Appendix B

Bench-Scale Test Results
Bench-scale Test
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Bench-scale tests were conducted to provide data for design of the reactive cap and in-situ amendments to be placed in the Cove Open Water Area and Heavily Vegetated Area, respectively. These activities were completed between April 21 and May 2, 2014. Attachments documenting procedures, test data sheets, results, and photologs for the (1) Reactive Media Bench-Scale Settling Test, (2) Organoclay Sorption Capacity Bench-Scale Test, and (3) PTS Laboratories Tests are enclosed. The bench-scale tests are briefly summarized below.

Reactive Media Bench-Scale Settling Test

The main objective of the Reactive Media Bench-Scale Settling Test is to evaluate the settling rate and characteristics of organoclay products (PM-199, PMFI, and AquaGate) and organoclay-sand mixtures (90% Sand – 10% PM-199 and 90% Sand – 10% PMFI). Data collected during each settling test are presented in Test Data Sheets and photolog.

Organoclay Sorption Capacity Bench-Scale Test

The main objective of the Organoclay Sorption Capacity Bench-Scale Test is to provide an estimate of the mass of site-specific oil (non-aqueous phase liquid [NAPL]) that can be sorbed by a specific mass of organoclay such that a sheen is not produced from the resulting material upon contact with water. Data collected during these tests are presented in Test Data Sheets and photolog.

PTS Laboratories Tests

Sediment cores were collected from Pre-Design Study locations within the Open Water Area for evaluation of residual oil content. Six cores were submitted to PTS Laboratories (PTS) of Santa Fe, California for evaluation. PTS conducted core photography (white light and UV light) on the six cores. The core photography was used to select nine samples with the most potential residual oil for analysis by Method API RP 40 (Dean-Stark Method). These tests were conducted to evaluate crude oil mass in the reactive capping and in-situ amendment area.

PTS indicated based on their evaluation of the cores that there was little or no physical evidence of hydrocarbon saturation presence based on the following observations: 1) UV fluorescence appears to be from mineral or organic material, 2) no presence of hydrocarbon odor, only organic odor, 3) no visual presence of hydrocarbon or NAPL, 4) the core material consists of very fine grained sediments and/or organic material which may yield false-positive oil (NAPL) saturation results. PTS core photography and laboratory report are enclosed as Attachments.

Attachments

Reactive Media Bench-Scale Settling Test Documentation

Organoclay Sorption Capacity Bench-Scale Test Documentation

PTS Laboratories Documentation
Reactive Media Bench-Scale
Settling Test
Bench-scale laboratory tests were conducted to evaluate settling rate and characteristics of organoclay products and organoclay-sand mixtures.

**Procedure**

The procedure for the settling test was adapted from the U.S. Army Corps of Engineers (USACE) Settling Column Test Procedures (modified October 2002) as follows:

1. **Prepare settling column.** Clean the column and fill with tap water.

2. **Prepare test material.** Weigh out sample of media and record weight.

<table>
<thead>
<tr>
<th>Organoclay Media/Mix</th>
<th>Target Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM-199</td>
<td>54 g</td>
</tr>
<tr>
<td>PMFI</td>
<td>54 g</td>
</tr>
<tr>
<td>AquaGate</td>
<td>181 g</td>
</tr>
<tr>
<td>Sand (90%) and PM-199</td>
<td>Sand = 588 g</td>
</tr>
<tr>
<td></td>
<td>PM-199= 65 g</td>
</tr>
<tr>
<td>Sand (90%) and PMFI</td>
<td>Sand = 588 g</td>
</tr>
<tr>
<td></td>
<td>PMFI = 65 g</td>
</tr>
</tbody>
</table>

**Note:**
g = grams

3. **Homogenize test material.** For media mixes with organoclay and sand, thoroughly mix the organoclay and sand prior to placement.

4. **Start test.** Pour media slowly into 2-liter graduated cylinder filled with potable water. Media should be placed into cylinder over approximately 3 minutes.

5. **Observe settling characteristics** every 15 minutes for the first hour, then every 30 minutes for up to 2 hours for a total of 3 hours.
   a. Photograph each graduated cylinder of material.
   b. Measure and record thickness of material at base of graduated cylinder.
   c. Record visual observations of material in suspension/float.
   d. Record visual observation of settled mixtures (stratification, etc.).

