

U.S. Geological Survey

Scientific Investigations Report 2005-5283

Appendix Data Documentation

Note: Locations have been adjusted to less precision for security purposes.

Appendix A: Well Logs

Title of the dataset: Well Logs.txt

Geographic area: St. Croix River Basin, Minnesota and Wisconsin.

Time period of the data: Unspecified

Geographical feature type: Point- well location

Coordinate system: Universal Transverse Mercator (UTM), Zone 15N

Datum: North American 1983 (NAD83)

What attributes are described: Project log id, well id, data source, coordinate location, land surface elevation, well depth, depth of well elevation, depth to top of first bedrock, top of first bedrock elevation, geologic formation of first bedrock unit, geologic formation of last (bottom) bedrock unit, depth to crystalline basement rock (if known), depth crystalline basement must be below (if known), and rock type at bottom of well

Who created the dataset: Cheryl Buchwald, USGS-WI, Water Science Center

To whom should users' questions be addressed: Report authors: Buchwald, Cheryl A., cabuchwa@usgs.gov, Feinstein, Daniel T., dtfeinst@usgs.gov, Dunning, Charles P., cdunning@usgs.gov

The objectives of this dataset were: 1) to compile existing geologic well logs in order to identify distribution and type of unconsolidated and lithified geologic deposits; 2) to calculate depth to bedrock and unconsolidated aquifer thickness

Data sources: Refer to the data sources table in the text or PDF file called "SIR05-5283 Codes" that accompanies the appendixes in the Codes directory

Data quality: Dependent on the accuracy of initial reports and subsequent data entry

Possible problems with dataset: The data have been collected and compiled from multiple sources and there has been no field check to verify the information

Possible problems with dataset: None known

Possible errors in dataset: Location coordinates, altitude, or intersected geologic formation may be incorrectly reported or estimated

How accurate are the well logs: Good to excellent

How accurate are geographic locations: Poor to very good, all coordinates were rounded to the nearest 100 meters (or approximately 300 feet) for security purposes.

Are there legal restrictions on data access or use: None

Summary:

The well log database in Appendix A contains mostly digitally available well logs compiled from a number of sources in both Minnesota and Wisconsin. This database provides information about 17,125 wells completed in both unconsolidated deposits and bedrock. If the log is completed in unconsolidated deposits, the value under the depth to bedrock field is coded -999. Many well logs from the Wisconsin DNR source do not specify the name of the geologic formation but rather the rock types intersected by the well. The data attribute '*completion*' refers to the rock type at the bottom of the well. The rock types are unconsolidated deposits, sedimentary bedrock, crystalline basement and basalt. Note that the attribute '*completion*' does not refer to the open interval of the pumped well. If the '*completion*' entry is denoted by '*bedrock-?*', it is because the well log reported no rock type data but only the depth to bedrock.

If any field contains an abbreviation it can be determined from the text or PDF file called "SIR05-5283 Codes" that accompanies the appendixes.

Appendix B: Lithology

Title of the dataset: Lithology.txt

Geographic area: St. Croix River Basin, Minnesota and Wisconsin.

Time period of the data: Unspecified

Geographical feature type: Point- well location

Coordinate system: Universal Transverse Mercator (UTM), Zone 15N

Datum: North American 1983 (NAD83)

What attributes are described: **Worksheet 1-** Project log id, well id, data source, coordinate location, well depth, depth to first bedrock, interval lithologic rock type, interval lithologic top depth, and interval lithologic bottom depth
Worksheet 2 (for separated CWI source)- Well id, data source, coordinate location, depth to top lithologic interval, depth to bottom lithologic interval, driller's description, interval color, hardness, stratigraphic code, primary lithology, secondary lithology, and minor lithology

Who created the dataset: Cheryl Buchwald, USGS-WI, Water Science Center

To whom should users' questions be addressed: Report authors: Buchwald, Cheryl A., cabuchwa@usgs.gov, Feinstein, Daniel T., dtfeinst@usgs.gov, Dunning, Charles P., cdunning@usgs.gov

