Evaluating the Fate of Metals from Management of FGD Gypsum from Implementation of Multi-Pollutant Controls at Coal-Fired Electric Utilities

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Outline

• Background

• Research Objectives

• Status of research to evaluate potential leaching from management of coal combustion residues (CCRs) resulting from implementation of multi-pollutant control technologies
  – Enhanced Sorbents for Hg Control (completed)
  – Residues from Wet SO₂ Scrubbers (ongoing)

• Decision support tool for future CCR management decisions

• Next Steps
Changes in air pollution control (APC) at power plants result in transferring metals from the flue gas to fly ash and other APC residues. The fate of these metals is tied to how CCRs are managed.

Key release route for land-managed CCRs is leaching to groundwater. Also concern for release to surface waters, re-emission of mercury (e.g., cement kilns), and potential for bioaccumulation.
Historical and Projected Electricity Production by Fuel for 1980 – 2030 (Billion kilowatt hours)

Source: DOE/EIA, 2006
Wide Range of Potential CCR Management Practices & Release Scenarios

EPA
United States Environmental Protection Agency

Mine Reclamation

Landfill

Road base

Agriculture

Plant

Surface Impoundment

Coastal Infills

Drinking water well

Drinking water well

Drinking water well

Drinking water well

Drinking water well
CCR Production and Utilization

Production
122 million tons in 2004

Utilization
40% Utilization
49 million tons in 2004

Source: ACAA 2004 CCR Survey; DOE, 2005
Illustration of Multi-Pollutant Control at a Coal-Fired Power Plant

- COAL SUPPLY
- Boiler
- Superheater
- SCR
- Ammonia Injection
- Sorbent Injection
- ESP or FF
- Ash + Sorbent Removal
- FGD or Scrubber Sludge Removal
- Wet Flue Gas Desulfurization (FGD) Scrubber
- Flue Gas Stack

EPA United States Environmental Protection Agency
Advanced Pollution Controls

- Increased coal generation under environmental constraints, including new State regulations and NSR settlements, leads to more advanced SO$_2$, NO$_x$, and mercury controls in IPM 3.0 installed earlier.

- Rise in subbituminous coal consumption leads to more ACI retrofits (and an increase in mercury allowance prices).

*2025 numbers are highly tentative due to more uncertainty in future years.
Projected Retrofits at Coal-Fired Units in 2010 after CAIR/CAMR/CAVR

* Retrofits also include Title IV, NOx SIP Call and other State programs.

Startbursts within circles represent Activated Carbon Injection retrofits.

“Scrubber” also includes Reagent Injection for Fluidized Bed Combustion units. These units achieve an SO2 removal efficiency similar to scrubbers.

“Non-Economic” indicates that a unit that is not projected to operate.

Coal-fired units also have additional particulate controls not shown.
Projected Retrofits at Coal-Fired Units in 2015 after CAIR/CAMR/CAVR *

* Retrofits also include Title IV, NOx SIP Call and other State programs.
Starbursts within circles represent Activated Carbon Injection retrofits.
*Scrubber* also includes Reagent Injection for Fluidized Bed Combustion units. These units achieve an SO2 removal efficiency similar to scrubbers.
*Non-Economic* indicates that a unit that is not projected to operate.
Coal-fired units also have additional particulate controls not shown.
Projected Retrofits at Coal-Fired Units in 2020 after CAIR/CAMR/CAVR

