

Data Management Protocol for the Minnesota Pollution Control Agency's Ambient Groundwater Monitoring Network



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Abbreviations and acronyms

American Society for Testing and Materials	ASTM
Contaminants of Emerging Concern	CEC
Chain of Custody	COC
County Well Index	CWI
Minnesota Department of Natural Resources	DNR
Environmental Data Access	EDA
Electronic Data Deliverable	EDD
EQuIS Data Gathering Engine	EDGE
EQuIS Data Processor	EDP
U.S. Environmental Protection Agency	EPA
EQuIS	EQuIS
Minnesota Department of Agriculture	MDA
Minnesota Department of Health	MDH
Minnesota Geological Survey	MGS
Minnesota	MN
Minnesota Information Technology Services	MNIT
Minnesota Pollution Control Agency	MPCA
Portable Document Format	PDF
Public Land Survey System	PLSS
Quality Assurance	QA
Sample Planning Module	SPM
United States Geological Survey	USGS
Water Quality Exchange	WQX

Executive summary

The Minnesota Pollution Control Agency (MPCA) monitors its Ambient Groundwater Monitoring Network each year to evaluate the current condition of the state's groundwater and track any trends in contamination. This report describes how the agency manages this information in accordance with the requirements of Minnesota State law. Good data management allows MPCA staff to promptly analyze and interpret the data they collect and quickly make it available to the public. The MPCA manages the information from its Ambient Groundwater Monitoring Network throughout its lifecycle from the initial installation of each well until the collection of the last sample from it. This report documents how MPCA staff manage and verify the field and laboratory groundwater data in its water-quality database as well as describes how written documents, such as access agreements for well sites and written laboratory reports are managed in the agency's electronic filing system.

Introduction

The Minnesota Pollution Control Agency (MPCA) maintains an Ambient Groundwater Monitoring Network to evaluate the occurrence of non-agricultural chemicals in groundwater and quantify how the concentrations of these chemicals change over time. The agency began building this network in 2004 and added over 100 new monitoring wells to it from 2009-2016. The network currently (2017) consists of 266 wells that MPCA staff sample annually; 210 dedicated to monitoring, 53 to domestic purposes, and three public water supply wells. The wells generally are shallow and located in urban areas, completed in aquifer systems that are naturally susceptible to contamination (Figure 1).

MPCA staff collect water samples annually from each of the network wells, and these samples are routinely analyzed for over 100 different chemicals. This includes nutrients, major ions, volatile organic compounds, and trace metals, as well as field measurements of water pH, specific conductance, dissolved oxygen concentrations, and water temperature. Each year the MPCA also samples a subset of the wells to determine the presence of over 100 contaminants of emerging concern (CEC) and pesticides. MPCA staff collect CEC samples from about 40 of the network wells each year and also collect 20 pesticide samples annually in collaboration with the Minnesota Department of Agriculture (MDA).

Purpose and scope

This report describes the data management associated with the MPCA's Ambient Groundwater Monitoring Network. It explains how MPCA staff manage the: 1) field and laboratory data collected for this network as well as the legal agreements that allow the agency to install wells on properties and 2) documents that describe the well construction and development.