6. If material has not completed settling, allow material to stand overnight in graduated cylinder.

7. **On the following day,** record settling characteristics.
   a. Photograph each graduated cylinder of material.
   b. Measure and record thickness of material at base of graduated cylinder.
   c. Record visual observations of material in suspension/float.
   d. Record visual observation of settled mixtures (stratification, etc.).
Results

Reactive media bench-scale settling tests were completed for two types of organoclay products (PM-199 and PMFI), two organoclay-sand mixtures (90% Sand – 10% PM-199 and 90% Sand – 10% PMFI), and AquaGate. Results from the settling tests are summarized below and presented in the attached test data sheets and photologs.

Comparison of Organoclay Products: PM-199 and PMFI

Comparing the two types of organoclay products, PM-199 and PMFI, results show that PMFI settles at a slightly faster rate (0.01 centimeters per minute [cm/min]) than PM-199 (0.005 cm/min). Upon adding PMFI to the potable water in the graduated cylinder, approximately 90% of the material settled to the bottom in 15 minutes. Within 35 to 40 minutes of application, PMFI finished settling, although residual material continued to float for the remainder of the test (up to 180 minutes after initial application). Upon adding PM-199 to the potable water in the graduated cylinder, approximately 80% of the material settled to the bottom in 15 minutes. PM-199 slowly settled for up to 120 minutes after application, although a majority (90%) of material settled after 60 minutes of initial application. Residual floating material persisted through the duration of the test (up to 180 minutes after initial application).

Comparison of Organoclay-Sand Mixtures: 90% Sand – 10% PM-199 and 90% Sand – 10% PMFI

For both organoclay-sand mixtures, material immediately settled to the bottom of the graduated cylinder upon initial application; however, foaming on the surface caused residual floating particles, which took longer to settle. For 45 to 60 minutes after initial application, the fine particles in both mixtures continued to settle, creating a distinct layer of fines on the surface of the organoclay-sand mixture. During this time, turbidity slowly decreased, although foaming persisted at the surface. For the PM-199-sand mixture, a majority of material finished settling after 60 minutes following initial application, whereas a majority of the PMFI-sand mixture finished settling after 120 minutes.

AquaGate

During the AquaGate settling test, the material settled immediately after application with some residual floating material on the surface. Settling conditions remained unchanged for the remainder of the test (up to 180 minutes after initial application).

Attachments

Test Data Sheets
- PM-199
- PMFI
- 90% Sand – 10% PM-199
- 90% Sand – 10% PMFI
- AquaGate

Photolog
### Column Settling Test

**Water/Solids Interface Settling Data**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Elapsed Time, min</th>
<th>Elapsed Time, hrs</th>
<th>Water/Solids Interface Height, (cm)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/21/2014</td>
<td>12:00 PM</td>
<td>0</td>
<td>0.00</td>
<td>1.5</td>
<td>Media added over the course of 7 minutes</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>12:15 PM</td>
<td>15</td>
<td>0.25</td>
<td>1.4</td>
<td>~80% of media settled</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>12:30 PM</td>
<td>30</td>
<td>0.50</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>4/21/2014</td>
<td>12:45 PM</td>
<td>45</td>
<td>0.75</td>
<td>1.3</td>
<td>Still settling slowly</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>1:00 PM</td>
<td>60</td>
<td>1.00</td>
<td>1.2</td>
<td>~10% of media remains on surface; still settling slowly</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>1:30 PM</td>
<td>90</td>
<td>1.50</td>
<td>1.2</td>
<td>Media still slowly settling; small air bubbles are causing residual floating particles</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>2:00 PM</td>
<td>120</td>
<td>2.00</td>
<td>1.2</td>
<td>Media still slowly settling; small air bubbles are causing residual floating particles</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>2:30 PM</td>
<td>150</td>
<td>2.50</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>4/21/2014</td>
<td>3:00 PM</td>
<td>180</td>
<td>3.00</td>
<td>1.2</td>
<td>Small amount of residual floating particles caused by small air bubbles; solution agitated to allow for even settling</td>
</tr>
</tbody>
</table>

![Graph showing water/solids interface height over time](image-url)
Client Name: ExxonMobil Environmental Services Company
Project Name: Mayflower, Cove Remediation Project
Test Material: PMFI
Test Start Date: 4/21/2014

