Ground Water Report W 21

1964

Hydrology of the New Oxford Formation in Adams and York Counties, Pennsylvania

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF INTERNAL AFFAIRS
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BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
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BULLETIN W21

Hydrology of the New Oxford Formation in Adams and York Counties, Pennsylvania

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Prepared by the United States Geological Survey, Ground Water Branch, in cooperation with the Pennsylvania Geological Survey

PENNSYLVANIA GEOLOGICAL SURVEY
FOURTH SERIES
HARRISBURG

1964

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ABSTRACT

The New Oxford Formation, of Late Triassic age, occupies a belt 3 to 5 miles wide that crosses Adams and York Counties in a northeasterly direction from the Maryland-Pennsylvania border, southeast of Gettysburg, to the Susquehanna River at York Haven, Pa.

Ground water in the formation occurs in two major units: (1) the regolith, or unconsolidated weathered rock mantle, which forms the land surface in much of the area, and (2) the hard, relatively unweathered bedrock beneath the regolith.

Ground water in the regolith occurs chiefly under water-table conditions in intergranular openings. In most places, the regolith is poorly permeable because of the high clay content derived chiefly from the weathering of mudstone and shale. Nevertheless, it can absorb relatively large amounts of precipitation and runoff and transmit the water to underlying rocks. Where it has sufficient saturated thickness, the regolith functions as a reservoir that yields water to shallow wells.

Ground water in the bedrock part of the formation occurs under both water-table and artesian conditions in fractures formed as a result of geologic stresses and, in some places, enlarged by the action of various weathering processes. The fractures occupy only a small part of the total volume of the rocks, but they function as reservoirs of small storage capacity and as pipes or conduits that transmit water from recharge areas to points of discharge. The permeability of the bedrock is determined largely by the number, extent, interconnection, shape, and size of the crevices.

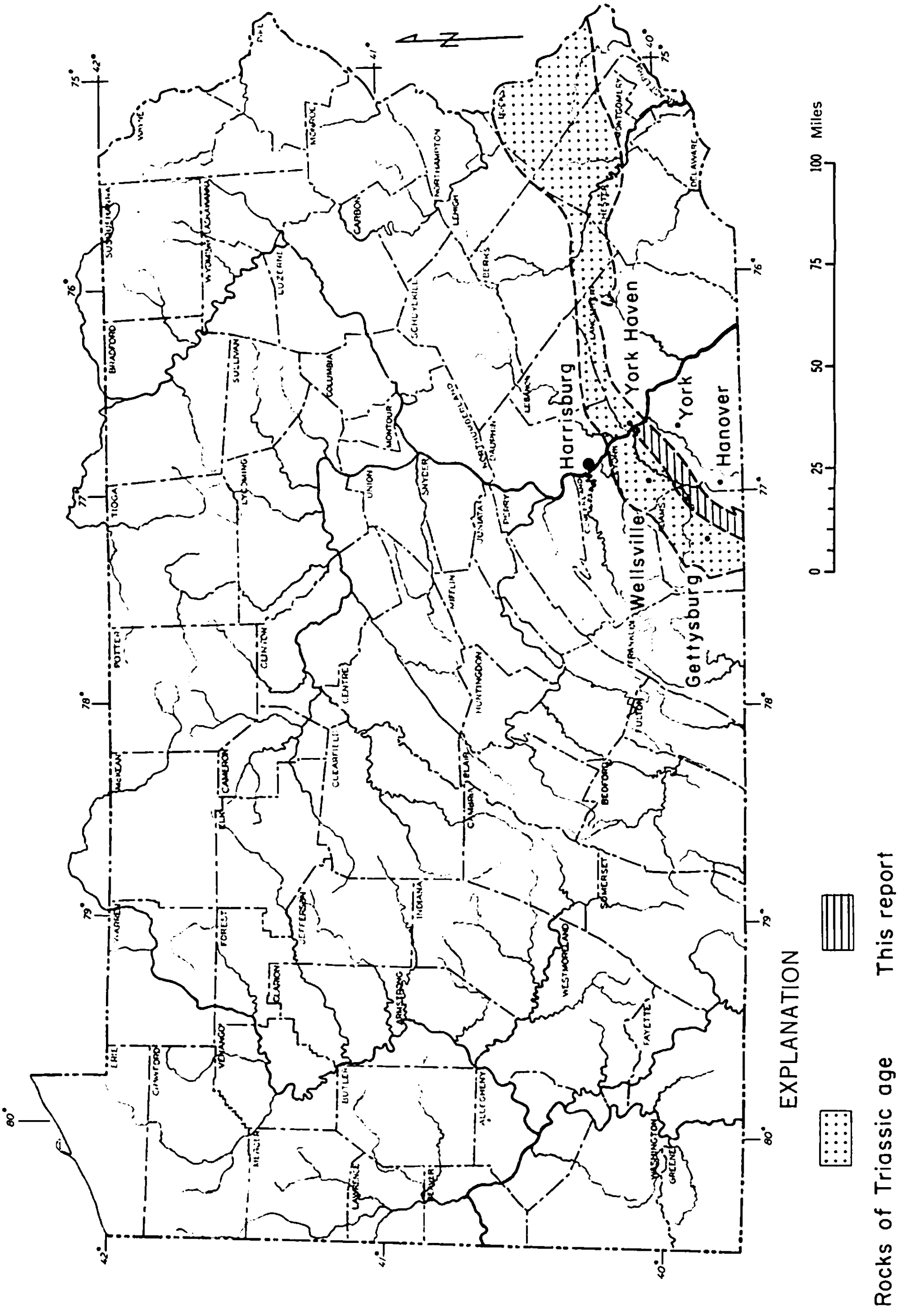
The depths of drilled wells, which produce most of the ground water used in the area, range from 31 to 1,005 feet, and the yields range from a fraction of a gallon to about 200 gpm (gallons per minute). Sixty percent of the wells, however, have depths ranging from 75 to 150 feet, and only 20 percent have depths greater than 150 feet. The yields of about 70 percent of the wells are 10 gpm or less, and only 15 percent have yields in excess of 20 gpm.

The chemical character of both ground and surface water is generally satisfactory for most purposes. However, in many places treatment for hardness may be desirable. Locally the water from wells may be mildly corrosive or contain objectionable concentrations of iron or nitrate.

INTRODUCTION

Purpose of this Investigation

The purpose of the ground-water investigation on which this report is based was to evaluate the New Oxford Formation as a source of ground water. The investigation was begun in April 1960 as a part of the continuing study of the ground-water resources of Pennsylvania being made by the U. S. Geological Survey in cooperation with the Pennsylvania Topographic and Geologic Survey. This report, the first of two planned for this investigation, is concerned with the part of the formation that is west of the Susquehanna River in Pennsylvania. (See Fig. 1.)


Harrisburg
York Haven
York
Hanover
Wellsville
Gettysburg
0
25
50
75
100 Miles
EXPLANATION
Rocks of Triassic age
This report

Scope and Methods of Study

During the investigation that led to this report, minor revisions were made to existing geologic maps, and studies were made of the effects of topography, structure, and stratigraphy on ground-water occurrence and movement. The subsurface geology was interpreted by means of geologic sections, information furnished by well drillers, and data obtained through the use of geophysical well-exploration equipment.

Hydrologic studies included an inventory of domestic, industrial, and municipal wells, controlled pumping tests of selected wells, and evaluations of water-level fluctuations, precipitation records, and water-use data.

During the well inventory, pertinent well-construction data were collected, water levels were measured, and the pH, hardness, temperature, and electrical conductivity of the water were determined. The records of 318 wells are assembled in Table 4, and the locations of the wells are shown on Plate 1.

The chemical analyses in Table 7 were made by the U. S. Geological Survey.

The geologic map (Pl. 1) was compiled by the senior author from published sources. In places the locations of diabase dikes were modified on the basis of field observations and aerial photographs.

The hydrologic properties of the formation were determined by means of single-well pumping tests at 45 wells.

Previous Investigations

Most of the literature, published and unpublished, that pertains to the Triassic rocks of southeastern Pennsylvania was briefly annotated by Cramer (1961) in his bibliography of Pennsylvania geology.

The Triassic rocks in Adams County were described by Stose (1932) in a report on the geology and mineral resources of the county, and by Stose and Bascom (1929) in a report on the geology of the Fairfield and Gettysburg quadrangles. In the report on the Fairfield and Gettysburg quadrangles, Stose and Bascom divided the Triassic rocks into two units, which were named the Gettysburg Shale and the New Oxford Formation.

Reports including a description of the Triassic rocks of York County were published by Stose and Jonas (1933, 1939) and by Stose and Stose (1944).

Ground-water conditions in Adams and York Counties were described briefly by Hall (1934) in a report on the ground water of southeastern Pennsylvania. That report, which was based on field work done during the summer of 1925, contained a description of the occurrence of ground water in the Triassic rocks and some information on wells penetrating the New Oxford Formation.

Acknowledgments

The writers are grateful to the residents, well drillers, borough officials, and private companies who cooperated and assisted in the collection of field data used in this report.

A special debt of gratitude is owed to those individuals who permitted the use of geophysical well-logging equipment in their wells and to those who generously allowed use of their wells for pumping tests designed to determine the capacity of the water-bearing materials to store and transmit water.

Well-numbering System

The well-numbering system used in this report shows the locations of wells and springs according to the latitude and longitude system illustrated in Figure 2.

The latitude and longitude system consists of a statewide grid of 1-minute parallels of latitude and 1-minute meridians of longitude. Wells in a 1-minute quadrangle are numbered consecutively in the order inventoried. For example, in the number 951-703-2, which was assigned to a well near New Oxford in Adams County, the first segment (951) is composed of the last digit of the degrees (39) and the two digits of the minutes (51) that define the latitude on the south side of a 1-minute quadrangle; the second segment (703) consists of the last digit of the degrees (77) and the two digits of the minutes (03) that define the longitude on the east side of a 1-minute quadrangle; and the last segment (2) indicates the consecutive number assigned to the well as it was inventoried. (See Fig. 2.)

GEOGRAPHY

Location, Topography, and Drainage

The part of the New Oxford Formation investigated in this study occupies a belt 3 to 5 miles wide that crosses Adams and York Counties in a northeasterly direction from the Maryland-Pennsylvania border southeast of Gettysburg to the Susquehanna River at York Haven. (See Fig. 1.)

In general, the surface of the formation is a gently rolling erosional plain that is characterized by broad shallow valleys and low ridges, which trend more or less parallel to the strike of the sedimentary rocks.

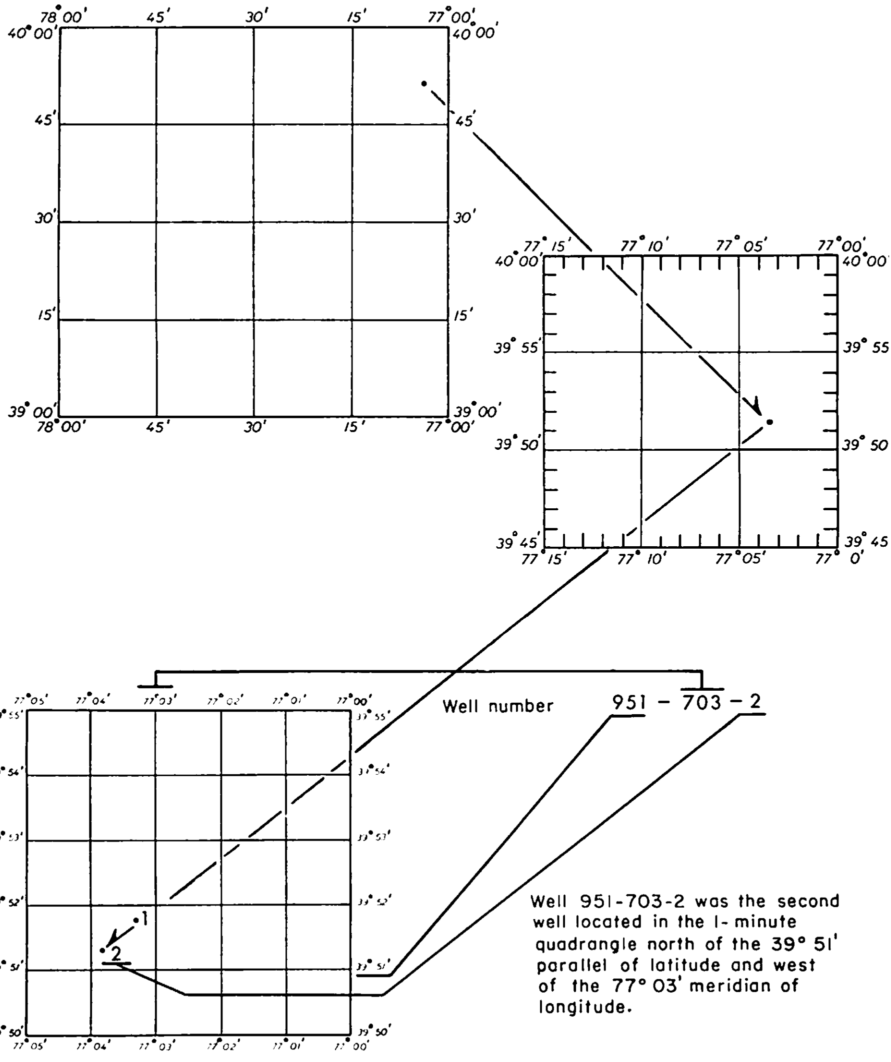


Figure 2. Explanation of the well-numbering system used in Pennsylvania since 1960.

In Adams County the New Oxford Formation crosses an indistinct northwest-trending divide (Pl. 1) that separates the drainage systems of the Susquehanna and Potomac Rivers in this area.

South of the drainage divide, the formation is drained chiefly by Alloway Creek, which empties into the Monocacy River—a major stream in the Potomac River drainage system.

North of the drainage divide, streams draining the formation join Conewago Creek, which carries most of the runoff from the Triassic rocks in Adams and York Counties. Conewago Creek empties into the Susquehanna River at York Haven. Major tributaries include South Branch, which drains much of the New Oxford Formation in Adams County before joining the main stream 2¼ miles north of New Oxford, and Little Conewago Creek, which together with its tributaries drains much of the formation in York County before joining the main stream near York Haven.

CLIMATE

The climate of Adams and York Counties is characterized by long, warm summers, short, cool winters, and a frost-free period of about 175 days. Precipitation data from five stations of the U. S. Weather Bureau in or near the area of investigation are summarized in Table 1, and the locations of the stations mentioned in the text are shown on Figure 1.

Table 1 shows that the average annual precipitation is approximately 40 inches, and that it is rather evenly distributed throughout the year.

The average temperatures at three stations near the area of investigation are summarized in Table 2.

Table 1. Average monthly and annual precipitation, in inches, at five stations in Adams and York Counties, Pa.

(Data from U. S. Weather Bureau annual summaries)

Month	Gettysburg (1839-1960)	Hanover (1904-1960)	Wellsville (1946-1958)	York, 3SSW (1888-1960)	York Haven (1921-1960)
January	3.05	3.09	2.49	3.01	2.73
February	2.69	2.65	2.36	2.68	2.42
March	3.38	3.44	3.16	3.35	3.24
April	3.61	3.52	3.47	3.31	3.48
May	3.95	3.65	4.23	3.73	3.93
June	3.79	3.86	3.51	3.74	3.96
July	3.90	4.16	3.82	4.08	3.90
August	4.02	4.20	4.11	4.28	3.76
September	3.39	3.08	2.65	3.32	3.15
October	3.24	3.07	2.75	3.16	3.23
November	2.78	2.63	3.44	2.77	2.65
December	3.12	3.06	3.22	2.91	2.78
Average annual	41.01	40.41	39.82	40.34	39.23
	[1]82	[1]56	[1]9	[1]73	[1]37

[1] Number of years' record used to compute average annual precipitation.

Table 2. Average temperatures, in degrees Fahrenheit, at three stations in Adams and York Counties, Pa.

(Data from U. S. Weather Bureau annual summaries)

Month	Gettysburg (1839 1960)	Hanover (1904 1961)	York, 3SSW (1898 1960)
January	30.6	32.5	31.1
February	32.0	33.1	32.4
March	40.5	41.6	41.0
April	51.8	52.4	51.7
May	61.7	63.0	62.1
June	70.4	71.2	70.7
July	74.7	75.6	74.9
August	72.6	73.3	73.0
September	66.0	67.2	66.6
October	54.1	55.7	54.8
November	44.6	44.7	43.6
December	34.0	34.2	33.5
Average annual	52.9	53.7	53.0
	[1]82	[1]56	[1]62

[1] Number of years' record used to obtain average monthly and annual temperatures.

GEOLOGY

Triassic System

Rocks of Triassic age in the East Coast region of the United States are exposed in a series of disconnected downfaulted basins that trend mainly northeastward from South Carolina to Massachusetts. Throughout this area, most of the exposed sedimentary rocks of Triassic age are red in color, exhibit similar lithologic, paleontologic, stratigraphic, and structural relationships, and show abundant evidence of their continental mode of origin. The structural framework in which the rocks were deposited consisted of narrow, elongate troughs, which are bounded along one side by steeply dipping faults. In many of the troughs the sedimentary rocks have been intruded by dikes and sills of diabasic composition, and in places the upper strata are interbedded with thick basalt flows.

Because of the similarities referred to above, all the exposed sedimentary rocks and interbedded lava flows of Triassic age in the eastern part of the United States have been designated as the Newark Group, for exposures at and around Newark, N.J. The intrusives also are of Triassic age, but because they are not conformable with the stratified rocks they are not included as part of the Newark Group, and are—at least in part—of later origin (Barksdale and others, 1958, p. 78).

The rocks of the Newark Group are considered to be of Late Triassic age (McLaughlin, 1959, p. 56-59). They rest with profound unconformity on the deeply eroded edges of deformed igneous and metamorphosed rocks of Precambrian and Paleozoic ages and show no effects of the structural deformation that occurred at the end of the Paleozoic Era. On the other hand, the Newark Group is distinctly older than the Cretaceous rocks that overlap it, because rocks of the Newark Group were intruded by diabase, were faulted and tilted, and then deeply eroded before being overlain by Cretaceous rocks.

The Newark Group and associated intrusives in Pennsylvania occupy part of an elongate Triassic basin that extends from southeastern New York across New Jersey, southeastern Pennsylvania, and central Maryland, into northern Virginia.

West of the Susquehanna River, in Pennsylvania, the rocks of the Newark Group dip northwestward at an average angle of 25°. The rocks were deposited in a nearly horizontal position but were tilted northwestward by progressive sinking of the floor of the Triassic basin and downfaulting of the northwest margin of the basin. The total thickness of the Newark Group, as computed from the dip of beds and width of outcrops, is about 16,000 feet in York County (Stose and Jonas, 1939, p. 108) and about 23,000 feet in Adams County (Stose and Bascom, 1929, p. 9). The sediments were deposited first in the southeastern part of the basin, but the basin was deepened by the gradual sinking of the floor on the west side, and later deposits spread progressively farther west, overlapping earlier sediments. Hence, only a fraction of the total thickness of the Newark Group should be encountered at any one place.

In Adams and York Counties the Newark Group is divided into a lower sandy and arkosic unit, termed the New Oxford Formation, and an upper shaly unit, termed the Gettysburg Shale (Stose and Bascom, 1929, p. 8). This broad division of the Newark Group into two formations can be recognized northeastward to Berks County, in eastern Pennsylvania, and southwestward into Maryland. The New Oxford Formation and the Gettysburg Shale correspond approximately with the Stockton and Brunswick Formations, respectively, of eastern Pennsylvania and New Jersey.

New Oxford Formation

The following discussion of the geology of the New Oxford Formation is taken largely from Stose and Bascom (1929), Stose (1932), Stose and Jonas (1939), and Stose and Stose (1944).

Name, distribution, and topographic expression

The New Oxford Formation was named for the borough of New Oxford, Adams County, where the rocks of Triassic age in southern Pennsylvania were first studied in detail and their thickness determined (Stose and Bascom, 1929). In Adams and York Counties the formation occupies a belt 3 to 5 miles wide that extends northeastward from the Maryland-Pennsylvania border southeast of Gettysburg to the Susquehanna River at York Haven (Pl. 1).

The north (or upper) boundary of the formation, which is not easily identified, is based on lithologic evidence and in most places approximately parallels the strike of the beds. The south (or lower) boundary is somewhat irregular. In most places it is easily recognized because of abrupt changes in rock types, soil colors, and topography. From the State line southeast of Gettysburg to the west end of the Pigeon Hills, the south boundary of the formation is marked by a low but prominent ridge that trends N. 30° E. and lies 40 to 100 feet above a lowland underlain chiefly by limestones and dolomites of Cambrian and Ordovician age. From the west end of the Pigeon Hills to a point near West York the outcrop of the New Oxford Formation trends generally N. 50° E. Northeastward, between West York and the Susquehanna River, the south boundary of the formation trends N. 35° E. Along the north side of the Pigeon Hills the New Oxford Formation rests on Cambrian quartzite and Precambrian metabasalt. East and northeast of the Pigeon Hills the south edge of the Triassic rocks is marked by a sinuous line of low hills and discontinuous ridges that rise 20 to 80 feet above a lowland underlain by easily eroded limestone and dolomite of Cambrian age.

