Managing Solid Drilling Waste Through Engineered Solutions

June 2014
About Scott

- Headquartered in Longview, Texas
- 20 years experience managing solid drilling waste
- Scott treats and recycles waste into drill pads, service roads and other infrastructure
- Partners with research universities on testing, solutions
Overview: The Shift to Drilling Efficiency

• Traditionally, an oil and gas well used to serve as a single access point
• In the new unconventional era, pad drilling and batch completions are more efficient and more sustainable
• Well count and drilled footage is up (industry efficiency)
The Problem: What is solid drilling waste?

• According to the American Petroleum Institute, for every foot drilled in the U.S., 1.21 barrels of drilling waste are generated.

• Approximately 50 percent of this is solid drilling waste.
The Problem: What is solid drilling waste?

- Solid drilling waste is comprised of drilling mud and cuttings that cannot be pumped which include contaminants such as:
  - Salts
  - Hydrocarbons
  - Metals
  - pH
The Problem: What is solid drilling waste?

- The various types of solid drilling waste are classified according to the mud that was used to drill the well. There are three basic types of solid drilling waste:
  - Water-Based Mud and Cuttings
    - Fresh-water mud and cuttings (FWMC)
    - Salt-water mud and cuttings (SWMC)
  - Oil-Based Drilled Cuttings (OBC)
  - Synthetic Oil-Based Cuttings
Characteristics of Different Types of Solid Drilling Waste from Various Fields*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>FWMC**</th>
<th>FWMC***</th>
<th>SWMC</th>
<th>OBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (S.U.)</td>
<td>8.9</td>
<td>10</td>
<td>7.2</td>
<td>10.5</td>
</tr>
<tr>
<td>EC (mmhos/cm)</td>
<td>4.26</td>
<td>18</td>
<td>120,000</td>
<td>8.23</td>
</tr>
<tr>
<td>ESP (%)</td>
<td>1.3</td>
<td>61</td>
<td>Not Analyzed</td>
<td>2.23</td>
</tr>
<tr>
<td>TPH (mg/kg)</td>
<td>1570</td>
<td>114</td>
<td>61,000</td>
<td>156,000</td>
</tr>
<tr>
<td>Arsenic (mg/kg)</td>
<td>13.1</td>
<td>92.8</td>
<td>31</td>
<td>74</td>
</tr>
<tr>
<td>Barium (mg/kg)</td>
<td>5970</td>
<td>148</td>
<td>143</td>
<td>215</td>
</tr>
<tr>
<td>Cadmium (mg/kg)</td>
<td>0.343</td>
<td>0.511</td>
<td>0.342</td>
<td>1.22</td>
</tr>
<tr>
<td>Chromium (mg/kg)</td>
<td>30.9</td>
<td>72.6</td>
<td>27.6</td>
<td>15.5</td>
</tr>
<tr>
<td>Lead (mg/kg)</td>
<td>70.2</td>
<td>390</td>
<td>120</td>
<td>248</td>
</tr>
<tr>
<td>Mercury (mg/kg)</td>
<td>0.140</td>
<td>0.970</td>
<td>0.566</td>
<td>0.628</td>
</tr>
<tr>
<td>Selenium (mg/kg)</td>
<td>0.552</td>
<td>0.876</td>
<td>0.419</td>
<td>2.13</td>
</tr>
</tbody>
</table>

* This data is not intended to be considered an average of the specified analytes from the mud types.
** This FWMC was used on the top section of the hole through the fresh-water zone.
*** This FWMC was used during the entire hole depth.
## Amounts of Selected Characteristics of Solid Drilling Waste Generated Per Well

<table>
<thead>
<tr>
<th></th>
<th>Arsenic&lt;sup&gt;A&lt;/sup&gt;</th>
<th>Lead&lt;sup&gt;A&lt;/sup&gt;</th>
<th>Mercury&lt;sup&gt;A&lt;/sup&gt;</th>
<th>TPH&lt;sup&gt;B&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pounds/Well</strong></td>
<td>68</td>
<td>227</td>
<td>1</td>
<td>143,208</td>
</tr>
<tr>
<td><strong>Gallons/Well</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>19,890</td>
</tr>
<tr>
<td><strong>Pounds/Year</strong></td>
<td>7,457,670</td>
<td>31,274,100</td>
<td>77,784</td>
<td>1,360,476,000</td>
</tr>
<tr>
<td><strong>Gallons/Year</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>188,955,000</td>
</tr>
</tbody>
</table>

<sup>A</sup> This is based on generating 2000 WCY of FWMC per well, metal values in TABLE 1 for FWMC for the entire hole, and 33,000 wells per year.

