Improvement of Wisconsin groundwater monitoring network. [DNR-149] 2000

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#149

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INTRODUCTION

Reliable water-level measurements are essential for understanding groundwater flow systems and recharge/discharge processes and for managing Wisconsin groundwater resources. The water-supply and well-construction industries and agriculture all have need for these data. Information regarding groundwater movement derived from observed fluctuations of the water table also are useful in determining the fate of contaminants in groundwater-quality studies.

The Wisconsin Geological and Natural History Survey (WGNHS) and the U.S. Geological Survey (USGS) have maintained and operated a statewide groundwater observation-well network for collecting water-level measurements since 1946. The network design, objectives, and history are described in *Wisconsin Groundwater Observation-Well Network, 1946-95* (Zaporozec, 1996). Water-level measurements and associated geologic and well construction data are stored in a computer data base, and are available to the public upon request.

Evaluation and use of the data from some older observation wells has been limited by a lack of basic well-construction information. Also, the amplitude of water-level fluctuations has declined in some of these older wells that are open to shallow sand-and-gravel deposits. This indicates that these wells may have gradually developed a poor hydraulic connection with the surrounding aquifer material. Therefore, in January 1994 and in December 1996, the WGNHS, in cooperation with the USGS, proposed studies to run geophysical logs and conduct hydraulic tests on selected network wells that had little or no well-construction data or were suspected to be in poor hydraulic connection with the surrounding aquifer. The proposed studies were funded by the Wisconsin Department of Natural Resources (DNR) and through the State of Wisconsin joint solicitation for project proposals to conduct research and monitoring on groundwater (DNR project No. 118 and 135, respectively).

Thirty-seven of the network wells were tested from July 1994 to June 1996 (Dunning and others, 1996). The testing indicated that 10 of these 37 wells were in poor hydraulic connection with the surrounding aquifer. Tests were conducted in an additional 19 network wells from July 1997 to April 1999 (Rauman and others, 1999). Results indicated that six of these wells were in poor hydraulic connection with the surrounding aquifer material. It was recommended that they be reconstructed or replaced . Eight poorly-functioning observation wells identified in the first study were chosen for replacement (Table 1 and Figure 1) in a proposal submitted to the DNR in November 1998. The proposal was accepted and funded through the Wisconsin joint solicitation program (DNR project no. NMJ00000140). Well replacement was carried out from July 1999 to June 2000 and is discussed in the following pages.

Table 1. Summary of observation-wells selected for replacement *(source: Dunning and others, 1996)*.

Well ID	Year drilled	Aquifer type	Well depth (feet)	Screened interval (feet)	Casing diameter (inches)
AD-17/06E/08-0076	1969	Sand & gravel	21	19-21	1.25
BT-39/16W/17-0002	1937	Sand & gravel	46	44.5-46	8.00
MR-27/09E/31-0028	1944	Sand & gravel	27	25-27	1.25
MT-37/20E/34-0007	1938	Sand & gravel	33	Open end	8.00
PT-23/08E/25-0376	1959	Sand & Gravel	36	34-36	1.25
SW-41/09W/28-0007	1937	Sand & gravel	25	22-25*	8.00
VI-40/10E/28-0033	1965	Sand & gravel	37	Open end	6.00
WS-19/08E/15-0008	1951	Sand & gravel	18	Open end	4.00

* Perforated casing.

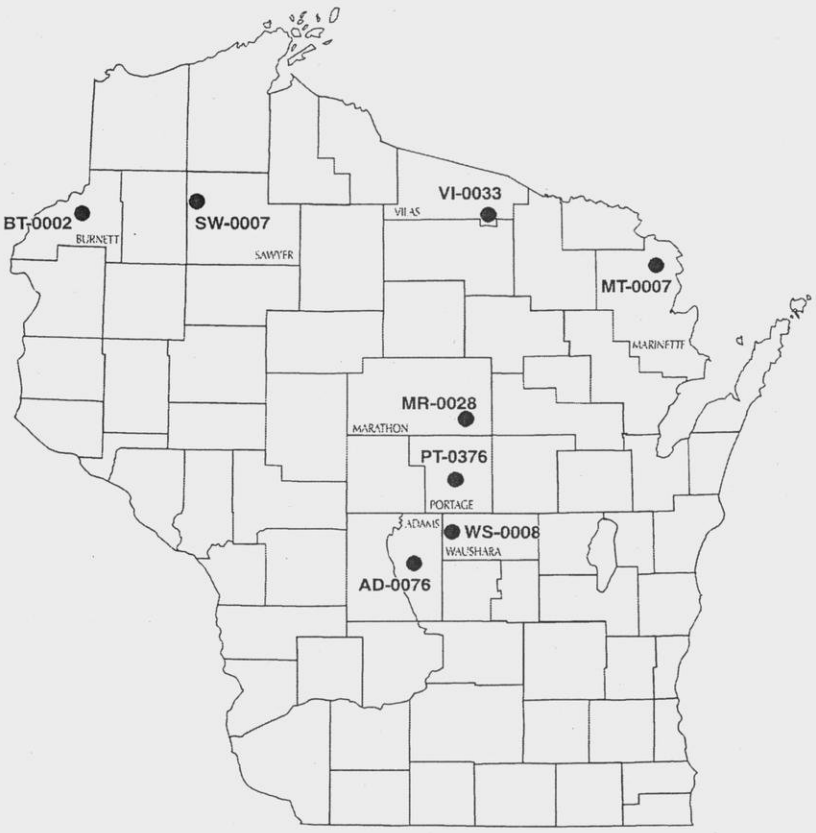


Figure 1. Location of observation wells selected for replacement

WELL-IDENTIFICATION SYSTEM

Each observation well is identified by a number starting with a two-letter abbreviation for the county name followed by numbers based on the cadastral-survey system of the U.S. Government and a unique four-digit number assigned to the well. For example, the identification number AD-17/06E/08-0076 indicates the well is located in Adams County (AD), township 17 north, range 6 east, section 8, and has a sequence number of 0076. For discussion purposes, the 8 wells shown in Figure1 are referenced with an abbreviation of the identification number that only uses the county abbreviation and the well sequence number. At the suggestion of the USGS, identification numbers of the abandoned wells were retained by the new wells.

METHODS

Well replacement was a two-step procedure. First, the existing well was abandoned (destroyed) and then a new well of similar depth was constructed within a 5-foot radius of the abandoned well.