**Column Settling Test**

**Water/Solids Interface Settling Data**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Elapsed Time, min</th>
<th>Elapsed Time, hrs</th>
<th>Water/Solids Interface Height, cm</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/21/2014</td>
<td>12:00 PM</td>
<td>0</td>
<td>0.00</td>
<td>1.7</td>
<td>Media added over the course of 7 minutes</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>12:15 PM</td>
<td>15</td>
<td>0.25</td>
<td>1.5</td>
<td>~90% of media has settled to bottom</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>12:30 PM</td>
<td>30</td>
<td>0.50</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>4/21/2014</td>
<td>12:45 PM</td>
<td>45</td>
<td>0.75</td>
<td>1.2</td>
<td>Media finished settling at 35 to 40 minutes</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>1:00 PM</td>
<td>60</td>
<td>1.00</td>
<td>1.2</td>
<td>Residual floating media on surface, done settling</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>1:30 PM</td>
<td>90</td>
<td>1.50</td>
<td>1.2</td>
<td>Residual floating particles; media done settling</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>2:00 PM</td>
<td>120</td>
<td>2.00</td>
<td>1.2</td>
<td>Floating, white &quot;fuzzy&quot; looking particles appear</td>
</tr>
<tr>
<td>4/21/2014</td>
<td>2:30 PM</td>
<td>150</td>
<td>2.50</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>4/21/2014</td>
<td>3:00 PM</td>
<td>180</td>
<td>3.00</td>
<td>1.2</td>
<td>Residual floating material; solution agitated to allow for even settling</td>
</tr>
</tbody>
</table>

![Graph of Water/Solids Interface Height vs. Time](image)
**Column Settling Test**  
**Water/Solids Interface Settling Data**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Elapsed Time, min</th>
<th>Elapsed Time, hrs</th>
<th>Water/Solids Interface Height, (cm)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/22/2014</td>
<td>3:05 PM</td>
<td>0</td>
<td>0.00</td>
<td>12.2</td>
<td>Media settled immediately; foaming on surface caused residual floating particles</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>3:20 PM</td>
<td>15</td>
<td>0.25</td>
<td>11.7</td>
<td>Fines still settling out</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>3:35 PM</td>
<td>30</td>
<td>0.50</td>
<td>11.2</td>
<td>Distinct layer of fines on surface of Sand/Organoclay mixture</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>3:50 PM</td>
<td>45</td>
<td>0.75</td>
<td>11.0</td>
<td>Fines still settling; foaming on surface has not changed; turbidity decreasing</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>4:05 PM</td>
<td>60</td>
<td>1.00</td>
<td>10.9</td>
<td>Foaming on surface has not changed; turbidity decreasing</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>4:35 PM</td>
<td>90</td>
<td>1.50</td>
<td>10.9</td>
<td>Foaming still persists</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>5:05 PM</td>
<td>120</td>
<td>2.00</td>
<td>10.9</td>
<td>Foaming still persists</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>5:35 PM</td>
<td>150</td>
<td>2.50</td>
<td>10.9</td>
<td></td>
</tr>
<tr>
<td>4/22/2014</td>
<td>6:05 PM</td>
<td>180</td>
<td>3.00</td>
<td>10.9</td>
<td></td>
</tr>
</tbody>
</table>

![Graph showing the change in interface height over time](image)
### Column Settling Test
#### Water/Solids Interface Settling Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Elapsed Time, min</th>
<th>Elapsed Time, hrs</th>
<th>Water/Solids Interface Height, (cm)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/22/2014</td>
<td>3:05 PM</td>
<td>0</td>
<td>0.00</td>
<td>12.5</td>
<td>Media settled rapidly; residual floating particles due to excessive foaming</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>3:20 PM</td>
<td>15</td>
<td>0.25</td>
<td>12.0</td>
<td>Foaming persists; fine particles still settling; fines beginning to make distinct layer on bottom</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>3:35 PM</td>
<td>30</td>
<td>0.50</td>
<td>11.3</td>
<td>Foaming persists; fines still settling</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>3:50 PM</td>
<td>45</td>
<td>0.75</td>
<td>11.1</td>
<td>Fines still settling; turbidity decreasing</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>4:05 PM</td>
<td>60</td>
<td>1.00</td>
<td>11.0</td>
<td>Turbidity decreasing; foam still persists</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>4:35 PM</td>
<td>90</td>
<td>1.50</td>
<td>11.0</td>
<td>Foaming still persists on surface</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>5:05 PM</td>
<td>120</td>
<td>2.00</td>
<td>10.9</td>
<td>Foaming still persists on surface</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>5:35 PM</td>
<td>150</td>
<td>2.50</td>
<td>10.9</td>
<td>Foaming still persists on surface</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>6:05 PM</td>
<td>180</td>
<td>3.00</td>
<td>10.9</td>
<td>Foaming still persists on surface</td>
</tr>
</tbody>
</table>

![Graph of Interface Height vs Time](image_url)

