Groundwater Monitoring Requirements of the CCR Rule – What’s Next?

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ABSTRACT

The U.S. Environmental Protection Agency published 40 CFR 257, Subpart D, the Coal Combustion Residuals (CCR) Rule on April 17, 2015. This Rule includes provisions for groundwater monitoring of active, inactive, and new CCR landfills and impoundments. Various deadlines are set for the establishment of a groundwater monitoring system, the sampling and analysis of groundwater, and the statistical evaluation of groundwater data. The CCR Rule created three phases of groundwater monitoring that include Detection Monitoring, Assessment Monitoring, and Corrective Action Monitoring. Groundwater protection standards will need to be developed based upon maximum contaminant levels (MCLs) or background levels. Criteria that trigger these phases of monitoring include a statistically significant increase (SSI) and a statistically significant level (SSL). If SSLs are determined in Assessment Monitoring, then the nature and extent of a release must be determined and a corrective action remedy developed. Reporting requirements that need to be a part of the operating record and/or posted to the public internet site are established. This presentation will provide an overview of upcoming CCR Rule requirements and corresponding deadlines. In addition, selected case studies of current CCR groundwater monitoring system designs including single units and multi-units with interconnected hydraulic water-bearing units, sampling and analysis programs, and data quality management challenges will be described.

INTRODUCTION

On April 17, 2015, in an effort to nationally regulate coal combustion residuals, the United States Environmental Protection Agency (USEPA) published the Final Rule of the Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments. This regulation addresses the safe disposal of coal combustion residuals (CCR) as solid waste under Subtitle D of the Resource Conservation and Recovery Act (RCRA) and is referred to herein as the CCR Rule. The CCR Rule became effective on October 19, 2015 and established national minimum criteria for the safe disposal of CCR. The regulations cover new and existing CCR landfills, surface impoundments, and lateral expansions. Requirements for the design and operation of
CCR units are identified along with groundwater monitoring and corrective action, closure and post closure care, and recordkeeping/notification.

This paper will focus on the groundwater monitoring and corrective action requirements of the CCR Rule as identified in 40 CFR Parts 257.90 through 257.98 and applicable record keeping and notification requirements. The activities initially required to comply with the CCR Rule will be discussed first and include development of the Site Conceptual Model, the design and installation of the CCR Monitoring Well Network, and the Sampling & Analysis Program. After these initial activities are complete, the remaining ‘What’s Next?’ CCR Rule groundwater monitoring requirements will be discussed. These requirements include:

1. Detection Monitoring (Initial Phase);
2. Statistical Evaluation;
3. Detection Monitoring;
4. Assessment Monitoring;
5. Assessment of Corrective Measures; and

PRELIMINARY CCR RULE GROUNDWATER MONITORING ACTIVITIES

Site Conceptual Model

A site conceptual model (SCM) provides a description of relevant site features and surface/subsurface conditions so that transport and migration of identified potential contaminants of concern can be understood. A hydrogeologic investigation is performed to collect the needed information to develop the SCM and can be refined through an iterative process through additional data gap investigations. The level of detail of the conceptual model should match the complexity of the site and available data. Development of the SCM will support eventual risk assessment evaluations and remedial decision making. If the migration pathways identified by the SCM are monitored, then the performance standard for the CCR Rule groundwater monitoring system design will be achieved.

CCR Monitoring Well Network Design and Installation

The CCR Rule contains a performance standard and a prescriptive requirement regarding the groundwater monitoring well network design and installation. The groundwater monitoring system should consist of a sufficient number of wells at
appropriate locations and depths to collect groundwater samples from the uppermost aquifer to meet the following performance criteria from 40 CFR 257.91(a):

- “Accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit.”

- “Accurately represent the quality of groundwater passing the waste boundary of the CCR unit. The downgradient monitoring system must be installed at the waste boundary that ensures detection of groundwater contamination in the uppermost aquifer. All potential contaminant pathways must be monitored.”

