

Field Standard Operating Procedures

For Activities of the
Agricultural Chemicals & Groundwater
Protection Program



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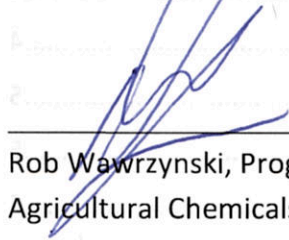
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FIELD SOP OVERVIEW

This manual provides detailed methodology for the three most common sampling approaches used by the Agricultural Chemicals & Groundwater Protection Program for its monitoring responsibilities: monitoring well sampling with either a peristaltic pump or pneumatic bladder pump, and sampling of domestic or irrigation wells. It is expected that all field personnel have reviewed and learned the methodology contained within this manual before attempting to conduct sampling events in the field.

As sampling technology and concepts evolve over time, it may require the program to update its methodology to either improve its effectiveness in acquiring samples representative of aquifer formation water quality or its efficiency. Any adjustments made to one of the three SOPs in this manual must be referenced in the Revisions section. In particular, only personnel fully aware of the purpose and intent of the information in each SOP should make changes to or authorize changes to the SOPs.

FUTURE APPROACHES

Given the advancement of electronic technology and the likelihood that hardcopy paper forms may be abandoned, it is likely the program will conduct the majority of its field data collection with electronic devices. In the event that occurs, the information contained in this manual will continue to be valid and all electronic collection techniques must adhere to the requirements set forth in the SOPs of this manual. Furthermore, given the vulnerabilities of electronic devices, it will be of utmost importance that program personnel conducting field work under this SOP manual with an electronic device should practice appropriate data management and stewardship principles to minimize the risk of data loss.

STANDARD OPERATING PROCEDURES

SOP GPP-1 Monitoring Well Purging, Sampling, Decontamination Using Athena® Peristaltic Pump

1.0 Scope & Applicability

- 1.1. This SOP highlights the correct protocol for acquiring a representative groundwater sample from a monitoring well with a peristaltic pump setup.
- 1.2. The use of a peristaltic pump can only occur when the depth to groundwater and the depth to the middle of the screened interval is less than 25 ft below ground surface.
- 1.3. This SOP will show how to arrange, deploy, and utilize all necessary equipment for purging the well with stabilization criteria, collecting a filtered and/or unfiltered sample, and how to decontaminate all non-dedicated equipment surfaces that transfer water into a sample bottle.
- 1.4. This method is intended for use on water quality monitoring well types only; however, if necessary, a domestic well may be sampled with this setup. Current Colorado regulations¹ allow authorized individuals, professional engineers, geologists, and hydrologists to remove a domestic water well seal for the purposes of measuring water levels, collecting samples, and the installation of pumps dedicated solely to scientific, engineering or regulatory purposes. However, this provision also requires that the person removing the well seal be responsible for disinfecting the well and reinstallation of the seal per the requirements of the Colorado Division of Water Resource's "Water Well Construction Rules" (2 CCR 402-2)¹.
 - If the planned sampling involves removing a well seal, Program personnel will need to meet the requirements of the above mentioned rule and have available the appropriate resources needed to thoroughly disinfect the well.

2.0 Summary of Method

- 2.1. After measurement of depth to water in the monitoring well, down-well equipment should be deployed and properly connected to equipment on the surface.
- 2.2. After the well is purged according to stabilization criteria through the use of a multi-parameter sonde and flow-through cell setup, the flow can be switched to the filtering apparatus with the 3-position 2-way valve.
- 2.3. Samples requiring no filtration should be collected first.
- 2.4. Upon completion of sample collection, the down-well equipment should be retrieved and the well re-sealed and secured.
- 2.5. Samples should be preserved according to requirements of the Quality Assurance Project Plan (QAPP) unless specified otherwise in this SOP.
- 2.6. Non-dedicated equipment should undergo the appropriate decontamination procedures.

3.0 Definitions/Abbreviations

- GPP = Groundwater Protection Program of the Colorado Department of Agriculture
- D.I. = Deionized water obtained through reverse-osmosis
- MP = Measurement Point
- MSDS = Material Safety Data Sheet
- Non-dedicated = Defined in this SOP as any equipment used for sampling a well which is not permanently dedicated to the well
- PM = Project Manager
- QAPP = Quality Assurance Project Plan
- QC = Quick Connect
- SWL = Static Water Level

4.0 Health & Safety Warnings

- 4.1. Some of the equipment used in this method can weigh over 50 lbs and should be lifted with proper lifting technique in order to prevent injury.
- 4.2. Environmental conditions encountered while utilizing this method can become threatening to health and safety.
- 4.3. Equipment decontamination involves the use of an alcohol like methanol or isopropanol which must be poured into a stainless steel column. Personnel should be familiar with a MSDS on either of these alcohols and should take the necessary precautions outlined in Section 8: Exposure Controls, Personal Protection of the MSDS.
 - Methanol cannot be made non-poisonous regardless of concentration, so take precautions when working with it. Isopropanol is also poisonous but its toxicity in the environment is less than that of methanol.
 - Methanol and isopropanol are highly flammable and can be ignited with a spark, so personnel should be cognizant of this fact and discharge any static buildup prior to attempting to pour either alcohol into the stainless steel column.
 - Given the pressures associated with the use of a peristaltic pump, use of appropriate eye protection is **required** during the decontamination procedure, and recommended for use during the entire sampling event.

5.0 Cautions

- 5.1. There are no cautions outside of the Health & Safety Warnings.

6.0 Interferences

- 6.1. This pumping method imparts a negative pressure on water as it is removed from the well. This negative pressure can alter the chemistry of water from its *in situ* state which may impact measured concentrations of dissolved gases or volatile analytes.

Changes in dissolved concentrations of O₂ or other gases may change the redox and pH of water that may in turn cause precipitation of some dissolved metals.

- It is **important** to ensure that analytes to be measured by the laboratory will not be negatively impacted by this pumping method.
- 6.2. It is important to ensure that probes used for measuring various physical parameters of the groundwater are properly calibrated as explained in SOP GPP-1 to prevent any stabilization errors during the purging process or introduction of unnecessary variability.
 - 6.3. It is critical to utilize clean, powder-free, nitrile gloved hands when handling any equipment or supplies that will come into contact with sampled water.
 - 6.4. It is important to be cognizant of what gloved hands (that will collect groundwater samples) have come in contact with, as any contact with any equipment that does not undergo decontamination could potentially lead to cross-contamination of samples.
 - 6.5. It is important to prevent contamination of the sample with any foreign matter that may be present in a sampling port or in/on the sampling bottle itself.
 - 6.6. Decontaminating the pump and all non-dedicated equipment between sample sites is critical to maintain sample quality and prevent cross-contamination.

7.0 Personnel Qualifications

- 7.1. Personnel should fully understand the procedures outlined in this SOP and the general concepts associated with groundwater sampling as it applies to the goals and purpose of the GPP as well as any rules established by Colorado Division of Water Resources.
- 7.2. Personnel should also be knowledgeable of equipment operability and maintenance as outlined in SOP GPP-1 to ensure proper functionality and prevention of sample contamination.
- 7.3. The PM should be sure that personnel involved with groundwater sampling thoroughly understand this SOP in its entirety.

8.0 Equipment & Supplies

- 8.1. Form SEF-1, Form SEF-2, and Diagram SED-1 (see Appendix)
- 8.2. All of the following equipment:
 - Well Sounder or other suitable device for measuring depth to groundwater
 - Athena® Peristaltic Pump and necessary tubing
 - Spare peristaltic tubing (1/4" ID)
 - All tubing pieces for connection of down-well equipment to the peristaltic pump and three-position, two-way valve, and the filtering apparatus:
 - Spare Teflon-lined PE tubing
 - The Diagram in the Appendix is necessary for understanding how the tubing connects together the different pieces of equipment.
 - YSI 556-MPS multi-parameter sonde and controller

- 200-mL or 500-mL flow-through cell for integration with multi-parameter measurements
- YSI ProODO sonde on 60-m cable and controller
- Filtering equipment:
 - Stainless Steel Filter Housing
 - Both the 47 mm or the 142 mm stainless steel housing should be available at the site
 - Disposable filters with barbed fitting for attachment to end of sample collection tubing
 - Borosilicate glass microfiber, non-binder, filter discs for use in stainless steel housing
 - Mesh sizes 0.45, 0.7, and 1.0 micron should be available for selection
- Decontamination Supplies:
 - Decontamination Tubes – (2) 4” PVC tubes and (1) 3” Stainless Steel tube in wooden holding rack
 - Tap water and Luminox (or other phosphate-free, biodegradable detergent)
 - D.I. water
 - Methanol or isopropanol mixed 50/50 with D.I. water (vol/vol)
 - There should be sufficient quantity of all decontamination liquids to allow for passing 3X the total internal volume of the sampling setup
- Personal Protective Equipment:
 - Powder-free, nitrile gloves
 - Eye protection
 - Portable emergency eye-wash bottle
- Other Necessary Gear:
 - Trash bags
 - Spare batteries: (6) C-cell batteries for YSI controllers
 - Weed Scythe
 - Worktable
 - Shade Tarp, stakes, poles
 - Various clamps

9.0 Sampling Event Procedure

9.1. Site Arrival and Inspection

- Begin sample event documentation as directed in QAPP.
- Ensure that both the sampling equipment and the well are out of direct sunlight through use of a tarp canopy or appropriate orientation of the truck.

9.2. Measuring Static Water Level in Well

- Determine Measurement Point (MP)
 - MP of well should be marked on or near top of PVC riser.

- It is important to always make measurements from the MP in order to minimize erroneous measurements.
 - Confirm or document the height of the MP above/below the ground surface to at least 1/10th of a foot.
 - Deploy Measurement Device
 - This is usually a sounding tape that must be turned on and deployed slowly down the well.
 - Push the 'red' test button to confirm that the unit is working
 - Turn the sensitivity to maximum
 - Once the signal is heard the sounder probe has encountered water in the well.
 - With the signal sounding move the marked cable to the MP and record the static water level (SWL) measurement to 1/10th of a foot on Form SEF-1.
 - If Well Depth is not known the sounder probe can be dropped slowly to the bottom of the well and a measurement to at least 1/10th of a foot can be recorded.
 - Retrieve Measurement Device
 - While reeling up probe from the well, wipe down the cable with a paper towel soaked with D.I. water.
 - Once the probe is at the surface, thoroughly rinse the probe with D.I. water.
 - Precautions
 - Be sure to drop the sounder probe through the well slowly in order to minimize agitation of the *in situ* conditions of the well.
- 9.3. Field Instrument Startup and Calibration Check**
- YSI 556-MPS startup and confirmation that instrument parameters measured with YSI Calibration Confidence Solution are within acceptable ranges.
 - YSI ProODO startup readings and confirmation that D.O. measured in calibration-cup is within 2% of True D.O.
 - True D.O. = Barometric Pressure mmHg (measured by onboard barometer) / 760 mmHg
 - If D.O. measured by either the 556-MPS or the ProODO is not within 2% of True D.O. then calibration is necessary.
- 9.4. Placing YSI ProODO Sonde and Pump Inlet at the Appropriate Depth**
- Pump Inlet Configuration for portable setup
 - The down-well tubing is ½" OD and ¼" ID and 25 ft in length
 - This is Section A on Diagram SED-1 (Peristaltic Pump Sampling Scheme) found in the Appendix.
 - Section A is Teflon-lined PE tubing that has a stainless steel weight attached to one end and a quick-connect (QC) fitting to the other.
 - The pump inlet is where water will enter the tubing near the middle of the

stainless steel weight.

