Next Generation of Leaching Methods
U.S. EPA’s LEAF Methods

A Discussion from the Environmental Testing Laboratories Perspective on Details of Generating Data Using the 4 Leaching Methods

Larry Matko - Technical Director, TestAmerica Pittsburgh
Patricia McIsaac - Product Manager
# Next Generation of Leaching Methods

## Agenda

<table>
<thead>
<tr>
<th>Background</th>
<th>New SW 846 Methods</th>
<th>Other Method</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaching</td>
<td>1313</td>
<td>ANSI/ASI 16.1</td>
<td>Stabilization / Solidification</td>
</tr>
<tr>
<td>TCLP</td>
<td>1314</td>
<td></td>
<td>Coal Combustion Residues [CCR]</td>
</tr>
<tr>
<td>SPLP</td>
<td>1315</td>
<td></td>
<td>Beneficial Use Application</td>
</tr>
<tr>
<td></td>
<td>1316</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Background on Leaching

Leaching is a process by which soluble constituents are dissolved from a solid material [solid or waste] into a contact water phase.

The extent to which the constituents dissolved are dependent on …
- site
- material specific conditions [chemical, physical & biological]
- length of time involved

The process of leaching includes:
- the partitioning of contaminants between a solid and liquid phase (e.g., assuming local equilibrium)
- coupled with the mass transport of aqueous or dissolved constituents
Environmental Leaching Processes

When fill material comes in contact with a liquid, which can include percolating rain water, surface water, groundwater, and liquids present in the fill material, constituents in the solid phase can dissolve into the liquid forming a leachate.

This leachate can impact the local water quality, which would be one of the key reasons to evaluate the leaching of the material prior to disposal.
EPA Method 1311 – TCLP
Toxicity Characteristic Leaching Procedure

- TCLP
  - adopted by USEPA in 1990 to replace EPTOX as the regulatory method for classifying wastes as hazardous based on toxicity

- Toxicity Characteristic [TC]
  - constituents and their thresholds are defined in 40 CFR 261.24
  - includes 10 Volatiles, 14 Semivolatiles, 7 Pesticides, 2 Herbicides, 8 Metals

- Pass/Fail
  - if the TCLP Extract contains one of the TC constituents equal to or exceeds the concentration specified → the material possess the characteristic of toxicity and is hazardous
Evolution of Leaching Tests

TCLP has been under criticism for overly broad application as well as technical specification [where regulatory tests are not required]. TCLP was designed to simulate leaching a waste will undergo if co-disposed with municipal solid waste.

1999, U.S. EPA SAB recommended:
- development of multiple leaching tests
- more flexible
- case specific
- tier testing or suite of related tests incorporating the most important parameters affecting leaching

Recognition that these new leaching tests would be more cumbersome to implement **BUT** it would better predict leachability.
Evolution of Leaching Tests


<table>
<thead>
<tr>
<th>Tiered, flexible framework</th>
<th>Incorporated a range of site conditions affecting waste leaching</th>
<th>Estimate leaching potential under conditions which are more representative of actual waste management</th>
<th>Specific application for inorganic species; future development for organic species</th>
</tr>
</thead>
</table>


# Evolution of Leaching Tests

Wastes are managed under many different settings and a range of conditions.

<table>
<thead>
<tr>
<th>Neither TCLP, SPLP or any other leaching test performed under a single set of conditions can provide an accurate assessment of hazards for all waste.</th>
<th>Waste testing should provide information about potential release from a waste in the context of the anticipated disposal or utilization conditions:</th>
<th>Therefore, the evaluation of constituent release should include the management and the mechanisms occurring in the scenario of the waste disposal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Form of the material [monolith or granular]</td>
<td>• Parameters that affect release [pH, L/S; release rate]</td>
<td></td>
</tr>
</tbody>
</table>
Broad Range of Conditions

Influence of pH on equilibrium

New Leaching Tests Takes Into Account...

