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GROUND-WATER SUPPLY AT THE LETTERKENNY ORDNANCE DEPOT, CHAMBERSBURG, PENNSYLVANIA

By

Jack R. Graham, District Geologist
United States Geological Survey
and
Robert C. Stephenson
Assistant State Geologist
Pennsylvania Topographic and Geologic Survey
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Introduction

This memorandum summarizes the results of a study made by the U. S. Geological Survey at the request of the Office of the Chief of Engineers, Department of the Army, to ascertain the availability of water from wells to supplement the present water supply of the Letterkenny Ordnance Depot, Chambersburg, Pennsylvania. Field work was done during May 1949.

Geology as Related to Ground Water

Letterkenny Ordnance Depot is situated in an area underlain by ancient marine sediments composed of limestone and shale. The depot lies south of the farthest extent of glaciation and, except for a thin veneer of residual soil and scattered remnants of stream-laid gravels from adjacent highlands, the bedrock formations are exposed at the surface.

Although the depot covers an area of about 20,000 acres, most of the personnel, office buildings, warehouses, and other facilities requiring water supply are located in a much smaller area in the southeastern part of the depot. Inasmuch as any new water supply must be developed in or carried to this part of the depot, the following description of geologic formations is confined to the area in question.

The oldest formation outcropping in the area is the Beekmantown limestone of Ordovician age. This formation, described in detail by Stose in the Mercersburg-Chambersburg folio, U. S. Geological Survey Atlas No. 170, is a thick-bedded limestone with a basal conglomerate member and several interbedded layers of dolomite and marble. The formation is about 2,300 feet thick. The average yield of 51 wells in this formation in southeastern Pennsylvania is 25 gallons a minute. Only the extreme eastern part of the depot lies within the outcrop area of the Beekmantown limestone.

The Beekmantown limestone is overlain by the Stones River limestone, which ranges in thickness from 675 to 1,050 feet. This limestone is unusually pure, with the result that solution openings are larger and more abundant than in other limestones in the area. The average recorded yield of wells in this formation in southeastern Pennsylvania is 75 gallons a minute.

Overlying the Stones River limestone is the Chambersburg limestone. This formation, 100 to 750 feet thick, contains clay partings and interbedded shale beds which retard the solution action of ground water. The yield of this limestone is comparable to that of the Beekmantown.

The youngest formation in the area is the Martinsburg shale, comprising about 2,000 feet of dark crumbly shale, changing to soft shaly sandstone in the upper part. Although the average yield of water wells throughout the outcrop area of this formation in southeastern Pennsylvania is 52 gallons a minute, wells in the Martinsburg in Franklin County have a much lower average yield.

All these formations lie within a regional area of crustal deformation, so that the once horizontal beds have been tilted, compressed into folds, and in places faulted and even overturned.

The movement of ground water through limestone and shale formations takes place along openings within the rock mass developed by fracturing, or along bedding planes. In carbonate rocks such underground conduits may be enlarged by the dissolving action of ground water. The success of wells drilled into the rock depends upon intersecting a sufficient number or sufficiently large openings to result in a satisfactory yield. There is no known method of predetermining the position, number, or depth of such subsurface water-bearing openings prior to drilling. However, a study of the structural conditions, including zones of pronounced fracturing, development and orientation of sinkholes, and general topographic expression, aid in the interpretation of underground conditions and materially increase the chance of encountering water-bearing openings upon drilling.

Of the several formations outcropping in the area, the Stones River limestone provides the best possibility for wells of large yield. Furthermore, its outcrop is advantageously situated with respect to the location of wells near the existing water-supply facilities. Field work by the authors during May 1949 was designed (1) to identify and map the Stones River limestone, considered to be the most favorable aquifer, and (2) to identify areas of folding or faulting where it is believed subsurface openings are likely to be more numerous and enlarged by solution. Such areas identified in the field are described later in the report.

Present Water Supply

The present water supply for the depot, averaging about 180,000 gallons a day, is obtained from Rocky Spring (see map), which is located in the southeastern part of the depot area. The spring issues from an outcrop of the Chambersburg limestone. No systematic record of the yield of the spring is available. However, the flow has been observed to fluctuate sharply in response to local precipitation as well as seasonal climatic variations. Moderate rains produce visible turbidity and an increase in flow within 5 to 6 hours after the beginning of precipitation. Conversely, the flow will clear and decrease in volume at a slow but noticeable rate following periods of rain. Dry periods of even a few weeks' duration may reduce the flow of the spring to rates insufficient for normal requirements of the depot.

The behavior pattern of the spring indicates nearby sources of recharge from precipitation and rapid underground movement to the spring outlet. The relation of variability of flow to precipitation and dry periods suggests a relatively small reservoir area for the spring, or very low storage capacity of the rocks drained by the spring. One visibly active sinkhole was found near the spring during the recent field examination of the area, and numerous other surface depressions in the limestone were noted. In view of the above considerations, the spring cannot be considered a dependable source of water supply from the standpoint of either quantity or quality. Further development of Rocky Spring would not materially change these conditions for the better.

