



WYOMING

Guidance Document:
Compliance Monitoring and Siting Requirements
for Unlined Impoundments Receiving Coalbed
Methane Produced Water

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(Revised)

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NOTE: All attachments can be downloaded from the WDEQ website at <http://deq.state.wy.us/wqd/groundwater/index.asp>

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I. INTRODUCTION

This document is designed to provide siting criteria and groundwater monitoring requirements in order to provide protection to waters of the State of Wyoming from the potential impacts of water infiltrating from unlined coalbed methane (cbm) impoundments. The information and requirements in this document supersede the requirements in the previous guidance documents that are entitled “*Compliance Monitoring for Groundwater Protection Beneath Unlined Coalbed Methane Produced Water Impoundments*”, June 14, 2004, (revised September, 2006 and November 2008) and “*Off channel, Unlined CBM Produced Water Pit Siting Guidelines for the Powder River Basin, Wyoming, August 6, 2002*.”

The Wyoming Department of Environmental Quality (WDEQ) has received data that demonstrates that the water infiltrating from unlined coalbed methane impoundments has the potential to pollute the state’s groundwater resources. These data indicate that the infiltrating water acts as a solvent in the subsurface, leaching compounds (e.g., sulfate salts), and other constituents (e.g., selenium) and eventually transporting these compounds to groundwater.

The ability of the infiltrating water to pollute groundwater is primarily a function of the amount and type of leachable compounds in the unsaturated zone, but other contributing factors include the depth to groundwater, size of the impoundment (volume being discharged), chemistry of the coalbed methane water being discharged, and the chemistry and classification of the receiving groundwater.

The requirements discussed below will apply to statewide on-channel and off-channel impoundments and will provide a mechanism to allow construction of unlined impoundments until the WDEQ determines whether more, or less stringent measures are necessary to afford protection of the state’s groundwater resources.

The operator must comply with the requirements as discussed below prior to discharge of coalbed methane produced water into an impoundment.

All plans, specifications, and reports submitted pursuant to this guideline must comply with the statutory requirements of Wyoming Statutes W.S. §33-41-101 through 121 (“Wyoming Geologists Practice Act.”) and associated regulations, as applicable. The reader should refer to “practice of geology before the public” in W.S. §33-41-102 for types of work that must be performed by a professional geologist. The geologic investigation and interpretation work discussed in sections III and IV below will generally require the supervision of a professional geologist licensed in Wyoming. If there are questions about whether a specific action discussed below requires the evaluation by a professional geologist, please contact the WDEQ Groundwater Section.

II. DEFINITIONS AND SITING REQUIREMENTS

Section 2.01 Definitions

For the purposes of this document, the following definitions shall apply:

- (a) Impoundment: an impoundment is an unlined reservoir, pond, pit, or natural depression that receives produced water from coalbed methane operations.
- (b) On-Channel Impoundment: an impoundment that receives coalbed methane produced water will be considered “on-channel” when sited on or within a distance of 500 feet of a designated water feature as defined on a United States Geologic Survey (USGS) 1:24,000 scale topographic map (Attachment 1), or within a distance of 500 feet of the floodplain or mapped alluvium (including alluvial mixtures) of a stream system as defined on a Wyoming State Geological Survey 1:100,000 scale surficial geology map. (<http://www.wsgs.uwyo.edu/>)
- (c) Off-Channel Impoundment: an impoundment that receives coalbed methane produced water will be considered “off channel” when the impoundment does not meet the criteria established for an “on-channel” above.
- (d) Existing Reservoir: is a reservoir that existed on the original date (August, 2005) of the DEQ guidance document entitled “*Implementation Guidance For Reclamation And Bonding Of On-Channel Reservoirs That Store Coalbed Natural Gas Produced Water*”, and was not constructed nor has been modified for the purpose of managing produced water from coal bed natural gas operations.

Note: These definitions are to provide criteria to protect the water quality of the state’s resources and may not coincide with the definitions of on-channel and off-channel established by other government agencies for other purposes.

Section 2.02 Establishing Setback Distances from Waters of the State:

- (a) The setback distance is the distance from the impoundment to the water feature as discussed above. This distance will be defined as a measurement between the inside edge of the berm of the impoundment to the nearest edge of the water feature or alluvium or floodplain discussed above. The geographic coordinates of the point of the inside berm closest to the edge of the water feature or alluvium or floodplain must be established and submitted to the WDEQ. The geographic coordinates must be in decimal degrees to six significant digits. The geographic coordinate system (projection) shall be NAD 83.
- (b) The operator must document any pre-existing springs or surface seeps prior to discharge into an impoundment. After discharge into the impoundment commences, any surface springs or “seeps” that occur within 500 feet of the impoundment will be considered by the WDEQ to be a result of the discharge into the impoundment.

Section 2.03 Proximity to Clinker Outcrops

- (a) Clinker deposits represent areas where coal fires have baked the overlying strata and are present in various areas of the Powder River Basin. These clinker deposits can be very permeable with high groundwater flow velocities due to fracture flow. Consequently, infiltrating water that intercepts the clinker deposits may resurface or intercept surface waters of the state in a relatively short time frame. Impoundments can be located on a clinker deposit or within 500 feet of clinker deposit only if it can be demonstrated that the water infiltrating through the clinker will not surface, reach surface waters of the state, or cause a groundwater standards violation as discussed below.

Section 2.04 Proximity to Existing Wells

- (a) Proximity to existing wells: No impoundments receiving cbm produced waters shall be located within ¼ mile of any domestic water supply well, irrigation supply well, or stock well unless it can be demonstrated that the well is constructed in a different aquifer than the shallow aquifer beneath the impoundment and the that aquifer will not be impacted by water infiltrating from the impoundment. In addition, any impoundment to be located within one mile of a public water supply well will be treated on a case by case basis.

III. MINIMUM SUBSURFACE INVESTIGATION REQUIREMENTS

Section 3.01 Groundwater to be Monitored:

- (a) Groundwater within a zone, stratum or group of strata that is capable of producing and sustaining a yield of 0.5 gallons/minute or more of water over a 24 hour period will be considered for compliance monitoring. A discussion of techniques to determine this yield is contained in Attachment 2. The determination of the yield of the groundwater bearing zone is an option and not a requirement. If groundwater is encountered in a boring, a monitoring well is properly completed and developed, and the groundwater is of sufficient quantity for sampling, then a sample must be submitted for analysis. The WDEQ will assume that the yield is of sufficient yield to be protected. Depending upon the resultant classification of the groundwater by the WDEQ, additional monitoring may be required.

Section 3.02 Groundwater Classified:

- (a) In accordance with Water Quality Rules and Regulations, (WQRR) Chapter VIII, groundwater is classified by the WDEQ in order to apply standards to protect water quality. Groundwater is classified by the WDEQ as Class I (domestic use), Class II (irrigation use), Class III (livestock use), Special A or Class IV (industrial use). Groundwater is classified by use, and by ambient water quality. If there is no existing (appropriated) use of the groundwater, the groundwater classification is based upon the parameters listed in Wyoming Water Quality Rules and Regulations, Chapter VIII, Table 1. A minimum list of analytes to be sampled is contained in Attachment 3.

Section 3.03 Impoundments Exempted From Subsurface Investigation:

- (a) The WDEQ will not require a subsurface investigation beneath the following classes of CBM impoundments:
 - (i) Impoundments less than 2.0 acre feet in capacity.
 - (ii) Impoundments that have a WYPDES permit issued prior to August 1, 2004.
 - (iii) On channel impoundments that are not required as part of a water management plan in a Wyoming Pollution Discharge Elimination System (WYPDES) permit. Please note that a subsurface investigation may be required for all unlined off channel pits permitted by the Wyoming Oil and Gas Conservation Commission.
 - (iv) Existing Reservoirs: See definition in Section 2.01 above. The permittee must provide a copy of the letter to the Groundwater Section that is required in Section 6 of the document entitled "*Implementation Guidance For Reclamation And Bonding Of On-Channel Reservoirs That Store Coalbed Natural Gas Produced Water*", available at the following link: http://deq.state.wy.us/wqd/WYPDES_Permitting/WYPDES_cbm/cbm.asp. This letter is from the landowner indicating the landowner's desire that an existing reservoir be retained after the CBM operations are complete, and provides certification from the SEO that the reservoir may be left permanently, no bond is required from the DEQ, and the reservoir does not have to be reclaimed.

- (v) Natural Playas, topographic depressions, dry lake beds: A subsurface investigation may not be necessary beneath these features if no manmade enhancement is constructed. These features will be treated on a case by case basis. Please contact the Groundwater Section for further information.

Section 3.04 Number Of Borings Required For Initial Subsurface Investigation:

- (a) In order to investigate the subsurface geology and occurrence of groundwater in a project area or plan of development, at least one boring must be advanced at each impoundment unless data is presented to demonstrate that the impoundments are located in a similar hydrogeologic setting. Please note that given the heterogeneity encountered in the geologic formations of concern, the placement of a boring at each potential impoundment site will almost always be required.
- (b) For impoundments equal to or larger than 100 acre feet in capacity, the operator must contact the WDEQ Groundwater Program for subsurface investigation requirements. Due to the large size and potential environmental concerns, these impoundments will be treated on a case by case basis by the WDEQ.