Page 1 of 1
Column Settling Test
Water/Solids Interface Settling Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Elapsed Time, min</th>
<th>Elapsed Time, hrs</th>
<th>Water/Solids Interface Height, cm</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/22/2014</td>
<td>1:20 PM</td>
<td>0</td>
<td>0.00</td>
<td>4</td>
<td>Media settled immediately; residual floating material on surface</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>1:35 PM</td>
<td>15</td>
<td>0.25</td>
<td>4</td>
<td>No change</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>1:50 PM</td>
<td>30</td>
<td>0.50</td>
<td>4</td>
<td>No change</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>2:05 PM</td>
<td>45</td>
<td>0.75</td>
<td>4</td>
<td>No change</td>
</tr>
<tr>
<td>4/22/2014</td>
<td>2:20 PM</td>
<td>60</td>
<td>1.00</td>
<td>4</td>
<td>No change</td>
</tr>
</tbody>
</table>

Notes:
1. Test stopped after 1 hour because media settled immediately.
Organoclay Product Materials

Photograph 1
PM-199

Photograph 2
PMFI

Photograph 3
AquaGate
**Photograph 4**
Left: 90% Sand mixed with 10% PM-199 (Organoclay); Right: 90% Sand mixed with 10% PMFI (Organoclay)

**Photograph 5**
Sand
Photograph 6
Elapsed Time: 0 minutes
PM-199 Thickness (left): 1.5 cm
PMFI Thickness (right): 1.7 cm

Photograph 7
Elapsed Time: 45 minutes
PM-199 Thickness (left): 1.3 cm
PMFI Thickness (right): 1.2 cm

Photograph 8
Elapsed Time: 60 minutes
PM-199 Thickness (left): 1.2 cm
PMFI Thickness (right): 1.2 cm
Photograph 9
Elapsed Time: 0 minutes
90% Sand – 10% PM-199 Thickness (left): 12.2 cm
90% Sand – 10% PMFI Thickness (right): 12.5 cm

Photograph 10
Elapsed Time: 60 minutes
90% Sand – 10% PM-199 Thickness (left): 10.9 cm
90% Sand – 10% PMFI Thickness (right): 11.0 cm

Photograph 11
Elapsed Time: 120 minutes
90% Sand – 10% PM-199 Thickness (left): 10.9 cm
90% Sand – 10% PMFI Thickness (right): 10.9 cm
Photograph 12
Elapsed Time: 0 minutes
AquaGate Thickness: 4 cm

Photograph 13
Elapsed Time: 60 minutes
AquaGate Thickness: 4 cm

Photograph 14
Elapsed Time: 0 minutes
AquaGate Thickness: 4 cm
Organoclay Sorption Capacity
Bench-Scale Test
Bench-scale tests were conducted to determine the organoclay (OC; PM-199) sorption capacity for site-specific residual oil (non-aqueous phase liquid [NAPL]). Specifically, the proposed tests were conducted to provide an estimate of the mass of NAPL that can be sorbed by a specific mass of OC, such that the resulting material does not produce a sheen upon contacting a clean water surface.

**Procedure**

The procedure for the organoclay NAPL-capacity batch test is as follows:

1. Place a clean mixing bowl on a scale and record its mass to the nearest 0.1 gram (g).
2. Add approximately 20 g of OC to the mixing bowl and again record the weight to the nearest 1 g. Remove the bowl from the scale.
3. Slowly add potable water and stir into OC to produce a water-saturated OC sample.
4. Decant water above the surface of the OC and wipe off any excess moisture from the outside of the bowl.
5. Record the total weight of OC and water to the nearest 0.1 g.
6. Slowly add site-specific NAPL so that the added mass of NAPL is a selected percentage of the weight of OC (e.g., for 50% ratio of NAPL:OC, weight 10 g of NAPL).
   a. Prepare samples of OC, water, and NAPL to achieve approximate NAPL:OC ratios as follows:
      i. 50% (10 g NAPL, 20 g OC)
      ii. 60% (12 g NAPL, 20 g OC)
      iii. 70% (14 g NAPL, 20 g OC)
      iv. 75% (15 g NAPL, 20 g OC)
      v. 100% (20 g NAPL, 20 g OC)
      vi. 125% (25 g NAPL, 20 g OC)
      vii. 150% (15 g NAPL, 10 g OC)
7. Record the total weight of water-saturated OC and NAPL to the nearest 0.1 g. Remove the bowl from the scale.
8. Stir to homogenize water-saturated OC and NAPL.
10. Place sample in tightly sealed container.
11. Allow sample to sit in sealed container at room temperature for at least 48 hours.
12. Place clean potable water in a large stainless steel bowl.
13. Open sample container and obtain "spoonful" of homogenized sample material.
14. Holding the sample in the spoon, touch the sample to the surface of the water, lower it and raise it several times across the water surface. Look for sheen (see example photograph below).
15. If no sheen is observed, using latex- or nitrile-gloved hands, transfer the material into hand. Break the mixed OC/water/NAPL material apart at the surface of the water in the stainless steel bowl.