*SCR Only
- <300 MW
- 300 MW/600 MW
- >600 MW

*SCR/Scrubbers
- <300 MW
- 300 MW/600 MW
- >600 MW

*SNCR Only
- <300 MW
- 300 MW/600 MW
- >600 MW

*SNCR/Scrubber
- <300 MW
- 300 MW/600 MW
- >600 MW

*Scrubber Only
- <300 MW
- 300 MW/600 MW
- >600 MW

*IGCC
- <300 MW
- 300 MW/600 MW
- >600 MW

*Repower
- <300 MW
- 300 MW/600 MW
- >600 MW

*Low NOx Burner
- <300 MW
- 300 MW/600 MW
- >600 MW

*Non-Economic
- <300 MW
- 300 MW/600 MW
- >600 MW

*Retros also include Title IV, NOx SIP Call and other State programs.
*Scrubber" also includes Reagent Injection for Fluidized Bed Combustion units. These units achieve an SO2 removal efficiency similar to scrubbers.
*Non-Economic" indicates that a unit is not projected to operate. Coal-fired units also have additional particulate controls not shown.
Installed, Committed and Projected Advanced SO₂ and NOₓ Controls for Coal-Fired Generations

- EPA has estimated the “Committed 2007-2009” upfront capital costs for pollution controls on existing plants to be over $12 billion.

- EPA has estimated the upfront capital costs for forecasted additional pollution control retrofits to be about $8 billion in 2010, $6 billion in 2015, and more than $3 billion by 2020. (Pollution control expenditures for new coal-fired units that EPA projects to be built are close to $4 billion in 2015 and over $9 billion in 2020.

- Roughly two-thirds of existing coal-fired capacity is located in a cost-of-service area.

- Many units will have both SCR and FGD installed (by 2020, about 320 existing coal-fired units and an additional 100 new coal-fired units that are projected to be built).

Source: EPA 2006 Base Case for CAIR, CAMR, and CAVR results from IPM and 2004 and 2006 NEEDS data sets for IPM

*Committed 2006-2010 based on reports from selected major companies. It is an understatement of controls going in place now.

**Total Units for Projected 2020 does not include new units or IGCC.
Projection of Hg Mass Balance in Response to CAIR and CAMR Implementation

Source: Thorneloe, 2006
Leach Testing Protocol

- ORD adopted OSW’s recommended approach to evaluating the leaching potential of CCRs that result from CAIR & CAMR implementation.

- OSW recommended the use of the leach testing framework and probabilistic assessment from Vanderbilt University, published at:
  

Leach Testing Protocol

- Allows evaluation of leaching potential across range of values for key parameters known to affect leaching and vary with disposal and beneficial use:
  - pH: The solubility of constituents of concern vary with pH.
  - Liquid to Solid ratio (L/S):
    - Reflects rainfall infiltration
    - Lower L/S ratio can result in different pH and contaminant concentration
  - Waste form –
    - Fine particles (equilibrium test)
    - Fixated and solid materials (mass transfer effects)
- A Single set of test results can be used to evaluate leaching potential for a range of management scenarios.
Research Objectives

1. Compare composition and leaching characteristics of coal combustion residues with and without use of multi-pollutant control for range of coal types and air pollution control configurations

2. Estimate potential release rate based on probabilistic assessment of plausible management practices for disposal and beneficial use

3. Develop background information document to support incorporation of leach testing framework into SW846 including comparison of leach lab results to field data

4. Develop report to meet requirement in EPA’s Mercury Road Map on fate of mercury and other metals from land disposal and commercial use of CCRs from plants equipped with multi-pollutant control technologies (p.67, http://www.epa.gov/mercury/roadmap.htm)
Research Outputs

• Report 1 – Published in 2006 – focus is characterization of fly ash from utilities using enhanced sorbents for mercury control
  – Samples obtained from six utilities with and without Hg control

• Report 2 – Expect public release by Spring 2008
  – Samples obtained from eight facilities with wet scrubbers
  – For five utilities, we obtained samples with and without NOx control in use

• Report 3 – Expect public release by Spring 2009
  – Will include six sites selected by OW for field testing to evaluate need for updating effluent guidelines
  – Will include data from about ten additional sites to attempt to span range of coal types and air pollution control configurations

• Report 4 – Comprehensive report to evaluate fate of mercury and other metals found in CCRs resulting from implementation of multi-pollutant control technologies (Mercury Roadmap Deliverable)
Recap of Coal Ash Results from Report 1 on Sorbents for Enhanced Mercury Capture