Section 3.05 Location of Initial Borings or Monitoring Wells

- (a) Given the heterogeneity of the geologic formations in the areas of concern, to determine if groundwater exists beneath the impoundment, the initial boring must be located within approximately 50 feet of the bank of the proposed impoundment to the required depth of investigation. If geographic constraints limit the location of the borings, evidence must be provided by the operator that demonstrates that the local subsurface geology beneath the location of the boring is similar to the hydrogeology beneath the impoundment.

The initial boring or monitoring well should be located in the apparent down gradient location with respect to the impoundment. In most instances, this location should be satisfactory to document if infiltrating water is impacting groundwater. The WDEQ Groundwater Section will evaluate the need to monitor confined aquifer systems on a case by case basis.

Section 3.06 Required Depth of Initial Subsurface Investigation¹:

- (a) For impoundments less than 50 acre feet in capacity, at least one boring must be advanced to the first occurrence of groundwater in bedrock or to a depth of 150 feet below the elevation of the ground surface at the impoundment if no groundwater is encountered. Please note that the depth of investigation requirement is based upon the surface elevation of the impoundment. For example, if the elevation of the boring location is 25 feet higher in elevation than the impoundment, then the required depth below ground surface of the boring would be 175 feet. Estimates from a USGS 1:24,000 scale topographic map should be adequate to establish the differences between the surface elevation of the impoundment and the surface elevation of the monitoring well.
- (b) For impoundments equal to or greater than 50 acre feet in capacity, a boring must be advanced to the first occurrence of groundwater in bedrock, or to a depth of 200 feet below the surface elevation of the impoundment if no groundwater is encountered.
- (c) For impoundments equal to or larger than 100 acre feet in capacity, the operator must contact the WDEQ Groundwater Program for subsurface investigation requirements.
- (d) The installation of more than one boring or monitoring well at each impoundment may be required if shallow groundwater is encountered in unconsolidated materials above bedrock (e.g., alluvium, colluvium). If a very thick sequence of unconsolidated sediments is encountered, a boring to the first occurrence of water in the bedrock may not be required if the operator demonstrates that the infiltrating water will not reach groundwater in the bedrock formation.

Section 3.07 Reporting Requirements: No Groundwater Encountered:

- (a) If groundwater is not encountered to the required depth of investigation, a report containing the following information must be submitted to the WDEQ:
- (b) WYPDES permit number associated with this impoundment.
- (c) Borehole logs, providing lithologic descriptions of borehole cuttings. A sample borehole installation diagram is attached (see Attachment 4).
- (d) USGS 1:24,000 topographic map(or larger scale, more detailed map) illustrating:
 - (i) Proposed location(s) of impoundment(s).
 - (ii) Location(s) of boreholes.

¹ The department may require deeper borings where necessary to protect ground water.

- (iii) Locations of existing water wells (domestic, irrigation, livestock) and existing impoundments that are within ¼ mile of the impoundment and any public water supply well within 1 mile of the proposed impoundment.
- (e) Available information on existing water wells, including well completion details, yield, water use, water quality and other relevant data. This information is required for all domestic, stock, and irrigation wells within ¼ mile radius of the proposed impoundment and for all public drinking water supply wells within a 1 mile radius.
- (f) All hard copy reports must be submitted to: WDEQ/WQD, Attn: Groundwater Program, 2100 West 5th Street, Sheridan Ave, Sheridan, WY 82801, (307)-673-9337. In addition, the applicable fields in the Compliance Monitoring Data Reporting spreadsheet (see: <http://deq.state.wy.us/wqd/groundwater/index.asp>) must be completed and submitted electronically to the WDEQ at the following address: DEQ-cbmgroundwater@wyo.gov.
- (g) Installation of borings are pre-authorized under the “Permit by Rule” provision of Water Quality Rules and Regulations, Chapter 3, Section 8 (Attachment 5) provided that the requirements set forth in that regulation are adhered to.
- (h) All boreholes must be abandoned and properly sealed.
- (i) The report must be signed and sealed by a professional geologist licensed in the State of Wyoming.
- (j) Upon review of the report, if the WDEQ concurs that no groundwater was encountered, the WDEQ will issue a letter to the operator stating that no further subsurface investigation or compliance monitoring is necessary. This letter must be received by the operator before discharge into the impoundment can occur.

IV. GROUNDWATER SAMPLING AND MONITORING REQUIREMENTS

Section 4.01 Groundwater Encountered During Subsurface Investigation.

- (a) If groundwater is encountered in the boreholes to the required depths of investigation, a monitor well must be installed in order to obtain a representative groundwater sample. The monitor well must be constructed and developed in accordance with Water Quality Rules and Regulations, Chapter 26 (Attachment 6). Additional recommendations for the design, construction, installation (Attachment 7) and documentation (Attachment 8) of monitor wells are also attached to this guideline.
- (b) After installation of a monitoring well, the operator has the option of determining the yield of the groundwater before submitting a sample for analysis. If the groundwater does not yield 0.5 gallons/minute as per the provisions of Attachment 2, no additional monitoring of that groundwater interval shall be required. However, the operator must investigate if other groundwater bearing zones exist to the required depth of investigation, which is defined in Section 3.06.
- (c) Installation of a site investigation monitor well is pre-authorized under the “Permit by Rule” provision of Water Quality Rules and Regulations, Chapter 3, Section 8 provided that the requirements set forth in that regulation are adhered to. (Attachment 5).
- (d) In order for the WDEQ to classify the groundwater, at a minimum, the sample must be analyzed for the parameters listed in Attachment 3. The operator can analyze for the full suite of parameters listed in Water Quality Rules and Regulations Chapter 8, Table 1.
- (e) Please review the document entitled “Groundwater Sampling for Metals” for requirements and recommendations on developing, purging, and sampling (including filtering requirements) of monitoring wells (Attachment 9).

Section 4.02 Reporting Requirements: Groundwater Encountered During Investigation But CBM Impoundment Will Not Be Constructed Near The Site.

- (a) If an operator encounters groundwater and constructs a monitoring well while conducting a subsurface investigation to investigate potential sites for a cbm impoundment, and the operator elects not to construct an impoundment or utilize an existing reservoir at this location, the following information must be submitted to the WDEQ Groundwater Program within 90 days of receipt of any laboratory analytical data:
 - (b) Copies of any laboratory report(s).
 - (c) ‘As-built’ construction detail for each monitoring well installed. A sample monitor well installation diagram is attached.
 - (d) Geographic coordinates of the monitoring well in decimal degrees.

- (e) Plugging and abandonment record of the monitoring well or plans including timeframe, to plug and abandon the monitoring well(s). In accordance with Water Quality Rules and Regulations Chapter 26, a report must be submitted to the WDEQ within 15 days after the plugging and abandonment occurs.
- (f) The analytical information from the investigation must be added to the groundwater database currently being compiled by the WDEQ Groundwater staff and is available upon request. This database should be available on the internet in the fall of 2006.

Section 4.03 Reporting Requirements: Groundwater Encountered During Investigation And CBM Impoundment Will Be Constructed Near the Site.

- (a) If groundwater is encountered during the subsurface investigation in unconsolidated materials and/or the bedrock formation and an impoundment will be utilized for storage of cbm produced water, the following information must be submitted in hard copy to the WDEQ in order to determine if a compliance monitoring plan is necessary:
 - (b) Copies of laboratory report(s).
 - (c) Borehole logs, providing lithologic descriptions of borehole cuttings.
 - (d) 'As-built' construction detail for each monitoring well installed. A sample monitor well installation diagram is attached (see Attachment 9).
 - (e) Well development procedures, purging procedures, and well sampling and chain of custody procedures.
 - (f) USGS 1:24,000 topographic map (preferably larger scale, more detailed map, such as 1:2,000), illustrating:
 - (i) Locations of monitoring wells.
 - (ii) Proposed locations of impoundments.
 - (iii) Locations of existing water wells (domestic, irrigation, livestock, industrial) and impoundments that are within ¼ mile of the impoundment and any public water supply wells within 1 mile of the impoundment.
 - (iv) Locations of any existing impoundments, or ranch reservoirs, within ¼ mile of the proposed impoundment.

- (g) Information on existing water wells, including well completion details, yield, water use, water quality and other relevant data. This information shall be required for all domestic, stock, and irrigation wells within ¼ mile radius of the proposed impoundment and within a 1 mile radius for all public drinking water supply wells.
- (h) The report must be signed and sealed by a professional geologist licensed in the State of Wyoming.
- (i) Electronic submittal: the applicable fields in the Compliance Monitoring Data Reporting spreadsheet (see: <http://deq.state.wy.us/wqd/groundwater/index.asp>) must be completed and submitted electronically to the WDEQ at the following address: DEQ-cbmgroundwater@wyo.gov. The data contained in the spreadsheet will be added to an electronic groundwater database that is maintained by the WDEQ and is available upon request.