16. Note if NAPL or sheen is present on the surface of the water. Photograph water surface. Record qualitative observations of sheen using the same “Description” terms used in the field (as summarized in the table below from National Oceanic and Atmospheric Administration 2007).

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Layer-Thickness Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Sheen (silver/gray)</td>
<td>0.04 - 0.30, 1.6 x 10⁻⁴ - 1.2 x 10⁻⁵</td>
</tr>
<tr>
<td>R</td>
<td>Rainbow</td>
<td>0.30 - 5.0, 1.2 x 10⁻⁸ - 2.0 x 10⁻⁹</td>
</tr>
<tr>
<td>M</td>
<td>Metallic</td>
<td>5.0 - 50, 2.0 x 10⁻⁸ - 2.0 x 10⁻⁹</td>
</tr>
<tr>
<td>T</td>
<td>Transitional Dark (or True) Color</td>
<td>50 – 200, 2.0 x 10⁻³ - 8 x 10⁻³</td>
</tr>
<tr>
<td>D</td>
<td>Dark (or True) Color</td>
<td>&gt;200, &gt; 8 x 10⁻³</td>
</tr>
</tbody>
</table>

**Results**

Organoclay sorption capacity bench-scale tests were completed for seven ratios of NAPL:OC ranging from 50% (10 g NAPL, 20 g OC) to 150% (15 g NAPL, 10 g OC). Results from sorption capacity tests are summarized below and presented in the attached test data sheets and photolog.

After allowing the samples to sit in sealed containers at room temperature for at least 48 hours (and up to 120 hours), the following sheen observations were made:

- No surface water sheen was observed when the sample was touched to the water surface or broken up by hand at the water surface for the NAPL:OC ratios of 50% (after 48 hours), 60% (after 96 hours), 70% (after 96 hours), 75% (after 48 hours), and 100% (after 48 hours).

- A surface water sheen was observed only when the sample was broken up by hand at the water surface for the NAPL:OC ratio of 125% (very weak, silver/grey sheen after 48 hours). After allowing
the sample to sit in a sealed container for 96 hours, no sheen was observed when the sample was broken up by hand.

- A surface water sheen was observed when the sample was touched to the water surface and broken up by hand at the water surface for the NAPL:OC ratio of 150% (strong, silver/grey sheen after 48 hours). After allowing the sample to sit in a sealed container for 96 hours, a sheen was only observed when the sample was broken up by hand at the water surface (extremely weak sheen).

**Attachments**

**Test Data Sheets**

- 50% NAPL:OC
- 60% NAPL:OC
- 70% NAPL:OC
- 75% NAPL:OC
- 100% NAPL:OC
- 125% NAPL:OC
- 150% NAPL:OC

**Photolog**
Client Name: ExxonMobil Environmental Services Company  
Project Name: Mayflower, Cove Remediation Project  
Project Location: Mayflower, AR  
Project Number: B0086022.1401.00200

Test Material (OC): **PM-199**  
NAPL:OC Ratio: **50%**  
Description: **10g NAPL, 20g OC**  
Moisture addition: **9.17 ml**

**NAPL Sorption Tests**

**Sheen Observations**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Sheen (Y/N)</th>
<th>Sheen Description</th>
<th>Elapsed Time, hrs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/24/2014</td>
<td>After 24hrs</td>
<td>N</td>
<td>N/A</td>
<td>24.00</td>
<td>No sheen when dipped or broken up by hand</td>
</tr>
<tr>
<td>4/25/2014</td>
<td>After 48 hrs</td>
<td>N</td>
<td>N/A</td>
<td>48.00</td>
<td>No sheen when dipped or broken up by hand</td>
</tr>
<tr>
<td>4/28/2014</td>
<td>After 120 hrs</td>
<td>N</td>
<td>N/A</td>
<td>120.00</td>
<td>No sheen when dipped or broken up by hand</td>
</tr>
</tbody>
</table>

Notes:  
g = grams  
hrs = hours  
ml = milliliter  
N = no  
NAPL = non-aqueous phase liquid  
N/A = not applicable  
OC = organoclay  
Y = yes

