Minnesota Department of Agriculture
Groundwater Monitoring Program

Field Data and Sample Collection

Standard Operating Procedures (SOP)

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Foreword
The Minnesota Department of Agriculture (MDA) staff and its cooperator’s should follow the Standard Operating Procedures (SOP) outlined in this manual. This SOP will be updated on an as needed basis and it should be used to complete activities defined in the MDA Ground Water Design Document, and annual work plans. MDA staff should be consulted with any questions regarding this SOP
Acronyms and Abbreviations

C      Celsius
DI     Deionized
EDA    Environmental Data Access
EQuIS  Environmental Quality Information System (Database)
GC-MS/MS Gas Chromatography with Tandem Mass Spectrometry
GLY    Glyphosate
GW     Groundwater
HPLC   High Performance Liquid Chromatography
ID     Identifier
LC-MS/MS Liquid Chromatography with Tandem Mass Spectrometry
MDA    Minnesota Department of Agriculture
MPCA   Minnesota Pollution Control Agency
NAWQA  National Water-Quality Assessment Program
NO3    Nitrate
NO2+NO3 Nitrate + nitrite
QA/QC  Quality assurance/quality control
SOP    Standard Operating Procedure
# Table of Contents

Field Data and Sample Collection ............................................................................................................. 1  
Standard Operating ................................................................................................................................. 1  
Procedures (SOP) ................................................................................................................................. 1  
Foreword ............................................................................................................................................... i  
Acronyms and Abbreviations .................................................................................................................. ii  
Table of Contents ................................................................................................................................... iii  

## SCOPE AND PURPOSE ....................................................................................................................... 4  

1.0 FIELD CONDITION DOCUMENTATION ....................................................................................... 5  
1.1 Field Notes .................................................................................................................................. 5  

2.0 Groundwater Sampling Equipment Cleaning ................................................................................... 5  
2.1 Pre-round and NAWQA Well Cleaning Procedures ........................................................................ 6  
2.2 Field Cleaning Procedures (Non-NAWQA Wells) .......................................................................... 7  

3.0 WATER QUALITY SAMPLING ......................................................................................................... 9  
3.1 Sample Bottle Selection ................................................................................................................ 9  
3.2 Preparing to Sample ..................................................................................................................... 10  
3.3 Well Purging ............................................................................................................................... 11  
3.4 Field Measurements Collected During Purging ............................................................................ 11  
3.5 Purging and Sampling Methods .................................................................................................. 12  

4.0 QUALITY ASSURANCE / QUALITY CONTROL SAMPLING METHODS ............................. 15  
4.1 Field Replicates and Duplicates .................................................................................................. 16  
4.2 Field Blanks ............................................................................................................................... 16  
4.3 Field Equipment Blanks (Pumping) ............................................................................................. 16  
4.4 Field Equipment Blanks (Bailing) ............................................................................................... 17  

5.0 Groundwater Field Numbering of Samples ..................................................................................... 18  

6.0 SAMPLE PROCESSING AND SHIPPING ...................................................................................... 18  
6.1 Sample Preservation .................................................................................................................... 18  
6.2 Sample Chain-of-Custody Log-in Submission Form .................................................................... 19  
6.3 Sample Submission to MDA Laboratory ..................................................................................... 21  
6.4 Cooler Packing Instructions ......................................................................................................... 22
SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) describes the methods followed by the Minnesota Department of Agriculture (MDA) staff and its cooperators for groundwater quality sample collection and management of related data. Adherence to these guidelines will allow for the consistent, efficient, and unbiased collection of scientifically defensible field and water quality data.

Information on the program framework is available in the MDA Groundwater Design Document, and information on the specifics of the individual monitoring locations, monitoring intensity, and laboratory analytical lists are available in the MDA annual work plans. The MDA presents all of the water quality results in an annual Water Quality Monitoring Report. All water quality data is managed in the Environmental Quality Information System (EQuIS) database that is accessible by multiple state agencies and publically accessible on the MPCA Environmental Data Access (EDA) webpage.

The MDA monitoring program uses a variety of methodologies to determine the occurrence and magnitude of pesticides in the waters of Minnesota. This SOP will focus on pesticide monitoring efforts in groundwater.
1.0 FIELD CONDITION DOCUMENTATION

Accurate and complete documentation of field conditions is critical when collecting and validating scientifically defensible data. Field notes should be recorded during or immediately after every field visit. Field notes are considered official and legal documents and so should be clearly legible, descriptive, and maintained according to established record retention schedules. Departure from any of the procedures documented in this SOP must be recorded in the Ground Water Field Log or the Hydrologist’s Field Log.

1.1 Field Notes

Field conditions must be documented when samples are collected to allow for the analysis of results. Field notes are to be recorded on the Ground Water Field Log (Appendix B) or in a bound, write-in-the-rain field book. Field books should be scanned at least monthly during the field season to create an electronic backup copy. On every field visit to a monitoring location, the following information must be recorded. Additional notes should be taken if there are noticeable changes to well, the land around the well or the surrounding land use.

1.1.1 Required Information for Field Notes

- Site ID
- Well Unique Number
- Sample Number
- Date (mm/dd/yyyy)
- Time: Military time (Central Standard Time)
- Static Water Level in well
- Total depth of the well
- Site conditions:
  - wind
  - air temp
  - sky conditions
  - humidity
  - nearby crops
  - whether or not the site is irrigated
  - is the irrigation system is running at the time of the visit
  - other information of note
  - take a picture of site
  - sketch a map on the field log depicting conditions at the site.

2.0 Groundwater Sampling Equipment Cleaning

MDA requires that all sampling equipment be cleaned prior to sampling. Departure from these procedures must be documented on the Ground Water Field Log or the Hydrologist’s Field Notebook. Cleaning will be conducted for each piece of sampling equipment prior to the start of the sampling season and at each sampling site. While cleaning equipment, check that all equipment is in working order and replace or repair worn or damaged equipment.
Supplies needed:

- non-phosphate soap
- de-ionized (DI) or distilled water
- methanol
- cleaning brushes (plastic) or cloths (disposable) as needed
- cleaning basin (plastic, stainless steel or glass)
- Nitrile gloves
- aluminum foil
- Kimwipes or equivalent

2.1 Pre-round and NAWQA Well Cleaning Procedures

The following cleaning procedure should take place in the office prior to the start of the sampling season and before sampling at each NAWQA well. (adapted from Chapter 3 National Field Manual for the Collection of Water-Quality Data, Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, United States Geological Survey). This cleaning procedure should be completed for all sampling equipment with the exception of the portable pH/Conductivity meters. The peristaltic pump should be wiped down and not immersed in the cleaning solutions.

