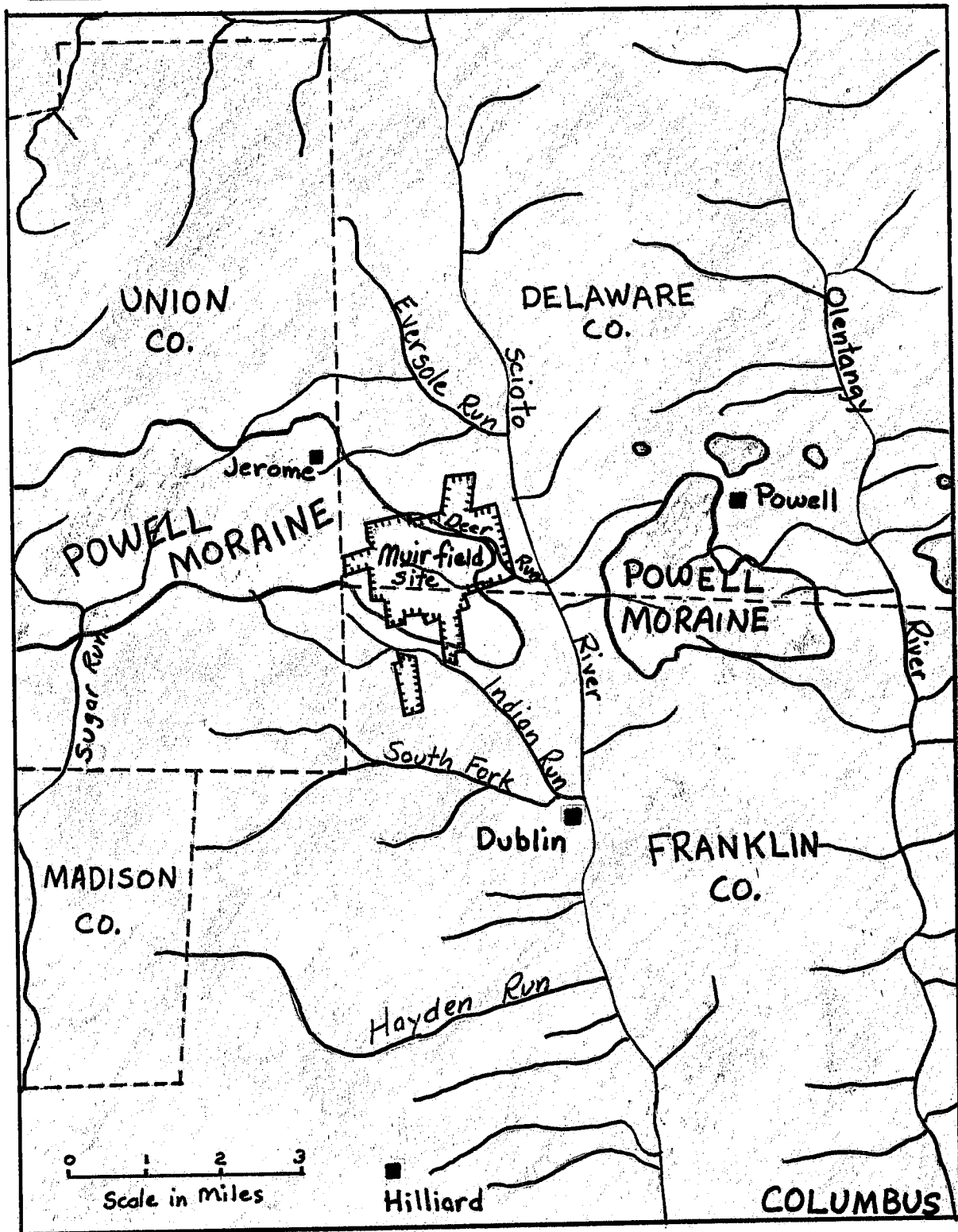


Figure 2. Surface Geology of the Area Surrounding the Muirfield Site.

SOILS

The soils of Delaware County have been mapped in great detail by the U. S. Soil Conservation Service (Francisco Matanzo et al, 1969). Franklin County has not been mapped in detail and only a very general soil map has been produced by the Ohio Department of Natural Resources, Division of Lands and Soils (F. J. Baker, 1960). Therefore, the degree of information available on the soil of Muirfield is excellent for the northern two-thirds of the site in Delaware County and poor for the southern one-third in Franklin County. The soils information presented in this report is based on data contained in reports cited above.

The soil of the Muirfield Site formed in Wisconsin glacial till or its alluvium on nearly level to sloping topography. Small areas along Deer Run are rolling to steep. The Muirfield Site contains soil of 10 different soils series and 20 different mappable soils units. (Table 1 and Plate 1). The various soils are a result of different parent materials and variations in natural drainage.

The following sections describe the soils series and mapping units shown on Plate 1 and Tables 1-5. Sections dealing with the suitability of various soils for wildlife habitats and engineering uses as well as a final section related to soil and land use planning are also presented.

Alexandria Series

The Alexandria series consists of deep, well-drained, sloping to steep soils that formed in clay loam or loam glacial till of Wisconsin age. A typical cultivated soil has a dark grayish-brown and brown silt loam surface layer that is strongly acid unless it has been limed. Below the surface layer is brown or dark-brown material in which the content of clay increases with increasing depth. The soil material is silty clay between depths of 19 and 45 inches. It is underlain by dark yellowish-brown and dark-brown, firm glacial till of clay loam texture. This till is generally so firm that it restricts the roots of plants and the movement of water. These soils have a moderately deep root zone in most places. Available moisture capacity is generally medium, but is low in most of the steep eroded areas. Permeability is moderately slow. Alexandria soils are cultivated in most places where slopes and erosion are not prohibitive. Crop response to fertilizer is good.

TABLE 1

SOIL OF MUIRFIELD

SYMBOL	NAME
AmF2	Alexandria & Morley silt loams, 25% to 40% slopes, moderate eroded
BIA	Blount silt loam, 0% to 2% slopes
BIB	Blount silt loam, 2% to 6% slopes
Ee	Eel silt loam
FnB	Fox silt loam, 2% to 6% slopes
MrB	Morley silt loam, 2% to 6% slopes
MrB2	Morley silt loam, 2% to 6% slopes, moderately eroded
MrC	Morley silt loam, 6% to 12% slopes
MrC2	Morley silt loam, 6% to 12% slopes, moderately eroded
MrD	Morley silt loam, 12% to 18% slopes
MrD2	Morley silt loam, 12% to 18% slopes, moderately eroded
MrE2	Morley silt loam, 18% to 25% slopes, moderately eroded
MsC3	Morley soils, 6% to 12% slopes, severely eroded
MsD3	Morley soils, 12% to 18% slopes, severely eroded
OcA	Ockley silt loam, 0% to 2% slopes
OcB	Ockley silt loam, 2% to 6% slopes
Pw	Pewamo silty clay loam
Sh	Shoals silt loam
So	Sloan silty clay loam
Wu	Westland silty clay loam

Alexandria and Morley silt loams, 25 to 40 percent slopes, moderately eroded (AmF2). - This mapping unit consists of Alexandria silt loam and Morely silt loam that were mapped together because they have similar limitations to use and need about the same management. Elsewhere in this report Morley silt loam is described as typical for the Morley series. These soils are subject to erosion unless a protective cover is maintained.

Blount Series

The Blount series consists of light-colored, somewhat poorly drained soils that formed in clay loam or silty clay loam glacial till of Wisconsin age. These soils are nearly level to gently sloping and occupy broad areas on uplands. A typical Blount soil has a surface layer of dark grayish-brown silt loam 8 inches thick. The subsoil extends to a depth of about 24 inches and is mottled throughout. It is grayish-brown silty clay loam in the upper part, grayish-brown silty clay in the middle part, and dark-gray, gray, and grayish-brown silty clay in the lower part. At a depth of 24 inches is dark grayish-brown clay. The substratum consists of calcareous (20 to 35 percent carbonates) glacial till. These soils have slow permeability in the subsoil and the substratum. They are seasonally saturated with free water for a significant period. Available moisture capacity is medium. The root zone is moderately deep in most places. The Blount soils are extensive in this county. Most of the acreage is used for cultivated crops. These soils are slow to dry out in spring unless they have been adequately drained.

