UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
Harvey Thorleifson, Director

Prepared and Published with the Support of
THE REDWOOD COUNTY BOARD OF COMMISSIONERS,
THE MINNESOTA ENVIRONMENT AND NATURAL RESOURCES TRUST FUND
AS RECOMMENDED BY THE LEGISLATIVE-CITIZEN COMMISSION ON MINNESOTA RESOURCES,
AND THE MINNESOTA LEGACY AMENDMENT'S CLEAN WATER FUND

COUNTY ATLAS SERIES
ATLAS C-36, PART A
Redwood County
Plate 1—Data-Base Map

GIS compilation by E.J. Bauer
Edited by Lori Robinson

Digital base modified from the Minnesota Department of Transportation BaseMap data; digital base annotation by the Minnesota Geological Survey.

Elevation contours were derived from the U.S. Geological Survey 30-meter Digital Elevation Model (DEM) by the Minnesota Geological Survey.

Universal Transverse Mercator Projection, grid zone 15
1983 North American Datum

SCALE 1:100 000

1 0 1 2 3 4 5 MILES
1 0 1 2 3 4 5 6 7 8 KILOMETERS

CONTOUR INTERVAL 15 METERS

MAP SYMBOLS

- Record of water-well construction (well driller's log)
- Scientific investigation hole
- Exploratory boring (exploration hole)
- Diamond drill core sample
- Rotary-sonic core sample
- Cutting sample
- Borehole geophysical log
- Soil boring
- Giddings probe hole
- Soil auger hole
- Field site
- Textural analysis
- Gravity data
- Passive seismic sounding
- Bedrock outcrop

Note: More than one symbol can occur at the same location

DATA-BASE MAP

By

Emily J. Bauer and V.W. Chandler

2016

INTRODUCTION

The public health and economic development of Redwood County are directly dependent on the wise use and management of its land and water resources. Geologic and hydrologic information are essential before decisions are made that affect natural resources. Although the amount of geologic information required for making specific decisions can vary, the information will not be used if it is unavailable when needed, or if it is available only in a highly technical form, or scattered in many different maps and reports. The data bases described here address this need.

County atlases, prepared jointly by the Minnesota Geological Survey and the Minnesota Department of Natural Resources, Division of Ecological and Water Resources, present detailed geologic and hydrologic information in an interpretive as well as descriptive form. Maps and texts summarize basic geologic and hydrologic conditions at a county scale, and interpret these conditions in terms of the impacts of possible land- and water-use decisions. Site-specific information is available in some areas at a greater level of technical detail than shown on the maps of this atlas. The data are too voluminous to present at the scale of this atlas, but have been incorporated into readily accessible files housed at the Minnesota Geological Survey.

Several sources commonly provide information about an area or an individual property, but they may use different classification schemes to describe the same geologic materials. As a result, discrepancies in interpreting the data may arise or the different sources may appear to contradict each other. For example, water-well drillers may describe glacial till as "clay," but engineering records will describe it as "clayey sand." Both descriptions are acceptable for their original purpose of describing the physical attributes of the material. "Clay," the term used by well drillers, defines the general inability of the till to yield groundwater to a well. "Clayey sand," the term from the engineering record, defines the physical composition of the till relative to particle size and engineering properties. The geologist must take the analysis one step further and define the material in terms of how it formed rather than how it is to be used. In this example, till consists of an unsorted mixture of rock fragments ranging in size from clay to cobbles and boulders, and it is interpreted by the geologist as having been deposited directly by glacial ice. Understanding the process by which the material formed allows geologists to make predictions about what lies between and beyond data points.

All of the types of data described on this plate were interpreted by geologists or hydrogeologists to make them meaningful for mapping purposes. The 1:100,000 and 1:200,000 scales of the maps in this atlas were chosen because they show the geologic and topical studies of the county while keeping the physical size of each plate to a manageable level. As a result, some detailed information that was gained by data interpretation and mapping cannot be shown on these maps or discussed in the texts. Some of this information is available in digital files that accompany the atlas.