Step 1. Preparation.

a. Prepare a contaminant-free space for the cleaning supplies and for cleaning and drying the sample-collection and sample-processing equipment.

b. Gather the cleaning supplies, the equipment to be cleaned, and clean storage bags or aluminum foil with which to wrap the cleaned equipment.

c. Cover the cleaning area with aluminum foil or clean Kimwipes or equivalent.

d. Put on disposable, powderless nitrile sampling gloves and safety glasses.

e. Prepare the detergent solution, using nonphosphate detergent and DI water. A 0.1- to 0.2-percent (v/v) solution is normally of sufficient strength. Using too much will require excessive rinsing.

f. Clean the items used to clean the equipment. This includes any brushes used and the washbasin.

g. Disassemble bailers (if using a non-disposable bailer) and remove and dispose of the flexible tubing from peristaltic pump.

Step 2. Detergent wash and DI water rinse.

a. Place small equipment parts into washbasin filled with soap/water. Soak equipment in detergent solution for 10 to 30 minutes or as needed.

b. Scrub the exterior and interior of equipment surfaces to the extent possible, using a Kimwipe, firm sponge or soft brush to remove any adhering material such as oil and grease, sediment, algae, or chemical deposits. Pay particular attention to removing material from areas where inorganic or organic materials might be trapped, such as grooves and crevices, O-rings, and nozzles. Rinse re-usable cleaning material thoroughly, dispose of disposable cleaning material.

c. Scrub exterior of the submersible pump. Attach pump to power and run detergent solution through the pump for at least 30 seconds.

d. Rinse equipment thoroughly with DI water to remove detergent residue. If necessary, use a wash bottle to rinse hard-to-reach places.

e. Pump clean DI water through the submersible pump.

f. Equipment rinsing is complete if no detergent bubbles appear when rinse water is agitated.
Step 3. Methanol rinse/wipe.

CAUTION: Use methanol sparingly and work under a fume hood or in a well-ventilated area, away from where an open flame or sparks can occur. Wear safety gloves, glasses, and apron.

Use pesticide-grade methanol. Contain all rinse methanol and any wipes containing methanol in a waste container(s) for disposal at MDA laboratory.

Reminder: methanol is flammable, wipes should be allowed to dry in a well-ventilated area (or outside) before containerizing for MDA lab disposal. Disposal of the methanol waste will be coordinated with appropriate MDA laboratory staff to ensure proper disposal. Methanol waste is not to be disposed of in the regular trash.

Methanol Cleaning steps

a. Change to clean gloves that are chemically resistant to methanol.

b. Place cleaned equipment into clean washbasin.

c. Rinse or wipe equipment exterior and interior with a minimum amount of methanol.

d. Rinse the interior of the pump tubing with methanol.

e. Pump a small amount of methanol through the submersible pump.

f. Place equipment components and tubing on a clean aluminum foil or Kimwipe surface.

g. Place used methanol and methanol containing wipes into an appropriate waste container.

Step 4. Triple rinse equipment with DI/distilled water.

After rinsing, allow all equipment to air dry. Reinstall flexible tubing in peristaltic pumps with new, clean tubing. Cover all equipment with aluminum foil or put in clean (following above procedures) traveling containers.

2.2 Field Cleaning Procedures (Non-NAWQA Wells)

The field cleaning procedures will be conducted after sampling at each well site in the MDA network. All equipment used for sampling at a site will be cleaned per the following procedures. All equipment must be cleaned per the office procedures (as above) before the start of the sampling season. Wells monitored for the NAWQA program should follow the Pre-Round and NAWQA Well Cleaning Procedures (Section 2.1) prior to sampling.

Supplies:

- de-ionized (DI) or distilled water
- aluminum foil or clean carrier for non-disposable bailer

Following sample collection, the sampling equipment (bailer, pumps and/or tubing) should be triple rinsed in DI water.
Replace sampling gloves with new gloves prior to cleaning.

2.2.1 Water Level Indicator

Triple rinse the tape, indicator probe, and reel by allowing the DI water to flow freely over the tape and reel surface.

Air dry and place in clean travel container.

2.2.2 Bailer and bailer wire and reel

**Disposable Bailer**

a. Disconnect the bailer wire from the bailer.
b. Place bailer in trash bag and dispose of properly.

**Bailer wire and reel.**

a. Roll bailer wire onto reel loosely.
b. Triple rinse the wire and reel by allowing the DI water to flow freely over the wire and reel surface.
c. Re-attach bailer wire to bailer.
d. Air dry and place in clean travel container.

**Non-disposable Bailer**

a. Disconnect the bailer wire from the bailer and remove the bailer check valve (bottom piece). Store these in a separate area for cleaning.
b. Triple rinse the bailer body and top piece with DI water. Place in clean container or on clean aluminum foil.
c. If the bailer top contains a lot of sediment, the top may need to be removed and cleaned separately.
d. Triple rinse the bailer check valve (bottom piece) with DI water and re-attach to bailer body.
e. Air dry.
f. Place cleaned bailer in clean travel container or wrap in aluminum foil.

2.2.3 Peristaltic Pump

**Peristaltic pump flexible tubing**

a. Turn pump off and remove downhole tubing. Fill small, clean container with at least 200 mls of DI/distilled water.
b. Place intake end of tubing in small container.
c. Turn pump on and allow water to be pumped through the tubing and out.

**Peristaltic pump housing**

a. Clean (wipe) outside of pump housing with DI water as needed.
b. Store pump in a clean travel container in the sampling vehicle for next site.
2.2.4 Submersible Pump

a. Remove any tubing.
b. Wipe clean exterior of pump housing with outside of pump with DI water.
c. Fill standpipe with DI water and place pump into standpipe.
d. Turn pump on, running clean water through the pump and discharging water outside of the standpipe.
e. Store pump in clean travel container.

2.2.5 Tubing

The MDA uses dedicated sample tubing that remains in the well or uses new tubing at each sample location. Tubing should not be cleaned but should be replaced if necessary. When installing new tubing, care must be taken to ensure that it does not come in contact with a potentially contaminated surface. If it does come in contact, it must be triple rinsed with DI water or not used and replaced with new, clean tubing.

2.2.6 pH/ CONDUCTIVITY METER

After each sample

- Triple rinse the probe with DI water.

Before each sampling round or as needed;

- Follow the probe cleaning directions in the probe manual.

The pH probe should be replaced per the manual recommendations.