Influence of L/S on equilibrium

Influence of Mass Transfer Rates
# U.S. EPA’s Leaching Environmental Assessment Framework [LEAF]

## Next Generation of Leaching Tests

<table>
<thead>
<tr>
<th>U.S. EPA response to the instances where TCLP or SPLP are being used outside of their intended use</th>
<th>U.S. EPA has completed the review and validation process</th>
<th>‘New’ SW-846 Methods [SW 846 methods are slightly different than the methods referenced in this document]</th>
</tr>
</thead>
</table>

[Background Information for the Leaching Environmental Assessment Framework (LEAF) Test Methods]

Copyright © 2016, TestAmerica. All rights reserved.
EPA Method 1311 –TCLP
Toxicity Characteristic Leaching Procedure

- TCLP is a batch leaching test
- Single point leachate test
- Particle Size reduction to 9.5mm
- Volatile Extraction fluid- pH 4.93
- Semivolatiles/Metals Extraction fluid- acetic acid / sodium hydroxide
- 20:1 liquid/solid ratio
- Leachate generation is 18 hrs.
- Designed to simulate leaching a waste will undergo if co-disposed with municipal solid waste
- Used for hazardous waste determination
EPA Method 1312 – SPLP
Synthetic Precipitation Leaching Procedure

- SPLP is a batch leaching test
- Single point leachate test
- Volatiles Extraction fluid - deionized water
- Semivolatiles/Metals - Extraction fluid Nitric Acid/Sulfuric Acid - Simulate acid rain
- Based on sample location
  - West of Mississippi River - pH of 5
  - East of Mississippi River – pH of 4.2
- 20:1 liquid/solid ratio
- Leachate generation is 18 hrs.
- Designed to assess the leaching potential of soils & wastes disposed in a monofill when exposed to rainfall
- No federal regulatory requirement for the use of SPLP
Method 1313 - Liquid/Solid Partitioning as a Function of Extract pH using Parallel Batch Extraction Procedure

Nine [9] parallel extractions
Contact time is determined by particle size

Schedule of acid/base is formulated from pre-test titration curve; pH ranges of 2-13 [2, 4, 5.5, 7, 8, 9, 12, 13, & natural] if natural is one of the listed pHs then 10.5 is used.

Analytical Component
- pH, Conductivity ORP, COPCs, Inorganics – metals, anions wetchem, Non-Volatile Organics
- Data Reporting
  - 9 eluates, 3 blanks = 12
  - All parameters x 12
### 1311, 1312 and 1313 comparison

<table>
<thead>
<tr>
<th></th>
<th>1311</th>
<th>1312</th>
<th>1313</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moisture Content</strong></td>
<td>As Received</td>
<td>As Received</td>
<td>Dry Weight corrected</td>
</tr>
<tr>
<td><strong>Particle size</strong></td>
<td>&lt; 9.5 mm</td>
<td>&lt; 9.5 mm</td>
<td>&lt; 5 mm</td>
</tr>
<tr>
<td><strong>L/S Ratio</strong></td>
<td>20/1</td>
<td>20/1</td>
<td>10/1</td>
</tr>
<tr>
<td><strong>Leaching Duration</strong></td>
<td>18 +/-2 hrs.</td>
<td>18 +/-2 hrs.</td>
<td>24-72 hrs.</td>
</tr>
<tr>
<td><strong>Data points</strong></td>
<td>1</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>
Why pH and ORP?

- **pH**: Affects the mobility of metals
- **ORP**: Oxidizing vs. reducing

30 cm x 5 cm glass column, particle size reduced material-2.5mm, default eluent is reagent water, up flow percolation, Minimize air entrapment and flow channeling, entire eluent volume is collected

Analytical Components
- pH, conductivity, ORP, COPC, inorganics-metals, wetchem, anions, nonvolatile organic
- Data reporting, based on option selected
- 9 eluates, 1 blank = 10
- All parameters x 10

Options are available, based on detail required:
- Complete
  - 9 eluates are collected & analyzed
- Limited Analysis
  - 9 elutate are collected & 6 analyzed [composting based on volume weight averaging]
- Index Testing
  - 9 elutate are collected & 3 analyzed [composting based on volume weight averaging]
Method 1316 - Liquid/Solid Partitioning as a Function of Liquid/Solid Ratio for Constituents in Solid Materials Using a Parallel Batch Extraction Procedure

Five parallel extractions, final L/S are 10, 5, 2, 1 and 0.5 mL/g-dry. Contact time is determined by particle size.