Blount silt loam, 0 to 2 percent slopes (BIA). - This nearly level soil occupies broad areas adjacent to Pewamo soils, which are in depressions. Locally, this soil is ponded in some places during wet periods. Some of these ponded areas include small areas of Pewamo soils that are too small to map separately. Excess water is a limitation to the use of this soil unless adequate drainage is provided.

Blount silt loam, 2 to 6 percent slopes (BIB). - Seasonal wetness is the major limitation to use of this gently sloping soil, but sheet erosion, especially on long slopes, is also a moderate hazard. The surface layer is highly susceptible to crusting. Included with this soil in mapping, particularly on slopes of about 4 to 6 percent, were some small areas of Morley soils.

Eel Series

The Eel series consists of deep, moderately well drained light-colored soils that formed in medium-textured sediments recently washed from Wisconsin glacial till and from soils formed from this till. These soils are nearly level and occur on bottom lands. A typical Eel soil has a dark grayish-brown, friable silt loam surface layer about 14 inches thick. This layer is underlain by brown light silty clay loam that extends to a depth of 28 inches. Below this, to a depth of 65 inches, is brown loam and fine sandy loam and grayish and brownish loam. Distinct mottles of grayish brown and yellowish brown are between depths of 28 and 52 inches. The Eel soils have a deep root zone when the water table is low. Permeability is moderate, and available moisture capacity is high. The water table is high in winter and spring, and flooding is a hazard. These soils occur in relatively small areas in this vicinity, but they are important for farming.

Eel silt loam (Ee). - Included with this nearly level soil in mapping were some areas of Genesee soils that were impractical to map separately. Eel silt loam is easy to cultivate; good tilth is easily maintained. Although this soil is flooded in places, the flooding normally does not limit use of this soil for the crops commonly grown. Erosion is not likely.

Fox Series

The Fox series consists of light-colored, well-drained soils that formed in silty or loamy glacial outwash material of Wisconsin age. These soils are underlain by stratified, calcareous sand and gravel at a depth of 24 to 42 inches. They occupy benches and terraces along streams. These soils are generally high enough above streams to avoid flooding.

Fox loam, 2 to 6 percent slopes (F1B). - This gently sloping soil has a surface layer that contains more sand and is coarser textured than the one in the profile described as typical for the Fox series. This soil generally has good surface tilth. Surface runoff is medium to rapid, and the hazard of erosion is moderate in cultivated areas.

Morley Series

The Morley series consists of light-colored moderately well

drained and well drained soils on uplands. These soils formed in limy silty clay loam or clay loam glacial till of Wisconsin age. They are gently sloping to steep. A typical Morley soil has a dark grayish-brown, friable silt loam surface layer 7 inches thick. The subsoil extends to a depth of 28 inches. It is brown silty clay loam in the upper part, dark-brown silty clay in the middle part, and dark-brown silty clay loam in the lower part. The underlying material is firm, calcareous, brownish glacial till of silty clay loam and clay loam texture. The clayey subsoil restricts the movement of water and the penetration of roots. These soils have a moderately deep root zone and slow permeability. Available moisture capacity is generally medium in the root zone but is low in the steep eroded areas. These soils are saturated with free water for short periods generally in spring and winter. Morley soils occupy a large acreage at the Muirfield Site. They are important for farming, and most of their acreage is used for cultivated crops.

Morley silt loam, 2 to 6 percent slopes (MrB). - This gently sloping soil occupies large irregular areas on undulating uplands. Included with this soil in mapping were some areas of the somewhat poorly drained Blount soils and some small pockets of the very poorly drained Pewamo soils. This soil has medium to rapid surface runoff, and erosion is a moderate hazard in cultivated areas. In some areas, particularly on the lower slopes, this soil is wet later in spring than are areas on the upper slopes.

Morley silt loam, 2 to 6 percent slopes, moderately eroded (MrB2). - This gently sloping soil occupies large irregular areas on undulating uplands. Its surface layer is a mixture of original surface soil and the upper part of the subsoil. The surface layer contains more clay than that of the uneroded Morley soils, and it is more crusty and is subject to puddling. Included with this soil in mapping were small areas of the somewhat poorly drained Blount and the very poorly drained Pewamo soils. Because this Morley soil has medium to rapid surface runoff, erosion is a severe hazard in cultivated areas. Some areas, generally those on the lower slopes, remain wet later in spring than other areas.

Morley silt loam, 6 to 12 percent slopes (MrC). - This sloping soil is in rather long narrow areas on uplands near streams. The surface runoff of this soil is rapid, and there is a severe hazard of erosion in cultivated areas.

Morley silt loam, 6 to 12 percent slopes, moderately eroded (MrC2). - This soil has lost some of its original surface soil through water erosion,

and where cultivated, its present surface layer is a mixture of the original surface soil and material from the subsoil. This soil is more difficult to plow than uneroded Morley soils, and it is more susceptible to crusting and puddling. This soil has rapid surface runoff and, in cultivated areas, the hazard of erosion is severe.

Morley silt loam, 12 to 18 percent slopes (MrD). - This moderately steep soil occupies small scattered areas along drainageways. It generally is in areas between higher lying Morley soils or Blount soils and the wet, dark-colored Pewamo soils. This soil has a thinner surface layer than the one in the profile described as typical for the Morley series. Where this Morley soil is cultivated, the hazard of erosion is very severe.

Morley silt loam, 12 to 18 percent slopes, moderately eroded (MrD2). - This soil occupies small scattered areas. Erosion has removed all but about 3 inches of the original surface layer and, in cultivated areas, the present plow layer is a mixture of about equal amounts of the original surface soil and subsoil material. Tillage generally is very poor. Surface runoff from this soil is rapid and, in cultivated areas, the hazard of erosion is very severe.

Morley silt loam, 18 to 25 percent slopes, moderately eroded (MrE2). - This steep soil occupies scattered breaks along drainageways. It has a thin surface layer because erosion has removed part of the original surface soil. Because this soil is steep and has very rapid surface runoff, erosion is a severe hazard unless a protective cover is maintained. Cultivated crops are not suitable.

Morley soils, 6 to 12 percent slopes, severely eroded (MsC3). - These soils have a silty clay loam or clay loam surface layer that is sticky when wet and can be worked only within a narrow range of moisture content. Locally, shallow gullies are common. Included with these soils in the mapping were some areas of moderately eroded Morley soils. These severely eroded soils crust easily. Unless practices are used to improve the surface soil, seed germination is poor. Runoff is rapid, and the hazard of erosion is very severe in cultivated areas.

Morley soils, 12 to 18 percent slopes, severely eroded (MsD3). - These moderately steep soils have a surface layer of silty clay loam that is sticky, crusts easily, and is difficult to till. Locally, shallow gullies are common. Included with these soils in mapping were small areas of moderately eroded or slightly eroded Morley soils. These severely eroded Morley soils are not suited to cultivated crops, because

of their slope and of past erosion. Seed germination is poor. Surface runoff is rapid or very rapid, and erosion is a very severe hazard unless a protective cover is maintained.

Ockley Series

The Ockley series consists of deep, well-drained, light-colored soils that formed in silty or loamy glacial outwash. These soils are underlain by stratified, limy sand and gravel. They are nearly level to moderately steep and occupy outwash valley trains or terraces. These soils are above the normal level of floods. A typical cultivated Ockley soil has a silt loam plow layer that is dark brown in the upper part and dark grayish brown in the lower part. This layer is friable and easy to till. The subsoil extends from a depth of 8 inches to 51 inches. It is dark reddish-brown to reddish-brown silty clay loam between depths of 14 and 19 inches. Below 19 inches the subsoil is dark reddish-brown and reddish-brown gravelly clay loam. Stratified sand and gravel is at a depth of 51 inches. These soils have a deep root zone. Permeability is moderate, and available moisture capacity is high. The substratum is a good source of sand and gravel. These soils occur in small areas and are not extensive at the site, but they are important for farming.