3.0 WATER QUALITY SAMPLING

Prepare for sampling by checking equipment needed against that suggested in the Monitoring Well Sampling Equipment Checklist (Appendix A). Ensure all equipment is clean and in good working order.

3.1 Sample Bottle Selection

The appropriate sample bottles must be used for all sample collection events. Each laboratory analysis requires a sample bottle. Table 1 presents the analysis, analysis code, bottle type, bottle size, bottle filling level, preservation, and maximum hold time from collection until extraction for analysis. Sample bottles that are certified quality assured “containment free sample container” should not be rinsed prior to filling. All other sample bottles should be triple rinsed with sample water before filling. All samples should be submitted to the MDA Laboratory within 7 days of collection. A temperature blank, filled with water, must be contained in each cooler sent to the MDA Laboratory.

Pesticide sample bottles (950 mL amber glass) for laboratory analysis involving gas chromatography with tandem mass spectrometry (GC-MS/MS) and liquid chromatography with tandem mass spectrometry (LC-MS/MS) require quality assured, trace clean bottles. All pesticide and nutrient bottles will be single use.
Table 1. Bottle type, preservation method, and holding time by laboratory analysis.

<table>
<thead>
<tr>
<th>Analyte Type</th>
<th>Analyses</th>
<th>Analysis Code</th>
<th>Bottle Type</th>
<th>Bottle Size [mL]</th>
<th>Fill Method</th>
<th>Preservation</th>
<th>Maximum Hold Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticide</td>
<td>GC-MEMS/MS</td>
<td>GC</td>
<td>Amber Glass</td>
<td>950</td>
<td>Full</td>
<td>Refrigerate (0-6°C)</td>
<td>21 days</td>
</tr>
<tr>
<td></td>
<td>LC-MEMS/MS</td>
<td>LC</td>
<td>Amber Glass</td>
<td>950</td>
<td>Full</td>
<td>Refrigerate (0-6°C)</td>
<td>21 days</td>
</tr>
<tr>
<td></td>
<td>Glyphosate</td>
<td>GLY</td>
<td>Centrifuge Tube</td>
<td>40</td>
<td>½ full</td>
<td>Freeze</td>
<td>21 days</td>
</tr>
<tr>
<td>Nutrients/Sediment</td>
<td>Nitrate + Nitrite</td>
<td>NO3+NO2</td>
<td>HDPE</td>
<td>125</td>
<td>¾ full</td>
<td>Freeze</td>
<td>28 days</td>
</tr>
<tr>
<td>Temp Blank</td>
<td>Temperature Blank</td>
<td>Temperature Blank</td>
<td>HDPE</td>
<td>125</td>
<td>Full</td>
<td>Refrigerate (0-6°C)</td>
<td>--</td>
</tr>
</tbody>
</table>

1 Refrigeration (0-6°C)-Temperature requirement is waived if samples are received by the lab on the same day as collected provided samples are shipped on ice.
2 Freeze – It is not necessary to freeze samples if shipped on the date collected and received by the lab within 24 hours provided samples are shipped on ice.

3.2 Preparing to Sample

a. Unload and prepare equipment at the site location for sampling.
   - Ensure that you will be able to keep sampling equipment from becoming contaminated and it is located so that you can work efficiently.
   - Sample bottles should be kept out of the sun and in a safe place, free of potential contamination, until ready to be filled with sample water.

b. Unlock the well.

c. Put on nitrile gloves.

d. Measure the water level in the well. Record water level on field log.

e. Lower the probe to the bottom of the well and take the depth measurement. Record the total depth of the well on the field log.
   - Water level and depth measurements are taken to the top of the inner (PVC) casing. For consistency measure to the mark on the top of the casing. If there is no mark, measure to the north side of the casing.
   - These measurements are used to determine the standing water column in the well and the required purge volume.

f. Any evidence of sediment or unusual conditions within the well should be noted on the field log.
g. Purging volumes (pumping and bailing) calculated for a 2 inch monitoring well are presented in Appendix C.
h. When measurements in a well are completed, the tape and contact meter (probe) must be thoroughly rinsed with clean deionized water as described in Section 2.2.

Nitrile gloves should be changed anytime there is contact with a potentially contaminated surface. It is a good idea to change gloves at any transition point in the procedure (i.e. moving from use of one piece of equipment to another).
3.3 Well Purging

Purging a well before sampling is necessary to ensure that sample water is collected from the aquifer and that any stagnant water in the well and the annular space has been removed. All wells must be purged before sampling.

Purging requires removing between 3 and 5 casing volumes (CV) from the well. The casing volume = standing water column * \( \pi \) * casing radius squared.

**Purging Calculation Example**

\[
\text{SWL} = 548 \text{ cm} \\
\text{Depth} = 820 \text{ cm} \\
\text{Water column} = 272 \text{ cm} \\
\text{CV} = \pi \times (272 \text{ cm}) \times (2.54 \text{ cm})^2 = 5,510 \text{ cm}^3 (\text{ml}) \\
3 \text{ CV} = 16,530 \text{ ml} \\
\text{Pumping Rate} = 550 \text{ ml/min} \\
\text{Required time to purge to 3 CVs} = 16,530 \text{ ml/550 ml/min} = 30 \text{ min} \\
\text{Stability readings at: } 0.6 \times (5,510 \text{ ml/550 ml/min}) = \text{every 6 min} \\
\text{Alternatively; to achieve five stability readings at 3 CV} = 30 \text{ min/5= every 6 min} \\
\]

The volume of a cylinder is \( \pi \times r^2 \times h \) (where \( r \) is radius of pipe and \( h \) is water column length)

Round up to whole numbers to be conservative in achieving required purging

Purging volumes (pumping and bailing) calculated for a 2 inch monitoring well are found in Appendix C.

Purging is complete when more than 3 CVs have been evacuated and temperature, pH, and conductivity are stable.

3.4 Field Measurements Collected During Purging

During the purging process, stability readings of temperature, pH and conductivity are taken at regular intervals and recorded on the field log. Stability readings provide reliable indicators that the stagnant water has been replaced by water from the aquifer.

a. The stability reading interval is approximately 0.6 of a casing volume. The period of time between stability readings is calculated by multiplying the pumping rate by 0.6 of the casing volume.

b. Stability readings are collected by directing the discharge water into a Styrofoam cup and measuring temperature, pH and conductivity.

c. Stability readings are taken immediately upon filling the Styrofoam cup.

d. Measurements are recorded along with the general appearance of the water sample.

e. Stability is considered achieved when measurements differ by no more than 1°C temperature, 0.1 pH unit, and 2% conductivity between consecutive readings.

f. If, after 3 CVs have been removed, the field measurements have not stabilized, additional CVs (up to 5) should be evacuated. If the parameters have not stabilized within 5 CVs, it is the discretion of the field hydrologist whether or not to collect a sample or continue purging.
3.5 Purging and Sampling Methods

3.5.1 Bailers

3.5.1.1 Purging using a Bailer

Bailers are used at wells with deeper water levels, at locations where pumps may not be appropriate, or if a pump is not available.