<sup>B</sup> This is based on generating 400 WCY of OBC per well, TPH values used in TABLE 1 for OBC, and 9500 wells per year.
How is solid drilling waste regulated?

• The U.S. enacted The Resource Conservation and Recovery Act (RCRA) in 1976
• RCRA was created to provide guidance for managing both hazardous and non-hazardous solid waste
• Most E&P wastes were exempted as hazardous under RCRA
How is solid drilling waste regulated?

• The oil and gas industry must dispose of solid drilling waste in accordance with various laws and regulations of federal, state and local governments
• Extreme variability in state laws
• Need for producers to have consistent approach
**Example:**
Comparison of Landspreading in Louisiana and Texas

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limitation</th>
<th>Parameter</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6-9</td>
<td>pH</td>
<td>N/A</td>
</tr>
<tr>
<td>Arsenic</td>
<td>≤10 mg/kg</td>
<td>Arsenic</td>
<td>N/A</td>
</tr>
<tr>
<td>Barium&lt;sup&gt;A&lt;/sup&gt;</td>
<td>≤40,000 mg/kg</td>
<td>Barium</td>
<td>N/A</td>
</tr>
<tr>
<td>Cadmium</td>
<td>≤10 mg/kg</td>
<td>Cadmium</td>
<td>N/A</td>
</tr>
<tr>
<td>Chromium</td>
<td>≤500 mg/kg</td>
<td>Chromium</td>
<td>N/A</td>
</tr>
<tr>
<td>Lead</td>
<td>≤500 mg/kg</td>
<td>Lead</td>
<td>N/A</td>
</tr>
<tr>
<td>Mercury</td>
<td>≤10 mg/kg</td>
<td>Mercury</td>
<td>N/A</td>
</tr>
<tr>
<td>Selenium</td>
<td>≤10 mg/kg</td>
<td>Selenium</td>
<td>N/A</td>
</tr>
<tr>
<td>Silver</td>
<td>≤200 mg/kg</td>
<td>Silver</td>
<td>N/A</td>
</tr>
<tr>
<td>Zinc</td>
<td>≤500 mg/kg</td>
<td>Zinc</td>
<td>N/A</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>&lt;10,000 mg/kg</td>
<td>Oil and Grease</td>
<td>&lt;10,000 mg/kg</td>
</tr>
<tr>
<td>Electrical Conductivity&lt;sup&gt;A&lt;/sup&gt;</td>
<td>&lt;4 mmhos/cm</td>
<td>Electrical Conductivity</td>
<td>N/A</td>
</tr>
<tr>
<td>SAR&lt;sup&gt;A&lt;/sup&gt;</td>
<td>&lt;12</td>
<td>SAR&lt;sup&gt;A&lt;/sup&gt;</td>
<td>N/A</td>
</tr>
<tr>
<td>ESP&lt;sup&gt;A&lt;/sup&gt;</td>
<td>&lt;15%</td>
<td>ESP&lt;sup&gt;A&lt;/sup&gt;</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<sup>A</sup> Upland Values

<sup>B</sup> These values only apply to fresh-water mud and cuttings with less than 3,000 mg/l chlorides and landspread on the same lease and with landowner permission.
U.S. EPA Waste Hierarchy

• Most states with closure criteria primacy over E&P waste have adopted the Federal waste hierarchy
How is the waste managed?

Traditional Approaches

- Exploration & production operators:
  - Bury waste after partial treatment
  - Land-spread it
  - Transport to commercial, centralized waste management facilities
  - Inject it into the annulus
Traditional Approaches: Burial

– Pros
  • Simplicity
  • Low cost
  • Limited surface area requirements
  • Most likely onsite, or nearby in pits

– Cons
  • Potential for waste to migrate and contaminate groundwater, resulting in liability
  • Not a choice for wastes with high concentrations of oil, salt, metals and industrial chemicals without further treatment
Traditional Approaches: Landspread

- **Pros**
  - Simplicity
  - Low cost
  - Potential to improve soil conditions
  - Naturally occurring microbes assimilate waste constituents in place

