WHITE PAPER

Does Your Groundwater Monitoring System Need Modification/Recertification?

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Introduction

TRC is working nationally in a Program Management capacity with Coal Combustion Residual (CCR) clients supporting the development of groundwater monitoring programs, investigation, and potential corrective action strategies for their regulated CCR units under federal and state CCR regulations. Since implementation of the federal CCR Rule in 2015, a significant volume of data has been collected for each regulated CCR unit. As part of TRC's Program Management role, we were tasked with developing a consistent groundwater management process that could maintain compliance reporting for a large portfolio of CCR units under the tight implementation schedule of the Federal CCR Rule (Attachment 1: Interpretation of CCR Groundwater Compliance Schedule).

When the Federal CCR Rule was promulgated in April 2015 (effective October 2015), it prompted power generators with regulated CCR units to establish a monitoring well network and implement a groundwater monitoring program. As part of the establishment of groundwater monitoring programs, a groundwater monitoring system was established for each (or multiple) CCR unit(s), with a minimum of one upgradient and three downgradient monitorng wells. Once wells were installed, groundwater background levels had to be established, using a minimum of 8 rounds of data, in about a 2-year period (October 2017). Some sites had pre-existing wells, other sites may not have had any wells or prior information on groundwater flow direction or groundwater quality. Some sites had multiple units and some clients had multiple sites. Furthermore, since 2015, potentially signficant operational changes have occurred in an expedited timeframe.

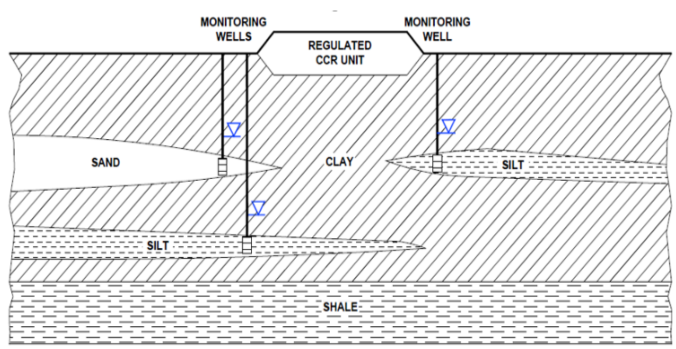
The focus of this paper is on conditions that present themselves during implementation of both federal and state CCR requirements that might result in the need to re-assess and modify the existing groundwater monitoring system.

Conceptual Site Models

To ensure that the unique considerations of each site were accounted for in the program space, strategies on a site-by-site basis were derived from the development of robust Conceptual Site Models (CSM's) comprised of historical documentation augmented with supplemental data from various subsurface investigations performed throughout the project life cycle.

CSM development was particularly important since conditions of site location, geology, and CCR depositional history varied widely across facilities. However, as existing CCR units were modified by CCR removal activities or reconstruction, the CSMs evolved as changes in site conditions occurred often due to discontinuation of hydraulic loading from sluiced ash or other factors as discussed below.

Groundwater monitoring systems and detection monitoring programs for these CCR units were initially established in 2015-2016, when the CCR rule first went into effect, in order to meet the requirements of §257.91. Since that time, conditions at many of these CCR units have significantly changed, and as a result the site CSMs have been updated, and monitoring systems have been revisited to maintain the monitoring system and comply with §257.91.



Emerging Considerations

There are a number of conditions or activities common to CCR sites that could result in the need to decommission monitoring wells, install replacement wells, or incorporate additional new wells.
For instance:

- The cessation of hydraulic loading after sluicing of CCR has stopped, the removal of CCR from the pond, or the installation of a final pond cover can significantly affect the groundwater flow conditions and appropriate horizontal and vertical placement of upgradient and downgradient monitoring wells.
- Data obtained during alternate source demonstrations (ASD's), CSM refinement studies, or nature and extent evaluations may lead to the need to reinstall failing wells or install additional wells at new locations to cover identified data gaps.
- Consideration of conforming RCRA CCR rule and State Permitting programs, cell expansions and other construction activities may also necessitate adjustments to monitoring systems.

Changing Conditions

Through the progression of implementing interim CCR removal activities and deactivation of bottom ash ponds, hydrogeological and geochemical changes may be taking place that could have a significant impact on your compliance monitoring system. The monitoring well network that made sense for detecton monitoring, may no longer be appropriate during assessment monitoring.

Be on the lookout for change and revisit your CSM frequently, especially if there has been a change to the pond status (e.g. cessation of hydraulic loading), pond closure, either by removal or capping, or implementation of corrective measures/other engineering controls.

