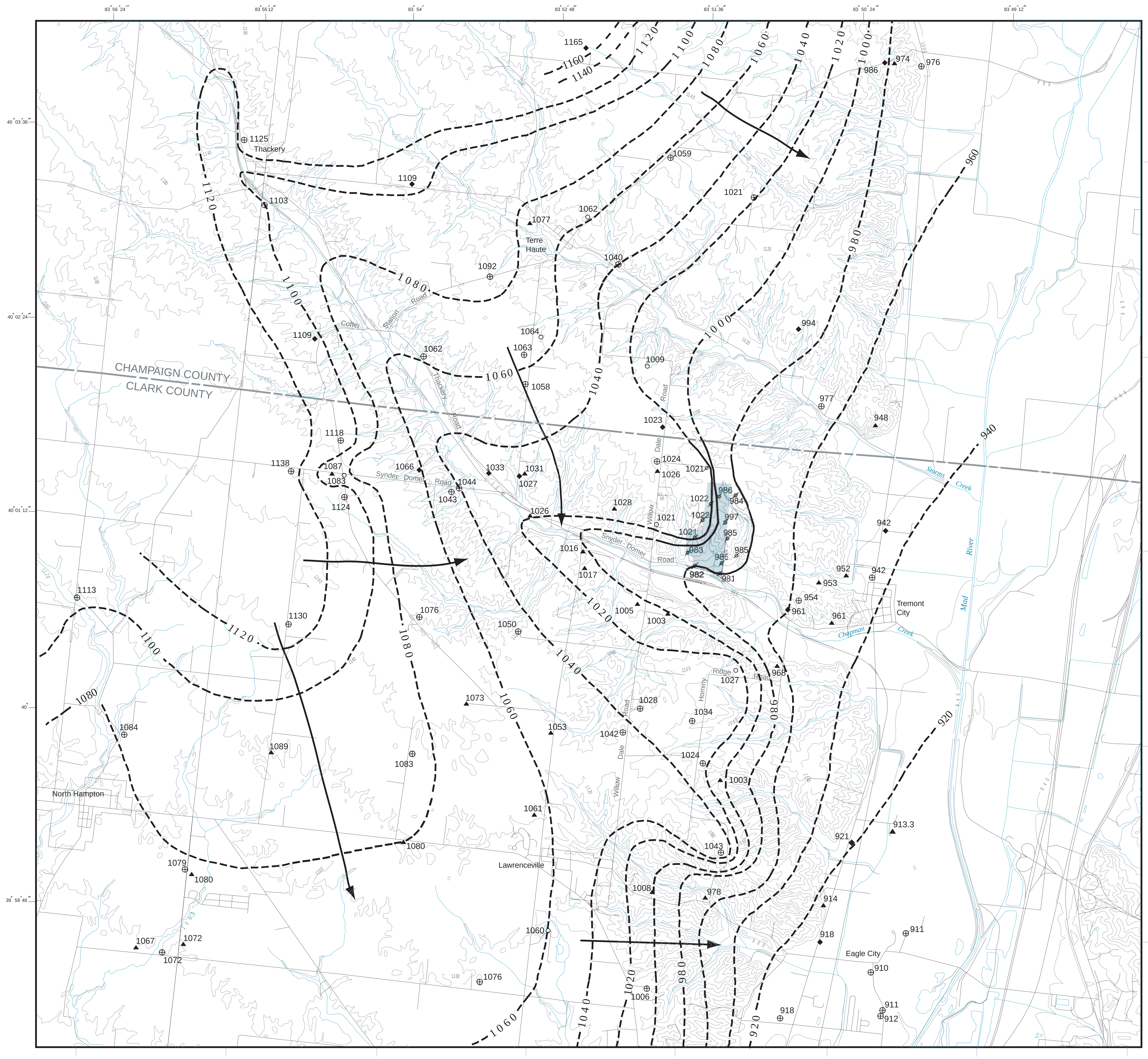
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

IN COOPERATION WITH
U.S. ENVIRONMENTAL PROTECTION AGENCY

WATER-RESOURCES INVESTIGATIONS REPORT 01-4224
Dumouchelle, D.H., 2001, Ground-water levels and flow directons in glacial sediments and carbonate bedrock near Tremont City, Ohio, October-November 2000



Ground-water levels and flow directions in glacial sediments and carbonate bedrock near Tremont City, Ohio, October-November 2000

Introduction

During summer 2000, the U.S. Environmental Protection Agency (USEPA) began an investigation of the Tremont City Landfill Site near Tremont City, Ohio. The site is about 1 mile west of Tremont City, just south of the Clark-Champaign County line. The closed site consists of three main areas: an 8.5-acre barrel fill, a 14-acre waste-transfer area, and a 58-acre landfill. The local hydrogeology is complex, and multiple ground-water-flow directions at the site have been described (Eagon & Associates, 1992, 1994); however, offsite ground-water levels and flow directions were poorly defined, because they were based on static water levels reported over many years by well drillers. In October 2000, the U.S. Geological Survey (USGS), in cooperation with the USEPA, measured water levels in residential and onsite monitoring wells to prepare a map of the potentiometric surface so that directions of regional ground-water flow could be better delineated in the vicinity of the site.