The objectives of this dataset were: 1) to extract geologic well logs that contained lithologic descriptions in order to identify distribution and unconsolidated and lithified rock types, and 2) to use these logs in determining unconsolidated and lithified deposit types and thickness

Data sources: Refer to the data sources table in the text or PDF file called "SIR05-5283 Codes" that accompanies the appendixes in the Codes directory

Data quality: Dependent on the accuracy of driller's or geologist's description and subsequent data entry

Possible problems with dataset: The data have been collected and compiled from multiple sources and there has been no field check to verify the information. The driller description from the CWI database often did not match the stratigraphic code. See note below for discussion

Possible problems with dataset: None

Possible errors in dataset: Location coordinates may be incorrectly reported or estimated

How accurate are the lithologic logs: Good to excellent

How accurate are geographic locations: Poor to very good, all coordinates were rounded to the nearest 100 meters (or approximately 300 feet) for security purposes. Refer to Appendix A for coded accuracy.

Are there legal restrictions on data access or use: None

Summary:

The well log database in Appendix B contains mostly digitally available well logs compiled from a number of sources in both Minnesota and Wisconsin. This database provides information about wells completed in both unconsolidated deposits and lithified bedrock. Unlike the Minnesota County Well Index (CWI) source, well logs from the Wisconsin DNR source do not specify the names of the geologic formations but rather the rock types intersected by the well, therefore, this database established on lithology type is able to considerably increase the total number of possible records that can be included. If the log is completed in unconsolidated deposits, the value under the depth to bedrock field is coded -999.

The lithologic database in Appendix B contains 11,047 well logs. This database includes all well logs with a complete lithological record from the Minnesota Observation Well Network and the Wisconsin Geologic and Natural History Survey's WiscLITH database but excludes well logs that are less than a specified depth from the two largest data sources to avoid unnecessary repletion of data wells. For Wisconsin well logs from the Water Well Data CD-ROM with depths less than 100 feet were excluded. For Minnesota well logs from the County Well Index with depths less than 200 feet were excluded.

If any field contains an abbreviation it can be determined from the text or PDF file called "SIR05-5283 Codes" that accompanies the appendixes.

Note about the CWI data source:

The CWI lithology data source in worksheet 2 was compiled and queried separately from the main lithology dataset in worksheet 1. The driller's description reported in the CWI dataset often did not match the stratigraphic code. By comparing the ambiguous descriptions to overlying and underlying rock units, rock color and the primary lithology field, it was possible to assign lithologies even in cases of discrepancies.

Appendix C: Thickness of Lithologic Groups

Title of the dataset: Thickness of Lithologic Groups.txt

Geographic area: St. Croix River Basin, Minnesota and Wisconsin.

Time period of the data: Unspecified

Geographical feature type: Point- well location

Coordinate system: Universal Transverse Mercator (UTM), Zone 15N

Datum: North American 1983 (NAD83)

What attributes are described: Project log id, well id, data source, coordinate location, well depth, depth to bedrock, depth to water level, and thicknesses of lithologic groups

Who created the dataset: Cheryl Buchwald, USGS-WI, Water Science Center

To whom should users' questions be addressed: Report authors: Buchwald, Cheryl A., cabuchwa@usgs.gov, Feinstein, Daniel T., dtfeinst@usgs.gov, Dunning, Charles P., cdunning@usgs.gov

The objectives of this dataset were: to compile water-level information from existing well logs in order to assist in the calibration of the ground-water screening model

Data sources: Refer to the data sources table in the text or PDF file called "SIR05-5283 Codes" that accompanies the appendixes in the Codes directory

Data quality: Dependent on the accuracy of initial reports and subsequent data entry

Possible problems with dataset: The data have been collected and compiled from multiple sources and there has been no field check to verify the information

Possible errors in dataset: Same errors as Appendix B with possible errors in the water-level observations due to incorrect measurement or recording of value

How accurate are the summarized lithologic groups: Good to excellent

How accurate are the water levels: Good to excellent

How accurate are geographic locations: Poor to very good, all coordinates were rounded to the nearest 100 meters (or approximately 300 feet) for security purposes. Refer to Appendix A for coded accuracy.