- If SWL is ABOVE top of screened interval
 - The ideal placement of the pump inlet will be in the middle of the screened interval.
 - The length of the screened interval should be known from well construction records.
 - **FIRST** place the ProODO Sonde about ½ ft below where the pump inlet is desired to be set.
 - **SECOND** place the pump inlet to the desired depth.
- If SWL is WITHIN the screened interval:
 - The ideal placement of the pump inlet will be nearer the bottom of the screened interval.
 - **FIRST** place the ProODO Sonde about ½ ft below where the pump inlet is desired to be set.
 - **SECOND** place the pump inlet to the desired depth.
- Precautions
 - Deploy the ProODO and Section A tubing slowly to minimize agitation of *in situ* conditions.
 - If a sump is part of the well construction, be sure to account for it when placing the pump inlet into position, especially when SWL is within the screened interval.
 - A sump is a section of solid PVC casing attached to the bottom of the screened interval so that sediment passing through the well can settle out and away from the screened portion of the well.

9.5. Stainless Steel Filter Apparatus Preparation

- The 142 mm stainless steel housing has (3) aluminum legs that hold it upright.
 - Take the top of the filter plate off and place on a clean surface.
 - Utilizing nitrile-gloved, clean hands and clean stainless steel forceps, place a 142 mm glass microfiber filter disc on the bottom part of the filter plate and pre-wet with D.I. water.
 - Replace the top of the filter plate and tighten the (3) nuts.
- The 47 mm stainless steel housing has no attachable stand and must be situated into an upright position after it is prepared.
 - DO NOT let this filter apparatus lay horizontal as the effective area of filtration will not be optimized.
 - Utilizing nitrile-gloved, clean hands and clean stainless steel forceps, place a 47 mm glass microfiber filter disc on the 'bottom' part of the filter plate and pre-wet with D.I. water.
 - Replace the top of the filter plate and hand-tighten the housing.
- Both of the stainless steel housings have QC fittings that are closed to the environment until Tubing Sections C & D are attached. This minimizes the chance

of airborne contaminants from entering the filter housing after it has been prepared and sealed.

- It is recommended to attach the necessary tubing sections as soon as possible after the filter housing has been prepared.
- **Precautions**
 - If windy conditions exist when trying to prepare the filtering apparatus, it may be necessary to conduct this procedure in a less windy or non-windy area, such as inside a truck cab.
 - If the glass microfiber filter disc is not pre-wetted prior to sealing up the filter housing, the effective filtration will not be optimized and could possibly result in the filter disc rupturing.

9.6. Connecting Tubing Section A to Remaining Equipment

- **Athena® Peristaltic Motor**
 - A 12" section of silicone tubing that has a female QC on each end should be properly clamped into position on the motor.
- Tubing Section A has a male QC that should connect with the QC that is toward the front of the tubing clamped into the peristaltic motor.
- Tubing Section B has a male QC that connects to the other QC on the tubing clamped into the peristaltic motor.
- The female end of Section B connects to the Inlet on the 2-way valve attached to the wooden frame that is holding the (3) tubes used for the decontamination procedure.
- Tubing Section E has yellow duct tape on the QC fittings and indicates that the tubing passes dirty water and a groundwater sample should NOT be collected from this tubing. Section E is NOT decontaminated.
 - One male QC fitting connects to the yellow fitting on the 2-way valve.
 - The other male QC fitting connects to the bottom inlet to the flow-through cell which holds the YSI 556-MPS multi-parameter probe.
 - Since the YSI probe has to screw into the flow-through cell it will need to be in place before the tubing connections are made.
- Tubing Section F has a yellow marked female QC fitting that connects to the outlet of the flow-through cell.
 - Again, yellow means the tubing passes dirty water and a groundwater sample should NOT be collected from this tubing.
- **WHEN FILTER PLATE IS USED**
 - Tubing Section C has red marked male QC fittings on both ends and indicates that this tubing is used ONLY for collecting groundwater samples. Section C undergoes decontamination procedures.
 - One male QC connects to the red marked QC fitting on the 2-way valve.
 - The other male QC connects to the top (Inlet) of the Filter Plate.

- As a guide, the air relief valve/screw on the filter plate is on the Inlet Side.
 - Tubing Section D has a red marked male QC that connects to the bottom (outlet) of the Filter Plate. Section D undergoes decontamination procedures.
 - The other end of Section D is where filtered groundwater samples are collected.
 - **WHEN A DISPOSABLE FILTER IS USED**
 - Tubing Section D has red marked male QC fitting that connects to the red marked QC fitting on the 2-way valve.
 - The other end of Section D does not have a fitting and can be utilized to collect UNFILTERED groundwater samples (when necessary) prior to attaching a disposable filter (equipped with a barbed fitting) for collecting filtered groundwater samples.
- 9.7. Monitoring Water Level Drawdown**
- This is necessary if there is a concern with the well yield not being able to withstand a pumping rate as potentially as low as 100 mL min⁻¹
 - If there is concern of inadequate well yield:
 - Install the well depth probe so that it is actively (audible or visual signal) monitoring the top of the water column in the well.
 - The depth to this point should still be the same that was recorded in **Section 9.2.**
 - If there is NO concern with inadequate well yield, then it is not necessary to monitor water level drawdown when pumping up to the maximum attainable rate of the Athena® Peristaltic Pump.
- 9.8. Pump Startup and Well Purging**
- Before continuing, be sure to record the following details on Form SEF-1:
 - Pump Depth (approximate)
 - ProODO Depth (approximate)
 - ProODO Pre-pump Measurements
 - Starting Ambient Conditions
 - Indicate whether QC sample(s) will be collected and what type(s)
 - Indicate whether Split sample(s) will be collected
 - Indicate sample filtration setup with regard to filter type, filter matrix, manufacturer Lot #, filter diameter, and filter housing
 - Indicate whether any samples (and if applicable, which samples) are chemically preserved
 - The normal agrichemical analyte list screened for by the Program does not require chemical preservation of any sample bottles.
 - **Ensure** the 2-way valve is positioned to direct flow to the flow-through cell.
 - Record **Time Pump Start** while simultaneously turning on Athena® peristaltic

pump.

- Ensure pump direction (forward/reverse) is correct so that water will be withdrawn from the well and atmospheric air is not pumped down into the well.
- If the tubing connections were made as explained above in **Section 9.4** then the pump should be ran in the forward direction.
- Adjust pumping speed to meet the following requirements:
 - Match the setting from the previous sampling event (if applicable).
 - Obtain a flow-rate that does not result in water level drawdown in the well as measured by the Well Depth Sounder installed in **Section 9.5** (if applicable).
 - Minimizes the agitation of water in the well to prevent increased turbidity of the pumped water.
- Determining Flow-Through and Measurement Cycle Times
 - Start timer when water in tubing begins discharging into the flow-through cell.
 - Stop timer when water begins discharging out of Tubing Section F and record **FC Cycle Time**.
 - On average – FC Cycle Time will be 1 to 1 ½ minutes.
 - Add approximately 30-60 seconds to that time in order to ensure the ability of personnel to accurately document information and conduct other necessary sampling event details in between purging measurements.
 - On average – **YSI Read Frequency** will be 2 to 3 minutes.
- Once FC Cycle Time and YSI Read Frequency have been determined and documented record **Time Purge Start** and record the first set of measurements on Form SEF-2 (Purging Parameter Information Sheet).
- Continue to record measurements at the YSI Read Frequency rate (or greater) until three consecutive measurements meet the Stabilization Criteria found at the top of Form SEF-2 **and** found below:
 - pH: ± 0.2 units
 - Specific Conductance:
 - $< 100 \mu\text{S cm}^{-1} \pm 3.0\%$
 - $> 100 \mu\text{S cm}^{-1} \pm 5.0\%$
 - ORP: ± 20 mV
 - D.O.: $\pm 2.0\%$ of reading or 0.2 mg L^{-1}
- **Upon stabilization** of parameters, record **Time Stabilized** on Form SEF-2.
- Temperature should be recorded while purging, but it is not required for stabilization.

9.9. Sample Collection

- **Upon Completion** of adequate purging switch 2-way valve to direct discharge to the filtration setup.

- Ensure the filtering setup is in place as according to need or no need of filtration outlined in **Section 9.4.**
- **Ensure** all labels on sample bottles are populated with the **Sample Date** and **Time Sample Collected** that should be recorded on Form SEF-1.
- Collection of Unfiltered Samples:
 - Unfiltered samples can be collected from the end of Tubing Section C before it is connected to the inlet of the stainless steel filter housing.
 - **If a disposable filter is planned for use** then the unfiltered samples will be collected from Tubing Section D as outlined in **Section 9.4.**
- Collection of Filtered Samples:
 - If necessary, connect Tubing Section C to the filter plate inlet.
 - **WARNING!** Ensure that Tubing Section D is already connected to the filter plate outlet or the back pressure will blow connections.
 - Open the pressure release valve (PRV) on top of the filter plate until water begins to emerge from it and then re-close the valve.
 - Purge an adequate amount of water to ensure a triple purging of Tubing Sections C & D as well as the filter housing prior to beginning sample collection.
 - On average, with one person conducting the sampling event, this will amount to upwards of 500 mL of water before sampling begins,
 - If a disposable filter is being used at the end of Tubing Section D as outlined in **Section 9.4**, the same purging criteria should be used.
 - **High Turbidity!** This can cause clogging of the filter matrix and purging and sampling should be conducted as quickly as possible.
- Order of Collection for Filtered Samples
 - The Program has a fairly set and defined sample need for the purposes of agrichemical evaluation (see QAPP), but if different sample types are required of the sampling event the following sampling order should be executed from most to least sensitive:
 - Volatile Organic Compounds (VOCs)
 - Total Organic Carbon (TOC)
 - Total Organic Halogen (TOX)
 - Samples Requiring Field Filtration
 - Samples for Additional Field Parameter Measurement (Independent of Purging Data, i.e. alkalinity)
 - Large-Volume Samples for Extractable Organic Compounds
 - Samples for Nutrient Anion Determinations

9.10. Upon Completion of sample collection, turn the Athena® Peristaltic Pump off and record **Time Pump Terminated**.

- This information will be useful in understanding the total volume of water removed from the well during the sampling event.