Analytical Components
- pH, conductivity, ORP, COPC, inorganics- metals, wetchem, anions, nonvolatile organic [not recommended for semivolatiles; need to modify container to reduce impact of absorption]
- Data reporting, 5 eluates, 1 blank = 6
- All parameters x 6
Comparison Results
Total, TCLP, SPLP, 1313, 1314 & 1316

<table>
<thead>
<tr>
<th>Magnesium [ Mg]</th>
<th>Total Results ug/Kg</th>
<th>1311 TCLP Results ug/L</th>
<th>1312 SPLP Results ug/L</th>
<th>1313 Results ug/L</th>
<th>1314 L/S ratios</th>
<th>1314 Results ug/L</th>
<th>1314 Results ug/L</th>
<th>1314 Results ug/L</th>
<th>1316 Results ug/L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1900000</td>
<td>15000 [pH5 final]</td>
<td>4000 [pH8 final]</td>
<td>250 [pH13]</td>
<td>0.2</td>
<td>430,000</td>
<td>260,000</td>
<td>480,000</td>
<td>7900 [L/S10]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>530 [pH12]</td>
<td>0.5</td>
<td>24,000</td>
<td>83,000</td>
<td>320000</td>
<td>16000 [L/S5]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>890 [pH10.5]</td>
<td>1.0</td>
<td>1,600</td>
<td>1,600</td>
<td>110000</td>
<td>32000 [L/S2]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>470 [pH9]</td>
<td>1.5</td>
<td>1,100</td>
<td>1,100</td>
<td>35000</td>
<td>48000 [L/S1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8100 [pH8]</td>
<td>2.0</td>
<td>980</td>
<td>1,200</td>
<td>34000</td>
<td>60000 [L/S 0.5]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>29000 [pH5.5]</td>
<td>4.5</td>
<td>2,200</td>
<td>2,700</td>
<td>25000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>43000 [pH4]</td>
<td>5.0</td>
<td>2,500</td>
<td>2,700</td>
<td>18000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>58000 [pH2]</td>
<td>9.5</td>
<td>2,900</td>
<td>3,700</td>
<td>11000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9400[natural/pH7]</td>
<td>10</td>
<td>4,200</td>
<td>5,200</td>
<td>6100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

L/S ratio for 1311 and 1312 is 20:1; 1313 is 10:1
Method 1315 - Mass Transfer Rates of Constituents in Monolith or Compacted Granular Material using a Semi-Dynamic Tank Leaching Procedure

Flux based leaching method for monolith/compacted material, sample immersed in reagent water at specific liquid/solid surface area, provides the mass transfer rate of COPC under diffusion control leaching conditions as a function of leaching time.

Shape of samples - variable

• Need to be able to determine surface area of sample
• Min. 5 cm in the direction of the mass transfer and Liquid to Surface area must be 9 +/- 1 ml/cm^2
• Leaching solution is refreshed at 9 intervals

Analytical Components
• pH, conductivity, ORP, COPC, inorganics-metals, wetchem, anions, nonvolatile organic
• Data reporting, based on option selected
• 9 eluates, 9 blank = 18
• All parameters x 18

<table>
<thead>
<tr>
<th>Interval Label</th>
<th>Interval Duration (days)</th>
<th>Cumulative Leaching Time (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T01</td>
<td>2.0 ± 0.25</td>
<td>0.08</td>
</tr>
<tr>
<td>T02</td>
<td>23.0 ± 0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>T03</td>
<td>23.0 ± 0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>T04</td>
<td>5.0 ± 0.1</td>
<td>7.0</td>
</tr>
<tr>
<td>T05</td>
<td>7.0 ± 0.11</td>
<td>14.0</td>
</tr>
<tr>
<td>T06</td>
<td>14.0 ± 0.1</td>
<td>28.0</td>
</tr>
<tr>
<td>T07</td>
<td>14.0 ± 0.1</td>
<td>42.0</td>
</tr>
<tr>
<td>T08</td>
<td>7.0 ± 0.1</td>
<td>49.0</td>
</tr>
<tr>
<td>T09</td>
<td>14.0 ± 0.1</td>
<td>63.0</td>
</tr>
</tbody>
</table>