During the construction of the depot, in the early part of World War II, six wells were drilled in an attempt to supply the depot requirements with well water. The locations of these six wells are shown on the map. Wells 1 and 2 were drilled in shale and are reported to have yielded very little water. Wells 3 and 4 were drilled in the Stones River limestone near the shale boundary. These wells were reported to yield 50 gallons a minute when tested. Wells 5 and 6 were drilled in the Stones River limestone, and though they had an initial yield of 125 gallons a minute each, the water was turbid and they were not put into use. In 1945, the Kohl Bros. Drilling Co., the original contractor for all six wells, again tested wells 5 and 6 and determined that, after 48 hours of pumping, the yield of each well was less than 50 gallons a minute and stability had not been reached. The water was too turbid for use. All but wells 5 and 6 have been destroyed. The following data were obtained for these two wells:

	Well 5	Well 6
Original depth	475 feet	425 feet
Depth - May 1949	440.5 feet	95.5 feet
Diameter	6 inches	5 inches
Aquifer	Stones River limestone	Stones River limestone
Original yield (reported)	125 gpm	125 gpm
Yield - 1945	Less than 50 gpm	Less than 50 gpm
Original depth to water level (reported)	25 feet	40 feet
Depth to water level - May 11, 1949	48.21 feet	52.20 feet

Sources of Additional Supply

For the past several years, the summer yield of the spring has been inadequate to supply the normal requirements of the depot and the curtailment of some uses has been necessary. Two sources may be considered for supplanting or augmenting the supply from Rocky Spring. A large spring approximately 4 1/2 miles west of Rocky Spring and in a limestone valley just east of North Mountain was tested earlier this year by pumping from the pool fed by the spring. At the time of the test the supply was far in excess of the quantity required by the depot. However, no seasonal record of flow of the spring is available, and it is not certain that the yield would be adequate during prolonged drought. Assuming the spring supply to be adequate, the cost of the 4 1/2 miles of pipe line to the distribution system is several times more than the estimated cost of developing a satisfactory supply from wells near the present water system, even though several wells may be required. The difference in estimated cost of the two sources is so greatly in favor of local wells that only the well supply is considered in this report.

Sites for New Wells

The enclosed map shows the outline of the catchment area feeding Rocky Spring. The boundary for the area is drawn along the topographic divide separating surface drainage toward Rocky Spring from drainage which must use other courses. This area, approximately 1,160 acres in extent, is underlain by limestone and shale in about equal amount. Assuming the average annual precipitation at the depot to be 40 inches, the average amount of water falling on the catchment area as drawn is 3,663 acre-feet a year. The present annual consumption at the depot, all of which is obtained from Rocky Spring, is about 201 acre-feet, or 5.2 percent of the total precipitation within the area.

In Pennsylvania in general, runoff approximates 50 percent of total precipitation, water losses primarily due to evaporation and transpiration accounting for the remaining 50 percent. However, there is no runoff from the Rocky Spring catchment area during most of the year. It is reported that only after the heaviest rains is there a flow in the valley above the spring. This is substantiated by the lack of a well-defined channel in the valley above Rocky Spring. Consequently, it is reasonable to assume that all the precipitation that normally would run off enters the underground reservoir, except for the part of the water from the heavier rains ~~which~~ that flows in the poorly defined surface drainage near Rocky Spring. It is believed that the ground-water recharge from precipitation in the catchment area is much larger than the flow of Rocky Spring, and a large part of the water recharged passes beneath the spring, coming out in the valley of Rocky Spring Creek at points below the spring. Rocky Spring merely skims the top of the ground-water reservoir. Wells which encounter adequate water-bearing openings, and located so as to draw on the volume of water passing beneath the spring could easily supply the amount required by the depot throughout the year.

The five sites for new water wells in the Letterkenny Ordnance Depot, shown on the map, were selected on the basis of the area in which the water supply is to be used, the geology of the area concerned, and the factors believed to have a bearing on the quality of water. In two earlier memoranda pertaining to ground-water supplies at the depot, dated May 7 and July 14, 1945, two promising areas for drilling water wells were designated. Both the drilling areas suggested at that time lie to the north of the sites suggested herein. The locations formerly suggested would require longer pipe lines to the present treatment plant, and are located near stock piles of ore, stored on the surface since 1945. These ore piles are believed to constitute potential sources of chemical pollution to wells drilled near them. Because of the conditions just enumerated, no further consideration of the former sites is given in this report.

The enclosed map shows the drilling sites chosen on the basis of field work by the authors in May 1949. All the sites are relatively close to existing water facilities and lie within a catchment area shown on the map by a heavy dashed line. The northern boundary of this catchment area is drawn along a low surface divide. It is believed that this surface divide has its counterpart in a ground-water divide, from which ground water moves northeast through the ore-pile area and southwest toward Rocky Spring.