Section 4.04 Groundwater classified by WDEQ as Class IV (Industrial Use).

- (a) Upon review of the report of investigation, if the WDEQ classifies a groundwater encountered beneath an impoundment as a Class IV groundwater, the WDEQ will issue a letter to the operator stating that no further compliance monitoring is required. However, there may be scenarios where shallow groundwater may be monitored in order to protect surface water standards when the groundwater has been classified as a Class IV groundwater.
- (b) When no compliance monitoring is required, the monitor wells must be properly plugged and abandoned in accordance with Water Quality Rules and Regulations Chapter 26. The plugging and abandonment report must be submitted to the WDEQ, Groundwater Section in Cheyenne (see address on form) within 15 days after the plugging and abandonment occurs.

Section 4.05 Groundwater classified by the WDEQ as Class I, II, or Special A.

- (a) Upon review of the report of investigation, if the WDEQ classifies the groundwater beneath an impoundment as a Class I, II, or connected to Special A groundwater, the WDEQ will contact the operator stating that an impoundment over this class of groundwater will not be utilized for receiving coalbed methane water.

Section 4.06 Groundwater Classified by the WDEQ as Class III.

- (a) Upon review of the report of investigation, if the WDEQ classifies the groundwater in the unconsolidated materials and/or bedrock formation beneath an impoundment as a Class III groundwater and the cbm water to be discharged into the impoundment is Class III or better quality, the following information must be submitted:
- (b) Number and location of compliance monitoring well(s):

- i) If evidence is provided that indicates that the monitoring well is located down gradient of the impoundment, this well will be utilized for compliance monitoring purposes. If the shallow groundwater in the unconsolidated formation and the bedrock groundwater are classified as Class III groundwater, compliance monitoring may be required in both groundwater settings.
 - ii) This monitoring well shall be located within 50 feet of the bank of the impoundment on the down gradient side of the impoundment unless otherwise authorized by the WDEQ.
- (c) Laboratory analyses of the cbm water to be discharged into the impoundment.

Section 4.07 Compliance Monitoring Plan/Permit to Construct Required:

- (a) If an impoundment that receives cbm produced water is to be constructed over a Class III groundwater, an operator must obtain an authorized compliance monitoring plan prior to any discharge into the impoundment. In order to obtain authorization of a compliance monitoring plan, a Wyoming Water Quality Rules and Regulations Chapter 3 Permit to Construct will be issued for the compliance monitoring well(s) associated with the impoundment(s).
- (b) A single Permit to Construct may be issued for compliance monitor wells at multiple impoundments in a plan of development or project area. Therefore, there is no need to submit a separate permit application for each monitoring well in a project area. The permit to construct will be only for those monitoring wells included in the permit application. If additional impoundments are eventually added in a plan of development or project area, additional permits will be required.
- (c) An application for a WQRR Chapter 3 Permit to Construct (Link: <http://deq.state.wy.us/wqd/groundwater/index.asp>) and the supporting documentation must be submitted in triplicate and provide the information listed as follows:
 - (i) The WYPDES permit and outfall number associated with each impoundment.
 - (ii) ‘As-built’ construction detail for each monitoring well installed. A sample monitor well installation diagram is attached (see Attachment 9).
- (d) Borehole logs that provide lithologic descriptions of borehole cuttings.
 - (i) Boring and monitor well locations (latitude/longitude, decimal degrees, NAD 1983).
 - (ii) Surveyed top of casing elevations.
 - (iii) Static water levels on all monitor wells.
 - (iv) Potentiometric surface map and supporting information.

- (v) Initial groundwater analytical results.
- (vi) USGS 1:24,000 topographic map (or larger scale, more detailed map), illustrating:
 - 1) Location(s) of monitoring wells, including distances to bank or toe of slope of impoundment.
 - 2) Proposed location(s) of impoundment(s).
 - 3) Locations of existing water wells (domestic, irrigation, livestock, industrial) and impoundments within ¼ mile radius of the proposed impoundment.
- (vii) Information on existing water wells, including well completion details, yield, water use, water quality and other relevant data. This information shall be required for all domestic, stock, and irrigation wells within ¼ mile radius of the proposed impoundment and within a 1 mile radius for all public drinking water supply wells.
- (viii) Size (surface acres and depth) and volume (acre feet) of the impoundment.
- (ix) The permit application and supporting documents must be signed and sealed by a professional geologist licensed in the State of Wyoming.
- (x) Well development procedures, purging procedures, and well sampling and chain of custody procedures for the wells that have been sampled.
- (xi) A Sampling and Analysis plan for the compliance monitor well(s), which describes, at a minimum:
 - 1) Well ID's and locations where samples are to be collected.
 - 2) Sampling equipment to be used.
 - 3) Well purging procedures.
 - 4) Sample collection procedures.
 - 5) Preservation, holding times and sample collection containers.
 - 6) Sampling equipment decontamination procedures.
 - 7) Collection and recording of field data, including weather conditions, date and time of sample collection, name(s) of field personnel, etc.

Section 4.08 Permit to Construct and Compliance Monitoring Program Authorization

- (a) If the WDEQ concurs with the findings in the permit application and supporting documentation, the WDEQ will issue a Permit to Construct (permit) for the compliance monitoring wells and a letter of authorization for the compliance monitoring program to the operator of the facility. Discharge of coalbed methane produced water into the impoundment shall not occur until the Compliance Monitoring Program Authorization letter and permit have been received.

Section 4.09 Permit to Construct (Compliance Monitoring) Conditions:

- (a) The applicant will provide immediate oral or written notice to the Wyoming Department of Environmental Quality/Water Quality Division, Groundwater Section, 2100 West 5th Street, Sheridan, WY 82801, 307-673-9337, fax 307-672-2213 when discharge to each impoundment covered under a permit commences.
- (b) Any exceedence of the water quality standards listed in a permit will be considered a violation of the permit. If an exceedence of groundwater or surface water standards occurs as a result of the operation of the impoundment, the WDEQ may require a more frequent monitoring schedule, further investigation of the groundwater impacts, remediation of the groundwater impacts, cessation of discharge into the impoundment, or other actions as may be necessary.
- (c) When compliance monitoring results and data analyses indicate that water infiltrating beneath the impoundment has reached groundwater and indicate that groundwater standards or any hydrologically-connected surface water standards will not be exceeded as a result of infiltration from the impoundment, the WDEQ may terminate or reduce the groundwater monitoring requirements.

Section 4.10 Compliance Sampling Schedules

- (a) New Impoundment Facilities:

One year of quarterly groundwater monitoring will typically be required after initial discharge into the impoundment. After analyses of the required quarterly data by the WDEQ, a change in the frequency of groundwater monitoring requirements may be warranted. For deeper confined aquifer systems, some scenarios may justify a less rigorous monitoring program or no additional monitoring requirements, based upon a site specific analysis of the subsurface and aquifer characteristics by the WDEQ.

- (b) Existing Impoundment Facilities (*where groundwater violations do not exist*)

Current sampling schedule requirement: Quarterly

Any change to sampling frequency requirements will be contingent on the WDEQ analysis of groundwater analytical results and data trends. Sites will be reviewed on a

case by case basis and changes to the sampling schedule will include analyses of:

- i) Data trends established by the 4 or more quarterly sampling events;
- ii) Proximity to any sensitive receptors;
- iii) Time of travel calculation as performed by Groundwater Section staff for deeper confined aquifer systems.

Depending on the analyses of the data trends, the sampling schedule may remain quarterly, changed to a semi-annual or annual sampling, or discontinued if the groundwater and discharged water has reached a chemical equilibrium. That is, if infiltrating water has reached native groundwater and has not caused a water quality violation and data indicate that the dissolution of salts will not result in a groundwater violation. Additional data such as chemical isotope analyses or geochemical plots (e.g., tri-linear or piper plots) may be required before cessation of groundwater monitoring will be authorized.

(c) Existing Impoundment Facilities (*where groundwater violations exist*)

Depending upon the severity of the water quality violation, an exceedence of groundwater standards may result in an increase of sampling frequency, installation of additional monitoring wells to delineate the extent of contamination, cessation of discharges into the impoundment, and remediation of the aquifer. Violations of groundwater standards will be addressed on a case by case basis.

(d) Reporting Dates:

The groundwater sampling reports shall be submitted electronically to CBM-Groundwater@wyo.gov by the dates listed below:

Sampling Frequency	Report Due Date(s)
Quarterly	Jan 15 th , April 15 th , July 15 th , Oct 15 th
Semi-Annual	Jan 15 th , July 15 th
Annual	Jan 15 th

Section 4.11 Compliance Sampling Parameters

The groundwater from the compliance monitoring well(s) shall be sampled and analyzed for the following parameters: Total Dissolved Solids, Sulfate, Selenium, field pH, and static water level elevation. An analysis for Arsenic is no longer required. Please refer to the individual permit for any site specific analyses that may be required.