Flux of Mg as a function of time

Cumulative release of Mg

pH as a function of time

Concentration of Mg as a function of time

Analytical Components
• pH, conductivity, ORP, COPC, inorganics-metals, wetchem, anions, nonvolatile organic
• Data reporting, based on option selected
• 9 eluates, 9 blank = 18
• All parameters x 18
Method 1315 - Mass Transfer Rates of Constituents in Monolith or Compacted Granular Material using a Semi-Dynamic Tank Leaching Procedure

Method states that it is for non-volatile organics
Projects may require volatiles

Drivers on many MGP projects are benzene and naphthalene and other PAHs

‘Performance Based Method’
EPRI Report evaluated the effectiveness of ISS for MGP material
Model approach based on EPRI report
  - Used of PDMS [polydimethylsiloxane] lined vessel - passive sampling material
TestAmerica Pittsburgh evaluating capabilities to support COPC [PAHs and VOAs] for MGP sites with alternative approaches for this method
1315 modified for PAHs

Polyethylene bag
1315 modified for PAHs

Water is extracted via SW-846 Method 3520A

PE is extracted via SW-846 Method 3580

Extracts are combined and analyzed via SW-846 Method 8270D
6 Laboratory Control samples were created.
Average recovery of 17 PAH compounds was 78%.
Average %RSD: 4.80 %
Benzo(a)Pryene: Average recovery 72%, 71% recovered from PE Bag. %RSD 4.5%
Naphthalene: Average recovery 84.2%, 57% recovered from PE Bag, 27% recovered from water. %RSD 3.5 %
1315 modified for VOAs

Lock for VOAs
### 1315 Amended Data: Samples Amended with Portland Cement [PC]

#### Magnesium [Mg]

<table>
<thead>
<tr>
<th>Total un-amended ug/Kg</th>
<th>Total 10% PC ug/Kg</th>
<th>Total 15% PC ug/Kg</th>
<th>Total 20% PC ug/Kg</th>
<th>1311 TCLP 10% PC ug/L</th>
<th>1311 TCLP 15% PC ug/L</th>
<th>1311 TCLP 20% PC ug/L</th>
<th>1312 SPLP 10% PC ug/L</th>
<th>1312 SPLP 15% PC ug/L</th>
<th>1312 SPLP 20% PC ug/L</th>
<th>Leaching Time for 1315 Results 10% PC ug/L</th>
<th>1315 Results 15% PC ug/L</th>
<th>1315 Results 20% PC ug/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900000</td>
<td>3200000</td>
<td>4500000</td>
<td>2000000</td>
<td>140</td>
<td>98</td>
<td>69</td>
<td>65</td>
<td>64</td>
<td>28.0</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>14</td>
<td>3.1</td>
<td>2.9</td>
<td>4.1</td>
<td>12.5</td>
<td>9.7</td>
<td>7.8</td>
<td>13.0</td>
<td>10.1</td>
<td>9.3</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>149</td>
<td>3.6</td>
<td>3.3</td>
<td>4.4</td>
<td>12.5</td>
<td>9.8</td>
<td>8.2</td>
<td>13.0</td>
<td>10.1</td>
<td>9.3</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>150</td>
<td>3.7</td>
<td>3.3</td>
<td>4.4</td>
<td>12.5</td>
<td>9.8</td>
<td>8.2</td>
<td>13.0</td>
<td>10.1</td>
<td>9.3</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>148</td>
<td>3.4</td>
<td>3.3</td>
<td>4.3</td>
<td>12.5</td>
<td>9.7</td>
<td>8.2</td>
<td>13.0</td>
<td>10.1</td>
<td>9.3</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>121</td>
<td>3.0</td>
<td>2.9</td>
<td>4.2</td>
<td>12.5</td>
<td>9.8</td>
<td>8.2</td>
<td>13.0</td>
<td>10.1</td>
<td>9.3</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>147</td>
<td>3.5</td>
<td>3.3</td>
<td>4.5</td>
<td>12.5</td>
<td>9.7</td>
<td>8.2</td>
<td>13.0</td>
<td>10.1</td>
<td>9.3</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>156</td>
<td>3.2</td>
<td>3.3</td>
<td>4.4</td>
<td>12.5</td>
<td>9.8</td>
<td>8.2</td>
<td>13.0</td>
<td>10.1</td>
<td>9.3</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>128</td>
<td>3.1</td>
<td>3.3</td>
<td>4.3</td>
<td>12.5</td>
<td>9.7</td>
<td>8.2</td>
<td>13.0</td>
<td>10.1</td>
<td>9.3</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>122</td>
<td>3.0</td>
<td>3.3</td>
<td>4.2</td>
<td>12.5</td>
<td>9.7</td>
<td>8.2</td>
<td>13.0</td>
<td>10.1</td>
<td>9.3</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>121</td>
<td>3.0</td>
<td>3.3</td>
<td>4.2</td>
<td>12.5</td>
<td>9.7</td>
<td>8.2</td>
<td>13.0</td>
<td>10.1</td>
<td>9.3</td>
<td>5.6</td>
<td>6.1</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Leaching times are expressed in hours (hrs.), days, and weeks (weeks).