Page 1 of 1
Test Material (OC): **PM-199**
NAPL:OC Ratio: **60%**
Description: **12g NAPL, 20g OC**
Moisture Addition: **9.49 ml**

### NAPL Sorption Tests

**Sheen Observations**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Sheen (Y/N)</th>
<th>Sheen Description</th>
<th>Elapsed Time, hrs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/25/2014</td>
<td>After 24hrs</td>
<td>Y</td>
<td>&quot;S&quot;</td>
<td>24.00</td>
<td>Slight silver/grey sheen when broken apart. Approximately &lt;5% of water surface coverage</td>
</tr>
<tr>
<td>4/28/2014</td>
<td>After 96 hrs</td>
<td>N</td>
<td>N/A</td>
<td>96.00</td>
<td>No sheen when dipped or broken apart by hand</td>
</tr>
</tbody>
</table>

**Notes:**
- g = grams
- hrs = hours
- ml = milliliter
- N = no
- NAPL = non-aqueous phase liquid
- N/A = not applicable
- OC = organoclay
- S = silver/gray
- Y = yes
Test Material (OC): **PM-199**  
NAPL:OC Ratio: **70%**  
Description: **14g NAPL, 20g OC**  
Moisture Addition: **9.8 ml**

**NAPL Sorption Tests**

**Sheen Observations**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Sheen (Y/N)</th>
<th>Sheen Description</th>
<th>Elapsed Time, hrs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/25/2014</td>
<td>After 24hrs</td>
<td>Y</td>
<td>&quot;S&quot;</td>
<td>24.00</td>
<td>Silver/grey sheen when broken apart. Approximately 10-15% of water surface</td>
</tr>
<tr>
<td>4/28/2014</td>
<td>After 96 hrs</td>
<td>N</td>
<td>N/A</td>
<td>96.00</td>
<td>No sheen when dipped or broken apart by hand.</td>
</tr>
</tbody>
</table>

**Notes:**
- g = grams
- hrs = hours
- ml = milliliter
- N = no
- NAPL = non-aqueous phase liquid
- N/A = not applicable
- OC = organoclay
- S = silver/gray
- Y = yes
Client Name: ExxonMobil Environmental Services Company  
Project Name: Mayflower, Cove Remediation Project  
Project Location: Mayflower, AR  
Project Number: B0086022.1401.00200

Test Material (OC): **PM-199**  
Tested By: Ricky Sams  
NAPL/OC Ratio: 75%  
Checked By: Dave Liles  
Description: 15g NAPL, 20g OC  
Moisture Content: 10.89 ml

### NAPL Sorption Tests

#### Sheen Observations

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Sheen (Y/N)</th>
<th>Sheen Description</th>
<th>Elapsed Time, hrs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/24/2014</td>
<td>After 24hrs</td>
<td>Y</td>
<td>&quot;S&quot;</td>
<td>24.00</td>
<td>Very weak, silver/grey sheen when broken apart. &lt;5% water surface coverage</td>
</tr>
<tr>
<td>4/25/2014</td>
<td>After 48 hrs</td>
<td>N</td>
<td>N/A</td>
<td>48.00</td>
<td>No sheen when dipped or broken apart by hand</td>
</tr>
<tr>
<td>4/28/2014</td>
<td>After 120 hrs</td>
<td>N</td>
<td>N/A</td>
<td>120.00</td>
<td>No sheen when dipped or broken apart by hand</td>
</tr>
</tbody>
</table>

Notes:
g = grams  
hrs = hours  
ml = milliliter  
N = no  
NAPL = non-aqueous phase liquid  
N/A = not applicable  
OC = organoclay  
S = silver/gray  
Y = yes

Page 1 of 1
Client Name: ExxonMobil Environmental Services Company
Project Name: Mayflower, Cove Remediation Project
Project Location: Mayflower, AR
Project Number: B0086022.1401.00200

Test Material (OC): PM-199
Tested By: Ricky Sams
NAPL:OC Ratio: 100%
Checked By: Dave Liles
Description: 20g NAPL, 20g OC
Moisture Addition: 10.05 ml