ATTACHMENT 1: USGS WATER FEATURES

RIVERS, LAKES, AND CANALS

Intermittent stream	
Intermittent river	
Disappearing stream	
Perennial stream	
Perennial river	
Small falls; small rapids	
Large falls; large rapids	
Masonry dam	
Dam with lock	
Dam carrying road	
Perennial lake; Intermittent lake or pond	
Dry lake	
Narrow wash	
Wide wash	
Canal, flume, or aqueduct with lock	
Elevated aqueduct, flume, or conduit	
Aqueduct tunnel	
Well or spring; spring or seep	

SUBMERGED AREAS AND BOGS

Marsh or swamp	
Submerged marsh or swamp	
Wooded marsh or swamp	
Submerged wooded marsh or swamp	
Rice field	
Land subject to inundation	

ATTACHMENT 2: FIELD METHODS FOR DETERMINING WELL YIELD

As defined above, for purposes of this document only, groundwater shall be defined as a zone, stratum or group of strata that is capable of producing and sustaining a yield of 0.5 gallons/minute (GPM) of water over a 24 hour period from a six-inch inside diameter (i.d.) water well.

In many cases it is apparent when the first significant groundwater has been encountered when drilling a test boring. In these cases, it is clear that the strata can produce more than 0.5 GPM and further groundwater sampling is necessary.

The following testing procedures are recommended for those situations where groundwater yield may not meet the 0.5 GPM criteria and therefore will not require additional groundwater monitoring.

If, in the course of drilling, any zones that may produce 0.5 GPM are encountered, that zone should be completed with a properly constructed, fully penetrating monitoring well. This means that the boring must be drilled into the lower confining layer and screened across the entire target production zone. The monitor well should be properly developed and allowed to stabilize prior to beginning any further testing.

It must be demonstrated that no groundwater bearing zone is present to the required depth of investigation discussed in Section 3.06 above before the WDEQ will issue a letter stating that no groundwater monitoring will be required. This may require the installation of multiple monitoring wells at a site to make the determination if groundwater exists.

One consideration when determining well yield is well diameter. The well yield measured in a 2-inch or 4-inch well will have to be scaled up to represent the yield of a six-inch well in the same formation before it can be compared to the 0.5 GPM criteria. For tests conducted in a 2-inch monitoring well multiply, the yield by 1.19 to obtain the equivalent yield in a six-inch well. For a four inch well multiply, the yield by 1.07 to obtain the equivalent yield in a six-inch well. These scaling factors are based on well diameter v. yield ratio data presented in Driscoll, 1986.

Two methods of testing are recommended to demonstrate whether the potential production zone can yield 0.5 GPM:

Recovery test, or
Constant rate discharge test.

In both cases, careful documentation of all methods used and measurements made is essential and must be certified by a professional geologist licensed in Wyoming. The documentation should include, but is not limited to: lithologic descriptions, drilling methods, well completion, well development, pumping and or bailing (equipment, rates, and periods), water level measurement, flow measurement, etc.

Recovery test method

The recovery test is conducted by stressing the well and measuring its recovery. The rate of recovery is then converted to a rate of flow into the well. The well is stressed by removing water (by pumping or bailing) until the available head in the well is reduced by at least 80%. Water levels are monitored as the well recovers and recorded with the time since pumping/bailing ceased. Monitoring of recovery can stop when water levels have recovered to 50% of the original available head. The volume of water produced from the well between the maximum drawdown and 50% drawdown level is calculated taking into account storage within the well casing and within the filter-packed annulus. This volume is divided by the amount of time it took to recover to the 50% level to obtain the flow rate into the well. If this calculated flow rate is less than 0.5 GPM then the target production zone will be considered insignificant and further monitoring will not be required.

An example of the recovery test method is presented in Figure 1 below. In this example, a target production zone has been identified between about 60 and 80 feet and the well has been constructed so as to be screened across the entire target production zone which is, in this case, unconfined. The static water level is at 60 ft, the bottom of the well is at 80 feet and the total available head is 20 ft. The water level which represents 80% of the total available head (DD80) is 76 ft, whereas the water level that represents 50% of the total head (DD50) is 70 ft.

The well should be either pumped or bailed until drawdown has reached the DD80 level. Pumping/bailing should be ceased at this point and the stop watch started. Water levels should be monitored as they recover. The stop watch should be stopped when the recovery water level has reached the DD50 level. For this example, the time it took for the water level to recover to the DD50 level is ten minutes. The flow calculations are presented in the figure. The final flow rate into the well was 0.395 therefore no additional groundwater would be required.

Constant rate discharge test method

The constant rate discharge test is conducted by pumping or bailing the well at a constant rate of 0.5 GPM. If a pump is used, the intake of the pump should be set at level that will allow water levels to be lowered by at least 80% of the available head. A variable speed pump and/or valved discharge line should also be used to maintain a constant pumping rate as drawdown increases. The constant discharge rate must be verified with periodic flow measurements. Water levels should be monitored within the well during pumping. This is most easily accomplished using a pressure transducer. At a minimum, water levels should be monitored until they fall below 80% of the original available head or until they stabilize (do not change significantly over time). A target production zone will be considered insignificant if water levels fall below 80% of the original available head while being pumped at 0.5 GPM and further monitoring will not be required. If water levels stabilize above the 80% drawdown mark then the target production zone will be considered significant and further groundwater monitoring will be required.

Example recovery test calculations
to determine if well yield is less than or greater than 0.5 GPM

Procedure:

- » Pump/bail well until depth to water is at least 76 ft.
- » Stop pumping/bailing, start stop watch and record the maximum depth to water (DD_{80}).
- » Monitor recovery until depth to water has reached 70 ft.
- » Stop stopwatch when water level has reached 70 ft (50% of available head) and record time (Δt), ($\Delta t=10$ min, for this example).
- » Calculate flow.

Assumptions:

Borehole radius r_b is 0.25ft (6" dia.)
Well casing radius r_c is 0.083ft (2" dia.)

Filter pack: Top is 50 ft,
Effective porosity (n) is 30%

Static Water Level (SWL) is 60ft

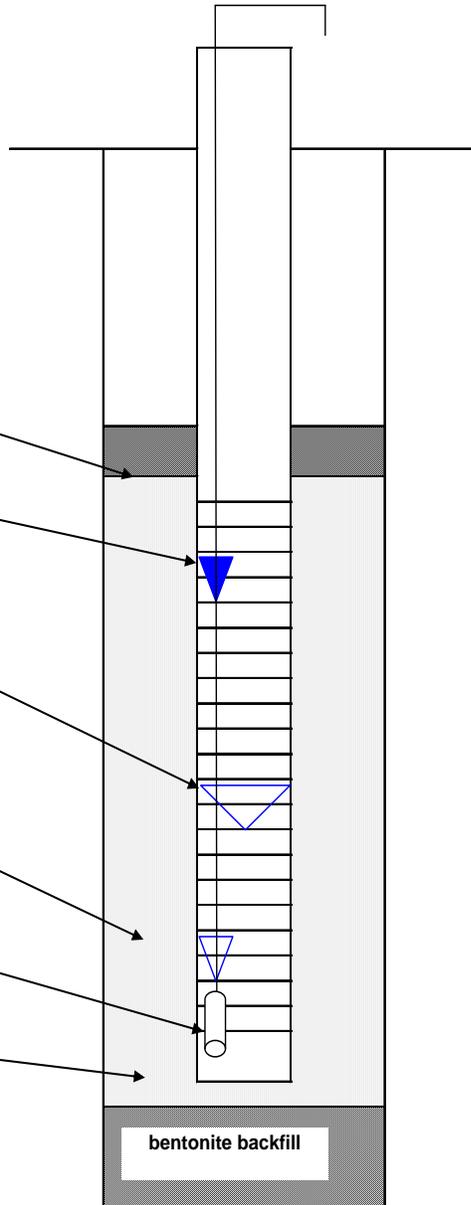
Water level when available head is reduced by 50% (DD_{50}) is 70ft

Water level when available head is reduced by 80% (DD_{80}) is 76 ft

Pump intake below DD_{80}

Bottom of well is 80 ft

Time from end of pumping until water level recovery to DD_{50} is 10 minutes



Computations:

Calculate volume in filter pack (V_f):

$$V_f = [n \times \pi \times (DD_{80} - DD_{50} \text{ or Top of filter, whichever is lower}) \times [r_b^2 - r_c^2]]$$

Calculate volume of casing (V_c):

$$V_c = \pi \times r_c^2 \times (DD_{80} - DD_{50})$$

$$= [3.1416 \times 0.083^2 \times (76 - 70)]$$

$$= 0.130 \text{ ft}^3$$

Calculate flow:

$$\text{Flow} = (V_f + V_c) \times (7.48 \text{ gal/ft}^3) / \Delta t$$

$$= [(0.314 + 0.130) \times 7.48] / 10$$

$$= 0.33 \text{ GPM}$$

Scale up to 6" well:

$$\text{Flow} \times 1.19 = 0.395 \text{ GPM}$$

Flow is LESS than 0.5 GPM, there for additional monitoring would NOT be required.