Are there legal restrictions on data access or use: None

Summary:

The lithologic group thickness database in Appendix C contains the same number of well logs that were used in the lithological database of Appendix B. However, in this database, each individual lithologic interval reported in the well log was assigned to one of five lithologic groups. Lithologic groups are rock types that are assumed to have similar hydraulic properties such as hydraulic conductivity. The five lithologic groups are: coarse-grained unconsolidated deposits, fine-grained unconsolidated deposits, carbonate bedrock (limestone and dolomite), sandstone bedrock, and other (shale, siltstone, igneous intrusions and conglomerate). Records were combined into these groups according to their lithologic descriptions provided in the well log. For example, a description containing coarse-grained materials such as sand and/or gravel were combined into the coarse-grained unconsolidated lithologic group, whereas, fine-grained materials such as silt and/or clay were combined into the fine-grained unconsolidated lithologic group. However, not always were the descriptions restricted to one of the two group types but often the reported description was a mix of the two grain-size categories. In these scenarios, if silt was used along with either sand and/or gravel the interval was then allocated into the coarse-grained lithologic group, but if ever clay was part of the description, such as in the descriptions 'sand, silt, and clay' or 'gravelly clay', then the interval was assigned into the fine-grained lithologic group. Multiple bedrock units reported in the descriptions were handled differently. If a bedrock interval was reported to be both sandstone and shale, the thickness was split equally into two lithologic groups; however, if the well log reported predominantly sandstone but with layers or some shale (frequently referred in the well log as shaley), then two-thirds of the total thickness was assigned into the major group and the remaining one-third into the minor group.

Every well is assigned five thickness categories corresponding to the five lithologic groups. The thickness entered represents the sum of all rock types corresponding to the group even if they are at different depths within the log. If no lithologic descriptions correspond to a lithologic group, then its lithologic group thickness is zero.

The database also includes depth to water for each well log. If the value is negative, the water level in the well was above land surface. A value of -999 is used when there is no depth to water level observation reported. The water level information provided in this appendix is not identical to that provided in Appendix D. Although there may be some overlap in wells used, specifically the Minnesota DNR Observation wells, the records in this appendix are typically greater than 100 feet in depth, whereas, almost all records in Appendix D have well depth less than 100 feet.

If any field contains an abbreviation it can be determined from the text or PDF file called "SIR05-5283 Codes" that accompanies the appendixes.

Appendix D: Ground-Water Levels

Title of the dataset: Ground-Water Levels.txt

Geographic area: St. Croix River Basin, Minnesota and Wisconsin.

Time period of the data: 1988-2003

Geographical feature type: Point- well location

Coordinate system: Universal Transverse Mercator (UTM), Zone 15N

Datum: North American 1983 (NAD83)

What attributes are described: Number for water-level observation corresponding to model calibration target, various well ids, site name, data source, county, coordinate location, aquifer monitored if specified, general lithology penetrated if specified, land surface elevation, well depth, water-level observation date, depth to water, calculated ground-water elevation, number of observations, water-level measurement accuracy, and well location accuracy

Who created the dataset: Cheryl Buchwald, USGS-WI, Water Science Center

To whom should users' questions be addressed: Report authors: Buchwald, Cheryl A., cabuchwa@usgs.gov, Feinstein, Daniel T., dtfeinst@usgs.gov, Dunning, Charles P., cdunning@usgs.gov

The objectives of this dataset were: to compile water level information from existing well logs in order to assist in the calibration of the ground-water screening model

Data sources: Refer to the data sources table in the text or PDF file called "SIR05-5283 Codes" that accompanies the appendixes in the Codes

Data quality: Dependent on the accuracy of initial reports and subsequent data entry

Possible problems with dataset: The data have been collected and compiled from multiple sources and there has been no field check to verify the information.