Well Abandonment

Existing wells AD-0076, MR-0028, and PT-0376 (Table 1) were abandoned by pulling the existing $1^1/_4$-inch diameter steel casing and drive point screen. At each of these sites, the saturated sand and gravel immediately filled the borehole below the water table. The borehole was then filled with ⅜-inch diameter bentonite chips to a depth of 1-2 feet below land surface and the remaining borehole was filled with native topsoil. Casing diameters of the other five wells ranged from 4 to 8-inches in diameter (Table 1). At these sites, the existing well casing was cut off at a depth of 3 feet below land surface. The well was then filled with ⅜-inch diameter bentonite chips to a depth of 1-2 feet below land surface and the remaining hole was filled with native topsoil.

New Well Construction

Wells were drilled using a CME-55 drill rig owned and operated by the WGNHS. Graphic illustrations that show construction details, field geologic logs, and location maps of each new well are shown in appendix A and construction details are summarized in Table 2. Each replacement well was constructed by advancing 6¼-inch (inside) diameter hollow-stem augers to depths nearly identical to the abandoned well. Flush-threaded 4-inch diameter schedule-40 PVC casing with attached well screen was then set in place. Well screens were five feet long with a 0.010-inch slot size. The annular space between the screen and the borehole wall was filled with a sand filter pack to a height of about 2 feet above the top of the screen. Bentonite chips were installed in the annular space for a distance of 5 feet up the borehole. Drill cuttings were then used to fill the annular space up to a depth of about 8-10 feet below land surface. Then, bentonite chips were installed and hydrated to about 1-2 ft below land surface. The remaining annular space was filled with native topsoil.

Each of the new wells was constructed so that the top of the casing extended the same height above ground as the original well. Therefore, the measuring points remained unchanged. Water-level measuring equipment removed from the abandoned wells was re-installed in the new wells. Floats with counter weights were installed in BT-0002, MT-0007, and SW-0007 (Table 2). A continuous recorder was installed in WS-0008. The remaining four wells are measured manually with a graduated steel tape so they required no equipment installation.

Table 2. Summary of replacement-well construction
[All wells finished and screened in sand and gravel deposits]

Well ID	Completion date	Well depth (feet)	Screened interval (feet)	Casing* diameter (inches)	Measurement Type
AD-17/06E/08-0076	06/14/99	21	16-21	4	Steel tape
BT-39/16W/17-0002	07/26/00	45	40-45	4	Float/counter weight
MR-27/09E/31-0028	06/15/99	30	25-30	4	Steel tape
MT-37/20E/34-0007	06/06/00	33	28-33	4	Float/counter weight
PT-23/08E/25-0376	06/05/00	35	30-35	4	Steel tape
SW-41/09W/28-0007	07/25/00	24	19-24	4	Float/counter weight
VI-40/10E/28-0033	07/24/00	36	31-36	4	Steel tape
WS-19/08E/15-0008	06/15/99	25	20-25	4	Continuous recorder

* PVC flush-threaded casing and slotted screen

RESULTS AND DISCUSSION

Eight wells were replaced during the current project. Cuttings returned during drilling were almost entirely variously-sized sand and gravel with minor lenses of silty sand (Appendix A). This confirmed that all eight wells are finished in the Pleistocene sand and gravel aquifer (Dunning and others, 1996).

Results of the hydraulic tests mentioned above (Dunning and others, 1996; Rauman and others, 1999) indicated that 16 of 56 tested observation wells were functioning poorly. Dunning suggested the hydraulic connection between these wells and the surrounding aquifer material may have been restricted by incrustation of the well screen, by fine-grained particles plugging the aquifer material surrounding the well screen, or by collapse of the well screen. Inspection of the three drive-point screens pulled during well replacement showed that iron- and manganese-oxide incrustation had almost entirely clogged screen openings. These oxides formed up to a half-inch thick, hard, reddish-brown to black scale over the length of the screen. It would seem likely that this type of clogging also had taken place in the other wells.

Abandoning and replacing shallow (<50 feet deep) observation wells finished in Pleistocene sand and gravel deposits is an effective and inexpensive way to improve the quality of data in the monitoring-well program. The problem of incrustation of observation-well screens is likely to continue in older wells given the relatively high concentrations of naturally-occurring iron and manganese in groundwater throughout the State.

RECOMMENDATIONS

All or some of the remaining eight wells that Dunning and others (1996) and Rauman and others (1999) found to be clogged should be replaced as funding becomes available.

Water-level data from all observation wells screened in sand and gravel deposits should be examined on a regular basis to detect changes such as a decline in the magnitude of seasonal fluctuations which could indicate the clogging of the well screen. These wells should be hydraulically tested. If they are found to be clogged, they should be replaced depending on priorities and availability of funding.

It appears to be cheaper to abandon and replace shallow (<50 feet deep) screened wells every 20 to 40 years rather than attempt to periodically reconstruct or acidify existing wells. The cost of reconstruction or acidification with no guarantee of the effectiveness of the procedure is not recommended.

The cost of abandoning and replacing deep screened wells with depths of 100 to 200 feet or more is probably prohibitive. Replacement of deep screened would need to be contracted to a professional well drilling company.

REFERENCES CITED

Dunning C.P., Ellefson B.R., and Zaporozec A., 1996. Collection of hydraulic and geologic data to improve the quality of Wisconsin ground-water monitoring network. Wisconsin Geological and Natural History Survey and U.S. Geological Survey, Report on Research and Monitoring Project funded by the Wisconsin Department of Natural Resources, ID No. 118, 6 p. and 37-p. Appendix.