The New Oxford Formation underlies a gently rolling plain that is characterized by broad, shallow valleys and low, flat-topped ridges. The ridges range in altitude from 400 to 640 feet above msl (mean sea level), and in most places approximately parallel the strike of the beds. Near the base of the formation, at Littlestown, Irishtown, eastward along the north side of the Pigeon Hills to a point near Thomasville, and south of the borough of Mount Wolf, beds of hard sandstone and conglomerate form distinct but discontinuous ridges that rise slightly above the general surface of the plain.

The diabase dikes that cut across the formation (Pl. 1) have no discernible topographic expression. They can be traced by residual rounded fragments, or balls of "ironstone," in the soil.

Character and thickness

The New Oxford Formation consists of red to purplish-red sandstone, shale, mudstone, light-colored arkosic sandstone, and conglomeratic sandstone. The beds of arkosic sandstone, which are the characteristic feature of the formation, are composed of grains of glassy quartz, white kaolinized detrital feldspar, and flakes of mica. Some of the beds contain rounded pebbles of quartz that range from less than 1 inch to as much as 3 inches in greatest diameter. Weathered outcrops of the arkosic sandstone commonly are yellowish gray or tan. Fresh exposures are light gray to greenish yellow or medium gray.

The beds of light-colored sandstone, arkosic sandstone, and conglomeratic sandstone are most common in the lower 3,000 feet of the formation. Beds of conglomerate also are most numerous near the base of the formation. A coarse conglomerate, consisting chiefly of subangular to subrounded quartzose cobbles and boulders in a poorly sorted red sand matrix, occurs at the base of the formation along the north side of the Pigeon Hills and on the north side of a group of hills southeast of Mount Wolf. In both areas the basal conglomerate is tightly bonded by red clayey material in the matrix and by ferruginous and siliceous cements.

In a few places, small outcrops of limestone conglomerate were observed at or near the contact with rocks of Paleozoic age.

Beds of conglomerate stratigraphically above the basal conglomerate consist chiefly of moderately rounded quartzose pebbles whose average diameter is about 1 inch. In most places the conglomerates contain interbeds of red sandstone or shaly red sandstone that range in thickness from less than 1 foot to about 3 feet.

The upper 4,000 feet of the formation consists largely of micaceous red mudstone, red shale, and soft red sandstone containing scattered beds of light-colored sandstone and arkosic sandstone.

According to Stose (Stose and Jonas, 1939, p. 114), the total thickness of the formation near the Susquehanna River is about 5,900 feet.

The upper boundary of the New Oxford Formation is placed where beds of light-gray arkosic sandstone end or become scarce and beds of red shale and soft red sandstone become prevalent. Such a boundary must be arbitrarily drawn in places and probably is not at the same stratigraphic horizon throughout the area, because the beds of arkosic sandstone are not clearly definable in many areas. The upper boundary as shown on Plate 1 is based on lithologic evidence and, in most places, approximately parallels the strike of the beds—trending N. 30° E. in the area between the Pennsylvania-Maryland line and New Oxford and N. 50° E. in the area between New Oxford and the Susquehanna River.

Structure

Beds in the New Oxford Formation dip to the northwest at an average angle of 25°, although the dip ranges from about 10° to 40°. According to Stose (1932, p. 86–87), the rather uniform monoclinal dip was produced partly by tilting of the deposits as the floor of the Triassic basin sank gradually beneath the weight of the accumulated sediments and partly by downfaulting along the western margin of the basin.

The extent of faulting within the formation is difficult to evaluate, because of the absence of easily recognizable mappable beds and the scarcity of outcrops.

The southeast border of the New Oxford Formation is offset by transverse faults in several places. The faults not only offset structures in the older rocks but extend into the New Oxford Formation.

Joints are common in outcrops of the New Oxford Formation. The most frequently occurring set of joints is approximately parallel to the strike of the beds and dips 70°–80° to the southeast. One prominent set of joints strikes N. 70°–85° E., and another set strikes roughly north-south (N. 20° E. to N. 20° W.); both of these sets dip vertically or steeply to either side of the strike.

Several narrow diabase dikes have intruded the New Oxford Formation. In most places the dikes strike a little east of north—approximately parallel to transverse faults that offset beds in the lower part of the New Oxford and to dikes of similar composition that have intruded rocks of Paleozoic age south of the New Oxford.

Water-bearing properties

The New Oxford Formation in Adams and York Counties does not yield large amounts of water to wells. Many drilled wells and some dug wells obtain enough water from the rocks for domestic and farm use, but only a few wells are known to yield as much as 100 gpm.

With respect to the occurrence and availability of ground water, the formation may be divided into the regolith, or unconsolidated weathered rock mantle, and the hard, relatively unweathered bedrock beneath the regolith.

Ground water in the regolith occurs chiefly in intergranular openings formed as a result of weathering processes. In most places, the regolith is poorly permeable because of the high percentage of clay derived from the weathering of mudstone and shale.

Ground water in the bedrock part of the formation occurs chiefly in joints and fractures formed as a result of geologic stresses. Accordingly, the success of a well depends principally on the number and size of the openings it encounters and the degree of interconnection between the openings.

Diabase

Diabase, an igneous rock of basaltic composition, has intruded the New Oxford Formation, in several places. The diabase in the upper part of the formation at York Haven (see Pl. 1) is part of an extensive intrusive body, called the York Haven sill. The sill and associated igneous rocks were described in considerable detail in a report by Stose and Jonas (1933, p. 41–44).

The narrow, steeply dipping diabase dikes that have intruded the New Oxford Formation are closely related to a large group of dikes of similar composition that have intruded Paleozoic rocks south of the Triassic border. In most places the dikes do not have any distinct topographic expression, and hence they were mapped chiefly on the basis of the distribution of rounded rust-covered cobbles and boulders of diabase at the land surface.

The lithology of the diabase in the dikes is remarkably uniform from place to place. The rocks have an ophitic or subophitic texture and contain approximately equal amounts of labradorite and augite, which are the predominant minerals.

The dikes probably do not greatly affect the occurrence or movement of ground water in the New Oxford Formation except perhaps in the regolith. Springs are common in ravines, draws, and other depressions crossed by the dikes, probably because the nearly impermeable dikes form underground dams that impound ground water moving downgradient through the regolith. The springs formed by ground water escaping over the bedrock surface of the dikes may provide sufficient quantities of water to meet rural domestic and stock requirements but they should not be depended upon for larger supplies because of the low permeability and small storage capacity of the regolith.

QUATERNARY SYSTEM

Deposits of Quaternary age include terrace deposits, at one or more levels along the larger streams, and alluvium that covers the flood plains of all except the smallest streams.

Terrace deposits

Terrace deposits along Conewago Creek were mapped and described by Stose and Bascom (1929, p. 11) and Stose and Jonas (1939, p. 135). The terrace deposits are composed chiefly of rounded quartz pebbles in a matrix of silty red sand. The pebbles average less than 1 inch in diameter but may reach as much as 4 inches.

The terrace deposits are thin and of small lateral extent, and in most places they are not saturated with water. Hence, they are not a source of ground-water supply.

Alluvium

Alluvium covers the flood plains of all except the smaller streams, but in most places it was not mapped because of its small lateral extent.

Alluvium along the west side of the Susquehanna River southeast of York Haven (Pl. 1) ranges from less than 1 foot to about 30 feet in thickness and consists chiefly of a chaotic assortment of gravel, sand, and silt containing waterworn boulders 6 feet or more in diameter.

Information obtained from test borings made by the Pennsylvania Power and Light Co., during construction of the Brunner Island Steam Electric Station, indicates that the alluvium was deposited on a relatively flat surface. It indicates also that only 1 to 15 feet of the alluvium is saturated with water. Hence, this body of alluvium is a poor source for large supplies of water.

The alluvium exposed on the flood plains of streams draining the New Oxford Formation is composed chiefly of rounded fragments of sandstone, quartz, and chert in a matrix of red-brown sand and silt. In most places these alluvial deposits are thin, of small lateral extent, and not a reliable source of ground water.

GROUND-WATER HYDROLOGY

General Hydrologic Principles

Most of the rocks that form the earth's crust contain openings that may contain water. The ratio of the openings in a rock unit to the total volume of the rock is called the porosity of the rock, and it is usually expressed as a percentage.

Unconsolidated rocks are said to have primary porosity because they contain interconnected openings between the grains of the rocks. Consolidated rocks, on the other hand, have lost much of their primary porosity because of compaction and cementation. They may, however, contain secondary openings along planes of bedding and foliation, and along joints and faults. In many consolidated rocks, these secondary openings have been enlarged appreciably by solution and other destructive weathering processes.

The capacity of a rock material to yield water to wells is determined by its permeability, or ability to transmit water under a hydraulic gradient. The permeability is governed chiefly by the number, size, shape, and degree of interconnection of the primary and secondary openings. Thus, a rock consisting of silt or clay may have a high porosity, but because of the small size of the interstices it may have a very low permeability. In sand or gravel, however, the larger openings allow water to move freely and the permeability is high. Because the primary porosity of the consolidated sedimentary rocks has been reduced by compaction and cementation, their permeability may depend principally on the size, extent, and degree of interconnection of the secondary openings in the rocks.

Ground water is the subsurface water in the zone of saturation—the zone where all the voids in the rock are filled with water under pressure greater than atmospheric. Rock that is capable of yielding water to wells in sufficient quantity to be important as a source of supply is called an aquifer (Meinzer, 1923a, p. 52).

Water in an aquifer may occur under either water-table conditions or artesian conditions. Water-table conditions exist where the upper surface of the zone of saturation is not confined and is free to fluctuate in response to recharge to or discharge from the aquifer. The upper surface of the zone of saturation under these conditions is called the water table and is considered to be coincident with the level at which water will stand in a well that taps the aquifer.

Artesian conditions exist where water in an aquifer is confined under hydrostatic pressure by relatively impermeable beds. When such an aquifer is tapped by a well, the confined water rises some distance above the top of the aquifer to a point on the piezometric surface of the aquifer in which the well is completed. The piezometric surface is an imaginary surface to which water from a given aquifer will rise in cased wells that tap the aquifer. In areas of artesian flow the piezometric surface is above the land surface.

Modifications of simple water-table conditions exist when an aquifer is partially confined and reflects characteristics common to both artesian and water-table aquifers. Also, water-table conditions in an artesian aquifer may be created locally when pumping or natural discharge causes a decline of the piezometric surface to a level below the top of the aquifer.

Occurrence, Recharge, Movement, and Discharge

The occurrence of ground water in the area underlain by the New Oxford Formation is controlled largely by geology, topography, and climate. The principal source of ground water in the area is precipitation that falls within the area. However, not all the precipitation that falls within the drainage area reaches the ground-water body; some returns to the atmosphere by evaporation and by the transpiration of plants, and some runs off the land surface into streams. A part of the water that becomes surface runoff may reach the ground-water body by downward percolation from the streams, although that is not common in this area. The water that reaches the water table percolates downward and laterally, down the hydraulic gradient, from areas of replenishment to areas of discharge. In the discharge areas some of the water is lost by evapotranspiration and the rest seeps into streams or other bodies of surface water.

Regolith

The regolith, or unconsolidated, weathered rock mantle, underlies the land surface throughout most of the area. It constitutes a water-bearing zone that is the direct source of ground water for practically all the dug wells in the area and indirectly is the source of water for most of the drilled wells. The regolith absorbs precipitation readily, thus increasing the opportunity for recharge to the underlying bedrock, and supplies water to shallow dug wells.

The regolith ranges from a few inches to more than 50 feet in thickness. Its thickness is a function of the rate of weathering of the bedrock and the rate of erosion of the weathered material. The predominance of one factor over the other determines whether relatively unweathered bedrock crops out or whether a thick weathered zone exists. The depth of weathering, on the average, is greater beneath the low, flat-topped ridges and gentle slopes than beneath the draws and valleys where erosion is accelerated by surface runoff. Many of the perennial streams flow over relatively fresh, hard rock.

Recharge to the regolith is derived from local precipitation, and water in the regolith occurs generally under water-table conditions. The amount of water recharged is determined by the duration and intensity of precipitation, the rate of snowmelt, the permeability of the soil, the type and density of vegetation, the degree or intensiveness of cultivation, soil-moisture conditions, rates of evaporation and transpiration, and the topography.

Within the zone of saturation ground water moves down the hydraulic gradient. In broad view, it moves down the slope of the water table from areas of recharge to points of discharge. In detail, however, the movement of water is very complex, because of the heterogeneity of rock materials and the differences in permeability.

The water table in the regolith is a subdued replica of the surface topography. Hence, ground water moves downward and laterally from the hills to the valleys. (See Fig. 3.) Ground water is discharged from the regolith chiefly through springs, by seepage into streams, by evaporation and transpiration, by subsurface movement into underlying rocks, and by pumping from wells.

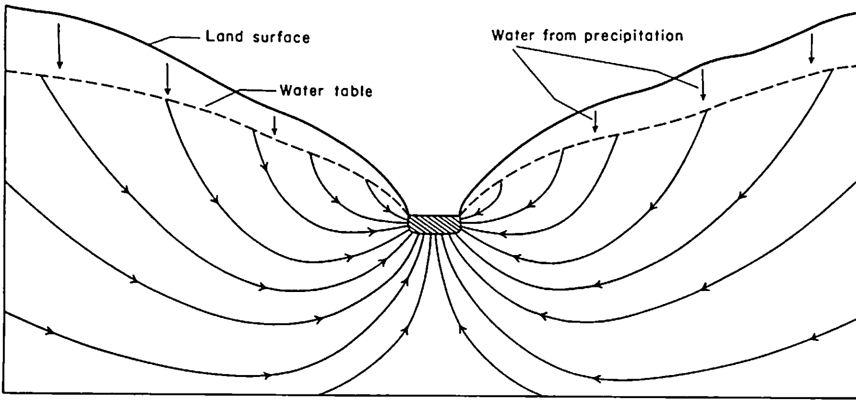


Figure 3. Schematic diagram showing the general pattern of ground-water flow into a stream.

Evaporation and transpiration affect recharge to and discharge from the ground-water reservoir. Much of the water derived from precipitation is lost by evapotranspiration before it reaches the ground-water reservoir. Some water is lost by evapotranspiration after it reaches the zone of saturation, particularly in stream valleys where the water table is close to the land surface and vegetation is dense.

A part of the total runoff of streams is ground-water discharge. During periods of little or no rainfall the flow of streams draining the area underlain by the New Oxford Formation is almost exclusively ground-water discharge.

Bedrock

In this discussion the term "bedrock" refers to the hard, relatively unweathered rocks that lie beneath the regolith in Adams and York Counties. The bedrock part of the formation is composed of beds of shale, mudstone, fine-grained siliceous sandstone, arkosic sandstone, and conglomeratic sandstone. In most places the bedding is so lenticular and erratic that single beds cannot be traced for any appreciable distance.

The primary porosity of the bedrock is very low because of compaction and cementation of the rock. Hence, it is unlikely that wells obtain any significant quantities of water from openings of primary origin. Most of the water obtained from wells in the bedrock is believed to come from secondary openings formed by earth stresses and destructive weathering processes. The most important of these openings are those developed along joint planes, bedding planes, and faults.

In areas where the water table is below the bedrock surface the bedrock above the water table (in the zone of aeration) may contain numerous fractures that have been enlarged by various weathering processes. Weathering results chiefly from exposure to the air or to the action of substances derived from the air, the most important of which are water, oxygen, and carbon dioxide.

The openings formed as a result of the various weathering processes tend to be fewer below the water table, as the weathering processes are not as active in the zone of saturation as in the zone of aeration. Below the water table the openings of greatest importance as sources of ground water are those developed along joints. The joints may be only a few inches apart, or they may be a few feet or even tens of feet apart. Above the water table the joints may form wide open fissures several inches wide, but within the zone of saturation the same joints may decrease rapidly in width from about an inch at the water table to a small fraction of an inch a few tens of feet below the water table.

Where there is free circulation of water through intersecting joints the openings may be enlarged as a result of the decomposition and disintegration of mineral constituents in the walls of the fractures.

The openings formed along joint planes and other fracture surfaces constitute reservoirs of small storage capacity, and they serve as conduits that transmit water from areas of recharge to points of discharge. Because of this, the permeability of the bedrock is determined largely by the number, continuity, interconnection, and size of the fractures.

Although ground water may occur under water-table conditions in the bedrock, it generally is confined within fractures and is therefore considered to be artesian.

Recharge to the ground-water reservoirs in the bedrock is accomplished by direct infiltration of precipitation in areas where the regolith is thin, or by percolation from the saturated regolith.

The movement of ground water in the bedrock is similar to the movement of ground water in the regolith, in that water moves downward from points of recharge in interstream areas to points of discharge along the valleys and streams. However, the pattern of flow is different because most of the water in the bedrock moves in angular paths along fractures. The pattern of flow is complicated also by the characteristic decrease in permeability of the bedrock as the depth increases.

Water-level Fluctuations

Records of water-level fluctuations in wells are useful tools for determining the availability of ground water, because the water level fluctuates in response to changes in the ground-water regimen. The rise or decline of this surface depends upon the relation between recharge into and discharge from the ground-water reservoir. Where withdrawal exceeds inflow the water level declines, and conversely, where inflow exceeds withdrawal the water level rises. Thus, the fluctuation of water levels in wells is an index to the inflow and outflow of water from a ground-water reservoir, just as the fluctuation of the water level in a surface reservoir indicates the amount of water in it.

In order to determine the character and magnitude of the water-level fluctuations in the New Oxford Formation, automatic recorders were installed on eight wells ranging from 11 to 910 feet in depth. The period of record at individual wells ranged from a few days to about 18 months. In addition, monthly measurements of the depth to water in about 60 wells were made between August 1960 and March 1961. These measurements were then discontinued, because the records obtained by the water-level recorders were adequate for defining the type of fluctuations that occur in the formation.

The hydrographs in Figure 4 show typical seasonal fluctuations. Factors such as evaporation, transpiration, or delay in recharge (due to frozen ground or to retention of precipitation in the form of snow) may affect the position of the water table temporarily. Abnormal changes in the pattern of fluctuations generally can be explained by unusual fluctuations in the amount or distribution of rainfall.

Well 951-705-2 (see Fig. 4) shows the largest seasonal fluctuation. It is an unused, large-diameter, dug well on a low, flat-topped ridge near New Oxford, Adams County, and obtains its water supply from the regolith. Wells 946-709-1 and 003-645-1 are drilled wells that obtain water from the bedrock part of the formation. Well 946-709-1 is in a cultivated field near Germantown, Adams County, and well 003-645-1 is in a shallow valley near Zions View, York County. Water levels in these three wells decline during the summer and early fall, even though the precipitation is fairly high. The rate of recharge during the summer months is low because evaporation and transpiration losses are high and much of the rainfall occurs in short, heavy showers that result in high surface runoff. In the winter months the vegetation is dormant, and precipitation is generally slower and steadier than it is in the summer months. The rate of recharge is therefore relatively high in the winter, and water levels rise as the ground-water reservoir is filled.