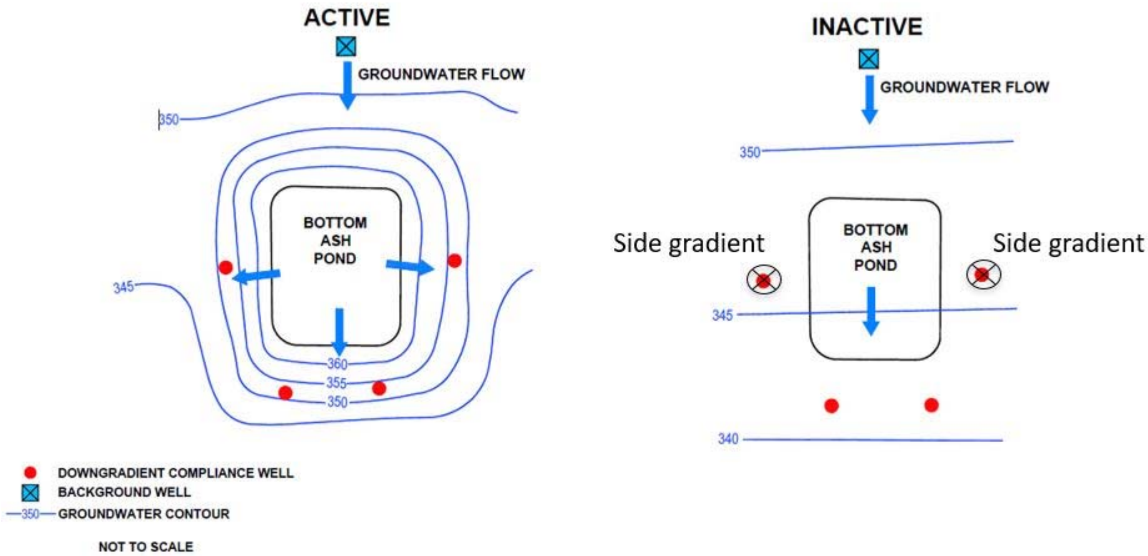
Flow direction changes can occur due to:

- Cessation of hydraulic loading;
- CCR removal/pond closure;
- Cap installation; or
- Interim measures such as cut-off walls, permeable reactive barriers, groundwater recovery, etc.

Under active conditions at an unlined impoundment, hydraulic loading is taking place that serves as a point of recharge into the subsurface. This loading often creates a localized mounding of water around the impoundment area, where the hydraulic head of the pond water is above the surrounding water table.

When this loading or recharge into the surface impoundment is terminated, changes in groundwater flow could be significant enough such that monitoring wells previously downgradient may no longer be appropriately positioned for compliance monitoring. New wells may need to be installed or relocated to maintain your groundwater monitoring system with a minimum of one upgradient and three downgradient wells in accordance with the CCR Rule.

As shown in the diagram below, while the pond was active, groundwater was mounded locally around the CCR unit with radial flow outward. During this period, four wells were used to monitor groundwater compliance downgradient from the unit. Under inactive conditions (sluicing was ceased), the groundwater flow in the area of the CCR unit re-stabilized post-hydraulic loading, the water table



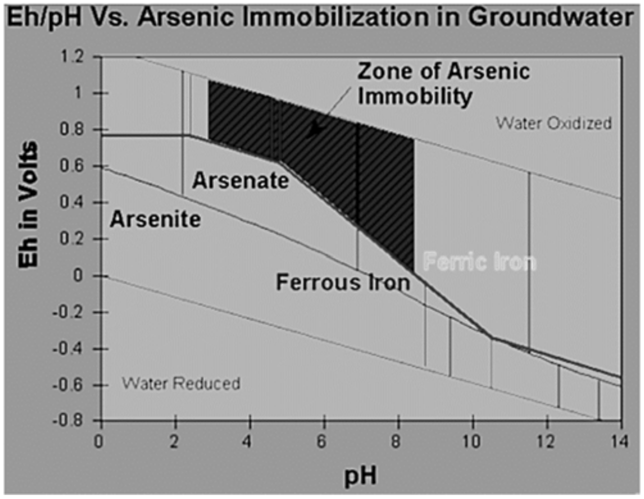
flattened, and groundwater flow changed to predominately one direction instead of radially outward. The change in groundwater flow has rendered two of the four monitoring wells side gradient to the predominant flow direction across the CCR unit.