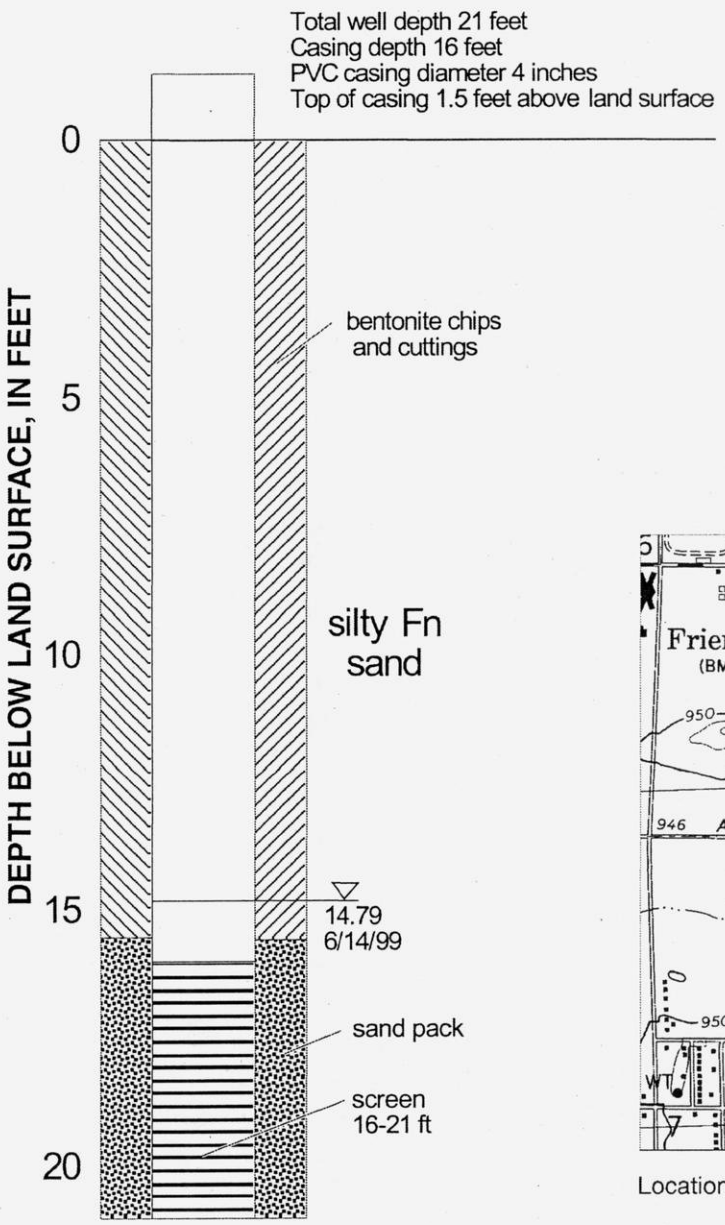
Rauman J.M., Ellefson, B.R., and Zaporozec, A., 1999. Evaluation of geology and hydraulic performance of Wisconsin ground-water monitoring wells. Wisconsin Geological and Natural History Survey and U.S. Geological Survey, Report on Research and Monitoring Project funded by the Wisconsi Department of Natural Resources, ID No. 135, 6 p. and 17-p. Appendix.

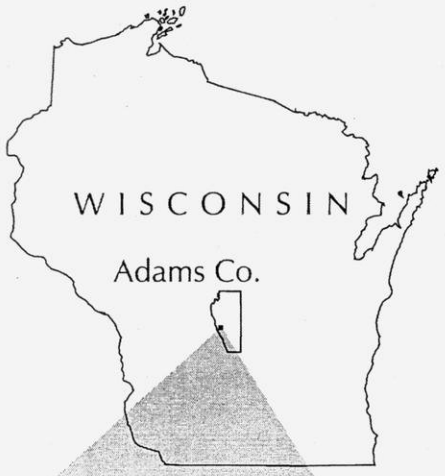
Zaporozec A. 1996. Wisconsin groundwater observation-well network, 1946-95: Wisconsin Geological and Natural History Survey Educational Series 40, 13 p.