In addition, the CCR Rule prescribes that the monitoring system must include a minimum of one upgradient and three downgradient monitoring wells; however, additional monitoring wells must be installed as necessary to accurately represent the quality of background groundwater and the quality of groundwater passing the waste boundary of the CCR unit.

Background groundwater quality determinations do not have to be from hydraulically upgradient monitoring wells of the CCR unit. These exceptions include hydrogeological conditions that prevent the determination of what wells are hydraulically upgradient or other wells that are not hydraulically upgradient provide an indication of background groundwater quality that is as representative as upgradient monitoring wells.

The downgradient wells “must be located at the hydraulically downgradient perimeter of the CCR unit or at the closest practical distance from this location.” Monitoring well locations must be chosen based on accessibility and proximity to the waste boundary at the unit to be in compliance with 40 CFR 257.91(a)(2). Typical well location restrictions include power transmission line right-of-ways, underground utilities, drainage ditches, wetland areas, seep areas, and drainage pipelines.

The uppermost aquifer is defined in the regulations at 40 CFR 257.53 as “the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility’s property boundary. Upper limit is measured at a point nearest to the natural ground surface to which the aquifer rises during the wet season.” In addition, the definition of an aquifer “means a geologic formation, group of formations, or portion of a formation capable of yielding usable quantities of groundwater to wells or springs.” Therefore, the definition of a usable groundwater is based on the natural quality and the quantity. An example of a CCR monitoring well network that monitors hydraulically interconnected aquifers in the downgradient groundwater flow direction is shown below.
The CCR Rule provides a performance standard requiring groundwater monitoring wells to be constructed in a manner that maintains borehole integrity, consists of a screen, and is properly sealed to prevent cross contamination (40 CFR 257.91(e)). In addition to monitoring well installation and as part of the well construction process, wells must be developed to remove drill fluids, clay, silt, sand, and other fines which may have been introduced into the formation or sand pack during drilling and well installation, and to establish communication of the well with the aquifer.

Documentation of field activities can be achieved using a combination of log books and field forms. Log books are completed to provide a general record of activities and events that occur during daily tasks including detailed descriptions of subsurface media encountered and observations made during boring installation. During installation and development of the monitoring well, boring logs are used to document lithology and details of boring advancement. Monitoring well construction logs are used to detail final monitoring well construction details and well development records are created to track the well development process for each newly installed monitoring well.

Owners or operators must obtain a certification from a qualified professional engineer stating that the groundwater monitoring system was designed and constructed to meet the requirements of 40 CFR 257.91. In addition, Owners or operators will adhere to the recordkeeping and notification requirements of 40 CFR 257.91, 257.105, and 257.107. For existing units, the groundwater monitoring system certification must be placed in the owner or operator’s operating record as it becomes available and then posted to the public internet site within 30 days of placing in the operating record.
The CCR Rule under 40 CFR 257.91(d) allows for groundwater monitoring of CCR units that are close to each other using a single system. A multi-unit groundwater monitoring system is allowed as long as this system is equally capable of detecting a release at the waste boundary as multiple single unit monitoring systems. With a multi-unit system, the number of monitoring wells required to meet the performance standard may be reduced. However, if the multi-unit system includes unlined CCR surface impoundments as defined in 40 CFR 257.71(a), then all of the unlined surface impoundments are subject to closure requirements under 40 CFR 257.101(a) if there is an Appendix IV statistical significant level detection (discussed later). Below is an example of a multi-unit system.

MULTI-UNIT GROUNDWATER MONITORING SYSTEM

Sampling and Analysis Program

Under 40 CFR 257.93(a), the CCR Rule requires the development of a sampling and analysis program so that consistent procedures and techniques result in an accurate representation of groundwater quality. The program should include procedures for sample collection, preservation, and shipment. In addition, techniques covering
analytical procedures, chain of custody control, and quality assurance and quality control (QA/QC) should be included. Though not expressly required by the CCR Rule, a sampling and analysis plan (SAP) is suggested to satisfy the sampling and analysis consistency requirements.