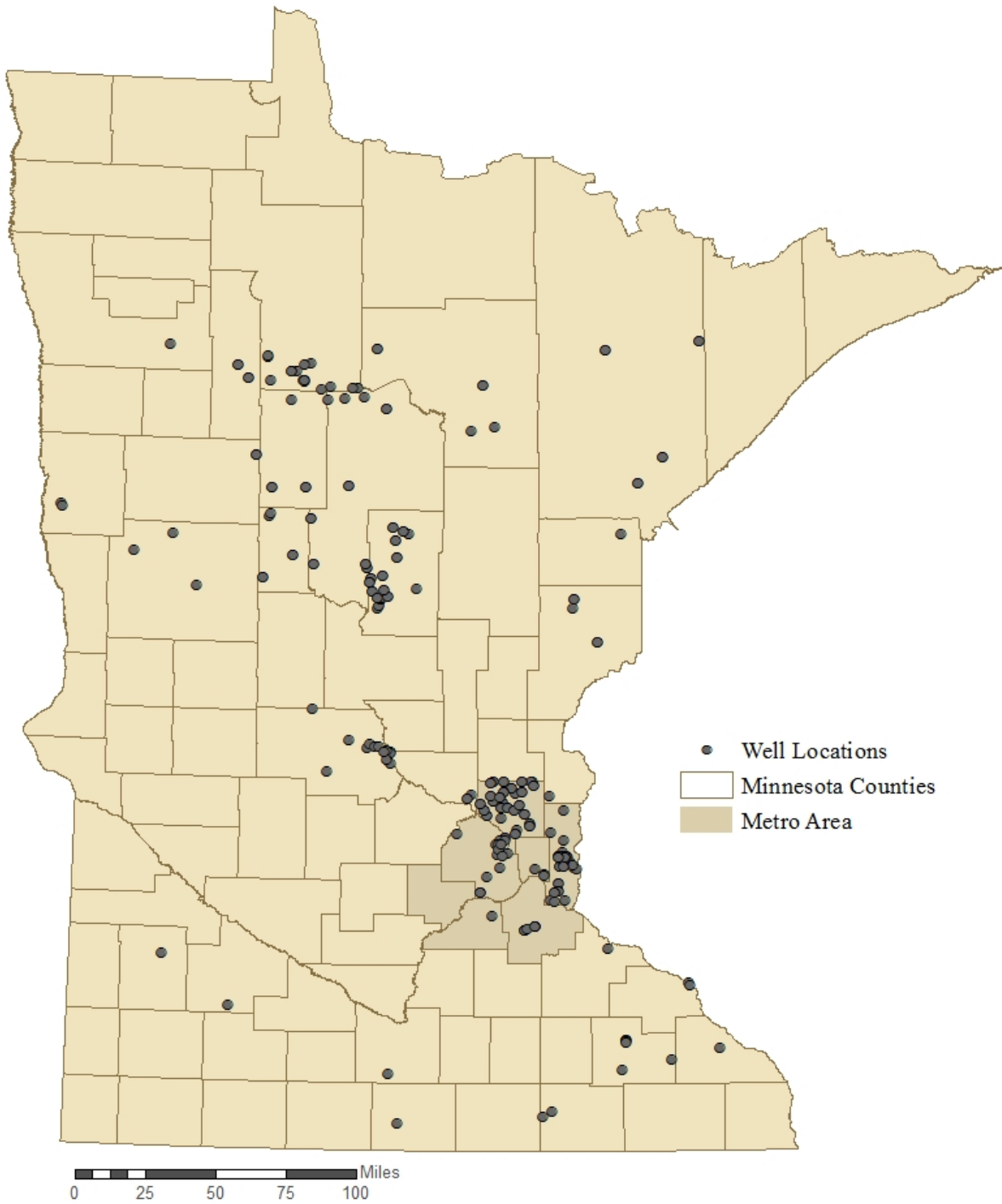


Figure 1. Locations of wells in the Minnesota Pollution Control Agency's Ambient Groundwater Monitoring Network, 2017

Roles and responsibilities

The MPCA and MNIT staff share the data management responsibilities for the Ambient Groundwater Monitoring Network. MPCA staff actively collect water samples and other field data for the network and ensure that this information are accurately entered into its water-quality data management system. MNIT staff provide information technology services to the MPCA, which includes building, maintaining, and securing the agency's water-quality data management system. The following sections describe the roles and responsibilities of the key staff associated with data management for the MPCA's Ambient Groundwater Monitoring Network.

MPCA groundwater monitoring staff

The MPCA groundwater monitoring staff are responsible for: 1) ensuring site locations and required metadata are entered into its water-quality data management system, 2) accurately recording field information, 3) accurately completing the Chain of Custody (COC) forms that are submitted to the laboratory along with the samples, and 4) ensuring all collected field and sample information are contained in electronic data deliverables (EDDs) and are entered into the agency's water-quality data management system.

MPCA data management staff

The MPCA data management staff are responsible for: 1) loading laboratory EDDs into the agency's data management system, 2) ensuring all water-quality data are stored in the database according to the MPCA's business practices, and 3) maintaining the MPCA's contract with the data management system's software vendor.

MPCA quality assurance staff

The MPCA quality assurance (QA) staff are responsible for: 1) maintaining contracts with state and commercial laboratories including requirements for them to provide data in electronic formats that integrate with the agency's data management system, 2) performing laboratory audits, and 3) providing basic quality assurance training to agency staff.

MNIT staff

MNIT staff are responsible for: 1) maintaining the MPCA's water-quality data management system and the computer systems that house this database and the associated software and 2) routinely migrating data to the U.S. Environmental Protection Agency's (EPA) Water Quality Exchange or WOQX.