The hydrograph of well 956-659-3 (Fig. 5) shows how a bedrock aquifer responds to the pumping of a nearby municipal well. The pumped well (956-659-4) and the observation well (956-659-3), which are owned by the Borough of East Berlin, Adams County, are about 200 feet apart, at opposite ends of an old brick-lined reservoir on a

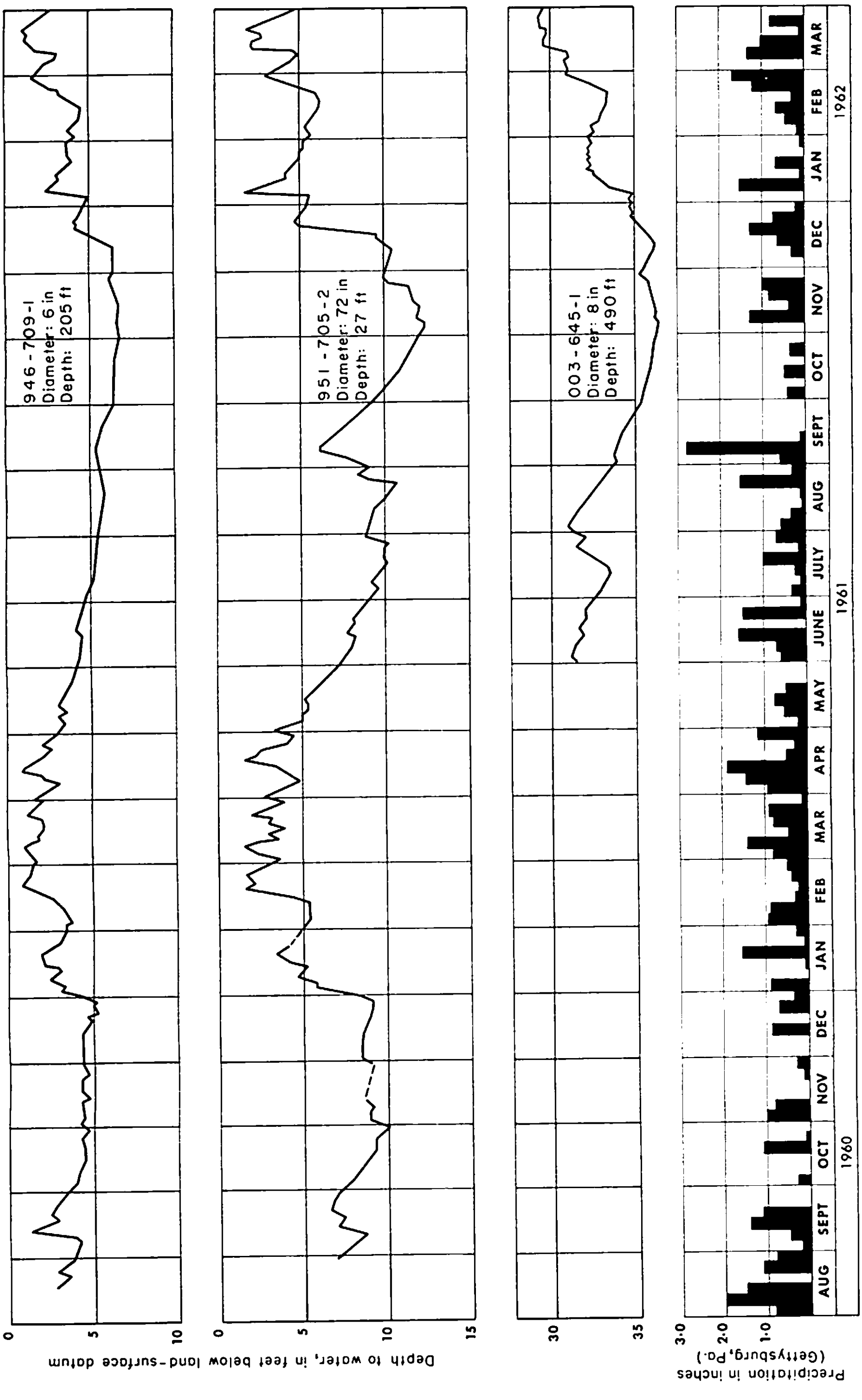


Figure 4. Representative hydrographs of water levels in three wells in the New Oxford Formation, and precipitation at Gettysburg, Pa.

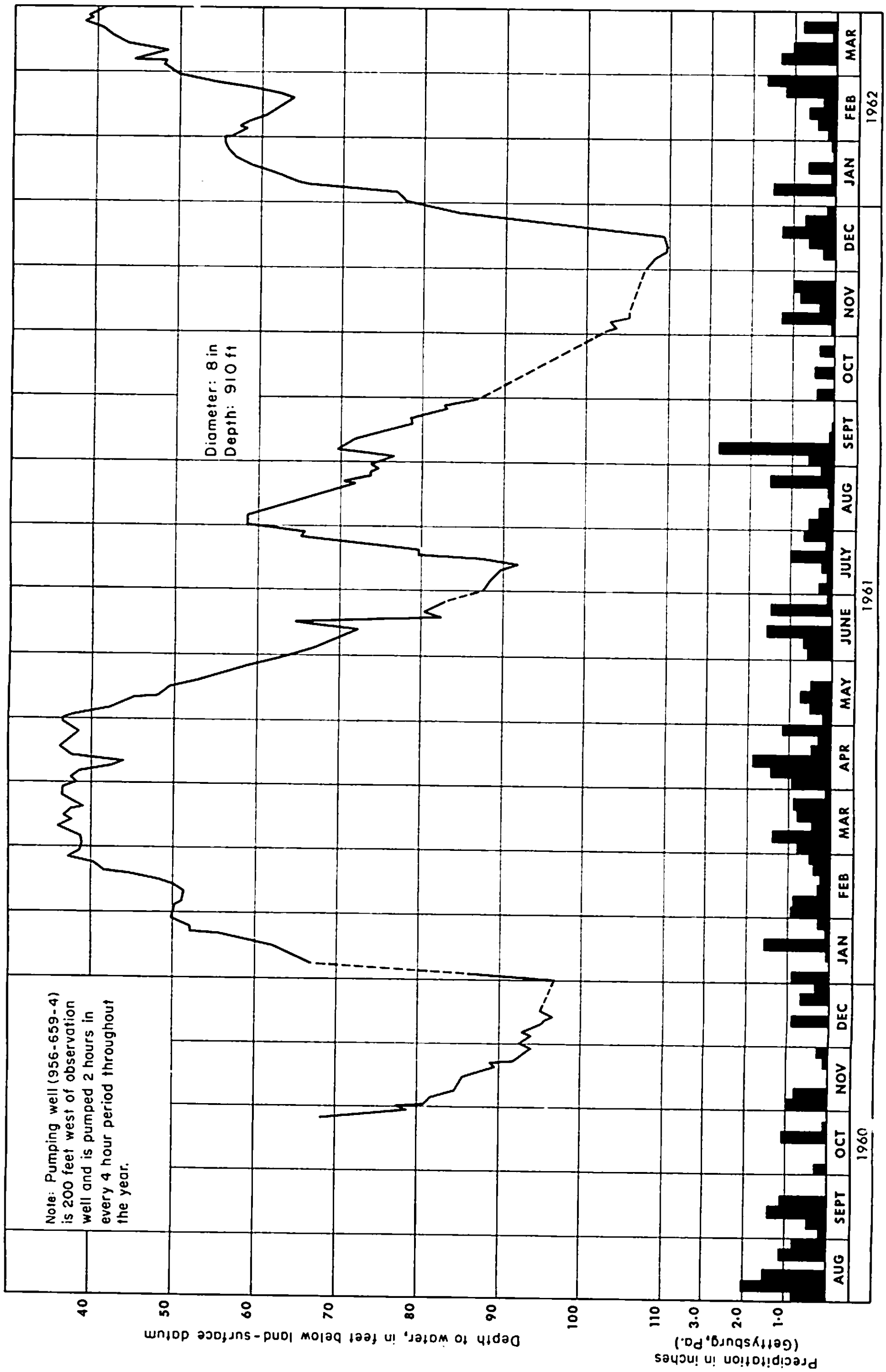


Figure 5. Hydrograph of the water level in well 956-659-3 near East Berlin, showing effects of pumping of a nearby well and precipitation at Gettysburg, Pa.

flat-topped ridge about a mile northwest of the borough. The pumped well is 256 feet deep and yields about 22,000 gallons per 24-hour period, 365 days a year. The pumping periods are controlled by an electric timing device that automatically starts and stops the pump at 2-hour intervals. The hydrograph shows clearly that during the late spring and summer the use of ground water by man and nature causes a sharp decline of water levels. The graph shows also that even though the withdrawal of water for man's use continues without interruption, the bulk of the recovery takes place during the late winter and early spring, when nature's demands for water are least and conditions are most favorable for recharge. The general pattern is not unlike that of the three wells shown in Figure 4, except that the seasonal fluctuations have been greatly accentuated by human activity.

Hydraulics

Depths, yields, and specific capacities of wells

Records of 318 wells inventoried during this investigation are given in Table 4. The locations of the wells are shown on Plate 1, and representative well logs are given in Table 5.

The well records shown in Table 4 are based on information obtained from many sources. Much of the information reported by well owners and local residents came from memory rather than from written records. Wherever possible a driller's written record was consulted, and the data from these records on depths of wells and the diameter and lengths of casings are considered to be reasonably accurate. The accuracy of the yields recorded by the drillers, however, is variable. Ordinarily a well for domestic use is subjected to a very brief (generally less than 30 minutes) bailing or pumping test to determine if it will yield an adequate supply for household use, and the methods used to measure yield generally are not precise. Hence, the yields reported for most domestic wells are only approximations. Reported yields of less than 10 gpm are usually somewhat higher than the yield that can be obtained when the well is pumped continuously for several hours. Reported yields of more than 20 or 30 gpm may indicate only the maximum capacity of the bailing or pumping method. On the other hand, municipal and industrial wells are usually tested at full capacity for long periods, and their reported yields are considered to be reliable.

Depths.—The depths of drilled wells, which supply most of the ground water used in the area, range from 31 to 1,005 feet and average about 150 feet. However, this average is misleading because of the unusual individual high and low values used in obtaining the average.

When the reported depths of wells are arranged according to their frequency of occurrence, as in Figure 6, it can be shown that 60 percent of the wells range in depth from 75 to 150 feet and only about 20 percent are deeper than 150 feet.

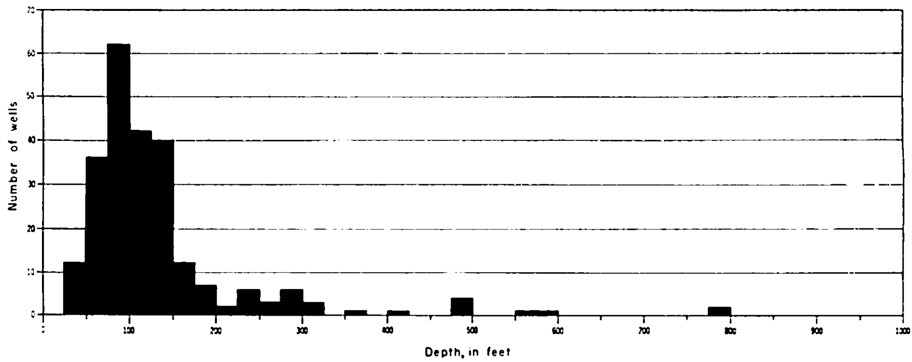


Figure 6. Frequency distribution of depths of drilled wells penetrating the New Oxford Formation in Adams and York Counties, Pa.

Yields.—The reported yields of the wells range from less than 1 gpm to 200 gpm. The frequency with which various yields are obtained from drilled wells is shown in Figure 7. The graph shows that 70 percent of the 166 wells yield 10 gpm or less, and that only about 15 percent yield more than 20 gpm.

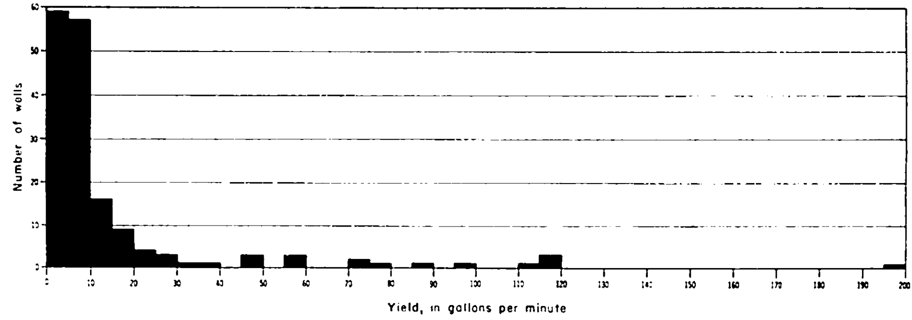


Figure 7. Frequency distribution of yields of drilled wells penetrating the New Oxford Formation in Adams and York Counties, Pa.

The yield of a well in the bedrock part of the formation is not directly proportional to the depth of the well because the permeability of the rocks is not uniform; ordinarily, each additional increment of depth does not cause a corresponding increase in the yield. Figure 8

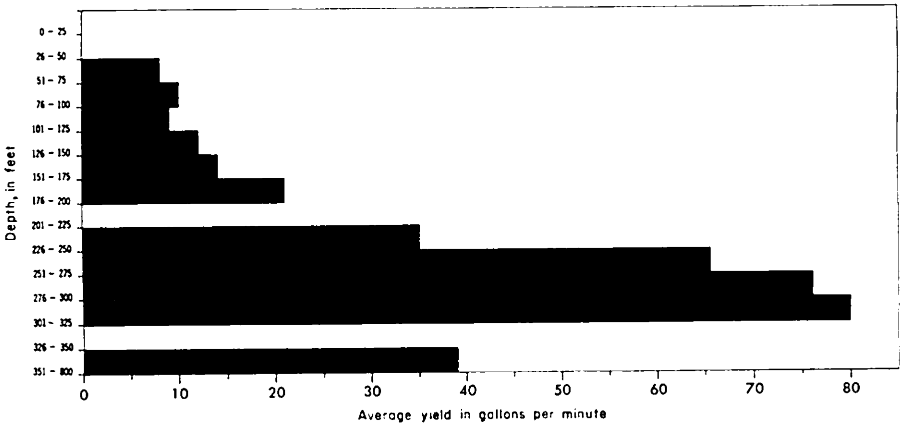


Figure 8. Graph showing the relation of the average yield of wells to depth.

shows graphically the data presented in table 3, a tabulation of yield versus depth of 241 wells. The relation of yield to depth may be true only in a general way, as the depth of a well in fractured rocks does not necessarily indicate the depth from which water is obtained. A well may obtain most of its water supply from a group of closely spaced fractures near the upper surface of the relatively unweathered rock, it may obtain its supply from a single fracture, or it may get its water from a number of small fractures opposite the entire uncased part of the well.

Table 3. Yields of wells in the New Oxford Formation by depth intervals

[Data based on information obtained from well drillers and land owners.]

Range in depth (feet)	Number of wells	Average depth (feet)	Yield, in gallons per minute			Percent of wells yielding 5 gpm or less
			Range	Average	Per foot of well	
0-25	0	....	....	....	....	....
26-50	12	41	<1-7	....	....	....
51-75	36	64	<1-20	8	0.13	30
76-100	62	90	<1-20	10	.11	23
101-125	42	112	1-60	9	.08	29
126-150	40	138	<1-50	12	.09	35
151-175	12	160	4-60	14	.09	33
176-200	7	194	<1-50	21	.11	50
201-225	2	208	7-75	41	.20	0
226-250	6	240	4-120	35	.14	2
251-275	3	267	30-120	58	.21	0
276-300	6	300	30-114	76	.25	0
301-325	3	311	20-200	80	.25	0
326-350	0	....	....	....	....	....
351-800	10	550	3-120	39	.07	25

The data in Figure 8 and Table 3 indicate that in general there is an increase in the yield of wells as their depth increases to 350 feet. The average yield of wells more than 350 feet deep is less than the average yield of wells between 250 and 325 feet deep. The reason for the decrease is not clear, but it may be partly the insufficient sampling and partly the fact that wells more than 350 feet deep were drilled in areas where the permeability of the rocks is unusually low. It seems reasonable to assume that wells are seldom drilled to depths of 400 feet or more unless it is impossible to obtain an adequate supply of water at shallower depths.

The data collected during this investigation suggest that in the New Oxford Formation maximum well yields may be obtained from the zone between 250 and 350 feet below land surface. Although the yields of individual wells cannot be predicted with certainty prior to their completion, Table 3 suggests yields ranging from 20 to 200 gpm from wells 250 to 350 feet deep.

Specific capacity.—The specific capacity of a well is the ratio of the yield of a well in gallons per minute to its drawdown in feet. It is a useful indication of a well's productivity; however, a figure based on a single determination of specific capacity may not mean much because the drawdown and, hence, the specific capacity of a well may change as the period of pumping or the pumping rate is increased.

Table 6 summarizes available information concerning the yield of wells tapping the bedrock of the New Oxford Formation. Unless otherwise indicated, the data were obtained from short pumping tests made by the authors. In order to minimize as many of the variables as possible, well yields were closely controlled, and the length of the individual tests were for comparable increments of time. An analysis of controlled pumping tests of 60-minute duration (Table 6) indicates that 84 percent of the wells tested have specific capacities that range from less than 0.1 to about 0.6 gpm per ft of drawdown and average about 0.2 gpm per ft.

Coefficients of permeability, transmissibility, and storage

The ability of an aquifer to store and transmit water is defined by the coefficients of storage, permeability, and transmissibility. The *coefficient of storage* is the volume of water released or taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. The *coefficient of permeability* is the rate of flow of water, in gallons per day, through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent, or 1 foot per foot, at a temperature of 60°F. The *field coefficient of permeability* is the same except that it is measured at the prevailing temperature in the aquifer. The *coefficient of transmissibility* is equal to the average field coefficient of permeability multiplied by the thickness, in feet, of the aquifer (Theis, 1935, p. 520).

The coefficients of transmissibility and storage can be determined by mathematical analyses of the behavior of the water table or piezometric surface around a pumped well. The analyses can be made by means of formulas based on equilibrium and nonequilibrium conditions. In this report, either the basic nonequilibrium formula (Theis, 1935) or one of its variations (Cooper and Jacob, 1946) was used to determine the aquifer coefficients. The formulas are based on ideal conditions that are seldom, if ever, realized in nature. They assume that the aquifer is infinite in areal extent, that it is homogeneous and isotropic (transmits water equally in all directions), that it is bounded at the top and bottom by impermeable material, that it has a uniform thickness, and that water is released instantaneously from storage with a decline in head. The formulas assume further that the discharging well is of infinitesimal diameter and completely penetrates the aquifer, and that the flow of the water toward the well is two dimensional.

The Theis nonequilibrium formula can be applied to the drawdown or recovery in one or more observation wells to determine the coefficients of transmissibility and storage. The nonequilibrium formula may be applied also to the rate of recovery or drawdown in the pumped well in order to calculate the coefficient of transmissibility. However, it is not possible to calculate the coefficient of storage from the rates of drawdown or recovery in pumped wells unless the effective radius of the well (which is usually difficult to determine) is known.

During the period of field work for this report, drawdown and recovery tests were made in 45 wells. Most of the wells tested were open-hole domestic wells 6 inches in diameter. Water levels dropped so rapidly in many of the wells, even at pumping rates of 5 gpm or less (see Table 6), that it was not possible to obtain data needed to determine aquifer coefficients. The coefficients of transmissibility given in Table 6 are perhaps most useful as a measure of the relative water-bearing potential of the New Oxford Formation at the sites tested.

WATER USE

Ground- and surface-water use in the area of this investigation, in 1960, was about 1.4 mgd (million gallons a day), exclusive of the water used in the production of electrical power. About 75 percent of this, or 1.1 mgd, was obtained from wells and springs in the New Oxford Formation; about 15 percent, or 0.2 mgd, was obtained from streams and farm ponds within the project area; and about 11 percent, or 0.1 mgd, was imported from sources outside the project area. All of the water used to produce electrical power is obtained from the Susquehanna River, the average amount used being about 11,000 mgd.

Approximately 82 percent of the water used in 1960 was used for domestic purposes. Water used to supply drinking water for cattle accounted for about 13 percent of the total, and commerce and industry used most of the remaining 5 percent. The main economic activity in the project area is farming, but because precipitation is abundant and evenly distributed throughout the year (see Table 1), little water is used for irrigation.

The population of the project area in 1960 was about 28,700. About 40 percent of the population was served by public supply systems. The other 60 percent obtained water supplies from private wells and springs.

The average per-capita use of water in 1960, as determined from metered, residential use in six communities served by public supply systems, was 40 gpd. The per-capita use in these six communities ranged from 26 gpd in East Berlin to 77 gpd in New Oxford. In 1955, the average use in five of these six communities was 28 gpd per person; in 1960, the average had increased to 38 gpd per person.

A little more than 20 percent of the 1.4 million gallons of water a day used in the project area is consumed; that is, it is lost to the atmosphere by evaporation and transpiration or incorporated into some product. The remainder is returned to the ground-water reservoir or streams where it becomes available for reuse. Data on consumptive use of water in the United States in 1960 (MacKichan and Kammerer, 1961) indicate that about 10 percent of the water used by public supply systems and by rural homes in Pennsylvania is consumed. This consumptive use probably applies also to water used in the project area by commerce and industry, as most of the water is used for sanitary purposes. Thus, assuming a 10 percent rate of consumption of water used by public supplies, rural homes, and commerce and industry from private sources, the amount consumed in 1960 was approximately 130,000 gpd. All of the 180,000 gpd used to supply cattle was consumed, bringing the total amount of water consumed in 1960 to about 310,000 gpd. Little, if any, of the water used in producing electricity was consumed.

Private Supplies

More than half of the population in the area of this investigation obtains its water from private supplies, and water used to supply cattle is obtained almost entirely from private supplies. Industries obtain about 70 percent of their water from private sources, but commercial establishments obtain only about 15 percent of their water from private supplies.

Private domestic supplies are obtained chiefly from wells. A few homes obtain part or all of their water supply from springs, but most spring supplies have been abandoned in favor of wells, which are less susceptible to contamination. The population served by private domestic supplies is estimated to have been 17,000 in 1960. Assuming the average amount of water use as 40 gpd per person, the quantity of water used was 680,000 gpd.