Groundwater samples are to be analyzed for total recoverable metals and field filtering is not allowed in accordance with 40 CFR 257.93(i). Analytical methods are required to be appropriate for groundwater and accurately measure constituent concentrations. Many sites may deal with turbid groundwater samples and low-flow sampling methods as well as proper well screen design should be considered to minimize this turbidity. Groundwater monitoring procedures including low-flow sampling should be developed in accordance with federal/state procedures such as the USEPA Region IV Field Branches Quality System and Technical Procedures.\(^3\) Other data quality challenges may occur when other sources other than from CCR units are suspected to be the cause of groundwater concentrations of Appendix III and IV constituents. Isotope analyses can be performed to investigate the source of a constituent in an aquifer. For example, boron concentrations in an aquifer located near a coast may be related to salt water intrusion and could be confirmed by analyzing for a particular marine boron isotope. Thus, it may be possible to show that the boron concentrations in groundwater are not entirely associated with materials from a CCR unit. Speciation evaluations can also be performed on groundwater for certain Appendix III and IV constituents to gain a better understanding of the presence of these metals originating from a CCR unit source or natural groundwater conditions.

**WHAT'S NEXT?**

**Detection Groundwater Monitoring (Initial Phase)**

In accordance with 40 CFR 257.90, groundwater monitoring and corrective action is required for CCR landfills, CCR surface impoundments, and lateral expansions of CCR units. As part of the first phase of detection monitoring, at least eight independent sampling events of initial monitoring is to be conducted for the Appendix III and Appendix IV constituents (Table 1) prior to October 17, 2017 for existing units. At new CCR units, EPA interprets the requirements of 40 CFR 257.90(b)(2) and 257.94(b) to mean at least eight sampling events in background wells are to be collected and analyzed before first placement of CCR. Sample results will be used to develop Site-specific background concentrations for each Appendix III and Appendix IV constituent that will be utilized during the detection monitoring phase.

The Appendix III constituents are considered by EPA to be the leading indicators of whether constituents are migrating from a CCR unit. Appendix III constituents include: boron, calcium, chloride, fluoride, pH, sulfate, and total dissolved solids.

After completion of the sampling and analysis of the initial Detection Monitoring phase, EPA interprets the regulations to mean that the first statistical evaluation (discussed next) is to be completed no later than October 17, 2017 for the Appendix III constituents
for statistically significant increases (SSI) over background concentrations for each constituent in every downgradient well. If there is a SSI for any constituent in any well, the Site must begin Assessment Monitoring within 90 days.

**Table 1. Part 257 Appendix III and Appendix IV Constituents**

<table>
<thead>
<tr>
<th>Appendix III - Constituents for Detection Monitoring</th>
<th>Appendix IV – Constituents for Assessment Monitoring</th>
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<tbody>
<tr>
<td>Boron</td>
<td>Antimony</td>
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<tr>
<td>Calcium</td>
<td>Arsenic</td>
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<tr>
<td>Chloride</td>
<td>Barium</td>
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<td>Fluoride</td>
<td>Beryllium</td>
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<td>pH</td>
<td>Cadmium</td>
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<td>Sulfate</td>
<td>Chromium</td>
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<tr>
<td>Total Dissolved Solids</td>
<td>Cobalt</td>
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<td></td>
<td>Fluoride</td>
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<td></td>
<td>Lead</td>
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<td>Lithium</td>
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<td>Mercury</td>
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<td>Molybdenum</td>
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<td>Selenium</td>
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<td></td>
<td>Thallium</td>
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<td></td>
<td>Radium 226/228 combined</td>
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**Statistical Evaluation**

The CCR Rule identifies four statistical methods (40 CFR 257.93(f)) that may be selected to evaluate the groundwater monitoring data in each well and for each constituent. In addition, an option is given to select another statistical method as long as the performance standards of 40 CFR 257.93(g) are met. The four identified methods include:

1. Parametric analysis of variance followed by multiple comparison procedures;
2. Analysis of variance followed by multiple comparison procedures;
3. Tolerance or prediction interval procedure; and
4. Control chart approach.