- Major findings include:
  - Mercury is strongly retained by the resulting CCR and unlikely to be leached at levels of environmental concern.
  - Arsenic and selenium may be leached at levels of potential concern both with and without enhanced mercury control technology -
    • Highest As leach values at 20% of toxicity characteristic (TC)
    • Highest Se leach value is 10 times the TC
  - Leachate concentrations and the potential release of mercury, arsenic, and selenium do not correlate with total content.
  - Laboratory leach data compares very well to field leach data.
Results for Leach Testing Analysis for Coal Fly Ash From Six Facilities Using Sorbents for Enhanced Hg Capture (Published in EPA/600/R-06/008, Feb 2006)

<table>
<thead>
<tr>
<th></th>
<th>Hg</th>
<th>As</th>
<th>Se</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total in Material (mg/kg)</td>
<td>0.1 -1</td>
<td>20 - 500</td>
<td>3 - 200</td>
</tr>
<tr>
<td>Leach results (ug/L)</td>
<td>Generally 0.1 or lower</td>
<td>&lt;1 - 1000</td>
<td>5 – 10,000</td>
</tr>
<tr>
<td>MCL (ug/L)</td>
<td>2</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>TC (ug/L)</td>
<td>200</td>
<td>5,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Variability relative to pH*</td>
<td>Low</td>
<td>Moderate to High</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

MCL - Maximum concentration limit (for drinking water)
TC - Toxicity Characteristic - Threshold for hazardous waste determinations

*Variability defined as-
low - <1 order of magnitude difference
med - 1 to 2 orders of magnitude difference
high - >2 orders of magnitude difference
Samples were collected from eight wet scrubber facilities:

- Wet scrubbers installed for SO\textsubscript{2} control but co-control metals
- Different configurations result in different CCRs
- Residues include:
  - Fly ash
  - FGD gypsum (oxidation forced to maximize CaSO\textsubscript{4} formation)
  - Scrubber sludge (natural or inhibited oxidation; mix of CaSO\textsubscript{3} and CaSO\textsubscript{4})
  - Fixated Scrubber Sludge (SS mixed with fly ash and often lime)
Variables being Evaluated Through Report 2 Analysis

• Samples were collected and tested to evaluate these variables:
  – Coal type: Bituminous and sub-bituminous
  – Differences in multi-pollutant controls
    • SO$_2$ controls - Forced and natural or inhibited oxidation
    • NOx controls -
      – Currently, NOx control is seasonal; therefore samples were collected with and without NOx controls in use.
      – In future, many plants will have year long NOx control.
  – Residue management - Landfill or surface impoundment
• Leach results
  – Allow comparison with relevant regulations or guidance: drinking water MCLs or Drinking Water Equivalent Levels (DWELs)
    • DWEL developed by EPA’s Office of Water as guidance for unregulated chemicals that may occur in drinking water.
  – Provide estimate of constituent release from the CCR; do not include groundwater fate and transport modeling.
Highlights from Report 2

- For FGD gypsum (four facilities):
  - Total metals concentration in FGD gypsum appears lower than fly ash and scrubber sludge.
  - Leach results appear to suggest that Hg leaching is of minimal concern but there may be a concern for leaching of other metals from some facilities (e.g., Cd, Mo, Se, Tl).

- For fly ash (three facilities), scrubber sludge (three facilities), and fixated scrubber sludge (four facilities), there are potential environmental concerns for some metals from some facilities if managed in an unlined unit (e.g., Sb, As, Ba, Cd, Cr, Mo, Se, Tl).

- For scrubber sludge and “fixated” scrubber sludge, there are potential environmental concerns if managed in an unlined unit (e.g., Hg, Sb, As, Ba, Cd, Cr, Pb, Mo, Se, Tl).