Once it has been confirmed that the altered groundwater flow condition is representative of the re-stabilized site condition, it is appropriate in this case to add a new well directly downgradient of the CCR unit and incorporate it into the compliance monitoring network in place of the two side gradient wells. The side gradient monitoring wells would still be useful for water level data collection to continue to monitor groundwater flow conditions, and groundwater quality monitoring at those locations could still provide valuable insight into changing conditions around the unit such as plume delineation/stabilization, or the effectiveness of interim measures or CCR removal. Although the side gradient wells may no longer be appropriate for compliance, groundwater data from those wells could be useful for monitoring geochemical changes in groundwater around the CCR unit post-hydraulic loading.

Geochemical changes can occur due to:

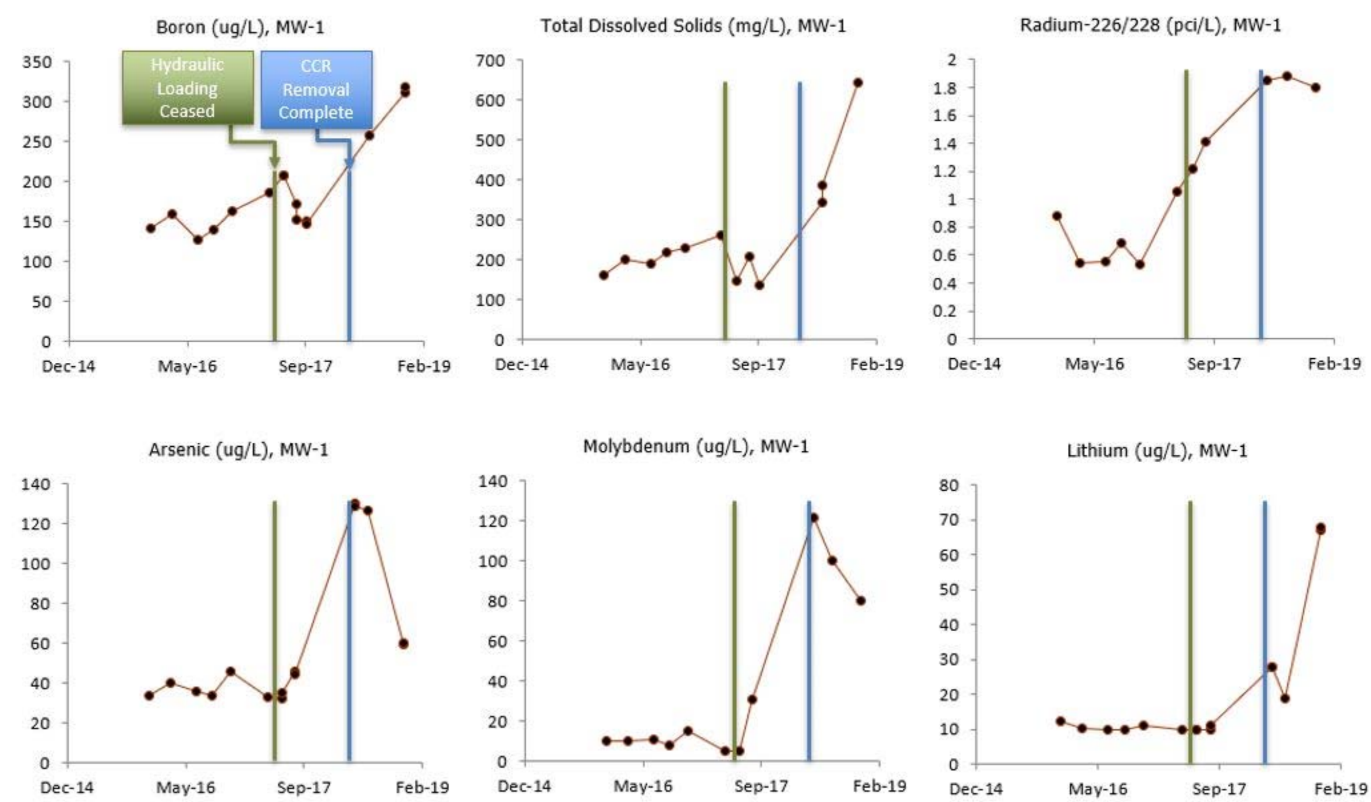
- Cessation of hydraulic loading;
- CCR removal/disturbance of soil;
- Cap installation;
- Interim measure (e.g. slurry wall, PRB, groundwater recovery); and/or
- Influence from nearby sources.

