Last Updated:
November 15, 2011

Voluntary Baseline Groundwater Quality Sampling Program

Example Sampling and Analysis Plan
Developed in Cooperation with the
Colorado Oil and Gas Conservation Commission

Prepared by:

Colorado Oil & Gas Association

1660 Lincoln Street
Suite 2710
Denver, CO 80264
(303) 861-2387

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

1.0 PROGRAM OVERVIEW

The Colorado Oil & Gas Association (COGA) has developed a voluntary groundwater testing program (the COGA Program) to establish baseline groundwater quality conditions around new oil and gas well locations and to monitor water quality in the vicinity of the oil and gas wells before and after drilling and completion activities have concluded.

Under the COGA Program, water samples will be collected from the two closest groundwater features with reasonable access, such as permitted and registered groundwater wells or groundwater seeps and springs, which are located within ½ mile of the surface location of newly developed oil and gas well pads or new expansions of existing oil and gas well pads. These baseline samples will be collected prior to the setting of the well conductor casing. A second sample will be collected from each of the groundwater features within one year of well completion, unless prior notification is filed with the Colorado Oil and Gas Conservation Commission (COGCC) (see Section 1.3 for pads with multiple wells).

Sampling will only be conducted if landowner access is granted and the landowner agrees that the laboratory analytical results will be submitted to the COGCC for posting to a database that can be viewed by the public.

Post-completion samples will also be collected from wells from which baseline samples were collected in response to landowner complaints of a distinct or measurable change in water quality, such as a change in odor, color, taste, or turbidity. If the landowner grants expeditious access and agrees that all data may be released to COGCC for posting to a public database, operators will make a best effort to collect a sample within 48 hours of notification. Operators will notify the COGCC upon receipt of a complaint.

All samples will be collected by individuals experienced with water quality sampling and sent to a laboratory accredited by the National Environmental Laboratory Accreditation Program for analysis. Laboratory results will be provided to each landowner within three months of collecting the sample. Laboratory results for baseline, post-completion and complaint response samples will be submitted to the COGCC within three months of collecting the sample(s) for inclusion in its electronic database. The data will be posted and made available to the public through the COGCC's website within three months after complete data are provided to the COGCC in the approved electronic data delivery (EDD) format.

COGCC and COGA will review the COGA program annually. COGA will generate a written summary report to be presented to the Commission at one of its hearings.

For further program details, please see http://www.coga.org/

1.1 Who is Eligible to Participate?

The COGA Program was developed based on input from industry participants and the COGCC. Participation in the COGA Program is voluntary and is not restricted to COGA members. Any operators drilling and completing oil and gas wells in Colorado may participate by simply notifying COGA of their intent to participate and agreeing to comply with all program guidelines. Participating operators will be required to annually confirm by written response to a COGA inquiry that they are following the program guidelines outlined in this example Sampling and Analysis Plan (SAP).

1.2 Location Restrictions

The COGA Program may be implemented in all areas of the state. However, operators are cautioned that participation in COGA's Program does not exempt them from nor change mandatory baseline groundwater monitoring requirements, such as COGCC's Greater Wattenburg Area Rule 318A.e.(4), COGCC's Coalbed Methane Wells Rule 608.b, or existing field-wide orders (such as various Ignacio-Blanco field orders in the San Juan Basin). Operations in the areas covered under these rules are not required to collect additional samples for COGA's Program.

1.3 Application to Pads with Multiple Wells

When multiple wells will be constructed on a single pad or as part of an expansion of an existing pad, baseline samples will be collected prior to installing the conductor casing of the initial well. These samples will serve as baseline for the initial well plus all future wells on that pad.

Post-completion samples must be collected every two years while wells are actively being drilled and completed on a pad, and within one year following completion of the final well on the pad.

If well additions or completion activities on the pad are suspended for more than a year, post-completion samples must be collected within one year of the last well completion. No further sampling is necessary until drilling and completion activities resume.

Analytical results can be applied to any wells completed on the pad prior to the sampling event.

1.4 Program Guidelines

This example SAP presents guidelines for oil and gas operators and their consultants and contractors to follow when collecting groundwater data as part of the COGA Program. The procedures for groundwater sampling presented herein have been developed to ensure the groundwater samples are collected and analyzed in a consistent manner and will accurately represent existing conditions at the site.

The primary objective of this SAP is to identify proper field data collection and data management procedures to:

- Provide consistency in data collection;
- Allow uniform and efficient data handling and transfer; and
- Provide clear documentation of sample locations, field procedures, and analytical methods.

This section provides an introduction to the COGA Program. Section 2.0 identifies detailed procedures for data collection. Section 3.0 describes the data management and reporting requirements. Schedule requirements are discussed in Section 4.0, and references are provided in Section 5.0.

2.0 DATA COLLECTION PROCEDURES

This section describes the procedures to be used when collecting baseline water quality data under the COGA Program. Procedures described in this section include: selection of sampling locations, field preparation/mobilization, sampling of wells and springs/seeps, equipment decontamination, analytical program and quality assurance, sample handling and shipment, personal protective equipment, documentation, and sample point global positioning system (GPS) coordinate documentation.

2.1 Selection of Sampling Locations

Groundwater samples will be collected from the two closest groundwater features with reasonable access located within a ½-mile radius of the proposed oil and gas well surface location. Groundwater features include: (1) permitted and maintained water wells (stock, domestic, public supply, etc.) or (2) groundwater springs or seeps, some of which may be permitted with the DWR.

The Division of Water Resources (DWR) of the Colorado Department of Natural Resources (DNR) maintains records of permitted water wells and some seeps and springs that may be used to identify candidate sampling locations. This information may be accessed in several ways:

1. The records may be downloaded directly from the DNR website (http://www.water.state.co.us/DataMaps/GISandMaps/Pages/GISDownloads.aspx) for use in a Geographic Information System (GIS) software program.