Ockley silt loam, 0 to 2 percent slopes (OcA). - Erosion is not likely on this nearly level soil, and there are few limitations to use. This soil generally has good till, and surface crusting is only a minor concern.

Ockley silt loam, 2 to 6 percent slopes (OcB). - This gently sloping soil has medium to rapid surface runoff and is subject to a moderate hazard of erosion in cultivated areas.

Pewamo Series

The Pewamo series consists of deep, dark-colored, very poorly drained soils that formed in limy clay loam glacial till. These soils are nearly level or depressional and occupy uplands. They also occur along some drainageways. In undulating areas, a distinct pattern of adjacent light-colored soils and the dark-colored Pewamo soils can be seen. In a typical profile, the surface layer is very dark gray silty clay loam about 6 1/2 inches thick. The subsoil extends to a depth of 74 inches. It is very dark grayish-brown silty clay loam in the upper part, dark-gray mottled silty clay in the middle part, and

dark-gray and yellowish-brown mottled silty clay loam in the lower part. Below the subsoil is brown calcareous clay loam. These soils have a deep root zone in drained areas. Permeability is moderately slow, and available moisture capacity is very high. These soils have a seasonal high water table for long periods unless they are artificially drained. The Pewamo soils are extensive throughout this area, and they are very important for farming. Crops grow well in artificially drained areas.

Pewamo silty clay loam (Pw). - The surface layer of this nearly level soil is high in content of organic matter. If this soil is cultivated at the optimum moisture content it has good structure and tilth generally is good. Ponding is likely in undrained areas. The erosion hazard is slight to none but wetness, even in adequately drained areas, is a moderate limitation.

Shoal Series

The Shoals series consists of deep, light-colored, somewhat poorly drained soils. These soils are nearly level, and they occupy flood plains. They formed in alluvium washed from the uplands. A typical Shoals soil has a surface layer of dark grayish-brown silt loam. The subsoil is dark grayish-brown heavysilt loam distinctly mottled with dark yellowish brown. Below the subsoil, to a depth of 60 inches or more, are strata of dark grayish-brown and very dark grayish-brown loam, silt loam, and gravelly loam distinctly mottled with yellowish brown. Shoals soils have a deep root zone when the water table is low. Available moisture capacity is high, and permeability is moderately slow. Surface runoff is slow to very slow, and the surface is ponded in some places. The water table is high in winter and spring, and flooding is a hazard. In most places the level of the water table depends on the water level of the river or the streams nearby.

Shoals silt loam (Sh). - This nearly level soil occurs in low areas along streams. Included with this soil in mapping were small areas of Sloan soils that are too small to be mapped separately. This soil is subject to flooding, and wetness is a limitation to use, even in drained areas. Establishing suitable drainage outlets is difficult on this soil because of its location.

Sloan Series

The Sloan series consists of deep, very poorly drained, dark-colored soils on flood plains. These soils formed in material that

washed from soils at a higher elevation. In a typical profile, the surface layer (A horizon) is very dark gray silty clay loam 13 inches thick. Below the surface layer are alternation layers of grayish and brownish clay loam and silty clay loam that extend to a depth of 61 inches. Mottling and gleying begin at a depth of 20 inches and extend to 61 inches. These soils have a deep root zone in drained areas. Permeability is moderately slow, and available moisture capacity is high. These soils are subject to overflow, and they have a seasonal high water table. These soils occupy a fairly large acreage in this area, and they are important for farming.

Sloan silty clay loam (So). - This nearly level soil is generally wet unless adequate drainage is provided. Included in mapping were some slightly higher areas that are not so poorly drained. Surface runoff on this soil is slow or ponded, and flooding is a limitation to use, even in drained areas.

Westland Series

The Westland series consists of dark-colored, very poorly drained soils that formed in silty and loamy glacial outwash material. These soils are underlain by limy sand and gravel at a depth of 42 inches or more. They occur in nearly level to concave areas on stream terraces. A typical Westland soil has a plow layer of very dark-gray silty clay loam 7 inches thick. Below this is very dark brown heavy silty clay loam. The subsoil is dark-gray clay loam and gravelly clay loam in which the content of gravel increases with increasing depth. Below a depth of 32 inches the content of gravel is 15 to 20 percent or more. Below the subsoil is dark-gray sand and gravel that extends to a depth of 54 inches and has a high content of lime. These soils have a deep root zone in drained areas. Available moisture capacity is high. The internal movement of water is moderately slow in the surface layer and the subsoil but is rapid in the underlying sand and gravel. These soils are saturated with free water for a significant period, generally in winter and spring.

Westland silty clay loam (Wu). - This nearly level soil has a sticky, clayey surface layer that is difficult to till when wet. Surface runoff is slow or ponded, and wetness is a limitation to use, even in drained areas.

Use of Soils for Wildlife and Fish

Wildlife is an important natural resource in Delaware County, and the development of wildlife habitat fits in well with other agricultural uses of the soils. Since the early days of settlement, and the clearing of the land, the wildlife in the area has changed in kinds, distribution, and numbers. Because of these changes in land use, and the resulting changes in wildlife distribution, it is difficult to correlate the kinds and numbers of wildlife with specific soils.

Soil properties such as slope, productivity potential, texture, drainage, and effective depth influence the use of the soils. These factors, along with factors of topography, largely control the amount of food, water, and cover available for wildlife and the kinds and numbers of wildlife in any area. Wildlife that are common at Muirfield include pheasants, rabbits, quail, deer, and squirrels. Also numerous are skunks, raccoons, and opossums. Birds are also numerous in the area and many of them are important because they eat harmful insects and also have esthetic value.

Generally, the largest number of each kind of wildlife frequent areas that provide enough of the kind of food and cover necessary for their survival. Pheasants prefer areas that are intensively cropped, and they are most numerous in the western two-thirds of the site in areas of Morley, Blount, and Pewamo soils. Waterfowl are abundant near the site during spring and fall migration because of the many drainageways and the O'Shaughnessy Reservoir on the Scioto River. This reservoir also furnishes good fishing for bluegill, bass, catfish, and other species.

In Table 2 the soils and land types of the Muirfield Site are rated according to their suitability for elements of wildlife habitat and for kinds of wildlife. Numbers indicate ratings as follows: 1, well suited; 2, suited; 3, poorly suited; and 4, unsuited. A rating of well suited means that the soil has few or no limitations to use as the element of wildlife habitat. A rating of suited indicates that the habitat element can be created, improved, or maintained, but that there are moderate limitations that affect management. Poorly suited means that the habitat element can be created, improved, or maintained, but that limitations are severe. A rating of unsuited indicates that the habitat cannot be created, improved, or maintained, or that it is impractical to do so under the prevailing conditions.

The following is a list of important plants for each of the elements of wildlife habitat related in Table 2.

Grain and seed crops. Corn, sorghum, oats, barley, rye, and wheat.

Grasses and legumes. Alfalfa, Ladino clover, red clover, fescue, brome grass, bluegrass, and timothy.

Wild herbaceous upland plants. Foxtail, ragweed, panicgrass, wild oats, native lespedeza, and herbs.

Hardwood woody plants. Trees and shrubs such as sumac, wild grape, dogwood, persimmon, multiflora rose, black haw, sweetgum, wild cherry, oak, hickory, and walnut. In Table 2, the soils are rated on the basis of their capacity for supporting plants that grow vigorously and produce a good crop of fruit or seeds.