Possible problems with dataset: None known

Possible errors in dataset: Location coordinates or land surface elevation may be incorrectly reported or estimated; errors in the water-level observations are possible due to incorrect measurement or recording of values

How accurate are the water levels: Good to excellent

How accurate are geographic locations: Poor to very good, all coordinates were rounded to the nearest 100 meters (or approximately 300 feet) for security purposes.

Are there legal restrictions on data access or use: None

Summary:

The ground-water-level database in Appendix D combines water-level observations made between the years 1988 and 2003 by the US Geological Survey, by the Minnesota and Wisconsin Departments of Natural Resources, and by private well drillers. The purpose of the database is to provide water-level calibration targets that correspond approximately to the elevation of the water table. In general, only shallow wells less than 100 feet in depth are entered in this database on the assumption that the water levels in these wells reflect unconfined conditions. In a few cases wells deeper than 100 feet are included; they correspond to well networks for which records are available specifying that a deep well monitors an unconfined aquifer. The database contains 5295 water-level observations.

If a multiple water-level measurements are available at a well for the period 1988-2003, then an average water level is calculated and paired with the most recent observation date closest to the average water level. A value of -999 is used when there is no depth to water level observation reported. Land surface elevation is not always provided in the data sources; if absent it is estimated from USGS topographic maps.

If any field contains an abbreviation it can be determined from the tab-delimited text file called "SIR05-5283 Codes.txt" that accompanies the appendixes. The code "RTL" means refer to the original well log if further lithologic detail is needed.

Also note that any reported lithologic information provided in Appendix D is not in any stratigraphic order.

Appendix E: Streamflow

Title of the dataset: Streamflow.txt

Geographic area: St. Croix River Basin, Minnesota and Wisconsin.

Time period of the data: 1902 - 2003

Geographical feature type: Point- location of surface water gaging station

Coordinate system: Universal Transverse Mercator (UTM), Zone 15N

Datum: North American 1983 (NAD83)

What attributes are described: USGS station id and name, abbreviated name for report figure, state, coordinate location, period of record, drainage area, and calculated flow duration statistics: Q50, Q65, Q80 (used to estimate base flow of streams)

Who created the dataset: Cheryl Buchwald, USGS-WI, Water Science Center

To whom should users' questions be addressed: Report authors: Buchwald, Cheryl A., cabuchwa@usgs.gov, Feinstein, Daniel T., dtfeinst@usgs.gov, Dunning, Charles P., cdunning@usgs.gov

The objectives of this dataset were: to provide an estimated range of base-flow values in order to assist in the calibration of the ground-water screening model

Data sources: Refer to the data sources table in the text or PDF file called "SIR05-5283 Codes" that accompanies the appendixes in the Codes directory

Data quality: The longer the period of record, the better accuracy is the description for streamflow

Possible problems with dataset: These data have been collected by trained USGS field hydrologic technicians and are considered reliable

Possible problems with dataset: None known

Possible errors in dataset: None known

How accurate are the discharge computations: Very good to excellent

How accurate are geographic locations: Very good to excellent, no security restrictions

Are there legal restrictions on data access or use: None

Summary:

The streamflow database in Appendix 5 combines discharge observations collected by the US Geological Survey between 1902 and 2003. Twenty-two of the possible twenty-eight USGS surface-water stations in the basin were selected and discharge data for those stations were compiled. The six gaging stations were omitted because they were on very minor tributaries that were not represented in the screening model. A list of the deleted six gaging stations is provided below.

Model targets were then computed in the Automated DATA Processing System (ADAPS) using a flow duration analysis program to characterize base flow for streams. Flow duration curves can be used to estimate what portion of the total streamflow, Q, is derived from ground water as base flow. In glaciated areas like the St. Croix Basin, base flow is assumed to fall between the Q50 and Q80 flow-duration values. A Q80 value means that for 80% of the record period, the streamflow rate is either met or exceeded. A Q50 value means that for 50% of the record period, the streamflow rate is either met or exceeded. The Q80 value generally corresponds to base flow in basins characterized by low-permeability sediments where runoff is high; the Q50 value generally corresponds to base flow in basins with more permeable sediments.