2. The records may be accessed using DNR's online mapping tool, AquaMap (http://www.water.state.co.us/DataMaps/GISandMaps/AquaMap/Pages/default.aspx). AquaMap can be used to develop customized figures showing a wide variety of data, including:
    - Permitted water wells registered with DNR
    - Seeps and springs
    - U.S.G.S. topo quads showing topography, surfaces water features, and springs
    - Oil and gas wells recorded by COGCC
    - Aerial imagery

3. The well records may be accessed directly from DWR's search tables located at http://www.dwr.state.co.us/waterwellpermitsearch/default.aspx.

The COGCC maintains a web based GIS mapping tool (GIS Online 2010 Prototype) that displays locations of facilities where samples have been collected and whose data have been uploaded into the COGCC Environmental Database. COGCC's mapping tool also links to the DWR database. It can be accessed by clicking on the Maps link on the left column of the COGCC website (http://www.cogcc.state.co.us). This mapping tool identifies DWR water wells, oil and gas wells, and other related information.

The COGCC GIS application must be checked to determine if a current facility ID is associated with a planned sample location. If no current facility ID exists then a new facility ID must be generated in the COGCC Environmental Data application for data to be successfully uploaded to the database.

The U.S. Geological Survey (USGS) also maintains seep and spring data. These data are contained within the National Hydrography Dataset GIS data for Colorado, which can be downloaded at ftp://nhdftp.usgs.gov/DataSets/Staged/States/ for use in a GIS software program.

From these sources, candidate sampling locations may be identified. In selecting the two sampling locations, preference should be given to sampling locations which are closest to the well pad, provided reasonable access can be obtained. At least one of the sampling locations should be located down gradient of the pad, if the groundwater flow direction is known or can be reasonably estimated from the topography and hydrologic setting.

It is preferable to select wells that are in good condition and being maintained by the well owner in order to produce data that are more representative of the ground water quality in the water-bearing zone.

Seeps and springs may be used as sampling locations, but may have reduced flow in certain seasons. This may result in sample timing limitations. Data from seeps and springs are likely to be more representative of the uppermost portion of the water-bearing zone than deep water wells.

Land owner contact and approval, along with field reconnaissance will be required to confirm the candidate sampling points are accessible, in suitable condition, and otherwise appropriate for inclusion in the monitoring program. Informal contacts with nearby land owners may also be used to identify water wells that are not currently registered with the DWR and may serve as appropriate sampling locations. However, operators are not obligated to conduct an extensive search for non-registered wells. Operators may deem unregistered wells to be unsuitable based on lack of use and/or poor well conditions or maintenance.

Final locations for sampling will be selected by the operator or its consultant or contractor.

2.2 Field Preparation and Mobilization

Field preparation and mobilization includes tasks that must be conducted prior to the start of field activities. Tasks included in field preparation are:

- Obtain executed access agreements from affected landowners (an example access agreement is available from COGA);
- Determine if the sampling location has a COGCC Facility ID number. If not, access the COGCC website and obtain a Facility ID for the sampling location;
- Contact the landowner or tenant to schedule the sampling event and reconfirm the day before sampling;
- Procure all necessary field instruments and sampling equipment, including pre-cleaned sample containers and required sample preservatives from the laboratory; and
- Develop a program-specific Health and Safety Plan for field personnel.

2.3 Sampling Procedures

Baseline groundwater samples must be collected any time prior to the setting of the oil and gas well's conductor casing. Previously collected groundwater data may be used in lieu of collecting

new samples if the data is less than three years old and it has been collected in a manner generally consistent with the procedures outlined in this SAP.

A second sample will be collected from each groundwater feature no later than one year after well completion, unless prior notification is filed with COGCC. Well pads with multiple wells should be sampled as described in Section 1.3.

All groundwater samples (baseline, post-completion and complaint response) will be analyzed for each of the constituents listed on Table 1.

It is recommended that sufficient sample volumes be collected for both the Basic Analysis and the Compositional Analysis in a single sampling event so that sampling crews do not need to return to the sampling location. The laboratory should be instructed to initially perform only the Basic Analysis. If dissolved methane is found at a concentration greater than 1 mg/L in the Basis Analysis, the Compositional Analysis should be performed. The laboratory should be directed to complete the Basic Analysis in a timely fashion so that the sample hold time limits for the Compositional Analysis are not exceeded.

Table 1. Groundwater Sampling & Analysis Program

Container/ Preservative[3]	Constituent	Field Method	Laboratory Method	Holding Time (Days)	Reporting Limit (mg/L)
Basic Analysis					
2 x 1000 mL plastic, non-preserved	pH	Unfiltered	SM4500 H	Immediate	1 (pH unit)
	Specific Conductance	Unfiltered	SM2510B	28	10 (umhos/cm)
	Total Dissolved Solids	Unfiltered	SM2540C	7	10
	Alkalinity (total, bicarbonate, and carbonate; as $CaCO_3$	Unfiltered	SM 2320B	14	10
	Major Anions		EPA 300.1	28	
	Bromide	Unfiltered			1
	Chloride	Unfiltered			1
	Sulfate	Unfiltered			1
	Nitrate and Nitrite as N	Unfiltered			0.1
250 mL plastic, sulfuric acid preserved	Phosphorus	Unfiltered	EPA 365.4	28	0.1
250 mL plastic, nitric acid preserved[1]	Major Cations (Dissolved)		EPA 200.7or 200.8/SW846 6010C or SW846 6020	180	
	Boron	Filtered[1]			0.05
	Calcium	Filtered[1]			1
	Iron	Filtered[1]			0.05
	Magnesium	Filtered[1]			1
	Manganese	Filtered[1]			0.015
	Potassium	Filtered[1]			1
	Selenium	Filtered[1]			0.01
	Sodium	Filtered[1]			1
	Strontium	Filtered[1]			0.050

Container/ Preservative[3]	Constituent	Field Method	Laboratory Method	Holding Time (Days)	Reporting Limit (mg/L)
3 x 45 mL VOA vial, non-preserved	Dissolved Gases		RSK175	14	
	Methane	Dissolved Gases			0.026
	Ethane	Dissolved Gases			0.026
	Propane	Dissolved Gases			0.026
3 x 45 mL VOA vial, hydrochloric acid preserved[2]	BTEX Compounds		SW846 8260B	14	
	Benzene	Unfiltered			0.001
	Toluene	Unfiltered			0.001
	Ethylbenzene	Unfiltered			0.001
	Xylenes (o-xylene, m- + p-xylene, total xylene)	Unfiltered			0.003
Compositional Analysis (Performed if the dissolved methane concentration exceeds 1 mg/L)					
Specialized (lab supplied), benzalkonium preserved	Fixed Gasses C1-C6	Dissolved Gases	RSK175	14	0.026 each
	Stable isotopic concentration of the carbon (^{12}C and ^{13}C) and hydrogen (^{1}H and ^{2}H) in the methane	Dissolved Gases	Laboratory Specific SOP	28	variable

Notes:

[1]Filtering may performed in the field or in the laboratory. Addition of acid preservative in the field should not be done if the sample is not field filtered.