Water for cattle is obtained partly from well supplies, but probably most of it is obtained from streams and small farm ponds. The amount of water used for this purpose was 180,000 gpd.

Practically all of the water used from private supplies by industry and commerce is obtained from wells. The only notable exception is the Pennsy Supply Company near York Haven, which uses an undetermined amount of water from the Conewago Creek to wash gravel. The average use of water from private supplies by both commerce and industry is estimated to be only 30,000 gpd.

The Metropolitan Edison Company and the International Paper Company use water from the Susquehanna River at York Haven to generate electrical power, and 1.2 miles downstream from York Haven, water is diverted from the river for use in a steam-electric plant owned by the Pennsylvania Power and Light Company. Water used by the plants at York Haven is unchanged in physical and chemical quality, but the water used by the steam-electric plant is returned to the river at considerably higher temperature. A small part (less than 10 percent) of the water used by the steam-electric plant is treated and returned to the river containing less suspended and dissolved matter than it had when taken from the river. Practically all of the 11 billion gallons of water a day estimated to be used by these three plants is returned to the river.

Municipal Supplies

Seven public-supply systems furnished water to about 11,700 persons in eight communities within the area in 1960. These public-supply systems distributed an average of 600,000 gallons of water per day, of which a little more than half was obtained from wells tapping the New Oxford Formation. The remainder was obtained from the South Branch of the Conewago Creek and from sources outside the area. The quantities of water used in each of the communities and municipalities served by public-supply systems is shown in Figure 9.

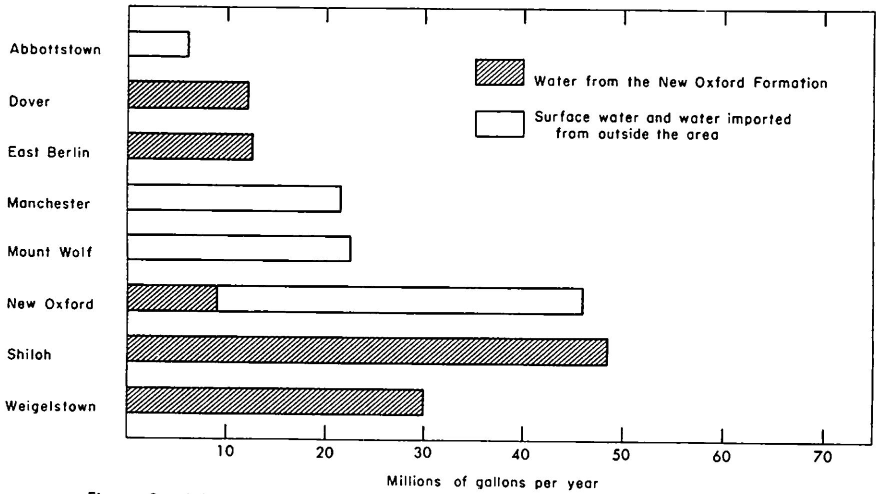


Figure 9. Water used in 1960 by communities served by public-supply systems.

The Boroughs of East Berlin and Dover, and the unincorporated communities of Shiloh and Weiglestown are supplied with water obtained entirely from wells tapping the New Oxford Formation.

The Borough of New Oxford obtains about 80 percent of its water supply from the South Branch of the Conewago Creek and about 20 percent from a well in the New Oxford Formation.

The Borough of Abbottstown obtains most of its water supply from three springs that issue from rocks of pre-Triassic age near the base of the New Oxford Formation. An auxiliary water supply is obtained from four wells. Two of these wells tap the pre-Triassic rocks in the vicinity of the springs, and two of them tap the base of the New Oxford Formation.

The Boroughs of Manchester and Mount Wolf are served by the York Water Company, which obtains its water from surface supplies south of the area underlain by the New Oxford Formation.

A few small industrial plants and commercial establishments along U. S. Route 111, near the base of the New Oxford Formation, are supplied with water by the Penvale Water Company.

Dover, York County

Population served in 1960: 975.
Owner: Dover Borough Water Works.
Source: Five wells in the New Oxford Formation.
Storage: 120,000 gallon earth reservoir and a 56,000 gallon elevated tank.
Treatment: Chlorination.
Remarks: The five wells (959-650-1, 959-651-1, 000-650-1, 000-651-1, and 000-651-2) range in depth from 300 to 800 feet and yield from 12 to 38 gpm. Total pumpage from these wells in 1960 was 12.2 million gallons.

East Berlin, Adams County

Population served in 1960: 1,040.
Owner: East Berlin Borough Council.
Source: Two wells, 956-659-2 and 956-659-4.
Storage: 510,000 gallon brick-lined earth reservoir, and a 150,000 gallon elevated tank.
Treatment: Chlorination.
Remarks: Well 956-659-2 is 8 inches in diameter and 300 feet deep. The reported yield in 1946 was 90 gpm, and the drawdown was about 110 feet. Well 956-659-4 is 6 inches in diameter, 256 feet deep, and when drilled in 1927, was reported to yield 110 gpm; it is now reported to yield about 35 gpm with a drawdown of about 150 feet. The total pumpage from these two wells in 1960 was 12.6 million gallons.

New Oxford, Adams County

Population served in 1960: 1,500 (estimated).
Owner: Borough of New Oxford and Municipal Authority.
Source: South Branch of the Conewago Creek and one well (951-703-2) in the New Oxford Formation.
Storage: 200,000 gallon elevated tank.
Treatment: Sedimentation, coagulation, rapid sand filtration, and chlorination.
Remarks: Well 951-703-2 is 500 feet deep. When drilled, in 1947, it yielded 40 gpm with a drawdown of about 170 feet. This well is pumped continuously, and in 1960 it yielded about 20 gpm, or 29,000 gpd. Approximately 20 percent of the water used in 1960 was obtained from this well.

Weiglestown, York County

Population served in 1960: 1,860 (estimated)
Owner: Dover Township, York County Authority.
Source: Two wells (959-648-4 and 959-648-5) in the New Oxford Formation.
Storage: 180,000 gallon elevated tank.
Treatment: Chlorination.
Remarks: Well 959-648-4 is 8 inches in diameter and 300 feet deep. When drilled, in 1955 it yielded 114 gpm with a drawdown of 160 feet during a 24-hour test. Well 959-648-5 is 8 inches in diameter, 268 feet deep, and is reported to yield 120 gpm. Total pumpage from both wells in 1960 was 29.8 million gallons.

Penvale Water Company, Manchester Township, York County

Number of customers in 1961: Industrial and commercial 9.
Domestic 4.
Source: One well (001-644-1) in the New Oxford Formation.
Storage: 6,000 gallon tank at ground surface.
Treatment: Chlorination.
Remarks: Well 001-644-1 is 8 inches in diameter and 785 feet deep. When drilled, in 1958, it yielded 75 gpm with a drawdown of about 165 feet during a 24-hour test. The well was put into service in the spring of 1960. In 1961 the total pumpage from this well was 1.2 million gallons.

Shiloh, York County

Population served in 1960: 2,800 (estimated).
Owner: West Manchester Township Authority.
Source: Three wells (958-648-1, 958-648-3, and 958-648-4) in the New Oxford Formation.
Storage: 100,000 gallon elevated tank.
Treatment: Chlorination.
Remarks: Well 958-648-1 is 8 inches in diameter and 300 feet deep. When drilled, in 1960, it yielded 70 gpm with a drawdown of about 200 feet. Well 958-648-3 is 8 inches in diameter and 300 feet deep. When drilled, in 1952, it yielded 100 gpm with a drawdown of 15 feet. Well 958-648-4 is 8 inches in diameter and 310 feet deep. When drilled, in 1955, it yielded 200 gpm with a drawdown of 12 feet. Total pumpage from wells 958-648-3 and 958-648-4 in 1960 was 48.6 million gallons. Well 958-648-1 was not operating.

Abbottstown, Adams County

Population served in 1960: 560.
Owner: Abbottstown Municipal Water Authority.
Source: Three springs and two wells in rocks of pre-Triassic age and two wells (951-659-1 and 952-659-1) in the New Oxford Formation.
Storage: Small reservoir.
Treatment: Chlorination.
Remarks: The principal water supply is obtained from three low-yielding springs in pre-Triassic rocks near the base of the New Oxford Formation. The wells are used to augment spring supplies during dry periods. The two wells in the pre-Triassic rocks each yield about 5 gpm. Well 951-659-1, which is drilled in the base of the New Oxford Formation, is 8 inches in diameter, 500 feet deep, and is reported to yield about 5 gpm when pumped continuously. Well 952-659-1, also drilled in the base of the New Oxford Formation, is 6 inches in diameter, 200 feet deep, and is reported to have yielded 55 gpm with a drawdown of about 160 feet when drilled; under sustained pumping conditions, however, the well yields only 27 gpm.

Manchester and Mount Wolf, York County

Population served in 1960: Manchester, 1,454.
Mount Wolf, 1,514.
Owner: York Water Company.
Source: Surface water from the Codorous Creek drainage basin, outside the project area.
Storage: *(local)*: 311,000 gallon elevated tank situated in Manchester.
Remarks: Manchester and Mount Wolf are served by a water line that also serves about 6,000 other people outside the project area. The amount distributed over this line in 1960 was 135 million gallons, which is equivalent to 41 gpd per person. The quantity of water used in these two municipalities in 1960 (21.6 million gallons in Manchester, 22.7 million gallons in Mount Wolf) was calculated by multiplying the per capita rate of use by their 1960 populations.

QUALITY OF WATER

The quality of ground water in the New Oxford Formation was evaluated from a study of chemical analyses of 27 water samples from 26 wells and one spring and from field measurements of specific conductance, hardness, hydrogen-ion concentration (as indicated by pH), and temperature. Results of laboratory analyses are given in Table 7, and the field measurements are given in Table 8. Determinations were made of the concentrations of the constituents that comprise the bulk of dissolved solids commonly present in most ground waters. These include the positively charged ions (cations) of calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K); and the negatively charged ions (anions) of bicarbonate (HCO_3), sulfate (SO_4), chloride (Cl), and nitrate (NO_3). Determinations were made also for constituents that are normally present in ground waters in very small amounts but which, even in trace amounts, may have a considerable effect on the utility of water. These constituents are iron (Fe), manganese (Mn), and fluoride (F). Silica (SiO_2), another constituent determined, is commonly present in most ground waters, but, unlike the other constituents, it is present in particles of sub-colloidal size that do not bear an ionic charge.

Dissolved solids in ground water are derived chiefly from the soils and rocks with which the water has been in contact. Several factors control the type and amount of constituents that the ground water contains, for example: (1) the mineral composition of the soils and rocks with which the water has been in contact, (2) the length of the time of contact, (3) the solvent power of the water (as related to its content of dissolved carbon dioxide and organic acids), and (4) the temperature and pressure of the environment in which the water occurs. In addition, human activities may have a considerable and generally adverse effect on the chemical quality of ground water. In the area underlain by the New Oxford Formation, such human activities as underground disposal of sewage, the spreading of fertilizers on crop lands, and the operation of sanitary land fills contribute additional dissolved matter to the ground water.

Native ground water from the New Oxford Formation is mostly moderately hard to very hard (61 to more than 181 ppm), and locally it contains iron in objectionable amounts. The water does not contain any other naturally occurring constituents in sufficient quantity to affect its usefulness for most purposes. However, water from many of the wells sampled was found to be somewhat contaminated by human activities. The contaminants, which consist chiefly of chloride, nitrate, and (possibly) sulfate, do not seriously affect the use of the water for most purposes, but nitrate was present in several samples in concentrations that exceeded the maximum limit for drinking water recommended by the U. S. Public Health Service, (1962, p. 2154).

The ranges in concentration of constituents present in ground water from the New Oxford Formation are summarized in the following table.

The high, low, and median concentrations of dissolved chemical constituents in 27 samples of ground water from the New Oxford Formation

Constituents	Concentrations in ppm (except specific conductance and pH) Low	High	Median
Silica	6.2	39	20
Iron	.03	22	.14
Manganese[a]	.00	.39	.03
Calcium	5.7	102	43
Magnesium	4.4	79	12
Sodium & Potassium	4.7	94	14
Carbonate	.0	.0	.0
Bicarbonate	14	302	145
Sulfate	0.8	120	27
Chloride	2.0	173	11
Nitrate	1.8	124	27
Fluoride[a]	.0	.4	.0
Total dissolved solids (sum)	67	750	217
Ca-Mg hardness as $CaCO_3$	34	550	159
Noncarbonate hardness as $CaCO_3$[a]	0	307	31
Specific conductance (micromhos/cm at 25°C)[a]	93	1,280	344
pH[a]	5.7	7.8	7.0

[a] Data not determined for 4 analyses.

Specific conductance and dissolved solids.—Specific conductance of water is a measure of its ability to conduct an electric current, and is reported in units of micromhos per centimeter at a temperature of 25°C. In relatively dilute solutions, such as the ground water from the New Oxford Formation, specific conductance is proportional to dissolved-solids content and, therefore, gives an approximate measure of total dissolved solids content.

Specific conductance measurements of 160 samples of ground water from the New Oxford Formation (see Table 8) ranged from 90 to 1300 micromhos per cm, with a median of 380 micromhos per cm. The approximate dissolved-solids content of these samples in parts per million can be determined by multiplying the specific conductance by 0.61.

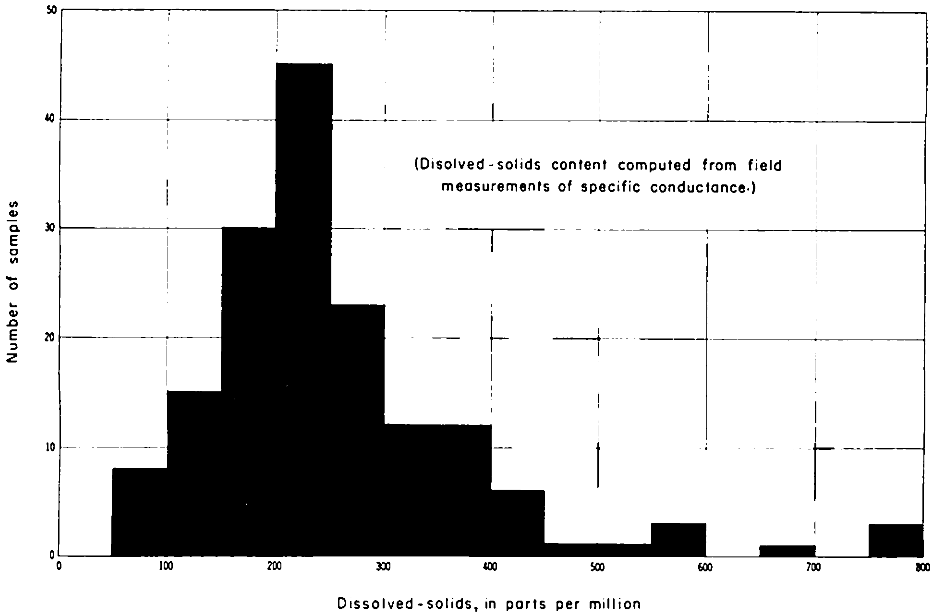


Figure 10. Dissolved-solids content of 160 ground-water samples from the New Oxford Formation.

The dissolved-solids content, calculated from specific conductance measurements, of ground water from the New Oxford Formation ranged from about 60 to about 800 ppm. The majority of samples contained between 150 and 300 ppm. Only eight (6 percent) of the samples contained more than 500 ppm. The frequency distribution of the dissolved-solids content of the 160 samples is shown (within intervals of 50 ppm) in Figure 10.

All of the chemically analyzed samples in which the dissolved-solids content exceeded 400 ppm contained constituents that are considered to be derived from man-made sources of contamination. Thus, most ground water in the New Oxford Formation in which the dissolved-solids content exceeds 400 ppm probably is similarly contaminated.

Water having no more than 500 ppm dissolved-solids content (provided it meets other requirements) is satisfactory for drinking purposes, according to standards of the U. S. Public Health Service (1962, p. 2154). Water having up to 1,000 ppm dissolved-solids content may be used for drinking where no better water is available.

Hardness.—Hardness is a property of water generally associated with its effect on the lathering of soap and with incrustations formed on containers when water is heated or evaporated. Most hardness is caused by calcium and magnesium, but minor constituents such as iron, manganese, aluminum, barium, and free acid also contribute to hardness. Hardness caused by cations in association with carbonate and bicarbonate is termed carbonate hardness; that resulting from cations in association with other anions, such as sulfate, chloride, and nitrate, is termed noncarbonate hardness. The total hardness of water is equivalent to that reported as calcium-magnesium hardness. Because hardness is not allocable to any one constituent, it is measured in terms of an equivalent quantity of calcium carbonate ($CaCO_3$). Most of the hardness of natural ground water in the New Oxford Formation is carbonate hardness.

Field determinations of hardness for 160 ground-water samples from the New Oxford Formation ranged from about 17 ppm to about 460 ppm, or from soft to very hard. Only about 4 percent of the wells and springs that were sampled, however, yielded soft water. Most of the water sampled was moderately hard to very hard.

The percentage distribution of the hardness of the 160 samples is given in the following table.

Hardness range[1] (ppm)	(grains/gal)	Description of hardness	Percent of 160 samples
0–60	1–3	Soft	4
61–120	4–7	Moderately hard	40
121–180	8–11	Hard	37
181+	12+	Very hard	19

[1] Ranges in grains per gallon are approximate (1 grain per gallon equals 17.1 ppm).

Substantial amounts of hardness-forming constituents in water cause increased consumption of soap and undesirable scale deposits on cooking utensils, hot water pipes, water heaters, and boilers. Such deposits may result in considerable economic loss through loss of heat transfer, increased fuel consumption, and breakdown of equipment. Water that is hard to very hard requires treatment before it is used for many industrial and commercial purposes, and treatment is generally desirable when it is used for domestic purposes. Water that is moderately hard generally may be used for domestic purposes with little or no treatment.

Sulfate.—Sulfate, in association with calcium and magnesium, contributes to the formation of hard scale in steam boilers and affects the use of water in other industrial processes. However, sulfate does not occur in ground water in the New Oxford Formation in quantities large enough to affect its use for most purposes. None of the 27 samples for which sulfate was determined contained as much as 250 ppm sulfate, the recommended maximum limit for sulfate in drinking water (U.S. Public Health Service, 1962, p. 2154). The sulfate content ranged from 0.8 to 120 ppm, but more than two-thirds of the samples contained less than 50 ppm.

Part of the sulfate probably is derived from readily dissolved sulfate minerals or from the oxidation of sulfide minerals that are present as accessory minerals in the rocks. However, the samples with the highest concentrations of sulfate are those that also have the highest concentrations of nitrate and chloride. These samples are believed to be contaminated by organic wastes; therefore, some of the dissolved sulfate may be derived from the oxidation of hydrogen sulfide formed by the decomposition of organic matter.

Iron and manganese.—Iron and manganese, which resemble each other in chemical behavior, are generally present in ground water in small amounts. Even in trace amounts, however, these constituents have a considerable effect on the utility of the water. Individual or combined concentrations of iron and manganese in excess of 0.3 ppm cause stains on plumbing fixtures, cooking utensils, and laundry; and concentrations greater than 1 ppm may cause clogging of pumps, distribution systems, and fixtures. The recommended maximum limit for these constituents in drinking water, according to standards of the U.S. Public Health Service, is 0.3 ppm for iron and 0.05 ppm for manganese (U.S. Public Health Service, 1962, p. 2154).

Iron and manganese are not present in objectionable concentrations in water from most of the wells tapping the New Oxford Formation, but they are high enough locally to require treatment of the water for domestic use and for use in many industrial processes. The iron content of 27 ground-water samples ranged from 0.3 to 22 ppm, and the median concentration was 0.14 ppm. The manganese content of 24 of these samples ranged from 0.00 to 0.39 ppm, and the median concentration was 0.03 ppm. The iron in the water sample containing 22 ppm iron may have been derived from the iron pump and pipe in the well. The well (951-705-2) is about 300 feet from another well (951-705-5) of similar depth that yielded water containing only 0.14 ppm iron.

Silica.—Silica concentrations in 27 samples of ground water from the New Oxford Formation ranged from 6.2 to 39 ppm. More than half the samples contained less than 20 ppm. Silica in these amounts has relatively little effect on the utility of water; however, silica contributes to boiler scale and is objectionable even in very small amounts in water used as boiler feed in high-pressure boilers.

Nitrate.—Important sources of nitrate in ground water are (1) plants known as legumes, which fix atmospheric nitrogen in the soil, (2) the oxidation of nitrogen in organic matter such as plant debris, animal excrement, and sewage wastes, and (3) inorganic nitrate fertilizers.