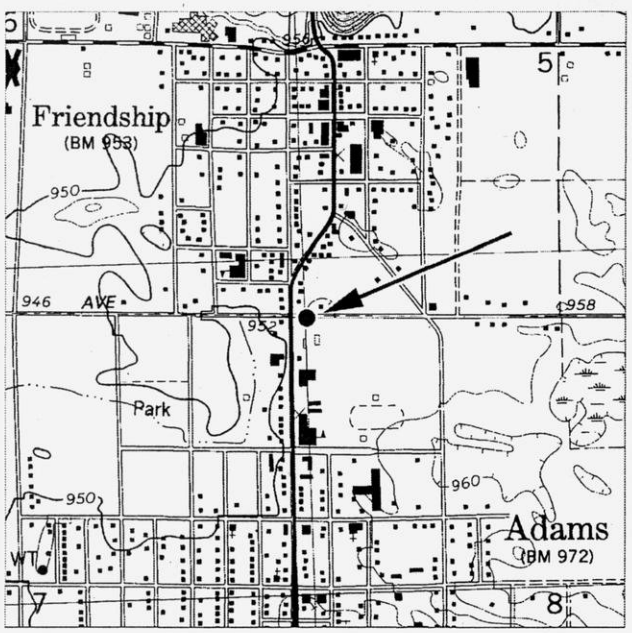
APPENDIX A

Construction and location of eight new observation wells

AD-17/06E/08-0076

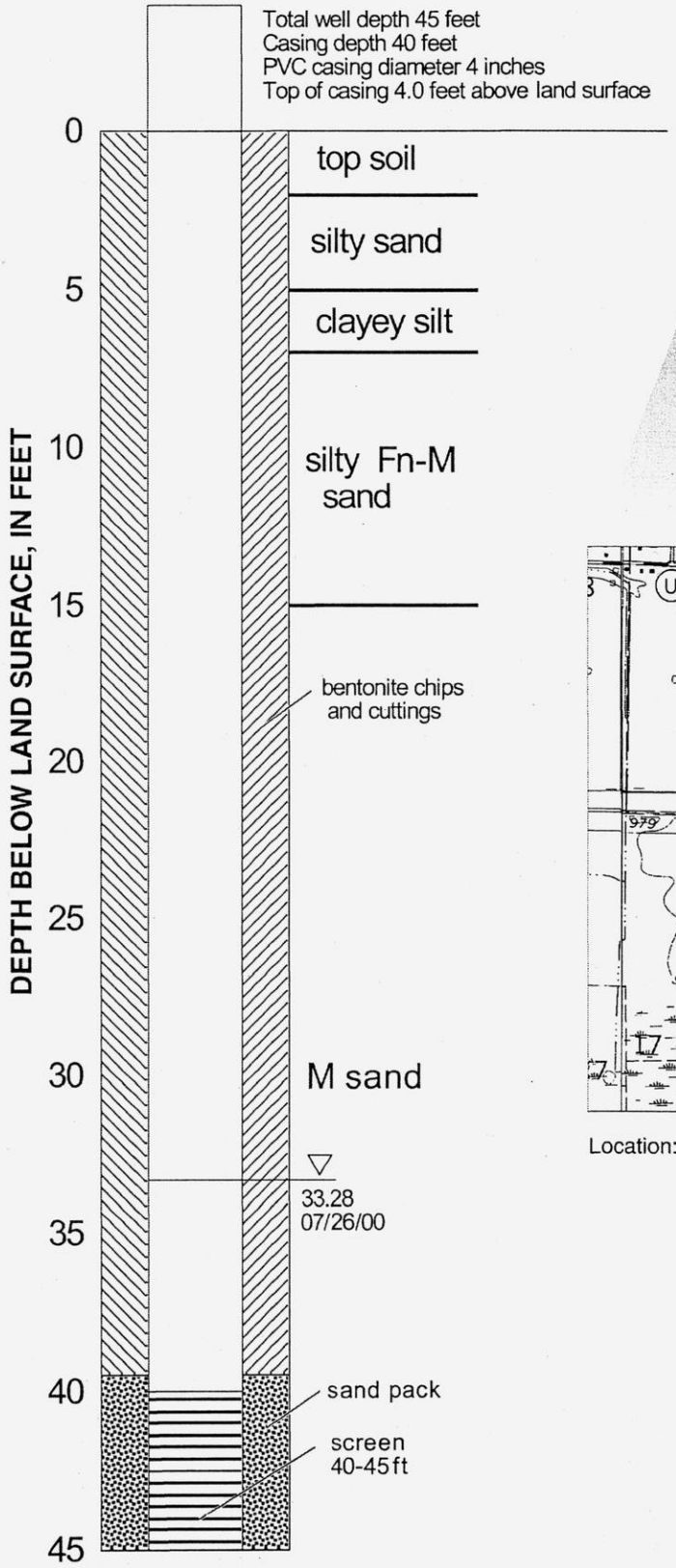


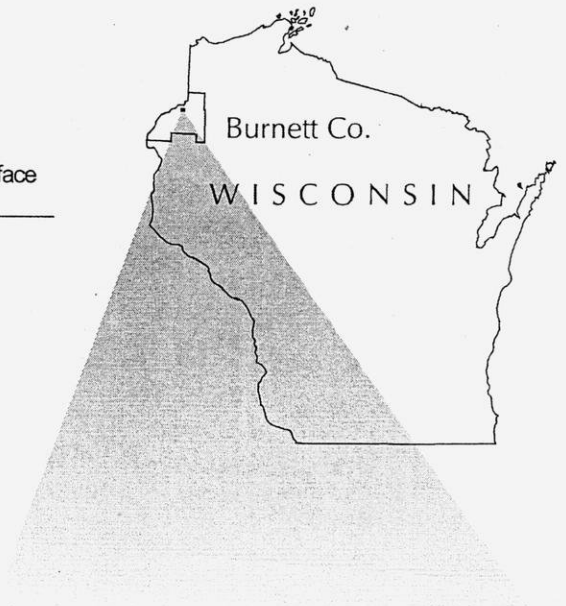


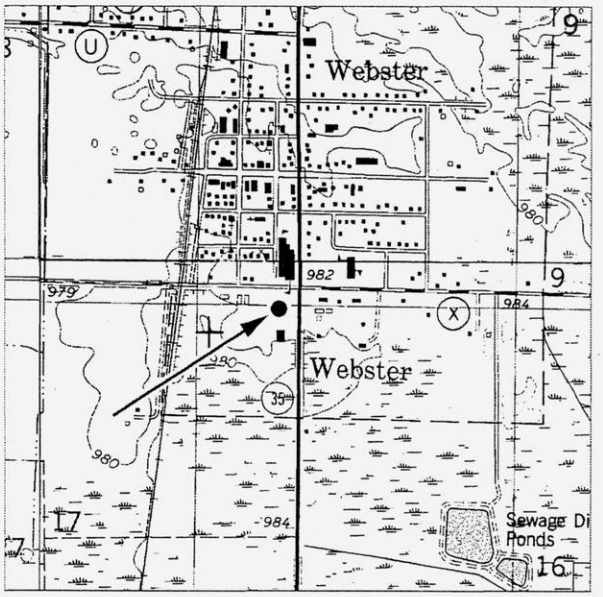


Location: NW ¼, NW ¼, NW ¼ of section 8, T17N., R6E.