[2]BETX samples must be acidified to a pH less than 2 with concentrated hydrochloric acid (1+1) with pH verified in the laboratory or field per CDPHE's Groundwater VOC Sample Preservation Policy (CDPHE, 1998).

[3]Equivalent laboratory-provided containers and preservatives that meet the method requirements may also be used.

[4] It is recognized that there may be naturally-occurring variability in constituent concentrations between the baseline and post-completion samples.

2.3.1 Water Well Sampling

The following procedure shall be used for collection of groundwater samples from water wells. This methodology is derived in part from procedures developed by the COGCC for water well sampling, as well as current industry practice.

Samples should be collected directly from the well column, if the well is accessible and the sample can be collected without interfering with any down hole pumps or wiring. If the well column is not accessible (sealed) and the well is equipped with a permanently installed pump, the well should not be opened and the sample should be collected using the installed pump at a location upstream of any ancillary equipment such as a holding tank, a pressure tank, water softener, or other treatment system, if access is readily available. In no cases should the septic seal of a water well be opened. Detailed procedures for sampling inaccessible and accessible wells are provided below.

Prior to initiating well purging, the following information should be recorded on a Field Sampling Data Sheet (Appendix A):

- The Facility ID number from the COGCC Environmental Database (obtain from COGCC website, if sampling location does not already have one)
- The site address, site contact and site contact phone number
- The landowner name, phone number, and mailing address
- Names of persons present during sampling
- GPS coordinates of the water well casing location (see Section 2.9 for GPS accuracy and data collection requirements)
- Water well permit and receipt number
- API number for the associated oil and gas well(s)
- Approximate distance from sampling point to the oil and gas well pad
- If the sample is a baseline (pre-drilling) or post-completion sample
- If photographs of the sampling location were taken
- If the site contact was provided a copy of:
    - Landowner Introduction Letter
    - Frequently Asked Questions (FAQ) sheet
    - Informational Pamphlet “How Well do You Know Your Water Well?”
- Description of the sample location (house tap, outside spigot, etc.)
- Visual appearance of the well head (e.g. does the well have a sanitary seal with a vent hole?, does the ground slope away from the well head?, other factors that could contribute to contamination of the well or sample)
- Results of any field screening for Lower Explosive Limit (LEL) or percent methane, if such screening is performed
- A description of the water well and related equipment configuration, specifically any water treatment that takes place upstream of the sampling location
- Date and time of sample collection
- Visual description of water including color, odor, sediment, field conditions, and field parameters
- Landowner comments on water quality

Well Purging (inaccessible wells with permanent pumps)

Purge volume and time should take into account well depth, well diameter, and static water level, if available. Prior to sampling, the water well owner should be contacted to determine the average yield of the water well based on typical use and the level of well use in the last 24 hours (e.g. has the well recently been pumped for an extended period for lawn watering). Care must be exercised to avoid over-purging water wells during testing. Some water wells with low yield can experience long delays in recharging before they can be used again.

If yield is not an issue, the well should be purged by running the pump to flow water from the sampling tap at a steady rate for at least 15 minutes. The 15 minute purge flow also allows for flushing of water through any pressure tanks and/or treatment systems, if sampling cannot be conducted upstream of these systems.

Field parameters, including temperature, pH, specific conductance, color/appearance, odor, and flow rate should be measured at regular time intervals (every 3 to 5 minutes) during well purging with instruments calibrated in accordance with manufacturer specifications. When the field parameters vary less than ±10% (for pH, less than 0.2 pH units) over three consecutive measurements, the well is adequately purged (stabilized). If this occurs before the 15 minute evacuation period, it may not be necessary to purge for the full 15 minutes. If the parameters have not stabilized in the first 15 minutes, the well should be purged for another 3 to 5 minutes with an additional set of field parameters collected prior to sampling. If field parameters still have not stabilized, this should be noted on the field log, and the well should be sampled at that time.

A clean, white 5-gallon bucket should be used to measure flow and monitor the water for color, odor, effervescence, and suspended sediment as the well is purged. Flow rate should be determined by using a watch capable of measuring time to the second, to measure the time required to fill the five gallon bucket. From this information, the purge flow rate should be calculated in gallons per minute (gpm). The watch should also be used to measure the total purge time. From the total purge time and the flow rate measurements, the approximate total purge volume should be estimated and recorded on the Field Sampling Data Sheet.

Once purging is complete, the flow rate should be reduced prior to collecting the samples (if possible) to minimize the potential for loss of dissolved gas or other volatile constituents, if present. In general, the submersible pumps in water wells do not have adjustable flow rates as might be found with pumps used to collect samples from monitoring wells. Decreasing the flow rate by adjusting a valve to a more closed position does not change the pump rate, but does cause turbulence in the drop pipe and water to be sampled, and should be avoided. If the pump rate can be slowed for sampling, the bucket and stop watch should be used to calculate the sampling flow rate in gpm, and this information should be recorded on the Field Sampling Data Sheet.

Well Purging (accessible wells without pumps)

Operators are not required to collect samples from wells without pumps. This section describes procedures to be followed should operators choose to collect samples from accessible wells that do not have permanently installed pumps.

Purge volume and time should take into account well depth, well diameter and static water level, if available. Wells not equipped with pumps with accessible and removable well head caps should be purged using a pre-cleaned sampling pump or pre-cleaned hand bailers. Pumps and bailers should be washed with potable water to remove any dirt or debris. Pumps or bailers

used on environmental remediation sites or with residual staining or odors should not be used for purging or sample collection.