MDA typically uses disposable bailers for purging and sampling. However, non-disposable bailers are available and could be used. If one is used at a well, it must be triple rinsed after use and returned to the PVC sleeve ready for the next sampling event as described in Section 2.2.

To purge a well using a bailer:

a. Connect the cable or rope to the bailer. Ensure there is a good connection to prevent the bailer from disconnecting from the cable and dropping into the well.
b. Lower the bailer to the bottom of the well. It is best to mark the cable in some way to identify the depth to a point slightly above the well bottom to avoid any sediment clogging the closure mechanism of the bailer. Often the closure mechanism will need to be seated. This can be accomplished with a quick pull on the cable (jerk) at the sampling point. The bailer should then be retrieved at a steady pace. Once retrieved the amount of water in the bailer is measured (estimated). It is important that this measurement reflects a properly collected and closed bail sample. This measurement is used to determine the number of bailer volumes required to properly purge the well.
c. Collect field measurements as detailed in Section 3.4.
d. Once purging is complete, collect a sample, as detailed below.

3.5.1.2 Sampling using a Bailer

a. Pour water from the top of the bailer into the appropriate sample bottle. The bailer may have a sample collection device (typically a piece of tubing that fits into the bottom of the bailer). Use of the sample collection device provides more control to fill the sample bottle. Try not to touch in the inside of the bottle during filling.
b. Label the bottles as detailed in Section 5.0.
c. Sample bottles must be placed and stabilized within a cooler and maintained at 4˚C as soon as possible after filling. Samples should be stored and transported as described in Section 6.0.
d. Once sampling is complete, close the well. Make sure the lock is properly attached and closed.
e. Police the site before leaving to ensure no equipment was left and that all trash has been removed.

Disposable bailers are placed into a trash bag to be disposed of properly.

3.5.2 Pumping

The MDA uses two different types of pumps, a peristaltic or a submersible. The peristaltic pump is most commonly used by the MDA and are used at wells with water levels approximately 25 feet or less from the top of the well casing. Submersible pumps are typically used at wells with water levels greater than 25 feet.
3.5.2.1 Purging and Sampling using a Peristaltic Pump

For MDA wells where a peristaltic pump is typically used, there may be dedicated sample tubing that remains in the well. At other wells, new tubing is used for each sampling event.

When installing new tubing, care must be taken to ensure that it does not come in contact with a potentially contaminated surface. If it does come in contact, replace it with new, clean tubing. Insert the new tubing into and lower to the bottom of the well. It is best to mark the tubing in some way to identify the depth to a point slightly above the well bottom and raise the tubing to that point to avoid any sediment clogging the tubing during pumping.

**Insert the well tubing into the tubing on the peristaltic pump.**

1. Connect pump to the power supply and start the pump. (Since the pump may run in both directions you may have to check that the tubing is inserted in the intake end).
2. Use a graduated beaker or other measuring container (preferably metric) to catch the discharge water and start the timer to obtain a pumping rate.
   a. It may be convenient to read the volume captured at 20 seconds and multiply by 3 to get the volume per minute rate, or a reading may be taken at 30 seconds and multiplied by 2 (the approach depends somewhat on how fast water is discharging at the time of measurement).
   b. Do not stop the pump during this process.
   c. This pumping rate is recorded on the field log. The pumping rate will determine when stability readings are to be taken and when purging of the well is complete.
3. Collect field measurements as detailed in Section 3.4.
4. Once purging is completed, the samples are collected as detailed below.

**Sampling**

1. Samples are collected by directing discharge water into the sample bottle. Care should be taken to not insert the tubing into the bottle or touch the interior of the bottle at any time.
2. Label the bottles as described in Section 5.0.
3. Filled sample bottles must be placed and stabilized within a cooler and maintained at 4°C as soon as possible after filling. Samples should be stored and transported as described in Section 6.0.
4. If there is dedicated tubing, lower it into the well, ensuring it is accessible for the next sampling round.
   If the tubing is removed, it must be properly disposed.
5. Field clean the pump as necessary.
7. Once sampling is complete, close the well. Make sure the lock is properly attached and closed.
8. Police the site before leaving to ensure no equipment was left and that all trash has been removed.

3.5.2.2 Purging and Sampling using a Submersible Pump

1. New, clean tubing is used at all sites where a submersible pump is used.
2. Connect tubing to submersible pump.
3. Lower pump and tubing into the well. Do not allow the pump or tubing to come in contact with any potentially contaminated surface. It is best to mark the tubing in some way to identify the depth to a point slightly above the well bottom and raise the tubing to that point to avoid any sediment clogging the tubing during pumping.
4. Connect pump to the power supply and start the pump.
5. Use a graduated beaker or other measuring container (preferably metric) to catch the discharge water and start the timer to obtain a pumping rate.
   - It may be convenient to read the volume captured at 20 seconds and multiply by 3 to get the volume per minute rate, or a reading may be taken at 30 seconds and multiplied by 2 (the approach depends somewhat on how fast water is discharging at the time of measurement).
   - Do not stop the pump during this process.
   - This pumping rate is recorded on the field log. The pumping rate will determine when stability readings are to be taken and when purging of the well is complete.

6. Collect field measurements as detailed in Section 3.4.
7. Once purging is completed, the samples are collected as detailed below.

**Sampling**

1. Samples are collected by directing discharge water into the sample bottle. Care should be taken to not insert the tubing into the bottle or touch the interior of the bottle at any time.
2. Label the bottles as described in Section 5.0.
3. Filled sample bottles must be placed and stabilized within a cooler and maintained at 4°C as soon as possible after filling. Samples should be stored and transported as described in Section 6.0.
4. Remove tubing and pump from the well. Disconnect tubing from pump and properly dispose of it.
5. Field clean the pump as necessary.
6. Once sampling is complete, close the well. Make sure the lock is properly attached and closed.
7. Police the site before leaving to ensure no equipment was left and that all trash has been removed.

**3.5.3 Domestic Wells**

The MDA samples domestic wells as part of the ambient monitoring program and for special projects. The total well volume for domestic wells can generally not be determined as it is not usually possible to access the well to measure water level and well depth. The MDA purges all domestic wells for 15 minutes unless well specific information is available.