- NOx control may be a factor in release of Cr and other metals from fly ash, scrubber sludge and fixated scrubber sludge. Collecting additional data to clarify what factors may influence this (i.e., type of catalyst, coal chloride content).
## Preliminary Results from Report 2 for FGD Gypsum from Four Facilities

<table>
<thead>
<tr>
<th></th>
<th>Hg</th>
<th>Sb</th>
<th>As</th>
<th>Ba</th>
<th>B</th>
<th>Cd</th>
<th>Cr</th>
<th>Co</th>
<th>Pb</th>
<th>Mo</th>
<th>Se</th>
<th>TI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total in Material (mg/kg)</strong></td>
<td>0.01 – 0.5</td>
<td>2 - 6</td>
<td>2 - 4</td>
<td>3 - 60</td>
<td>NA</td>
<td>0.3 – 0.5</td>
<td>6 – 20</td>
<td>1 - 4</td>
<td>1 - 12</td>
<td>2 - 12</td>
<td>2 - 30</td>
<td>0.6 - 2</td>
</tr>
<tr>
<td><strong>Leach results (ug/L)</strong></td>
<td>&lt;0.01-0.6</td>
<td>&lt;0.3 - 10</td>
<td>0.5 - 10</td>
<td>40 - 400</td>
<td>40 – 70,000</td>
<td>&lt;0.2 - 50</td>
<td>&lt;0.3 - 50</td>
<td>&lt;0.2 - 10</td>
<td>1 - 600</td>
<td>4 – 3,000</td>
<td>&lt;0.3 - 20</td>
<td></td>
</tr>
<tr>
<td><strong>MCL (ug/L)</strong></td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>2,000</td>
<td>7,000 DWEL</td>
<td>5</td>
<td>100</td>
<td>15</td>
<td>15</td>
<td>200 DWEL</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td><strong>TC (ug/L)</strong></td>
<td>200</td>
<td>-</td>
<td>5,000</td>
<td>10⁵</td>
<td>6,500</td>
<td>10³</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>-</td>
<td>1,000</td>
<td>-</td>
</tr>
<tr>
<td><strong>Variability relative to pH</strong></td>
<td>Low to Med</td>
<td>Low to Med</td>
<td>Low</td>
<td>Low to Med</td>
<td>High</td>
<td>Med. to High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low to Med</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

- **MCL** - Maximum concentration limit (for drinking water)
- **DWEL** - Drinking water equivalent level
- **TC** - Toxicity Characteristic - Threshold for hazardous waste determinations

*Variability defined as-
- low - <1 order of magnitude difference
- med - 1 to 2 orders of magnitude difference
- high - >2 orders of magnitude difference
# Preliminary Results from Report 2 for Fly Ash from Three Facilities

<table>
<thead>
<tr>
<th></th>
<th>Hg (mg/kg)</th>
<th>Sb (ug/L)</th>
<th>As (mg/kg)</th>
<th>Ba (mg/kg)</th>
<th>B (ug/L)</th>
<th>Cd (ug/L)</th>
<th>Cr (ug/L)</th>
<th>Co (ug/L)</th>
<th>Pb (ug/L)</th>
<th>Mo (ug/L)</th>
<th>Se (ug/L)</th>
<th>Ti (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total in Material</strong></td>
<td>0.04 - 0.6</td>
<td>3 - 15</td>
<td>70 - 90</td>
<td>600 – 1,500</td>
<td>NA</td>
<td>0.7 – 1.5</td>
<td>100 – 200</td>
<td>20 – 50</td>
<td>40 – 90</td>
<td>10 – 20</td>
<td>2 – 30</td>
<td>3 – 13</td>
</tr>
<tr>
<td><strong>Leach results</strong></td>
<td>&lt;0.01 - 0.4</td>
<td>&lt;0.3 - 200</td>
<td>7 - 300</td>
<td>90 – 4,000</td>
<td>200 – 300,000</td>
<td>&lt;0.2 - 30</td>
<td>1 – 4,000</td>
<td>&lt;0.3 – 200</td>
<td>&lt;0.2 – 2</td>
<td>100 – 40,000</td>
<td>7 – 400</td>
<td>&lt;0.3 - 300</td>
</tr>
<tr>
<td><strong>MCL (ug/L)</strong></td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>2,000</td>
<td>7,000 DWEL</td>
<td>5</td>
<td>100</td>
<td>-</td>
<td>15</td>
<td>200 DWEL</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td><strong>TC (ug/L)</strong></td>
<td>200</td>
<td>-</td>
<td>5,000</td>
<td>10^5</td>
<td>6,500</td>
<td>1,000</td>
<td>5,000</td>
<td>-</td>
<td>5,000</td>
<td>-</td>
<td>1,000</td>
<td>200</td>
</tr>
</tbody>
</table>