Data management

The MPCA manages the information generated as part of its Ambient Groundwater Monitoring Network according to agency policy and Minnesota State law. All government data in the state of Minnesota must be maintained and stored according to a state law called the Minnesota Government Data Practices Act (Minnesota Statutes, section 13). This law requires that the MPCA and all other governmental entities preserve all information related to the agency's activities. The information that must be preserved by the MPCA's Ambient Groundwater Monitoring Network includes: 1) field notes

and sheets prepared by the agency's groundwater monitoring staff that contain measurements of water temperature, pH, specific conductance, and dissolved oxygen concentration taken from the network wells, 2) analytical results submitted to the agency in an electronic format by the contracted laboratories, 3) written laboratory reports that further describe the analytical laboratory results and include other sample-related information, such as the COC and Sample Condition Upon Receipt Forms, and 4) access agreements for groundwater monitoring sites with federal, state, and local units of government as well as private parties.

Electronic data management systems

Two electronic data management systems are used to store and manage the electronic data and reports associated with the Ambient Groundwater Monitoring Network. MPCA staff use the EQuIS data management system to store and manage the water-quality data collected from each sampling event. Reports and other program documents are electronically stored and managed using an electronic filing system called OnBase.

EQuIS

EQuIS is a commercial data management system that the MPCA uses to store environmental field measurements and laboratory analyses. This system is comprised of a database and a set of software that allow users to load, edit, download, and visualize the stored data.

An Oracle Database Server currently (2017) houses the MPCA's EQuIS database. The schema or set of related tables that make up the database is comprised of over 150 tables, including both data and reference tables. The data tables contain the information collected during each field trip or sampling event. The reference tables contain lists of valid values such as chemical names or unit values used to maintain consistency in the database. The MPCA's EQuIS schema also includes a set of tables designed to facilitate sending the agency's ambient ground and surface water information to the EPA's WQX system.

The information in the MPCA's EQuIS database is split among several hundred facilities. "Facility" is an EQuIS database term that corresponds to an area of interest or a group of locations. Users also are assigned read and write access to EQuIS databases by facility. In the MPCA's EQuIS database, each facility corresponds to either a statewide program or an individual solid waste or remediation site. This structure permits only selected agency staff to have write access to the database.

The water-quality data collected by the MPCA's Ambient Groundwater Monitoring Network is contained in the "Minnesota Pollution Control Agency – Ambient Groundwater" facility. Other ambient groundwater data also are contained within this facility. One large notable set of historical ambient groundwater data in this facility is from the agency's Groundwater Monitoring and Assessment Program. The MPCA maintained this groundwater monitoring program primarily in the 1990s and sampled over 1,000 wells for it. The "Minnesota Pollution Control Agency – Ambient Groundwater" facility also contains information from several special studies that typically assessed the effectiveness of various best management practices on groundwater quality.

The MPCA differentiates the data associated with all of the various projects in the "Minnesota Pollution Control Agency – Ambient Groundwater" facility through the use of a field called the project task code (also referred to in the database tables as Task_Code_2). The database users can use this code to retrieve data by specific monitoring projects (Table 1). The data from the agency's Ambient Groundwater Monitoring Network is stored under a project task code of "PRJ07229."

Table 1. Project task codes in the MPCA’s EQiS “Minnesota Pollution Control Agency – Ambient Groundwater” facility

PROJECT TASK CODE	DESCRIPTION
PRJ07229	Ambient Ground Water Monitoring Network
PRJ00084	Ground Water Monitoring and Assessment Program
PRJ04245	Iron/Manganese in GW Pumpout Water
PRJ04248	Bailey Lake Stormwater Infiltration Monitoring
PRJ07082	Sentinel Lakes Monitoring Project
PRJ07181	Deer Creek and Pokegama Lakes: A Diagnostic Study
PRJ07265	PCA Special Studies: wells or springs in MN ag areas
PRJ07273	PCA Special Studies: wells in MN urban areas
PRJ07855	Shoreview Pervious Pavement – Stormwater
PRJ07856	Perham Feedlot Site
PRJ07926	Southeast Minnesota Domestic Well Network
PRJ07989	Evaluating CECs in GW at Wastewater Land Application Sites

A team consisting of both MNIT and MPCA staff administer and manage the MPCA’s EQiS data management system. One MNIT staff person serves as the EQiS database administrator. Besides maintaining all of the software and tables associated with this data management system, the EQiS database administrator also routinely performs a series of routine maintenance checks on the system to ensure data integrity and sends ambient surface and groundwater data that were reviewed and flagged with an approval code of “Final” by MPCA staff to the EPA’s WQX system. One MPCA staff person serves as the EQiS project manager. The EQiS project manager interacts with MPCA management, staff, and external partners on a variety of EQiS database related issues. This includes providing support to the data management system users, prioritizing system enhancements, and working with MPCA contracted laboratories and the software vendor to provide data to the agency in an EQiS EDD or “EQiS-ready” format. A team comprised strictly of MPCA staff works with the project manager to manage the information in EQiS. This includes loading new data into the system, performing database retrievals, assigning new users to the system and providing user assistance.