Before leaving the office, contact the homeowner and let them know you are coming to sample their well and give them an approximate time when you expect to be there. If the homeowner wishes to be home while you are sampling, arrange a day and time for the sampling with them.

In addition to the regular sampling equipment needed as listed in the Monitoring Well Sampling Equipment Checklist (Appendix A), you will need a garden hose that is at least 10 feet long. The hose is used during the purging of the well.

a. Knock on the door and introduce yourself to the homeowner if someone is home. Explain why you are there. If the homeowner is not home, leave a business card and a note, notifying them that you had sampled their well. At homes where the MDA has sampled for a number of years, this may not be necessary.

b. Put on a pair of nitrile gloves. Spray the spigot with DI water, wipe off the spigot to make sure that it doesn’t drip on the hose and hook up the hose to the tap. Then, run the purge hose away from any dwellings or septic systems, preferably onto a lawn area. Make sure that the discharge will not cause any problems for the well owner.

c. Fully open the tap and begin to purge the well. Note the time that purging began on the field log form.
d. Calculate the discharge rate by filling a pre-measured container and time how long it takes to fill it up. Divide the volume by the time and that will equal the "discharge rate" as the unit of volume per the time interval. Record this on the field log form.

e. At a minimum, readings of temperature, pH, and conductivity should be recorded at the start of purging, as well as an observation of the appearance of the water. Check and record the time on the field log form for the first stabilization reading entry.

f. Take an additional reading every 3 minutes for 15 minutes. Note if the field parameters stabilize (final three readings are within 0.1 units for pH, 10% for conductivity, and 1.0 °C for temperature). If the field parameters have not stabilized after 15 minutes, proceed with sample collection and note which parameters did not stabilize.

g. After 15 minutes of purge time have elapsed, turn the tap off and remove the hose so that sample collection can be performed directly from the tap. Open the tap slowly until a steady stream is flowing. Discard the old pair of nitrile gloves and put on a new pair for sampling. Triple rinse (if necessary) and fill the respective sample bottle(s).

h. Turn off the tap. Put the hose and respective sampling items away and place them back into the vehicle. Police the site before leaving to ensure no equipment was left and that all trash has been removed.

3.5.4 Springs

The MDA samples springs in a number of locations in southeastern Minnesota. Some are in fish hatcheries and some are accessible through public lands. Verify locations of all springs prior to leaving the office. For springs at fish hatcheries, contact the hatchery prior to leaving the office and inform them of your planned visit. Some hatcheries may require that a hatchery employee accompany you during the sampling. Abide by the rules and procedures at the hatcheries to prevent causing harm to fish or property.

When visiting springs, be aware of site and weather conditions and do not proceed if it appears unsafe to collect the sample.

3.5.4.1 Sampling

1. If you need to enter the stream to access the spring, enter the stream downstream of the spring with prepared sample bottles. If you can access the spring without entering the stream, proceed to Step 2.
   a. Wade upstream to the representative sample collection location, moving slowly to avoid suspension of stream bed sediments.
2. Remove the sample bottle lid.
3. Facing upstream, fill the sample bottles following the direction in Table 2.
4. Repeat steps 3 through 5 for each sample bottle.

4.0 QUALITY ASSURANCE / QUALITY CONTROL SAMPLING METHODS

This section will present the protocol for the collection of the various quality assurance / quality control (QA/QC) samples. QA/QC samples should only be collected if rainfall cannot enter the sample bottles. QA/QC samples should not be filled when pesticide applications are occurring in close proximity to the sample site at the time of collection. QA/QC samples will be handled in the same manner as routine samples after
collection, and submitted blindly to the MDA Laboratory. The MDA will determine the locations and types of all QA/QC samples prior to the start of the monitoring season.

The MDA uses several types of QA/QC samples including field replicate samples, field duplicate samples, field blank samples, field equipment blank samples, and laboratory equipment cleaning blank. Each type of QA/QC sample is described below.

All sample bottles will be stored, transported and handled in the same manner as other collected samples as described in Section 6.0. The QA/QC samples will be numbered as described in Section 5.0. QA/QC samples are indicated on the field log immediately below the sample number box as the next sequential field number, with a note indicating the type of QA/QC sample that was collected. Departure from these procedures must be documented in the Ground Water Field Log or the Hydrologist’s Field Notebook.

4.1 Field Replicates and Duplicates

Replicates and duplicate samples are associated with the site at which they were collected for the purposes of laboratory log-in.

REPLICATE SAMPLES

Replicates will be collected at the sample site sequentially, immediately after the environmental sample. Replicates are collected in the same manner as the original sample.

DUPLICATE SAMPLES

It is assumed that variation in aquifer water is so small as to be negligible for the purposes of replicate sampling in the field. In some cases, however, (such as for laboratory method development purposes) true duplicates may be required. To collect true duplicate samples, the sample is collected in a large clean container, such as a cleaned carboy. The cleaned container is triple rinsed with sampled water and filled to the point where there is more than enough water for the required number of duplicate samples. The sample is then thoroughly mixed and the required samples drawn from the container. The sample water in the container continues to be mixed between collecting each duplicate sample.

4.2 Field Blanks

Quality control field blanks will be collected at the sample site after completion of regular sampling. A field blank is collected by pouring certified clean HPLC water from its original container into the appropriate sample bottle(s) at the sampling site. Field blanks are associated with the site at which they were collected for the purposes of laboratory log-in.

4.3 Field Equipment Blanks (Pumping)

Quality control field equipment blanks will be collected at the sample site after completion of regular sampling.

A pump blank is collected by drawing certified clean HPLC water from its original container into the appropriate sample bottle(s) at the sampling site.
Peristaltic Pump

1. Collect the regular sample from the well as defined in Section 3.5.2.
2. Clean the pump as outlined in Section 2.2.
3. Cut a short length of new poly tubing and insert one end into the intake end of the pump tubing.
4. Insert the other end into the HPLC supply.
5. Turn on the pump.
6. Samples are collected by directing discharge water into the sample bottle. Care should be taken to not insert the tubing into the bottle or touch the interior of the bottle at any time.
7. Label the bottles as described in Section 5.0.
8. Filled sample bottles must be placed and stabilized within a cooler and maintained at 4°C as soon as possible after filling. Samples should be stored and transported as described in Section 6.0.

Submersible Pump

1. Collect the regular sample from the well as defined in Section 3.5.2.
2. Clean the pump as outlined in Section 2.2.
3. Fill a clean container that is deep enough to hold all the water needed to fill the sample bottles with HPLC water.
4. Place the submersible pump in the clean container with the HPLC water.
5. Cut a short length of new poly tubing and insert one end into the discharge end of the pump.
6. Turn on the pump.
7. Samples are collected by directing discharge water into the sample bottle. Care should be taken to not insert the tubing into the bottle or touch the interior of the bottle at any time.
8. Label the bottles as described in Section 5.0.
9. Filled sample bottles must be placed and stabilized within a cooler and maintained at 4°C as soon as possible after filling. Samples should be stored and transported as described in Section 6.0.

4.4 Field Equipment Blanks (Bailing)

Sampling is conducted with disposable and non-disposable bailers. Field equipment blanks are collected differently from each type of bailer and each method is detailed below.

Disposable bailers

1. Field equipment blanks will be collected at the sample site before completion of regular sampling using a non-disposable bailer.
2. Pour certified clean HPLC water directly into the bailer.
3. The HPLC water is then poured from the bailer into the appropriate sample bottles.
4. Collect regular sample from the well as defined in Section 3.5.

Non-disposable bailers

1. Field equipment blanks will be collected at the sample site after completion of regular sampling using a disposable bailer.
2. Collect regular sample from the well as defined in Section 3.5.
3. Clean the bailer as outlined in Section 2.2.
4. Pour certified clean HPLC water directly into the bailer; or into the PVC storage sleeve and retrieving it using the bailer.
5. The HPLC water is then poured from the bailer into the appropriate sample bottles.

5.0 Groundwater Field Numbering of Samples

Numbering of groundwater samples is important and needs to be done in a consistent manner so that samples are properly identified for tracking, analysis, and reporting. Departure from these procedures must be documented in the Hydrologist’s Field Notebook or the sample submission form.

A number of bottles may be filled for separate laboratory analysis during the same field site visit; however, the sampling event is technically considered a single event and sample. Bottles are filled sequentially (as opposed to using a sample splitting apparatus). Each bottle is labeled with the following information; field sample number, date, time, analysis request. An example is provided below:

Field Sample Number: JWH08041
Date: 5/20/2008
Time: 13:45 (in military time, Central Standard Time)
Analysis: LC

Field numbers for groundwater samples contain minimal information within the number itself. Field numbers are an eight digit alpha/numeric string. The first character position is the initial of the field staff’s first name. The second character is the initial of the field staff’s middle name (or “X” if unknown or unavailable). The third character is the initial of the field staff’s last name. The next two characters represent the calendar year of collection. The final three characters are the sample number collected by the staff person for the year. This number is sequential throughout the year.

In the above example the label represents the 41st sample collected by John W. Hines in calendar year 2008.

6.0 SAMPLE PROCESSING AND SHIPPING

6.1 Sample Preservation

6.1.1 Sample Transportation and Preservation
_No chemical preservation methods are used for MDA samples._ All samples must be placed in an iced cooler (< 4° C) immediately following sample collection. Upon arrival back at the field office, the samples should be refrigerated or frozen following the guidelines in Table 1. Samples should be allowed to cool, or freeze, overnight prior to shipping or delivery for MDA Laboratory submission. Thermal preservation will minimize biological activity, thereby preserving sample integrity. Cooler temperatures will be verified with the temperature blank and thermometer. A temperature blank, filled with water, must be contained in each cooler when delivered to the MDA Laboratory.

6.1.2 Sample Storage and Holding Times
Samples must be stored in a dedicated refrigerator and/or freezer, instrumented with a thermometer, with audio alarm, to ensure proper sample storage conditions. The refrigerator and/or freezer must be clean and in an area
without prior history of pesticide storage. All samples must be submitted to the MDA Laboratory within seven days of collection. Holding times for each analysis are presented in Table 1.

6.2 Sample Chain-of-Custody Log-in Submission Form

The sample COC log-in should be completed in the field or soon after returning to the field office. The sample COC log-in contains important information, such as the sample location, dates/times, sample IDs, parameters to analyze for, and contact information. A stand-alone sample COC log-in must accompany the sample(s) and be included in every cooler upon delivery to the MDA Laboratory. The sample COC log-in should be checked several times for accuracy and completeness prior to shipment or delivery to the MDA Laboratory. The MDA utilizes an electronic COC log-in that is used by the MDA staff and cooperators.

The MDA Laboratory will send all sample COC log-in forms with receiving notes to the “Report To” staff identified on the form. At the end of the year, these forms should be scanned, and the file stored in this folder:

H:\PFMD\ENVIRONMENTAL\MONU\Groundwater Master Database\Field Logs and log-in files\Sample Season yyyy.

6.2.1 MDA Electronic Sample Chain-Of-Custody Log-In Submission Form

MDA staff will have access to the current version of the groundwater sample COC log-in form on the MDA’s network drive (H:\PFMD\ENVIRONMENTAL\MONU\Data Warehouse\Groundwater Master Database\Field Logs and log-in files\GW Log-in\yyyy\yyyy GW SampleCollectionForm.xlsm). MDA staff will need to print the completed Organic and Inorganic sample COC log-in, in color, for sample submission to the MDA Laboratory.

6.2.1.1 Populating the MDA electronic sample COC log-in

The MDA electronic sample COC log-in is an Excel file and adherence to this data entry procedure is necessary in order to accurately document field and sample collection data. When the file is opened, “Read Only” and the “Enable Content” button should be selected.

Table 2 provides a list of field names found on the sample COC log in form, with instructions to the right of each field in the table.
### Table 2. MDA Electronic Sample COC Log-in Fields.

<table>
<thead>
<tr>
<th>Data Entry Field</th>
<th>Description / Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspector</td>
<td>Use dropdown to select appropriate name/organization</td>
</tr>
<tr>
<td>Delivered By</td>
<td>Use dropdown to select appropriate name/organization</td>
</tr>
<tr>
<td>Delivery Method</td>
<td>Use dropdown to select delivery method</td>
</tr>
<tr>
<td>Inspector Sample ID</td>
<td>Enter Sample Bottle ID</td>
</tr>
<tr>
<td>LIMS Sample Site</td>
<td>Use dropdown to select monitoring location</td>
</tr>
<tr>
<td>Sample Type</td>
<td>Use dropdown to select sample type. Hover over field for descriptions</td>
</tr>
<tr>
<td>Collection Method</td>
<td>Use dropdown to select sample collection method</td>
</tr>
<tr>
<td>Sample Comments</td>
<td>Record weather comments and sample comments</td>
</tr>
<tr>
<td>Date Sampled</td>
<td>Enter the date and time (CST, military time) of sample collection.</td>
</tr>
<tr>
<td>Analysis and Thermal Preservation</td>
<td>Use the check boxes to request each analysis for each sample. Also indicate the thermal preservation method for each analysis type in the grey cell above the analysis.</td>
</tr>
<tr>
<td>Priority Level</td>
<td>Use dropdown to select the analysis priority level. “P3” is the default and should be used for most samples. “P1” should be used in emergency situations requiring immediate analysis and reporting, and “P2” should be used in instances requiring faster reporting. “P1” and “P2” should not be used without pre-approval from the MDA MAU supervisor, and only after pre-notifying the MDA Laboratory.</td>
</tr>
<tr>
<td>Double check all entries</td>
<td>Review all entries for accuracy</td>
</tr>
</tbody>
</table>