If a control chart, prediction interval, or tolerance interval approach is used, it must be at least as effective in evaluating groundwater data as any other procedure identified in the CCR Rule. Non-detect data must also be evaluated with a statistical method that is at least as effective as any other identified method.

A certification from a qualified professional engineer is required that states the “selected statistical method is appropriate for evaluating the groundwater monitoring data for the CCR management area” (40 CFR 257.93(f)(6)). In addition, the certification must include a narrative description of whatever statistical method(s) was selected. For existing and new CCR units, the statistical method certification must be placed in the owner or operator’s operating record as it becomes available and then posted to the public internet site within 30 days of placing in the operating record. The CCR Rule also requires that statistical procedures be developed by October 17, 2017 for existing facilities per 40 CFR 257.90(b).
Conclusions drawn from the statistical evaluation may be invalid or in error if sample data do not satisfy basic statistical assumptions, such as the data are not independent or identically distributed. The groundwater samples need to be representative of the underlying population. EPA is concerned about false negative results from the statistical evaluation. Therefore, EPA suggests that for groundwater sampling and statistical evaluations the guidelines in the *Unified Guidance Document: Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities* be followed. These guidelines were cited throughout the preamble to the final CCR Rule.

**Detection Monitoring**

Groundwater is monitored for evidence of a release under Detection Monitoring. Upon completion of the Initial Phase of Detection Monitoring described above, Detection Monitoring will begin after October 17, 2017 for existing units and after first placement of CCR at new units or lateral expansions. The same wells used for the Initial Phase of Detection Monitoring will be used to collect groundwater samples for the Appendix III constituents. These groundwater samples will be collected semiannually. It is possible to perform a demonstration for an alternative detection monitoring frequency that is greater than semiannual. As described in 40 CFR 257.94 (d), an evaluation may be conducted to support an alternative frequency based upon the following factors:

- “Lithology of the aquifer and unsaturated zone;
- Hydraulic conductivity of the aquifer and unsaturated zone;
- Groundwater flow rates; and
- Information documenting that the alternative frequency is no less effective in ensuring that any leakage from the CCR unit is discovered within a timeframe that will not materially delay establishment of an assessment monitoring program.”

A statistical evaluation must be completed within 90 days after completing sampling and analysis. The Appendix III constituents must be evaluated for SSIs over background concentrations for each constituent in every downgradient well. If there is a SSI for any Appendix III constituent in any downgradient well, the CCR unit must begin Assessment Monitoring within 90 days. The Detection Monitoring results must be reported in the Annual Report.

If there is a SSI, a written demonstration can be made within 90 days of the SSI determination that a source other than the CCR unit was the cause or the SSI resulted from a sampling and analysis error, statistical evaluation error, or natural groundwater quality variations as described under 40 CFR 257.94(e)(2). A CCR unit may continue with the detection monitoring program if a successful demonstration is made.

**Assessment Monitoring Program**

If a SSI above background groundwater concentrations has been determined for one or more constituents in Appendix III at one or more downgradient wells under Detection
Monitoring, then Assessment Monitoring is triggered. Appendix IV constituents must be sampled and analyzed within 90 days for each well. During Assessment Monitoring, all wells will be sampled at least annually for the Appendix IV constituents.

In accordance with 40 CFR 257.95(d)(1), within 90 days after receiving the analytical results and on a semiannual sampling basis thereafter, Appendix III and Appendix IV constituents with detected concentrations will be sampled and analyzed in all wells. An alternative monitoring frequency may also be demonstrated based upon the same factors as described above under Detection Monitoring.

Groundwater protection standards (GWPS) will also be established at this time for all constituents under the Assessment Monitoring program. The GWPS will be based upon maximum contaminant levels (MCLs) as established under 40 CFR 141.62 and 141.66 or background concentrations for constituents without an MCL identified or if background concentration is higher than the MCL. During assessment monitoring, downgradient concentrations will be evaluated for statistically significant levels (SSLs) relative to the GWPS.