9.11. Post-collection Sample Preservation and Storage

- Collected samples should be promptly secured in a cooler maintained at $< 10^{\circ}\text{C}$ as according to the Program's QAPP.

9.12. Retrieve instrumentation and pump from well ensuring that exterior surfaces are wiped down with D.I. soaked paper towel during retrieval.

- Any instrument probes, tubing weights or other down-well pump equipment should be thoroughly rinsed with D.I. water to remove visible particles.

9.13. Remove and dispose of glass microfiber filter disc from filtering apparatus, rinse housing internals with D.I. water, reassemble filter plate, and reconnect Tubing Sections B & D.

9.14. Decontamination of Equipment Used in Sample Collection

- For the peristaltic pump setup the decontamination procedure is essentially the same as pumping from a well except the 'well' now consists of the (3) different decontamination columns.
- The total internal volume of surface to be decontaminated with this setup is at a maximum the additive volumes of Tubing Sections A, B, C, and D plus the filter housing.
 - This is approximately 500 mL worth of volume that will require at least 1500 mL of each decontamination fluid to be passed through for a triple rinse.
- The Athena[®] Peristaltic Pump can run at maximum capacity during the entire decontamination procedure.
- The pump inlet at the end of Tubing Section A is placed in **Column 1** filled $\frac{1}{2}$ to $\frac{3}{4}$ full with tap water and a phosphate free, biodegradable detergent and the appropriate volume is cycled through.
- The pump inlet is then moved to **Column 2** filled $\frac{1}{2}$ to $\frac{3}{4}$ full with D.I. water and the appropriate volume is cycled through.
- The pump inlet is then moved to **Column 3** (stainless steel) filled $\frac{3}{4}$ full with a 50/50 (vol/vol) mixture of methanol (or isopropanol) and D.I. water, and the appropriate volume is cycled through.
- **Upon completion** of cycling the contents of all three columns through the sampling setup, the pump can be terminated and the different tubing sections can be drained and stored in a clean, sealable plastic bag.
- The internal surfaces of the stainless steel filter housing should be rinsed of any alcohol residue with D.I. water before reassembling and tightly sealing the filter plate for storage.

9.15. Disposal of Decontamination Fluids

- The detergent used in column one can be disposed of on any ground surface with care taken to prevent any deposition into the well itself.
- The methanol or isopropanol and D.I. water mixture can be toxic to birds, wildlife, aquatic species, and soil organisms so it should not be disposed of in a fashion that endangers any of these pathways.
 - If there is no spot around the well to dispose of the mixture onto an

impermeable or insignificant surface without causing harm to the local environment, then the mixture should be captured and transported to the laboratory for disposal.

9.16. Wrapping up Sampling Event

- Ensure cap is properly replaced on the well riser and that the protective casing is sealed and locked.
- Ensure the following information is recorded/confirmed on Form SEF-1:
 - Ending Ambient Conditions and/or notes
 - Indication of whether decontamination procedures were completed
 - Event Notes (as necessary)
- Record **Time Depart** on Form SEF-1

10.0 Data and Records Management

10.1. Be sure that Form SEF-1 is filled out as thoroughly as possible.

- Any well construction information is useful.
- Well Permit # is very helpful in gathering well information.
- Any pertinent discussion with land or well owner.

10.2. Store all documentation for the sampling event in the network-specific 3-ring binder until they can be digitally entered in the office as outlined in the QAPP. In the event that digital sampling event documentation forms are used for data collection in the field, it is important to follow the data handling requirements in the QAPP.

SOP GPP-2 Monitoring Well Purging, Sampling, Decontamination Using Pneumatic Bladder Pump

1.0 Scope & Applicability

- 1.1 This SOP highlights the correct protocol for acquiring a representative groundwater sample from a monitoring well with a pneumatic bladder pump setup.
- 1.2 The main limitation of a pneumatic bladder pump is a combination of the available air pressure and the pressure capacity of the tubing and fittings, bladder, and pump housing. With the equipment and setup described in this SOP, it is possible to obtain a maximum pressure of 115 psi which will allow for a maximum water column lift of approximately 260 ft (assuming 0.434 psi requirement to raise water one foot).
- 1.3 This SOP will show how to arrange, deploy, and utilize all necessary equipment for purging the well with stabilization criteria, collecting a filtered and/or unfiltered sample, and how to decontaminate all non-dedicated equipment surfaces that transfer water into a sample bottle.
- 1.4 This method is intended for use on water quality monitoring well types only; however, if necessary, a domestic well may be sampled with this setup. Current Colorado regulations allow authorized individuals, professional engineers, geologists, and hydrologists to remove a domestic water-supply well seal for the purposes of measuring water levels, collecting samples, and the installation of pumps dedicated solely to scientific, engineering or regulatory purposes. However, this provision also requires that the person removing the well seal be responsible for disinfecting the well and reinstallation of the seal per the requirements of the Colorado Division of Water Resource's "Water Well Construction Rules" (2 CCR 402-2)¹.
 - If the planned sampling involves removing a well seal, Program personnel will need to meet the requirements of the above mentioned rule and have available the appropriate resources needed to thoroughly disinfect the well.

2.0 Summary of Method

- 2.1 After measurement of depth to water in the monitoring well, down-well equipment should be deployed and properly connected to equipment on the surface.
- 2.2 After the well is purged according to stabilization criteria through the use of a multi-parameter sonde and flow-through cell setup, the flow can be switched to the filtering apparatus with the 3-position 2-way valve.
- 2.3 Samples requiring no filtration should be collected first.
- 2.4 Upon completion of sample collection the down-well equipment should be retrieved and the well re-sealed and secured.
- 2.5 Samples should be preserved according to requirements of the Quality Assurance Project Plan (QAPP) unless specified otherwise in this SOP.

- 2.6 Non-dedicated equipment should undergo the appropriate decontamination procedures.

3.0 Definitions/Abbreviations

- GPP = Groundwater Protection Program of the Colorado Department of Agriculture
- D.I. = Deionized water obtained through reverse-osmosis
- MP = Measurement Point
- MSDS = Material Safety Data Sheet
- Non-dedicated = Defined in this SOP as any equipment used for sampling a well which is not permanently dedicated to the well
- PM = Project Manager
- QAPP = Quality Assurance Project Plan
- QC = Quick Connect
- SWL = Static Water Level

4.0 Health & Safety Warnings

- 4.1 Some of the equipment used in this method can weigh upwards of 50 lbs and should be lifted with proper lifting technique in order to prevent injury.
- 4.2 Environmental conditions encountered while utilizing this method can become threatening to health and safety.
- 4.3 The gas-powered generator creates the possibility of explosion and exposure to hazardous fumes.
- 10.3. Equipment decontamination involves the use of an alcohol like methanol or isopropanol which must be poured into a stainless steel column. Personnel should be familiar with a MSDS on either of these alcohols and should take the necessary precautions outlined in Section 8: Exposure Controls, Personal Protection of the MSDS.
- Methanol cannot be made non-poisonous regardless of concentration, so take precautions when working with it. Isopropanol is also poisonous but its toxicity in the environment is less than that of methanol.
 - Methanol and isopropanol are highly flammable and can be ignited with a spark, so personnel should be cognizant of this fact and discharge any static buildup prior to attempting to pour either alcohol into the stainless steel column.
 - Given the pressures associated with the use of a peristaltic pump, use of appropriate eye protection is **required** during the decontamination procedure, and recommended for use during the entire sampling event.
 -

5.0 Cautions

- 5.1 There is potential to contact hot surfaces on both the oil-less air compressor and the

inverter generator during and shortly after operation.

6.0 Interferences

- 6.1** The air compressor is of the oil-less variety which should prevent introduction of hydrocarbon constituents to the sampling process; however, there is still the possibility of introduction of air-borne contaminants if the inline filter and moisture trap are not properly maintained according to manufacturer specifications.
- 6.2** It is important to ensure that probes used for measuring various physical parameters of the groundwater are properly calibrated, as explained in QAPP, to prevent any stabilization errors during the purging process or introduction of unnecessary variability.
- 6.3** It is critical to utilize clean, powder-free, nitrile gloved hands when handling any equipment or supplies that will come into contact with sampled water.
- 6.4** It is important to be cognizant of what gloved hands (that will collect groundwater samples) have come in contact with as any contact with any equipment that does not undergo decontamination could potentially lend to cross-contamination of samples.
- 6.5** It is important to prevent contamination of the sample with any foreign matter that may be present in a sampling port or in/on the sampling bottle itself.
- 6.6** It is important to ensure the gas-powered generator is placed down-wind and well away from the location of the well and other sampling equipment to prevent sample contamination with combustion by-products.
- 6.7** Decontaminating the pump and all non-dedicated equipment between sample sites is critical to maintain sample quality and prevent cross-contamination.

7.0 Personnel Qualifications

- 7.1** Personnel should fully understand the procedures outlined in this SOP and the general concepts associated with groundwater sampling as it applies to the goals and purpose of the GPP as well as any rules established by Colorado Division of Water Resources.
- 7.2** Personnel should also be knowledgeable of equipment operability and maintenance, as outlined in QAPP, to ensure proper functionality and prevention of sample contamination.
- 7.3** The PM should be sure that personnel involved with groundwater sampling thoroughly understand this SOP in its entirety.