MPCA staff typically do not import and retrieve the information stored in the EQiS database directly, but access and load data to it through several programs, including EQiS Professional, Enterprise, Data Processor, Sample Planning Module (SPM), EQiS Data Gathering Engine (EDGE), and EQiS for ArcGIS. The EQiS Professional software allows advanced users to edit the reference and data tables, load new data, create customized data retrievals, and visualize the stored information. EQiS Enterprise is web-based software that also allows users to retrieve and load data. Plus, users can develop dashboards that allow other less experienced staff to visualize and export information from the EQiS database. There are distinct differences between the EQiS Professional and Enterprise programs. The EQiS Professional software is more powerful compared to EQiS Enterprise, but the MPCA has limited licenses available for the EQiS Enterprise software. An unlimited number of staff can access the EQiS Enterprise software. The SPM and EDGE programs are used together to plan and collect data during sampling events. The SPM software allows users to develop sampling plans used to track progress and prepopulate COC forms for the laboratory. The MPCA field staff use the EDGE software to record information collected during individual sampling events.

Controlling user privilege settings is one way that the MPCA maintains the data quality in its EQulS database. The user privileges control which staff can enter, change, or delete data from EQulS. The EQulS database administrator, project manager, and database team assign the user privileges to all MPCA staff. Data editing privileges in each EQulS facility typically are restricted to the program staff, database administrator, project manager, and database team. Editing of the reference tables is even more restricted and is limited to just the database administrator, project manager, and database team. Each of the agency's data coordinators (the lead data management staff from each agency program that stores data in EQulS) approve all reference table changes prior to implementation.

The MPCA structured its EQulS data management system so the data meets the agency's business requirements. The database requires that: 1) all locations have coordinates, 2) the user must populate selected site and sample-related information before data can be imported, 3) the database does not permit entry of the duplicate data, and 4) analytes are classified using specific agency defined identifiers that are listed in reference tables. EQulS enforces these requirements when data is imported using the data management system's default error checking module. This software forces the user to correct all discovered errors before importing the data into the database. In addition, the EQulS database administrator also routinely runs a series of reports that capture anything that escaped these error checks or resulted from manual editing of the tables in the database (which is not encouraged).

OnBase

OnBase is a commercial data management system used by the MPCA to manage and store documents. In this database, documents are stored in their native format such as Microsoft Word or PDF. The MPCA scans physical paper documents and converts them into an image file before importing them into the system. The MPCA classifies all files in OnBase according to an agency-defined classification system, and these are indexed by document type, date, and a set of keywords supplied by the user.

The MPCA's Ambient Groundwater Monitoring Program uses OnBase to store key documents that are essential for operating and maintaining the network. These documents include: 1) access agreements and leases to place MPCA-owned monitoring wells on property owned by other entities such as federal, state, or local units of government or private parties, 2) field notes taken during sampling events, 3) laboratory reports and electronic data files such as spreadsheets, and 4) reports published by the program. All of these documents are stored according to the program's recordkeeping plan (Minnesota Pollution Control Agency, 2016).

Data management for the ambient groundwater monitoring network

The MPCA manages all of the information associated with the Ambient Groundwater Monitoring Network to ensure that it is complete and accurate. This includes ensuring that sufficient metadata about the sites is stored, along with the water level and water-quality measurements. In addition, the agency has procedures in place to minimize data entry errors, and verify and approve the information stored in it.

Location, construction, and lithology data

The MPCA maintains information about each network well's location, construction, and lithology. This information is essential for the agency staff to properly interpret the data. For example, to meet the network's goal of assessing temporal trends in groundwater quality, the field staff must sample the identical wells each year. To meet this goal, the MPCA has procedures in place to ensure that staff

sample the correct wells for the Ambient Groundwater Monitoring Network each year and properly identify them in the EQulS database.

The MPCA staff use field folders that contain site information to ensure they sample the same wells each year. Each field folder contains a photographic log of the site as well as driving directions and a detailed site sketch showing its location relative to roads and land features. This is especially important for old wells because these are more difficult to identify in the field. A tag placed on each registered well that lists the Minnesota Unique Number is the best well identifier. The Minnesota Department of Health (MDH) has assigned this identifier to all wells drilled in the state since 1972 and a substantial number of pre-1972 wells. However, MPCA staff cannot always use the Minnesota Unique Well number to differentiate wells during sampling events because the state did not require wells to have well tags placed on them until 1992. Alternatively, some monitoring programs have used property owner information to identify wells. This information, however, is not always reliable to identify wells because it can change over time and some owners have multiple properties.