Most of the area underlain by the New Oxford Formation is used for agricultural purposes, thus, some of the nitrate in the ground water probably is derived from inorganic and organic fertilizers that have been added to croplands. There are few sanitary landfill operations in the project area, but considerable quantities of nitrate generally are added to ground water in the vicinity of such burial sites. Sewage discharged into septic tanks and cesspools appears to be an important local source of nitrate in ground water in the New Oxford Formation. This source is indicated by the fact that samples with the highest nitrate concentrations were obtained from wells near septic tanks or cesspools. Twenty-one of 22 wells that were near domestic sewage-disposal systems yielded water containing more than 10 ppm nitrate, whereas 4 of 5 wells that were not near a source of sewage contamination yielded water with less than 10 ppm nitrate. The presence of coliform bacteria has been reported in the water in several wells that were inventoried but not sampled as a part of this study. This strengthens the indication that sewage contamination is one source of the nitrates found.

The nitrate content of 27 ground-water samples from the New Oxford Formation ranged from 1.8 to 124 ppm; the median nitrate content was 27 ppm. Seven of the samples contained more than 45 ppm, the recommended maximum limit for nitrate in drinking water according to standards of the U.S. Public Health Service (1962, p. 2154).

Nitrate has little effect on the use of water for most purposes. However, large concentrations of nitrate in drinking water may cause methemoglobinemia, the so-called "blue-baby disease," in infants whose feeding formulas are mixed with these waters.

Chloride.—The content of chloride in 27 ground-water samples from the New Oxford Formation ranged from 2 to 173 ppm, with a median content of 11 ppm. Relatively high concentrations of chloride in some of the samples may be the result of contamination from sewage.

The concentrations of chloride observed are well below the levels that would significantly affect the utility of water for most purposes, including drinking. The recommended limit for chloride in drinking water is 250 ppm, according to standards of the U.S. Public Health Service (1962, p. 2154).

Fluoride.—The common fluoride-bearing minerals are not very soluble; hence, concentrations of the fluoride ion in ground water are generally very small. The fluoride content of 23 water samples from the New Oxford Formation ranged from 0.0 to 0.4 ppm. Twelve of these samples had concentrations of less than 0.05 ppm.

The fluoride content of water used in industrial and commercial processes is generally of little importance, but its concentration in water used for drinking is of considerable importance. Fluoride is desirable in small amounts in drinking water because of its effectiveness in reducing the incidence of dental caries in children. In large amounts, however, fluoride causes a dental defect known as mottled enamel. The U.S. Public Health Service (1962, p. 2155) has established maximum limits for the average fluoride content in drinking water that depend on the average maximum air temperature. In the area of this investigation, where the average maximum air temperature is about 65°F, the recommended maximum fluoride content in drinking water is 1.8 ppm.

Temperature.—Ground-water temperatures at depths of more than 50 feet below land surface are generally constant throughout the year, but at depths of less than 50 feet may vary over a range of a few degrees between winter and summer. Ground-water temperatures measured in 65 wells in the New Oxford Formation ranged from 52°F to 58°F, and averaged 55°F.

POSSIBILITIES FOR FURTHER DEVELOPMENT

Domestic ground-water supplies (yields of a few gallons per minute) can be obtained from the New Oxford Formation almost anywhere in Adams and York Counties. Water supplies for small urban or suburban communities and for small industries are available in most places—provided they are obtained from several widely spaced wells ranging from 250 to 400 feet in depth. Because of the generally low permeability of the rocks, a wide spacing of wells is necessary to minimize interference between the wells.

The principal limiting factors in the development of ground-water supplies in the New Oxford are (1) the number, size, and degree of interconnection of the fractures in the formation and (2) the hydraulic efficiency of the wells that intersect the crevices.

Through the years, the yields of wells have been increased appreciably by improved methods of construction and development and by improvements in the engineering design and maintenance of pumping tests.

Although there is a close similarity between the technology of crude-oil production and the technology of ground-water production, the new techniques developed by the oil-well industry to improve the productivity of oil wells have seen little use in the water industry. One reason may be that well owners and drillers fear that the increased productivity of the well will not offset the cost of treatment. Koenig (1960a and b), however, concluded from a survey and analysis of technical and economic data pertaining to well stimulation that in most instances the well stimulation added specific capacity at a unit cost less than the unit cost of that produced by the original well.

The well-stimulation techniques analyzed by Koenig (1960a, p. 336-349; 1960b, p. 631-637) include surging, shooting, vibratory explosion, pressure acidizing, and hydraulic fracturing. Surging, the most commonly used and probably the least effective method of stimulation involves a movement of water back and forth through the water-bearing zone. The movement is accomplished with a surge block, by air pressure, or by starting and stopping the pump.

Shooting, the oldest method of stimulation, consists of setting off massive charges of explosives in the well. The use of explosives to blast a hole may increase the effective diameter of the well, especially if the debris loosened by the explosion is cleaned out of the hole. However, the cost of cleanout may greatly exceed the increased water productivity of the well.

Vibratory explosion is a special form of shooting in which the explosive is divided into small charges and arranged to fire in rapid sequence, producing a vibrating effect to remove incrustation and other impediments from the well casing and the interstices of the surrounding rocks. This method of stimulation probably has little applicability in areas of densely consolidated rocks, such as the New Oxford Formation, where the wells are largely uncased.

Pressure acidizing is an advanced technique that involves treatment with large volumes of an acid solution, which is forced under high pressure and at high rates of injection into the producing zone. Pressure acidizing requires the use of trained personnel and special equipment of the type used by oil-well service companies. It can be applied only when the zone to be treated is sealed off from overlying and underlying rocks, and it is most effective in areas of carbonate rocks.

Hydraulic fracturing is the most advanced of the stimulation techniques used. It was introduced into the oil industry about 1950 and has been used since on thousands of oil wells throughout the United States. Although its use in the water industry has been limited, the hydraulic-fracturing method can substantially increase the productivity of wells in tightly consolidated rocks. The method consists of injecting fluid into the well under such a high pressure that the rocks are actually parted, or fractured. When the pumping pressure is released, the fractures tend to close up. Sand is contained in the fluid, however, and it remains in the fractures—propping them open permanently. The fractures thus formed may be only a few millimeters wide, depending upon the grade of sand used for propping purposes, but they may extend hundreds of feet from the well.

Thus the artificial fractures greatly increase the effective diameter of the well, and in many instances they probably intersect natural fractures that otherwise would not supply water to the well. Even if the artificial fractures do not intersect other fractures, the effective storage capacity of the well has been increased many times. As a result, larger quantities of water can be pumped during a given pumping period.

The hydraulic-fracturing method of well stimulation can be used to increase significantly the yields of wells in poorly permeable rocks. The method requires the use of trained personnel and special equipment of the type used by oil-well service companies. The service companies usually have a fixed base charge regardless of the size of the job. The type of equipment needed, mileage traveled, and time required to complete a job are usually added to the base charge. However, in many places the cost of treatment is less than the cost of constructing a new well at another location.

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Table 4. Records of wells in the New Oxford Formation and adjacent rocks, in Adams and York Counties, Pa.

Well number: See text for description of well-numbering system. Well locations are shown on plate 1.
Method of construction: Dr, drilled; Du, dug.
Total depth: r, reported depth.
Aquifier: Qal, alluvium; TRd, diabase; TRg, Gettysburg Shale; TRn, New Oxford Formation.
Static water level: Reported depths are given in feet; measured depths are given in feet and tenths; b, composite water level of dug and drilled parts of well.
Use: C, commercial; D, domestic; Id, industrial; It, institutional; P, public supply; R, recreational; S, stock; U, unused; X, destroyed.
Remarks; C, chemical analysis of ground water in table 7; F, field analysis of ground water in table 8. Comments are based on reported information.

Well number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer	Static water level: Date measured	Static water level: Depth below land surface (feet)	Reported yield (gpm)	Use	Remarks
Adams County														
943-706-1	Raymond Reed			540	Du	48	11		TRn	8- 3-60	5.2		D	
2	Holman Sell		1924	560	Dr	8	242 r	20	TRn	1924	17	120	U	
3	do.		1906	560	Dr	6	140 r		TRn	8-26-60	15.2	40	U	
4	do.			560	Dr	6	54		TRn				D	C, F
5	John Goulden			558	Du	36	19		TRn	8- 8-60	9.7b		D	F
					Dr	6	38		TRn				D	F
6	Charles E. Koontz			548	Spring				TRn				D	C, F
707-1	Walter F. Crouse		1947	560	Dr	6	120 r		TRn			60	R	C, F
2	do.	A. C. Reider and Son	1958	560	Dr	6	153 r		TRn	8- ?-58	21	60	R	Has been pumped 10 hours at 60 gpm.
3	do.			565	Du	42	19		TRn	8- 5-60	14.1		U	
4	Olin H. Bair			575	Dr	6	53		TRn	8- 3-60	20.9		D	
5	Charles Ecker			582	Dr	4	36		TRn	8- 8-60	22.1	<1	U	F
6	do.			584	Dr	6	31		TRn	8- 8-60	23.3		U	
7	do.			584	Dr	6	165 r		TRn			5	D	F
708-1	Norman B. Barney			540	Du	42	24		TRn	7- 2-60	16.6		U	
2	William Fissel			510	Dr	6	100		TRn	8- 3-60	12.0		D,S	F
3	Russel Moser			554	Du	48	33		TRn	8- 3-60	7.8		U	
4	do.			554	Dr	6	67	10	TRn	8- 3-60	26.3	<3	U	
5	do.			554	Dr	6	65 r		TRn			<3	D	F
6	Holman Sell		1921	542	Du	60	17		TRn	8- 9-60	b8.5		U	F. Top of casing is about 15 ft. below land surface.
					Dr	6	61		TRn				U	
943-710-1	Donald L. Sentz		1940	517	Du	60	17		TRn	7- 2-60	9.6		U	Polluted by cesspool 20 ft. from well.
2	H. L. Darmstadt			508	Du	36	28		TRn	7- 2-60	10.8		U	
3	David Yealy	Harvey Wantz	1940	528	Dr	6	65	11	TRn	8- 3-60	11.9		D	C, F
711-1	Harvey Clifton			518	Du	36	15		TRn	7- 1-60	2.6		U	
2	Charles M. Shildt	Harvey Wantz	1950	516	Dr	6	135		TRn	7- 1-60	16.5	<5	U	
3	do.			516	Dr	6	60 r		TRn			<5	D	F
944-707-1	Richard Shoemaker	Mummert and Sterner	1961	542	Dr	6	120	20	TRn	8- 2-61	20.5		D	F

Table 4. Records of wells in the New Oxford Formation and adjacent rocks, in Adams and York Counties, Pa.—Continued

Well number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer	Static water level: Date measured	Static water level: Depth below land surface (feet)	Reported yield (gpm)	Use	Remarks
Adams County—Continued														
710-1	Hoffman Orphanage		1912	572	Dr	6	150 r		TRg	1961	40	50	It	
945-705-1	Sterling Sell			590	Du	40	33		TRn	7-29-60	23.1		D	
3	C. L. Mehring Estate		1946	614	Dr	6	114		TRn	8-10-60	41.9	<5	D,S	F. Polluted.
706-1	Harry Weissel			566	Du	30	15		TRn	7-28-60	13.0		U	
					Dr	6	59		TRn	7-28-60	13.8		U	Top of 6-in. casing is 4.5 ft below land surface.
2	A. A. Straley			560	Du	40	23		TRn	7-28-60	9.3		D	
3	Harry Weisel			562	Du	40	30		TRn	7-28-60	7.4		U	
708-1	Carl Zeigler		1942	555	Dr	6	64		TRn	7-28-60	2.8	<1	U	
2	Charles Slusser			540	Du	40	17		TRn	7-28-60	8.1		U	
709-1	Sydney Yingling	John S. Funt	1961	570	Dr	6	60 r		TRn	7-25-60	16	12	D	Water enters well at 50 ft.
946-707-1	James L. Cool	W. W. Reichart	1957	580	Dr	6	127	14	TRn	7-29-60	7.0	5	D	F
708-1	Howard A. Snyder			577	Du	60	26		TRn	7-28-60	4.3		U	F
709-1	Walter D. Shoemaker	A. C. Reider and Son		561	Dr	6	205		TRn	8-17-60	2.8	7	U	F
2	William K. Thomas			565	Du	36	14		TRn	7-27-60	2.8		U	Flows during rainy periods.
3	Charles C. Little			543	Du	40	16		TRn	8- 9-60	12.4b		D	
					Dr	6	49		TRn					
710-1	William Meyers	C. C. Fair, Jr.	1951	495	Dr	6	108		TRg	8- 9-60	11.3		U	F. Most water enters well at about 100 ft.
947-704-1	Marvin Wolf	A. C. Reider and Son		598	Dr	6	61		TRn	8-29-60	19.2	13	U	F
2	Aaron Bange			613	Dr	5	42		TRn	8-10-60	9.4		D	F
3	Ralph J. Hoffacker			585	Du	60	12		TRn	8-26-60	9.5		U	
948-705-1	John Hartlaub			584	Du	48	19		TRn	8- 8-60	8.4		D	F
2	do.	W. W. Reichart	1960	585	Dr	6	107		TRn	8-18-60	9.3		D	
3	Merle Bittle			601	Du	36	30 r		TRn	8- ?-60	3		U	F
4	Ruth Naylor		1951	563	Dr	6	65 r		TRn	8-23-60	6.9		D	F
706-1	Louis W. Wagaman			627	Du	48	25		TRn	8-18-60	5.4		D	C, F
2	do.	John S. Funt	1957	625	Dr	6	96	20	TRn	8- ?-57	2	1	D	C, F
3	John Hartlaub			616	Du	36	26		TRn	8-18-60	4.7		U	
4	Percell Worley			610	Du	36	21		TRn	8-18-60	2.2b		D	F
			1930		Dr	6	100 r		TRn					
5	Charles Brown			625	Du	36	16		TRn	8-18-60	5.4b		D	F
		Mummert and Sterner	1944		Dr	6	40		TRn					No casing in 6-in. hole.
707-1	William N. Jago			627	Du	48	21		TRn	8-15-60	2.2		U	Polluted.
2	Donald Gebhart			622	Du	48	18		TRn	8-15-60	3.6		D	F
3	Leroy Harner	W. W. Reichart	1947	621	Dr	6	47		TRn	8-15-60	7.5		D	

708-1	Eugene E. Hartlaub	Kohl Bros.	1960	597	Dr	6	86	30	Trg	11-3-60	5.7	6	D	F
2	Bernard Claybaugh	C. G. Fair	1951	600	Dr	6	97		Trg	10-?-51	10	1	D	F
950-702-1	N. Rinehart			575	Du	40	25		Trn	8-24-60	2.5		D	F
2	Margaret Wagner	Kohl Bros.	1960	598	Dr	6	91		Trn	12-7-60	5.2	5	D	
950-703-1	Martin Storm			535	Du	40	20		Trn	8-31-60	6.5		D	F
2	Norval S. Beaver			573	Du	40	14		Trn	8-31-60	9.8		U	
3	do.			573	Dr	6	135		Trn				S	C, F
4	do.			575	Du	48	34		Trn	8-31-60	12.2		D	C, F
5	S. G. Lawrence Estate			585	Du	60	32		Trn	8-31-60	10.5		D	F
951-659-1	Abbottstown Municipal Water Authority	Kohl Bros.		620	Dr	8	500 r		Trn			5	P	
700-1	S. G. Slaybaugh	do.	1961	610	Dr	6	82	58	Trn	5-25-61	4.8		D	F. Most water enters well at 77 ft.
701-1	Charles Bryer			595	Dr	6	100		Trn	9- 6-60	19.9		U	
2	Charles F. Hartlaub	Kohl Bros.	1958	598	Dr	6	115 r	78	Trn	7-14-58	21	5	D	Water enters well at 85 ft. and 110 ft.
3	John H. Shank	do.	1955	642	Dr	6	108 r	39	Trn	2-10-55	70	>14	P	
4	do.	do.	1956	642	Dr	6	249 r	21	Trn	2-28-56	70	4	P	4 gpm at 75 ft.
6	Philip Eisenhart			600	Du	42	9		Trn	9- 6-60	2.4		U	
7	Kenneth L. Kapp	Kohl Bros.	1960	598	Dr	6	71	20	Trn	9- 6-60	9.2		D	F. Polluted.
703-1	Borough of New Oxford and Municipal Authority	A. C. Reider and Son	1950	561	Dr		369 r	27	Trn			3	U	Yielded 18 gpm for first 6 months of use.
2	do	Kohl Bros.	1947	490	Dr		500 r	15	Trn	11-22-48	30	21	P	C, F. Yield decreased from 44 gpm to 21 gpm in 6 months.
704-1	John Riddell	A. C. Reider and Son	1956	522	Dr	8	148 r	18	Trn	9- ?-56	20	25	D	Most water enters well at 129 ft.
3	Joseph Todt			530	Du	42	20		Trn	8-25-60	2.8		U	
4	Leo Moore			505	Du	60	23		Trn	8-31-60	14.3		U	
705-1	Ellis Miller	Henry Lower	1907	540	Dr	6	85		Trn	8-25-60	18.9	<5	U	
2	Vernon G. Rife			584	Du	72	27		Trn	8-29-60	6.5		U	C, F
951-705-4	M. J. Smith	C. G. Fair	1960	585	Dr	6	182 r		Trn	3- ?-60	16		P	F. Most water enters well at about 150 ft.
5	Frank Beshore			584	Du		20		Trn				U	C, F
706-1	R. H. Mackey			535	Du	42	28		Trn	8-25-60	11.6		D	F
952-659-1	Abbottstown Municipal Water Authority	Kohl Bros.	1957	555	Dr	6	200 r	31	Trn	9-25-57	11	27	P	Originally yielded 55 gpm.
700-1	John Bair		1935	545	Dr	6	250 r		Trn				D	F
701-1	Brethren Home, Inc.	Kohl Bros.	1937	588	Dr	8	237 r		Trn			10	X	Water level reported to be at 230 ft., after pumping 36 hours at 17 gpm.
2	do.	do.	1953	588	Dr	6	200 r	25	Trn			6	It	
3	J. H. Brady			572	Dr	6	90 r		Trn			<5	D	Polluted by nearby septic tank. Water chlorinated.
4	Charles Roach	York Drilling Co., Inc.	1960	548	Dr	6	81		Trn	9-14-60	Flowing	11	D	
5	Ralph Hankey	do.	1960	553	Dr	6	139		Trn	9-14-60	3.0	5	D	C, F. Trace of oil.
6	Cross Keys Diner		1934	580	Dr	6	160 r		Trn			<5	C	
7	E. Shriver			550	Du	60	55 r		Trn				D	C, F
702-1	Vernon Lehr	Kohl Bros.	1960	545	Dr	6	141 r		Trn	7- 7-60	9	18	D	F. 5 gpm at 30 ft.
2	Roy Garber		1920	555	Du	48	27		Trn				D	
					Dr	6	85		Trn			<1	D	F
3	do.			542	Du	54	23		Trn	9-21-60	1.3		U	
4	Thomas Kiser	Mummert and Sterner	1956	545	Dr	6	57 r		Trn			7	X	Polluted by nearby septic tanks. Water milky.
5	do.	John S. Funt	1959	545	Dr	6	46 r		Trn			7	X	do.
6	do.	do.	1959	545	Dr	6	102 r	65	Trn			11	D	Polluted. Water milky at times; chlorinated.
7	Woodrow Martz	Kohl Bros.	1960	558	Dr	6	112	66	Trn	11-25-60	8.5	5	D	F

Table 4. Records of wells in the New Oxford Formation and adjacent rocks, in Adams and York Counties, Pa.—Continued