**MCL** - Maximum concentration limit (for drinking water)

**DWEL** - Drinking water equivalent level

**TC** - Toxicity Characteristic - Threshold for hazardous waste determinations

*Variability defined as:

- Low - <1 order of magnitude difference
- Med - 1 to 2 orders of magnitude difference
- High - >2 orders of magnitude difference
## Preliminary Results from Report 2 for Scrubber Sludge from Three Facilities

<table>
<thead>
<tr>
<th></th>
<th>Hg</th>
<th>Sb</th>
<th>As</th>
<th>Ba</th>
<th>B</th>
<th>Cd</th>
<th>Cr</th>
<th>Co</th>
<th>Pb</th>
<th>Mo</th>
<th>Se</th>
<th>TI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total in Material (mg/kg)</strong></td>
<td>0.04 – 0.6</td>
<td>4 - 15</td>
<td>4 - 40</td>
<td>80 – 2,500</td>
<td>NA</td>
<td>0.3 – 1.5</td>
<td>9 – 350</td>
<td>1 – 40</td>
<td>2 – 30</td>
<td>9 – 30</td>
<td>2 – 4</td>
<td>2 – 12</td>
</tr>
<tr>
<td><strong>Leach results (ug/L)</strong></td>
<td>&lt;0.01 – 0.8</td>
<td>&lt;0.3 – 1.0</td>
<td>0.6 – 1.0</td>
<td>20 – 2,000</td>
<td>20 – 200,000</td>
<td>&lt;0.2 – 2.0</td>
<td>&lt;0.8 – 8.0</td>
<td>&lt;0.3 – 2.5</td>
<td>&lt;0.2 – 2.5</td>
<td>0.4 – 1.5</td>
<td>2 – 3.0</td>
<td>&lt;0.3 – 1.0</td>
</tr>
<tr>
<td><strong>MCL (ug/L)</strong></td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>2,000</td>
<td>7,000 DWEL</td>
<td>5</td>
<td>100</td>
<td>-</td>
<td>15</td>
<td>200 DWEL</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td><strong>TC (ug/L)</strong></td>
<td>200</td>
<td>-</td>
<td>5,000</td>
<td>10^5</td>
<td>6,500</td>
<td>1,000</td>
<td>5,000</td>
<td>-</td>
<td>5,000</td>
<td>-</td>
<td>1,000</td>
<td>200</td>
</tr>
<tr>
<td><strong>Variability relative to pH</strong></td>
<td>Low to High</td>
<td>Low to Med.</td>
<td>Med. to High</td>
<td>Low to Med.</td>
<td>Low to High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low to High</td>
<td>Med.</td>
<td>High</td>
</tr>
</tbody>
</table>

**MCL** - Maximum concentration limit (for drinking water)

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**TC** - Toxicity Characteristic - Threshold for hazardous waste determinations

*Variability defined as:
- low - <1 order of magnitude difference
- med - 1 to 2 orders of magnitude difference
- high - >2 orders of magnitude difference
# Preliminary Results from Report 2 for Fixated* Scrubber Sludge from Four Facilities *(Fixated using fly ash and sometimes lime)