8.0 Equipment & Supplies

- 8.1** Forms SEF-1 and SEF-2 and Diagrams SED-2 and SED-3 (see Appendix)
- 8.2** All of the following equipment:
 - Well Sounder or other suitable device for measuring depth to groundwater
 - Athena® Peristaltic Pump and necessary tubing

- Spare peristaltic tubing (1/4" ID)
- Geotech 1.66" Stainless Steel Portable Bladder Pump and associated reel and tubing of appropriate length.
 - The GPP currently has two reels to choose from: a smaller reel that has a tubing length of 80 ft and a larger reel with a tubing length of 225 ft,
 - Be sure the reel that is appropriate for the well depths to be sampled is selected and used,
- Solinst 464 Electronic Control Unit
- Spare PTFE bladders, and pump maintenance kit
- All tubing pieces for connection of down-well equipment to the peristaltic pump and three-position, two-way valve, and the filtering apparatus:
 - Spare Teflon-lined PE tubing
 - The Diagram in the Appendix is necessary for understanding how the tubing connects together the different pieces of equipment
- YSI 556-MPS multi-parameter sonde and controller
- 200-mL or 500-mL flow-through cell for integration with multi-parameter measurements
- YSI ProODO sonde on 60-m cable and controller
- Filtering equipment:
 - Stainless Steel Filter Housing
 - Both the 47 mm or the 142 mm stainless steel housing should be available at the site
 - Disposable filters with barbed fitting for attachment to end of sample collection tubing
 - Borosilicate glass microfiber, non-binder, filter discs for use in stainless steel housing
 - Mesh sizes 0.45, 0.7, and 1.0 micron should be available for selection
- Decontamination Supplies:
 - Decontamination Tubes – (2) 4" PVC tubes and (1) 3" Stainless Steel tube in wooden holding rack
 - Tap water and Luminox (or other phosphate-free, biodegradable detergent)
 - D.I. water
 - Methanol (or isopropanol) and D.I. Water mixed 50/50 (vol/vol)
 - There should be sufficient quantity of all decontamination liquids to allow for passing 3X the total internal volume of the sampling setup between each sample site in the network.
- Personal Protective Equipment:
 - Powder-free, nitrile gloves
 - Eye protection
 - Portable emergency eye-wash bottle
- Honda EU-2000 Gas-powered Invertor Generator

- GMC Cyclone 4610A 4-gal Oil-less electric air compressor
- Extension cords (25 to 50 ft)
- (2) Engelman MT60F-U1 Electric Refrigerator
- Other Necessary Gear:
 - Trash bags
 - Spare batteries: (6) C-cell batteries for YSI controllers; (4) AA-cell batteries for Solinst 464
 - Weed Scythe
 - Worktable
 - Shade Tarp, stakes, poles
 - Various clamps

9.0 Sampling Event Procedure

9.1 Site Arrival and Inspection

- Begin sample event documentation as directed in QAPP.
- Ensure that both the sampling equipment and the well are out of direct sunlight through use of a tarp canopy or appropriate orientation of the truck.
 - The exception is the Honda Inverter Generator that can be placed in direct sunlight but should be kept downwind of the well and other sampling equipment used in the sampling event.

9.2 Measuring Static Water Level in Well

- Determine Measurement Point (MP)
 - MP of well should be marked on or near top of PVC riser.
 - It is important to always make measurements from the MP in order to minimize erroneous measurements.
 - Confirm or document the height of the MP above/below the ground surface to at least 1/10th of a foot.
- Deploy Measurement Device
 - This is usually a sounding tape that must be turned on and deployed slowly down the well.
 - Push the 'red' test button to confirm that the unit is working.
 - Turn the sensitivity to maximum.
 - Once the signal is heard the sounder probe has encountered water in the well.
 - With the signal sounding move the marked cable to the MP and record the static water level (SWL) measurement to 1/10th of a foot on Form SEF-1.
 - If Well Depth is not known, the sounder probe can be dropped slowly to the bottom of the well and a measurement to at least 1/10th of a foot can be recorded.

- Retrieve Measurement Device
 - While reeling up probe from well wipe down the cable with a paper towel soaked with D.I. water.
 - Once the probe is at the surface, thoroughly rinse the probe with D.I. water.
 - Precautions
 - Be sure to drop the sounder probe through the well slowly in order to minimize agitation of the *in situ* conditions of the well.
- 9.3 Field Instrument Startup and Calibration Check**
- YSI 556-MPS startup and confirmation that instrument parameters measured with YSI Calibration Confidence Solution are within acceptable ranges.
 - YSI ProODO startup readings and confirmation that D.O. measured in calibration-cup is within 2% of True D.O.
 - True D.O. = Barometric Pressure mmHg (measured by onboard barometer) / 760 mmHg
 - If D.O. measured by either the 556-MPS or the ProODO is not within 2% of True D.O. then calibration is necessary.
- 9.4 Taking Pre-Purge D.O. and Temp Measurements with YSI ProODO**
- There is a screened inlet at the bottom of the Geotech Bladder Pump.
 - The pump inlet should be positioned so a representative groundwater sample is collected.
 - If SWL is ABOVE top of screened interval:
 - The ideal placement of the pump inlet will be in the middle of the screened interval.
 - The length of the screened interval should be known from well construction records.
 - If SWL is WITHIN the screened interval:
 - The ideal placement of the pump inlet will be nearer the bottom of the screened interval.
 - Place the ProODO Sonde at the same depth the pump inlet will be set and record **Time Deployed** on Form SEF-1.
 - After **at least** 5 minutes have passed record **Time Measured** and other measurements under Pre-Pump ProODO Readings on Form SEF-1.
 - Retrieve YSI ProODO sonde from the well ensuring to follow appropriate protocols for cleaning surfaces exposed to groundwater with D.I. water.
 - Precautions
 - Deploy and retrieve the ProODO slowly to minimize agitation of *in situ* conditions.
 - If a sump is part of the well construction be sure to account for it when placing the ProODO, especially when SWL is within the screened interval.
 - A sump is a section of solid PVC casing attached to the bottom of the screened interval so that sediment passing through the well can settle out

and away from the screened portion of the well.

9.5 Placement of Bladder Pump

- **Upon retrieval of YSI ProODO** deploy the Geotech Bladder Pump to its appropriate position within the screened interval of the well.
 - Be sure to secure reel and tubing once pump is in position.
 - Ensure the 2-way valve attached to the inside of the tubing reel is appropriately positioned to allow for necessary tubing connections.

9.6 Connection of Air Supply Lines

- From the GMC Cyclone connect the black air-line hose to the Solinst 464 Controller.
- From Solinst 464 Controller connect the black air-line hose to the bladder pump air-supply line.
- If applicable, locate the saved timings for the sample site.
 - The Solinst 464 has the capacity to store purge time, fill time, and pressure settings information for 99 sample locations.
 - **NOTE** that the pressure must be manually adjusted to match what is saved in the settings information as the controller unit cannot adjust the pressure automatically.

9.7 Stainless Steel Filter Apparatus Preparation

- The 142 mm stainless steel housing has (3) aluminum legs that hold it upright.
 - Take the top of the filter plate off and place on a clean surface.
 - Utilizing nitrile-gloved, clean hands and clean stainless steel forceps, place a 142 mm glass microfiber filter disc on the bottom part of the filter plate and pre-wet with D.I. water.
 - Replace the top of the filter plate and tighten the (3) nuts.
- The 47 mm stainless steel housing has no attachable stand and must be situated into an upright position after it is prepared.
 - **DO NOT** let this filter apparatus lay horizontal as the effective area of filtration will not be optimized.
 - Utilizing nitrile-gloved, clean hands and clean stainless steel forceps, place a 47 mm glass microfiber filter disc on the 'bottom' part of the filter plate and pre-wet with D.I. water.
 - Replace the top of the filter plate and hand-tighten the housing.
- Both of the stainless steel housings have QC fittings that are closed to the environment until Tubing Sections C & D are attached. This minimizes the chance of airborne contaminants from entering the filter housing after it has been prepared and sealed.
 - It is recommended to attach the necessary tubing sections as soon as possible after the filter housing has been prepared.
- **Precautions**
 - If windy conditions exist when trying to prepare the filtering apparatus it may

be necessary to conduct this procedure in a less windy or non-windy area like inside the truck cab.

- If the glass microfiber filter disc is not pre-wetted prior to sealing up the filter housing, the effective filtration will not be optimized and could possibly result in the filter disc rupturing.

9.8 Pre-Startup Connections

- See Diagram SED-2 (Bladder Pump Sampling Scheme) in the Appendix.
- **WHEN FILTER PLATE IS USED:**
 - Tubing Section C has red marked male QC fittings on both ends and indicates that this tubing is used ONLY for collecting groundwater samples. Section C undergoes decontamination procedures.
 - One male QC connects to the red marked QC fitting on the 2-way valve.
 - The other male QC connects to the top (Inlet) of the Filter Plate.
 - As a guide, the air relief valve/screw on the filter plate is on the Inlet Side.
 - Tubing Section D has a red marked male QC that connects to the bottom (outlet) of the Filter Plate. Section D undergoes decontamination procedures.
 - The other end of Section D is where filtered groundwater samples are collected.
- **WHEN A DISPOSABLE FILTER IS USED:**
 - Tubing Section D has red marked male QC fitting that connects to the red marked QC fitting on the 2-way valve.
 - The other end of Section D does not have a fitting and can be utilized to collect UNFILTERED groundwater samples (when necessary) prior to attaching a disposable filter (equipped with a barbed fitting) for collecting filtered groundwater samples.
- Tubing Section F has a yellow marked female QC fitting that connects to the outlet of the flow-through cell.
 - Again, yellow means the tubing passes dirty water and a groundwater sample should NOT be collected from this tubing.
- Tubing Section E has a male QC on the end that will connect to the two-way valve mounted on the inside of the tubing reel.
- The other end of Section E has a female QC that should have the short 1-foot length tubing with a male QC fitting connected to it.

9.9 Monitoring Water Level Drawdown

- This is necessary if there is a concern with the well yield not being able to withstand a pumping rate as potentially as low as 100 mL min^{-1}
 - If there is concern of inadequate well yield:
 - Install the well depth probe so that it is actively (audible or visual signal) monitoring the top of the water column in the well.
 - The depth to this point should still be the same that was recorded in

Section 9.2.

- If there is NO concern with inadequate well yield, then it is not necessary to monitor water level drawdown when pumping up to the maximum attainable rate of the Athena® Peristaltic Pump.

9.10 Pump Startup and Well Purging

- **Ensure** that Tubing Section E is **NOT** connected to the flow-through cell but instead has the short 1-foot length tubing attached to it.
 - Place the open end of the 1-foot section into the calibrated 2-liter Nalgene jug.
- **Before continuing** be sure to record the following details on Form SEF-1:
 - Pump Depth (approximate)
 - Starting Ambient Conditions
 - Indicate whether QC sample(s) will be collected and what type(s)
 - Indicate whether Split sample(s) will be collected
 - Indicate sample filtration setup with regard to filter type, filter matrix, manufacturer Lot #, filter diameter, and filter housing
 - Indicate whether any samples (and if applicable, which samples) are chemically preserved.
 - The normal agrichemical analyte list screened for by the Program does not require chemical preservation of any sample bottles.
- **Ensure** the 2-way valve is positioned to direct flow to the flow-through cell.
- Record **Time Pump Start** while simultaneously turning on the Solinst 464 controller.
- Adjust pump settings to meet the following requirements:
 - Match the pressure setting from the previous sampling event (if applicable).
 - Obtain a flow-rate that does not result in water level drawdown in the well as measured by the Well Depth Sounder installed in **Section 9.5** (if applicable).
 - Minimizes the agitation of water in the well to prevent increased turbidity of the pumped water.
 - Does not introduce air bubbles into the line due to over-pressurization of the bladder.
- The tubing on the reel is stored with a methanol/water mixture in the tubing which needs to be purged out prior to connecting the discharge to the flow-through cell.
 - This ensures that the sensors on the YSI 556-MPS sonde are not adversely affected by the methanol.
 - A total purge of at least 1000 mL is necessary to flush the tubing and the bladder.
- **Once the tubing is purged**, then Tubing Section E can be connected to the bottom of the flow-through cell.