Whether to use the atlas alone, or in combination with the data bases, depends on the amount of detail needed. Generally, data-base information must be used to evaluate site-specific conditions.

DATA-BASE MANAGEMENT

All of the data shown on the maps were plotted on 7.5-minute topographic quadrangle maps or highway alignment maps and assigned inventory numbers. Automated data bases and a few manual files were developed to provide easy access and rapid retrieval of these site-specific data. The data may be obtained from the Minnesota Geological Survey.

Computer storage and retrieval systems are better than manual files for manipulating large amounts of data because automated geologic data bases can be designed to interact with other computer files, such as land-use data. Such interaction permits more efficient assessment of cause-and-effect relationships concerning natural resources than is commonly possible with manual files.

REDWOOD COUNTY DATA BASES

Computerized files were developed for point-source data such as wells and borings in Redwood County. They use Public Land Survey descriptions, Universal Transverse Mercator (UTM), and latitude-longitude coordinates as location criteria; thus, they are compatible with the natural-resource data bases housed at the Minnesota Land Management Information Center (LMIC). The computerized data base developed for Redwood County by the Minnesota Geological Survey is the County Well Index (CWI).

County Well Index (CWI)—Information from water-well records and exploration holes is entered into this statewide data base. Each well log is assigned a six-digit unique number and each exploration drill hole is assigned either a five- or six-digit unique number. These reference numbers are also used by state agencies and the Water Resources Division of the U.S. Geological Survey. Elevations, expressed in feet above sea level, were determined from topographic maps (see the index to 7.5-minute quadrangles) and are generally accurate to plus or minus five feet (1.5 meters). The street address of each well is also included wherever possible to provide data users with a well-location system that is compatible with local regulatory programs. Software at the Minnesota Geological Survey is used to display and tabulate many of the data elements contained on the original well log.

The County Well Index is currently stored in a data base that consists of ten related tables. These tables contain information such as well depths, well construction, addresses, aquifers, dates drilled, static water levels, and pumping test data. They also contain alternate well identifiers such as permit numbers or emergency-service numbers, the well stratigraphy (the geologic materials encountered during drilling), and the azimuth and inclination of angled exploration holes.

CWI application software developed by the Minnesota Department of Health provides two types of reports:

WELL LOG contains all the information about the well as it was reported by the contractor (Fig. 1). There may also be additional location information, land-surface elevation, aquifer designation, and remarks about the drill holes.

WELL STRATIGRAPHY contains the geologic log with a geologist's stratigraphic interpretations, which are based on her or his knowledge and understanding of the geology of Redwood County and augmented in some cases by additional data sources, such as cuttings, borehole geophysical logs, or core (Fig. 2). Only those drill holes with verified locations have stratigraphy assigned to them.

File data of the Minnesota Geological Survey—Details about other types of data shown on this plate are available from digital (including the Quaternary Data Index, an internal working data base) and paper files at the Minnesota Geological Survey. These include descriptions of cutting samples, soil borings, Giddings probe holes, field sites, soil auger holes, textural analyses, gravity and aeromagnetic data, passive seismic sites, and aggregate resources sites.

FUTURE DATA COLLECTION

Additional geologic information is generated continuously as new water wells are drilled, construction activities expose more bedrock, or additional wells are tested for water quality. To address this, the library of information prepared for Redwood County is flexible so that old data can be reevaluated in light of new information, and new forms of data can be added if required. The need to manage groundwater and other natural resources wisely will never become outdated. Future demands on these resources will require current data to assess the impacts.

ACKNOWLEDGEMENTS

The staff from the Redwood County Environmental Office contributed greatly to the development of the County Well Index (CWI) data base. We thank local water-well contractors and landowners for their valuable assistance.