<table>
<thead>
<tr>
<th></th>
<th>Hg</th>
<th>Sb</th>
<th>As</th>
<th>Ba</th>
<th>B</th>
<th>Cd</th>
<th>Cr</th>
<th>Co</th>
<th>Pb</th>
<th>Mo</th>
<th>Se</th>
<th>Ti</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total in Material (mg/kg)</td>
<td>0.02 – 1.0</td>
<td>5 - 20</td>
<td>3 - 70</td>
<td>80 – 1,000</td>
<td>NA</td>
<td>0.7 – 2</td>
<td>40 – 150</td>
<td>2 - 50</td>
<td>4 - 100</td>
<td>9 - 30</td>
<td>2 - 30</td>
<td>0.8 - 8</td>
</tr>
<tr>
<td>Leach results (ug/L)</td>
<td>&lt;0.01 -25</td>
<td>&lt;0.3 - 200</td>
<td>0.5 – 4,000</td>
<td>9 – 10,000</td>
<td>6 – 200,000</td>
<td>&lt;0.2 - 20</td>
<td>&lt;0.3 – 2,000</td>
<td>&lt;0.3 - 150</td>
<td>&lt;0.2 - 50</td>
<td>10 - 40,000</td>
<td>9 – 1,000</td>
<td>2 - 100</td>
</tr>
<tr>
<td>MCL (ug/L)</td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>2,000</td>
<td>7,000 DWEL</td>
<td>5</td>
<td>100</td>
<td>-</td>
<td>15</td>
<td>200 DWEL</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>TC (ug/L)</td>
<td>200</td>
<td>-</td>
<td>5,000</td>
<td>10^5</td>
<td>6,500</td>
<td>1,000</td>
<td>5,000</td>
<td>-</td>
<td>5,000</td>
<td>-</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Variability relative to pH</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Med. to High</td>
<td>Low to Med.</td>
<td>High</td>
<td>Low to High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low to Med.</td>
<td>Low to Med</td>
<td></td>
</tr>
</tbody>
</table>

**MCL** - Maximum concentration limit (for drinking water)

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**TC** - Toxicity Characteristic - Threshold for hazardous waste determinations

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- Med - 1 to 2 orders of magnitude difference
- High - >2 orders of magnitude difference
Preliminary Results of Mercury Leaching Across pH Range Comparing Potential Differences with NOx Control in Use

Fly Ash (Facility A, SNCR)

Scrubber Sludge (Facility B, SCR)

NOx Off

NOx On
Applying Probabilistic Analysis to Release Models

- **Inputs**
  - Distribution of inputs
    - LS ratio
    - Field pH
  - Use of experimental solubility curves

- **Outputs**
  - Distribution of outputs
  - 100 yr Cumulative Release Estimates [µg/kg CCR]
    - 5th percentile
    - Median
    - 95th percentile
    - Compare with total content

**Percolation/Equilibrium Model**

\[ M_{\text{mass}}^{t_{\text{year}}} = L S_{\text{site}} \times S_{\text{field pH}} \]
Preliminary Results of Mercury Leaching Concentration (5.4<pH<12.4) and 100-year Landfill Release Rates
Preliminary Results of Arsenic Leaching Across pH Range Comparing Different CCR types

- **Fly Ash, Facility B – SCR off**
- **Scrubber Sludge, Fac. B – SCR in use**
- **Gypsum (U), Facility Q**
- **Fixated ScS, Fac. M – SCR not in use**
Preliminary Results of Arsenic Leaching Across pH Range Comparing Any Potential Differences with NOx Control in Use
Preliminary Results of Chromium Leaching Across pH Range Comparing Any Potential Differences with NOx Control In Use

Fly Ash (Facility B, SCR)

Scrubber Sludge (Facility B, SCR)

SCR Off

SCR On
Preliminary Results of Chromium Leaching Concentration (5.4<pH<12.4) and 100-year Landfill Release Rates
Example Results of Molybdenum Leaching Across pH Range and Liquid to Solid Ratio

