Remedial Technologies to Address CCR Constituents in Groundwater

Environmental Show of the South – May 2018
Agenda

• Topics to be Covered
  ▪ Overview of CCR Rule Groundwater Monitoring Program and Timeline
    - Baseline Monitoring
    - Detection Monitoring
    - Assessment Monitoring
  ▪ Corrective Measures Assessment
  ▪ Selection of Remedy
  ▪ Remediation and Timeline
Initial (Baseline) Monitoring

- Minimum of 8 independent samples per well or spring required (background/upgradient and downgradient)
- Analyze for all Appendix III and Appendix IV parameters
- Sufficient number of samples obtained and analyzed for all four CCR units

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<tr>
<th>Appendix III</th>
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Statistical Analysis of Data

• Goals of Statistical Analysis:
  - Determine if statistically significant increase (SSI) greater than background concentrations for each Appendix III parameter for Detection Monitoring
  - Determine if statistically significant level (SSL) greater than MCL or alternative criteria concentrations for each Appendix IV parameter for Assessment Monitoring
  - Determine if Appendix IV parameters in downgradient wells have been below MCL or alternate criteria for 3 consecutive years after Corrective Action Measures implemented

• Statistical Analysis is Dynamic

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General Characteristics of Sites

• Located near rivers or other major water bodies
• Selection of upgradient and downgradient monitoring well locations
• Sites located on Karst with selection of springs as monitoring locations
• Existing water treatment systems
Next Steps in CCR Compliance Timeline

• CCR Rule Overview

• Next steps in CCR Compliance Timeline
  ▪ Detection Monitoring
    - Error Analysis
    - Natural Groundwater Quality Variation
    - Alternate Source Determination
  ▪ Assessment Monitoring
    - Same as Above

• What is Unknown
## Detection Monitoring

### Appendix III

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- Minimum semi-annual (2x year) monitoring for Appendix III

**DEC 2017**
- Complete Lab Analysis, Data Validation, and Statistical Analysis

**App III SSI Determination**

**Error, Natural Groundwater Quality Variation (NGQV), or Alternate Source Demonstration (ASD)**

**MAR 2018**
### Assessment Monitoring-Baseline Data

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- If Appendix III SSI’s are confirmed (no errors, natural groundwater variation, or alternate sources), initiate Assessment Monitoring

**Timeline:**
- **MAR 2018:** First Round of Assessment Monitoring (AM) Sampling (All App IV)
- **JUN 2018:** 2nd Round of AM Sampling (All App III / Detected App IV)
- **SEP 2018:** App IV SSL Determination
- **DEC 2018:** Develop Groundwater Protection Standards (GWPS) for Detected App IV

**Chemicals:**
- Boron
- Antimony
- Lead
- Calcium
- Arsenic
- Lithium
- Chloride
- Barium
- Mercury
- Fluoride
- Beryllium
- Molybdenum
- pH
- Cadmium
- Radium 226+228
- Sulfate
- Chromium
- Selenium
- Total Dissolved Solids
- Cobalt
- Thallium
- Fluoride
- pH
- Cadmium
- Radium 226+228
- Sulfate
- Chromium
- Selenium
- Total Dissolved Solids
- Cobalt
- Thallium
- Fluoride
Assessment Monitoring-Baseline Data

• Initially analyze for App IV and establish Groundwater Protection Standards (GWPS) for each App IV constituent

• GWPS = Maximum Contaminant Level (MCL) if one exists, or background concentration, whichever is higher

• Within 90 days, resample for App IV constituents that were previously detected plus App III list

• If Appendix IV constituents are detected at a Statistically Significant Level (SSL) > GWPS, must characterize the nature and extent of the release

• Within 90 days, initiate assessment of corrective measures

• If SSL > GWPS for an unlined impoundment, cease receipt of CCR and initiate closure within 6 months (Ash Pond June 2019)

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Corrective Measures Assessment & Selection of Remedy

**DEC 2018**
- Initiate Nature and Extent of Release Characterization
- 3rd Round of AM Sampling (All App III and Detected App IV)
- Initiate Assessment of Corrective Measures

**MAR 2019 (MAY 2019)**
- Complete Assessment of Corrective Measures

**JUN 2019 (AUG 2019)**
- Selection of Remedy
- Public Meeting
- Ongoing AM Sampling

**As Soon as Feasible**
- Implement Corrective Action Plan (CAP)
- 1st Round of Corrective Action (CA) Sampling
- Ongoing AM Sampling

**90 Days**
- Ongoing CA Sampling
- Ongoing AM Sampling
- Completion of CAP

**2020 and Beyond**
Corrective Measures Assessment & Selection of Remedy

• Corrective Measures Assessment Goals:
  ▪ Prevent further releases
  ▪ Remediate any releases
  ▪ Restore affected area to original conditions