Well number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer	Static water level: Date measured	Static water level: Depth below land surface (feet)	Reported yield (gpm)	Use	Remarks
Adams County—Continued														
952-703-1	C. F. Geisler	Kohl Bros.	1961	510	Dr	6	85	16	TRn	5-17-61	7.8	1	D	F
953-702-1	Sara Hoover			545	Dr	6	117 r		TRn	9-21-60	Flowing		S	F
2	do.			546	Du	48	11		TRn	9-22-60	2.6		U	
3	G. C. Chronister			544	Du	48	25 r		TRn				U	F. Polluted.
4	do.	Kohl Bros.	1956	544	Dr	6	162 r	20	TRn	Summer 1956	18	7	D	F
5	Robert A. Lemmon			568	Du	40	31 r		TRn	9-22-60	4.0		D	F
6	do.	Kohl Bros.	1957	568	Dr	6	114 r	23	TRn	10-7-57	17	7	D	F
7	Roscoe Yingling	A. C. Reider and Son	1958	568	Dr	6	100 r	17	TRn	12- ?-58	4		D	
8	Paul Prutzman	do.	1958	569	Dr	6	110 r		TRn	12- ?-58	6		D	F. Hard rock to 95 ft. Water enters well from soft rock at about 96 ft.
9	do.	Mummert and Sterner		569	Dr	6	47		TRn	9-22-60	7.5		U	
10	Roy Snyder	Kohl Bros.	1960	563	Dr	6	138	30	TRn	5-15-61	15.5	3	D	F
954-658-1	Adams County Fair Grounds			510	Dr	6	83		TRn	5-24-61	17.5		R	
2	do.			525	Dr	6	133		TRn	5-24-61	6.8		R	
702-1	John Baugher			550	Du	48	25 r		TRn				D	F
2	Lloyd Hoff	Kohl Bros.	1956	530	Dr	6	149 r	29	TRn	3- ?-56	3	4	D	F
3	Luther Myers	do.	1956	533	Dr	6	140 r	26	TRg	2- 8-56	30	12	D	
955-658-1	Walter Shellenberger			430	Du	48	45		TRn	9- ?-59	35		D,S	F
659-1	Joseph Eshelman	Kohl Bros.	1960	400	Dr	6	75	22	TRn	12- 6-60	14.4	5	D	F
956-658-1	R. B. Jacobs			434	Du	48	33		TRn	10- 4-60	13.8		U	F
659-1	Peter C. Brown			420	Dr	10	600 r		TRn	Summer 1945	34	120	D	F. Most water enters well near bottom.
2	East Berlin Borough Water Co.	Kohl Bros.	1946	413	Dr	8	300 r	13	TRn	10-30-46	10	90	P	C, F. Well is 300 feet from creek.
956-659-3	East Berlin Borough Water Company	Kohl Bros.	1927	529	Dr	8	910		TRg	10- 4-57	58	28	U	C, F. Water enters in first 500 ft. Originally yielded 50 gpm.
4	do.	do.	1927	527	Dr	8	256 r		TRg	1927	30	35	P	C, F. Pumping level 200 ft. Originally yielded 110 gpm.
5	Earle A. Deily	W. W. Reichart	1949	417	Dr	6	96 r		TRn			3	D	F
6	Melvin Meyers	R. S. Toomey and Son	1953	530	Dr	6	120 r		TRg			7	D	F
7	do.		1928	530	Dr	6	144 r		TRg			<5	S	F
8	do.			527	Du	48	55		TRg	10-19-60	11.8b	<5	U	
					Dr	6	90		TRg			<5	U	
9	Melvin L. Boyer			460	Du	48	28 r		TRg	10-19-60	18.1		U	
10	do.			460	Dr	6	74 r		TRg				D	F
11	do.			430	Du	36	11		TRn	10-19-60	5.6		U	

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952-657-1	Emory Messinger	Kohl Bros.	1961	620	Dr	6	60	54	Trn	5-16-61	13.6	<1	D	
953-656-1	Harry Hoke		1927	603	Dr	6	62		Trn	9-27-60	9.4	10	D	C, F. Water corrosive.
2	Albert Meyers, Jr.	Mummert and Sterner	1952	618	Dr	6	65 r	22	Trn			6	D,S	Water corrosive.
3	do.			617	Du	42	24 r		Trn			<5	U	F
657-1	J. J. Hamme	A. C. Reider and Son	1956	565	Dr	6	137 r	15	Trn	Summer 1956	15	5	D	F
2	Earl Rodgers		1927	562	Dr	6	268 r		Trn	Summer 1957	30	>20	D,S	F. Most water enters well at 250 ft.
3	do.			561	Dr	6	80 r		Trn			<5	U	
953-657-4	Earl Rodgers			567	Dr	6	77		Trn	9-28-60	34.0		U	F
5	Robert Geiman	A. C. Reider and Son	1954	557	Dr	6	72 r		Trn	8- ?-54	9		D	F
6	Joseph Topper	do.	1954	555	Dr	6	80 r		Trn	9- ?-60	6		D	F
7	Robert Rodgers	do.	1959	553	Dr	6	69 r		Trn	9- ?-59	4		D	
8	Curtis Fleming	W. W. Reichart	1949	572	Dr	6	96 r	13	Trn	7- ?-49	25	6	U	Water milky.
9	do.	A. C. Reider and Son	1957	572	Dr		135 r		Trn	Fall 1957	25	7	X	Most water entered well at 130 ft. Contaminated by gasoline.
10	do.	do.	1957	572	Dr	6	95 r	13	Trn	Fall 1957	25		D	F
658-1	Paradise Protectory			475	Dr	8	212 r		Trn	1930	10	75	H	
2	do.			525	Dr		1,005 r		Trn			5	U	Casing capped with concrete.
3	John Haar	Kohl Bros.	1961	525	Dr	6	149	20	Trn	5-16-61	22.1		D	F
4	Frank Butler	do.	1957	540	Dr	6	186		Trn	5-24-61	29.6		D	F
954-656-1	Charles Kulynyck	Young Bros.	1961	503	Dr	6	155	24	Trn	4-17-61	44.3	7	D	F
2	John Dalheimer			522	Du	36	22		Trn				D	C, F
657-1	J. J. Hamme			530	Du	48	28		Trn	9- 2-60	9.1		U	
2	do.	A. C. Reider and Son	1957	530	Dr	6	142 r	17	Trn	8- ?-57	15	12	D,S	
3	A. Krebbs			543	Dr	6	93		Trn	9-28-60	26.4		U	F
4	Donald Grimm		1950	460	Dr	6	115 r	16	Trn			6	D	Most water enters well at about 110 ft.
5	Raymond Hoke		1935	490	Dr	6	84 r		Trn	Spring 1935	1		D	F
6	Harold Hamme	A. C. Reider and Son	1956	510	Dr	6	200 r	21	Trn	Summer 1956	20	1	D	
954-657-7	J. Copenheaver	R. S. Toomey and Son	1959	515	Dr	6	115 r	6	Trn	9-23-60	34.8	3	D	
658-3	Joseph Altland			465	Du	40	27		Trn	8- 7-61	12.3		D	F
•		Young Bros.	1961		Dr	6	94	27	Trn	8- 7-61	10.2	>13	D	F. Top of casing is 2.5 ft. below surface.
955-651-1	C. F. Rife	G. M. Brillhart	1952	480	Dr	6	93 r		Trn	Fall 1952	30	6	D	Water treated for low pH.
2	do.			480	Dr	6	70 r		Trn			2	U	
653-1	Sylvester Barnes	P. E. Kohler	1954	525	Dr	6	160 r		Trn				D	F
2	Henry Kapp	A. C. Reider, and Son	1955	525	Dr	6	120 r	14	Trn	7- ?-55	20	4	D	F
654-1	Robert Dunbar	P. E. Kohler	1949	495	Dr	6	100 r		Trn	Spring 1960	30	8	D	F
2	Harry L. Krout	R. S. Toomey and Son	1955	460	Dr	6	84 r	12	Trn	Summer 1955	10		D	F
3	do.			460	Du	48	23		Trn	10-26-60	13.2		S	F
657-1	A. Swanson			423	Du	48	26		Trn	10- 3-60	14.7		D	F
2	Nevin C. Mummert	A. C. Reider and Son	1944	518	Dr	6	137 r	20	Trn			<5	U	Polluted.
3	do.			518	Du	42	40 r		Trn			<5	U	Polluted. Dug part filled with clay.
					Dr	6	140 r		Trn			<5	U	Polluted.
4	Mary E. Hallman			505	Dr	6	129		Trn	5- 4-61	42.6	<1	U	F
5	Nevin C. Mummert	A. C. Reider and Son	1949	518	Dr	6	231 r	20	Trn			<10	D,S	Polluted.
6	Wayne Mummert	Young Bros.	1961	480	Dr	6	142	22	Trn	8- 7-61	41.4	5	D	F. Water enters well from contacts between mudstone and sandstone at 120 ft. and 130 ft.

Table 4. Records of wells in the New Oxford Formation and adjacent rocks, in Adams and York Counties, Pa.—Continued

Well number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer	Static water level: Date measured	Static water level: Depth below land surface (feet)	Reported yield (gpm)	Use	Remarks
							York County—Continued							
658-2	M. C. Winters	Kohl Bros.	1953	420	Dr	6	101 r		TRn	1952	14	8	D	F
4	do.			420	Dr	6	33		TRn	10- 4-60	11.4	<1	U	
956-650-1	John Lau	Young Bros.	1961	520	Dr	6	91 r	30	TRn	8-16-61	20	8	D	Water enters well from red mudstone at 46 and 81 ft.
651-1	Preston Snyder		1929	482	Dr	6	108 r		TRn	Summer 1958	9		D	F
2	Henry Heiland		1941	518	Dr	6	100 r		TRn				D	F
3	John F. Biesecker	A. C. Reider and Son	1956	425	Dr	6	86 r	54	TRn	Fall 1956	16	6	D	F. Most water enters well at 80 ft.
4	do.			427	Du	36	25		TRn	11- 9-60	9.1		U	Polluted by septic tank 40 ft. upslope from well.
5	do.	G. M. Brillhart	1940	420	Dr	6	68 r		TRn	1940	12	6	D	F. Most water enters well at 62 ft.
6	Glenn Biesecker			500	Du	42	27		TRn	11-14-60	24.7b	<5	D	
					Dr	6	67		TRn			<5	D	F. Water corrosive.
7	Barry Biesecker	Young Bros.	1956	515	Dr	6	100 r	20	TRn	8- ?-56	26	7	D	C, F
8	Jacob A. Maul	G. M. Brillhart		445	Dr	6	90 r		TRn	11-15-60	18.0		D	F.
9	R. C. Sterner	A. C. Reider and Son	1951	440	Dr	6	72		TRn	1-13-61	5.3	<3	U	F
10	Earl Cleaver	Young Bros.	1961	525	Dr	6	76 r	35	TRn	6- ?-61	24	15	D	F. Most water enters well from loose conglomerate at 44 ft.
11	Robert Schlegel	do.	1960	485	Dr	6	100 r	39	TRn	12-11-60	35	7	D	Water enters well from red shale at 80 ft. and from red sandstone at 100 ft.
652-1	Warren Bushey		1952	500	Dr	6	69 r	14	TRn	1952	14	>10	D	
2	Robert Leighty	Young Bros.	1960	505	Dr	6	80 r		TRn			18	D	F
3	Kenneth Myers	do.	1960	500	Dr	6	87 r	22	TRn			10	D	Water enters well from red mudstone at 76 ft.
654-1	George Butt	do.	1957	518	Dr	6	90 r		TRn			7	D	F
655-1	Roy Gruver			535	Du	48	27		TRn	10-26-60	13.0		D	F
956-655-2	Allen J. Reynolds			518	Dr	4	55		TRn	10-26-60	14.1		U	F
3	Paul Meyers			475	Dr	6	60		TRn	11-16-60	11.7		U	C, F
4	Ivan Maul	Young Bros.	1961	500	Dr	6	120 r	12	TRn	6- 2-61	25	5	D	Water enters well from contact between red shale and mudstone at 110 ft.
5	George Lockman	do.	1960	560	Dr	6	104 r	21	TRn	8- 3-61	9.5	>15	D	Water enters well from hard gray sandstone at 34 ft. and 89 ft.
6	Jonas Gruver	do.	1960	560	Dr	6	144 r	35	TRn	6-10-60	10	12	D	Water enters well from red mudstone between 132 and 144 ft.
957-649-1	C. S. Morthland	do.	1957	465	Dr	6	110 r	30	TRn	4-25-57	14	7	D	F. Water enters well from red mudstone between 105 and 110 ft.

651-1	Ennie C. Bish	G. M. Brillhart	1946	460	Dr	6	90 r		TRn				D	F
652-1	W. F. Dummer			538	Du	48	22		TRn	11-16-60	13.0b		D	
					Dr	6	62 r		TRn					F
2	John M. Maul			560	Du	60	28		TRn	11-17-60	7.1		D	F
3	Samuel Brillhart	G. M. Brillhart	1952	559	Dr	6	98 r		TRn	11- ?-52	5	2	D	C, F. Bailed 2 gpm at 50 ft.
4	John M. Maul			560	Dr	6	46		TRn	1-13-61	8.6		U	
5	Floyd Leib	A. C. Reider, and Son	1961	559	Dr	6	110		TRn	8- 8-61	12.1		D	F
653-1	Joseph V. Martin	G. M. Brillhart	1959	485	Dr	6	97 r	23	TRn	4-22-59	15	20	D	F. Most water enters well from shale at 95 ft.
655-1	Phillip Roser			447	Du	48	25		TRn	11- 7-60	12.1b		D,S	
					Dr	6	90 r		TRn					F
2	Jennie Henry			477	Dr	6	80 r		TRn				D	F
656-1	Carroll Leppo	Young Bros.	1952	497	Dr	6	66 r		TRn			5	D	F
2	do.			497	Du	48	16		TRn	11- 4-60	8.3		U	Polluted.
957-656-3	Sherman Becker, Jr.	R. S. Toomey and Son	1952	498	Dr	6	72 r		TRn			6	D	F
4	Ray Wentz			462	Dr	6	67 r		TRn	9- ?-58	22		S	F
5	do.			458	Du	42	28		TRn	11-9-60	12.3		D	F
657-1	Jacob G. Spangler			382	Du	36	24 r		TRn	1960	18		D	F
2	E. Bywaters			378	Du	42	28		TRn	11- 8-60	16.9		D	F
3	Harris S. Horn			385	Du	42	27 r		TRn				D,S	Dry Dec. 1955.
		Young Bros.	1955		Dr	6	92 r		TRn	12- ?-55	30	>16		F. Bailed 8 gpm above 80 ft. Most water entered well beneath bed of hard sandstone at 90 ft.
958-648-1	West Manchester Township Authority, Shiloh, 3	A. C. Reider and Son	1960	388	Dr	8	300	36	TRn	11-17-60	7.1	79	P	C, F. Bailed 6 gpm at 95 ft., 25 gpm at 150 ft.
2	John E. Smith	J. P. Kohler	1960	385	Dr	6	60	13	TRn	9-14-61	7.1		D	
3	West Manchester Township Authority, Shiloh, 1	Kohl Bros.	1952	405	Dr	8	300 r		TRn	3- 4-55	17	100	P	
4	West Manchester Township Authority, Shiloh, 2	A. C. Reider, and Son	1955	390	Dr	8	310	40	TRn	3- 4-55	Flowing	200	P	
5	Harry Jacoby	Young Bros.	1961	450	Dr	6	105 r	18	TRn	6- 6-61	25	5	D	F. Water enters well from red rock at 40 ft. and 90 ft.
6	Lewis Yohe	do.	1957	435	Dr	6	111 r	28	TRn			6	D	F. Water enters well from red sandstone at 106 ft.
652-1	Evan Swartz			480	Du	36	18		TRn	11-18-60	10.8		D	F
2	Melvin Keller			505	Du	36	19		TRn	11-18-60	5.6		U	C, F
3	Richard Baustian	G. M. Brillhart	1947	502	Dr	6	105 r		TRn			4	D	
4	J. A. Carey	Young Bros.	1959	480	Dr	6	118 r	20	TRn			7	D	F
958-652-5	Ray Brillhart	G. M. Brillhart	1957	500	Dr	6	110 r	31	TRn	7- 8-57	17	5	D	Water enters well at contacts between red and gray sandstone at 38, 92, and 108 ft.
653-1	O. M. Livingston	do.	1957	466	Dr	6	112 r	24	TRn			5	D	F. Water enters well from red sandstone at 108 ft.
2	Dale Brillhart	G. M. Brillhart	1958	490	Dr	6	130 r	19	TRn	4-16-58	17	3	D	
3	E. J. Smith	Young Bros.	1958	500	Dr	6	112 r	23	TRn	8-20-58	27	10	D	Most water enters well at contact between red shale and sandstone at 84 ft.
654-1	Floyd Raffensberger	do.	1960	473	Dr	6	100 r	21	TRn	10- ?-60	20	>15	S	F. Bailed 10 gpm at 85 ft.
2	do.			473	Du	36	30 r		TRn				U	
					Dr	6	80 r		TRn			<3	U	
3	Harold Shoemaker	G. M. Brillhart	1956	475	Dr	6	148 r	8	TRn			10	D	F
4	Wayne Stump	Young Bros.	1960	475	Dr	6	147 r	25	TRn	4- 7-60	15	10	D	Most water enters well from red mudstone at 137 ft. Bailed 2 gpm at 90 ft.
5	Tasker Zeigler	G. M. Brillhart	1957	475	Dr	6	144 r	21	TRn			7	D	Water enters well at 85 ft., and 140 ft.
6	James M. Shoemaker	do.	1957	475	Dr	6	135 r	18	TRn			10	D	F
7	Emanuel Witman	Young Bros.	1960	465	Dr	6	121 r	34	TRn	4- 2-60	22	6	D	Water enters well from red mudstone at 115 ft.

Table 4. Records of wells in the New Oxford Formation and adjacent rocks, in Adams and York Counties, Pa.—Continued

Well number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer	Static water level: Date measured	Static water level: Depth below land surface (feet)	Reported yield (gpm)	Use	Remarks
York County—Continued														
655-1	Dale F. Shoemaker	G. M. Brillhart	1958	400	Dr	6	107 r	15	TRn			6	D	F. Water enters well at 60 ft. and 102 ft.
959-648-1	Francis J. Zimmerman	A. C. Reider and Son	1952	375	Dr	6	200 r	30	TRn	5- 3-55	11.0	50	R	
2	do.	do.	1954	375	Dr	6	82	38	TRn	5- 3-55	8.1	10	R	
959-648-3	Francis J. Zimmerman	A. C. Reider and Son	1947	380	Dr	6	72 r	13	TRn	1947	13	7	D	Polluted by nearby cesspools.
4	Dover Township, York County Authority, Weigelstown, 1	Kohl Bros.	1955	380	Dr	8-6	300 r	207	TRn	5-12-55	3.0	114	P	8-in. casing set at 15 ft. 6-in casing set at 207 ft. Casing slotted 152 to 207 ft.
5	Dover Township, York County Authority, Weiglestown, 2	do.	1959	380	Dr	8	268 r	42	TRn	4-20-61	3.0	120	P	
6	Richard Cline	G. M. Brillhart	1956	505	Dr	6	100 r	25	TRn			5	D	Water enters well at 45, 89, and 97 ft.
649-1	David A. Pipher	do.	1957	435	Dr	6	111 r	45	TRn			7	D	F. Water enters well at 50 and 107 ft.
650-1	Dover Borough Water Works	A. C. Reider and Son	1953	418	Dr	8	314 r	25	TRn	6- ?-53	Flowing	21	P	
2	Lavan H. Miller	Young Bros.	1957	410	Dr	6	100 r	23	TRn	12-16-57	13	15	D	Most water enters well from gray sandstone at 90 ft.
3	R. Emig	G. M. Brillhart	1958	455	Dr	6	122 r	14	TRn	7-17-58	22	7	D	Water enters well at 70 and 117 ft.
4	Richard Fickes	do.	1957	460	Dr	6	152 r	16	TRn			7	D	Water enters well at 95 and 150 ft.
5	Clarence Webb	do.	1957	415	Dr	6	86 r	18	TRn				D	F. Water enters well at 60 and 81 ft.
651-1	Dover Borough Water Works	A. C. Reider and Son	1960	435	Dr	8	300 r	30	TRn			31	P	
2	Leathery Trailer Court	Young Bros.	1961	485	Dr	6	145 r	21	TRn			5	P	F
3	do.	G. M. Brillhart	1958	485	Dr	6	85 r	18	TRn			5	U	Water enters well at 80 ft. Has bad taste.
653-1	A. M. Holmes	Young Bros.	1959	442	Dr	6	130 r	28	TRn	11- ?-59	24	12	D	C, F. Bailed 5 gpm at 121 ft.
959-653-2	Mearl Zeigler	G. M. Brillhart	1958	445	Dr	6	90 r	16	TRn	6- 3-58	30	6	D	F. Water enters well at 85 ft.
3	Russel Leib	Young Bros.	1958	465	Dr	6	70 r	22	TRn	9-24-58	37	5	D	F
4	Kenneth H. Holmes	do.	1959	435	Dr	6	97 r	28	TRn	10- 3-59	25	16	D	F. Bailed 8 gpm at 87 ft. Water enters well from very hard red rock.
654-1	K. M. Border	G. M. Brillhart	1950	462	Dr	6	117 r		TRn			9	D,S	F
2	Floyd Stine			440	Du	42	28 r		TRn					
		Young Bros.	1957		Dr	6	131 r	29	TRn	9-12-57	20	>20	D	Water enters well from red sandstone at 125 ft. Water level at 85 ft. after bailing 30 min. at 20 gpm.
000-645-1	Manchester Township School	P. E. Kohler	1957	525	Dr	6	265 r		TRn			30	It	Yield inadequate at depth of 162 ft.
646-1	Outdoor Country Club	do.	1959	485	Dr	6	300 r	50	TRn	2-17-59	45	30	R	C, F. Bailed 4 gpm at 125 ft., 8 gpm at 180 ft., 20 gpm at 270 ft.