The six gages that were omitted from the streamflow database were:

<u>USGS Station ID</u>	<u>Station Name</u>
05335380	Bashaw Brook Near Shell Lake, WI
05341375	Rice Creek Near Balsam Lake, WI
05341402	Balsam Branch at Balsam Lake, WI
05341404	Deer Lake Trib. #1 Upstream Site Nr Centuria, WI
05341405	Deer Lake Trib. #1 Downstream Site Nr Centuria, WI
05335010	Loon Creek Near Danbury, WI

Appendix F: Well Pumpage

Title of the dataset: Well Pumpage.txt

Geographic area: St. Croix River Basin, Minnesota and Wisconsin.

Time period of the data: 1991 - 2003

Geographical feature type: Point- well location

Coordinate system: Universal Transverse Mercator (UTM), Zone 15N

Datum: North American 1983 (NAD83)

What attributes are described: Project water use id, well number, various identification numbers, state, county, private land survey township and range, coordinate location, location accuracy, water use classification type, construction date, well depth, 2003 pumping status, source aquifer, comments, and pumpage rates. Note: Information can not be made available for well owner, operator, private land survey section and legal description.

Who created the dataset: Cheryl Buchwald, USGS-WI, Water Science Center

To whom should users' questions be addressed: Report authors: Buchwald, Cheryl A., cabuchwa@usgs.gov, Feinstein, Daniel T., dtfeinst@usgs.gov, Dunning, Charles P., cdunning@usgs.gov

The objectives of this dataset were: to compile a list of wells with withdrawal rates greater than 1 million gallons per year

Data sources: Refer to the data sources table in the text or PDF file called "SIR05-5283 Codes" that accompanies the appendixes in the Codes directory

Data quality: Very good to excellent

Possible problems with dataset: Minnesota DNR requires all high capacity water use of more than 1 million gallons per year to be reported, whereas only the public water utilities in Wisconsin are required by law to report water use to the Wisconsin DNR. Wisconsin does not require non-municipal water use to be reported so these data are estimated (see below)

Possible problems with dataset: None known

Possible errors in dataset: Location coordinates may be incorrectly reported or estimated; some water-use rates are estimated by methods with appreciable uncertainty

How accurate are the water extraction rates: Fair to excellent

How accurate are geographic locations: Good to excellent

Are there legal restrictions on data access or use: Regulations issued by the Department for Homeland Security prohibit disclosure of public supply water use and therefore no owner or operator names as well as locations may be published or released to public. Authorization is needed to share location information and is limited to trusted sources.

Summary:

High capacity well pumpage data used in the model were compiled from a number of sources and are contained in Appendix 6. Both Minnesota and Wisconsin pumpages for the period from 1991 to 2003 were calculated and/or estimated for individual wells. Wells that withdraw a minimum of 1 million gallons per year (MGY) were identified from federal and state resources. Two standby wells (Water Use ID W236 and W259) were also included into the database because their withdrawal rate between 1991 and 2000 was 12.2 and 30.7 MGY, respectively. In this dataset, high capacity wells are divided into four water use classification types:

- 1) 'Production Well' denotes water withdrawn for public supply such as by a private community, public community or other non-community systems;
- 2) 'HiCap-CII' codes water withdrawn for commercial, industrial, power generation and institutional uses;
- 3) 'HiCap-Irrigation' signifies water extracted for crop and golf course irrigational requirements; and
- 4) 'HiCap-Other' includes all other high capacity water uses for places such as waysides or camps.

A more detailed explanation about water use classification is available in USGS Open-File Report 82-444 (Lawrence, 1982).