Coniferous woody plants. Eastern redcedar, Virginia pine, Scotch pine, and Austrian pine. In Table 2, the soils are rated on the basis of slow growth and delayed canopy closure.

Wetland food and cover plants. Cattails, sedges, reeds, barnyard grass, duckweed, and various willows.

Shallow water developments. These are areas that have been made by impounding water, by digging excavations, or by using devices to control water. In Table 2, the soils are rated on the basis of their suitability for water developments that are more than 5 feet deep.

Excavated ponds. These are excavations that hold enough water of suitable quality to support fish or wildlife. The ponds should have an average depth of at least 6 feet in at least one-fourth of the area.

The following is a list of important animals and birds in each of the three categories of wildlife listed in Table 2.

Openland wildlife. Quail, pheasants, meadow larks, cottontail rabbits, red foxes, and woodchucks.

Woodland wildlife. Birds and mammals commonly found in wooded areas. Examples are: gray and fox squirrels, whitetail deer, red foxes, raccoons, woodchucks, warblers, woodpeckers, and buntings.

Wetland wildlife. Muskrats and beavers, as well as ducks, geese, rails, herons, and other waterfowl.

Engineering Uses of Soils

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, pipelines, building foundations, facilities for water storage, structures for erosion control, drainage systems, and sewage disposal systems. The soil

properties most important to the engineer are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell characteristics, grain size, plasticity, pH, depth to water table, depth to bedrock, and topography. These properties of the soils at the Muirfield Site are given in Table 3.

With the soil map for identification, the engineering interpretations in Table 4 can be useful for many purposes. It should be emphasized however, that the interpretations do not eliminate the need for sampling and testing at the site of specific engineering works where loads are heavy and where the excavations are deeper than here reported. Even in these situations, however, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

In Table 3, depth to a seasonal high water table refers to the shallowest depth to which the water table rises in winter and early in spring. This water table may be a perched one or an ordinary groundwater table. If precipitation is less than normal during the wet season the water table and the saturated soil are farther from the surface. Soil conditions immediately after heavy precipitation are not considered. In all soils, particularly those on slopes and on uplands, the depth to the water table is generally greater late in spring, in summer, and in fall than the depth shown in Table 3. All of the soil at Muirfield is deeper than 5 feet to bedrock. The textural terms used to describe the soil material in the main horizons are those used by the U. S. Department of Agriculture.

Permeability reflects the ability of the soil to transmit water and air. In Table 3, permeability, estimated in inches of water percolation per hour, is based on the texture, structure, and porosity of the soil and on selected permeability tests. These tests assume that the soil is saturated but that there is no hindrance to free drainage.

The available moisture capacity, estimated in inches per inch of soil depth, is the approximate amount of capillary water in a soil that is wet to field capacity. When the soil is air dry, this amount of water wets the soil material to a depth of 1 inch without deeper percolation. For medium-textured and fine-textured soils, the estimated values listed are based on the difference in percentage of moisture retained at $1/3$ and 15 atmospheres of tension. For sandy soils, the estimated values are based on the difference between $1/10$ and 15 atmospheres of tension. For compact glacial till, the estimated values listed in Table 3 are lower than normal for a given texture; the increased bulk density reduces the penetration of roots and, therefore, not all of the stored moisture is available to plants.

In Table 4, reaction is given in pH values, which indicate the degree of acidity or alkalinity of the soil material. Higher values indicate alkaline material and lower values acid material.

Shrink-swell potential is an indication of the change in volume of the soil material expected when its moisture content changes. Soils that have a high shrink-swell potential are normally undesirable for some engineering uses because their bearing capacity is generally lessened when their volume is increased by swelling when wet. Shrink-swell potential is estimated primarily on the basis of the amount and kind of clay the soil contains.

Corrosion potential is important because it indicates the effect that solvents in a soil have on the corrosion of utility pipelines. In Table 3 estimates are for steel and concrete pipes.

In Table 4 the soils of the site are rated according to their suitability for winter grading, susceptibility to frost action, and suitability as a source of topsoil, sand and gravel and road fill. In addition, Table 4 lists soil features that affect suitability of the soils for highway location and for engineering structures and practices. The following explanations are for data in Table 4/

Suitability for winter grading. - Because of wetness, plasticity, and susceptibility to frost action, most of the soils in the area are poorly suited to winter grading.

Susceptibility to frost action. ~~Silty and clayey soils that are~~ Wet, most of the winter are the most susceptible to damaging frost action.

Suitability as a source of topsoil, sand and gravel, and road fill. - The thickness, texture, and natural fertility of the surface layer determine suitability of a soil for use as a topdressing. The amount, quality and accessibility of granular (coarse-grained) materials are the most important features that affect suitability of a soil for use of sand and gravel as construction material. Well-graded coarse materials or a mixture of clay and coarse-grained materials is suitable as a source of road fill. Highly plastic clayey soils, poorly graded silty soils, and organic soils are difficult to compact and are unsuitable for road fill or are poorly suited. In the columns under the heading "Soil Features Affecting: " are listed properties of soils that affect the location of highways, construction and maintenance of ponds, and other engineering work.

Highway location. - Soil features that affect the location of highways include depth to rock a high water table, steep slopes, slippage of soil material, and susceptibility to flooding.

Ponds. - The sealing potential of the soil material is the main factor affecting the reservoir area of farm ponds, though depth to bedrock and susceptibility to flooding are also important. Stability, ease or difficulty of compaction, and permeability of soil material affect construction and maintenance of the embankments of farm ponds.

Agricultural drainage. - The soils are described relative to their natural drainage, their in-place permeability, and the presence of a high water table.

Irrigation. - The rate of water intake, permeability, natural drainage, and available water capacity are properties of soils that affect irrigation. Slopes and susceptibility to flooding are also important.

Terraces and diversions. - Slope and susceptibility to erosion are the main features that affect terraces and diversions, though depth to bedrock and height of the water table are also important.

Waterways. - Soil features that affect waterways are about the same as those affecting terraces and diversions, though the degree of the effect may differ.

Soils and Land Use Planning

The Muirfield Site is only a few miles north of the expanding metropolitan area of Columbus, Ohio, and expansion has already affected land use in the southern part of Delaware County. Competition for land is increasing. The farming areas are being reduced as residential, industrial, transportation, and recreational facilities are developed. Table 5 provides information on the properties of the soils and their effect on selected non-farm use of land. It is intended to help planners identify areas that are least costly to develop and maintain. Development and maintenance costs are related to soil limitations. Table 5 gives the estimated degree and kinds of limitation of soils for some selected land uses. By using this information, alternative uses can be developed as a basis for long-range planning and zoning. Because extensive manipulation of the soil alters some of its natural properties, the ratings for some uses will no longer apply to areas that have undergone extensive cutting and filling.

The estimated degree of limitations of the soils for a specified land use are slight, moderate, and severe. A rating of slight indicates that the soil has no important limitation to the specified use. Moderate shows that the soil has some limitations to the specified use. These limitations need to be recognized, but they can be overcome or corrected. A rating of severe indicates that the soil has serious limitations that are difficult to overcome. A severe rating, however, does not mean that the soil cannot be used for the specific use.

The following are explanations of the uses rated in Table 5.

Cultivated crops. - The soils have been rated according to their limitations to use for cultivated crops. The degree of limitation is based on the land capability classes, which are explained in the section "Capability Groups of Soils." Erosion, wetness, droughtiness, stoniness, and other hazards to cropping were considered in making these ratings. Cultivated crops are rated in this table to aid planners for land use when they consider whether or not farming is a sound use.

Homesite locations. - In this area the major features that limit the use of soils as homesite locations are depth to bedrock, slope, natural drainage, hazard of flooding, and stoniness or rockiness of the soil surface. Not considered is a method for disposing of sewage. The ratings in Table 5 are for houses of three stories or less that have a basement, but the ratings also apply to sites for small industrial, commercial, and institutional buildings. Flooding is a severe hazard when it occurs. Homes constructed on naturally wet soils probably will have wet basements unless adequate drainage is provided. The wet soils at the site are the Pewamo and Blount. In many areas tile drains and open ditches have been installed for agricultural use, but excavations for homes or other structures can disrupt these systems.