If all downgradient Appendix III and IV constituents are shown to be at or below background and/or the GWPS after evaluating for SSLs for two consecutive sampling events, then the groundwater monitoring program for that CCR unit may return to the Detection Monitoring program. If any of the Appendix III or IV constituents are above background concentrations but below all of the GWPS, then the CCR unit will remain in the Assessment Monitoring program.

If there is an SSL above the GWPS for any constituent in any of the downgradient wells under Assessment Monitoring, Assessment of Corrective Measures must begin within 90 days or immediately upon determination of a release from a facility. The vertical and horizontal nature and extent of the Appendix IV constituent release must be determined. In addition, 40 CFR 257.95(g)(1)(iii) requires the installation of at least one additional groundwater monitoring well in the downgradient flow direction at the facility boundary.

If constituents have migrated off-site, property owners or residents affected must be notified and the notifications placed in the operating record.

If the CCR unit is an existing unlined CCR surface impoundment operating after October 19, 2015 and an SSL determination has been made, the unlined surface impoundment is subject to closure or retrofit requirements under 40 CFR 257.101(a). Within 6 months of making the SSL determination, the existing unlined surface impoundment must cease accepting CCR and non-CCR waste streams and either close or retrofit.

If there is a SSL, a demonstration can be made within 90 days of the SSL determination that a source other than the CCR unit was the cause or the SSL resulted from a sampling and analysis error, statistical evaluation error, or natural groundwater quality variations as described under 40 CFR 257.95(g)(3). A CCR unit may continue with the assessment monitoring program if a successful demonstration is made.
**Assessment of Corrective Measures**

An Assessment of Corrective Measures is triggered by an SSL of any Appendix IV constituent from the Assessment Monitoring phase, or immediately upon detection of a release from a CCR unit. A 60 day extension for the Assessment of Corrective Measures is available upon a demonstration certified by a qualified professional engineer. The assessment evaluates the effectiveness of potential corrective measures to achieve the goals of the remedy including protectiveness of human health and the environment, achievement of the GWPS, and source control.

As soon as feasible, a remedy is selected upon the completion of the corrective measures assessment. As part of selecting the remedy, a remedial implementation and completion schedule must be developed. The corrective measures must be discussed in a public meeting at least 30 days prior to remedy selection.

Under the Assessment of Corrective Measures, the groundwater monitoring will be the same as the Assessment Monitoring program for that CCR unit. Additional monitoring wells may be installed within the plume boundaries to monitor the corrective action activities and the effectiveness of the remedy.

Corrective action groundwater monitoring, remedial activities and any interim actions must begin within 90 days of selecting a remedy for a CCR unit. When concentrations of Appendix IV constituents at all groundwater monitoring wells beyond the Detection Monitoring groundwater well system have not statistically exceeded the GWPS for 3 consecutive years, corrective action remediation and corrective action monitoring will be complete. The groundwater monitoring program can then return to the Detection Monitoring program.

The groundwater monitoring system must be operated and maintained throughout the Detection Monitoring Program, the Assessment Monitoring Program, or Correction Action Program. The post-closure care period will last 30 years unless the CCR unit is operating under the Assessment Monitoring Program at that time, then post-closure care continues after the 30 years until the CCR unit returns to the Detection Monitoring Program.

**Annual Report**

An Annual Groundwater Monitoring and Corrective Action Report will be prepared and placed into the operating record by January 31, 2018 for existing CCR landfills and CCR surface impoundments and annually thereafter, as required by 257.90(e). For new CCR units, this annual report is to be completed and placed into the operating record by January 31 of the following year after the groundwater monitoring system has been established. The annual report must also be posted to the public internet site within 30 days of placing in the operating record.
The annual report must describe the groundwater monitoring activities conducted, key actions, problem resolutions, and plans for the upcoming year. The minimum information required to be included in the annual report, if it is available, is found in 40 CFR 257.90(e). Some of these report elements include a figure showing the CCR unit and the surrounding monitoring well network, new or abandoned wells, a summary of the groundwater data, and the status of the groundwater monitoring program.

REFERENCES:


