UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
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COUNTY ATLAS SERIES
ATLAS C-31, PART A
Morrison County
Plate 1—Data-Base Map

DATA-BASE MAP

By

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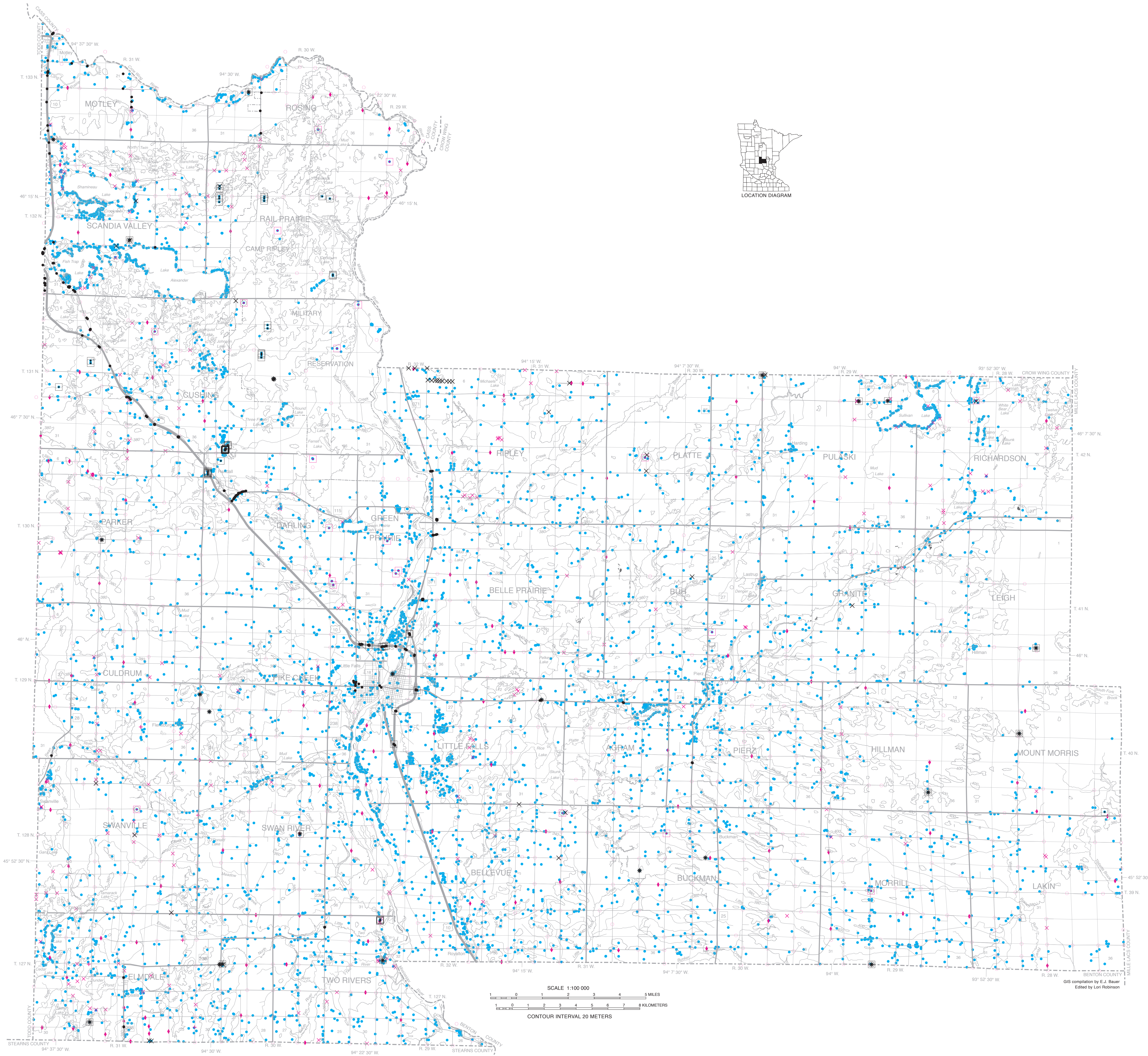
2014

LOCATION DIAGRAM



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

INTRODUCTION

The public health and economic development of Morrison 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.

County atlases, prepared jointly by the Minnesota Geological Survey and the Minnesota Department of Natural Resources, Division of Waters, 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 ground water 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 had to be interpreted by geologists or hydrogeologists before they were meaningful for mapping purposes. The 1:100,000 and 1:200,000 scales of the maps in this atlas were chosen because they can 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.