Soils that have a high content of silt are not so suitable for supporting foundations of buildings as are the Fox and other coarser textured soils. Soils that have a high shrink-swell potential are likely to heave and cause foundations to crack. In addition, shrinking and swelling disrupts the alignment of sidewalks, patios, floors, and rock walls. These effects can be lessened by placing layers of sandy or gravelly material below the structure. Excavating for basements and installing underground utility lines are difficult and expensive on soils that are shallow to bedrock. On slopes of more than 12 percent, erosion is a hazard and excavation and grading are difficult.

Disposal of sewage effluent. - The suitability of soils for disposing effluent from septic tanks depends on permeability, depth to rock, slope, natural drainage, and hazard of flooding. The use of a soil in the

disposal of effluent is severely limited by flooding, by very poor drainage, or by moderately slow to very slow permeability. See Table 5. for estimates of permeability. If filter fields for septic tanks are located on slopes of more than 12 percent, erosion and seepage downslope may be a problem, or the soil may be unstable when saturated. A severe limitation is caused by a restrictive layer, such as solid bedrock, a dense, compact layer, or a layer of clay that interferes with adequate filtration and the removal of effluent.

Some soils in the county have a gravelly and sandy substratum or are underlain by creviced bedrock through which effluent that is inadequately filtered can contaminate the ground water or nearby springs, lakes, or streams. Before a septic tank system is installed, an investigation should be made at the proposed site to determine the condition of the soil.

Sewage lagoons. - Sewage lagoons are shallow ponds built to dispose of sewage through oxidation. They may be needed in an area if septic tanks or a central sewage system is not feasible or practical. Among the features that control the degree of limitation are drainage, the hazard of flooding, degree of slope, depth to rock, and permeability.

Lawns, landscaping, and golf fairways. - In most areas developed for homes and golf courses, the natural surface soil, or topsoil, can be used for lawns, glowers, shrubs, and trees and should be saved. It can be removed from the site, stored until construction and grading are completed, and then returned. The natural surface soil from areas graded for streets also can be used for lawns and fairways. Among the soil preperities that determine whether a good lawn or golf fairway can be established are natural drainage, degree of slope, depth to bedrock, texture of the surface soil, stoniness and rockiness, and hazard of flooding.

Streets and parking lots. - The ratings in Table 5 are for soils used for streets and parking lots in subdivisions where traffic is not heavy. Considered in estimating the ratings were drainage, slope, depth to bedrock, hazard of flooding, and stoniness or rockiness. For streets and parking lots in subdivisions, limitations are severe on slopes of more than 6 percent. The percentage of slope selected for the sides of cuts and fills depends on erodibility and on the capacity of the soil for supporting close-growing vegetation.

Athletic fields and other intensive play areas. - These areas are fairly small tracts used for baseball diamonds, football fields, and tennis, volleyball, and badminton courts. Because the areas must be

nearly level, considerable shaping may be needed. For this reason, the limitation is moderate or severe on slopes of more than 2 percent. Also important is the texture of the surface layer. The limitation is slight for soils that have a surface layer of silt loam, fine sandy loam, very fine sandy loam, loam, or sandy loam. It is moderate for clay loams, sandy clay loams, silty clay loams, or loamy sands, and severe for loose sand and for gravelly, very stony, flaggy, or rocky soils. Flood plains can be used as intensive play areas.

Picnic and extensive play areas. - Considered in rating the soils for picnicking, hiking, nature study, and similar uses were degree of slope, texture of the surface soil, natural drainage, stoniness, and hazard of flooding. Paths in picnic and play areas should be constructed and maintained in a way that controls gullying. Flood plains can be developed and used as extensive play areas.

TABLE 2

ELEMENTS OF WILDLIFE HABITATS

KEY											
1 = well suited											
2 = suited											
3 = poorly suited											
4 = unsuited											
Soil Series and Symbols	Grain and Seed Crops	Grasses and Legumes	Wild Herbaceous Upland Plants	Hardwood Woody Plants	Coniferous Woody Plants	Wetland Food and Cover Plants	Shallow Water Developments	Excavated Ponds	Openland Wildlife	Woodland Wildlife	Wetland Wildlife
Alexandria AmF2	4	3	2	2	3	4	4	4	3	3	4
Blount BIA	2	2	2	2	3	2	2	2	2	2	2
BIB	2	2	2	2	3	3	4	4	2	2	4
Eel Ee	2	1	1	1	3	3	3	3	1	1	3
Fox FnB	2	1	1	1	3	4	4	4	1	1	4
Morley MrB, MrB2	2	1	1	1	3	3	3	3	1	1	3
MrC, MrC2	2	1	1	1	3	4	4	4	1	1	4
MrD, MrD2	3	2	1	1	3	4	4	4	2	2	4
MrE2	3	2	1	1	3	4	4	4	2	2	4
MsC3	3	2	2	2	3	4	4	4	2	3	4
MsD3	3	2	2	2	3	4	4	4	2	3	4
Ockley OcA	1	1	1	1	3	4	4	4	1	1	4
OcB	1	1	1	1	3	4	4	4	1	1	4
Pewamo Pw	4	3	3	1	1	1	1	1	3	2	1
Shoals Sh	2	2	1	1	3	2	2	3	1	2	2
Sloan So	4	3	3	1	1	1	1	3	3	2	1
Westland Wu	4	3	3	1	1	1	1	3	3	1	2

TABLE 3-A

ESTIMATED ENGINEERING PROPERTIES OF SOILS

Soil Series	Depth to Seasonal High Water Table (ft.)	Depth to Bedrock (ft.)	Depth from Surface (in.)	Texture
Alexandria	3	5	0-7 7-19 19-45 45-60	Silt loam Silty clay loam/clay loam Silty clay Clay loam & loam
Blount	1.5	5	0-8 8-29 29-60	Silt loam Silty clay loam, clay/silty clay Clay loam
Eel	1.5-3	5	0-14 14-35 35-65	Silt loam Loam/silty clay loam Fine sandy loam/loam
Fox	4	5	0-6 6-30 30-60	Loam/silt loam Silty clay loam-gravelly clay loam Sand/gravel
Morley	1.5	5	0-7 7-34 34-60	Silt loam Silty clay/silty clay loam Clay loam
Ockley	3	5	0-8 8-19 19-51 51-60	Silt loam Silt loam & silty clay loam Gravelly clay loam Sand & gravel
Pewamo	0-1	5	0-13 13-40 40-74	Silty clay loam Silty clay/silty clay loam Silty clay loam
Shoals	0-1.5	5	0-13 13-30 30-50	Silt loam Silt loam/loam Gravelly loam
Sloan	0-1	5	0-13 13-49 49-61	Silty clay loam Silty clay loam/clay loam Clay loam-silty clay loam
Westland	0-1	5	0-12 12-42 42-54	Silty clay loam Gravelly clay loam/clay loam Sand & gravel