To minimize the occurrence of misidentified wells (described further in the subsequent sections of this report), MPCA policy requires that the staff enter the site location information into its EQulS database before any other data can be stored, such as water levels, field measurements, or laboratory analyses. This requirement helps point out wells whose identifiers were incorrectly recorded on the COC forms submitted to the laboratory. The database itself also enforces this requirement, and the users cannot enter any field or laboratory measurements into it if there is no site information present. At a minimum, the MPCA staff must store the well's identifier (usually the Minnesota Unique Well Number), coordinates (in latitude/longitude), and well type (i.e. monitoring or non-public water supply) in the water-quality database.

The MPCA's database also includes tables that store many other well attributes other than location. This includes the: 1) well construction, 2) lithology, 3) land surface elevation information, 4) county and basin in which the well is located, 5) drilled depth of the well, 6) aquifer, 7) installation date, 8) disinfection status, 9) drilling method, and 10) driller's log. The MPCA's database administrator imports most of this information into the EQulS database from another one called the County Well Index (CWI), which is the master database of well records in the state. The MPCA staff use geographic information from the DNR to determine the major and minor surface water drainage basin in which each network well is located. The MPCA staff also enter some additional information about any newly installed wells for the network into the MPCA's EQulS database, including the well construction, the geologist's soil boring log (classified using the ASTM convention), and top of casing elevation. The MPCA staff enters this information into EQulS by preparing an EDD from the information in the report written by the consultant hired by the agency to oversee the well installation.

The MPCA obtains the location for its wells from several sources. For the wells that were newly installed for the network (2010 to the present), the horizontal coordinates were taken using a field GPS unit by the consultant hired by the MPCA to oversee the well installation. For the existing wells in the network, the MPCA obtained the coordinates from the CWI, USGS, or historical agency records.

The CWI is the source of much of the well information stored in EQulS. The Minnesota Geological Survey (MGS) and MDH jointly maintain this database, which contains the most comprehensive information about wells installed in Minnesota including their location, construction, use, and status. The MDH and MGS provide the well's coordinates in CWI in the Universal Transverse Mercator (UTM) projection if MGS, MDH, or DNR staff verified the well's location. The MPCA staff first convert these UTM coordinates into latitude and longitude before entering them into their database. The CWI also contains the well and boring construction record if the driller submitted the documentation to the MDH. This is the driller's log of the geologic materials and well construction data. MGS geologists reinterpret these logs on a

county-by-county basis, as part of an on-going effort to develop geologic atlases for each county in the state. Data on old wells generally is more limited in the CWI because the drillers were not required to report water well records to the state until 1974. Furthermore, enforcement of this standard was lax until about 1990 (J. Blum, personal communication).

The MDH and MGS maintain the CWI's data quality by limiting the ability to store and edit information in the database and conducting detailed well inventories before adding new information into the system. Currently, only MDH and MGS staff can store and edit data in CWI. All other users of the database have read-only access to the information. MDH and MGS staff enter the information associated with newly installed wells into the database using the Minnesota Unique Well Number as the primary identifier. MDH staff also assign Minnesota Unique Numbers to pre-1972 wells located during routine investigations if it has associated downhole information such as a driller's log. However, before the MDH and MGS staff add any new well information to the CWI, they first thoroughly review the information associated with it, especially for the pre-1972 wells, to ensure that they do not duplicate the same well in the database. This review includes comparing the well diameter to the one listed on the well record (if it is available), verifying with the property owner that the well exists on that property, and verifying the well location by property address, property owner, name on the mailbox, or site plan.

Sampling plans

Sampling plans also are an integral part of the data management process for the MPCA's Ambient Groundwater Monitoring Network. These plans are prepared to delegate the sampling work among the field staff and track data entry into its water-quality database. The staff develop these plans before the annual sampling of the network using the EQuIS SPM software. Each annual sampling plan includes the: 1) wells scheduled for sampling, 2) field staff designated to sample each well, 3) proposed sampling date, 4) laboratory contracts associated with the network, and 5) field and laboratory methods associated with the sampling. The software also includes several reports that help the staff prepare for sampling by listing the laboratory analyses scheduled for each site and the number and types of bottles required for it. In addition, the software also has reports that the MPCA staff use to track whether all of the data planned for each well was entered into the agency's EQuIS database.