Wisconsin's municipal pumpage was totaled from pumpage reports on file at the Wisconsin Department of Natural Resources (WDNR) in 1979, 1994, and 1997, and is presented in USGS publications (Lawrence, et al., 1984, Ellefson et al., 2002). Additional data for 2003 were attained in person at the WDNR and by calling individual water utilities for verification. Total public-supply pumpages by municipality reported by the Wisconsin Public Service Commission (PSC) from 1998 to 2002 were included. Wisconsin's high capacity values are less certain than Minnesota records because for the 1991-2003 period it was not mandatory to report this category of water extraction in Wisconsin. An effort was made by the Wisconsin DNR between 1978 and 1989 to solicit voluntary reporting of this water use; these data were retrieved from the website <http://dnr.wi.gov/org/water/dwg/> and added to the database.

Another source of data for Wisconsin are water-use permitting records that contain approximate location, well completion, and pumping rates estimated from pump capacity. These data are publicly distributed on the WDNR Bureau of Drinking Water & Groundwater Water Well Data CD-ROM. Therefore, if current pumpage rates were not available, an estimated rate was calculated based on either past reported pumpage or an average pumping rate of wells under the same classification.

For specific details on how Wisconsin's non-reported high-capacity water withdrawals were estimated, refer to the Wisconsin explanation for estimation section following this summary.

Minnesota's DNR (MDNR) Water Appropriations Permit Program requires users to report the volume of water used each year if pumpage is permitted to be greater than 1 million gallons per year; however, it is possible that there may be years in which the user did not reach the MDNR allocated minimum but pumpage was still reported. If that is the case, these water use sites were not omitted if the overall yearly average for the period 1991-2003 was 1 million gallons. The location and pumpage data are made available through their website as an Adobe Acrobat PDF document and ArcView shapefile at http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html.

The total number of high-capacity wells in the database is 154 in the Wisconsin portion of the basin and 170 in the Minnesota portion of the basin for a total of 324 high-capacity water use wells in the basin.

If any field contains an abbreviation it can be determined from the tab-delimited text file called "SIR05-5283 Codes.txt" that accompanies the appendixes. For specific details on how Wisconsin's non-reported high-capacity water withdrawals were estimated, refer to the section below.

Estimation of Non-Municipal Well Pumpage in Wisconsin

The following explanation contains specific details for how Wisconsin's non-municipal high-capacity water withdrawal estimates were made. A working dataset for these active and stand-by high-capacity wells was queried from Wisconsin's DNR Bureau of Drinking Water & Groundwater's Water Well Data 2003 CD-ROM that contains high-capacity well permits and often its corresponding well log and from Wisconsin DNR website mentioned in the above summary. Location data from this source are provided only by the Private Land Survey System (PLSS) and were converted into the UTM coordinate system. Not every permit included a full description of its location so a default quarter assignment was adopted for wells that have known township, range and section but either one or two of the quarter sections unknown in order to account for its water use. If the quarter-quarter section was not available a default of SW was assigned, meanwhile, if both quarter and quarter-quarter sections were not available then the default NE and SW were assigned, respectively. These location uncertainties are reflected in column 'Location_accuracy' for which a key to determine the accuracy code can be found in the file called "SIR05-5283 Codes".

As mentioned above, there are no current water use laws requiring reporting of non-municipal high capacity water use. All reported pumpage between the 12-year period 1978 -1989 was obtained from the WDNR website (<http://dnr.wi.gov/org/water/dwg/>) and summarized. If the site reported pumpage during this period the overall average rate was applied to reflect current conditions. If no water use data were provided by the data sources, a default water use amount based on the site's classification type was applied. The default water use was only needed for 2 of the 7 water use classification types: HiCap-CII and HiCap-Irrigation. Water use assigned to the commercial, industrial, power generation and institutional uses category was analyzed but no pattern in reported pumpage could be determined; therefore, a default minimum high-capacity water use rate of 2.8 MGY was assumed. On the other hand, an estimated water use value for irrigation was determined from the reported pumpage of 31 irrigation sites. The 12-year period average for these sites was close to 12 MGY. This value was assumed to be the current discharge rate for each irrigation well without water-use records.