- The short 1-foot tubing section will need to be removed in order to make this connection to the flow-through cell.
- This step can be done quickly when in between discharge cycles or the Solinst 464 can be stopped.
- **Important!** Do not allow the Solinst controller to continue running if Tubing Section E is not plugged into either the flow-through cell or the short 1-foot tubing section. Doing so would cause there to be no outlet for the water which could cause pressure to build up in the bladder which might induce seals to leak.
- Determining Flow-Through and Measurement Cycle Times
 - Start timer when water in tubing begins discharging into the flow-through cell.
 - Stop timer when water begins discharging out of Tubing Section F and record **FC Cycle Time**.
 - On average – FC Cycle Time will be 1 to 1 ½ minutes.
 - Add approximately 30-60 seconds to that time in order to ensure the ability of personnel to accurately document information and conduct other necessary sampling event details in between purging measurements.
 - On average – **YSI Read Frequency** will be 2 to 3 minutes.
- Once FC Cycle Time and YSI Read Frequency have been determined and documented, record **Time Purge Start** and record the first set of measurements on Form SEF-2 (Purging Parameter Information Sheet).
- Continue to record measurements at the YSI Read Frequency rate (or greater) until three consecutive measurements meet the Stabilization Criteria found at the top of Form SEF-2 **and** found below:
 - Temperature: ± 0.2 °C
 - pH: ± 0.2 units
 - Specific Conductance:
 - $< 100 \mu\text{S cm}^{-1} \pm 3.0\%$
 - $> 100 \mu\text{S cm}^{-1} \pm 5.0\%$
 - ORP: ± 20 mV
 - D.O.: $\pm 2.0\%$ of reading or 0.2 mg L^{-1}
- **Upon stabilization** of parameters, record **Time Stabilized** on Form SEF-2.

9.11 Sample Collection

- **Upon Completion** of adequate purging switch 2-way valve to direct discharge to the filtration setup.
 - Ensure the filtering setup is in place as according to need or no need of filtration outlined in **Section 9.8**.
- **Ensure** all labels on sample bottles are populated with the **Sample Date** and **Time Sample Collected** and that they match what is recorded on Form SEF-1.
- Collection of Unfiltered Samples:

- Unfiltered samples can be collected from the end of Tubing Section C before it is connected to the inlet of the stainless steel filter housing.
 - **If a disposable filter is planned for use** then the unfiltered samples will be collected from Tubing Section D as outlined in **Section 9.4**.
 - Collection of Filtered Samples:
 - If necessary, connect Tubing Section C to the filter plate inlet.
 - **WARNING!** Ensure that Tubing Section D is already connected to the filter plate outlet or the back pressure may weaken seals and connections.
 - Open the pressure release valve (PRV) on top of the filter plate until water begins to emerge from it and then re-close the valve.
 - Purge an adequate amount of water to ensure a triple purging of Tubing Sections C & D as well as the filter housing prior to beginning sample collection.
 - On average with one person conducting the sampling event, this will amount to upwards of 500 mL of water before sampling begins.
 - If a disposable filter is being used at the end of Tubing Section D as outlined in **Section 9.4** the same purging criteria should be used.
 - **High Turbidity!** This can cause clogging of the filter matrix and purging and sampling should be conducted as quickly as possible.
 - Order of Collection for Filtered Samples
 - The Program has a fairly set and defined sample need for the purposes of agrichemical evaluation (see QAPP), but if different sample types are required of the sampling event the following sampling order should be executed from most to least sensitive:
 - Volatile Organic Compounds (VOCs)
 - Total Organic Carbon (TOC)
 - Total Organic Halogen (TOX)
 - Samples Requiring Field Filtration
 - Samples for Additional Field Parameter Measurement (Independent of Purging Data, i.e. alkalinity)
 - Large-Volume Samples for Extractable Organic Compounds
 - Samples for Nutrient Anion Determinations
- 9.12 Upon Completion** of sample collection turn the Solinst 464 controller off and record **Time Pump Terminated**.
- This information will be useful in understanding the total volume of water removed from the well during the sampling event.
- 9.13 Post-collection Sample Preservation and Storage**
- Collected samples should be promptly secured in a cooler maintained at $< 10^{\circ}\text{C}$ as according to the Program's QAPP.
- 9.14 Retrieve instrumentation and pump from well** ensuring that exterior surfaces are

wiped down with D.I. soaked paper towel during retrieval.

- Any instrument probes or other down-well pump equipment should be thoroughly rinsed with D.I. water to remove visible particles.

9.15 Remove and dispose of glass microfiber filter disc from filtering apparatus, rinse housing internals with D.I. water, reassemble filter plate, and reconnect Tubing Sections B & D.

- If a disposable filter is used remove it from the end of Tubing Section D and discard it in the trash.

9.16 Decontamination of Equipment Used in Sample Collection

- See Diagram SED-3 (Bladder Pump Decontamination Scheme) in the Appendix.
- Once the decontamination adapter is placed over the bladder pump inlet, attach Tubing Section B to the back female QC fitting on the silicone tubing clamped into the Athena® Peristaltic Pump.
- Tubing Section G is a 5-ft long Teflon-lined PE tubing with a stainless steel foot-valve screwed into one end and a male QC fitting on the other.
 - The foot-valve end should be installed into decontamination Column 1
 - The male QC should be attached to the front female QC fitting on the silicone tubing clamped into the Athena® Peristaltic Pump.
- The total internal volume of surface to be decontaminated with this setup is at a maximum the additive volumes of the bladder pump tubing on the reel, the bladder volume, Tubing Sections C and D, plus the filter housing (if used).
 - This is approximately 1000 mL worth of volume that will require at least 3000 mL of each decontamination fluid to be passed through for a triple rinse.
- The Athena® Peristaltic Pump can run at maximum capacity during the entire decontamination procedure.
 - The Decontamination Adapter must be adequately tightened to ensure the pressure generated by the Athena® Peristaltic Pump does not leak decontamination fluids around the bladder pump inlet.
- The pump inlet at the end of Tubing Section G is placed in **Column 1**, filled $\frac{3}{4}$ full with tap water and a phosphate free, biodegradable detergent and the appropriate volume is cycled through.
- The pump inlet is then moved to **Column 2** filled $\frac{3}{4}$ full with D.I. water and the appropriate volume is cycled through.
- The pump inlet is then moved to **Column 3** (stainless steel) filled nearly full with a 50/50 (vol/vol) mixture of methanol (or isopropanol) and D.I. water, and the appropriate volume is cycled through.
- **Upon completion** of cycling the contents of all three columns through the decontamination setup, the pump can be terminated and the different tubing sections can be drained and stored in clean, sealable plastic bags.
- The screened inlet of the bladder pump should be inspected and verified as clean of visual particles.
- The inside of the decontamination adapter should be rinsed with D.I. water before

being stored.

- The internal surfaces of the stainless steel filter housing should be rinsed of alcohol residue with D.I. water before reassembling and tightly sealing the filter plate for storage.

9.17 Disposal of Decontamination Fluids

- The detergent used in Column 1 can be dispersed of on any ground surface with care taken to prevent any deposition into the well itself.
- The methanol or isopropanol and D.I. water mixture can be toxic to birds, wildlife, aquatic species, and soil organisms so it should not be disposed of in a fashion that endangers any of these pathways.
 - If there is no spot around the well to dispose of the mixture onto an impermeable or insignificant surface without causing harm to the local environment, then the mixture should be captured and transported to the laboratory for disposal.

9.18 Wrapping up Sampling Event

- Ensure cap is properly replaced on the well riser and that the protective casing is sealed and locked.
- Ensure the following information is recorded/confirmed on Form SEF-1:
 - Ending Ambient Conditions and/or notes
 - Indication of whether decontamination procedures were completed
 - Event Notes (as necessary)
- Record **Time Depart** on Form SEF-1

10.0 Data and Records Management

10.1 Be sure that Form SEF-1 is filled out as thoroughly as possible.

- Any well construction information is useful.
- Well Permit # is very helpful in gathering well information.
- Any pertinent discussion with land or well owner.

10.2 Store all documentation for the sampling event in the network-specific 3-ring binder until they can be digitally entered in the office as outlined in the QAPP.

- In the event that digital sampling event documentation forms are used for data collection in the field, it is important to follow the data handling requirements in the QAPP.

SOP GPP-3 Purging and Sampling Domestic or Irrigation Wells

1.0 Scope & Applicability

- 1.1 This SOP will show how to properly collect a representative groundwater sample from a domestic or irrigation type well through adequate purging of necessary plumbing components and collection of a sample that is not unnecessarily impacted by various components that may exist in a constructed domestic or irrigation well setup.
- 1.2 Measurements with a multi-parameter meter may not be made on every sampled domestic or irrigation well, but this SOP highlights how such measurements should be made.
- 1.3 The GPP primarily samples domestic and irrigation wells through currently installed plumbing feeding a surface discharge point where the sample can be collected.
- 1.4 Current Colorado regulations allow authorized individuals, professional engineers, geologists, and hydrologists to remove a domestic water-supply well seal for the purposes of measuring water levels, collecting samples, and the installation of pumps dedicated solely to scientific, engineering or regulatory purposes. However, this provision also requires that the person removing the well seal be responsible for disinfecting the well and reinstallation of the seal per the requirements of the Colorado Division of Water Resource's "Water Well Construction Rules" (2 CCR 402-2). If the planned sampling involves removing a well seal, Program personnel will need to meet the requirements of the above mentioned rule and have available the appropriate resources needed to thoroughly disinfect the well.
 - Thorough disinfection of the well also means that any non-dedicated equipment used to obtain the sample needs to be decontaminated **before** using it in another well.
- 1.5 It is the ultimate responsibility of the PM to ensure that the procedures outlined in this SOP are strictly adhered to and that QA/QC is maintained at a premium.

2.0 Summary of Method

- 1.6 Upon determining the point of discharge that is closest to the well and free of any components that may compromise sample representativeness (water softener, filtration media, disinfection, or pressure tanks) the well is adequately purged.
- 1.7 After adequate purging, filtered (if possible) and unfiltered samples are collected from the point of discharge.
- 1.8 Decontamination of any non-dedicated sample equipment used for sampling.