Leaching Time for 1315:
- 2 hrs.
- 1 day
- 2 days
- 7 days
- 14 days
- 28 days
- 42 days
- 49 days
- 63 days
The Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-term Test Procedure

- Developed for low-level radioactive waste
- Can be used to measure the leach resistance of any waste solidified into a well defined geometric shape

Basic
- 7 data points over 5 days
- 2, 7, 24, 48, 72, 96, & 120 hrs.

Extended
- 10 data points over 90 days
- 2, 7, 24, 48, 72, 96, & 120, 456, 1128, 2160 hrs
Tiered Testing

Each tier can provide leaching data which is more specific to the material being tested and leaching conditions.

<table>
<thead>
<tr>
<th>The result of a single test can be used as a conservative approach</th>
<th>L/S ratio based on equilibrium</th>
<th>Mass Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Method 1314 - column percolation procedure</td>
<td>• Method 1315 - mass transfer</td>
</tr>
<tr>
<td></td>
<td>• Method 1316 - parallel batch procedure</td>
<td>• Method 1313 – parallel batch procedure</td>
</tr>
</tbody>
</table>
LEAF Methods

ALL PRICING WILL BE PROVIDED BY THE LAB on Project by Project Basis

Many variables

LEAF Methods are flexible framework, which may be tiered

Pricing will be modeled on a project specific basis

- More data is generated than TCLP or SPLP
- Cost is higher
- Test for the COPC, not a regulatory list
<table>
<thead>
<tr>
<th>Regulatory Requirements</th>
<th>TCLP</th>
<th>SPLP</th>
<th>LEAF 1313</th>
<th>LEAF 1314</th>
<th>LEAF 1315</th>
<th>LEAF 1316</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulatory Requirements</strong></td>
<td>40 CFR 261; designed to simulate leaching if material is co-disposed with solid waste</td>
<td>No regulatory requirement; assess leaching if material is in a monolith and is exposed to rain</td>
<td>Environmental leaching assessment for disposal, beneficial use, treatment effectiveness &amp; site remediation options; tiered &amp; flexible framework of leaching testing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test Type</strong></td>
<td>pH</td>
<td>pH</td>
<td>Equilibrium; pH</td>
<td>Equilibrium; L/S</td>
<td>Mass Transfer</td>
<td>Equilibrium; L/S</td>
</tr>
<tr>
<td><strong>Timeframe for Leachate Generation</strong></td>
<td>18 hrs.</td>
<td>18 hrs.</td>
<td>Between 24 to 72 hrs.; dependent on particle size</td>
<td>14 days</td>
<td>63 days</td>
<td>Between 24 to 72 hrs.; dependent on particle size</td>
</tr>
<tr>
<td><strong>Standard Leachate &amp; Analysis Turnaround</strong></td>
<td>14 days</td>
<td>14 days</td>
<td>35 days</td>
<td>42 days</td>
<td>84 days</td>
<td>21 days</td>
</tr>
<tr>
<td><strong>MINIMUM Mass of material - depends on analytical tests required</strong></td>
<td>500g</td>
<td>500g</td>
<td>800g</td>
<td>1200g</td>
<td>20 cm squared; 2x4 monolith</td>
<td>4000g</td>
</tr>
<tr>
<td><strong>Number of leachate/eluate samples generated</strong></td>
<td>1</td>
<td>1</td>
<td>pre-test, up to 9; 9, 3 blanks total of 12 samples</td>