Another key feature of the sampling plan is that the information contained in it is outputted into EDD templates which simplifies data entry and minimizes errors on the laboratory COC forms and field data EDDs. An EDD template is a file that can be imported into the EQuIS EDGE software that the MPCA uses for field data entry (described further in the next section) and contains all of the information that was provided in the sampling plan. This simplifies field data entry because the staff only need to enter the sampling event specific information, such as the sampling date and time, weather conditions during sampling, and the field measurements. The use of the EDD template greatly simplifies the completion of the field EDD and COC forms which are prepared using EDGE software and reduces errors in several ways. For example, when the MPCA field staff use the EDD template they need only to select the identifier for the sampled well from a specified list rather than manually enter this information which reduces transcription errors. It is also much easier for MPCA staff to accurately complete the laboratory COC form when they use the EDGE software in conjunction with an EDD template because the software by default only shows the truncated list of laboratory analytes and analytical methods that are planned for the project rather than the numerous selections available in the MPCA's database.

Field data recording and storage

The MPCA Ambient Groundwater Monitoring Network staff use both field notebooks and the EQuIS EDGE software to record field data, enter it into the agency's water-quality database, and prepare laboratory COC forms. The EDGE software contains a GUI-based interface in which MPCA staff enters the information collected during field-sampling events. Behind the scenes, the software formats the entered information into an EDD that the MPCA staff import into its EQuIS database. As mentioned in the previous section, the MPCA staff also use the SPM software to produce an EDD template that simplifies field data entry in EDGE and the completion of the COC forms. The MPCA's use of the EDGE software also minimizes data entry errors because a substantial number of the required fields can be completed using drop-down menus instead of entering the information manually. In addition, the MPCA set up the EDGE software to automatically populate many other key fields with the correct information including the sampling method, project code, and sampled medium.

The EDGE software also contains error checking to ensure the recorded data are of the highest quality and meets the MPCA's technical and business requirements. The software requires the MPCA staff to record this information for each sampling event: 1) the well identifier which is the Minnesota Unique Well Number, 2) sampled medium (e.g. water or air), 3) sampled matrix (e.g. groundwater or surface water), 4) sample type (e.g. routine environmental sample, replicate sample, or trip blank), 5) sample date and time, 6) sampler, 7) sampling method, and 8) project task code or identifier (e.g. PRJ07229). The EDGE software returns an alert or error if any of these fields are not completed or if an incorrect value is used. In addition, the software performs several routine calculations associated with groundwater sampling, including calculating the water level elevation, purge volume, and stabilization checks for the field parameters. The program also highlights when: 1) field measurements made during well purging that have stabilized and 2) out of range field measurements such as water temperatures over 40 degrees Celsius.

MPCA monitoring staff typically import the field data into the EQuIS database as soon as possible after the sampling event. There are several steps involved with importing these field EDDs into EQuIS. First, the staff process the completed field EDD using the "EDP Export" function in the EDGE program. This step formats the field EDD into a .ZIP file comprised of several text files; this is the required EDD format to import the data into the agency's EQuIS database using the web-based EQuIS Enterprise program. In addition, the "EDP Export" function only marks the last field measurement is marked as "reportable" in the MPCA's EQuIS database. This is notable because the primary reports used by the users of the MPCA's EQuIS database by default only retrieve data marked as "reportable." Data that is marked as "not reportable" in the MPCA's EQuIS database include the purge measurements associated with groundwater sampling, surrogate compounds analyzed by the contract laboratories, and data that was reviewed and rejected. After the "EDP Export" step is completed, the staff import the resulting file into the EQuIS database using a program called EQuIS EDP (EQuIS Data Processor). The EDD undergoes a second round of error checking during this step to assure the data meets the MPCA's business requirements before it is uploaded into the database. These error checks include: 1) verifying that the well identifiers already are present in the database and 2) informing the user if the data already are present in the database. The MPCA staff are required by the EQuIS data management software to correct any errors identified by the EDP program before the information is accepted into the database.

Laboratory data storage

There also are procedures in place to ensure that MPCA staff enter high-quality analytical laboratory data into its EQuIS database. Much of this focuses on training MPCA staff to properly complete the

laboratory COC form and requiring the laboratories to provide data to the agency in an “EQuIS-ready” format.

Filling out the laboratory COC form is a key step to ensure that groundwater data imports smoothly into the agency’s EQuIS database. The COC form conveys all of the information the laboratory needs to analyze the sample and report the data back to the agency as an EQuIS EDD that readily imports into its water-quality database. The information on the COC form includes the analyses that the laboratory will perform plus the EQuIS facility and project task codes.