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.

MORRISON COUNTY DATA BASES

Computerized files were developed for point-source data such as wells and borings in Morrison 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 bases developed for Morrison County by the Minnesota Geological Survey are County Well Index (CWI) and Quaternary Data Index (QDI).

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 nine 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, and the well stratigraphy (the geologic materials encountered during drilling).

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 Morrison County (Fig. 2). Only those drill holes with verified locations have stratigraphy assigned to them.

Quaternary Data Index (QDI)—Information from Quaternary samples collected and analyzed and from site descriptions is entered into this data base. QDI contains locations, the name of the sample collector, elevations, depths from where the samples were collected, proportions of sand, silt, and clay, and proportions of crystalline, carbonate, and shale fragments. Information pertaining to borings obtained from the Minnesota Department of Transportation can also be found in this database.

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 Morrison 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 ground water 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 Morrison County Soil and Water Conservation District 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 Morrison 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 ground water. 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 Morrison County; about 6,400 logs were used for this atlas; they can be found in the County Well Index (CWI).

Core samples were collected at various sites throughout Morrison County as a means to establish the nature of the subsurface material. In addition to the Minnesota Geological Survey, core samples were collected by mineral exploration companies, the Minnesota Department of Transportation, the Minnesota Department of Natural Resources, the U.S. Bureau of Mines, the University of Minnesota Duluth, and St. Cloud State University. Eighty-three bedrock core samples were collected 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 from 21 sites in the county to aid the interpretation of the Quaternary deposits and for mineral exploration. 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. A detailed geologist's log is entered into the County Well Index (CWI) and any sampling results are entered into the Quaternary Data Index (QDI). The core is available for inspection at the Minnesota Department of Natural Resources, Division of Lands and Minerals offices.

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 or the Minnesota Department of Natural Resources, Division of Lands and Minerals.

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 outcrops, 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 and the Minnesota Geological Survey. They are limited in distribution; in Morrison County they are concentrated along the U.S. Highway 10 and Minnesota Highway 101 corridors. These data are most useful in determining the composition of unconsolidated deposits. The geologic materials penetrated are entered into the Quaternary Data Index (QDI); all other information collected is contained in paper files.

Giddings probe holes are continuous cores 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.

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, and road cuts.

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.

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, soil auger holes, and the rotary-sonic cores. They help determine the origin, correlation, and hydrologic properties of unconsolidated materials.

Gravity data can be used to help map the thickness of overlying glacial 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 glacial 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 Morrison County; the Precambrian bedrock signature is too strong, and it overlaps the wavelength characteristics of that associated with bedrock topography and glacial sediment. Thus, the gravity data in Morrison County were primarily used to help map structures within the Precambrian bedrock (Plate 2, *Bedrock Geology*).