648-1	Cletus Hunt		1961	395	Dr	6	172		TRn	9- 8-61	28.2	6	D	F
649-1	Alda Ketterman	Young Bros.	1961	460	Dr	6	91	28	TRn	9- 8-61	9.5	>15	D	F. Bailed 2 gpm at 51 ft, 6 gpm at 65 ft. Water enters well from red siltstone.
2	Otis Craun	G. M. Brillhart	1958	360	Dr	6	95 r	23	TRn			6	D	F
3	Alda Ketterman	Young Bros.	1961	380	Dr	6	117 r	34	TRn	9- 2-61	24	12	D	Bailed 6 gpm at 101 ft.
650-1	Dover Borough Water Works	A. C. Reider and Son	1954	440	Dr	8	800 r	22	TRn	11-24-54	7	25	P	Pumped at 38 gpm for 4 hours at 390 ft.
651-1	do.	G. E. Hammar	1905	480	Dr	8	310 r	50	TRn	1905	27	20	P	C, F. Originally yielded 30 gpm.
2	do.	A. C. Reider and Son	1950	465	Dr	8	415 r	22	TRn			12	P	
000-652-1	C. J. Harlacker	G. M. Brillhart	1957	480	Dr	6	105 r	17	TRn			7	D	
653-1	Erwin Seifert	Young Bros.	1957	600	Dr	6	143 r	20	TRg	8-10-57	59	7	D	Water enters well at 59 and 140 ft.
2	William Walgamouth	do.	1957	620	Dr	6	128 r	20	TRg	7-29-57	51		D	Water enters well from red sandstone at 78 and 123 ft.
3	Sylvan Peiffer	do.	1957	620	Dr	6	228 r	28	TRg			8	D	Water enters well at contact between red sandstone and red mudstone at 218 and 228 ft.
654-1	John Meyers	do.	1957	470	Dr	6	120 r	23	TRg	6- 7-57	40	4	D	F
2	H. A. Meyers	do.	1958	470	Dr	6	130 r	17	TRg	7-25-58	46	8	D	Water enters well from red sandstone at 52 ft.
001-644-1	Penvale Water Co.	Herman Hake	1958	522	Dr	8	785 r	90	TRn	4-29-57	38	75	Id	Bailed 10 gpm at 475 ft. Most water enters at about 600 ft.
2	William A. Kauffman	W. A. Sprenkle	1961	520	Dr	6	93		TRn	8-10-61	20.2	<5	D	F. Most water enters well at 85 ft.
3	William Quigley		1959	520	Dr	6	99		TRn	8-10-61	16.3	<4	D	F
4	Albert Einsig	Young Bros.	1961	520	Dr	6	81		TRn	9-20-61	22.6	20	D	F
5	D. E. Bailey	do.	1961	495	Dr	6	65 r	23	TRn	9-13-61	18	>15	Id	F. Water enters well from brown sandstone at 35 ft.
6	J. W. Thompson	do.	1961	495	Dr	6	101 r	23	TRn	8-28-61	17	12	Id	Water enters well from hard gray sandstone at 41 ft., from red shale at 66 ft., from red mudstone at 93 ft.
7	Pennsylvania Prestress, Inc.	A. C. Reider and Son	1956	520	Dr	8	190 r	21	TRn			20	Id	
8	do.	do.	1958	525	Dr	6	104 r	18	TRn			7	Id	
9	York Lintel Co.	Young Bros.	1958	520	Dr	6	65 r	22	TRn	6-22-58	17	20	Id	Water enters well from red sandstone at 49 and 55 ft.
001-644-10	John Guss	Young Bros.	1959	520	Dr	6	157 r	20	TRn	10-12-59	31	20	D	Water enters well from red sandstone at 114 ft. and 147 ft. Water level lowered 27 ft. after bailing 20 gpm for 20 minutes.
645-1	Paul Hoffman	A. C. Reider and Son	1961	510	Dr	6	92 r	48	TRn	9-16-61	17.9	12	D	F
647-1	Guy L. Davis	Young Bros.	1959	442	Dr	6	142 r	20	TRn	7-24-59	39	10	D	F. Most water enters well from red mudstone at 135 ft.
652-1	Clarence Hollinger	Herman Hake	1961	555	Dr	6	126	28	TRg	5-26-61	33.7		D	F
2	Russel E. Beam	Young Bros.	1961	640	Dr	6	109 r	35	TRg			15	D	
3	Robert Danner	do.	1957	640	Dr	6	196 r	30	TRg	10-29-61	65	10	D	F. Water level at 150 ft. after bailing for 30 min. at 10 gpm.
4	Westerholt and Shaffer	G. M. Brillhart	1959	540	Dr	6	118 r	27	TRg	5-20-59	53	10	D	Water enters well at 60 ft., and 115 ft.
002-643-1	Luther Wilt			525	Du	42	46		TRn	2-23-61	5.8		D	C, F
2	do.	P. E. Kohler	1952	525	Dr	6	127		TRn	5-22-61	24.3	7	X	F
648-1	Paul Stambaugh	G. M. Brillhart	1958	422	Dr	6	156 r	18	TRn	10-15-58	45	8	D	F
649-1	Russel Hollinger	Young Bros.	1958	700	Dr	6	112 r	18	TRg			7	D	F. Water enters well from contact between red sandstone and red shale.
652-1	Russel Blank		1940	625	Dr	6	86 r		TRg				D	C, F
003-645-1	New York Wire Cloth Co.			360	Dr	8	490		TRn	5-19-61	26.7		U	F
2	do.			340	Dr	8	493		TRn	6- 2-61	14.3		U	F

Table 4. Records of wells in the New Oxford Formation and adjacent rocks, in Adams and York Counties, Pa.—Continued

Well number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer	Static water level: Date measured	Static water level: Depth below land surface (feet)	Reported yield (gpm)	Use	Remarks
	York County—Continued													
3	Robert Stine	W. A. Sprenkle	1961	400	Dr	6	131	30	TRn	7-21-61	31.8	10	D	F
4	Gary Jordon	A. C. Reider and Son	1961	365	Dr	6	151	20	TRn	7-24-61	47.6	4	D	
003-646-1	Louis W. Arnold	A. C. Reider and Son	1940	420	Dr	6	96 r		TRn			20	D	C, F
647-1	C. R. Wintermeyer	do.	1961	500	Dr	6	131	16	TRn	5-26-61	51.37	5	D	F
648-1	George Sowers	Young Bros.	1959	525	Dr	6	136 r	8	TRn	6- 9-59	55	5	D	Water enters well from gray sandstone at 130 ft.
649-1	Elmer Alloway	do.	1957	520	Dr	6	110 r	24	TRg	9-23-57	20	1	D	F
004-641-1	Sherrill Sand Co.	A. C. Reider and Son	1958	425	Dr	6	555 r	22	TRn	3- ?-58	50	50	Id	Flowed <1 gpm at 90 ft. At about 160 ft. water level dropped to 50 ft. and yield was 50 gpm.
642-1	W. C. Ray Bailey	Young Bros.	1961	460	Dr	6	142	36	TRn	7-25-61	53.6	9	D	F. Most water enters well from red sandstone at about 135 ft.
646-1	Wilbur Nichols	do.	1957	438	Dr	6	132 r	26	TRg	10-14-57	49	6	D	F. Most water enters well from red mudstone at 122 ft.
2	J. R. Spangler	do.	1959	400	Dr	6	94 r	21	TRn			12	D	F. Most water enters well from red shale at 90 ft.
005-641-1	Pennsylvania Power and Light Co.			275	Dr	6	106		TRn	5- 1-61	16.2		U	
2	do.			275	Dr	6	40		TRn	5- 1-61	21.0		U	
3	do.			273	Du	36	23		Qal	5- 1-61	18.9		U	
4	do.			269	Du	42	28		Qal	5- 1-61	11.9		U	
5	do.	Herman Hake	1957	283	Dr	10	127 r	34	TRn	8- ?-57	28	60	Id	
643-1	Fred Walters	A. C. Reider and Son	1958	340	Dr	6	141 r		TRn				D	C, F
2	Mervin Hollerbush			320	Dr	6	87		TRn	2-22-61	48.4		U	
005-643-3	Lloyd Krone	A. C. Reider and Son	1961	340	Dr	6	172 r	40	TRn			8	D	
5	A. Gatewood	do.	1961	345	Dr	6	97	52	TRn	9-21-61	43.8	10	D	F
006-642-1	Pennsylvania Power and Light Co.			278	Du	36	24		Qal	2-22-61	17.8		U	F
2	International Paper Co.			285	Dr	6	118 r		TRn			12	Id	
3	do.			320	Du	42	51		TRn	7-23-61	47.1	<5	U	
4	Metropolitan Edison Co.	A. C. Reider and Son	1952	260	Dr	6	114 r	26	TRn	11- ?-52	14	40	Id	F. Has been pumped continuously for 6 months at 40 gpm.
643-1	Benjamin Sprenkle	do.	1959	430	Dr	6	60 r	12	TRd	3- ?-59	23	9	D	F
2	Pythian Park			400	Spring				TRd			<1	U	

Table 5. Drillers' logs of wells in the New Oxford Formation in Adams and York Counties, Pa.

Well 952-702-7

Owner: Woodrow Martz
Altitude: 558 ft
Driller: Kohl Bros., 1960
Static water level: 8.5 ft below land surface, November 25, 1960
Reported yield: 5 gpm

Description	Thickness (feet)	Depth (feet)
Sand, yellow-brown, very coarse	60	60
Mudstone, red, micaceous; red shale	42	102
Sandstone, gray and red	10	112

Well 955-657-6

Owner: Wayne Mummert
Altitude: 480 ft
Driller: Young Bros., 1961
Static water level: 41.4 ft below land surface, August 7, 1961
Reported yield: 5 gpm

Description	Thickness (feet)	Depth (feet)
Soil and red shale	8	8
Sandstone, pink	9	17
Sandstone, yellow-brown, and clay	26	43
Shale, red, and clay	10	53
Sandstone, yellow-brown	6	59
Shale, red	8	67
Sandstone, yellow-brown	33	100
Clay and brown shale	3	103
Sandstone, light-brown	10	113
Sandstone, light-brown, and clay (water enters at 120 ft)	7	120
Red rock (water enters at 131 ft)	11	131
Sandstone, gray, hard	11	142

Well 956-650-1

Owner: John Lau
Altitude: 520 ft
Driller: Young Bros., 1961
Static water level: About 20 ft below land surface, August 16, 1961
Reported yield: 8 gpm

Description	Thickness (feet)	Depth (feet)
Soil, red	10	10
Conglomerate, loose	6	16
Red rock	16	32
Shale, gray	6	38
Red rock (water enters at 46 ft)	38	76
Shale, red (water enters at 81 ft)	5	81
Red rock	4	85
Shale, red	6	91

Table 5. Drillers' logs—Continued

Well 956-652-3

Owner: Kenneth Myers
Altitude: 500 ft
Driller: Young Bros., 1960
Reported yield: 10 gpm

Description	Thickness (feet)	Depth (feet)
Sand and soil	6	6
Sandstone, brownish-gray	30	36
Shale, red, and sandstone	16	52
Red rock (water enters at 76 ft)	35	87

Well 956-655-6

Owner: Jonas Gruver
Altitude: 560 ft
Driller: Young Bros., 1960
Static water level: About 10 ft below land surface, June 10, 1960
Reported yield: 12 gpm

Description	Thickness (feet)	Depth (feet)
Soil, red, shaly	8	8
Soil, yellow, sandy	17	25
Clay, yellow	5	30
Sand rock	3	33
Clay, soft	1	34
Sandstone, red	6	40
Sandstone, red and gray	60	100
Red rock	20	120
Sandy rock, white and gray, hard	6	126
Granite, gray	6	132
Red rock (water bearing)	12	144

Well 957-649-1

Owner: C. S. Morthland
Altitude: 465 ft
Driller: Young Bros., 1957
Static water level: About 14 ft below land surface, April 25, 1957
Reported yield: 7 gpm

Description	Thickness (feet)	Depth (feet)
Soil, brown, sandy	10	10
Shale, red	8	18
Shale, red, and red sandstone	7	25
Shale, brown, and sandstone	10	35
Red rock (water enters below 105 ft)	75	110

Table 5. Drillers' logs—Continued

Well 958-648-1

Owner: West Manchester Township Authority, well 3
Altitude: 388 ft
Driller: A. C. Reider and Sons, 1960
Static water level: 7.1 ft below land surface, November 17, 1960
Reported yield: 79 gpm. Yielded 2 gpm at 75 ft depth, 6 gpm at 95 ft, and 25 gpm at 150 ft. Samples for the interval 110-300 ft collected by driller and described by H. E. Johnston

Description	Thickness (feet)	Depth (feet)
Soil and clay	15	15
Shale, soft	11	26
Sandstone, medium-hard	24	50
Mudstone, red, and hard, red shale	130	180
Sandstone, gray, medium- to fine-grained	20	200
Mudstone, red, micaceous; some fine-grained sandstone	25	225
Sandstone, gray, fine-grained	20	245
Mudstone, red, and fine-grained; red sandstone	35	280
Sandstone, gray, fine- to medium-grained	10	290
Sandstone, red, medium-grained	5	295
Sandstone, gray, medium-grained	5	300

Well 958-648-4

Owner: West Manchester Township Authority, well 2
Altitude: 390 ft
Driller: A. C. Reider, 1955
Static water level: About 4 ft above land surface, when drilled
Reported yield: 200 gpm. Samples collected by the driller and described by C. G. Gray and R. C. Bolger of the Pennsylvania Topographic and Geologic Survey

Description	Thickness (feet)	Depth (feet)
Not logged	15	15
Sandstone, gray, micaceous, 55% ; red shale, 40% ; some red to pink limestone fragments	5	20
Not logged	5	25
Shale, red, 35% ; gray micaceous sandstone, 30% ; red slightly calcareous sandstone, 30% ; small fragments of pink limestone and yellow micaceous clay	5	30
Not logged	5	35
Sandstone, gray, micaceous, 70% ; red shale, 15% ; gray siltstone, 5% ; some dark-brown (manganiferous?) fine sand. Less limestone than above. One piece of creamy-white crystalline dolomite; some micaceous clay	5	40
Not logged	5	45
Sandstone, gray, 80% ; less micaceous than above; red shale, 10% ; gray siltstone (schist?) 5% ; occasional fragments of limestone	5	50
Not logged	5	55
Sandstone, gray to dark-gray, 65% ; red shale, some green spots, 20% ; green to gray siltstone, 5% ; limestone and calcareous sandstone, 5% ; some clay and red sandstone	5	60
Not logged	5	65
Shale, red, many green spots, 40% ; gray to dark-gray sandstone, 40% ; greenish-gray siltstone, 10% ; limestone, 5%	5	70

Table 5. Drillers' logs—Continued

Well 958-648-4—Continued

Description	Thickness (feet)	Depth (feet)
Not logged	5	75
Shale, red, few green spots, 80% ; gray sandstone, 15% ; some, but not all, of the shale is calcareous; some gray siltstone	5	80
Not logged	5	85
Shale, red, 95% ; green shale, 5% ; about 50% of the shale effervesces; one piece of vein quartz	5	90
Not logged	5	95
Similar to 85–90-ft interval, except more calcareous	5	100
Not logged	5	105
Sandstone, gray, fine, calcareous cement, 95% ; red shale, calcareous, 5%	5	110
Not logged	5	115
Sand, quartzose, slightly arkosic, calcareous, 95% ; red and green shale, 5%	5	120
Not logged	5	125
Similar to 115–120-ft interval, except more red shale	5	130
Not logged	5	135
Shale, dark-red, with greenish-gray spots, 95% ; greenish-gray shale, 5% ; partly calcareous	5	140
Not logged	5	145
Similar to 145–150-ft interval, except a deeper shade of red	5	150
Not logged	5	155
Shale, red, calcareous, 95% ; greenish-gray shale, and arkosic sandstone, 5% . One grain of malachite	5	160
Not logged	5	165
Shale, red, 98% ; some fine-grained arkosic sandstone	5	170
Not logged	5	175
Arkose, reddish-gray, fine-grained, slightly calcareous, 98% ; some gray shale, and gray sandstone	5	180
Not logged	5	185
Shale, red, calcareous, 95%	5	190
Not logged	5	195
Shale, red, 50% ; red calcareous sandstone, 50%	5	200
Not logged	5	205
Shale, red, 70% ; fine red micaceous sandstone, 25% ; white quartz sandstone, 5%	5	210
Not logged	5	215
Shale, red, silty, 98% ; some gray arkosic sandstone	5	220
Not logged	5	225
Shale, red	5	230
Not logged	5	235
Shale, red	5	240
Not logged	5	245
Shale, red, silty, calcareous	5	250
Not logged	5	255
Shale, red, silty, 50% ; red siltstone, 50%	5	260
Not logged	5	265
Sandstone, white, fine-grained, 70% ; red siltstone, 30%	5	270
Not logged	5	275
Sandstone, white, fine-grained, quartzose, 80% ; gray, very fine-grained sandstone, 10% ; red silty shale, 10% ; all units calcareous	5	280
Not logged	5	285
Siltstone, red, micaceous, 60% ; white and gray fine-grained sandstone, 20% ; red shale, 20%	5	290
Not logged	5	295
Shale, red, silty, 99% ; fine-grained white quartz sandstone	5	300

Table 5. Drillers' logs—Continued

Well 958-652-4

Owner: J. A. Carey
Altitude: 480 ft
Driller: Young Bros., 1959
Reported yield: 7 gpm

Description	Thickness (feet)	Depth (feet)
Soil and soft shale	8	8
Red rock	7	15
Sandstone, brown	17	32
Sandstone, blue-gray, hard	13	45
Sandstone, brownish-gray, hard	7	52
Red rock	20	72
Sandstone, red	33	105
Red rock	13	118

Well 959-650-2

Owner: Lavan H. Miller
Altitude: 410 ft
Driller: Young Bros., 1957
Static water level: About 13 ft below land surface, December 16, 1957
Reported yield: 15 gpm

Description	Thickness (feet)	Depth (feet)
Shale, red	17	17
Red rock	39	56
Red rock and red sandstone	14	70
Sandstone, red	15	85
Sandstone, gray (most water enters at 90 ft)	5	90
Sandstone, gray and red	10	100

Well 959-653-1

Owner: A. M. Holmes
Altitude: 442 ft
Driller: Young Bros., 1959
Static water level: About 24 ft below land surface, November 1959
Reported yield: 13 gpm. Yielded 5 gpm at 121-ft depth

Description	Thickness (feet)	Depth (feet)
Shale, red	8	8
Red rock	96	104
Sandstone, red	4	108
Red rock	13	121
Red rock or red sandstone, very hard	10	131

Table 5. Drillers' logs—Continued

Well 000-646-1

Owner: Outdoor Country Club
Altitude: 485 ft
Driller: P. E. Kohler, 1959
Static water level: About 45 ft below land surface, February 17, 1959
Reported yield: 30 gpm. Yielded 4 gpm at 125-ft depth, 8 gpm at 180 ft, and 20 gpm at 270 ft

Description	Thickness (feet)	Depth (feet)
Soil and subsoil	11	11
Sandstone, red, hard	21	32
Shale, red, soft	18	50
Sandstone, red	65	115
Red rock	15	130
Not reported	115	245
Sandstone, gray	30	275
Red rock	25	300

Well 000-649-3

Owner: Alda Ketterman
Altitude: 380 ft
Driller: Young Bros., 1961
Static water level: About 24 ft below land surface, September 2, 1961
Reported yield: 12 gpm

Description	Thickness (feet)	Depth (feet)
Soil and red shale	12	12
Rock, brown	8	20
Red rock	22	42
Sandstone, gray, hard	17	59
Red rock	58	117

Well 001-644-10

Owner: John Guss
Altitude: 520 ft
Driller: Young Bros., 1959
Static water level: About 31 ft below land surface, October 12, 1959
Reported yield: 20 gpm

Description	Thickness (feet)	Depth (feet)
Shale, red	8	8
Sandstone, brownish-gray	36	44
Sandstone, light-gray	4	48
Shale, red, and red rock	6	54
Sandstone, red, hard	103	157

Table 5. Drillers' logs—Continued

Well 001-647-1

Owner: Guy L. Davis
Altitude: 442 ft
Driller: Young Bros., 1959
Static water level: About 39 ft below land surface, July 24, 1959
Reported yield: 10 gpm

Description	Thickness (feet)	Depth (feet)
Sandstone, light-yellowish-brown	18	18
Sandstone, yellow	37	55
Red rock (most water enters at 135 ft)	87	142

Well 003-648-1

Owner: George Sowers
Altitude: 525 ft
Driller: Young Bros., 1959
Static water level: About 55 ft below land surface, June 9, 1959
Reported yield: 5 gpm

Description	Thickness (feet)	Depth (feet)
Sandstone and boulders	15	15
Shale, soft	50	65
Shale, dark	40	105
Shale, red	15	120
Sandstone, gray (water enters at 130 ft)	16	136