Hydraulic loading from sluiced ash can contribute to aerobic groundwater conditions, so when the unit is deactivated or decommissioned, it could prompt a change in redox conditions. There are several redox sensative constituents in the Appendix IV list, such as arsenic, chromium, mercury, and selenium to name a few. A change in oxidation potential (Eh) and/or pH could result in a change in concentration for these redox-senstive metals, causing either an increase or decrease in concentration depending on the constituent-specific Eh/pH conditions in which each chemical remains stable or unstable in the environment.



There is a high potential for site conditions to change as a result of deactivating or decommissioning CCR units that can have a profound effect on groundwater quality and may prompt the need to install additional wells to refine nature and extent or evaluate alternative sources that may be contributing to unexpected changes in groundwater.

For example, Appendix III/IV concentrations in groundwater were expected to decrease after cessation of hydraulic loading from sluiced ash and completion of CCR removal. Instead, as shown in the charts below, the concentrations of several constituents increased. While the pond was active, groundwater concentrations for these contituents were relatively stable with no distinct trends. After the ponds were deactivated, concentrations went up noticably. The evaluation of the change is currently underway, and, in addition to groundwater flow direction and geochemical changes, the potential for alternative on-site and off-site sources located upgradient from the CCR unit are being considered.



Alternate sources to consider include historical fill areas, coal storage or CCR management areas, spills or realeases, dust suppression, among others. In order to investigate the potential for these sources, historical site plans, topographic maps, and aerial photos are being reviewed and additional wells may be added upgradient from the CCR unit between the background wells and the upgradient edge of the CCR unit.

Adjust Monitoring System as Needed

As hydrogeologic conditions change or the understanding of the CSM improves, consider whether or not the current monitoring program needs to be refined by adding, removing or replacing wells, or relocating them altogether. If CCR removal is going to take place, think ahead about which monitoring wells may be at risk of being damaged or destroyed during construction. Incidental damage can be prevented by decommissioning those wells properly prior to or during CCR removal, and reinstalling them when the coast is clear.

Update your CSM before reinstalling or replacing the monitoring wells to ensure they are located appropriately to account for any groundwater flow changes. It may be more appropriate to relocate the replacement wells and re-establish background at a new location.

Administrative Housekeeping

Lastly, be sure to document and manage any changes in your monitoring network administratively. This can be accomplished through regular reporting required by the CCR rule, or consider developing a new document specific to the changes that lays out supporting justification for the change and why it is appropriate. Preparation of an Assessment Monitoring Plan is also a good way to document changes in the monitoring program and helps ensure that data quality objectives are being met. Consider updating the original groundwater monitoring system certification using the revised well network.

Graham Crockford, Program Manager for CCR Groundwater Compliance, TRC

Graham has over 28 years of experience in the fields of consulting, environmental engineering, geology, and hydrogeology. He currently serves as the Environmental Practice Lead for TRC's Michigan offices. He also serves as a Client Services Manager/Program Manager for TRC's utility and industrial clients. Graham has a long history with the liquid, solid waste, and Coal Combustion Residual (CCR) waste industry, including active-life/post-closure care. He has extensive experience in landfill permitting, groundwater compliance monitoring and remediation, and construction/operations. He also served as a program manager for a regional liquid and solid waste management firm where he was responsible for implementing groundwater protection and compliance programs for over 12 TSDFs across the US. Graham has served on several technical committees providing advocacy and industry perspective during development of solid waste rules in response to RCRA Subtitle D. His education includes a B.S. in Geology from Grand Valley State University and M.S. coursework in geology/hydrogeology at Wayne State University.

Sarah Holmstrom, P.G., Senior Hydrogeologist/Project Manager, TRC

Sarah Holmstrom is a Senior Hydrogeologist and Project Manager with TRC and serves as the geosciences group leader for Michigan environmental operations. Sarah is a Licensed Professional Geologist (IN) with over 13 years of experience assessing hydrogeological conditions for a wide range of projects, including manufactured gas plant (MGP), coal-combustion residuals (CCR), power delivery and industrial sites throughout the Midwest. She specializes in site characterization, groundwater-surface water interactions, conceptual site model development, risk-based corrective actions and solid waste compliance. Her education includes a B.S. in Professional Geology from Eastern Michigan University and completion of M.S. coursework in Environmental Geosciences (specializing in hydrogeology) at Michigan State University.

