Drilling Waste and Well Site Restoration

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Drilling Waste: Introduction

- Mud controls subsurface pressures, lubricates drill bit, carries cuttings to surface.
- Cuttings are separated from mud and mud is recirculated
- Mud and cuttings may be contaminated with salts, hydrocarbons, heavy metals, and radioactive materials

Solidification and Stabilization

• Cuttings may need further treatment to remove excess mud.
• Cuttings may contain oil and metals that are leachable. To reduce potential hazards,
  – **Solidification** encapsulates the waste in a solid matrix
  – **Stabilization** decreases the mobility of contaminants by converting them to some other form


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Solidification and Stabilization

• Additives for solidification and stabilization
  – Cement, fly ash, lime (tend to have high pH)
  – Limitations
    • Ineffective if high organics content (> 45 %)
    • Not practical for offshore applications because of equipment and space requirements
    • Additives increase volume
    • Additives may prevent plant growth and limit disposal options

Minimizing Generation of Drilling Waste and Disturbance of Surface

• Directional drilling permits drilling several wells from a single platform, extended reach drilling, and multiple laterals from a single main bore.


Minimizing Generation of Drilling Waste and Disturbance of Surface

• Directional drilling from artificial islands (City of Long Beach, CA)

Minimizing Generation of Drilling Waste and Disturbance of Surface

- Drilling smaller diameter holes
  - Closer spacing of successive casing strings
  - Slimhole drilling (90% of hole drilled with bit < 6”)
  - Coiled tubing drilling (smaller diameter than traditional pipe)
  - Mono-bore and expandable casing


Minimizing Generation of Drilling Waste and Disturbance of Surface

- Drilling techniques that use less fluid
  - Some wells do not require the use of drilling fluids
  - Pneumatic drilling uses air as circulating fluid
    - Air dust drilling
    - Air mist drilling
    - Foam drilling
    - Aerated mud drilling
  - Synthetic-based muds (SBMs) can generate lower volumes of drill cuttings than water-based muds

Using Muds and Additives with Lower Environmental Impacts

• Introduction to mud ingredients: base fluid, weighting agent, bentonite clay, detergents, etc.
  – Water-based muds (WBM)s are least expensive and can be discharged from platforms
  – Oil-based muds (OBM)s are sometimes needed with deep wells, reactive shales, extended-reach wells, horizontal drilling
  • Fluid may be diesel or mineral oil and requires special disposal for onshore wells


Using Muds and Additives with Lower Environmental Impacts

• Synthetic-based muds (SMBs)
  – Avoid the use of oils or diesel: olefins, esters, paraffins
  – Are less prone to cause sloughing and generally drill a cleaner hole with lower volume of cuttings
  – SMBs are recycled “to the extent possible”
  – New formulations are being developed that can be treated biologically

Using Muds and Additives with Lower Environmental Impacts

- Weighting agents (e.g., barite, $\text{BaSO}_4$)
  - $P = \rho gh$
  - Used to prevent blowout in deep wells
  - Nonmagnetic
- Possible substitute is calcite, $\text{CaCO}_3$


Beneficial Reuse of Drilling Wastes

- Recycling of muds
  - WBM are usually disposed of at end of drilling
  - OBM and SBM are recycled when possible
- Reuse of cuttings (most are discarded)
  - Road spreading is sometimes allowed
  - Further treatment to remove mud sometimes allows use as fill or aggregate
  - Restoration of wetlands

Onsite Burial (Pits, Landfills)

- Burial is most common onshore disposal method for cuttings and mud
  - A large landfill may be operated for multiple wells
  - Pits with liners are generally used for drilling waste, stormwater, and wastewater


Land Application

- Land application is a form of bioremediation
  - Land farming involves repeated applications of oily waste, sometimes with water, manure, straw and pretreatment by composting; however,
    - Higher molecular weight compounds degrade slowly
    - High levels of salt can accumulate
  - Land treatment involves one-time application

Bioremediation

- **Composting**
  - Waste is mixed with organic matter (e.g., husks) to increase porosity and aeration

- **Bioreactors**
  - Occurs within vessel or impoundment
  - Provide better control of temperature, nutrients, pH


Discharge to Ocean

- **U.S. Offshore Requirements for Drilling Wastes**
  - No discharge of free oil
  - No discharge within 3 miles of shore
  - Must have LC50 > 30,000 ppm (mysid shrimp test)
  - SMBs may not be discharged
  - Cuttings with up to 6.9% SMBs may be discharged
  - SMBs must satisfy biodegradation and toxicity tests
  - No discharge of formation oil

Commercial Disposal

• Why use?
  – Onsite disposal may not be allowed
  – May be more economical
• How?
  – Land farming and land filling
  – Salt taverns
  – Screen waste and inject liquids deep underground
• Cost – facilities need to be within 75-mile radius of wells because of transportation costs
• For example, a permitted, 90-acre disposal site is operated by Integrated Energy Companies (http://www.ie-cos.com/) just north of Duchesne, Utah.


Slurry Injection of Drilling Wastes

• Underground injection
  – Waste is screened and or ground and mixed with water to form slurry
  – Injected into underground formations at high pressure to fracture rock
• Types of slurry injection

Disposal in Salt Caverns

- Bedded and domal salt with chambers created by solution mining
- Surface footprint is small
- Transportation costs are limiting


Thermal Treatment of Drilling Waste

- High temperature is used to destroy hydrocarbons and immobilize metals and salts
- Cost is relatively high ($100 - $200 / ton)
- Two types of thermal treatment
  - High T in rotary kilns or cement kilns
  - Low T in thermal desorbers (usually rotary kilns): hydrocarbon vapors can be burned or collected.

Federal and State Regulations

- Disposal Practices and Applicable Regulations
  - U.S. Environmental Protection Agency (EPA)
  - Bureau of Land Management (BLM)
  - Bureau of Ocean Energy Management (BOEM)
  - Bureau of Safety and Environmental Enforcement (BSEE)
  - Utah Division of Oil, Gas, and Mining


Well Site Restoration

- Utah Administrative Code: R649-3-34
  - Governs how plugged and abandoned wells must be restored
  - For land that is under federal, Indian or state ownership, the operator must meet their requirements
  - For land that is under fee or private ownership, the operator must meet the owner’s requirements or those of the Division of Oil, Gas, and Mining

Source: R649-3-34, http://utah.eregulations.us/rule/r649-3-34