The five sites shown on the map lie within the area of outcrop of the Stones River limestone. They are located along the small valley that carries surface runoff during the heavier rains. In general, statistics for both southeastern Pennsylvania and other areas indicate that subsurface openings in soluble rocks are better developed along valleys than in interstream areas. Further, the location of the sites ~~are~~ is in the southwestern or down-gradient part of the catchment area, where the Stones River limestone is constricted in a relatively narrow zone between outcrops of the less permeable Chambersburg limestone. Therefore, interception of a large part of the recharge to the catchment area is possible.

The location and character of each site are as follows:

Site No. 1 is on the northwest side of the intermittent drainage near a line of small abandoned lime pits. Observation of the character of the rocks in these pits indicates that this is the locus of sharp folding and/or faulting. The fracturing of the limestone in such zones frequently provides the original openings along which ground-water movement may occur. Enlargement by solution of such openings produces fissures or cavities capable of yielding large quantities of water to wells intersecting them.

Field data suggest that site 1 and an active sinkhole approximately 800 feet north of the site lie along the same structural axis. ~~While~~ Although this evidence is favorable for the occurrence of water-bearing openings at site 1, the possibility that fairly direct recharge of surface water may occur through the sinkhole should be considered. If a well drilled at site 1 is found to be directly connected to the sinkhole, steps may be taken to seal off the entrance of surface water into the sink.

Site No. 2 is north of the sewage-disposal plant, on the southeast side of the intermittent drainage. It lies on the axis of a minor fold in which the bedding shows less disturbance than at site 1. Site 2 is the northeasternmost of the five locations and is situated up the ground-water gradient from the sinkhole previously mentioned, and therefore it would be less subject to direct surface recharge than site 1.

Site No. 3 is on the south side of the intermittent drainage and about 600 feet southwest of site 1. This location is just east of the contact of the Stones River and Chambersburg limestones and within the outcrop of the more soluble Stones River limestone. The location was chosen to take advantage of ground-water movement in the Stones River limestone along the contact with the less soluble Chambersburg limestone. Further, structural conditions noted at site 1 may extend southwestward to site 3.

This site is the southwesternmost of the five locations and, therefore, has the advantage of the greatest area of recharge.

Site No. 4 is just west of the road leading from South Patrol Road to the sewage-disposal plant. It lies about 800 feet south of site 2, on the same structural axis. Site 4 is near an area of perennial seepage that may indicate relatively great permeability of the limestone at this place.

Site No. 5 is about 250 feet east of site 1. The choice of this site is based on the favorable structural conditions described for site 1. Site 5 lies across a synclinal axis from No. 1. It is believed that a single well may not adequately test the possibilities of intersecting water-filled openings related to the rock deformation at this locality. Should the first test at site 5 prove to be unsuccessful, a second is considered to be warranted.

Quality of the Water

It is recognized that the present supply from Rocky Spring is inadequate in quantity during periods of deficient rainfall and is also subject to contamination. The turbidity of the spring flow after rains, and the nearness of Rocky Hill Cemetery and debris-filled depressions immediately east of the spring, are undesirable features.

It is believed that properly constructed wells drilled at the sites suggested will provide water free of turbidity and bacteriologically safe. With the exception of the sinkhole referred to near site 1, no other surface conditions were observed that are believed likely to affect the chemical or bacteriological character of the ground water. If the sinkhole referred to is found to be connected more or less directly to one or more of the wells, corrective measures such as filling the sink with shale or grout, curbing it, or covering it may be undertaken.

Chemically, water obtained from deep wells will be similar to that yielded by the spring. Because the wells may tap water that circulates to greater depths than that feeding the spring, the well water may be somewhat harder than water from the spring during high flow following rains or prolonged thaws. During such periods the movement of ground water through the soil and rock to the spring outlet is accelerated so that there is less time for the water to pick up soluble minerals, than during periods of slow movement. However, the difference between the chemical quality of the well water and the spring supply probably would be small and would not materially increase softening costs.

Recommended Procedures

It is recommended that the first well be drilled at site 1. It is further suggested that this and subsequent wells, if required, be at least 8 inches in diameter. This diameter is believed to be the minimum permitting sufficiently deep pump settings to obtain the desired quantity. Unless a sufficient quantity is obtained at shallower depths, drilling should be carried to approximately 500 feet. The well or wells should be cased and grouted to a depth of 20 to 50 feet, depending upon the rock conditions encountered. Casing may be carried to greater depths to shut off openings connected to nearby surface openings. A driller's log and well cuttings for each 5 feet of depth should be kept. Operating wells should be equipped with an air line and pressure gage for determining static and pumping levels, and any well drilled and not equipped with a pump should be retained and used for observation purposes. Wells 5 and 6, drilled in 1942, should also be equipped with recorders for observation of water levels.

It is suggested that the Philadelphia office, Ground Water Branch, United States Geological Survey, be notified upon completion of drilling at site 1. The authors will assist in testing the wells and may wish to alter certain of the recommendations listed herein on the basis of data obtained from the first well.

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