As a safety precaution for the field crew, measurement of %LEL (or $\%CH_4$) at the well bore is recommended for accessible wells. Prior to sampling, a pre-cleaned water level indicator should be used to determine the height of the original water column (total well depth minus depth to water). The well should be pumped or bailed until at least three casing volumes of water have been removed[1]. The purge rate must be slow enough such that the water recharging the well does not enter in an agitated manner. If the yield is low such that the well can be bailed or pumped dry, purging can be stopped and the well can be sampled after the well has recovered to 90% of the original standing water volume or after 2 hours, whichever occurs first.

Field parameters, including temperature, pH, specific conductance, color/appearance, odor, and flow rate (if pumping) should be measured at regular time intervals (every 3 to 5 minutes) during well purging with instruments calibrated in accordance with manufacturer specifications. When the field parameters vary less than ±10% (for pH, less than 0.2 pH units) over three consecutive measurements, the well is adequately purged (stabilized). If this occurs before three casing volumes have been removed, it may not be necessary to purge for the full three casing volumes. If the parameters have not stabilized after three casing volumes have been removed, remove an additional two casing volumes and collect an additional set of field parameters prior to sampling. If field parameters still have not stabilized, this should be noted on the field log, and the well should be sampled at that time.

Sample Collection

Wells should be sampled immediately following, but no later than 2 hours after purging. The individual collecting the samples should wear disposable, powder free “exam-type” gloves to prevent possible cross contamination of the samples and/or the domestic water supply. The gloves should be changed between sample locations.

A complete set of samples should be obtained from each well, as specified in Table 1. Samples should be collected and preserved as unfiltered samples, filtered samples, or dissolved gas samples according to the sampling protocol listed on Table 1. Specific sampling methods for each type of sample are described below.

Unfiltered Samples

Unfiltered samples should be directed from the pump discharge, tap, or bailer directly into the laboratory-supplied sample containers. If sampling from a tap equipped with an aerator, remove the aerator prior to sampling, with landowner consent. The samples should be carefully transferred to the sample containers in a manner that minimizes agitation and aeration. For those sample containers with preservative, special care should be taken to not overfill the container.

[1] Casing volume (CV) in gallons is calculated from the height of the standing water column (h) in feet and the casing diameter (d) in inches as: $CV = H \times d^2 \times 0.0407$. Minimum purge volume (PV) in gallons is calculated as $PV = H \times d^2 \times 0.122$

Filtered Samples

Samples that will be field filtered must be collected using an in-line disposable 0.45-micron glass-fiber filter. When field filtering is performed, disposable tubing with the in-line filter should be connected to the tap (aerator removed) or pump discharge line. For hand bailed wells, a hand vacuum pump and tubing should be used to draw water from the bailer and push it through the filter. In all cases, the tubing and filter should be flushed and the filtered water should be collected directly into the pre-cleaned sample containers provided by the laboratory. New filters must be used for each sample location. For those sample containers with preservative, special care should be taken to not overfill the container. Filtration at the laboratory after receipt followed by appropriate preservation is an acceptable alternative to field filtration.

Dissolved Gases Samples

There are two methods for collection of water samples for dissolved gases analysis. The first and preferred method should be used for samples that are collected from wells using pumps and for effervescent water samples. The second sampling method is a traditional method of sampling and can be used for samples collected with bailers.

Method 1 – Wells with Pumps & Effervescent Samples

This method is for samples that will be collected from wells using pumps. It is also to be used to analyze all effervescent samples. Samples may be retrieved from wells with permanent pumps or with temporary sampling pumps. Bailers should not be used to collect samples under this method. The samples should be collected in 45-mL volatile organic analysis (VOA) vials equipped with a Teflon gas-tight septum (methane, ethane, propane analysis) or other specialized containers supplied by the laboratory (isotopic analysis).

To collect a sample from a tap or sampling pump, fill a clean 5-gallon bucket with water from the tap and set aside. Connect a section of clean 5/8-inch hose to the pump discharge or tap to be sampled. Attach a 6-inch length of small diameter ¼-inch tubing to the end of the 5/8-inch hose nozzle using a step down valve. Adjust the flow through the valve so that the flow rate through the tubing is low. If necessary, attach a high flow bypass valve with another 6-inch length of ¼-inch tubing to keep the flow in the ¼-inch sample line low. Maintain laminar flow through the hose and tubing assembly at all times. Submerge the closed sample container to the bottom of the 5-gallon bucket. While under water, open the sample container, insert the ¼-inch sampling line and flush the sample container with water from the sample line. Monitor the time to allow enough water volume to flow through the container to displace twice the volume of the container. Then slowly remove the sample line. For the isotopic analysis, quickly insert a benzalkonium tablet into the container and replace the container screw cap while holding the container under water and as far down to the bottom of the bucket as possible. For the methane, ethane, propane sample, the benzalkonium tablet is not required. The container should be held near the bottom of the bucket while the screw cap is replaced so that any dissolved methane is trapped under the pressure head of the water and the sample is not easily degassed.

Make sure that no air is allowed into the sample container during sample collection. After the sample container is capped, take it out of the bucket, invert and inspect it to make certain that there are no bubbles in the container. If bubbles are visible, collect another sample. If it is not possible to collect a gas free sample because the water is too effervescent, a gas headspace in

the VOA vial is acceptable, but the laboratory should be notified to analyze the gas headspace to determine the gas composition.

The containers should be packed in a baggie filled with ice, placed in a secure upside down position within a pre-cooled ice chest, and shipped overnight to the analytical laboratory. The samples should be kept on ice or refrigerated until they are analyzed, and the analyses should be completed no later than 48 hours after the samples are collected.

Method 2 – Wells Sampled with Bailers

This method is only to be used for wells sampled with bailers. This method should **not** be used to sample water that effervesces. It should also **not** be used to collect samples of groundwater known to have high bicarbonate content as the sample preservatives may cause the samples to degas and lose methane.