THE DATA-BASE MAP

The types, locations, and density of information used to prepare the Redwood County atlas are shown on this map. The data are described below to aid the user in assessing what types may be useful for a particular information need. The Data-Base Map serves as a guide to the precision of the other maps in the atlas. It shows where data are sparse or lacking, and interpretation and extrapolation were required to prepare the maps. All data were collected by Minnesota Geological Survey staff unless otherwise specified.

DRILL-HOLE INFORMATION

A **record of water-well construction (well driller's log)** is a water-well contractor's description of the geologic materials penetrated during drilling and the construction materials used to complete the well. Not all wells extend to bedrock. In areas of thick, unconsolidated Quaternary deposits, drillers commonly do not need to drill through the entire thickness of overburden to find sufficient groundwater. Hydrologic data, such as the static water level and test-pumping results, are commonly included. Before any driller's log can be used, the location of the well must be verified, and a geologist must interpret the log. Driller's logs are the primary source of subsurface geologic and hydrologic data for Redwood County; about 2,050 logs were used for this atlas. They can be found in the County Well Index (CWI).

Scientific investigation holes are soil auger holes, test wells, and observation wells drilled by the U.S. Geological Survey, Water Resources Division to determine the hydrologic properties of local and regional aquifers. Geologic logs were generated for each hole and entered into the County Well Index (CWI). Study results and conclusions may be found in U.S. Geological Survey published reports.

An **exploratory boring (exploration hole)** is an explorationist's description of the geologic materials penetrated during mineral exploration. Exploratory work may include the collection of core and/or cuttings samples of the geologic materials encountered for descriptive and analytical purposes. In Minnesota, these core or cuttings are eventually transferred to the Minnesota Department of Natural Resources, Division of Lands and Minerals and are available for public inspection at their offices in Hibbing. Data for these holes can be found in the County Well Index (CWI).

Core samples were collected at various sites throughout Redwood County as a means to establish the nature of the subsurface material. The Minnesota Geological Survey and the mineral exploration company Exmin collected 3 bedrock core samples using diamond core drilling. This method uses a diamond bit rotating at the end of a drill rod. A column of rock moves up the drill pipe and is recovered at the surface for study. Rotary-sonic cores were collected by the Minnesota Geological Survey from 10 sites in the county (labelled RWR-1 through RWR-10) to aid the interpretation of the Quaternary deposits and to determine bedrock depth and nature (where encountered). The coring technique enables recovery of a continuous core, 3.5 inches (8.9 centimeters) in diameter, from glacial deposits and bedrock (if intersected). It provides excellent subsurface samples for detailed study and comparison with cuttings, geophysical logs, and driller's logs from surrounding sites. Detailed geologist's logs for all of the rotary-sonic cores are shown on Plate 4, *Quaternary Stratigraphy*. These logs are entered into the County Well Index (CWI) and any sampling results are available in Minnesota Geological Survey file data. The core is available for inspection at the Minnesota Department of Natural Resources, Division of Lands and Minerals offices in Hibbing.

Cutting samples collected during drilling provide physical evidence of subsurface geologic materials. Cuttings are the samples generated as the drill bit cuts through the subsurface material and are used to interpret and verify driller's logs. They are logged and stored at the Minnesota Geological Survey.

Borehole geophysical logs are created by lowering instruments down a well or drill hole and measuring the physical and chemical properties of the geologic materials through which the hole passes. Different logging techniques measure naturally occurring gamma radiation, spontaneous potential, and resistivity. Gamma logs characterize in graphic form the geologic formations penetrated. Spontaneous potential and resistivity are mainly used to locate water levels in wells and the depth of the well casing. An interpretive log is prepared by a geologist from the geophysical log and correlated with drilling samples from the same hole, information obtained from nearby exposures, or a geophysical log from a nearby drill hole. Geophysical logs can provide high-quality subsurface geologic and hydrologic information for wells that have little or no other information available. The information obtained from a geophysical log is added to the County Well Index (CWI) and the paper log is on file at the Minnesota Geological Survey.