ATTACHMENT 3: MINIMUM CLASSIFICATION ANALYTES

Aluminum (Al)
Arsenic (As)
Boron (B)
Cadmium (Cd)
Chloride (Cl)
Chromium (Cr)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Manganese (Mn)
Selenium (Se)
Sulfate (SO₄)
Total Dissolved Solids (TDS)
Zinc (Zn)
pH
Sodium Adsorption Ration (SAR)

Note: Operators may analyze for full suite of parameters in Wyoming Water Quality Rules and Regulations Chapter 8, Table 1.

ATTACHMENT 4: BORING LOG

BOREHOLE INSTALLATION DIAGRAM				
Project _____		Borehole No. _____		
Location _____		Monitor Well No. _____		
Contractor _____		Date _____		
Driller _____		Logged by _____		
Method _____		Checked by _____		
		Sheet _____ of _____		
Depth	Description/Lithology	Blows/ Depth	Field Screening Method _____	
			Reading	Notes
				
<div style="display: flex; justify-content: space-between;"> <div style="width: 15%;">  </div> <div style="width: 80%;"> <p>Depth to Water During Drilling, Ft. _____ Date _____</p> <p>Static Water Level Depth, Ft. _____ Date _____</p> <p>Measured From _____</p> <p>Remarks _____</p> </div> </div>				

ATTACHMENT 5: WQRR CHAPTER 3, SECTION 8 – PERMIT-BY-RULE

Section 8. Permit by Rule.

(a) The following facilities are permitted by rule in accordance with the requirements of this section:

(i) Monitoring wells, boreholes, test holes installed using direct push methods, soil vapor surveys, and test pits that are used to characterize subsurface conditions at sites where pollution is not known to exist;

(ii) Monitoring wells and other subsurface investigation facilities used to obtain information for a permit application under Section 17 of this chapter.

(b) When pollution is found in facilities described in subsection (a) (i) and (ii) that has entered or threatens to enter waters of the state, including groundwater, the property owner or owner of the test facility shall immediately notify the Water Quality Division and submit a report within three (3) months after the initial samples have been collected describing:

(i) The name, address, and telephone number of the operator and the owner, if not the same for the specified property;

(ii) A legal description of the specified property by ¼ section, township and range or by latitude and longitude if accurate to within ten (10) meters;

(iii) The type, nature and known extent of the pollution;

(iv) A brief description of the suspected source, or sources of pollution;

(v) A description of any known imminent or immediate threat to human health or safety, or to the environment;

(vi) A description of any corrective actions that have been taken or are planned to be taken;

(vii) Any sample results obtained must be provided to the department;

(viii) All plans, specifications and reports submitted under this section shall be sealed, signed and dated by a licensed professional engineer under W.S. Title 33, Chapter 29 and/or by a licensed professional geologist under W.S. Title 33, Chapter 41, as applicable.

(c) Monitoring wells shall be designed and constructed to protect groundwater resources according to Chapter 26 of these regulations. In addition, proper sealing to prevent intermingling of different quality aquifers and pollution of groundwater from the surface shall be emphasized, as well as proper design and materials used in drilling and construction. The use of

toxic glue is prohibited.

(d) Monitoring wells shall be plugged and abandoned in accordance with Chapter 26 of these regulations (**see Attachment 6**). All other subsurface investigation facilities must be abandoned by proper sealing to prevent surface contamination from reaching groundwater and to prevent the intermingling of aquifers.

(e) The administrator may request information from the owner or operator of a facility permitted by rule to determine whether that facility may be causing a violation of groundwater use standards in Chapter 8 of these regulations, the construction standards found in Chapter 26 of these regulations, or any other requirements of this chapter. Any request for information under this section shall be made in writing and include a brief statement of the reasons for requesting the information. An owner or operator shall submit the information within the time frame provided in the request for information.

(f) The administrator may require any owner or operator of a facility permitted by rule to obtain an individual permit for that facility when a review of the information submitted under subsection (b) indicates that the permit by rule would not be protective of groundwater in that specific case.

(g) Failure of the owner or operator to meet the requirements under this section is a violation of these regulations.

ATTACHMENT 6: WQRR CHAPTER 26 - WELL CONSTRUCTION

Section 1. General Information. This part contains minimum standards for design and construction and for the abandonment of wells covered by this part. The applicant or permittee shall provide for design and construction to protect groundwaters of the state in accordance with the water quality standards contained in Chapter VIII, Water Quality Rules and Regulations.

All American Society for Testing of Materials (ASTM), American Water Works Association (AWWA) and American Petroleum Institute (API) specifications listed are intended to mean the latest revision.

Section 2. Definitions Specific to Chapter 26.

(a) “Abandoned well” means a well regulated under this part for which use has been discontinued for more than one year and the owner does not desire to maintain this well for future use; or its use has been permanently discontinued or is in such a state of disrepair that it cannot be used for its intended purpose.

(b) “Annular space” means the space between the well casing and the wall of the drilled hole or between two well casings.

(c) “Artificial recharge well” means well constructed to introduce water into the ground as a means of replenishing groundwater basins.

(d) “Commercial, municipal and industrial waste well” means well constructed to dispose of unusable waste or contaminated water resulting from a commercial activity, municipal collection, storage or treatment facility or an industrial activity.

(e) “Conductor casing” means a tubular retaining structure installed in the upper portion of a well between the wall of the drilled hole and the inner well casing.

(f) “Confining formation” means an impermeable bed or a bed of distinctly lower permeability than the adjacent material in which groundwater may be moving.

(g) “Destroyed well” means a well that has been properly filled so that it cannot produce water nor act as a vertical conduit for the movement of groundwater.

(h) “Geothermal well” means a well constructed to extract or return water to the ground after it has been used for heating or cooling purposes.

(i) “Key seating” means a stuck drill pipe or casing caused by an abrupt change in direction or dogleg in the drilled hole.

(j) “Miscellaneous discharge well” means a well constructed for a special process discharge of limited time and scope.

(k) “Observation and monitor well” means a well constructed for the purpose of observing or monitoring groundwater conditions.

(l) “Production casing” means a tubular retaining structure installed in the upper portion of a well between the wall of the drilled hole and the inner well casing.

(m) “Sounding tube” means the access to the well casing that allows the water level in the well to be periodically determined. All sounding tubes should have a screw cap.

(n) “Special process discharge well” means a well constructed for the use of a subsurface discharge for recovering a product or fluid at the surface. Special process discharges are defined in detail in Chapter IX, Wyoming Water Quality Rules and Regulations.

(o) “Test well” means a well constructed for obtaining information needed to design a well prior to its construction. Test wells are cased and could be converted to observation or monitoring wells.

(p) “Watertight” means impermeable to water except when under such pressure that structural discontinuity is produced.

Section 3. Application. These standards shall apply to the types of wells listed below. Before a change of use for an existing well can occur, construction standards contained in this part shall be met for the new use.

(a) Well type list requiring permits under Water Quality Rules and Regulations.

(i) Commercial, municipal and industrial waste wells.

(ii) Special process discharge wells.

(iii) Artificial recharge and miscellaneous discharge wells.

(iv) Geothermal wells.

(v) Observation and monitoring wells.

(vi) Test wells.

(b) Standards concerning construction, maintenance and operation of oil or gas producing, storage, injection or disposal wells are administered by the Oil and Gas Conservation Commission and therefore are not contained herein.

Section 4. Well Construction Not Specifically Covered By This Part; Deviations.

(a) The administrator may grant a deviation from the standards provided the applicant or permittee can supply documentation of reliability, mechanical integrity, design and construction to protect groundwaters of the state in accordance with the water quality standards contained in Chapter VIII, Wyoming Water Quality Rules and Regulations. Such documentation shall include:

- (i) Theoretical technology; or
- (ii) Full scale operation at another site with similar conditions; or
- (iii) A pilot project of scope and length to justify a deviation.

Section 5. Well Location/Siting.

(a) The top of the casing shall terminate above grade or above any known conditions of flooding from runoff or standing water.

The area around the well shall slope away from the well. Surface drainage shall be directed away from the well.

(b) Where a well is to be near a building, the well shall be located at a distance from the building to provide access for repairs, maintenance, etc.

Section 6. Sealing the Annular Space. The annular space shall be sealed to protect it against contamination or pollution by entrance of surface and/or shallow subsurface waters. Annular seals shall be installed to provide protection for the casing against corrosion, to assure structural integrity of the casing, and to stabilize the upper formation.

(a) Minimum depths of seal below ground surface for various uses of wells will be:

Type Well	Minimum Depth of Seal
Commercial, municipal and industrial waste	30 feet
Special process discharge	30 feet
Artificial recharge and miscellaneous discharge	30 feet
Geothermal wells	30 feet
Observation and monitoring	20 feet ₂₅
Test wells	30 feet

(b) Sealing conditions. Following are requirements to be observed in sealing the annular space.

(i) Wells situated in unconsolidated, caving material shall have an oversized hole, at least four inches greater in diameter than the production casing, drilled. A conductor casing shall be installed. The space between the conductor casing and the production casing shall be filled with sealing material. The conductor casing may be withdrawn as the sealing material is placed.