Under this method, the samples are collected in 45-ml glass VOA vials equipped with a Teflon gas-tight septum containing an HCl or H_2SO_4 preservative. The sample should be collected by slowly filling the vial. Allow the water to run down the inside surface of the vial until the vial is full and a meniscus develops along the upper edge of the sample vial. Remove any bubbles floating on the top of the meniscus with the vial cap, and seal the vial. Be careful to not overfill the sample as over filling will result in a loss of the sample preservative. If that happens, collect a new sample.

After confirming that no gas bubbles are present in the sample vials, the vials should be packed in a baggie filled with ice, placed in a secure upside down position within a pre-cooled ice chest, and shipped to the analytical laboratory. The samples should be kept on ice or refrigerated until they are analyzed.

2.3.2 Spring/Seep Sampling

The following procedure shall be used for collection of groundwater samples from springs and seeps. Samples should be collected directly from the spring or seep if at all possible.

Prior to sampling, the following information should be recorded on a Field Sampling Data Sheet (Appendix A):

- The Facility ID number from the COGCC Environmental Database (obtain from COGCC website, if sampling location does not already have one)
- The site address, site contact and site contact phone number
- The landowner name, phone number, and mailing address
- Names of persons present during sampling
- GPS coordinates of the sampling location (see Section 2.9 for GPS accuracy and data collection requirements)
- DWR permit and receipt number if applicable
- API number for the associated oil and gas well(s)
- Approximate distance from sampling point to the oil and gas well pad
- If the sample is a baseline (pre-drilling) or post-completion sample
- If photographs of the sampling location were taken
- If the site contact was provided a copy of:
    - Landowner Introduction Letter
    - Frequently Asked Questions (FAQ) sheet

- Description of the sample location
- Visual appearance of the spring or seep (i.e., factors that could contribute to contamination of the spring or seep or if the spring an improved spring with a well box and pipe)
- Results of any field screening for Lower Explosive Limit (LEL) or percent methane, if such screening of unventilated areas is performed
- Date and time of sample collection
- Landowner comments on water quality

Measurement of Field Parameters

Prior to sampling, the field parameters (temperature, pH, specific conductance, color/appearance, and odor) should be measured and recorded. Measurements should be made with instruments calibrated in accordance with manufacturer specifications. A clean, white 5-gallon bucket should be used to monitor the water for color, odor, and effervescence.

Sample Collection

The individual collecting the samples should wear disposable powder free "exam-type" gloves to prevent possible contamination of the samples. The gloves should be changed as need and at a minimum following the collection of samples from each sample location.

A complete set of samples should be obtained from each spring/seep, as specified in Table 1. Samples should be collected and preserved using the field methods for unfiltered samples, filtered samples, and dissolved gas samples according to the sampling protocol listed on Table 1. Specific sampling methods for each type of sample are described below.

Unfiltered Samples

Unfiltered samples should be collected by submerging a pre-cleaned sample container or dipper directly into the spring and carefully transferring the sample to the laboratory-supplied sample container. If the sampling point is a seep, it may be necessary to use a pre-cleaned glass beaker to collect the water. Care should be taken to prevent the re-suspension of sediment into the water during sampling. The collected sample should be transferred from the dipper or beaker by allowing the water to run down the inside wall of the sample container to minimize sample disturbance. For those sample containers with preservative, special care should be taken to not overfill the container.

Filtered Samples

Samples that will be field filtered must be collected using an in-line disposable 0.45-micron glass-fiber filter. When field filtering is performed, the required water volume should be collected from the spring or seep using the dipper or beaker and placed in a pre-cleaned bucket. A hand vacuum pump and tubing should then be used to draw water from the bucket and push it through the in-line filter and into the sample container. In all cases, the tubing and filter should be flushed prior to sample collection and the filtered water should be collected directly into the pre-cleaned sample containers provided by the laboratory. New filters must be used for each sample location. For those sample containers with preservative, special care should be taken to not overfill the container. Filtration at the laboratory after receipt is an acceptable alternative to field filtration.

Dissolved Gases Samples

There are two methods for collection of water samples for dissolved gases analysis. The first and preferred method should be used for most samples, including all effervescent water samples. The second sampling method is an alternate method of sampling and should only be used where the preferred method is not possible.

Method 1 – Preferred Method & Effervescent Samples

This method is for most samples, including all effervescent samples. The samples should be collected in 45-mL (VOA vials equipped with a Teflon gas-tight septum (methane, ethane, propane analysis) or other specialized glass containers supplied by the laboratory (isotopic analysis).

To collect a sample of spring or seep water, create a pool of water in a depression as close to the discharge point as possible. Allow the flow of water from the spring or seep to flush suspended sediment from the pool prior to sampling. Submerge a 500 mL beaker in the water. Allow water to slowly flow into the beaker until it is filled. Avoid getting suspended sediment into the beaker by allowing water to flow into the beaker close to the air-water interface. Keeping the beaker submerged in the pool of water, submerge the sample container in the beaker upside down, open it, and allow water to fill the sample container slowly by gradually increasing the tilt of the sample container. For the isotopic analysis, quickly insert a benzalkonium tablet into the container and replace the container screw cap while holding the container under water and as far down to the bottom of the beaker as possible. For the methane, ethane, propane sample, the benzalkonium tablet is not required.

Seal the sample container and check for bubbles. If it is not possible to collect a gas free sample because the water is too effervescent, a gas headspace in the VOA vial is acceptable, but the laboratory should be notified to analyze the gas headspace to determine the gas composition. Empty the beaker outside of the pool and repeat the sampling procedure as necessary until all sample containers have been collected.

The sample containers should be packed in a baggie filled with ice, placed in a secure upside down position within a pre-cooled ice chest, and shipped overnight to the analytical laboratory. The samples should be kept on ice or refrigerated until they are analyzed, and the analyses should be completed no later than 48 hours after the samples are collected.

Method 2 – Alternate Method

This method is only to be used when site conditions prevent collection of the sample using the preferred method described above. This method should **not** be used to sample water that effervesces. It should also **not** be used to collect samples of groundwater known to have high bicarbonate content as the sample preservatives may cause the samples to degas and lose methane.