<td>9 or 6 or 3; depending on the option chosen</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td><strong>COPC</strong></td>
<td>8 metals, 20 VOA, 16 semivolatiles; 2 Pesticides; IRC project specific VOAS, semivolatiles &amp; metals</td>
<td>Inorganics; non-volatile organics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Holding Times for leachate/eluate generated; analytical holding times</strong></td>
<td>14 days for VOA/Semivolatiles, 28 days Hg, 180 days for metals; analytical holding times apply</td>
<td>14 days for VOA/Semivolatiles, 28 days Hg, 180 days for metals; analytical holding times apply</td>
<td>Within 1 month of receipt; analytical holding times apply to COPC analysis</td>
<td>Within 1 month of receipt; analytical holding times apply to COPC analysis</td>
<td>Leachate generation holding times are not defined; analytical holding times apply to COPC analysis</td>
<td>Within 1 month of receipt; analytical holding times apply to COPC analysis</td>
</tr>
<tr>
<td>Costs</td>
<td>TCLP</td>
<td>SPLP</td>
<td>LEAF 1313</td>
<td>LEAF 1314</td>
<td>LEAF 1315</td>
<td>LEAF 1316</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Leaching Costs</td>
<td>$120-$160 includes ZHE</td>
<td>$120-$160 includes ZHE</td>
<td>$1,200</td>
<td>$1,500</td>
<td>$900</td>
<td>$500</td>
</tr>
<tr>
<td>Number of Analytical Samples</td>
<td>1</td>
<td>1</td>
<td>pre-test, up to 9; 3 blanks total of 12 samples</td>
<td>9 or 6 or 3; 1 blank; total of 10 or 7 or 4; depending on the option chosen</td>
<td>9 field samples; 9 blanks; total of 18 samples</td>
<td>5 samples; 1 blank; total of 6 samples</td>
</tr>
<tr>
<td>Additional Assay Required</td>
<td>none</td>
<td>none</td>
<td></td>
<td></td>
<td></td>
<td>pH, Conductivity, ORP</td>
</tr>
<tr>
<td>Analytical Scope</td>
<td>VOA, Semivolatiles, Pesticides, Metals, IRC</td>
<td></td>
<td>Chosen by project team</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Example: Total Analytical Costs including Short List of Metals [As, Se, Tl] excluding leaching costs</td>
<td>NA</td>
<td>$135 Metals cost = $35 per sample</td>
<td>$420 Metals cost = $35 per sample</td>
<td>Option A: $350; Option B: $245; Option C: $140 Metals cost = $35 per sample</td>
<td>$630 Metals cost = $35 per sample</td>
<td>$210 Metals cost = $35 per sample</td>
</tr>
<tr>
<td>Example: Total Analytical Costs including Long List of Metals [As, Se, Tl, Hg, As, Ba, B, Cd, Cr, Co, Pb, Mo, Se] excluding leaching costs</td>
<td>NA</td>
<td>$185 Metals cost = $85 per sample</td>
<td>$1020 Metals cost = $85 per sample</td>
<td>Option A: $850; Option B: $595; Option C: $340 Metals cost = $85 per sample</td>
<td>$1530 Metals cost = $85 per sample</td>
<td>$510 Metals cost = $85 per sample</td>
</tr>
<tr>
<td>Comment</td>
<td>Range of full TCLP Costs $690-$850</td>
<td>There is no regulatory list of compounds in SPLP</td>
<td>Leaching generates limited volume; if additional volume is required for extended testing, additional columns may need to be set up at an additional cost</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Summary of Methods