Fly Ash (Facility B, SCR On)

Gypsum (Facility O, Gyp-U)
Preliminary Results of Molybdenum Leaching Concentration (5.4<pH<12.4) and 100-year Landfill Release Rates
Preliminary Results of Selenium Leaching Concentration (5.4<pH<12.4) and 100-year Landfill Release Rates
Preliminary Results of Thallium Leaching Concentration (5.4<pH<12.4) and 100-year Landfill Release Rates
Decision Support Tool for Beneficial Use Determinations and Land Disposal Permitting
Decision Support Tool for CCR Management

• We anticipate developing a Decision Support Tool (DST) for environmental assessment of CCRs.

• The DST would be used by:
  – Power plants to assess CCR management options
  – State EPA’s to evaluate proposed CCR management methods

• Industry (EPRI) has expressed interest in development of a tool for its members; EPRI is discussing potential collaboration with EPA through a Cooperative Research and Development Agreement

• The DST would facilitate:
  – Management and assessment of leaching data
  – Consistent assessment of data across the industry
  – Use of leaching data as a more realistic source term for groundwater fate and transport models.
Decision Support Tool for CCR Beneficial Use Decisions

• DST inputs would include:
  – Waste type
  – Leach testing results (metals concentrations, pH)
  – Facility data (management unit type, size, pH and other conditions)
  – Waste characterization data from EPA/ORD reports (preloaded)
Decision Support Tool for CCR Beneficial Use Decisions

• DST outputs would include:
  – Probabilistic assessment of metals leaching that matches specific materials to specific management practices. Will evaluate leaching potential over 100 years or other specified time horizon.
  – A leaching source term that can be used with a groundwater fate and transport model to estimate likelihood of groundwater contamination –
    • Focus is on beneficial use decisions
    • Also can be used as input for permitting land disposal units.
Next Steps

• Continued collection and analysis of CCR samples to get a more representative data set including probabilistic assessment and documentation

• Prepare information and documentation needed to meet Mercury Roadmap deliverables

• Continued coordination with various organizations and support of program and regional offices

• Initiate development of decision support tool to facilitate more informed and timely beneficial use decisions
Questions?

Courtesy of J. Bachmann
Appendix – Details of Facility Configuration and Materials Tested
# List of Wet Scrubber Facilities Providing Residues for Leach Testing

1Results for these facilities included in “Report 2” except for Facilities R, S, and T.

2 NOx controls are by-passed during winter months, this will change in response to CAIR. For facilities A, B, and M, we have CCRs with and without NOx control.

<table>
<thead>
<tr>
<th>Facility Code</th>
<th>Coal Rank</th>
<th>Oxidation Type</th>
<th>NOx Control</th>
<th>Particulate Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Bit</td>
<td>Natural</td>
<td>SNCR (w/ &amp; w/o)²</td>
<td>Fabric Filter</td>
</tr>
<tr>
<td>B</td>
<td>Bit</td>
<td>Natural</td>
<td>SCR (w/ &amp; w/o)²</td>
<td>CS-ESP</td>
</tr>
<tr>
<td>K</td>
<td>Sub-Bit</td>
<td>Natural</td>
<td>SCR</td>
<td>CS-ESP</td>
</tr>
<tr>
<td>M</td>
<td>Bit</td>
<td>Inhibited</td>
<td>SCR (w/ &amp; w/o)²</td>
<td>CS-ESP</td>
</tr>
<tr>
<td>N</td>
<td>Bit</td>
<td>Forced</td>
<td>SCR</td>
<td>CS-ESP</td>
</tr>
<tr>
<td>O</td>
<td>Bit</td>
<td>Forced</td>
<td>SCR</td>
<td>CS-ESP</td>
</tr>
<tr>
<td>P</td>
<td>Bit</td>
<td>Forced</td>
<td>SCR &amp; SNCR</td>
<td>CS-ESP</td>
</tr>
<tr>
<td>Q</td>
<td>Sub-Bit</td>
<td>Forced</td>
<td>SCR</td>
<td>CS-ESP</td>
</tr>
<tr>
<td>R</td>
<td>PRB Sub-Bit</td>
<td>Forced</td>
<td>None</td>
<td>CS-ESP</td>
</tr>
<tr>
<td>S</td>
<td>High sulfur Bit</td>
<td>Forced</td>
<td>SCR</td>
<td>CS-ESP</td>
</tr>
<tr>
<td>T</td>
<td>Bit</td>
<td>Forced</td>
<td>SCR</td>
<td>CS-ESP</td>
</tr>
</tbody>
</table>
Description of Fly Ashes (FA) to Evaluate