(ii) Wells situated in unconsolidated material stratified with significant clay layers shall have an oversized hole of at least four inches greater in diameter than the production casing drilled, with the annular space filled with sealing material. If a clay formation is encountered within five feet of the bottom of the seal, the seal should be extended five feet into the clay formation.

(iii) Wells situated in soft consolidated formations shall have an oversized hole of at least four inches greater in diameter than the production casing. The annular space between the production casing and the drilled hole shall be filled with sealing material.

(iv) Wells situated in “hard” consolidated formations (crystalline or metamorphic rock) shall have an oversized hole drilled with the annular space filled with sealing material.

(c) Sealing material. The sealing material shall consist of neat cement grout, sand-cement grout, bentonite clay or concrete.

(i) Cement used for sealing mixtures shall meet the requirements of ASTM C150 “Standard Specifications for Portland Cement” or API 10B “Recommended Practices for Testing Oil-Well Cements and Cement Additives”. Materials used as additives for Portland Cement mixtures in the field shall meet the requirements of ASTM C494 “Standard Specifications for Chemical Admixtures for Concrete” or API RP 10B.

(ii) Neat cement shall be composed of one sack of Portland Cement (94 pounds) to 4½ to 6½ gallons of clean water.

(iii) Sand-cement grout shall be composed of not more than two parts by weight of sand and one part of Portland cement to 4½ to 6½ gallons of clean water per sack of cement.

(iv) Concrete used shall be “Class A” or “Class B”. Aggregates shall meet the requirements of ASTM C33 “Standard Specifications for Concrete Aggregates”.

(v) Special quick-setting cement, retardants to setting, and other additives, including hydrated lime to make the mix more fluid or bentonite to make the mix more fluid and reduce shrinkage, may be used.

(vi) Bentonite clay mixtures shall be composed of bentonite clay and clean water thoroughly mixed before placement so that there are no balls, clods, etc.

(vii) Used drillers mud or cuttings or chips from drilling the borehole shall not be used as sealing material.

(viii) The minimum time that must be allowed for materials containing cement to “set” shall be in accordance with ASTM C150 or API RP10B.

When necessary these times may be reduced by use of accelerators as determined by the well contractor.

(d) Thickness of seal. The thickness of the seal shall be at least two inches and not less than three times the size of the largest coarse aggregate used in the sealing material.

(e) Placement of seal. Before placing the seal, all loose cuttings, chips, or other obstructions shall be removed from the annular space by flushing with water or fluid drilling mud. The sealing material shall be placed when possible, in one continuous operation from the bottom up. The fluid used to force the final sealing material through the casing shall remain under pressure, to prevent back flow, until the sealing material is set.

Section 7. Surface Construction Features.

(a) Openings. Openings into the top of the well which are designed to provide access to the well, i.e., for measuring, chlorinating, adding gravel, etc., shall be protected against entrance of surface waters or foreign matter by installation of water tight caps or plugs. Access openings designed to permit the entrance or egress of air or gas shall terminate above the ground and above known flood levels and shall be protected against the entrance of foreign materials by installation of down turned and screened “U” bends. All other openings (holes, crevices, cracks, etc.) shall be sealed.

A sounding tube, taphole with plug or similar access for the introduction of water level measuring devices may be affixed to the casing of the well as long as the proper seal is maintained. Access ports for water level or pressure measuring devices are required by the State Engineer on all wells greater than four inches diameter.

Section 8. Casing. (a) The casing shall provide structural stability to prevent casing collapse during installation as well as drillhole wall integrity when installed, be of required size to convey liquid at a specified injection/recovery rate and pressure, and be of required size to allow for sampling.

(i) Steel casing shall meet the following conditions:

(A) Standard and line pipe. This material shall meet one of the following specifications:

(I) API Std. 5L, “Specifications for Line Pipe.”

(II) API Std. 5LX, “Specifications for High-Test Line Pipe.”

(III) ASTM A53 “Standard Specification for Pipe Steel, Black and Hot Dipped, Zinc Coated Welded and Seamless.”

(IV) ASTM A120 “Standard Specifications for Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless, for Ordinary Uses.”

(V) ASTM A134 “Standards Specifications for Electric-Fusion (arc) - Welded Steel Plate Pipe (Sizes 16 in. and over).”

(VI) ASTM A135 “Standard Specifications for Electric - Resistance - Welded Steel Pipe.”

(VII) ASTM A139 “Standard Specification for Electric-Fusion (arc) - Welded Steel Pipe (Sizes 4" and over).”

(VIII) ASTM A211 “Standard Specifications for Spiral - Welded Steel or Iron Pipe.”

(IX) AWWA C200 “AWWA Standard for Steel Water Pipe 6 inches and Larger.”

(B) Structural steel. This material shall meet one of the following specifications:

(I) ASTM A36 “Standard Specification for Structural Steel.”

(II) ASTM A242 “Standard Specifications for High Strength Low Alloy Structural Steel.”

(III) ASTM A283 “Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars of Structural Quality.”

(IV) ASTM A441 “Tentative Specifications for High-Strength Low Alloy Structural Manganese Vanadium Steel.”

(V) ASTM A570 “Standard Specification for Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality.”

(C) High Strength Carbon steel sheets or “well casing steel.” Each sheet of material shall contain mill markings which will identify the manufacturer and specify that the material is well casing steel which complies with the chemical and physical properties published by the manufacturer.

(D) Stainless Steel casing shall meet the provisions of ASTM A409 “Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High Temperature Service.”

(ii) Plastic can also be used for casing in many locations and under a variety of circumstances.

The two groups of plastic materials available are thermoplastics and thermosets.

(A) Thermoplastics. This material shall meet the requirements of ASTM F 480 “Standard Specification for Thermoplastic Water Well Casing Pipe and Couplings made in Standard Dimension Ratios (SDR).”

(B) Thermosets. This material shall meet the requirements of the following specifications.

(I) ASTM D2996 “Standard Specification for Filament Wound Reinforced Thermosetting Resin Pipe.”

(II) ASTM D2997 “Standard Specification for Centrifugally Cast Reinforced Thermosetting Resin Pipe.”

(III) ASTM D3517 “Standard Specification for Reinforced Plastic Mortar Pressure Pipe.”

(IV) AWWA C950 “AWWA Standards for Glass - Fiber - Reinforced Thermosetting - Resin Pressure Pipe.”

(iii) Concrete pipe used for casing should conform to the following specifications:

(A) ASTM C14 “Standard Specifications for Concrete Sewer, Storm Drain, and Culvert Pipe.”

(B) ASTM C76 “Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.”

(C) AWWA C300 “AWWA Standards for Reinforced Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids.”

(D) AWWA C301 “AWWA Standards for Prestressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids.”

(iv) Galvanized sheet metal pipe or natural wood shall not be used as casing.

(b) All casing shall be placed with sufficient care to avoid damage to casing sections and joints. All joints in the casing above the perforations or screens shall be watertight. The uppermost perforations shall be at least below the minimum depth of seal. Casing shall be equipped with centering guides to ensure even thickness of annular seal and/or gravel pack.

(i) Metallic casing. Steel casing may be joined by either welding or by threading and coupling.

(ii) Plastic (non-metallic) casing. Depending on the type of material and its fabrication, plastic casing may be joined by solvent welding or may be mechanically joined. Compatibility between potential contaminants and the sealing agent used shall be demonstrated.

Section 9. Sealing/Cementing Off Strata. Where a well penetrates more than one aquifer or water bearing strata, every aquifer and/or strata shall be sealed off to prevent migration of water from one aquifer or strata to another.

(a) Strata shall be sealed off by placing impervious material opposite the strata and opposite the confining formation(s). The seal shall extend above and below the strata no less than ten feet. The sealing material shall fill the annular space in the interval to be sealed, and the surrounding void spaces which might absorb the sealing material. The sealing material shall be placed from the bottom to the top of the interval to be sealed.

(b) Commercial, municipal and industrial waste and artificial recharge wells shall be sealed/cemented in order that all aquifers are isolated over the entire length of casing(s) and shall be surrounded by a minimum of two inches of sealant. The sealant/cement plug used to isolate the aquifer(s) shall extend 50 feet above and below the interface between confining layer and the aquifer(s).

(c) Sealing material shall consist of neat cement, cement grout, or bentonite clay as per Section 65(c).

Section 10. Well Construction, Completion, Development and Evaluation.

(a) Developing, redeveloping, or conditioning a well shall be done by methods which will not cause damage to the well or cause adverse subsurface conditions that may destroy barriers to the vertical movement of water between aquifers.

(b) The well opening shall be closed with a cover to prevent the introduction of undesirable material into the well and to insure public safety whenever the well is not in use or when maintenance is being performed on the well.

(c) During well development, every well shall be tested for plumbness and alignment in accordance with AWWA or API approved standards, i.e., deviation checks. The plumbing and alignment tests shall be documented to ensure problems such as key seating, or fatigue failures will not occur.

(d) All injection/recharge wells used for discharge of commercial, municipal or industrial wastes shall inject fluid through a tubing with a packer set immediately above the injection zone or tubing with an approval fluid seal as an alternative.