### NAPL Sorption Tests

**Sheen Observations**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Sheen (Y/N)</th>
<th>Sheen Description</th>
<th>Elapsed Time, hrs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/24/2014</td>
<td>After 24hrs</td>
<td>Y</td>
<td>&quot;S&quot;</td>
<td>24.00</td>
<td>Slight silver/grey sheen when broken apart. Approximately 5-10% of water surface coverage</td>
</tr>
<tr>
<td>4/25/2014</td>
<td>After 48 hrs</td>
<td>N</td>
<td>N/A</td>
<td>48.00</td>
<td>No sheen when dipped or broken apart by hand</td>
</tr>
<tr>
<td>4/28/2014</td>
<td>After 120 hrs</td>
<td>N</td>
<td>N/A</td>
<td>120.00</td>
<td>No sheen when dipped or broken apart by hand</td>
</tr>
</tbody>
</table>

**Notes:**
g = grams
hrs = hours
ml = milliliter
N = no
NAPL = non-aqueous phase liquid
N/A = not applicable
OC = organoclay
S = silver/gray
Y = yes
Test Material (OC): **PM-199**  
NAPL:OC Ratio: **125%**  
Description: **25g NAPL, 20g OC**  
Moisture Addition: **9.12 ml**

### NAPL Sorption Tests

#### Sheen Observations

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Sheen (Y/N)</th>
<th>Sheen Description</th>
<th>Elapsed Time, hrs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/29/2014</td>
<td>After 24 hrs</td>
<td>Y</td>
<td>&quot;S&quot;</td>
<td>24.00</td>
<td>Silver/grey sheen when broken apart. Approximately 10-15% of water surface</td>
</tr>
<tr>
<td>4/30/2014</td>
<td>After 48 hrs</td>
<td>Y</td>
<td>&quot;S&quot;</td>
<td>48.00</td>
<td>Very weak, silver/grey sheen when broken apart. &lt;5% water surface coverage</td>
</tr>
<tr>
<td>5/2/2014</td>
<td>After 96 hrs</td>
<td>N</td>
<td>N/A</td>
<td>96.00</td>
<td>No sheen when broken apart</td>
</tr>
</tbody>
</table>

### Notes:
- g = grams
- hrs = hours
- ml = milliliter
- N = no
- NAPL = non-aqueous phase liquid
- N/A = not applicable
- OC = organoclay
- S = silver/gray
- Y = yes
Test Material (OC): PM-199  
NAPL:OC Ratio: 150%  
Description: 15g NAPL, 10g OC  
Moisture Addition: 6.11 ml

### NAPL Sorption Tests
#### Sheen Observations

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Sheen (Y/N)</th>
<th>Sheen Description</th>
<th>Elapsed Time, hrs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/29/2014</td>
<td>After 24hrs</td>
<td>Y</td>
<td>&quot;S&quot;</td>
<td>24.00</td>
<td>Very prominent silver/grey sheen when dipped into water. Total surface coverage</td>
</tr>
<tr>
<td>4/30/2014</td>
<td>After 48 hrs</td>
<td>Y</td>
<td>&quot;S&quot;</td>
<td>48.00</td>
<td>Still strong silver/grey sheen when dipped into water. Total surface coverage</td>
</tr>
<tr>
<td>5/2/2014</td>
<td>After 96 hrs</td>
<td>Y</td>
<td>&quot;S&quot;</td>
<td>96.00</td>
<td>Extremely weak sheen when broken apart. &lt;2% total surface coverage</td>
</tr>
</tbody>
</table>

**Notes:**  
g = grams  
hrs = hours  
ml = milliliter  
N = no  
NAPL = non-aqueous phase liquid  
OC = organoclay  
S = silver/grey  
Y = yes
FIGURE 1
MAYFLOWER PIPELINE INCIDENT RESPONSE
EXXONMOBIL ENVIRONMENTAL SERVICES COMPANY
OC SORPTION CAPACITY BENCH-SCALE TEST

Photograph 1
Elapsed Time: 0 minutes
Homogenized Sample Composition:
• 20 g OC
• 10 g NAPL
• 9.17 ml water

Photograph 2
Elapsed Time: 48 hours
Surface Water Sheen Observed?
• Hand Dipped – No
• Broken Up By Hand - No
Sheen Description:
• Not applicable

Acronyms:
g = grams
ml = milliliters
NAPL = non-aqueous phase liquid
OC = organoclay (PM-199)
Photograph 3
Homogenized Sample Composition:
- 20 g OC
- 12 g NAPL
- 9.49 ml water

Elapsed Time: 96 hours
Surface Water Sheen Observed?
- Hand Dipped – No
- Broken Up By Hand - No
Sheen Description:
- Not applicable

Acronyms:
g = grams
ml = milliliters
NAPL = non-aqueous phase liquid
OC = organoclay (PM-199)
Photograph 4
Elapsed Time: 0 minutes
Homogenized Sample Composition:
• 20 g OC
• 14 g NAPL
• 9.8 ml water