Soil borings are test holes drilled to obtain information about the physical properties of subsurface materials for engineering, mapping, or exploration purposes. They are logged by an engineer or a geologist using a variety of classification schemes based on particle sizes, penetration rate, moisture content, and color. Soil-boring data were collected by the Minnesota Department of Transportation. They are limited in distribution; in Redwood County they are concentrated along the State Highway 19 corridor. These data are most useful in determining the composition of unconsolidated deposits. Description of the geologic materials penetrated can be accessed in digital and paper files at the Minnesota Geological Survey; all other information collected is contained in paper files. The data are available from the Minnesota Department of Transportation, Foundations Unit web page (http://www.mrr.dot.state.mn.us/geotechnical/foundations/Gis/gi5_splash.html).

Giddings probe holes are borings of glacial materials, 2 inches (5.1 centimeters) in diameter, collected by a truck-mounted hydraulic auger. A description was generated at every site and samples were taken for textural analyses at most locations. Samples were generally taken about every 5 feet (1.5 meters), at unit contacts, or where the geologist believed it was important.

Soil auger holes are shallow borings created with a hand auger to generate a description of the subsurface material. They are generally less than 5 feet (1.5 meters) in depth.

OTHER INFORMATION

Field sites are natural and artificial exposures of unconsolidated Quaternary deposits that were described in detail; samples from many sites were texturally analyzed. Field sites include stream and river cuts, gravel pits, excavations, and road cuts. Data from field sites can be found in Minnesota Geological Survey files.

Textural analyses express the proportion of sand-, silt-, and clay-size particles that make up a sample. The samples analyzed were taken from natural and artificial exposures, Giddings holes, and the rotary-sonic cores. They are helpful in determining origin, correlation, and hydrologic properties of unconsolidated sediments. Textural analyses are available in Minnesota Geological Survey files.

Gravity data can be used to help map the thickness of overlying Quaternary deposits. The application of this method relies primarily on the strong density contrasts that exist between bedrock and unconsolidated deposits. The method also relies on the ability to separate the gravity effect associated with the bedrock topography and Quaternary sediment from that of density variations occurring within the underlying Precambrian bedrock. Unfortunately, no suitable means of isolating the two effects could be achieved in Redwood County; the Precambrian bedrock signature is too strong, and it overlaps the wavelength characteristics of that associated with bedrock topography and Quaternary sediment. Thus, the gravity data in Redwood County were primarily used to help map structures within the Precambrian bedrock.

Passive seismic depth to bedrock soundings provide information based on measurement and analysis of ambient shear and surface wave energy in the ground that allow a calculation of the depth to bedrock (thickness of Quaternary deposits) beneath that point. The measurements employ a recording seismograph system that is implanted into the ground surface and records ambient ground vibrations in three orthogonal directions (2 horizontal and 1 vertical) during a 16-minute interval. The method is called passive because no energy is directly input into the ground at the time of measurement, such as is the case for conventional seismic sounding. Instead, the unit measures background vibrations from a variety of natural and artificial sources that include machinery, traffic, and wind. The averaged horizontal spectra of the seismic noise is divided by the corresponding vertical spectrum, and the resulting Horizontal to Vertical Spectral Ratio (HVSR) should display a prominent peak that closely approximates the resonant frequency (shear-wave) of the unconsolidated sequence overlying the bedrock surface. The resonant frequency of unconsolidated overburden is a useful parameter for seismic risk investigations, but here it is used to estimate the thickness of the overburden itself, which in our case is the Quaternary sequence. In this application the HVSR method is calibrated by taking measurements at about 30 locations (control points) where the thicknesses of Quaternary deposits are known from either well data or from conventional seismic sounding. The control points are selected to approximately span the expected range of bedrock depths for the region, and the calibration curve that is fitted to these data can be used to estimate bedrock depth in areas lacking either drill hole or seismic control. Most bedrock depths from the HVSR method are estimated to be accurate to within an error of 15 to 25 percent, which is somewhat more than the 5 to 15 percent error that is generally expected with conventional seismic methods. Nonetheless, HVSR depth estimates are adequate for many county geologic atlas applications, and the HVSR method is considerably faster and cheaper, assuring that many soundings over a large area can be inexpensively acquired by one or two operators.

Bedrock outcrops are exposures of solid rock at the land surface. The areas shown typically represent multiple closely spaced exposures. Most are natural outcrops in and around the Minnesota River valley; however, some are exposures created during construction. They serve as reference points for mapping and for checking the accuracy of subsurface data. Bedrock at or near the surface must be considered in land-use planning decisions such as pipeline routing, sewage-system design, and excavation.

Unique Well Number 221750
County Redwood | Quad Sanborn | Quad Id 60B
MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
MINNESOTA STATUTES CHAPTER 1031
Entry Date 1988/04/17 | Update Date 2014/05/20 | Received Date

Well Name SANBORN 2 | Township 109 | Range 36 | Dir W | Section 25 | Subsection CCBBBB | Field Located | Elevation MGS 1086.00 ft.
Well Address SANBORN 2 JOHN ST
SANBORN MN 56083 Changed
Contact Address CITY OF SANBORN
SANBORN MN 56083 Changed

Well Depth 308.00 ft | Depth Completed 308.00 ft | Date Well Completed 1957/12/19
Drillhole Angle
Drilling Method Cable Tool
Drilling Fluid | Well Hydrofractured? YES NO From ft. to
Use Abandoned
Casing Type Steel (black or low | Drive Shoe? YES NO | Hole Diameter (in.) | Diameter 12 | Depth 233 | 12.00 in. from 0.00 to 233.00 ft. lbs/ft
Screen No | Open Hole(ft.) From 233.0 to 308.0 | Make | Type | Diameter | Slot | Length | Set

Description	Color	Hardness	From	To (ft.)
CLAY	YELLOW		0	90
BLUE CLAY OR SHALE			90	100
SHALE	BLUE	HARD	100	107
SHALE	BLUE	HARD	107	221
SHALE LAYERS OF SANDROCK			221	225
SANDROCK AND SHALE			225	230
SHALE AND SANDROCK		V.HARD	230	234
SHALE	BROWN		234	290
SANDROCK AND SHALE			290	304
SHALE		V.HARD	304	308

Static Water Level 23.00 ft. Land surface | Date measured 1957/12/18
Pumping Level (below land surface) 150.00 ft. after 18.00 hrs. pumping | 300.00 g.p.m.
Wellhead Completion
Pitless adapter manufacturer | Model
Casing Protection | 12 in. above grade
At-grate (Environmental Wells and Borings ONLY) | Basement offset
Grouting Information Well grouted? YES NO
Nearest Known Source of Contamination | feet | Direction | Type
Well disinfected upon completion? YES NO
Pump Not Installed | Date Installed | Manufacture's name | Model number | HP | Volts | Length of drop pipe | Material | Capacity 250 g.p.m | Type Turbine
Abandoned Wells Does property have any not in use and not sealed well(s)? YES NO
Variance Was a variance granted from the MDH for this well? YES NO
Well Contractor Cerfication Bergerson-Caswell 27058
License Business Name | Lic. or Reg No.
Remarks GAMMA LOGGED 3-30-1999. WELL SEALED 06-21-1999 BY 08258. ORIGINAL USE PC - COMMUNITY SUPPLY.
First Bedrock KRET | Last Strat KRET | Aquifer Cretaceous,Undiff. | Depth to Bedrock 107.00 ft.
County Well Index v.5 REPORT Printed on 5/20/2014
Name of Driller | Date | HE-01205-07 (Rev. 2/99)