Under this method, the samples are collected in 45-mL glass VOA vials equipped with a Teflon gas-tight septum containing an HCl or H_2SO_4 preservative. The sample should be collected by using the dipper or beaker to retrieve the sample and slowly transfer it to the vial. Allow the water to run down the inside surface of the vial until the vial is full and a meniscus develops along the upper edge of the sample vial. Remove any bubbles floating on the top of the meniscus with the vial cap, and seal the vial. Be careful to not overfill the sample as over filling

will result in a loss of the sample preservative. If that happens, collect a new sample. After collecting the sample, invert the VOA vial to confirm there are no air bubbles in the vial. If an air bubble is present, collect a new sample.

After confirming that no gas bubbles are present in the sample vials, the vials should be packed in a baggie filled with ice, placed in a secure upside down position within a pre-cooled ice chest, and shipped to the analytical laboratory. The samples should be kept on ice or refrigerated until they are analyzed.

2.4 Decontamination

In order to prevent cross contamination of samples, disposable sampling equipment should be used whenever possible. All non-disposable equipment (e.g., sampling pumps with non-disposable tubing, dippers, beakers, sample collection tubing and valve assemblies, etc.) and instruments that contact the samples must be decontaminated prior to use and between samples using the following procedure:

1. Remove gross contamination by dry brushing followed by a tap water rinse.
2. Wash with a laboratory grade detergent solution, such as Alconox or equivalent.
3. Rinse with tap water.
4. Rinse with distilled or deionized water.
5. Air dry.

Decontamination solutions should be pumped through sampling pumps and non-disposable discharge tubing to decontaminate this equipment.

Initial decontamination should be performed prior to arriving at the sampling location. All decontamination solutions should be collected and properly disposed. Decontaminated equipment should be stored in sealed containers such as zipper-lock plastic bags or boxes with tight lids to protect from airborne dust contamination prior to use.

2.5 Analytical Program and Quality Assurance

Data integrity will be assured and verified through: 1) field sampling practices that comply with this Sampling and Analysis Plan, 2) sample analysis by accredited analytical laboratories, 3) laboratory practices which follow approved analytical methods, when available, 4) collection and analysis of field quality assurance samples, and 5) data quality reviews of the laboratory and field practices.

All samples will be analyzed by laboratories that are accredited by the National Environmental Laboratory Accreditation Program for the analytical procedures that will be used for sample analysis, where such accreditation exists. As specified in Table 1, U.S. Environmental Protection Agency (EPA) analytical methods such as Test Methods for Evaluating Solid Waste SW-846 or other methods such as Standard Methods for the Examination of Water and Wastewater, which are recognized standard industry practice, will be used for sample analysis. Where EPA-approved methods are not available, standard industry practices will be followed.

Laboratory quality assurance samples, such as matrix spike/matrix spike duplicates, will be prepared in the laboratory and analyzed as specified by the designated method. Laboratory quality assurance sample results must be reported along with the original sample results on the laboratory report, and an analytical narrative shall be provided as part of the laboratory report.

Field quality control samples shall be collected at the following frequency:

- Field Duplicate Samples – one complete set of duplicate samples shall be collected for every twenty groundwater samples collected by the operator, but not less than one per year. Duplicate samples should be collected immediately following the original sample using identical sampling methods. Each duplicate sample should be given a fictitious sample identification number, which is recorded on the Field Data Sheet, and submitted to the laboratory as a blind duplicate. Duplicate samples should be analyzed for the same parameters as the original sample.

  Data Quality Objective: Field duplicate sample results should be evaluated based on the Relative Percent Difference (RPD) between the sample result and the duplicate. RPD is calculated as:

$$RPD = \frac{|S - D|}{0.5(S + D)} \times 100$$

  Where,

  RPD = Relative Percent Difference
  |S-D| = Absolute value of S - D
  S = Sample Result (original)
  D = Duplicate Result

  A data quality objective of RPD ≤ 20% will be used for original and duplicate sample values that are ≥ five times (5x) the practical quantitation limit (PQL).

- Field Equipment Blanks – Equipment blanks should be collected if decontaminated sampling equipment (e.g. sampling pump with dedicated discharge hose, sample dipper, beaker, etc.), is used to collect the samples. One equipment blank sample shall be collected for every ten (10) groundwater samples taken with decontaminated sampling equipment by the operator, but no less than one per year. Equipment blanks should be collected immediately following equipment decontamination by running distilled or deionized water through or over the sampling equipment and collecting the rinse water in the sample container. Equipment blanks should be analyzed for major cations (dissolved) and BTEX.

  Data Quality Objectives: Equipment blanks should have individual cation and BTEX constituent concentrations below method detection limits.

- Field Blanks – Field blanks will only be collected if the sampling technician believes that site conditions might cause the sample to become cross contaminated by VOCs or methane (e.g. the well is located adjacent to hydrocarbon or methane storage or fueling area). Field blanks will be collected by filling a clean glass VOA vial equipped with a Teflon gas-tight septum with distilled water and leaving the sample container open during the entire period of volatile sample collection. Immediately prior to capping, a few drops of distilled water should be added to the vial to create a positive meniscus. The vial should then be capped and inverted to check for air bubbles. If bubbles are present, the vial should be opened, additional water should be added, and the vial should be resealed and checked again for air bubbles. This procedure should be repeated until a

bubble-free container is obtained. Field blanks should be analyzed for BTEX and dissolved gasses (methane, ethane, and propane).

Data Quality Objectives: BTEX and dissolved gases concentrations should be below method detection limits in field blanks.

Data quality reviews should be performed after all data reports have been received from the laboratory. Data quality reviews should be documented on a Data Quality Review Sheet (Appendix B) which should be stored in the project files with the Field Sampling Data Sheet and the laboratory data reports analytical data. The objective of the Data Quality Review Sheet is to confirm that all data were properly collected and are suitable for release to COGCC (with land owner approval). The data quality review should include:

- Review all field sampling data sheets to confirm that:
  - The wells were properly purged,
  - The flow rate was reduced prior to sampling,
  - The water quality field parameters had stabilized prior to sampling, and
  - No conditions were noted that suggest the samples may not be representative.