TABLE 3-B

Soil Series	Percentage Passing Sieve			Permeability Inches per Hour
	No. 4 (4.7mm)	No. 10 (2.0mm)	No. 200 (0.074mm)	
Alexandria	95-100	95-100	80-90	0.2-2.0
	95-100	95-100	85-95	0.2-0.63
	95-100	95-100	75-90	0.2-0.63
	95-100	95-100	70-85	0.2-0.63
Blount	95-100	95-100	80-95	0.63-2.0
	100	100	85-95	0.06-0.20
	95-100	85-100	70-85	0.06-0.20
Eel	85-100	80-100	70-90	0.63-2.0
	85-100	80-100	65-90	0.63-2.0
	85-100	80-90	40-80	2.0-6.3
Fox	85-100	85-100	65-80	0.63-2.0
	85-95	70-90	55-75	0.63-2.0
	25-60	20-35	0-15	6.3-12.0
Morley	90-100	90-100	75-85	0.63-2.0
	95-100	95-100	80-90	0.2-0.63
	85-100	80-100	75-85	0.2-0.63
Ockley	90-100	90-100	75-90	0.63-2.0
	80-100	80-100	80-95	0.2-2.0
	85-100	60-80	45-65	0.2-2.0
	25-60	20-30	0-15	>6.3
Pewamo	100	95-100	85-100	0.2-2.0
	100	95-100	80-95	0.2-0.63
	95-100	85-95	70-85	0.2-0.63
Shoals	100	95-100	80-90	0.63-2.0
	85-95	80-90	60-85	0.2-0.63
	80-90	55-75	40-60	0.63-2.0
Sloan	100	95-100	75-80	0.63-2.0
	100	95-100	65-85	0.2-2.0
	75-95	60-95	50-80	<0.2-2.0
Westland	100	100	75-95	0.63-2.0
	95-100	75-95	65-85	0.2-0.63
	35-90	20-50	5-25	>6.3

TABLE 3-C

Soil Series	Available Moisture Capacity-Inches per Inch of Soil	Reaction pH	Shrink- Swell Potential
Alexandria	0.17-0.22	5.1-5.5	Low
	0.15-0.18	4.5-5.0	Moderate
	0.12-0.16	5.1-6.0	Moderate
	0.06-0.10	Calcareous	Low
Blount	0.16-0.22	5.1-6.0	Moderate
	0.12-0.16	5.5-6.5	Moderate to high
	0.06-0.20	Calcareous	Moderate
Eel	0.17-0.22	6.6-7.3	Moderate
	0.15-0.20	6.6-7.3	Moderate
	0.12-0.17	6.6-7.8	Moderate
Fox	0.16-0.22	6.6-7.3	Low
	0.10-0.17	6.1-7.3	Moderate
	0.01-0.05	Calcareous	Low
Morley	0.17-0.22	6.6-7.3	Moderate
	0.12-0.16	5.6-7.3	High
	0.06-0.10	Calcareous	Moderate
Ockley	0.17-0.22	6.6-7.3	Low
	0.12-0.17	6.1-6.5	Moderate
	0.12-0.16	6.1-7.3	Moderate
	0.03-0.08	Calcareous	Low
Pewamo	0.15-0.22	5.6-6.0	Moderate
	0.12-0.16	5.6-7.3	High
	0.08-0.12	Calcareous	Moderate
Shoals	0.17-0.22	6.6-7.3	Moderate
	0.15-0.20	6.6-7.3	Moderate
	0.09-0.12	6.6-7.3	Low
Sloan	0.15-0.22	5.5-7.3	Moderate
	0.15-0.20	6.6-7.3	Moderate
	0.10-0.17	7.3-7.8	Moderate
Westland	0.15-0.22	6.6-7.3	Moderate
	0.14-0.17	6.6-7.8	Moderate
	0.04-0.10	Calcareous	Low

TABLE 3-D

Soil Series	Corrosion Potential	
	Steel	Concrete
Alexandria	Low	Moderate
	Moderate	Moderate to high
	Moderate	Moderate
	Low	Low
Blount	Moderate	Moderate
	Moderate to high	High
	Moderate	High
Eel	Moderate	Low
	Moderate	Low
	Moderate	Low
Fox	Low	Low
	Moderate	Low
	Very Low	Low
Morley	Moderate	Low
	Moderate to high	Moderate
	High	Low
Ockley	Low	Low
	Low	Low
	Low	Low
	Low	Low
Pewamo	Moderate	Moderate
	Moderate to high	Moderate to low
	Moderate	Low
Shoals	Moderate	Low
	High	Low
	High	Low
Sloan	High	Moderate to low
	High	Low
	High	Low
Westland	Moderate	Low
	High	Low
	High	Low

TABLE 4--A
ENGINEERING INTERPRETATIONS OF THE SOILS

Soil Series	Suitability for Winter Grading	Susceptibility to Frost Action	SUITABILITY AS SOURCE OF:			
			Topsoil	Sand & Gravel	Solum	Road Fill Substratum
Alexandria	Poor	Moderate	Fair	Not suitable	Fair	Fair
Blount	Poor	High	Fair	Not suitable	Poor	Fair
Eel	Poor	Moderate	Good	Not suitable	Fair	Fair
Fox	Fair to depth of 24" to 40" & good below	Low	Fair	Good below depth of 2' to 3'. Well graded & stratified sand & gravel	Fair	Good
Morley	Poor	High	Fair	Not suitable	Fair	Fair
Ockley	Fair to depth about 50" & good below	Moderate	Good	Good for sand & below 50", good for gravel well graded & stratified	Fair	Good
Pewamo	Poor	High	Good	Not suitable	Poor ¹	Poor ¹
Shoals	Poor	High	Good	Not suitable	Poor ¹	Poor ¹
Sloan	Poor	High	Good	Not suitable	Poor ¹	Poor ¹
Westland	Poor	High	Good	Good for gravel below depth of 3'-5'; good for sand; poorly graded & stratified	Fair	Good

¹Fair when soil material is removed and dried to optimum moisture content.

TABLE 4-B
ENGINEERING INTERPRETATIONS OF THE SOILS

SOIL FEATURES AFFECTING:					
Soil Series	Highway Location	Ponds		Agricultural Drainage	
		Reservoir Area	Embankment		
Alexandria	Slope	Slow seepage	Fair stability; slow permeability; fair compaction	Not needed	
Blount	Seasonal high water table, clayey subsoil, mod. slow perm.	Slow seepage	Fair stability; slow perm.; fair compaction	Mod. slow perm.; seasonal high water table	
Eel	Subject to flooding seasonal high water table	Subject to flooding permeable substratum	Fair stability; slow perm.; fair to good compaction	Moderate permeability	
Fox	Soil features favorable	Excessive seepage in sand & gravel	Adequate strength & stability; mod. permeability	Not needed	
Mortley	Mod. slow perm. seasonal high water table	Slow seepage	Fair stability; mod. slow perm.; fair compaction	Mod. slow perm.; seasonal high water table	
Ockley	Soil features favorable	Excessive seepage in substratum	Good stability; slow perm.; good compaction	Not needed	

TABLE 4-B (continued)

ENGINEERING INTERPRETATIONS OF THE SOILS

SOIL FEATURES AFFECTING:					
Soil Series	Highway Location	Ponds		Embankment	Agricultural Drainage
		Reservoir Area			
Pewamo	High water table; clayey subsoil; mod. slow perm.	Very slow seepage		Fair stability; slow perm.; fair to poor compaction	Seasonal high water table; mod. slow perm.
Shoals	High water table; subject to flood; mod. slow to slow perm.	Subject to flooding perm. in sub-stratum		Fair stability; slow perm. good compaction	Subject to flood; mod. slow to slow perm. high water table
Sloan	High later table; subj. to flood; mod. low perm.; soil material soft when wet	Subj. to flood; slow seepage; previous layers of sand in some places		Fair stability; perm.; good compaction; wet barrow material	High water table; mod. slow to slow perm.; subj. to flooding
Westland	Seasonal high water table; mod. slow permeability	Excessive seepage in substratum; seasonal high water table		Good stability; permeable; fair compaction	Seasonal high water table; mod. slow permeability