3.0 Definitions/Abbreviations

- CAFO = Concentrated Animal Feeding Operation

- GPP = Groundwater Protection Program of the Colorado Department of Agriculture
- D.I. = Deionized water obtained through reverse-osmosis
- GPS = Global Positioning System
- MSDS = Material Safety Data Sheet
- Non-dedicated = Defined in this SOP as any equipment used for sampling a well which is not permanently dedicated to the well
- PM = Project Manager
- PWS = Public Water Supply
- QAPP = Quality Assurance Project Plan
- QC = Quick connect

4.0 Health & Safety Warnings

- 4.1** Decontamination of non-dedicated equipment can involve the use of methanol. Personnel should be familiar with an MSDS on methanol and should take the necessary precautions outlined in Section 8: Exposure Controls, Personal Protection of the MSDS.
- Methanol cannot be made non-poisonous regardless of concentration so take caution when working with it.
 - Methanol is highly flammable and can be ignited with a spark so personnel should be aware of this and discharge any static buildup prior to attempting to pour the methanol into the stainless steel column.

5.0 Cautions

- 5.2** There are no cautions outside of the Health & Safety Warnings above

6.0 Interferences

- 6.1** If used, it is important to ensure that the multi-parameter probe is properly calibrated as explained in the GPP's QAPP to prevent any stabilization or reading errors.
- 6.2** It is important to prevent contamination of the sample with any foreign matter that may be present in a sampling port or in/on the sampling bottle itself.
- 6.3** Decontaminating the pump and all non-dedicated equipment between sample sites is critical to maintain sample quality and prevent cross-contamination.

7.0 Personnel Qualifications

- 7.1** Personnel should fully understand the procedures outlined in this SOP and the general concepts associated with groundwater sampling as it applies to the goals and

purpose of the CDA-GPP as well as any rules established by Colorado Division of Water Resources.

- 7.2** Personnel should also be knowledgeable of equipment operability and maintenance as outlined in the QAPP to ensure proper functionality and prevention of sample contamination.
- 7.3** The PM should be sure that personnel involved with groundwater sampling thoroughly understand this SOP in its entirety.

8.0 Equipment & Supplies

8.1 Forms SEF-1 and SEF-2

8.2 All of the following equipment:

- 2-Liter Nalgene jug (or equivalent)
- Teflon-lined-PE tubing sections with hose bib attachment and stainless steel QC fittings to connect different sections
- YSI 556-MPS multi-parameter sonde and controller
- Disposable filters with barbed fitting for attachment to end of sample collection tubing
- Decontamination Supplies:
 - Tap water and Luminol (or other phosphate-free, biodegradable detergent)
 - D.I. water
 - Methanol and D.I. water mixed 50/50 (vol/vol)
 - There should be sufficient quantity of all decontamination liquids to allow for triplicate cleaning of non-dedicated, reused sample tubing.
- GPS
- Personal Protective Equipment:
 - Powder-free, nitrile gloves
 - Eye protection
- (2) Engelman MT60F-U1 Electric Refrigerator (or other non-electric cooler equipped with sufficient “wet” ice)
- Other necessary gear:
 - Trash bags
 - Spare batteries: (4) C-cell; (2) AA-cell
 - Weed Scythe
 - Worktable
 - Shade Tarp, stakes, poles
 - Various clamps
 - Writing utensils
 - Clipboard

9.0 Procedure

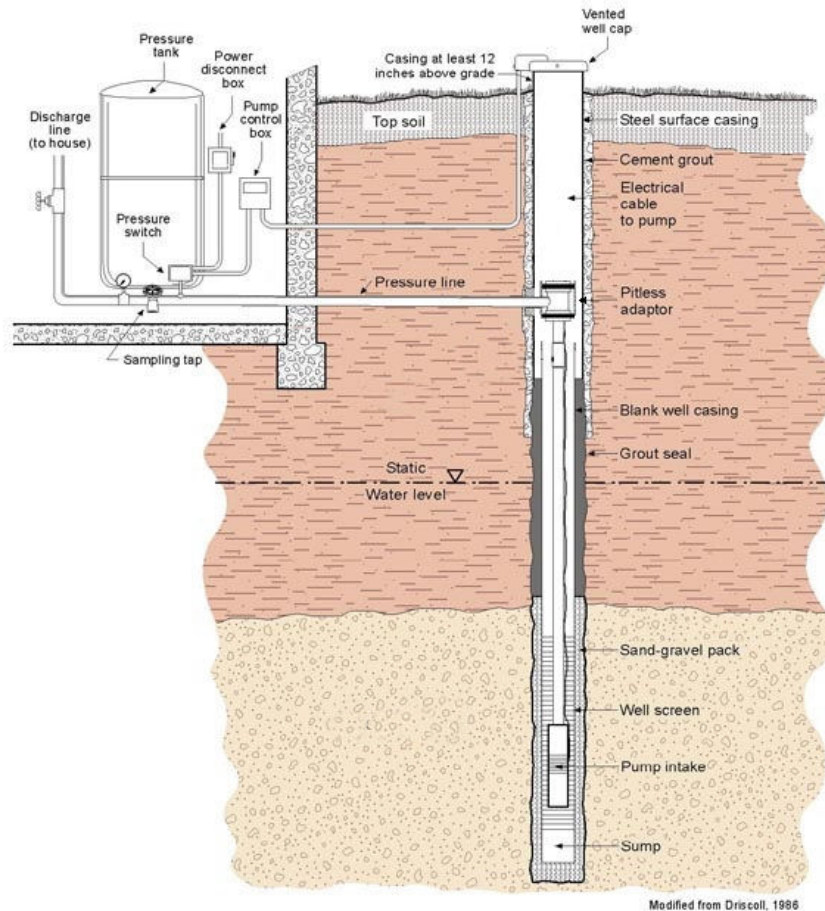
9.1 Site Arrival and Inspection

- Begin sample event documentation as directed in QAPP.
- Ensure that both the sampling equipment and the well are out of direct sunlight through use of a tarp canopy or appropriate orientation of the truck.
 - This may not be possible in all cases, but of primary concern is to ensure that collected samples are not unnecessarily exposed to conditions that may compromise their integrity and representativeness

9.2 Locating Well Construction Elements / Selecting Sample Point

• Domestic and Household Water System Setup

- Most present-day domestic wells have been driven or drilled and have a steel casing installed with an aluminum or steel cap on the surface or below the surface in a pit or accessible man-hole.
- Most present-day wells have a submersible pump installed into the well but some may have a motorized pump on the surface that draws water from the aquifer through tubing placed into the well.



- Most present-day wells have a pressure tank incorporated for creating the necessary pressure for efficiently delivering well water to the various points of

use.

- If a cistern is used a pressure tank will likely be installed after the cistern.
 - If the cistern is at a sufficient elevation above the points of use to provide adequate pressure then a pressure tank may not be in use
- A pressure tank may also be directly attached to the pump outlet.
 - An exception would be if the tapped aquifer is under sufficient natural pressure (artesian) to provide adequate pressure.
- Sometimes well water will flow through one or more of the following water treatment systems:
 - Filtration systems
 - Could be a membrane barrier, a biological process, or a sediment catching matrix
 - Water softeners
 - Used for treating hardness which involves replacing the ions of Ca^{+2} and Mg^{+2} with those of Na^{+} and K^{+}
 - Distillation Systems
 - Involves a process of boiling water and subsequent condensation of steam to remove solid contaminants
 - Disinfection with Chlorine (or the like) or Ultra-violet Radiation
 - Can be a physical (ultraviolet light, electronic radiation, or heat) or chemical (chlorine, chlorine dioxide, ozone) process
- **Sampling Point Options**



- Frost-free hydrant
 - Emerging from top of well casing or installed in between well and pressure tank/cistern
 - Installed after pressure tank



- Outside hose bib
 - Installed on top of well or on section of plumbing between well and

pressure tank/cistern

- Installed after pressure tank



- Inside faucet
 - Very likely this option will be after a pressure tank and/or cistern
 - Ensure faucet is not after any water treatment systems
 - Select a faucet that is closest to where the main water line enters the building AND that which has the capability of removing the aerator

- **Irrigation Well Setup**

- Most irrigation wells are large-diameter well casings that were drilled and have a high capacity, submersible pump installed.



- Some lower yielding setups may have a motorized pump on the surface that withdrawals water through tubing inserted into the well.
- Irrigation wells usually have a large pump motor housing that is either unenclosed on the surface or sheltered within a small structure.
- Most of the plumbing from an irrigation well is visible on the surface but may include a pipe that goes underground towards an output source some distance and direction from the well.
- **Sampling Point Options**
 - Pipe Outlet



- To Irrigation Ditch or to land surface
- Gated Pipe Outlet to Furrow



- Center-Pivot Discharge



- From leak nearest well or from drop tube outlet closest to well
- From anti-siphon/pressure relief valve on irrigation well pipe



- **CAUTION:** Be sure to avoid taking an irrigation well sample from a location that is down-stream of a chemical input (chemigation). Be sure to note any potential influence such a input might have on the sample collected.

9.3 Purging the well and associated plumbing

- It is important to purge the well casing and plumbing as thoroughly as possible prior to collecting a sample.
 - It may not be possible to get desired amount of purging if the conditions (sampling location) or well owner does not prefer to run the well for extended lengths of time (usually irrigation well owners).
- If the selected sampling location is after a large cistern, it will not be possible to entirely replenish the tank with freshly pumped groundwater.

- In this case it is important to thoroughly purge the plumbing between the cistern and the selected sampling location.
- **If Using Multi-Parameter Probe**
 - Usually this is only utilized on domestic wells with a suitable frost free hydrant or hose bib for connecting necessary tubing to.
 - This allows for use of the 2-Liter Nalgene Jug and tubing in a configuration that minimizes the introduction of air for more accurate dissolved oxygen measurements.
 - If the necessary hose attachment is not available, grab samples spaced at 2-3 minute collection intervals can suffice to provide measurements for most of the stabilization criteria.
 - Ensure multi-parameter probe is properly calibrated prior to use as according to QAPP.
 - Utilizing Form SEF-2, record measurements every 2-3 minutes until the following criteria are met:
 - Temperature: ± 0.2 °C
 - pH: ± 0.2 units
 - Specific Conductance:
 - $< 100 \mu\text{S cm}^{-1} \pm 3.0\%$
 - $> 100 \mu\text{S cm}^{-1} \pm 5.0\%$
 - ORP: ± 20 mV
 - D.O.: $\pm 2.0\%$ of reading or 0.2 mg L^{-1}
 - If grab samples are being collected the D.O. readings can only be used as estimates and will not likely stabilize over multiple measurements.