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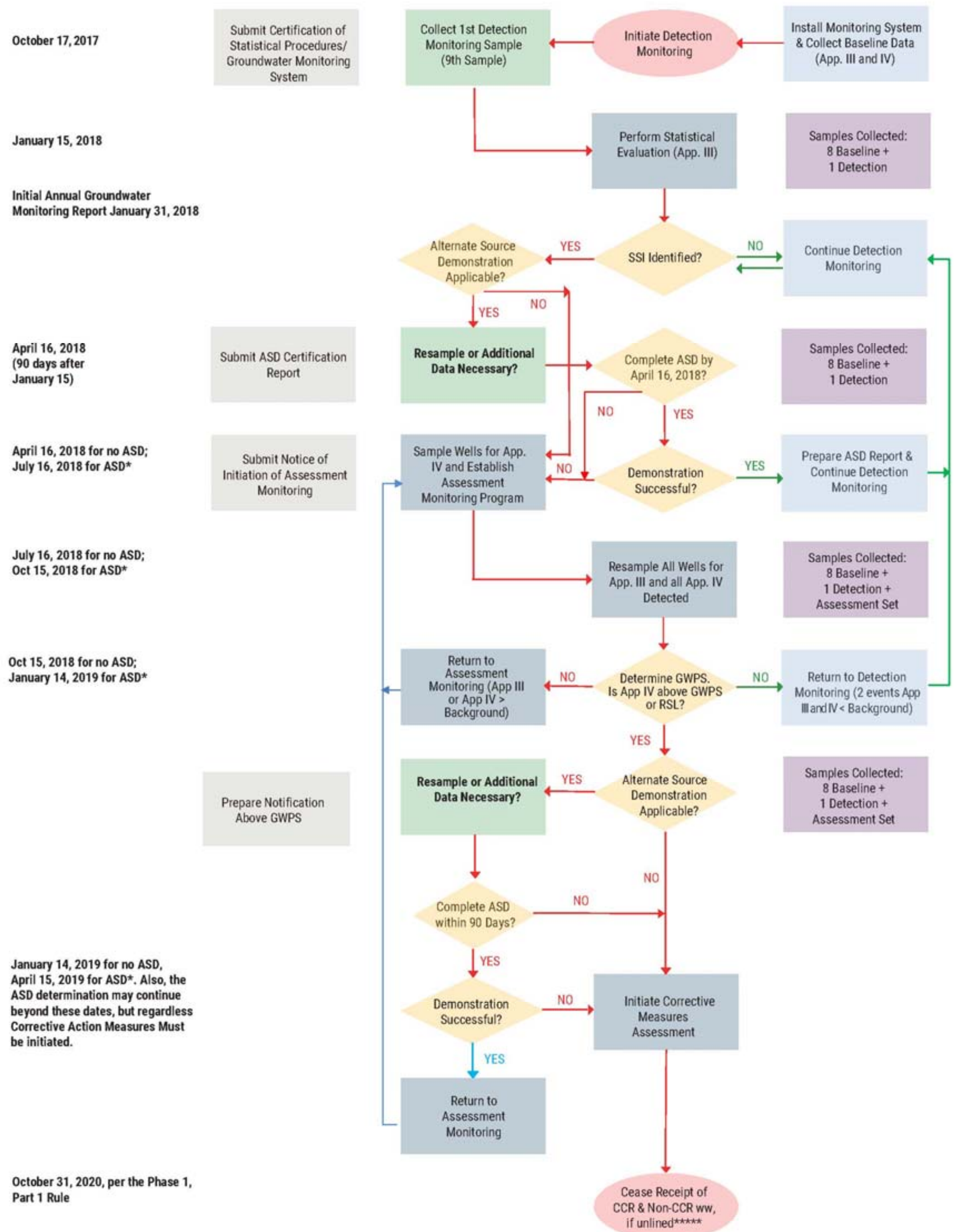
Interpretation of CCR Groundwater Compliance Schedule



* These are based on USWAGs recent interpretation of sampling and analysis, statistical windows and regs and EPA's responses to USWAG's letter dated November 27, 2017.
**The Preamble language defines "sampling and analysis" to mean sampling and completion of data validation (p. 21402). Therefore, this could influence some deadlines. Additionally, specific utilities may have different interpretations of the rule based on rule language, deadlines, etc.
*** This flow chart does not include additional samples beyond the first sample(s) collected as part of the routine detection or assessment programs.
**** This flow chart does not identify all required PE Certifications or Notifications to the Operating Record.
***** Unless Alternative Closure Requirements are met per 257.103 (CCR only).
****** This Compliance Schedule excludes any implications from the August 21, 2018 DC Circuit Court Ruling.

Critical Path towards Corrective Action
Pathway to Remaining in Detection Monitoring
Pathway to Remaining in Assessment

Draft preliminary interpretation of CCR Groundwater Compliance - Subject to Clarification and Revision. User should seek legal advice regarding site-specific CCR compliance.