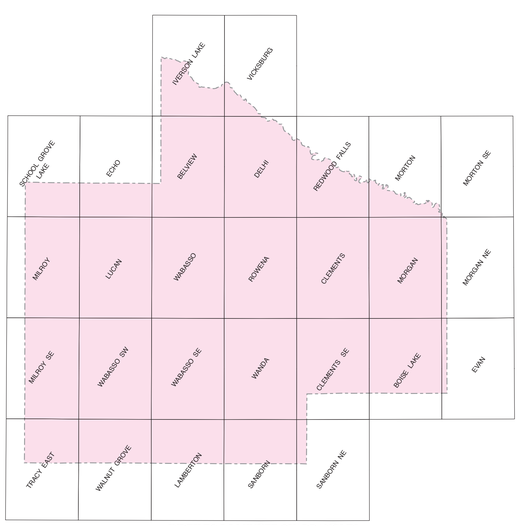
Figure 1. An example of a WELL LOG record, showing all the information about the well as reported by the well driller.

Unique Well Number 221750
County Redwood | Quad Sanborn | Quad Id 60B
MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
MINNESOTA STATUTES CHAPTER 1031
Entry Date 1988/04/17 | Update Date 2014/05/20 | Received Date

Well Name SANBORN 2 | Township 109 | Range 36 | Dir W | Section 25 | Subsection CCBBBB | Depth Drilled 308 ft | Depth Completed 308 ft | Date Completed 1957/12/19 | Lic/Reg. No. 27058 | Driller Name
Elevation 1086.00 ft. | Method 7.5 minute topographic | Aquifer Cretaceous,Undiff. | Depth to Bedrock 107 ft. | Open Hole 233-308 | SWL 23
Field Located Minnesota Geological Survey | Location Method | Universal Transverse Mercator(UTM) - NAD83 - Zone 15 - Meters
Program | Input Source Minnesota Geological Survey | UTM Easting (X) 329983 | UTM Northing (Y) 4897743
Uni No.Verified Information from owner | Input Date 1994/01/01
Geologic Interpretation Dale Setterholm | Agency MGS | Interpretation Method Geologic study 1:24k to 1:100k

Geological Material	Color	Hardness	DEPTH From	DEPTH To	Thick	ELEVATION From	ELEVATION To	Stratigraphy	LITHOLOGY Primary	LITHOLOGY Secondary	LITHOLOGY Minor
CLAY	YELLOW		0	90	90	1086	996	clay-yellow	Clay		
BLUE CLAY OR SHALE			90	100	10	996	986	clay-gray	Clay		
SHALE	BLUE	HARD	100	107	7	986	979	clay-gray	Clay		
SHALE	BLUE	HARD	107	221	114	979	865	Cretaceous undiff.	Shale		
SHALE LAYERS OF SANDROCK			221	225	4	865	861	Cretaceous undiff.	Shale	Sandstone	
SANDROCK AND SHALE			225	230	5	861	856	Cretaceous undiff.	Sandstone	Shale	
SHALE AND SANDROCK		V.HARD	230	234	4	856	852	Cretaceous undiff.	Shale	Sandstone	
SHALE	BROWN		234	290	56	852	796	Cretaceous undiff.	Shale		
SANDROCK AND SHALE			290	304	14	796	782	Cretaceous undiff.	Sandstone	Shale	
SHALE		V.HARD	304	308	4	782	778	Cretaceous undiff.	Shale		

Figure 2. Example of a WELL STRATIGRAPHY record, which contains a geologist's interpretation of the geologic materials listed by the driller in the WELL LOG record (Fig. 1). Additional downhole information for this well (as noted in the Interpretation Method on the record above) controls the geologist's interpretation, which may not match the driller's description of the geologic material penetrated.



INDEX TO 7.5-MINUTE QUADRANGLES

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND
CLEAN WATER LAND & LEGACY AMENDMENT

GEOLOGIC ATLAS OF REDWOOD COUNTY, MINNESOTA