TABLE 4-C

ENGINEERING INTERPRETATIONS OF THE SOILS

SOIL FEATURES AFFECTING:			
Soil Series	Irrigation	Terraces & Diversions	Waterways
Alexandria	Moderate water holding capacity mod. slow perm.	Gentle to strong slopes; moderate erodibility	Susceptibility to erosion
Blount	Mod. slow infiltration & perm.; seasonal high water table	Nearly level to gentle slopes; mod. erodibility	Seasonal high water table
Eel	Mod. infiltration & perm.; high water-holding capacity, subj. to flooding	Nearly level; subject to flooding	Nearly level, subject to flooding
Fox	Mod. infiltration; med. water-holding capacity	Nearly level to mod. steep slopes; mod. permeability	Nearly level to mod. steep slopes; mod. perm.; erodible on mod. steep slopes
Monley	Mod. slow perm.; seasonal high water table	Gentle to steep slopes; erodibility	Gentle to steep slopes; erodibility
Ockley	Mod. perm.; high water-holding capacity	Soil features favorable	Erodibility
Pewamo	Seasonal high water table; mod. slow perm.	Seasonal high water table; nearly level	Seasonal high water table; nearly level

TABLE 4-C (continued)

ENGINEERING INTERPRETATIONS OF THE SOILS

SOIL FEATURES AFFECTING:			
Soil Series	Irrigation	Terraces & Diversions	Waterways
Shoals	High water table; subj. to flood; mod. slow to slow permeability	High water table; subj. to flooding	High water table; subj. to flooding
Sloan	High water table; mod. slow to slow perm.; subj. to flooding	Nearly level; high water table; subj. to flooding	High water table; subj. to flooding
Westland	Seasonal high water table; mod. slow perm.	Seasonal high water table	Seasonal high water table

TABLE 5-A
ESTIMATED DEGREE AND KINDS OF LIMITATIONS
FOR LAND USE PLANNING

Soil Series & Map Symbols	Cultivated Crops	Homesite Locations: Rating also applies to com- mercial, institutional, and light industry sites
Alexandria AmF2	Severe: Slope, erosion hazard	Severe: Slope
Blount B1A B1B	Slight Slight	Moderate: Somewhat poorly drained Moderate: Somewhat poorly drained
Eel Ee	Slight	Severe: Subject to flooding
Fox FnB	Slight	Slight
Morley MrB MrB2 MrC, MrC2 MsC3 MrD, MrD2, MrE2, MsD3	Slight Moderate: Slope, erosion hazard Moderate: Slope, erosion hazard Severe: Past erosion Severe: Slope erosion hazard	Slight Slight Moderate: Slope Moderate: Slope Severe: Slope
Ockley OcA OcB	Slight Slight	Slight Slight
Pewamo Pw	Slight	Severe: Very poorly drained; soft when wet
Shoals Sh	Slight	Severe: Subject to flood; soft when wet
Sloan So	Moderate: Very poorly drained	Severe: Subject to flood; soft when wet
Westland Wu	Slight	Severe: Very poorly drained

TABLE 5-B
ESTIMATED DEGREE AND KINDS OF LIMITATIONS
FOR LAND USE PLANNING

Soil Series & Map Symbols	Disposal of Sewage Effluent	Sewage Lagoons
Alexandria AmF2	Severe: Slope	Severe: Slope
Blount B1A B1B	Severe: Slow permeability Severe: Slow permeability	Slight Moderate: Slope
Eel Ee	Severe: Subject to flooding	Severe: Subject to flooding
Fox FnB	(Nearby wells, springs, or ponds may be contaminated by seepage of waste liquids) ² Slight	Severe: Permeable material
Morley MrB MrB2 MrC, MrC2 MsC3 MrD, MrD2, MrE2, MsD3	Severe: Mod. slow perm. Severe: Mod. slow perm. Severe: Mod. slow perm. Severe: Mod. slow perm. Severe: Slope; slow perm.	Moderate: Slope Moderate: Slope Severe: Slope Severe: Slope Severe: Slope
Ockley OcA OcB	(Nearby wells, springs, or ponds may be contaminated by seepage of waste liquids.) ² Slight	Severe: Permeable substratum Severe: Permeable substratum
Pewamo PW	Severe: Very poorly drained; ² mod. slow perm.	Slight
Shoals Sh	Severe: Subject to flooding	Severe: Subject to flooding
Sloan So	Severe: Subject to flooding	Severe: Subject to flooding
Westland Wu	Severe: Very poorly drained	Severe: Permeable substratum

TABLE 5-C
ESTIMATED DEGREE AND KINDS OF LIMITATIONS
FOR LAND USE PLANNING

Soil Series & Map Symbols	Lawns, Landscaping and Golf Fairways	Streets and Parking Lots
Alexandria AmF2	Severe: Slope	Severe: Slope
Blount BIA BIB	Moderate: Somewhat poorly drained Moderate: Somewhat poorly drained	Moderate: Somewhat poorly drained Moderate: Slope; somewhat, poorly drained
Eel Ee	Severe: Subject to flood	Severe: Subject to flooding
Fox FnB	Slight: Droughty	Moderate: Slope
Morley MrB MrB2 MrC, MrC2 MsC3 MrD, MrD2, MrE2, MsD3	Slight Slight Moderate: Slope Severe: Erosion hazard Severe: Slope	Moderate: Slope Moderate: Slope Severe: Slope Severe: Slope Severe: Slope
Ockley OcA OcB	Slight Slight	Slight Moderate: Slope
Pewamo Pw	Severe: Very poorly drained	Severe: Very poorly drained
Shoals Sh	Severe: Subject to flooding	Severe: Subject to flooding
Sloan So	Severe: Subject to flooding	Severe: Subject to flooding
Westland Wu	Severe: Very poorly drained	Severe: Very poorly drained

TABLE 5-D
ESTIMATED DEGREE AND KINDS OF LIMITATIONS
FOR LAND USE PLANNING

Soil Series & Map Symbols	Athletic Fields & Other Intensive Play Areas	Picnic & Extensive Play Areas
Alexandria AmF2	Severe: Slope	Severe: Slope
Blount BIA BIB	Severe: Slow permeability; Severe: Slow permeability	Moderate: Somewhat poorly drained Moderate: Somewhat poorly drained
Eel Ee	Slight	Slight
Fox FnB	Moderate: Slope	Slight
Morley MrB MrB2 MrC, MrC2 MsC3 MrD, MrD2, MrE2, MsD3	Moderate: Slope; mod. slow perm. Moderate: Slope; mod. slow perm. Severe: Slope Severe: Slope Severe: Slope	Slight Slight Moderate: Slope Moderate: Slope Severe: Slope
Ockley OcA OcB	Slight Moderate Slope	Slight Slight
Pewamo Pw	Severe: Very poorly drained; mod. slow perm.	Severe: Very poorly drained
Shoals Sh	Moderate: Somewhat poorly drained	Moderate: Somewhat poorly drained
Sloan So	Severe: Subject to flooding	Severe: Subject to flooding
Westland Wu	Severe: Very poorly drained	Severe: Very poorly drained

CLIMATE

The climate of the Muirfield Site is classified as Humid Continental (Long Summer phase) and is characterized by fairly well distributed rainfall throughout the year. Temperature and precipitation data for the site is given in Table 6.

Rainfall averages 17.32 inches in the 160-day growing season (May-September). Although precipitation is low in the winter, this is the recharge season when soil-moisture reserves are replenished because very little moisture is being used in plant growth.

In an average year, there are 101 clear days, 118 partly cloudy days and 146 cloudy days. Summer, the season of most sunshine, has 70% of its days sunny; cloudy days are most numerous in winter. Relative humidity averages about 50% on summer afternoons when the air is normally driest, but may fall below 30% on some days. Relative humidity is highest early in the morning and averages as high of about 80% for the year.

Central Ohio is so situated as to come under the influence of many cyclonic storms and the development of local disturbances, such as thunderstorms, hail storms, windstorms and heavy rainstorms, is favored. The heaviest rainfall and highest winds (up to 70 mph) usually accompany thunderstorms and the Muirfield location may expect an average of 40 to 50 such storms each year. Tornadoes are not unknown for central Ohio, but they are less frequent and cause less damage than those in the states farther west. Most of the tornadoes in Ohio are poorly developed and are in short, narrow paths. (Wright, 1957).