6.2.1.2 Printing the MDA electronic sample COC log-in
MDA staff are required to print, in color, separate sample COC log-in forms for organic (pesticide) samples and inorganic (nutrients) samples. To print the sample COC log-in form, move to the organic or inorganic tab. Select File→Print→Custom Scaling→Fit All Columns on One Page→”Print”

6.2.1.3 MDA electronic sample COC log-in data management
MDA staff members are required to update their running electronic log of all samples collected and submitted to the MDA Laboratory after each laboratory submission. This effort helps streamline the management of laboratory results and field data. Each MDA staff member must update their own running log of samples collected and submitted after each sample collection event to the most current file in the Monitoring Unit file on the MDA network H:\PFMD\ENVIRONMENTAL\MONU\Data Warehouse\Groundwater Master Database\Field Logs and log-in files\GW Log-in\yyyy

To copy the electronic data from the electronic sample COC log-in form to the compiled page:

1. On the “GW Sample Login” tab, select the entire row for any row with sample collection data. Use numbered column on far left to highlight rows containing data. Once highlighted, copy data (control + c).
2. Click onto the “GW StaffFieldLoginCompileSheet” tab.
3. Click on the number of the first unused row to highlight it. In the clipboard section of the toolbar, select “Paste Values” or keystroke: Alt+S; V; Enter. All sample information should be transferred, along with new cells that are automatically populated based on hidden lookup tables. Analysis selected for the
sample will have “True” in the cell indicating that results will be returned from the laboratory for those samples.

4. Open the master compile sheet in the network folder listed above and select the approximate tab (staff name or office).

5. Copy information from each log-in into this file.

6. Save the file using “Save As” with the date in the file name. If the current date is already used, add a consecutive letter behind the date to save the file (i.e.” …09.21.2016b”). This process will ensure a back-up file is always available.

6.3 Sample Submission to MDA Laboratory

Samples can be delivered directly to the MDA Laboratory by hand or through a commercial shipper. All submissions must include an accurate, complete, and dry sample COC log-in. Regardless of method, sample submission should not occur on the same day of collection, to allow samples to be chilled or frozen overnight. A temperature blank, filled with water, must be contained in each cooler upon arrival at the MDA Laboratory. The temperatures of samples will be recorded upon arrival at the MDA Laboratory. It is critical that all samples delivered to the MDA Laboratory be submitted at a temperature below 6°C. The sampler is responsible for ensuring sufficient ice is used during transport. Extreme care should be taken to ensure samples are not jeopardized during the submission process due to broken bottles or elevated temperatures.

Special projects may utilize other laboratories. Submission procedures for those laboratories must be established prior to the collection of samples.

6.3.1 Hand Delivery

Samples can be delivered directly to the MDA Laboratory rear loading dock area access (601 Robert St N, St. Paul, MN 55155). Upon arrival at the MDA Laboratory loading dock, staff should ring the doorbell. Staff will be escorted into the receiving area of the MDA Laboratory. Large deliveries must be coordinated with MDA staff in St. Paul prior to arrival. Samples must be on ice and chilled below 6°C at the time of submission.

6.3.2 Delivery with Commercial Carrier

Samples can be shipped in coolers with a commercial carrier (Spee Dee, UPS, etc.). Samples to be shipped to the MDA Laboratory should be placed in a cooler containing sufficient ice. Cooler packing instructions are available in Section 6.0. The sample chain-of-custody login should be placed in a sealed plastic bag to keep it dry inside the cooler and taped to the cooler lid. Extreme care should be taken to ensure samples are not jeopardized during the submission process due to broken bottles or elevated temperatures. Shipments of samples should be delivered to:

Minnesota Department of Agriculture
Laboratory Services Division
601 North Robert Street
St. Paul, MN 55155

Shipping should not occur until samples are chilled and/or frozen overnight and shipped in a cooler with sufficient wet ice. Shipments should not be picked up on Friday, as shipments are only received at the MDA Laboratory Monday through Friday. If samples are collected on a Thursday or Friday, the pick-up should occur on Monday. The request for cooperator shipping can be made in advance (for example, a Monday pick-up can be submitted on the previous Thursday).
The MDA utilizes Spee Dee for cooperator sample shipments. This is a three day process.

**Day 1:** Request shipment pick-up by 3:00 PM.

Contact the MDA mail room contacts below via e-mail or phone.

<table>
<thead>
<tr>
<th>Name</th>
<th>E-mail</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joyce Walkosz</td>
<td><a href="mailto:Joyce.Walkosz@state.mn.us">Joyce.Walkosz@state.mn.us</a></td>
<td>651-201-6155</td>
</tr>
<tr>
<td>Debra Gennow</td>
<td><a href="mailto:debra.gennow@state.mn.us">debra.gennow@state.mn.us</a></td>
<td>651-201-6153</td>
</tr>
</tbody>
</table>

Provide the following information in the request:

a. Date of requested pick-up.
b. Pick-up sample information.
c. Name of sampler and/or sampling organization and pick-up address.
d. Number of coolers in shipment.
e. Approximate weight of each cooler.
f. Include this statement “Shipment for statewide pesticide water quality monitoring”.
g. Laboratory delivery address:

Minnesota Department of Agriculture  
Laboratory Services Division  
601 Robert Street North  
St. Paul, MN 55155-2531

**Day 2:** Prepare the cooler for shipment and cooler pick-up.

Prepare the cooler(s) according to the procedures in Section 6.4. The cooler should be kept in an air conditioned area prior to pick-up.

**Day 3:** Package delivered to MDA Laboratory

### 6.4 Cooler Packing Instructions

The guidelines described below should be used for all shipments to the MDA Laboratory. Example photographs should be used to guide cooler packing procedures.