The MPCA groundwater monitoring staff also use the EDGE software in conjunction with SPM to prepare COC forms with minimal errors. MPCA staff must completely fill out the COC form in order for the laboratory to prepare an EQuIS-ready EDD. Incomplete COC forms are the main reason why the laboratories do not produce error-free EDDs. It also takes longer for the data management staff to import EDDs with errors into EQuIS because the data management staff first must edit them to correct the problems. The Ambient Groundwater Monitoring staff’s use of the EDGE program circumvents most of these problems. With the EDGE EDD template, the user only selects from the anticipated wells and lists of the chemical analyses assigned to the project, rather than entering these manually or sorting through the hundreds of available chemical analyses present in the EQuIS database. The use of the EDGE software also prepopulates several pieces of the project-specific information on the COC form, such as the project manager and contact information, project name, billing code, and turnaround time. Preparing the field EDD and laboratory COC form using the EDGE software also ensures that the laboratory data properly merge with other sample-related data that are stored in EQuIS before the laboratory data are received, such as sampling weather conditions or sampling method.

The MDH Environmental laboratory is the primary lab used by the Ambient Groundwater Monitoring Network to provide analytical data. This laboratory provides information to the MPCA as both an electronic report and as an EQuIS EDD from its laboratory information management system (LIMS), as is required by the interagency agreement between the MPCA and the MDH laboratory. The electronic laboratory report is stored in OnBase as previously described, and the EQuIS database team imports the laboratory EDD into the EQuIS database. Similar to the field data storage, the EQuIS database team first uses the EQuIS EDP software to check the laboratory EDD for any errors. If any are found, the MPCA Ambient Groundwater Monitoring staff, EQuIS database team, and MDH laboratory work together to resolve the errors. Typically, these are very few.

SGS AXYS Analytical Labs is another lab that provides analytical data to the MPCA. This laboratory is located in British Columbia, Canada, and analyzes CEC samples including antibiotics, medications, DEET and bisphenol A. This laboratory does not currently provide these data to the MPCA in the form of an “EQuIS-ready” EDD. Currently, these data are imported into a MicroSoft Access database, and an in-house program is used to transform this information into an EQuIS EDD that can be entered into the agency’s database.

Sample tracking

The MPCA groundwater staff use the electronic sampling plans developed using the EQuIS SPM software to track the entry of all of the scheduled data into the agency’s water-quality database. The staff tracks the data by running a SPM Completeness Report from EQuIS Professional or Enterprise. The completeness report lists all of the scheduled sampling tasks for the network, summarizes the percentage of completed tasks, and specifically lists which, if any, wells are missing water level, field measurement data such as water temperature and specific conductance, or laboratory analytical data. MPCA staff periodically review the SPM completeness report for any missing data. If the staff finds any

missing data, they either import the missing field EDDs into the database or work with the MPCA database team to process any missing laboratory EDDs.

Data verification

The MPCA groundwater monitoring staff must verify whether the field and laboratory information initially entered into the water-quality database is accurate before they disseminate this information to the public. The staff do this by following a written data verification procedure. After this is complete, the groundwater monitoring staff change the approval codes in the agency's water-quality database (if approved this is set to "Final"). This is a key step because the approval code controls how this information is disseminated to others (discussed further in the Data Dissemination section of this report).

As part of the data verification process, the MPCA groundwater monitoring staff reviews the COC forms before submitting them to the laboratory. This ensures that the forms do not contain any incorrect information such as well identifiers or sampling dates. These types of errors usually result from a typographical error. The MPCA staff correct any errors before the COC form is sent to the laboratory.

The groundwater monitoring staff also review the written analytical reports from the contracted laboratory(ies) to ensure that no typographical errors are present in them, the quality control data associated with the chemical analysis is within the established limits, and evaluate any data that does not conform to these criteria. Typographical errors occasionally occur in the laboratory reports because their current process (2017) is to have the staff transcribe the information about the samples contained on the COC form into their LIMS by hand. The written reports received from the analytical laboratory(ies) contain a summary of the samples received, a copy of the original COC form, a Sample Condition Upon Receipt Form, and the QA results which usually include a method blank, laboratory control sample, matrix spike samples, and duplicates. Organic chemistry results, such as volatile organic compounds or CECs, also contain surrogate recovery information. The MPCA monitoring staff compares the summary of samples received in the laboratory report to the submitted COC form to ensure that all of the sample information, including well identifiers and sampling dates, match. If the MPCA staff notice any discrepancies during this review, the MPCA and the laboratory both make the corrections in the laboratory's LIMS and MPCA's water-quality database. It is important to update both databases with any changes. In some rare instances, the laboratory makes a correction to their data and reissues the information to the MPCA. Sometimes these data reissuances can occur years after the original sample collection date, and the reissued data readily import much smoother into the EQUIS database when there are no discrepancies between the agency's database and the laboratory's LIMS. The MPCA monitoring staff also reviews the quality control data contained in the report to ensure they meet the acceptance criteria. This review includes ensuring that any data that does not conform to these criteria are qualified appropriately.