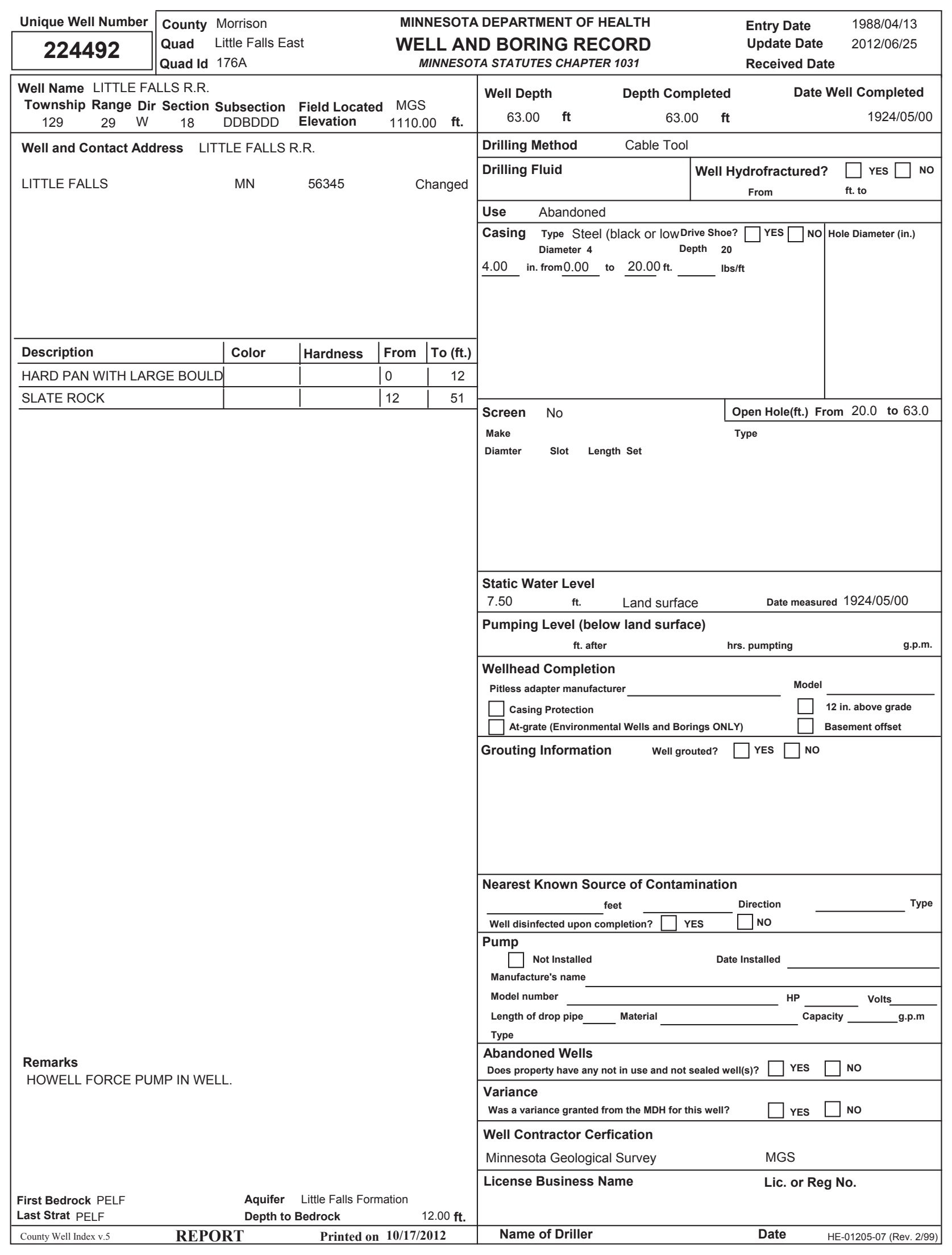
Passive seismic depth to bedrock soundings provide information based on measurement and analysis of ambient shear and surface wave energy in the ground that allow a calculation of the depth to bedrock (thickness of glacial deposits) beneath that point. The measurements employ a recording seismograph 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 is the glacial sequence. In this application the HVSR method is calibrated by taking measurements at 30 or so locations (control points) where the thicknesses of glacial 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 15 to 25 percent error, 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. Most are natural outcrops; 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.

MAP SYMBOLS

●	Record of water-well construction (well driller's log)
▣	Diamond core sample
▣	Rotary-sonic core sample
✱	Cutting sample
○	Borehole geophysical log
●	Soil boring
♦	Giddings probe hole
×	Field site
+	Soil auger hole
○	Gravity reading
✕	Passive seismic sounding
▨	Bedrock outcrop

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



Unique Well Number 224492
County Morrison
Quad Little Falls East
Quad Id 176A

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
MINNESOTA STATUTES CHAPTER 1031

Entry Date 1988/04/13
Update Date 2012/06/25
Received Date

Well Name LITTLE FALLS R.R.

Township	Range	Dir	Section	Subsection	Field Located	Elevation
129	29	W	18	DDBDDD	MGS	1110.00 ft.

Well Depth 63.00 ft
Depth Completed 63.00 ft
Date Well Completed 1924/05/00

Well and Contact Address LITTLE FALLS R.R.
LITTLE FALLS MN 56345 Changed

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 4 Depth 20
4.00 in. from 0.00 to 20.00 ft. lbs/ft

Description	Color	Hardness	From	To (ft.)
HARD PAN WITH LARGE BOULD			0	12
SLATE ROCK			12	51