TABLE 6

CLIMATE DATA FOR MUIRFIELD SITE

MONTH	TEMPERATURE			PRECIPITATION		
	Average Daily Maximum (°F)	Average Daily Minimum (°F)	Ave Average (°F)	Average Monthly (Inches)	Average Days/w Snow on Ground	Average Snow Depth (Inches)
January	36.7	19.9	28.3	2.92	18	1.5
February	39.8	21.5	30.6	2.39	15	1.3
March	49.7	28.8	39.2	3.60	9	1.1
April	62.4	38.4	50.4	3.73	1	Trace
May	73.6	48.6	61.1	3.44	0	0
June	82.4	57.7	70.0	4.49	0	0
July	85.9	66.7	73.4	3.67	0	0
August	84.4	59.4	71.9	3.03	0	0
September	77.9	52.2	65.0	2.69	0	0
October	66.7	41.5	54.1	2.10	1	Trace
November	51.1	31.4	41.2	2.40	4	1.1
December	38.9	22.6	30.7	2.30	15	2.2
Year	62.5	40.8	51.4	36.76	62	1.5

Source: U. S. Weather Service, Delaware, Ohio
(period of record 1935-1965)

WATER QUALITY

Both water from bedrock wells and springs from the glacial till are characterized by high hardness and sulfates (Tables 7 and 8). Deer Run and the new lakes are considerably lower in these parameters (Table 8). Phosphorus is fairly low in the water except in the large lakes (Station 3) where fertilizer may have leached into the water. Some attached algae was noted on the boulders downstream from the lakes near the east edge of the property. This situation can be expected to persist and become more of a problem as the leaching process continues to supply nutrient for algal growth.

Iron springs, depositing rusty-brown iron oxide (limonite) have been found on both the north and south branches of Deer Run. The source of the limonite is probably the pyrite (iron sulfide, FeS) which occurs in the till and in minute grains in the limestone. Descending ground water, carrying air in solution oxidizes the pyrite to the soluble iron sulfate (FeSO_4), which is carried in solution to the point of exit where it is further oxidized and precipitated as the insoluble, rusty-brown limonite. Several filamentous bacteria have been found in the waters of iron springs and are believed to be instrumental in the precipitation of the limonite. (Westgate, 1926). At several places in the bed of Deer Run the limonite deposits are a few millimeters thick. At these places the stream appears to be devoid of macroscopic benthic or bottom dwelling organisms.

TABLE 7

CHEMICAL ANALYSIS OF BEDROCK WATER
FROM A WELL AT MUIRFIELD SITE¹

PARAMETER	CONCENTRATION
Alkalinity (total as CaCO_3)	414 ppm
Hardness (total as CaCO_3)	1200 ppm
Hardness (carbonate as CaCO_3)	414 ppm
Calcium (as CaCO_3)	750 ppm
Calcium (as Ca)	300 ppm
Magnesium (as CaCO_3)	450 ppm
Magnesium (as Mg)	109 ppm
Chlorides (as Cl)	7 ppm
Iron (as Fe)	1.9 ppm
Sulfates (as SO_4)	837 ppm
Sodium (as Na)	34 ppm
Solids (total)	1760 ppm
Specific Conductance	1400 umohs/cm
Phenol	negative

1. Well Data: located in southeastern portion of site, 500 feet east of Ashbaugh Road near cemetery at ground elevation of 940 feet; drilled in September 1967 to a depth of 215 feet, lower 104 feet in Columbus Limestone; test in September 1967 indicated well capable of 100 gpm pumping rate for 2 hours with a 11.3-foot drawdown from 33.0 to 44.3 feet below ground level; above water sample analysis by Burgess & Niple, Ltd., September 29, 1967.

TABLE 8

CHEMICAL ANALYSIS OF SURFACE WATER
AT MUIRFIELD SITE

PARAMETER	CONCENTRATION			
	SAMPLE STATION			
	1	2	3	4
Hardness (total as CaCO_3 , ppm)	1190	240	380	760
Hardness (carbonate as CaCO_3 , ppm)	700	150	260	460
Chloride (as Cl, ppm)	35	10	25	25
Sulfate (as SO_4 , ppm)	1200	124	380	850
Phosphate (ortho as PO_4 , ppm)	0.02	0.01	5.5	---
pH (units)	6.6	7.7	7.9	7.3
Turbidity (JTU)	38	7	6	38
Specific Conductance ($\mu\text{mhos/cm}$)	2600	510	800	1550

Test Data: Samples collected on July 8, 1973 and analyzed on July 10, 1973.

Station Location:

Sample 1. Spring near the south branch of Deer Run 600 feet west of Ohio Route 745 (Dublin Road).

Sample 2. Deer Run at relocation crossing of Ashbaugh Road 600 feet south of Glick Road.

Sample 3. At outlet to large lake 250 feet northwest of golf course fairway for hole no. 2.

Sample 4. At outlet to pond on north branch of Deer Run 200 feet northwest of Ohio Route 745 highway bridge.

RELATIONSHIPS OF PHYSICAL AND BIOLOGICAL COMPONENTS OF THE ENVIRONMENT

A dense forest covered Delaware and Franklin Counties when they were first settled in the late 1700's, but today woodlands occupy only about 5% of the total land area. At the present time woodland occurs as widely scattered, small woodlots. Generally, remnants of the original forest occupy small areas of soil that are least suited for other crops. These trees are generally in undrained areas of Pewamo and other seasonally wet soils such as the northwestern corner of the Muirfield Site. Other forested areas which have survived are in steep, shallow soil of the Morley series such as in ravines of Deer Creek.

The Muirfield Site is fortunate in that approximately 20% of its area is forested. In addition, Blount and Morley soils, which cover a majority of the site, have a high potential for successful reforestation. The climatic, topographic and hydrologic factors of the environment at the Muirfield Site also indicate that woodlands can be established at most locations in the area.

In considering plans for the residential development within woodlots or fringing golf courses it is important to recognize certain geologic and pedologic limitations of the terrain. Several of the tables presented in the soils section of this report can be useful in the degree of limitations to specific types of development within the site. In order to preserve the maximum natural plant life and wildlife the requirements of biological communities should take on the same importance as physical constraints.

RECOMMENDATIONS

One of the most severe limitations of this report is the lack of detailed soils information for the Franklin County portion of the site. Muirfield, Ltd. is encouraged to contact the U. S. Soils Conservation Service and request that soil mapping be conducted at the site. No attempt has been made to investigate hydrologic factors other than water quality and precipitation. The hydrology of Deer Run including flood potential and necessary runoff storage basins should be explored.

Monitoring Program

As development proceeds it seems essential that some form of environmental monitoring program be undertaken to document any ecological changes which may occur as a result of specific construction activities. Observation points should be established at several types of localities: (1) woodlots, (2) wooded and exposed ravines, (3) open fields (grass and shrub), (4) springs, (5) streams, (6) lakes and ponds and (7) wells. The types of observations, measurements and frequency of visitation will depend on the particular environmental situation and the degree of disturbance anticipated. The results of such a monitoring program will provide a guide to further development and also serve as a caution when an area is experiencing degradation. It should be designed to signal a warning in time so that corrective measures can be applied.

Nature Center Program

Because of the natural beauty of the Muirfield Site it seems appropriate that a nature center be established to stimulate an appreciation of this vanishing attribute and to provide education information on the preservation and enhancement of natural areas. Such a nature center could be affiliated with the local board of education and staffed by university students with assistantships in outdoor education. A wide range of educational and recreational activities could be developed in and around the Muirfield Site. These might include (1) nature trails, (2) trailside museum, (3) shelter and activities center, (4) plant and wildlife identification, (5) geology and fossil collection and (6) star watching.

This program will have important benefits to the Muirfield community as a whole by stimulating a greater interest in the natural environment on the part of all the inhabitants. This interest should be easily translated in greater care and concern for protecting these woodlands and streams that add so much beauty to the community.

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