BT-39/16W/17-0002

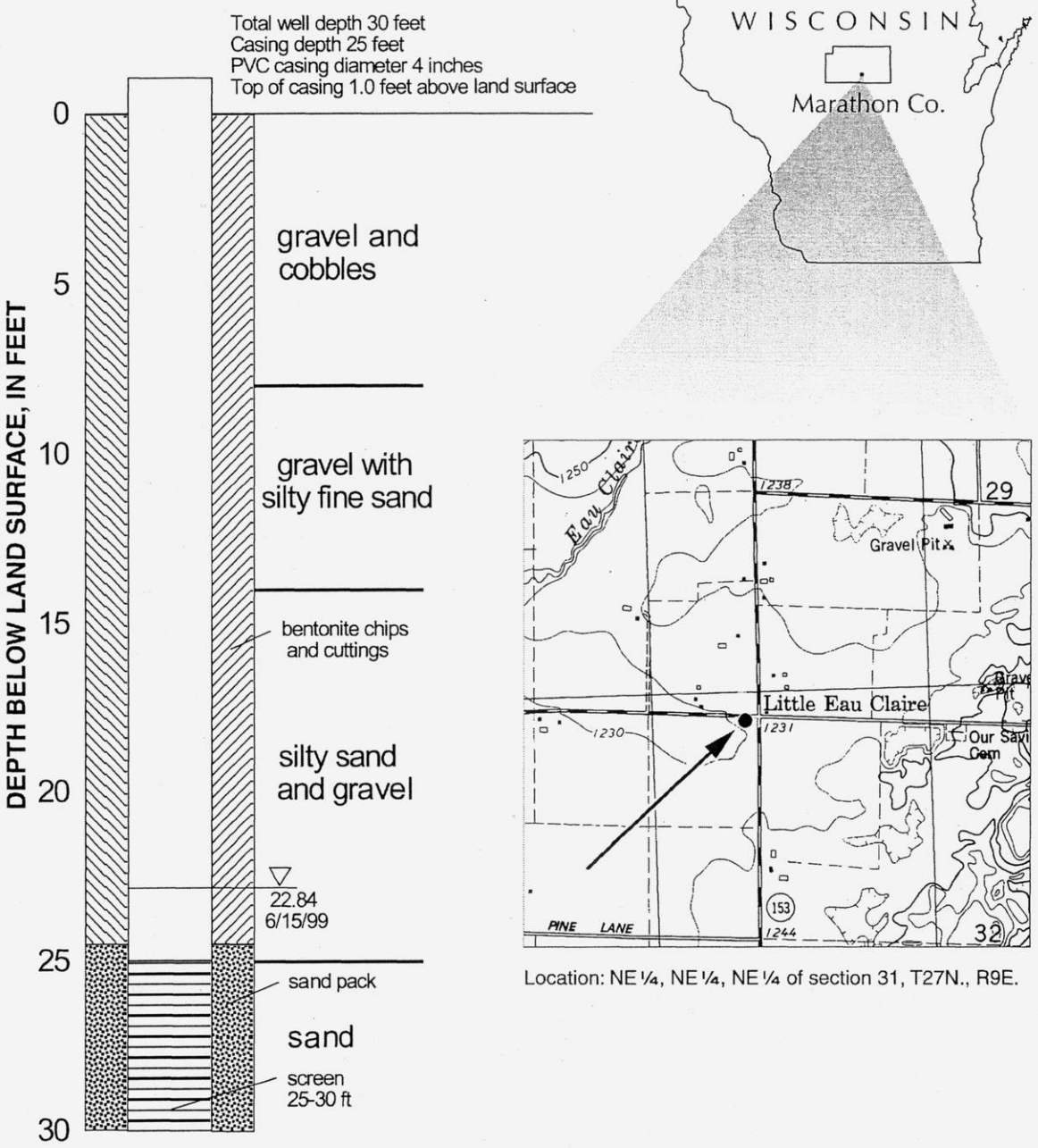






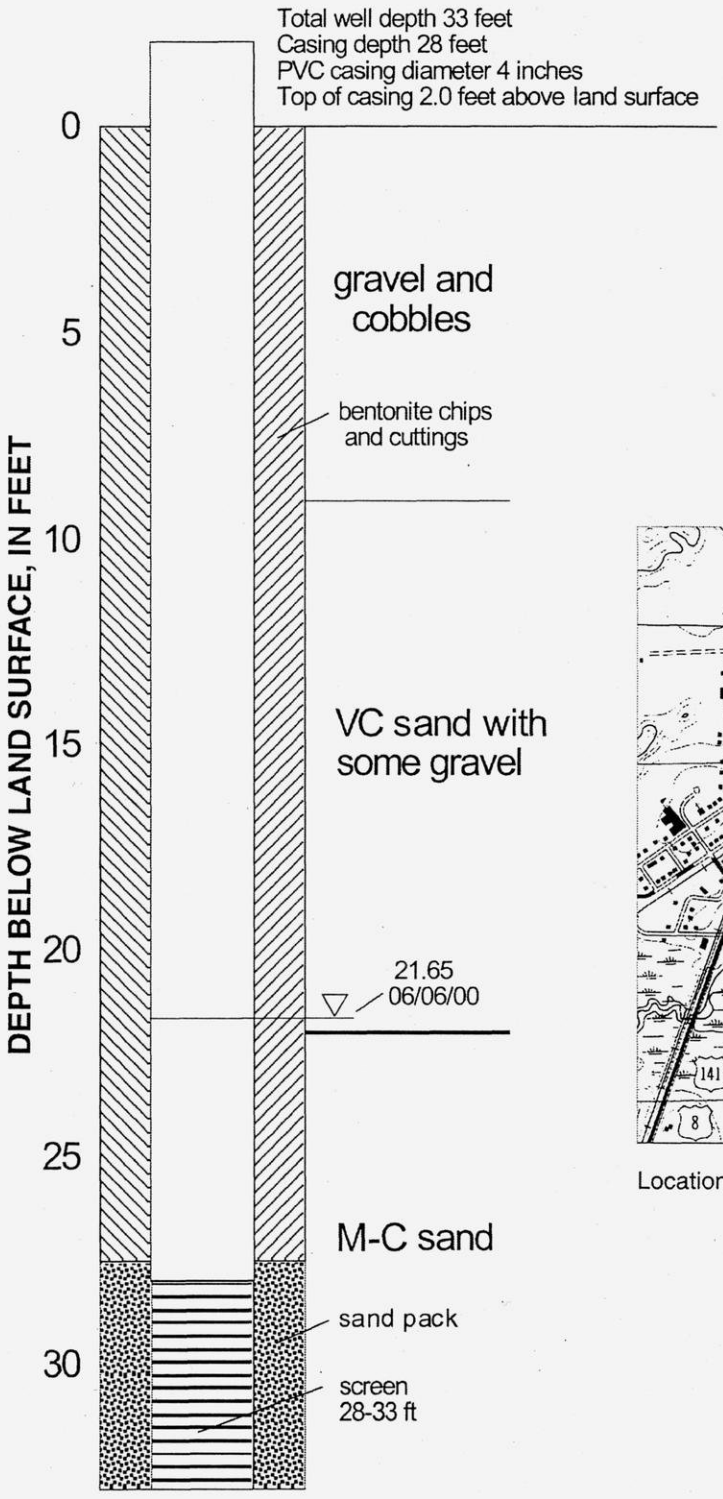
Location: NE ¼, NE ¼, NE ¼ of section 17, T39N., R16W.

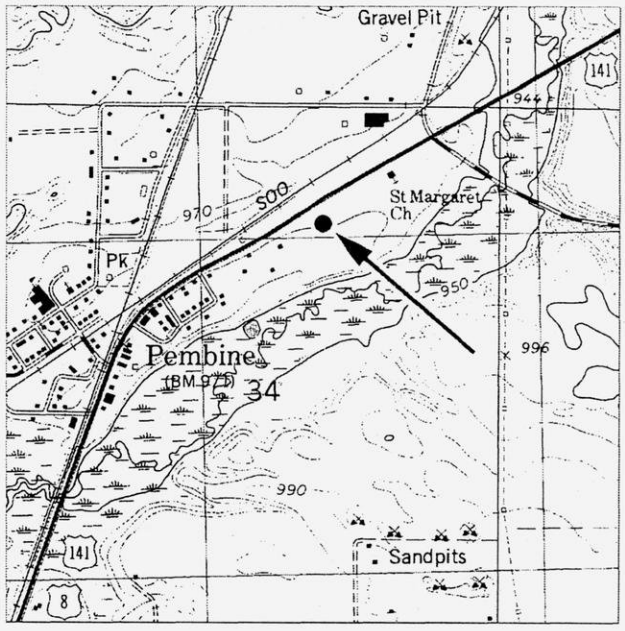
MR-27/09E/31-0028



Location: NE ¼, NE ¼, NE ¼ of section 31, T27N., R9E.