**Supplies**

- Cooler (> 3 day ice holding rating)
- Bulk bubble wrap (1/2 inch) for cooler lining
- Bubble wrap bags for all glass amber bottles
- Sealable plastic bags for each sample set
- Temperature blank (empty bottles can be provided)
- Cooler liner bag
- Zip ties
- Wet ice
- Completed sample chain-of-custody log-in form in sealed bag

<table>
<thead>
<tr>
<th>Cooler Packing Procedures:</th>
<th>Example photographs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Properly chill/refrigerate or freeze samples following standard operating procedures prior to preparing shipment to the MDA Laboratory. Shipping samples at ambient temperatures will quickly melt the ice in the cooler and may affect the acceptance of samples at the MDA Laboratory.</td>
<td><img src="image1.jpg" alt="Example photographs" /></td>
</tr>
<tr>
<td>2. Line the bottom of the cooler with bulk bubble wrap.</td>
<td><img src="image2.jpg" alt="Example photographs" /></td>
</tr>
<tr>
<td>3. Line the cooler with cooler liner bag.</td>
<td><img src="image3.jpg" alt="Example photographs" /></td>
</tr>
</tbody>
</table>
| 4. Prepare samples for shipping:  
  a. Place amber glass bottles into bubble wrap bag and seal it.  
  b. Place amber glass bottles and associated plastic bottles into sealed plastic bag. Use the same bag the empty sample bottles were shipped in.  
  c. Place one temperature blank into a sealed plastic bag with samples. One temperature blank is required in each cooler, and should be collected following standard operating procedures. | ![Example photographs](image4.jpg) |
| 5. Place sealed bags of samples upright inside cooler liner bag. Do not lay samples on their side or double stack. If possible, pack sealed bags limiting direct contact between glass bottles. | ![Example photographs](image5.jpg) |
| 6. Fill the cooler liner with wet ice, ensuring wet ice is in contact with the sides and overtop of the sealed bags of samples. Ice should fill approximately 1/3 to 1/2 of the cooler. (A 28 quart cooler will require at least 8 pounds of ice; a 50 quart cooler will require at least 20 pounds of ice.) | ![Example photographs](image6.jpg) |
| 7. Twist cooler liner top to close it and use the provided plastic zip tie to close the cooler liner bag. | ![Example photographs](image7.jpg) |
### Cooler Packing Procedures:

8. If there is space between the cooler liner bag and the sides or top of the cooler, add additional bulk bubble wrap between the cooler liner bag and the cooler. Add enough bubble wrap to prevent any movement of the cooler liner bag inside the cooler during shipping.

9. Place sample chain-of-custody (COC) log-in form in a sealed plastic bag and tape it to the bottom of the cooler lid. The sample COC log-in should only include samples contained in that particular cooler.

10. Seal the cooler with packing tape:
   a. Tape along cooler where the lid meets the cooler.
   b. Tape completely around the cooler in two locations preventing the cooler lid from opening.
   c. Cooler handle should be taped down to avoid handle breakage / dropping during shipping.
   d. Tape over the delivery address to protect it from falling off or getting wet (shown in step 12 photo).

11. Keep packed cooler in an air conditioned, well shaded location prior to shipment pick-up by a commercial carrier.

12. Do not ship on Fridays as the MDA Laboratory does not accept samples on weekends.

13. The MDA Laboratory will return all packing materials and temperature blank bottle with the cooler.
Appendix A: Groundwater Monitoring Sampling Equipment Checklist

Standard

☐ sampling schedule
☐ maps/ directions to wells
☐ keys
☐ field logs
☐ clipboard
☐ permanent waterproof marker
☐ pen/pencil
☐ peristaltic pump
☐ power (extension) cords
☐ power inverter
☐ bailer (w/ reel and line)
☐ 1L amber glass bottles
☐ 125ml poly bottles
☐ adhesive bottle labels
☐ nitrile gloves
☐ water level meter
☐ temp/pH/con meter
☐ tubing (poly and FEP)
☐ wash bottle
☐ stop watch
☐ 200ml beaker
☐ styrofoam cups
☐ thermometer
☐ calculator
☐ DI water
☐ HPLC water
☐ plastic bags
☐ coolers
☐ styrofoam shippers
☐ ice (or cold packs/ equivalent)
☐ purge tables (pumping and bailing)
☐ wind scale
☐ pipe wrenches (2)
☐ tool kit
☐ first aid kit
☐ camera
☐ safety vest

Optional or Special Applications

☐ extra bailer bottom
☐ replacement pump tubing (masterflex)
☐ replacement carboy spigot
- j-plugs for 2” pvc casing
- padlocks
- marine battery
- battery charger
- gps unit
- orange safety cones
- shovel (winter)

**Tool Kit**

- Hex keys (allen wrenches)
- Screw drivers (flat blade and Phillips)
- Pliers (standard, needle nose, channel lock)
- Crescent wrench
- Vice grips
- Hammer
- Knife (straight blade or folding locking back)
- Utility scissors
- Flashlight
- Measuring tape
- Treble hook and line
Appendix B: Groundwater Field Log
## Minnesota Department of Agriculture Monitoring Unit

### Ground Water Field Log

<table>
<thead>
<tr>
<th>Well Unique#</th>
<th>Sample#</th>
<th>Date</th>
<th>Time</th>
<th>SWL (units)</th>
<th>Depth (units)</th>
<th>Water Column</th>
</tr>
</thead>
</table>

Sample Type: ___Regular; ___ Cleaning Blank; ___ Field Equip Blank; ___ Replicate; ___ Field Blank

[ ] BAIL

[ ] PUMP

RATE: ______________

<table>
<thead>
<tr>
<th>Elapsed Time or BV</th>
<th>Temp (units)</th>
<th>pH</th>
<th>Specific Cond.</th>
<th>Appearance/ Notes</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Wind (units)</th>
<th>Air temp (units)</th>
<th>Sky Conditions</th>
<th>Humidity</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

COMMENTS:

28
Appendix C: Well Purge Bail and Pumping Volumes
## Well Purge Bail and Pump Volumes

<table>
<thead>
<tr>
<th>Water Column (cm)</th>
<th>Volume 2” Well (CV) (ml)</th>
<th>Purge Volume (3CV) (ml)</th>
<th>bail volumes (BVs) for 4.5cm diameter and 80cm length bailer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1/4</td>
</tr>
<tr>
<td>15</td>
<td>304</td>
<td>912</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>405</td>
<td>1215</td>
<td></td>
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<td>25</td>
<td>506</td>
<td>1518</td>
<td></td>
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<td>30</td>
<td>608</td>
<td>1824</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>709</td>
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<td>810</td>
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<td>55</td>
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<td>2127</td>
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<td>2228</td>
<td>6684</td>
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Appendix D: Well Purge Times
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