- Review all laboratory data reports to confirm that:
  - Proper custody was maintained from the time of sampling until receipt by the laboratory.
  - All samples were analyzed for the requested analyses.
  - Proper laboratory methods were used.
  - All sample holding times were met.
  - Laboratory quality assurance samples such as matrix spikes and matrix spike duplicates were collected and analyzed according to the laboratory method, and all laboratory quality control sample results were within method acceptance limits).
  - All field quality control samples meet the data quality objectives listed above.

- Specify corrective actions needed and dates by when those corrective actions should be completed.

- Certification by the data reviewer confirming that the data were collected in accordance with the COGA Voluntary Baseline Groundwater Sampling Program and that the data are suitable for incorporation into the COGCC database.

2.6 Sample Handling and Shipment

All sample containers should be pre-labeled using an indelible ink pen. Sample container labels will include the sample identification number (likely the Facility ID created in the COGCC Environmental Database), date and time the sample is collected, requested laboratory analyses, and sampler initials. Labels should be covered with clear plastic tape after being filled out to keep the ink from running due to contact with water during sampling and moisture in the sample shipping cooler. A Facility ID must be used so that the EDD can be uploaded into the COGCC Environmental Database.

After the samples have been collected they should be immediately placed on ice in a pre-cooled insulated ice chest. The cooler should be kept at or below 4ºC during storage and shipment to the analytical laboratory. Each cooler should be packed and sealed in a manner to help

minimize potential damage to sample containers, help maintain the required temperature, and to help prevent tampering. The coolers should be clearly labeled in order to expedite delivery to the selected laboratory and shipped in a timely manner (preferably, nightly) to minimize the potential for hold time exceedances.

Samples must be handled, stored, and shipped in accordance with Chain-of-Custody (COC) procedures. COC procedures require that all samples be maintained under the control of the sampler (i.e., in sight or in a secure, locked environment controlled by the sampler) from the time of collection until delivery to the analytical laboratory or release to a third-party shipping company. Request for Analysis and Custody forms should be provided by the analytical laboratory and filled out completely. The sampler must sign the COC form releasing the samples to the laboratory at the time of delivery to the lab or at the time of release to the shipping company. The laboratory must sign the COC form accepting custody of the samples at the time of delivery by the sampler or the shipping company. The COC form, Request for Analysis, and any other documentation should be sealed in a zipper lock plastic bag and taped to the inside top of the cooler. The cooler should be secured with shipping tape and custody seals (adhesive labels signed and dated by the sampler) should be securely placed on the cooler such that the cooler cannot be opened without breaking the seal.

2.7 Personal Protective Equipment

Personal protective equipment (PPE), such as hard hats, safety glasses, chemical resistant gloves, sturdy boots, long pants, etc., should be used as necessary to protect personnel during sample collection. Operators and/or their consultants should develop a health and safety program which specifies the types of PPE that should be used during sampling. While at the home and water well, the field staff should explain to the landowner or representative what PPE is required at their home and why it is required, if the landowner or representative seems concerned by the use of the equipment.

2.8 Documentation

Field records should be kept during sampling to document the procedures used. A Field Sampling Data Sheet should be completed for each sample. Each page should be completed with an indelible-ink pen and legible. The second page of the Field Sampling Data Sheet should be used to record general information such as, equipment used for the activity, equipment calibration records, daily weather conditions (temperature, wind direction, precipitation), locations and times of sampling, any extra level of effort that was extended to perform the duties, or other information deemed pertinent by the sampler.

2.9 Sample Point GPS Coordinate Documentation

Water well and spring/seep sampling locations shall be surveyed using hand held Global Position System (GPS) equipment to determine horizontal and vertical coordinates. Operators are encouraged to collect, store, and process GPS data in a manner consistent with COGCC Rule 215. At a minimum, mapping grade GPS equipment capable of achieving an accuracy of 5 meters or less with real-time or post-processing correction shall be used. Latitude and longitude coordinates shall be provided in decimal degrees using the North American Datum (NAD) of 1983.

The field recorded GPS location should be documented on the Field Sampling Data Sheet. Following post processing, the corrected GPS location should be added to the Field Sampling Data Sheet.

3.0 DATA MANAGEMENT & REPORTING REQUIREMENTS

This section describes how the laboratory results for the voluntary baseline data quality samples will be reported to the landowner and COGCC.

3.1 Landowner Notifications

Sampling will only be conducted if landowner access is granted and the landowner agrees that the laboratory analytical results will be submitted to the Colorado Oil and Gas Conservation Commission (COGCC) for posting to a database that can be viewed by the public, as described in Section 2.2.

Within three months of sample collection (baseline, post-completion, or complaint response), the operator shall provide the landowner with a letter explaining the testing and analyses completed and a copy of the analytical laboratory report. The landowner will also be provided with educational materials developed specifically for the COGA Program that address topics such as water well integrity, groundwater quality, and water well maintenance.

Example land owner notification letters are available from COGA.

3.2 Data Submittal to COGCC

The operator will enter the following information from each sampling event (baseline, post-completion, or complaint response) into an eForm for electronic submission and uploading into the COGCC's database:

- Date and time each sample was collected
- Facility ID created in the COGCC system
- Permit and receipt number for the sampling location
- GPS coordinates for each sampling location
- API number for the associated oil and gas well
- Sample type – baseline, post-completion, or complaint response
- Analytical results for each sample collected will be submitted in EDD and PDF format.

The eForm is currently being developed by COGCC.

If access cannot be obtained to collect groundwater samples from two locations within ½ mile of the oil and gas well, the operator will notify COGCC that samples could not be obtained.

4.0 SCHEDULE

Schedule requirements for various aspects of the COGA program are listed in Table 2.