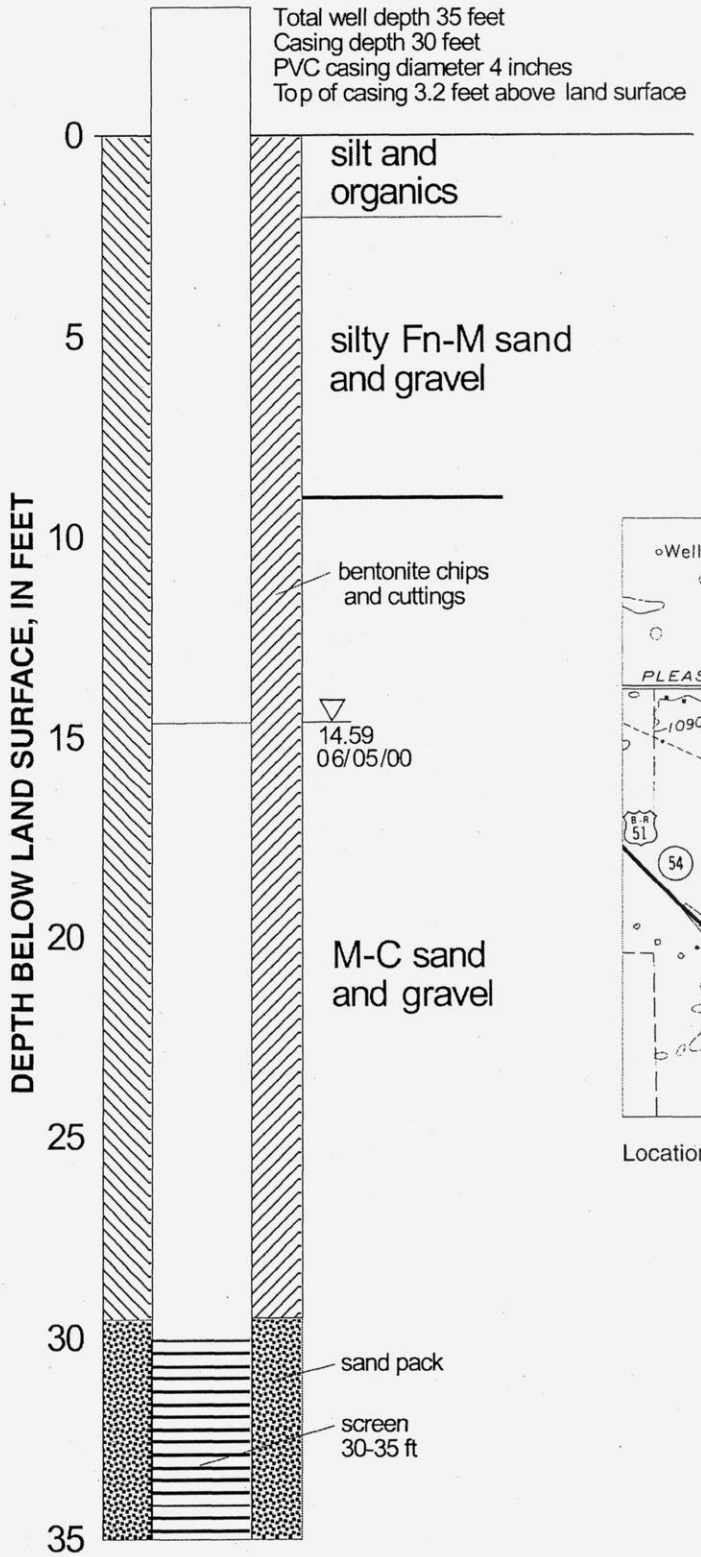
MT-37/20E/34-0007

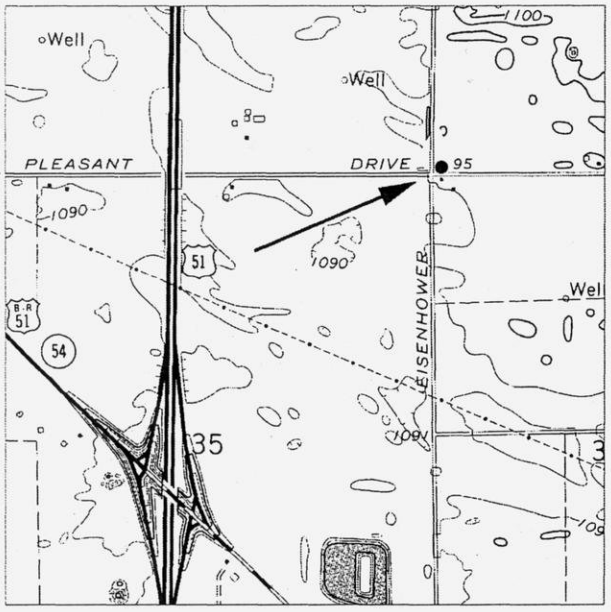




Location: SE ¼, NW ¼, NE ¼ of section 34, T37N., R20E.