The topography of the study area (extent of map) is characterized by a nearly level till plain with minor relief along incised streams draining east-southeast to the Mad River. The Tremont City Landfill Site is in an upland area between two east-southeast-trending streams. Storms Creek is about 1 mile north of the site. The southern extent of the landfill is within about 500 feet of Chapman creek.

The surficial geology of the study area consists of unconsolidated glacial sediments that overlie Silurian-age Lockport Dolomite. These glacial sediments consist of fine-grained till interbedded with layers of silt, sands, and gravels. Sand and gravel layers are commonly found just above the bedrock surface (Norris and others, 1952). Onsite monitoring wells have been installed into several thin, permeable zones in the glacial sediments. Most residential wells in the area produce sufficient water for residential use (as much as 100 gallons per minute), from either sand and gravel layers in the glacial sediments or from the carbonate bedrock. The most productive aquifer in the area is the highly permeable glacial outwash in the buried bedrock valley beneath the Mad River. These outwash sands and gravels can yield more than 1,000 gallons per minute (Schmidt, 1982). If weathered, the Lockport Dolomite can be a productive source of water near the top of the unit (Norris and Fidler, 1973).

Methods of Investigation

Drillers' logs for wells throughout the study area were copied from files at the Ohio Department of Natural Resources. Logs with addresses or street directions were preferentially selected to increase the chance of accurately locating wells. Wells completed in glacial sediments and bedrock were selected.

From October 30 to November 3, 2000, personnel from the USGS and USEPA measured water levels in 88 privately owned wells in the area. During the same time, 61 site-monitoring wells were measured by contractors for the USEPA. Private wells were selected on the basis of availability and information on well logs, access, geographic location, and geologic setting. Sparse housing, lack of well logs, or an inability to gain access to wells affected the distribution of measured wells. In addition, a number of wells for which logs were not available were measured during the fieldwork to help fill in data gaps. After the fieldwork was completed, attempts were made to locate logs for these wells; however, this effort met with limited success.

After obtaining permission from the well owner, the depth to water in a well was measured with either a chalked steel tape or an electric tape. Because the wells were in regular use for household needs, multiple measurements were made to confirm that the water level was stable. Measurements were recorded to the nearest 0.01 foot. The top of the well casing was used as the measuring point. The distance from the top of the casing to the land surface also was measured; the depth to the water below land surface was then computed. The measuring tapes were disinfected with household bleach after each measurement.

Of the 88 privately owned wells, 41 were completed in glacial sediments and 31 were completed in carbonate bedrock. The depth of wells in the glacial sediments ranged from 26 to 172 feet. Wells in the Lockport Dolomite were completed as open holes. The depth to the top of the bedrock ranged from 16 to 207 feet. The length of the open hole ranged from 0 to 123 feet, with a median of 17.5 feet. Logs could not be located for 16 wells, so the type of aquifer that these wells tap is unknown. Water levels in four wells were nearly stable but slowly recovering at the time of measurement, and levels in three other wells were considered to be nonstatic. Of the 61 site-monitoring wells, about half are apparently completed in perched zones above the regional water levels in the glacial sediments. Data from these presumably perched wells were not used in preparing the map. Because of the density of some onsite well locations, only wells needed to define the water-level contours are shown on the map.

USEPA and USGS personnel determined locations of the measured wells with a Global Positioning System (GPS). Locations were entered into a computerized mapping program (geographic information system, or GIS). For privately owned wells, land-surface elevations were estimated from digital USGS topographic maps and are accurate to within 5 feet, or half the map contour interval. The water-level elevation was computed by subtracting the measured depth to water (below the land surface) from the estimated land-surface elevation. The elevations of well casings of onsite monitoring wells were surveyed by contractors for USEPA.

Water-level elevations at the measured wells were plotted on a topographic map and contoured by hand. Land-surface elevations were considered to indicate the maximum possible ground-water elevation. Local residents have reported flowing wells within a few hundred feet of Chapman Creek; however, no flowing wells were found during this investigation. Ground-water levels are commonly below land-surface elevations, and land-surface elevations are not usually used in contouring water levels. In areas where data are sparse or where topography is variable, however, land-surface elevations can provide a maximum limit on ground-water levels. In this study, land-surface elevations were particularly useful for drawing contours near streams. So that water-level contours would not cross streams above land surface, many of the contours were conservatively drawn further upstream than might be expected if the contours had been based only on measured data.