• Step 1 – Collect and Evaluate Additional Data (Remedial Investigation/RFI)
  ▪ Define nature and extent of contamination
    - Additional monitoring wells, dye traces
    - Additional sampling for broad suite of analytes
    - Update the conceptual site model
      - Geology
      - Hydrogeology
      - Geochemistry
    - Data to support analysis of remedial alternatives
Corrective Measures Assessment & Selection of Remedy

• Step 2 – Evaluate a Range of Corrective Measures (Feasibility Study/CMS)
  - Select feasible remedial approach
    - Addresses the contaminants
    - Implementable
    - Cost-effective

• Step 3 – Select preferred approach (Proposed Plan)
  - Detailed analysis of selected approach
  - Regulator approval
  - Public meeting

• Step 4 – Finalize preferred approach (Record of Decision/Statement of Basis)
  - Final adjustments to preferred approach
  - Schedule for design and implementation

• Step 5 – Detailed design (Remedial Action Work Plan/Design)
  - Possible Pre-design data collection
  - Define performance evaluation criteria

• Step 6 – Design Implementation (Remedial Action/CMI)
  - Remedy construction/installation
  - Remedy operation and maintenance
Corrective Measures Assessment & Selection of Remedy

• Options
  ▪ Pump and Treat (existing water treatment systems)
  ▪ Monitored Natural Attenuation (MNA)
  ▪ In-Situ Treatments (i.e., Sorption/Precipitation)
  ▪ Permeable Reactive Barriers
  ▪ Cut-Off Walls (in combinations)
MNA – Application to Inorganics

• Inorganic MNA applicable to the Appendix IV metals

• MNA relies on physical and chemical processes in the aquifer to address mobile contaminant

• MNA as a remedy normally requires:
  • Source control
  • Detailed conceptual model to predict behavior
  • Long-term monitoring with periodic updates of the conceptual model

Source: ITRC 2010
MNA and Appendix IV Inorganics

- Data to evaluate MNA as corrective action collected as part of investigation to define nature and extent of contamination

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<th>Tier 1</th>
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<td>Tier 2</td>
<td>Identification of Attenuation Mechanisms</td>
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<tr>
<td>Tier 3</td>
<td>Attenuation Ability and Capacity</td>
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<tr>
<td>Tier 4</td>
<td>Long Term M&amp;M</td>
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Tier 1: Plume Stable or Shrinking

Tier II: Identification of Attenuation Mechanisms

Tier III: Attenuation Ability and Capacity

Tier IV: Long Term M&M

Performance Monitoring Parameters
Manipulate Aquifer Geochemistry

**Approach: Oxidize As (III) to As(V), Increase sorptive capacity**

- Oxidants under study: Permanganate, Calcium Peroxide
- Manganese oxides: Increase sorptive capacity
- Ferrous sulfate oxidation: Increase sorptive capacity
- Calcium peroxide: pH buffer on iron hydrolysis
Manipulate Aquifer Geochemistry

- Can you manipulate the aquifer to precipitate Appendix IV metals from groundwater?
  - Metal phosphates, sulfates, sulfides and hydroxides can be insoluble
    - Permeable reactive barrier design could incorporate sources of anions
    - Aquifer chemistry may be manipulated to precipitate metals (e.g., modification of in situ bioreactor)

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<tr>
<th>Appendix IV Metal</th>
<th>Phosphate</th>
<th>Sulphate</th>
<th>Sulfide</th>
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<td>Cadmium</td>
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<td>1x10^{-27}</td>
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<td>Cobalt</td>
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<td>6x10^{-22}</td>
<td>1.68x10^{-44}</td>
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Permeable Reactive Barrier

- Reactive media in the PRB tailored to the contaminants of concern, e.g.,
  - Alumina to adsorb As
  - Apatite (phosphate) to precipitate lithium
  - Iron filings to sorb arsenic and molybdenum oxyanions
  - Sulfate source to precipitate radium
Field Design of Packed Bed

- Direction of flow
- Baffles
- Packing
- Capped Drain Pipe with Filter Fabric
- Sock covering for sampling and feeding
- Rock Cover Layer

Flow events above design flow will bypass over the treatment area.

Flow will be forced into and through treatment area by baffles.

Source: US Army Corps of Engineers, Engineer Research and Development Center – Patent Pending
Pilot Scale Implementation
Sampling and Data Logging Unit
Permeable Reactive Barrier Installation

• Long Stick Excavation
  ▪ Slurry Trench
  ▪ Bench Setting

• One-Pass Trencher
In Situ Bioreactors

- Engineered subsurface mechanism to control the groundwater chemistry
  - Provides an initial “jolt” to the system
  - Mechanism for recharging the feed system
  - Biotic or abiotic actions can be stimulated
Case Study I – In Situ Bioreactors
Summary and Questions

• Sites often present physical limitation on remedial approaches (e.g., proximity to rivers)

• Sites often have extensive experience with conventional water treatment systems – pump and treat may be an attractive option

• CCR-related metals can be addressed with conventional remedial approaches

• CCR-related metals may be amenable to innovative in situ approaches

• Questions