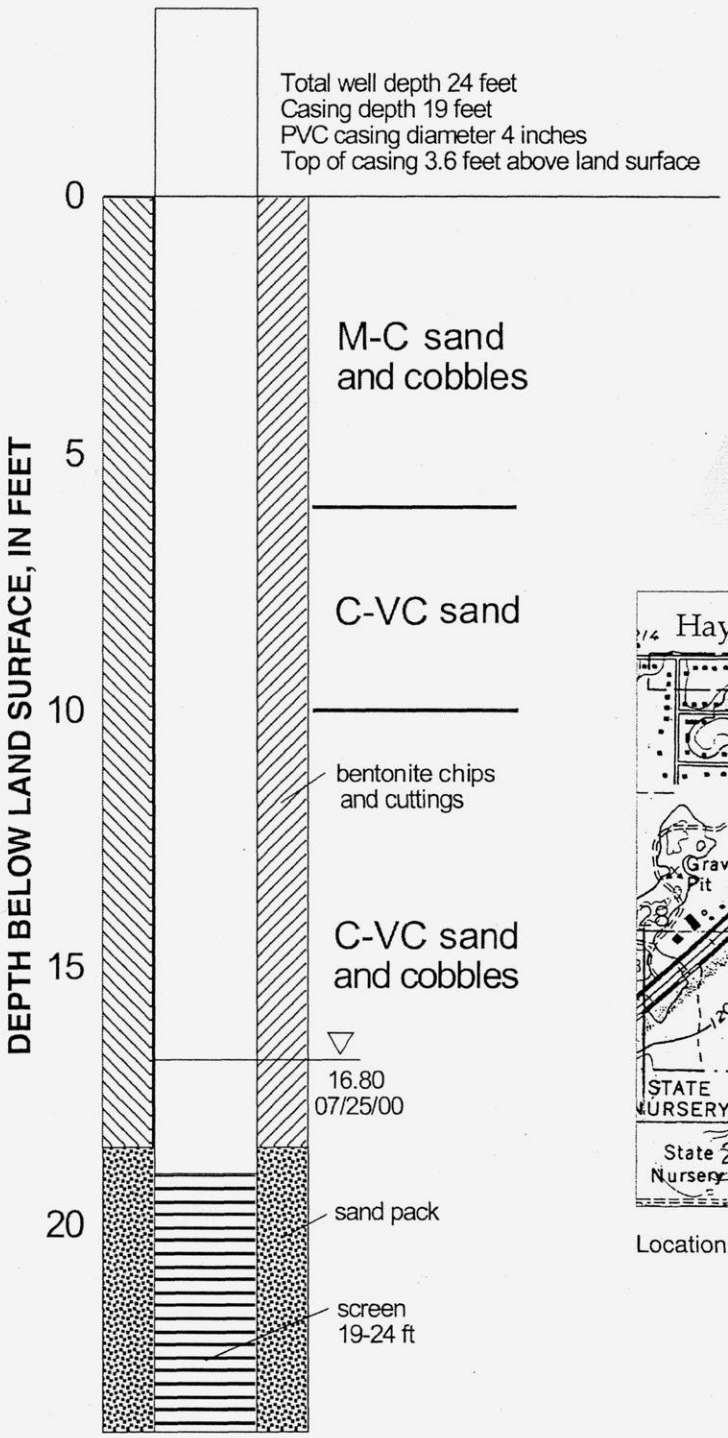
PT-23/08E/25-0376

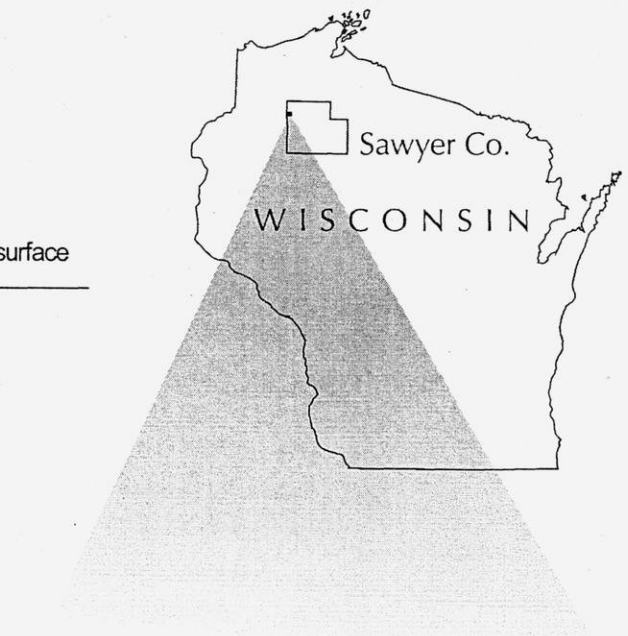


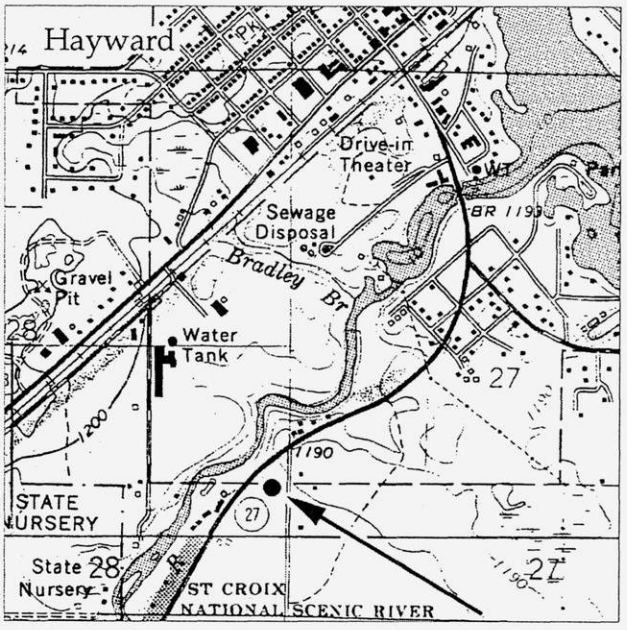


Location: SW ¼, SW ¼, SW ¼ of section 25, T23N., R8E.