(e) At a minimum, all commercial, municipal and industrial waste, special process discharge, artificial recharge and miscellaneous discharge wells deviation checks and cement bond logs shall be conducted and documented. The Water Quality Division should be contacted prior to well construction or operation to determine the need for additional logs and tests.

Section 11. Plugging and Abandonment.

(a) All wells that are no longer useful (including test wells) must be plugged in order to assure that groundwater supply is protected and preserved for further use and to eliminate the potential physical hazard. A well is considered “abandoned” when it has not been used for a period of one year, unless the owner demonstrates his intention to use the well again by properly maintaining the well in such a way that:

(i) The well has no defects which will allow the impairment of quality of water in the well or in the water bearing formations penetrated.

(ii) The well is covered and the cover is watertight.

(iii) The well is marked so that it can be clearly seen.

(iv) The area surrounding the well is kept clear of brush or debris.

Observation or test wells used in the investigation or management of usable sources of groundwater by state agencies or by engineering or research organizations are not considered “abandoned” so long as they are maintained for this purpose. These wells shall be covered with an appropriate cap, and labeled for their particular use.

(b) Preliminary work. Before a well is plugged and abandoned, it shall be investigated by the permittee (owner/ operator) to determine its condition, details of construction and whether there are obstructions that will interfere with the process of filling and sealing.

(c) Filling and sealing. Following are requirements to be observed when plugging wells.

(i) Wells wholly situated in unconsolidated material in an unconfined groundwater zone shall have the uppermost 30 feet sealed with impervious material. The remainder of the well shall be filled with clay, sand, or other suitable inorganic matters as described in paragraph e.

(ii) Wells penetrating several aquifers or formations containing usable water sources shall have the uppermost 30 feet sealed with an impervious material. All screened or perforated intervals shall be sealed to prevent vertical movement of waters from the producing or injected formation. Impervious material shall be placed opposite the confining formation above and below (and including) the screened or perforated interval for a minimum of 50 feet or more.

(iii) Any uncased hole below the well shoe shall be filled with an impervious material as described in paragraph e. to a depth of at least 50 feet above the shoe.

(iv) Whenever production casing has been severed or inadvertently removed the well bore shall be filled with impervious material from a point 50 feet below to a point 50 feet above the point of severance or to the surface limit.

(v) Wells penetrating creviced or fractured rock shall have the portions of the well opposite this formation sealed with neat cement, sand cement grout or concrete. If these formations extend to considerable depth, alternate layers of coarse stone and cement grout or concrete may be used to fill the well.

(vi) Wells in nonfractured, consolidated formations shall have the uppermost 30 feet filled with impervious material and the non-creviced, consolidated formation portion of the well may be filled with clay or other suitable material.

(d) Placement of material. The following requirements shall be observed in placing fill or sealing a plugged or abandoned well.

(i) No material shall be placed in the well unless the administrator has been notified that plugging and abandonment operations are to commence. A minimum of 30 days notice must be given.

(ii) The well shall be filled with the appropriate material as described in paragraph e. from the bottom of the well up.

(iii) Sealing materials shall be placed in the interval or intervals to be sealed by methods that prevent free fall, dilution and/or separation of aggregates from cementing materials.

(iv) When the underground pressure head producing flow is such that a counterpressure must be applied to force a sealing material into the annular space, this counter-pressure shall be maintained for the length of time required for the cementing mixture to set as specified in Section 65, paragraph (c) (viii) of this part.

(v) To assure that the well is filled and there has been no bridging of the material, verification shall be provided that the volume of material placed in the well installation at least equals the volume of the empty hole.

(e) Material. Requirements for sealing and fill materials are as follows.

(i) Impervious sealing materials. Sealing materials shall have a permeability of 10⁻⁷ cm/sec or less. Impervious materials include neat cement, sand-cement grout, concrete, and bentonite clay as described in Section 66, paragraph (c). Used drilling muds are not acceptable.

(ii) Filler material. Materials such as clay, silt, sand, gravel, crushed stone, native soil, and mixtures of these materials, as well as those described in the preceding paragraph may be used as filler material. Material containing organic matter or used drilling muds shall not be used.

(f) Markings. The top of the plug of any plugged and abandoned well shall show clearly, by permanent markings, whether inscribed in the cement or on a steel plate embedded in the cement, the permit number, well identification number and date of plugging.

(g) Reports. Within 15 days after a well has been plugged and abandoned, the owner shall file a plugging record with the Water Quality Division.

ATTACHMENT 7

DEQ/WQD Additional Recommendations for the Design, Construction, and Installation of Monitor Wells

DEQ recommends that the following measures also be taken during the design, construction, and installation of monitoring wells. These measures should help to ensure that the well's lifetime and usability will be maximized and that samples collected from the well will be representative of true groundwater quality.

Downhole drilling, monitoring, and sampling equipment should be de-contaminated between boreholes and wells to minimize the potential for cross-contamination.

The borehole diameter should be at least four (4) inches larger in diameter than the casing diameter.

Factory screen casing is recommended for the perforated section of the well.

For water table (unconfined) aquifers, the screened interval should extend at least two (2) feet above the highest expected groundwater level and five (5) feet below the lowest expected water table.

To minimize the entrance of fine grained material into the wells, the filter pack should be designed to be compatible with the perforation size and the geologic materials encountered within the perforated interval.

The filter pack should extend to a minimum of one (1) foot above the screened interval.

Filter pack, annular seal, and surface seal material should be placed into the well in a manner such that no voids or bridging occur.

A minimum two foot (2') thickness of bentonite or bentonite grout is recommended at the top of the filter pack to serve as an annular seal. If bentonite chips are used they should be less than ½ inch in diameter and sufficiently hydrated with clean water to insure a proper seal.

The annular space above the bentonite seal to within one foot (1') of the surface should be sealed with neat cement grout, sand-cement grout, bentonite, or concrete according to the specifications provided in WQD Chapter XI, Section 65(c)(i-viii).

Where PVC pipe is used, sections should be installed using threaded joints, couplings, or mechanical connectors without the use of solvents or glues.

A protective casing should be cemented into place with the upper one (1) foot of the annular space completed in cement, forming a cement cap sloping away from the well.

Top and bottom well caps of the same material as the well casing should be installed to prevent

sediment and surface water from entering the well.

Well caps should be kept locked at all times other than for monitoring purposes.

Any tampering with wells should be investigated, documented, and reported to DEQ.

Wells should be clearly numbered using either a stamp to permanently engrave the number into the well cap or by writing the number in the wet concrete of the surface seal.

Wells should be developed by the use of a pump or bailer so that representative groundwater samples can be collected.

Wells that penetrate more than one aquifer must be constructed in accordance with Chapter XI, Section 68 of Water Quality Division Rules and Regulations. Co-mingling water from aquifers of differing quality may cause a violation of state groundwater standards.

Samples and measurements taken for the purpose of monitoring should be representative of the known or suspected pollutant(s).

Records of all monitoring information should be retained by the facility owner for a period of at least three years from the date of the sample collection. This period may be extended by request of the Administrator during the three year minimum retention period.

Prior to sampling, wells should be purged until a minimum of three (3) casing volumes have been removed or until three successive well purges followed by measurement of groundwater temperature, pH and conductivity indicate groundwater stabilization within the well.