Table 2. Program Milestones and Delivery Requirements

Sample Type	Event	Timing
Baseline	Baseline Sampling	Before conductor casing is installed
	Reporting to Landowner and COGCC	Within 3 months of sample collection
	COGCC posting of data to database for public access	Within 3 months of complete submittal
Complaint Investigation	Complaint Investigation Sampling	Within 48 hours of receipt of complaint[1]
	Reporting to Landowner and COGCC	As soon as possible, but no later than 3 months after sample collection
	Notification to COGCC[2]	Within 48 hours
Post completion	Post-completion	No later than one year after the well is completed (see Section 1.3 for pads with multiple wells)
	Reporting to Landowner and COGCC	Within 3 months of sample collection
	COGCC posting of data to database for public access	Within 3 months of submittal

Note:
[1] Sampling is contingent on expeditious landowner access
[2] If a reportable spill or impact to surface water or groundwater is indicated by the complaint investigation

REFERENCES

Colorado Department of Public Health & Environment (CDPHE). 1998. Groundwater VOC Sample Preservation Policy. Viewed at: http://www.cdphe.state.co.us/hm/vocplcy.pdf, viewed on September 15, 2011.

United States Environmental Protection Agency (USEPA). (2008). *National Functional Guidelines for Superfund Organic Methods Review*. USEPA-540-R-08-01. Office of Superfund Remediation and Technology Innovation (OSRTI). June.

United States Environmental Protection Agency (USEPA). (2010). *National Functional Guidelines for Superfund Inorganic Methods Review*. USEPA-540-R-10-011. Office of Superfund Remediation and Technology Innovation (OSRTI). January.

Colorado Department of Public Health & Environment Water Quality Control Commission (5 CCR 1002-41) Regulation No. 41 – The Basic Standards for Ground Water, most current version.

APPENDIX A
EXAMPLE FIELD SAMPLING DATA SHEET

Field Sampling Data Sheet

COGCC Facility ID: _____
Site Address: _____
Site Contact: _____
Phone #:_____
Date of Sample: _____
Sample Type (baseline, post-drill, complaint): _____
Oil & Gas Well API Number: _____

Property Owner Name: _____
Property Owner Phone Number: _____
Property Owner Mailing Address: _____
_____

Individuals Present (Who was on-site during the sampling event?)
_____
_____

Water Well Information from Permit Records
Permit No.: _____
Receipt No.:_____
Total Depth (ft.): _____
Static Water Level (ft.):_____
Yield (GPM): _____
Well Diameter (in.):_____

<u>Water Well Information Onsite</u>
GPS Location (field): _____
GPS Location (post-processed): _____
Water well casing height (in.): _____
Ground Elevation (ft.):_____ How determined: _____
Approximate distance to the Oil & Gas well pad:_____
%LEL at wellhead (if measured): _____
%CH_4 at wellhead (if measured): _____
Weather conditions:_____
Photo(s) Taken? **Y N**
Handed Out Landowner Introduction Letter? **Y N**
Handed Out FAQ Sheet? **Y N**
Handed Out "How Well Do You Know Your Water Well" Pamphlet? **Y N**

Where was the Sample Taken? _____
(Outside Tap, Well House, Kitchen Tap, Spring, Seep, etc.)

Condition of the Well, Spring or Seep (Wellhead sealed? Does the ground slope away from the well?, Visible contamination of spring/seep?, etc.):
_____
_____

Field Sampling Data Sheet – Page 2

Landowner Comments on Water Quality: _____
_____
_____
_____

Water Quality Field Parameters:

Time	Purge Vol. (gal)	pH	Conductivity	Temp	Color/Appearance /Sediment	Odor	Bubbles/Effervescence?

Purge rate (gpm): _____ Purge Time (min.): _____
Total Purge Volume (gal.): _____
Sampling flow rate (gpm): _____

ADDITIONAL INFORMATION: _____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Sampler's Name _____ Company: _____
(Print)
Sampler's Signature _____ Date: _____

APPENDIX B
EXAMPLE DATA QUALITY REVIEW SHEET

Data Quality Review Sheet

Sample Information

Sample ID: _____
Date Collected: _____
Site Address: _____
Site Contact: _____
Phone #:_____

Field Sampling Data Sheet Review

Wells:
Was the well properly purged? **Y N**
Was the flow rate reduced prior to sampling? **Y N**
Did field parameters stabilize prior to sampling? **Y N**
Did site conditions or other factors suggest that the samples may not be representative of groundwater? **Y N** If Yes, describe: _____
_____

Seeps/Springs:
Were field parameters measured prior to sampling? **Y N**
Did site conditions or other factors suggest that the samples may not be representative of groundwater? **Y N** If Yes, describe: _____
_____

Laboratory Data Package Review

Was proper chain-of-custody maintained? **Y N**
If No, describe: _____
_____
Were all samples analyzed for the requested analyses? **Y N**
If No, can the remaining sample be analyzed within hold time? **Y N**
Were the proper methods used? **Y N**
If No, can the remaining sample be analyzed within hold time? **Y N**
Were all sample holding time limits met? **Y N**
Were laboratory quality assurance samples collected and analyzed? **Y N**
Were laboratory quality assurance sample results within acceptance limits? **Y N**
If No, describe: _____
_____
_____
_____
Were field duplicate samples submitted? **Y N**
If field duplicate samples were submitted, were the original and duplicate sample values ≥ five times (5x) the practical quantitation limit (PQL)? **Y N**
If the original and duplicate sample values were ≥ five times (5x) the PQL, were the RPD values ≤ 20%? **Y N**
If No, describe: _____
_____

_____
_____
_____

If equipment blanks were submitted, did the results meet the equipment blank data quality objectives specified in the Sampling and Analysis Plan? **Y N**

If No, describe: _____
_____
_____
_____

If field blanks were submitted, did the results meet the field blank data quality objectives specified in the Sampling and Analysis Plan? **Y N**

If No, describe: _____
_____
_____
_____

Corrective Actions

Are corrective actions required to remedy any data quality issues? **Y N**

If Yes, describe: _____
_____
_____
_____
_____
_____

Date by when corrective actions must be completed:_____

Summary of Corrective Actions (once completed)

_____
_____
_____
_____
_____
_____
_____

Data Suitability Statement

Based upon this data quality review and your professional judgment, have the data been collected and analyzed in general accordance with the COGA Voluntary Baseline Groundwater Quality Sampling Program? **Y N**

Are the data suitable for release for incorporation into the Colorado Oil and Gas Conservation Commission environmental database? **Y N**

Data Quality Reviewer's Name _____Company: _____
(Print)

Data Quality Reviewer's Signature _____ Date: _____