<table>
<thead>
<tr>
<th>Description</th>
<th>1311</th>
<th>1312</th>
<th>1313</th>
<th>1314</th>
<th>1315</th>
<th>1316</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single batch as a function of pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single batch as a function of pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel batch as a function of pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Column test with up flow percolation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank test with periodic eluent renewal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel batch as a function of L/S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass/volume required</th>
<th>500 grams</th>
<th>500 grams</th>
<th>800 grams dry weight</th>
<th>1200 grams dry weight</th>
<th>2”x4” monolithic cylinder</th>
<th>4000 grams dry weight</th>
</tr>
</thead>
<tbody>
<tr>
<td># eluates generated</td>
<td>1</td>
<td>1</td>
<td>9 + 3 Method Blanks</td>
<td>9 + 1 Method Blank</td>
<td>9 + 9 Method Blanks</td>
<td>5 + 1 Method Blank</td>
</tr>
<tr>
<td>Leaching Timeframe</td>
<td>18 hrs.</td>
<td>18 hrs.</td>
<td>24-72 hrs.</td>
<td>14 days</td>
<td>63 days</td>
<td>24-72 hrs.</td>
</tr>
<tr>
<td>TAT</td>
<td>14 days</td>
<td>14 Days</td>
<td>35 days</td>
<td>42 days</td>
<td>84 days</td>
<td>21 days</td>
</tr>
</tbody>
</table>

Copyright © 2016, TestAmerica. All rights reserved.
Data Reporting for U.S. EPA’s LEAF Methods - Additional Deliverables

Need to graphically & visually display the data
- Vanderbilt University developed LeachXS™ Lite

Shortcomings
- Not all COPC are in LeachXS™ Lite

TestAmerica will populate a EDD [spread sheet] and the client can upload the data into Vanderbilt’s LeachXS™ Lite
Instances where LEAF Methods have been Referenced
Evaluation of the Effectiveness of In situ Stabilization & Solidification [ISS] for MGP Sites

- **Column Test** [L/S partitioning from equilibrium based test using particle sized material]
  - Important when water is expected to percolate through permeable material
- **Mass transfer** in monolithic materials [Mass transportation test]
  - Used PDMS[polydimethyl siloxane] lined vessel

**Results-** Current regulatory tests [TCLP or SPLP] may over predict the release of 6 parent PAHs

Over prediction does not mean that regulatory tests are conservative and may increase liability in the long run
Leachability is the primary performance parameter to assess the ability of the material to stay on site.

Conclusion - no single leaching test is applicable for all purposes.

U.S. EPA SW-846 LEAF Methods are included in this document.
Characterization of CCR -- Changes in CCR associated with changes in control technologies and evaluated the release during CCR management [land disposal & commercial applications]

| Increase use & application of air pollution control systems will change CCR, shifting contaminants from flue gas to CCR | The potential for leaching is based on the characteristic of the material and the conditions under which it is managed | The potential for leaching does NOT correlate to the total constituents in the material |

Leaching test used in this report were the LEAF Methods
Beneficial Use of CCR

The Environmental Protection Agency (EPA or the Agency) published a final rule to regulate the disposal of coal combustion residuals (CCR) as solid waste under Subtitle D of the Resource Conservation and Recovery Act (RCRA).

- The rule does not regulate practices which meet the requirements of beneficial use of CCR
- EPA defers its final decision on the Bevill Regulatory Determination

FEDERAL REGISTER

Vol. 80  Friday,  
No. 74  April 17, 2015

Part II

Environmental Protection Agency

40 CFR Parts 257 and 261  
Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule
Bevill Amendment- Special Wastes

Congress enacted the Resource Conservation and Recovery Act (RCRA) (Public Law 94-580) on October 21, 1976. RCRA required EPA to “promulgate regulations identifying characteristics of hazardous waste and listing particular hazardous waste” that would be subject to hazardous waste management standards.

In response to this mandate, EPA proposed regulations for managing hazardous waste under Subtitle C of RCRA on December 18, 1978 (43 FR 58946). Included in these proposed regulations was a deferral of hazardous waste requirements for six categories of waste—which EPA termed “special wastes”—until further study and assessment could be completed to determine their risk to human health and the environment. The six categories of special wastes included:

- Cement kiln dust
- Mining waste
- Oil and gas drilling muds and oil production brines
- Phosphate rock mining, beneficiation, and processing waste
- Uranium waste
- Utility waste (i.e., fossil fuel combustion waste)

These wastes typically are generated in large volumes and, at the time, were believed to possess less risk to human health and the environment than the wastes being identified for regulation as hazardous waste.