ATTACHMENT 8

DEQ/WQD Recommendations for Documentation of Monitor Well Construction

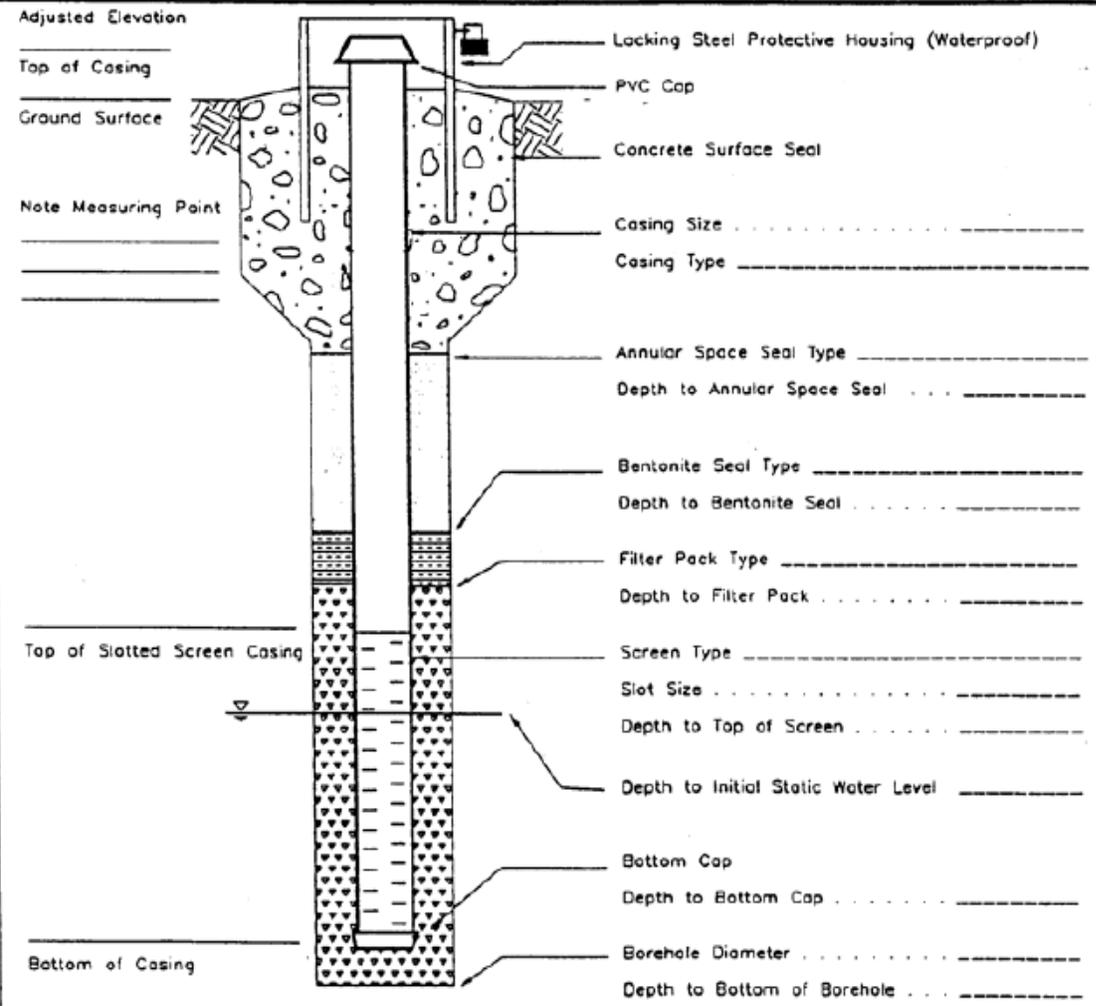
DEQ recommends that the following information be documented during actual construction and installation of your monitoring wells. This information is useful for future reference and may be of value to future owners of the property. Example Borehole and Monitor Well Installation Diagrams are attached for use in recording this information.

1. Type of facility, date and time of construction.
2. Names of persons collecting information and other persons on site, including their association to the project.
3. Construction or drilling method used and type of fluids used, if any.
4. Facility name, ID number.
5. Lithologic descriptions of geologic materials encountered.
6. Description and depth of seasonal water level indicators.
7. Depth to static water level.
8. Facility location (Centerline \pm 0.5 ft.).
9. Facility depth (Centerline \pm 0.1 ft.).
10. For wells: Borehole diameter and well casing diameter.
11. For other facilities: Length, width, diameter and depth.
12. Construction, drilling and lithologic logs (See Attached Borehole and Monitor Well Installation Diagrams)
13. Field Screening Results: identify sample depth and interval; time of sample measurement; description of sample measurement location; visual and olfactory descriptions; field screening equipment readings; description of weather, or other, conditions that may affect equipment readings.
14. Casing: Material type, dimensions, specs, interval(s).
15. Casing and screen joint type.
16. Screen: Material type, dimensions, specs, interval(s).
17. Filter pack: Material, size, placement method, interval(s).
18. Annular seal: Material type; placement method, interval(s).
19. Surface seal: Material type, design, dimensions.
20. Surface casing: Material type, dimensions, depth below surface, height above surface.
21. Type of well development procedure applied.
22. Type of protective well caps (top and bottom).
23. Surveyed elevation (\pm 0.01 ft. Mean Sea Level) of top of well casing (TOC), or measuring point if not TOC.
24. Location of facility identification marking.

ATTACHMENT 9: MONITORING WELL DIAGRAM

MONITOR WELL INSTALLATION DIAGRAM

Project _____	Monitor Well No. _____
Location _____	Borehole No. _____
Contractor _____	Date _____
Driller _____	Observed by _____
Method _____	Checked by _____
	Sheet _____ of _____



Surveyed by _____ Date _____

Remarks _____



Plugging and Abandonment Report for Monitoring, Observation, and Public Water Supply Wells

(Regulations governing plugging and abandonment of monitoring and other wells can be found in Water Quality Division Rules and Regulations Chapter 26, available at <http://deq.state.wy.us/wqd/>.

Note: One well per form.) **See DEQ website for updated forms.**

Date well was plugged: _____

DEQ Permit or Facility ID number authorizing well installation: _____, or Permitted-by-Rule? _____ (Yes or No)

Name of facility where well was installed: _____

Name, address, and phone number of well owner:

Phone: _____

Name, address, and phone number of person overseeing plugging operations:

Phone: _____ E-mail: _____

Location in decimal degrees (Lat. +DD.dddddd North, Long. -DDD.dddddd East):

_____ NAD 83

Address of location, if applicable: _____

County: _____

Description of plugging procedures, type, intervals, specifications, etc.:

Description of the top of plug (markings, type, visible at surface?):

Questions? Contact the WQD Groundwater Section at 307-777-7781, or e-mail deqwyo@state.wy.us

Return to: WDEQ/WQD, 122 W. 25th – 4W, Cheyenne, WY, 82002 ATTN: Groundwater Section Manager



ATTACHMENT 11

Groundwater Sampling For Metals: Summary April 6, 2005

Discussion: The goal of sampling groundwater is to obtain a sample that is representative of existing conditions. This becomes especially difficult when trying to obtain a representative sample for certain inorganic constituents, such as metals. The method in which the sample is collected has a significant impact on the sample quality, accuracy and reproducibility. In order to obtain a sample representative of existing groundwater, subsurface disturbance and sample handling must be kept to a minimum. "Sample collection practices that induce artificially high levels of turbidity have been shown to have the greatest negative impacts on sample quality." (Puls and Powell, 1992)

In order to allow the well to recover from drilling and development activities, the WDEQ does not recommend sampling monitoring wells within 48 hours of development. The following discussion outlines procedures that are acceptable to the WDEQ for analyses of metals in groundwater. Because of the potential for turbid samples to bias the analyses for total metals, the WDEQ recommends the use of low stress (low flow) purging techniques to minimize turbidity during collection of unfiltered samples.

Option 1: Conventional Purging Procedures (e.g., 3 well volumes evacuated).

Purge well and monitor field parameters that include turbidity, temperature, specific conductance, and pH (careful documentation of sampling procedures is required). When field parameters stabilize (measurements have stabilized when three consecutive readings spaced 5 minutes apart, are within 10 % of previous reading) and if turbidity readings are:

a.) Less than or equal to 20 NTUs

Collect analytical sample for WDEQ groundwater classification parameters listed in Table 1 for total metals analysis.

b.) Greater than 20 NTUs - Go to Options listed below:

Option 2: Low Stress (Low Flow) Technique

Conduct Low Stress (Low Flow) purging as described by Puls and Barcelona, 1996, and measure field parameters as discussed in Option 1. Other documents describing low stress techniques are referenced below.

a.) If turbidity is less than or equal to 20 NTUs, collect sample for WDEQ groundwater classification parameters listed in Table 1 for total metals analysis.

b.) If turbidity is still greater than 20 NTUs, but turbidity and other indicator parameter measurements have stabilized as discussed above, collect sample for WDEQ groundwater classification parameters listed in Table 1 for total metals analysis.

Option 3: Re-develop and Re-sample Monitoring Well

Re-develop well, wait a minimum 48 hours, re-purge and measure field parameters as in Option

1 above.

- a.) If turbidity is less than or equal to 20 NTUs then collect sample for groundwater classification for total metals analysis;
- b.) If turbidity is still greater than 20 NTUs, collect sample for groundwater classification parameters listed in Table 1 for dissolved metals analysis (filtered with 0.45 micron filter and preserved).

Option 4: Collect Groundwater Sample for Dissolved Metals Analyses

Collect analytical sample for groundwater classification parameters listed in Table 1 for dissolved metals (filtered with 0.45 micron filter and preserved).

**Table 1:
Classification Analytes**

Aluminum (Al)
Arsenic (As)
Boron (B)
Cadmium (Cd)
Chloride (Cl)
Chromium (Cr)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Manganese (Mn)
Selenium (Se)
Sulfate (SO ₄)
Total Dissolved Solids (TDS)
Zinc (Zn)
pH
Sodium Adsorption Ration (SAR)

References:

Puls, R.W. and Barcelona, M.J. (1996) Low-flow (minimal drawdown) groundwater sampling procedures: Washington, D.C., U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, EPA Ground Water Issue, EPA/540/S-95/504, 12 pp. <http://www.epa.gov/tio/tsp/download/lwflw2a.pdf>

Puls, R.W. and R.M. Powell (1992), Acquisition of Representative Ground Water Quality Samples for Metals: Ground Water Monitoring Review, Vol 12, No. 3, pp.167-176.

Yeskis, D. and Zavala B. (2002) Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers: Washington, D.C., U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Ground Water Forum Issue Paper, EPA/542/S-02/001, 53 pp. http://www.epa.gov/tio/tsp/download/gw_sampling_guide.pdf