- **Cons**
  - Salts and metals cannot biodegrade
  - Potentially large land requirements
  - Soil may be damaged, depending on amount of high-molecular weight compounds
  - **Extreme variability in contaminant levels in material**
## Traditional Approaches: Example of Variability

### Chloride Variability in Stockpiles

<table>
<thead>
<tr>
<th>Load</th>
<th>Pile A (mg/kg)</th>
<th>Pile B (mg/kg)</th>
<th>Pile C (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12,400</td>
<td>17,700</td>
<td>20,800</td>
</tr>
<tr>
<td>2</td>
<td>13,600</td>
<td>14,000</td>
<td>22,700</td>
</tr>
<tr>
<td>3</td>
<td>14,500</td>
<td>20,700</td>
<td>18,600</td>
</tr>
<tr>
<td>4</td>
<td>8,620</td>
<td>20,900</td>
<td>16,600</td>
</tr>
<tr>
<td>5</td>
<td>15,900</td>
<td>39,600</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>10,700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>9,870</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>13,800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>9,980</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Traditional Approaches: Haul to a Commercial Facility

– Pros
  • When a regulatory agency does not allow onsite disposal
  • When onsite techniques are problematic (e.g. in marshy, high water table environments)
  • For relatively small volumes of waste

– Cons
  • Less universal regulations
  • Large processing facilities could have impact on nearby populations or surrounding environment (including increased risks associated with airborne particulate emissions)
  • Drilling can be interrupted
  • Some states have few or no disposal sites (cost-prohibitive)
Traditional Approaches: Annular Injection

- **Pros**
  - Returns material to subsurface strata below underground source drinking water.
  - May be conducted during drilling – after annulus is available and reduces required storage capacity.
  - Provides adequate documentation of mechanical integrity, analytical data and process.
  - Does not require additional land.

- **Cons**
  - **Potential for groundwater contamination** (no proof of disposal zone).
  - Increased mechanical risk factors (during drilling).
  - **50/50 Failure** (broach/bridge) Potential
Cost Considerations

• Near-term Costs
  – Closure criteria
    • State rules and/or corporate policy
  – Volume of each type of waste both liquid and solid
  – Contaminant levels of each type of waste
  – Mud type choice on ROP, mud costs

• Future Costs
  – Environmental footprint of inconsistent management
  – Environmental concerns from inadequate sampling/testing

• Other Considerations
  – Beneficial reuse
    • Spud mud for liquids or reuse of mud
    • Construction material use from drilling solids
  – Reliable results of chosen management method
Cutting-Edge Solutions: Solidification/Stabilization

• Evidence-supported field technology used to treat contaminated sediment, sludge and soils
• Involves mixing contaminated solid waste materials with treatment reagents to cause physical or chemical changes that will reduce environmental impact
  • **Solidification**: encapsulates contaminants
  • **Stabilization**: adsorbs contaminants
The Benefits

Why solidification and stabilization technology?

• To meet and often exceed the requirements of state and federal E&P waste management laws
• Limits offsite movement of drilling waste - reduces environmental impact, including possibility of accidental spills and other liabilities
• Peace of mind in efficient control of the waste produced from unconventional drilling – it’s never mixed or commingled with another company’s waste
The Benefits

Why solidification and stabilization technology?

• Provides a mechanism for the recycling of solid drilling waste in the construction of roads, drilling pads, and other such structures, thereby reducing costs associated with construction materials

• Saves the industry money in areas with high disposal and construction costs (which are on the rise)

• Drilling is not interrupted - the service is mobile
The Benefits

Why solidification and stabilization technology?

• Evidence-supported results
• Follows the waste hierarchy
The Process

1. Identify constituents of the solid drilling waste
2. Determine/design the most appropriate reuse, treatment and/or disposal options
3. Build/close the site accordingly
4. Verify success or indicate additional treatment requirements
The Results

• S/S Process Option: Treat and Reuse for a Pad

**Before:** Reserve pit with oil-based cuttings

**During construction:** Mixing processed material and compacting
The Results

- S/S Process Option: Treat and Reuse for a Pad and Road

*After:* Solidified/Stabilized and recycled into a pad

*After:* Solidified/Stabilized and recycled into a road
In Conclusion

• There are specialized, cost-effective solutions that reduce the oil and gas industry’s environmental footprint

• By applying these solutions to solid drilling waste management practices, we can optimize a company’s sustainability practices and its economic stability

• Technological, engineered approaches make sense
Thank you

Questions?

For more information:

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