The Bevill and Bentsen Amendments also required EPA to complete full assessments of each exempted waste and submit a formal report to Congress on its findings. Section 8002 explicitly identified the requirements for each special waste study and established deadlines for submission of the final reports. After completion of each respective “Report to Congress”, EPA was then required to make a final regulatory determination within six months as to whether the special waste in question warranted regulation as a hazardous waste under Subtitle C of RCRA.

https://www3.epa.gov/epawaste/nonhaz/industrial/special/
In the proposed rule, EPA revisited its Bevill regulatory determination. EPA is deferring its final decision on the because of regulatory and technical uncertainties that cannot be resolved at this time.

Chief among the uncertainties for EPA is the evolving character & composition of the CCR due to utility upgrades & pollution control

- EPA used **LEAF** data to make this decision
- 73 air pollution control residues
- Methods 1313 [pH] & 1316 [L/S]
- Leachate concentrations for metals were variable
  - Variability was also seen for similar residue types and facility configurations
- Variability of leaching of metals in the CCR was greater than the variability in the total concentrations
Beneficial use of CCR means the CCR meet all of the following conditions:

1. The CCR must provide a functional benefit;
2. The CCR must substitute for the use of a virgin material, conserving natural resources that would otherwise need to be obtained through practices, such as extraction;
3. The use of the CCR must meet relevant product specifications, regulatory standards or design standards when available, and when such standards are not available, the CCR is not used in excess quantities; and
4. When unencapsulated use of CCR involving placement on the land of 12,400 tons or more in non-roadway applications, the user must demonstrate and keep records, and provide such documentation upon request, that environmental releases to groundwater, surface water, soil and air are comparable to or lower than those from analogous products made without CCR, or that environmental releases to groundwater, surface water, soil and air will be at or below relevant regulatory and health-based benchmarks for human and ecological receptors during use.

EPA is developing a FRAMEWORK to address the risk associated with unencapsulated CCR.
U.S. EPA’s LEAF Methods...

takes into consideration the impact of management decisions and plausible field condition
addresses the concerns raised by SAB & NAS of the use of a single pH test
were developed for inclusion into SW846
can be compared to reference indicators to provide a context for the data
TestAmerica is supporting all 4 LEAF methods at our Pittsburgh Facility

| TestAmerica Pittsburgh can generate an EDD to allow the client to upload the data into LeachXS™ Lite | Pricing for these tests will be provided on a project by project basis | We have supported stabilization/solidification, CCR & beneficial use of soil & CCR projects | All the projects which we have supported have been customized |

Copyright © 2016, TestAmerica. All rights reserved.
LEAF Methods

ALL PRICING WILL BE PROVIDED BY THE LAB ON PROJECT BY PROJECT BASIS

<table>
<thead>
<tr>
<th>LEAF Methods are flexible framework, which may be tiered</th>
<th>Many variables</th>
<th>Pricing will be modeled on a project specific basis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Number of samples</td>
<td>• More data is generated than TCLP or SPLP→ Cost is higher</td>
</tr>
<tr>
<td></td>
<td>• Variety of matrices</td>
<td>• Test for the COPC, not a regulatory list</td>
</tr>
<tr>
<td></td>
<td>• Method modifications</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Analysis to be performed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Volume of leachate generated and available for analysis [multiple columns/setups may need to be set up]</td>
<td></td>
</tr>
</tbody>
</table>
LEAF Points of Contact

TestAmerica Pittsburgh Points of Contact -
Larry Matko - Technical Director
Larry.Matko@TestAmericaInc.com

Carrie Gamber - Senior Project Manager
Carrie.Gamber@TestAmericaInc.com

Phone 412.963.7058

Patricia McIsaac - Product Manager
Patricia.McIsaac@TestAmericaInc.com
Phone 703.623.3872
Ask The Expert Webinar Series

Thank you for attending

The Next Generation of Leaching Methods – U.S. EPA's LEAF Methods

To submit a question, type it into the Questions panel in the GoToWebinar toolbar and click Send.

If you have any additional questions for today’s presenter you may submit them directly to:

www.testamericainc.com/services/asktheexpert/experts/larry-matko

Please be sure to visit the Ask the Expert Webinar Series web page for other scheduled webinars at:

www.testamericainc.com/services/webinar_series

To view a recording of this webinar session, please contact:

info@testamericawebinars.com

Copyright © 2016, TestAmerica. All rights reserved.