Well 004-641-1

Owner: Sherrill Sand Co.
Altitude: 425 ft
Driller: A. C. Reider and Son, 1958
Static water level: About 50 ft below land surface, March 1958; flowed less than 1 gpm at 90-ft depth
Reported yield: 50 gpm

Description	Thickness (feet)	Depth (feet)
Soil and subsoil	10	10
Sandstone	34	44
Red rock	20	64
Clay, blue-gray	2	66
Red rock	24	90
Clay, blue-gray	3	93
Sandstone (most water enters at about 160 ft)	87	180
Red rock	20	200
Sandstone	150	350
Red rock	35	385
Sandstone	20	405
Sandstone, brown	10	415
Sandstone	95	510
Limestone, very fossiliferous	45	555

Table 5. Drillers' logs—Continued

Well 004-642-1

Owner: W. C. Ray Bailey
Altitude: 460 ft
Driller: Young Bros., 1961
Static water level: 53.6 ft below land surface, July 25, 1961
Reported yield: 9 gpm

Description	Thickness (feet)	Depth (feet)
Soil, brown sand, and sandstone	18	18
Red rock	45	63
Sandstone, hard, dark-brown	14	77
Red rock	7	84
Sandstone, dark-red-gray	17	101
Shale, light-green and red	8	109
Slate, dark-blue-gray	3	112
Slate, dark-blue-gray, very hard, light-gray sandstone	11	123
Sandstone, red (most water enters at 135 ft)	18	141

Well 004-646-2

Owner: J. R. Spangler
Altitude: 400 ft
Driller: Young Bros., 1959
Reported yield: 12 gpm

Description	Thickness (feet)	Depth (feet)
Soil and soft shale	8	8
Shale, hard	18	26
Red rock, hard	9	35
Sandstone, hard	7	42
Shale, hard	9	51
Shale, red (most water enters at 90 ft)	43	94

Well 005-641-5

Owner: Pennsylvania Power and Light Co.
Altitude: 283 ft
Driller: Herman Hake, 1957
Static water level: About 28 ft below land surface, August 1957
Reported yield: 60 gpm

Description	Thickness (feet)	Depth (feet)
Gravel fill	13	13
Gravel and boulders	17	30
Rock	8	38
Shale, red	14	52
Rock	11	63
Shale, red	22	85
Sandstone, greenish	40	125
Shale, red	2	127

Table 6. Summary of yield characteristics of wells tapping the New Oxford Formation in Adams and York Counties, Pa.—Continued

(Data from tests conducted by the Geological Survey, except as indicated)

Well number	Depth (feet)	Drawdown (feet)	Yield (gpm)	Specific capacity (gpm per ft of drawdown)	Yield per foot of well (gpm)	Length of test (min.)	Pumping equipment[1]	Depth of pump below land surface (feet)	Date of test	Field coefficient of transmissibility (gpd per ft)[2]
Adams County										
944-707-1	120	103	3.5	0.03	0.03	60	A	110	8- 5-61	7
946-709-1	205	47	5	.10	.02	60	A	121	8- 4-61	40
....	......	59	5	.08	.02	120	A	121	...do...	....
947-704-1	61	11	13.5	1.2	.22	60	A	50	11-22-60	1,000
....	......	13	13.5	1.0	.22	120	A	50	...do...	....
948-705-2	107	14	7.8	.55	.07	60	A	92	11-30-60	350
....	......	21	7.0	.33	.06	120	A	92	...do...	....
950-702-2	91	62	7	.11	.07	60	A	81	12- 7-60	40
....	......	71	6	.08	.06	120	A	81	...do...	....
....	......	72	5	.07	.05	180	A	81	...do...	....
951-700-1	82	62	6.8	.10	.08	60	A	70	5-25-61	....
952-702-7	112	98	11	.12	.01	60	A	82	11-25-61	....
....	......	49	6	.12	.05	60	A	92	...do...	....
953-702-10	138	60	6	.10	.04	60	A	90	5-14-61	....
955-659-1	75	61	5	.13	.06	60	A	61	12- 6-60	....
York County										
953-658-4	186	89	4.8	0.05	0.02	60	A	120	5-25-61	....
954-656-1	155	70	8	.11	.05	60	A	120	5-10-61	....
954-658-3	94	26	13	.50	.13	60	A	80	8- 7-61	....
....	......	28	13	.47	.13	120	A	80	...do...	....
955-657-6	142	38	5	.13	.03	60	A	110	8- 7-61	....
956-651-9	72	23	2.3	.10	.03	60	A	62	5- 3-61	....
956-655-3	60	26	8	.30	.13	60	A	50	5- 8-61	....
....	......	29	8	.27	.13	120	A	50	...do...	....
....	......	36	7.5	.20	.12	360	A	50	...do...	....

Table 6. Summary of yield characteristics of wells tapping the New Oxford Formation in Adams and York Counties, Pa.—Continued

Well number[4]	Depth (feet)	Drawdown (feet)	Yield (gpm)	Specific capacity (gpm per ft of drawdown)	Yield per foot of well (gpm)	Length of test (min.)	Pumping equipment[1]	Depth of pump below land surface (feet)	Date of test	Field coefficient of transmissibility (gpd per ft)[2]
York County—Continued										
957-652-5	110	39	5	.13	.04	60	A	100	8- 8-61	....
958-648-1	300	12	13.7	1.14	.04	60	A	66	5- 2-61	....
....	......	12	13.7	1.14	.04	120	A	66	...do...	....
....	......	22	24.5	1.11	.08	60	B	99	7-14-61	1,400
....	......	24	24.5	1.02	.08	120	B	99	...do...	....
....	......	26	24.5	.90	.08	360	B	99	...do...	....
959-648-4[3]	300	160	114	.70	.38	1,440	C	170	5- ?-55	....
000-648-1	172	38	3.8	.10	.02	60	A	110	9-12-61	....
000-649-1	91	11	6.5	.59	.07	60	A	77	9-12-61	....
....	......	18	10.4	.58	....	120	A	77	...do...	....
000-650-1[3]	800	380	38	.10	.04	240	C	500	11-24-54	....
001-644-1[3]	785	160	80	.50	.10	1,440	C	220	4-29-57	....
001-644-2	93	32	6	.19	.06	60	A	81	8-10-61	....
....	......	45	6	.13	....	120	A	81	...do...	....
001-644-3	99	54	6	.11	.06	60	A	90	8-10-61	....
001-644-4	81	8	13	1.62	.16	60	A	70	9-20-61	2,000
....	......	16	19	1.19	.19	60	B	72	9-28-61	....
001-644-5	65	2	13	6.50	.20	60	A	51	9-19-61	....
....	......	2.3	13	5.65	....	120	A	51	9-19-61	....
001-645-1	92	18	9	.50	.10	60	A	80	9-20-61	....
002-643-2	127	83	6.5	.05	.05	60	A	120	5-22-61	....
003-645-1	490	9	36	4	.07	60	B	130	6- 1-61	5,200
....	......	9	39	4.33	.07	60	B	80	6- 1-61	....
....	......	10	38	3.80	.07	120	B	80	...do...	....
003-645-2	493	45	25	.55	.05	60	B	114	7-12-61	200
....	......	50	24	.48	.05	120	B	114	...do...	....
....	......	54	24	.44	.05	420	B	114	...do...	....
003-645-3	131	30	6	.20	.05	60	A	110	7-24-61	....
....	......	35	6	.17	.05	120	A	110	...do...	....

003-647-1	131	58	4.5	.08	.03	60	A	120	5-26-61	....
004-642-1	142	22	5.8	.26	.03	60	A	120	7-25-61	....
....	......	46	9.5	.21	.06	60	A	120	7-25-61	....
005-641-5[3]	127	16	37	2.2	.29	480	C	....	8-28-57	....
005-643-5	97	20	9	.45	.09	60	A	80	9-21-61	....

[1] A. ⅓-hp submersible turbine pump operated by a portable generator.
B. 1½-hp submersible turbine pump operated by a portable generator.
C. Deep-well turbine pump used by well contractor.

[2] Formula used for analysis was the graphical method of Cooper and Jacob (1946, p. 526–534).

[3] Date from well contractor's record.

Table 7. Chemical analyses of ground water from the area underlain by the New Oxford Formation in Adams and York Counties, Pa.

[Well number: a, analysis from Hall (1934). Results in parts per million except as indicated.]

Well number	Date of collection	Temperature °F	Silica (SiO_2)	Total iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Sum total dissolved solids	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH
																Calcium-magnesium	Non-carbonate		
Adams County																			
943-706-4	11– 3–60	55	22	1.2	0.03	102	55	26	1.2	212	120	104	0.0	124	658	481	307	1,040	7.6
(spring)-6	..do..	54	10	.04	.03	5.7	4.9	4.0	1.5	14	.8	5.2	.0	28	67	34	23	93	5.7
707-1	..do..	—	25	.04	.00	42	13	9.1	.8	156	20	11	.1	15	213	159	31	329	7.2
710-3	..do..	—	15	.06	.02	22	7.8	7.4	1.4	42	30	11	.1	36	151	87	53	235	6.4
948-706-1	10–31–60	—	13	.14	.03	38	17	18	4.2	72	53	24	.0	81	284	165	106	432	6.4
-2	..do..	55	18	.78	.09	82	33	34	5.0	180	76	72	.3	99	508	340	193	806	6.7
950-703-3	11– 3–60	56	20	.19	.05	69	44	26	32	232	104	78	.0	38	525	353	163	857	7.0
-4	..do..	55	23	.43	.11	90	79	56	4.0	302	93	173	.3	83	750	550	302	1,280	6.8
951-703-2	..do..	56	21	.03	.01	45	12	20	1.1	174	23	22	.2	18	248	161	30	394	7.5
705-2[a]	11– 1–25	54	6.2	22	..	8.2	4.7	4.1	.6	16	22	5.8	..	5.7	72	40	..	..	..
-5[a]	..do..	54	16	.14	..	47	11	24		105	73	22	..	27	288	163	..	..	..
952-701-5	10–31–60	55	20	2.4	.03	30	7.4	10	1.0	142	2.5	2.0	.0	6.7	150	106	0	233	7.7
-7[a]	11– 1–25	52	8.4	.08	..	97	19	15		248	37	30	..	84	411	320	..	..	..
956-659-2	10–31–60	..	18	.03	.03	52	12	17	1.0	198	27	13	.0	1.8	239	179	17	411	7.1
York County																			
953-656-1	11– 4–60	..	20	.17	.03	9.8	5.7	7.5	1.0	14	7.1	9.2	.0	45	112	48	37	139	6.0
954-656-2[a]	11– 1–25	52	8.4	.17	..	27	14	94		90	54	8.0	..	7.1	161	125	..	..	..
956-651-7	2–24–61	..	28	.05	.01	26	7.3	8.3	.5	56	13	11	.1	47	169	95	49	243	6.3
-655-3	2–28–61	53	20	.22	.06	46	8.8	13	.8	168	18	5.5	.0	22	217	151	14	344	7.8
957-652-3	2–24–61	..	35	.45	.08	57	30	30	2.0	145	51	5	.1	30	392	266	147	659	6.9
958-648-1	11–21–60	54	22	.05	.02	33	6.7	7.9	1.0	123	9.4	4.9	.1	18	164	110	9	253	7.7
-652-2	2–24–61	45	8.4	.08	.00	45	6.6	8.2	4.0	146	31	2.8	.4	5.0	183	140	20	314	7.7
959-653-1	..do..	..	18	.09	.05	59	14	16	.5	230	19	7.3	.0	17	264	205	16	424	7.7
000-646-1	..do..	..	20	.06	.00	34	6.9	9.2	1.5	124	12	4.7	.0	23	172	114	12	270	7.3
651-1	..do..	..	21	.24	.05	.64	12	16	.5	184	26	20	.0	46	296	209	58	469	7.5
002-643-1	2–23–61	..	39	.32	.39	.43	18	6.3	4.5	153	43	11	.1	28	268	182	56	402	6.7
003-646-1	2–23–61	..	26	.14	.03	.27	8.8	18	1.0	102	41	6.0	.0	18	196	104	20	306	6.6
005-643-1	2–22–61	..	21	.06	.04	.23	4.4	7.5	2.0	96	3.6	3.0	.1	14	126	76	0	190	6.8

Table 8. Field analyses of ground water from the New Oxford Formation in Adams and York Counties, Pa.

Well number	Date collected	pH	Hardness (grains per gallon)	Specific conductance (micromhos at 25°C)	Temperature (°F)
			Adams County		
943-706-4	8- 8-60	...	25	1,275	56
-5	8- 8-60	...	21	920	..
-6 (Spring)	8- 8-60	5.6	3	90	55
707-1	11- 4-60	7.2	8	355	..
-5	9-29-60	...	21	920	..
-7	9-13-60	...	17	650	..
708-2	8- 3-60	...	10	430	..
-5	8- 3-60	...	15	700	..
-6	8-11-60	...	6	320	..
710-3	8- 3-60	...	5	210	..
711-3	8-11-60	...	10	350	..
944-707-1	8- 4-61	...	6	260	55
945-705-3	8-10-60	...	8	340	..
946-707-1	7-29-60	7.8	10	410	58
708-1	7-28-60	...	5	...	54
709-1	8- 4-61	7.4	8	375	56
710-1	8- 9-60	...	7	320	54
947-704-1	11-22-60	7.9	9	375	55
-2	8-10-60	...	12	380	..
948-705-1	8-18-60	...	12	600	..
-3	8-23-60	...	14	480	55
-4	8-23-60	...	14	550	..
706-1	8-18-60	...	8	440	53
-2	8-18-60	...	20	1,100	54
-4	8-18-60	...	8	375	..
-5	8-18-60	...	12	450	..
707-2	8-15-60	...	7	380	..
950-702-1	8-24-60	...	9	370	57
950-703-1	8-31-60	...	9	380	..
-3	8-31-60	...	26	950	..
-4	8-31-60	...	27	1,280	55
-5	8-31-60	...	10	625	54
951-700-1	5-25-61	7.3	7	315	53
701-7	9- 6-60	...	9	380	55
703-2	9- 6-60	7.6	8	420	57
951-705-2	8-29-60	...	7	...	54
-4	10-17-60	...	7	350	56
-5	11- 1-25	...	..	...	54
706-1	9-19-60	...	10	255	53
952-700-1	10-17-60	...	8	380	..
701-5	9-14-60	...	7	255	56
-7	11- 1-25	...	..	...	52
702-1	9-14-60	...	6	180	..
-2	9-21-60	...	6	300	..
-7	11-25-60	7.4	4	160	55
703-1	5-17-61	7.6	7	400	56
953-702-1	9-22-60	...	6	265	57
-3	9-22-60	...	21	730	57
-4	9-22-60	...	19	760	..
-5	9-22-60	...	19	720	55
-6	9-22-60	...	10	400	..
-8	9-22-60	...	9	390	..
-10	5-14-61	7.3	12	540	55
954-702-1	9-21-60	...	21	850	..
-2	9-21-60	...	10	350	..

Table 8. Field analyses of ground water from the New Oxford Formation in Adams and York Counties, Pa.—Continued

Well number	Date collected	pH	Hardness (grains per gallon)	Specific conductance (micromhos at 25°C)	Temperature (°F)
		Adams County—continued			
955-658-1	10- 4-60	...	4	240	..
659-1	12- 6-60	7.4	9	355	54
956-658-1	10- 4-60	...	4	235	57
659-1	10- 4-60	...	7	445	..
-2	10-31-60	...	8	450	57
-3	10-21-60	...	10	535	55
-4	10- 5-60	...	11	495	55
-5	10- 5-60	...	2	125	..
-6	10-19-60	...	10	515	..
-7	10-19-60	...	14	710	..
-10	10-19-60	...	7	380	..
		York County			
953-656-1	9-27-60	6.5	3	135	..
-3	9-27-60	...	7	410	54
953-657-1	10- 3-60	...	10	500	..
-2	9-28-60	...	10	575	..
-4	9-28-60	...	..	...	55
-5	9-28-60	...	4	180	..
-6	9-28-60	...	4	185	..
-10	10- 3-60	...	14	630	..
658-3	5-16-61	7.6	8	405	55
-4	5-25-61	...	11	555	56
954-656-1	5-10-61	...	9	385	55
-2	11- 1-25	...	..	...	52
657-3	9-28-60	...	10	450	55
-5	9-27-60	...	5	300	..
658-3					
(Dug part)	8- 7-61	...	7	360	..
(Drilled part)	8- 7-61	7.6	5	225	55
955-653-1	10-19-60	...	9	440	..
-2	10-19-60	...	10	390	..
955-654-1	10-25-60	...	8	325	..
-2	10-26-60	...	8	450	..
-3	10-26-60	...	9	450	..
657-1	10- 3-60	...	5	435	..
-4	10-20-60	...	8	360	57
-6	8- 7-61	...	5	240	56
658-2	10- 4-60	...	5	300	..
956-651-1	11- 9-60	6.8	4	195	..
-2	11- 9-60	6.1	3	155	..
-3	11- 9-60	7.4	9	410	..
-5	11-14-60	7.4	9	345	..
-6	11-14-60	6.2	5	265	..
-7	11-14-60	6.1	6	270	..
-8	11-15-60	6.9	10	410	56
-9	5- 3-61	...	7	220	54
-10	8- 3-61	6.0	5	325	..
956-652-2	8- 9-61	...	2	135	..
654-1	10-26-60	...	9	335	..
655-1	10-26-60	6.8	4	195	..
-2	10-26-60	...	..	...	56
-3	11- 4-60	7.8	7	350	55
957-649-1	9-27-61	6.9	7	260	..
651-1	11-16-60	7.6	12	450	..

Table 8. Field analyses of ground water from the New Oxford Formation in Adams and York Counties, Pa.—Continued

Well number	Date collected	pH	Hardness (grains per gallon)	Specific conductance (micromhos at 25°C)	Temperature (°F)
York County—continued					
652-1	11–16–60	6.4	6	325	..
-2	11–17–60	6.4	6	315	..
-3	11–18–60	6.9	13	615	..
-5	8– 8–61	7.2	6	320	55
653-1	9–29–61	6.5	5	280	..
655-1	11– 7–60	7.0	7	335	..
-2	11– 8–60	7.4	7	370	..
656-1	11– 4–60	7.4	12	600	..
-3	11– 8–60	7.0	14	640	..
-4	11– 9–60	7.7	11	575	..
-5	11– 9–60	7.2	12	735	55
957-657-1	11– 8–60	6.5	9	410	..
-2	11– 8–60	6.0	5	275	..
-3	11– 8–60	7.2	11	480	..
958-648-1	11–21–60	7.6	7	275	54
-5	9– 8–61	...	7	310	..
-6	9–27–61	7.5	7	300	..
652-1	11–18–60	6.7	7	335	..
-2	11–18–60	7.3	13	520	..
-4	9–29–61	7.4	..	370	..
653-1	9–29–61	7.6	10	455	..
654-1	9– 8–61	...	12	615	..
-3	9–29–61	7.3	15	710	..
-6	9–29–61	7.5	12	605	..
655-1	9–29–61	7.6	9	430	..
959-649-1	9–27–61	7.4	6	325	..
650-5	9–27–61	7.6	7	385	..
651-2	8– 9–61	...	6	215	..
653-1	2–24–61	7.4	11	440	..
959-653-2	9–29–61	7.4	9	440	..
-3	9–29–61	7.4	..	365	..
-4	9–29–61	7.4	10	430	..
654-1	9– 8–61	...	11	475	..
000-646-1	2–24–61	6.8	6	300	..
648-1	9–12–61	7.8	5	280	55
649-1	9–12–61	7.6	9	410	55
-2	9–26–61	7.0	7	360	..
651-1	2–24–61	7.4	10	500	..
654-1	9–29–61	7.6	8	380	..
001-644-2	8–10–61	6.8	6	280	55
-3	8–10–61	5.8	6	315	55
-4	9–20–61	...	4	275	54
-5	9–19–61	...	4	240	54
645-1	9–20–61	...	6	360	..
647-1	9–26–61	6.9	7	290	..
002-643-1	2–23–61	6.7	11	595	..
-2	5–22–61	...	23	1,300	54
648-1	9–26–61	7.5	9	465	..
003-645-1	6– 1–61	7.9	5	390	55
-2	6– 2–61	7.6	9	525	55
-3	7–24–61	7.8	11	520	56
646-1	7–23–61	6.4	7	355	..
647-1	5–26–61	6.3	2	105	54
649-1	9–26–61	6.8	4	180	..
004-642-1	7–25–61	7.5	9	450	55
646-1	9–26–61	7.3	10	390	..

Table 8. Field analyses of ground water from the New Oxford Formation in Adams and York Counties, Pa.—Continued

Well number	Date collected	pH	Hardness (grains per gallon)	Specific conductance (micromhos at 25°C)	Temperature (°F)
York County—continued					
-2	9-26-61	7.3	12	540	..
005-643-1	2-22-61	6.4	4	180	..
-5	9-21-61	...	3	100	54
006-642-4	5-25-61	...	11	555	56