In the last step of the data verification process, the MPCA monitoring staff compare the field and laboratory data to any prior measurements collected from the well. The staff use a script developed using the statistical package R to make these comparisons. This script runs beneath a graphical user interface and outputs summary statistics and plots to identify any chemicals that have concentrations outside of the normal range expected for the site (outliers). If the MPCA staff notice any outliers in this review, they then examine the analytical data associated with the entire batch of the chemicals analyzed with the outlier. The staff do this to determine the source of the suspect value. The outlying value could result from a bottle switch in the field or laboratory. In rare instances, the laboratory inadvertently does not apply a dilution factor when performing calculations. The MPCA monitoring staff work with the laboratory to correct any of these errors if they are identified. In these cases, the laboratory issues an

amended data report and laboratory EDD to the MPCA. To date, data verification reviews by the MPCA have not found any errors resulting from bottle switches. In the event that a bottle switch was found, the data would be set with an approval code of "Rejected" unless other supporting information from the field or laboratory justify changing information.

Laboratory audits

Staff from the MPCA's Environmental Data Quality Unit audits the data packages completed for the agency's Ambient Groundwater Monitoring Network. These audits currently focus on the CEC data packages, but these QA/QC efforts also can include reviews of project or program data quality objectives, contract compliance, and laboratory quality assurance project plans. The MPCA uses these audits to detect deficiencies requiring specific program or laboratory corrective actions, and are crucial to verifying that MPCA staff and contractors follow all required protocols. The probability of errors, undetected problems, and compromised data quality objectives increase enhancing the need to re-sample or redesign the program when the MPCA does not conduct audits. Unresolved errors may corrupt datasets and render data useless.

If the MPCA finds any irregularities during the data package audits, the agency may require an explanatory narrative that fully discusses sample results and the problems encountered followed by a corrective action. These data audits will require the laboratory to submit a variety of information such as instrument printouts, chromatograms, raw data, sample calculations, complete project/COC records, detection limits for current instrument studies, documentation for the preparation, analyses, and reporting of the sample data, all of the laboratory's internal QC information, and documentation on source and tracking of standards. The MPCA staff use these data to verify that the data reported is meeting the quality criteria stated in the laboratory's Quality Assurance Manual and Standard Operating Procedures.

Data dissemination

The approved information from the MPCA's Ambient Groundwater Monitoring Network is available to all staff in the agency, as well as the public. The data is available to all agency staff through either the EQuIS Enterprise or EQuIS Professional programs. By default, the most-commonly used EQuIS reports retrieve water-quality data that the MPCA staff set with an approval code of "Final" in the database. The MPCA also disseminates approved data to the public online through the MPCA's Environmental Data Access (EDA) Portal and the EPA's WQX. In the EDA portal, the user can download the information, view it in a tabular format, or display it on a map. While viewing in tabular form in EDA, the user can filter the results by the station identifier, name, purpose, and/or type as well as specify a start date, analyte group, geographic type or a specific area within the chosen geographic type. In the map view there is the option to display groundwater stations, and drinking water supply management areas, as well as boundaries for cities, townships, public land survey system (PLSS), zip code, MN districts (i.e. house, and senate), counties, and watersheds. There is also the option while viewing the map display of the data to use tools such as zoom, pan, search, draw, measure, print, retrieve the coordinates of a location, and change the base map.

These two data portals are available online from either the MPCA or EPA at:

<https://www.pca.state.mn.us/environmental-data>

<https://www.epa.gov/waterdata/storage-and-retrieval-and-water-quality-exchange>

MPCA policies and memorandums

Agency policy and state law governs the management of the data from the MPCA's Ambient Groundwater Monitoring Network. Some of the key data management policy documents and statutes are listed below.

Minnesota Data Practices Act. 13 Minnesota Statutes (2017).

Minnesota Pollution Control Agency. *Record Retention Schedule* (2010).

Minnesota Pollution Control Agency. *Administrative Policy: Not Public Data Protection*. (2016).

Minnesota Pollution Control Agency. *Administrative Policy: Records and Data Management*. (2016).

Minnesota Pollution Control Agency. *Ambient Groundwater Monitoring Network Recordkeeping Procedures* (2016).