9.4 Collection of samples

- **Upon** completion of purging, samples can be collected.
 - If the necessary tubing required for attaching a disposable filter capsule are not in use then no samples can be field filtered.
 - This is usually the case with any of the sampling point options for irrigation wells and also for any domestic wells that have excessive pressure.
 - If a disposable filter is being used then it should be attached to the tubing connected to the frost free hydrant or hose bib.
 - Order of Collection for Filtered Samples:
 - The GPP has a fairly set and defined sample need for the purposes of agrichemical evaluation (see QAPP), but if different sample types are required of the sampling event the following sampling order should be executed from most to least sensitive:
 - Volatile Organic Compounds (VOCs)
 - Total Organic Carbon (TOC)
 - Total Organic Halogen (TOX)
 - Samples Requiring Field Filtration

- Samples for Additional Field Parameter Measurement (Independent of Purging Data, i.e. alkalinity)
- Large-Volume Samples for Extractable Organic Compounds

9.5 Decontamination of tubing (As Necessary)

- It is important to decontaminate the tubing used for collecting samples from the frost-free hydrant or hose bib of a domestic well.
- Decontamination of the sampling tubes is difficult because it involves having to manually pour water into the tubes in order to flush them out.
 - It will be necessary to hold a finger on one end of the tubing while filling the other end in order to thoroughly flush the two sections of tubing.
 - Once the tubing section is filled with the selected decontamination fluid, agitate by shaking the tubing with both ends sealed.

9.6 Finishing Up at Sample Site

- Be sure any sampling ports used are turned off completely.
- Close any doors/gates or locks before leaving.
- Clean up any trash and leave the area better than your found it.

10.0 Data and Records Management

10.1 Be sure that the necessary field forms are filled out as thoroughly as possible.

- Ask the well owner about any well construction information that may impact sample results.
- Getting the well permit # is very helpful in determining well construction.
- Store the sampling sheets in the 3-ring binder until you can get back to the office to input them into the computer.

10.2 In the future it may be possible that CDA-GPP personnel will be using electronic devices to record and store data while at the sample site.

- If this technique is used then upon arrival to the office be sure to download the PDA onto a PC and backup the file.

10.3 All collected data should be uploaded and stored as according to the QAPP.

FORMS

FORM SEF-1 Sample Site Information Sheet

Sample Site Information Sheet (FORM SEF-1)

WellCode: _____ Sample Date: _____ Sample Party: _____ Sample Personnel: _____
 SampleCode: _____ Time Arrive: _____ Time Sampled: _____ Time Depart: _____

WELL INFORMATION

Location LATDdeg: _____ LONDDeg: _____ GEODatum: _____
 UTMEastg: _____ UTMNorthg: _____ UTMDatum: _____
 LandElevation: _____ GWFlowDir: _____
 County: _____ MonitoringNetwork: _____ ConservationDistrict: _____
 AquiferType: _____ AquifDesc: _____ AquifName: _____
 HUCRegion: _____ HUCSubRegion: _____
 HUCBasin: _____ HUCSubBasin: _____
 PhysLocDetail: _____
 WellheadLocDetails: _____
 LocationComments: _____

Construction/Use Construction: _____

Measure Point (MP): _____ MP Datum to Ground Surface (+/- ft): _____
 Measurements from MP (ft): _____ Total Depth: _____ TPERF: _____ BPERF: _____
 Sump(Yes/No): _____ Sump Length: _____ Top Sump: _____
 WellTypeUse: _____ LawnIrrig? Yes/No _____ Livestock? Yes/No _____ DrinkWater? Yes/No _____ DWSource _____

Condition Well Status: Good / In Need of Repair _____ Protection Casing Sealed? Yes/No _____ Riser Sealed? Yes/No _____
 Repair Items: _____

Ownership

OwnerType: _____	OwnerName: _____	ATTN: _____	City: _____	St: _____	Zip: _____
AddressType: _____	Address: _____			Send Mail To? Yes/No	
ContactType: _____	ContactInfo: _____				
ContactType: _____	ContactInfo: _____				

OwnerType: _____	OwnerName: _____	ATTN: _____	City: _____	St: _____	Zip: _____
AddressType: _____	Address: _____			Send Mail To? Yes/No	
ContactType: _____	ContactInfo: _____				
ContactType: _____	ContactInfo: _____				

SAMPLING INFORMATION

Ambient Conditions START Temp(°C): _____ Cloud Cover(%): _____ Wind Speed(mph): _____ Wind Direction: _____
 END Temp(°C): _____ Cloud Cover(%): _____ Wind Speed(mph): _____ Wind Direction: _____
 Notes (dust/odors/etc): _____

Equipment Used PumpType: Peristaltic / Bladder / Other _____ YSI 556-MPS Used? Yes/No _____ YSI ProODO Used? Yes/No _____
 Sample Tube Information: Inside Diameter _____ Unit _____ Length _____ Unit _____
 PumpSettingComment: _____

Instrument Check

556-MPS Last Full Calibration: Date: _____ Time: _____ Personnel: _____
 Confidence Solution Check: Date: _____ Time: _____ Personnel: _____
 Solution Ranges: T(°C): _____ SC (uS/cm): _____ ORP (mV): _____ pH: _____
 Measured Values: T(°C): _____ SC (uS/cm): _____ ORP (mV): _____ pH: _____
 Notes: _____

ProODO Last Calibration: Date: _____ Time: _____ Personnel: _____
 Startup Readings: T(°C): _____ DO(mg/L): _____ BP(mm Hg): _____ / 760 mmHg = _____ (True DO)

Measurements SWL: Last Sampling: _____ ft PumpDepth: Last Sampling: _____ ft ProODODepth: Last Sampling: _____ ft
 This Sampling: _____ ft This Sampling: _____ ft This Sampling: _____ ft
Pre-Pump ProODO Readings
 Time Deployed: _____ Time Measured: _____ T(°C): _____ DO(mg/L): _____ DO(%Sat): _____

Filtration Filtered Samples Collected?: Yes/No _____ Un-Filtered Samples Collected?: Yes/No _____
 Filter Type: _____ Filter Mesh Type: _____ Filter Mesh Size: _____ µm Filter Man Lot #: _____

Samples Collected QA/QC? Yes/No _____ Type: Replicate / Blind Replicate / Rinse / Spike / Trip Blank _____
 Type ID(s): _____ Type Notes: _____
 SPLIT? Yes/No _____ Split Lab(s): _____ Analyzes: _____

Preservation Sample Chemically Preserved? Yes/No _____ Preservative Description: _____
 Samples Placed in Cooler? Yes/No _____ Temperature of Cooler: _____ °C

DECONTAMINATION COMPLETE? Yes / No NOTE: _____

Previous Sampling Event Notes

Sample Comment: _____

Permit Own Comment: _____

Land Own Comment: _____

Other Comment: _____

Current Sampling Event Notes

Sample Comment: _____

Permit Own Comment: _____

Land Own Comment: _____

Other Comment: _____

Land Use Land Cover (500-m buffer w/ preference to upgradient LULC)

LULC MAIN #1: Crop/Pasture (Dryland / Irrigated) Other Ag Urban/Built-up Rangeland Water Other

Comment: _____

Distance: _____ Unit: _____ Direction: _____

Sub #1: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

Sub #2: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

Sub #3: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

Sub #4: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

LULC MAIN #2: Crop/Pasture (Dryland / Irrigated) Other Ag Urban/Built-up Rangeland Water Other

Comment: _____

Distance: _____ Unit: _____ Direction: _____

Sub #1: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

Sub #2: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

Sub #3: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

Sub #4: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

LULC MAIN #3: Crop/Pasture (Dryland / Irrigated) Other Ag Urban/Built-up Rangeland Water Other

Comment: _____

Distance: _____ Unit: _____ Direction: _____

Sub #1: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

Sub #2: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

Sub #3: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

Sub #4: _____ Distance _____ Direction _____

(FOR IRRIGATED CROP) Type: _____ Source: GW / SW Comment: _____

DIAGRAMS

DIAGRAM SED-1 Peristaltic Pump Sampling Scheme

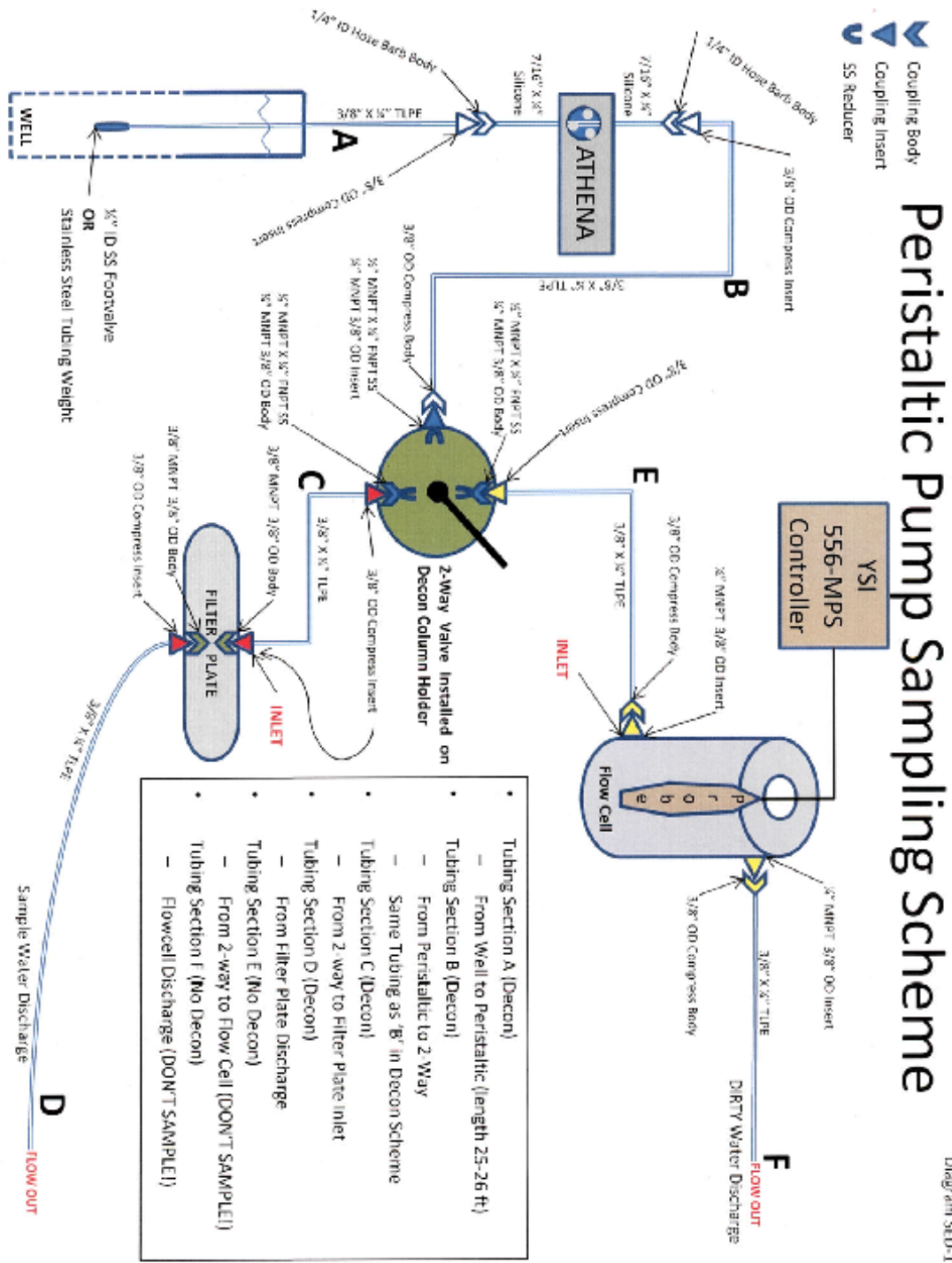
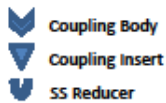