Screen No
Open Hole(ft.) From 20.0 to 63.0
Make
Type
Diamter Slot Length Set

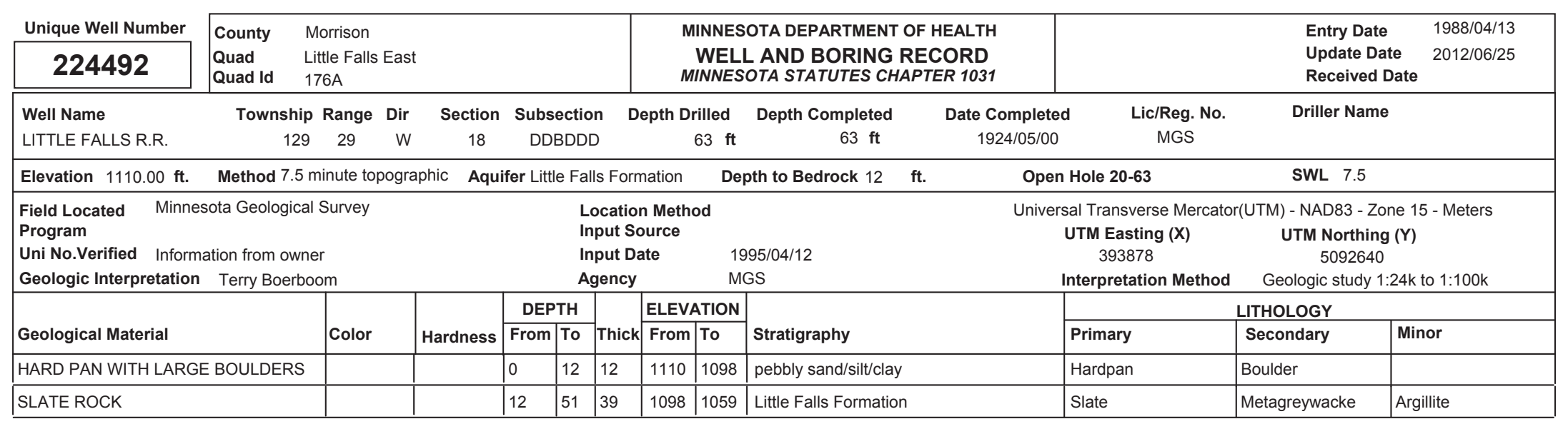
Static Water Level
7.50 ft. Land surface Date measured 1924/05/00
Pumping Level (below land surface)
ft. after hrs. pumping g.p.m.
Wellhead Completion
Pitless adapter manufacturer Model
☐ Casing Protection ☐ 12 in. above grade
☐ At-grate (Environmental Wells and Borings ONLY) ☐ Basement offset
Grouting 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 g.p.m
Type
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
Minnesota Geological Survey MGS
License Business Name Lic. or Reg No.

Remarks
HOWELL FORCE PUMP IN WELL.

First Bedrock PELF Aquifer Little Falls Formation
Last Strat PELF Depth to Bedrock 12.00 ft.
County Well Index v.5 REPORT Printed on 10/17/2012
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.



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WELL AND BORING RECORD
MINNESOTA STATUTES CHAPTER 1031

Entry Date 1988/04/13
Update Date 2012/06/25
Received Date

Well Name	Township	Range	Dir	Section	Subsection	Depth Drilled	Depth Completed	Date Completed	Lic/Reg. No.	Driller Name
LITTLE FALLS R.R.	129	29	W	18	DDBDDD	63 ft	63 ft	1924/05/00	MGS	

Elevation 1110.00 ft. Method 7.5 minute topographic Aquifer Little Falls Formation Depth to Bedrock 12 ft. Open Hole 20-63 SWL 7.5

Field Located Minnesota Geological Survey
Program
Uni No.Verified Information from owner
Geologic Interpretation Terry Boerboom
Location Method Universal Transverse Mercator(UTM) - NAD83 - Zone 15 - Meters
Input Source
Input Date 1995/04/12
Agency MGS
UTM Easting (X) 393878
UTM Northing (Y) 5092640
Interpretation Method Geologic study 1:24k to 1:100k

Geological Material	Color	Hardness	DEPTH		Thick	ELEVATION		Stratigraphy	LITHOLOGY		
			From	To		From	To		Primary	Secondary	Minor
HARD PAN WITH LARGE BOULDERS			0	12	12	1110	1098	pebbly sand/silt/clay	Hardpan	Boulder	
SLATE ROCK			12	51	39	1098	1059	Little Falls Formation	Slate	Metagreywacke	Argillite

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) informed the geologist's interpretation, which may not match the driller's description of the geologic material penetrated.

INDEX TO 7.5-MINUTE QUADRANGLES

GEOLOGIC ATLAS OF MORRISON COUNTY, MINNESOTA