SW-41/09W/28-0007

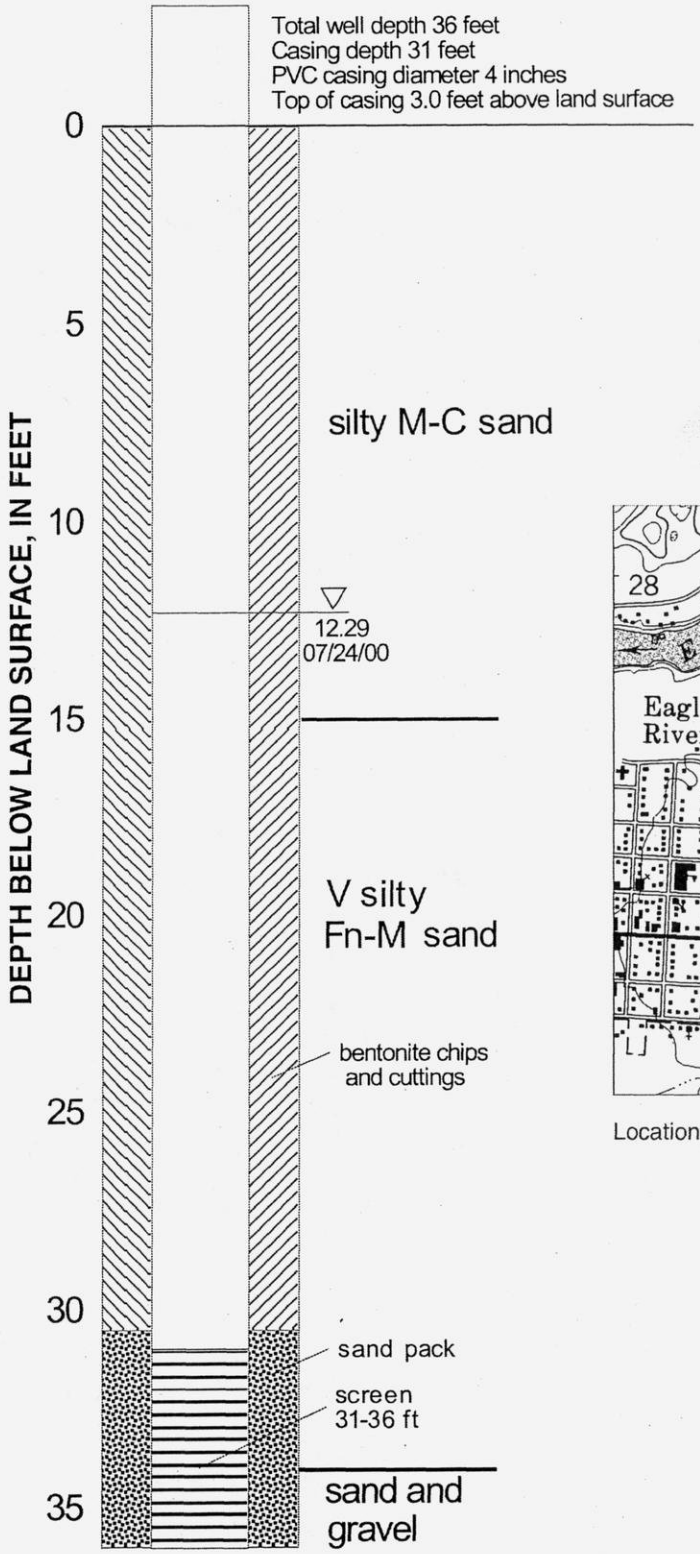






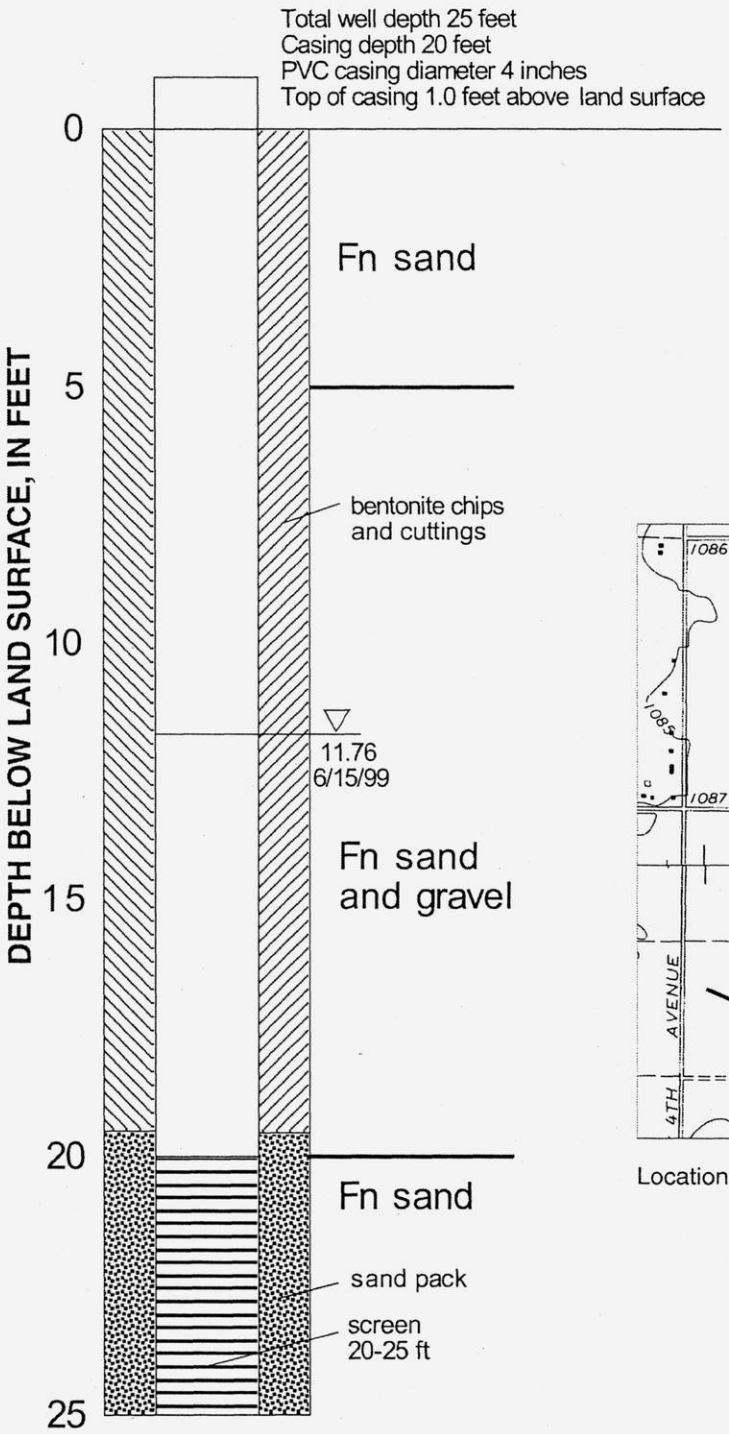
Location: NE ¼, SE ¼, SE ¼ of section 28, T41N., R9W.

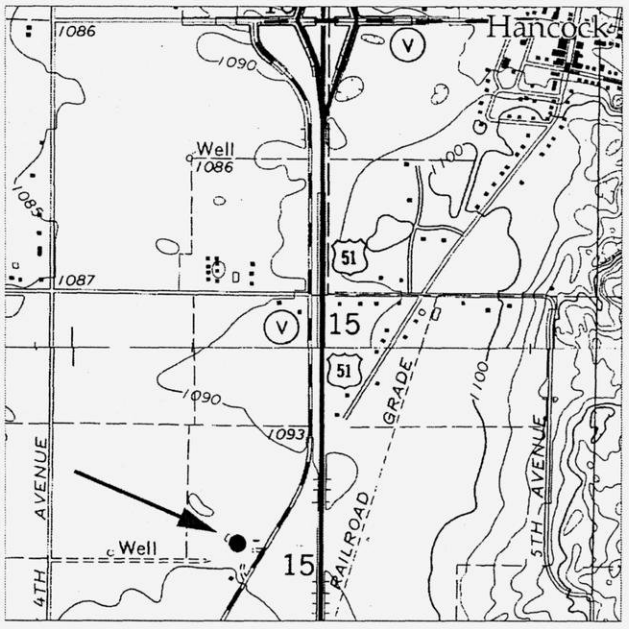
VI-40/10E/28-0033



Location: SE ¼, NW ¼, SE ¼ of section 28, T40N., R10E.

WS-19/08E/15-0008





Location: SW ¼, SE ¼, NW ¼ of section 15, T19N., R8E.

Project Summary

Title: **Improvement of Wisconsin groundwater monitoring network**

Project I.D.: NMJ00000140

Investigators: Principal Investigators:
Alexander Zaporozec, Senior Scientist, WGNHS
William Batten, Geotechnician, WGNHS
Project Assistant:
Bernard Ellefson, Hydrologist, USGS

Period of Contract: July 1, 1999 - June 30, 2000;funding provided by the Groundwater Management Practice Monitoring Program

Background/Need: Some monitoring wells with long-term records no longer provide accurate water-level data because of clogged screens. These wells need to be replaced. Wells with particularly long records are a valuable tool for research and resource management.

Objectives: The main objective is to improve the reliability of the statewide groundwater monitoring network in Wisconsin, which in turn will contribute to the collection of higher quality baseline groundwater data.

Methods: Eight shallow observation wells were abandoned and replaced with nearly identical wells in eight different counties over the period from July, 1999 to June, 2000.

Results and Discussion: Well screens in old wells were incrusted with iron and manganese oxide scale. Wells were open to shallow sand and gravel deposits.

Conclusions/ Implications/ Recommendations: Incrustation is a likelihood in well screens. Abandoning and replacing shallow wells is a cost-effective measure.

Related Publications: None

Key Words: Groundwater monitoring network, well-screen incrustation

Funding: Wisconsin Department of Natural Resources

Final Report: A final report containing more detailed information on this project is available for loan at the Water Resources Center, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706, (608) 262-3069.