DIAGRAM SED-2 Bladder Pump Sampling Scheme



Bladder Pump Sampling Scheme

Diagram SED-2

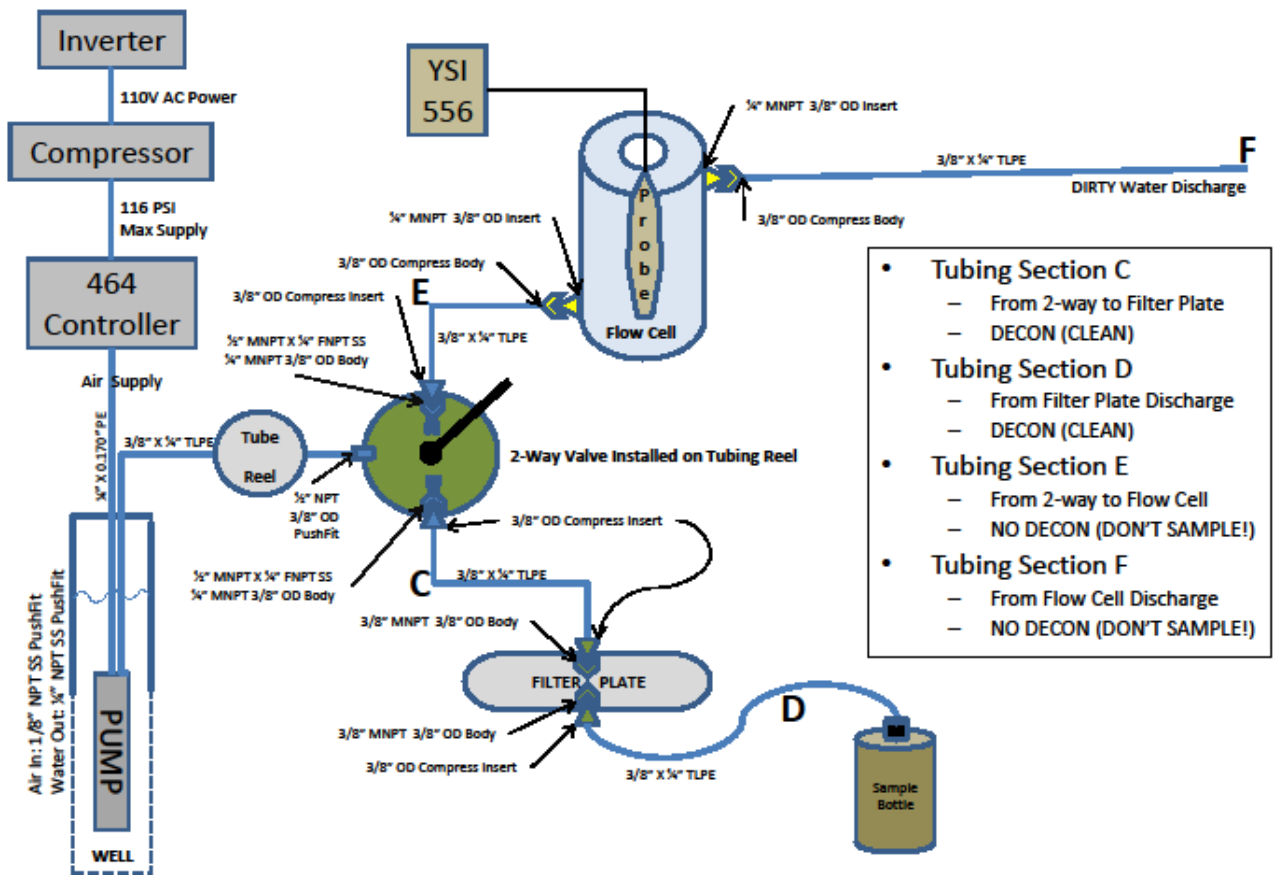





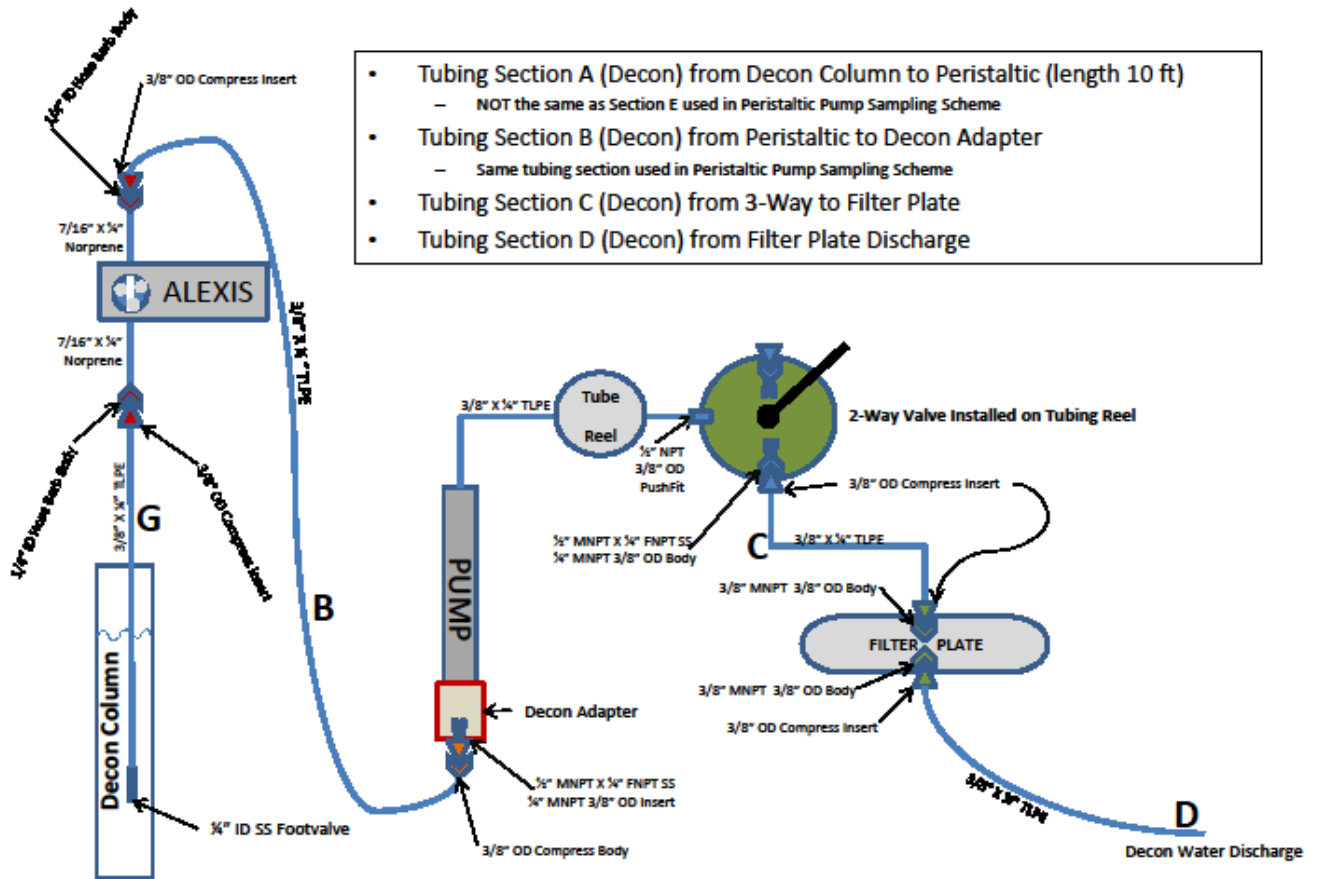
DIAGRAM SED-3 Bladder Pump Decon Scheme

Diagram SED-3

-  Coupling Body
-  Coupling Insert
-  SS Reducer

Bladder Pump Decon Scheme

- Tubing Section A (Decon) from Decon Column to Peristaltic (length 10 ft)
 - NOT the same as Section E used in Peristaltic Pump Sampling Scheme
- Tubing Section B (Decon) from Peristaltic to Decon Adapter
- Tubing Section C (Decon) from 3-Way to Filter Plate
- Tubing Section D (Decon) from Filter Plate Discharge



REFERENCES

1. Rules And Regulations for Water Well Construction, Pump Installation, Cistern Installation, and Monitoring and Observation Hole/Well Construction (Water Well Construction Rules), 2 CCR 402-2, Effective Date January 1, 2005
2. Nielsen, David M. Practical Handbook of Environmental Site Characterization and Groundwater Monitoring. 2nd Ed. September 28, 2005 by CRC Press

REVISIONS

All revisions made to any portion of this document after its inception, should be listed in a format similar to the one shown below in the box.

Revision: Adjust decontamination protocol
Date of Revision: January 08, 2007
Revision made by: Karl Mauch
Position Title: Groundwater Monitoring Specialist
Description of Revision:

- Updated the header and footer as necessary
- Included final peer reviewed SOPs for field tasks

Revision: Initial documentation and development of Field SOP Manual

Date of Revision: February 2014

Revision made by: Andrew Ross & Karl Mauch

Position Title: CDPHE & CDA

Description of Revision(s):

- Created the initial format and content of this manual
- Created accompanying FORMS and DIAGRAMS

Revision:

Date of Revision:

Revision made by:

Position Title:

Description of Revision:

-