Although water levels in some wells were noted as being nonstatic at the time of measurement, these data were considered during contouring. Field observations at the time of the measurement indicate that most of the nonstatic wells were probably within a few feet of static level. Those wells with nonstatic water levels were represented with a different symbol and were considered as additional but less accurate data. Water-level data from wells for which no logs were available also were represented with a different symbol and included in the contouring.

Ground-water levels and flow directions

Contours on a ground-water-level map represent lines of equal hydraulic head. Ground water flows in the direction of decreasing head and, theoretically, is generally perpendicular to contour lines. Ground-water-flow directions can therefore be determined by drawing flowlines perpendicular to ground-water-level contours, in the direction of decreasing head.

The first step in determining directions of ground-water flow was to compare water-level data from the glacial sediments with data from the bedrock. If hydraulic connection between these aquifers was minimal, then water levels in glacial sediments should differ from levels in bedrock. In several areas, wells completed in glacial sediments and bedrock were near each other and were measured. For example, southeast of North Hampton (southwest corner of the study area), water levels in three bedrock wells and two glacial wells were measured. Water levels in these wells were all within 5 feet of each other, which is within the error of estimated land surface. Northwest of the landfill along Willow Dale Road, water levels in one glacial and one bedrock well were measured. Water-levels in these wells were also within 5 feet of each other. The similarity in water levels indicates likely hydraulic connection between the glacial sediments and bedrock in these areas. Because of the similarity of water levels in the aquifers, the absence of well logs for the 16 wells is not a significant concern.

Two factors may affect the accuracy of the water-level contours shown on this map: the combining of two different geologic units (glacial sediments and the bedrock) and the estimation of the land-surface elevation. For these reasons the contours are dashed—indicating the limitations of the data— and a 20-foot contour-interval was used.

In the absence of confined conditions or human-induced changes (such as pumping), ground-water-level contours typically are a subdued reflection of the land-surface topography. In general, ground-water flow in the study area is from northwest to southeast, with the flow direction becoming more easterly near the edge of uplands adjacent to the Mad River Valley. Between North Hampton and Lawrenceville, ground water flows more toward the south. Between Lawrenceville and Tremont City, ground water flows generally northward toward Chapman Creek. The steeper and more convoluted topography along the streams results in variable local flow directions. General ground-water-flow directions are indicated on the map with arrows. The general pattern of flow from the uplands toward the Mad River Valley is consistent with findings from previous work (Sheets and Yost, 1994).

Water-level contours indicate that ground water flows toward Chapman and Storms Creeks; in other words, these are gaining streams. This interpretation of the water-level data is supported by a gain-loss study done along a 3-mile reach of Chapman Creek at about the same time that the water levels were measured. The gain-loss study confirmed that Chapman Creek is gaining ground water from Coffin Station Road to Hominy Ridge Road (Dumouchelle, in press). Flowing wells are reported close to Chapman Creek between Snyder-Domer Road and the creek, upstream from Willow Dale Road, and between Thackery Road and the creek. Although not located or considered in contouring, the effect of flowing wells in these areas would be to move contours closer to the creek and perhaps downstream.

Near the Tremont City Landfill, ground-water-flow directions diverge in a semiradial pattern. From the northern part of the site, ground water flows northeast; from the central part of the site, ground water flows east-southeast; and from the southern part of the site, flow is south towards Chapman Creek. This pattern of ground-water flow is consistent with general topographic trends. Seasonal changes in ground-water levels could cause minor local changes in flow directions; however, the general flow directions are unlikely to be significantly affected.

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EXPLANATION

- **Ground-water-level contour**–Shows altitude in measured wells and at selected land-surface features, October 2000. Dashed where approximately located. Contour interval 20 feet. Datum is sea level
- ▨ **Approximate boundary of landfill site**
- **Measured wells**–Number is water-level elevation in feet above sea level.
  - ⊕ Well completed in glacial sediments
  - ▲ Well completed in bedrock
  - ◆ Well for which aquifer is unknown
  - ○ Well with nonstatic water level
  - ø Selected site-monitoring well
- ← General directions of ground-water flow

0 1 2 MILES
0 1 2 KILOMETERS

Base from U.S. Geological Survey, 1:24,000 Digital Data

GROUND-WATER LEVELS AND FLOW DIRECTIONS IN GLACIAL SEDIMENTS AND CARBONATE BEDROCK NEAR TREMONT CITY, OHIO, OCTOBER - NOVEMBER 2000

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2001

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