**Facility A**
Coal: low sulfur bituminous
APC: NO+SNCR+FF

**Facility B**
Coal: low sulfur bituminous
APC: NO+SCR+ESP(CS) [Mg lime]

**Facility K**
Coal: sub- bituminous
APC: NO+SCR+ESP(CS) [Mg lime]
Description of CCRs Obtained from Wet Scrubbers Identification of Samples Obtained After Flue Gas (color=Mg lime absorber sampled)

Absorber (Forced Oxidation)
- Wet Gypsum
- Drying
- Landfill
  - Unwashed Gypsum; Gyp-U
    - Facilities O, N, P, Q
  - Rinsing & Drying
    - Washed Gypsum; Gyp-W
      - Facilities O, N
- Wallboard

Absorber (Inhibited Oxidation or Natural Oxidation)
- Thickener
- Impoundment
  - Scrubber Sludge; ScS
    - Facility A, SNCR off & on
    - Facility B, SCR on & off
    - Facility K, SCR on
  - Drying
  - Mix w/ Fly Ash & Lime
    - Fixated Sludge (FA+ScS)
      - SNCR off & on
        - Facility A
      - SCR off & on
        - Facility M
        - Facility B
        - Facility K
  - Landfill or Beneficial Use

Facilities O, N, P, Q, O, N, SNCR off & on Facility A, SCR on & off Facility M, SCR off & on Facility B, SCR on Facility K
Facility N
Coal: bituminous
APC: FO+SCR+ESP(CS)

Facility O
Coal: bituminous
APC: FO+SCR+ESP(CS)

Facility P
Coal: bituminous
APC: FO+SCR & SNCR +ESP(CS)

Facility Q
Coal: sub-bituminous
APC: FO+SCR+ESP(CS)

Gyp-U
NAU (unwashed)

Gyp-W
NAW (washed)

OAU (unwashed)

OAW (washed)

PAD (U) (unwashed)

QAU (unwashed)

APC Codes:
FO – forced oxidation
IO – inhibited oxidation
NO – natural oxidation
SCR –
SNCR –
ESP(CS) – electrostatic precipitator (cold side)
FF – fabric filter
Description of Facilities for Scrubber Sludge Comparisons

**Facility A**
Coal: low sulfur bituminous  
APC: NO+SNCR+FF

**Facility B**
Coal: low sulfur bituminous  
APC: NO+SCR+ESP(CS) [Mg lime]

**Facility K**
Coal: sub- bituminous  
APC: NO+SCR+ESP(CS) [Mg lime]
Description of Facilities for Fixated Sludge Comparisons (FSS: FA+ScS FSSL: FA+ScS+lime)

**Facility A (FSS)**
Coal: low sulfur bituminous
APC: NO+SNCR+FF

**Facility B (FSSL)**
Coal: low sulfur bituminous
APC: NO+SCR+ESP(CS) [Mg lime]

**Facility K (FSSL)**
Coal: sub-bituminous
APC: NO+SCR+ESP(CS) [Mg lime]

**Facility M (FSSL)**
Coal: bituminous
APC: IO+SCR+ESP(CS)