Elapsed Time: 96 hours
Surface Water Sheen Observed?
• Hand Dipped – No
• Broken Up By Hand - No

Sheen Description:
• Not applicable

Acronyms:
g = grams
ml = milliliters
NAPL = non-aqueous phase liquid
OC = organoclay (PM-199)
Photograph 5
Elapsed Time: 0 minutes
Homogenized Sample Composition:
• 20 g OC
• 15 g NAPL
• 10.89 ml water

Acronyms:
g = grams
ml = milliliters
NAPL = non-aqueous phase liquid
OC = organoclay (PM-199)

Photograph 6
Elapsed Time: 48 hours
Surface Water Sheen Observed?
• Hand Dipped – No
• Broken Up By Hand - No
Sheen Description:
• Not applicable
**Photograph 7**
Elapsed Time: 0 minutes
Homogenized Sample Composition:
- 20 g OC
- 20 g NAPL
- 10.05 ml water

**Acronyms:**
g = grams
ml = milliliters
NAPL = non-aqueous phase liquid
OC = organoclay (PM-199)

**Photograph 8**
Elapsed Time: 48 hours
Surface Water Sheen Observed?
- Hand Dipped – No
- Broken Up By Hand - No
Sheen Description:
- Not applicable
Photograph 9
Homogenized Sample Composition:
• 20 g OC
• 25 g NAPL
• 9.12 ml water

Elapsed Time: 48 hours
Surface Water Sheen Observed?
• Hand Dipped – No
• Broken Up By Hand - Yes

Sheen Description:
• Very weak, silver/grey sheen
• <5% water surface coverage

Acronyms:
g = grams
ml = milliliters
NAPL = non-aqueous phase liquid
OC = organoclay (PM-199)
Photograph 10
Homogenized Sample Composition:
• 10 g OC
• 15 g NAPL
• 6.11 ml water

Elapsed Time: 48 hours
Surface Water Sheen Observed?
• Hand Dipped – Yes
Sheen Description:
• Strong silver/grey sheen
• Total water surface coverage

Acronyms:
g = grams
ml = milliliters
NAPL = non-aqueous phase liquid
OC = organoclay (PM-199)
### Qualitative Sheening Amount

<table>
<thead>
<tr>
<th>Sampling Depth (inches)</th>
<th>Qualitative Sheening Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 6</td>
<td>Medium Sheen</td>
</tr>
<tr>
<td>6 - 12</td>
<td>Lighter Sheen</td>
</tr>
</tbody>
</table>

* = Varies for some samples
<table>
<thead>
<tr>
<th>Boring ID: OW-27R-041014</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sampling Depth (inches)</strong></td>
</tr>
<tr>
<td>0 - 6</td>
</tr>
<tr>
<td>6 – 12 *</td>
</tr>
</tbody>
</table>

* = Varies for some samples
### Boring ID: OW-34R-041014

<table>
<thead>
<tr>
<th>Sampling Depth (inches)</th>
<th>Qualitative Sheening Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 6</td>
<td>Heavier Sheen</td>
</tr>
<tr>
<td>6 – 12 *</td>
<td>Medium Sheen</td>
</tr>
</tbody>
</table>

* = Varies for some samples
## MAYFLOWER PIPELINE INCIDENT RESPONSE

### EXXONMOBIL ENVIRONMENTAL SERVICES COMPANY MITIGATION ACTION PLAN

#### PTS LABORATORIES CORE PHOTOLOG

<table>
<thead>
<tr>
<th>Boring ID: OW-40R-041014</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sampling Depth (inches)</strong></td>
</tr>
<tr>
<td>0 - 6</td>
</tr>
<tr>
<td>6 – 12 *</td>
</tr>
</tbody>
</table>

* = Varies for some samples
### Boring ID: OW-46R-041014

<table>
<thead>
<tr>
<th>Sampling Depth (inches)</th>
<th>Qualitative Sheening Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 6</td>
<td>Heavier Sheen</td>
</tr>
<tr>
<td>6 – 12 *</td>
<td>Heavier Sheen</td>
</tr>
</tbody>
</table>

* = Varies for some samples
**MAYFLOWER PIPELINE INCIDENT RESPONSE**

**EXXONMOBIL ENVIRONMENTAL SERVICES COMPANY**

**MITIGATION ACTION PLAN**

**PTS LABORATORIES CORE PHOTOLOG**

<table>
<thead>
<tr>
<th>Boring ID: OW-49R-041014</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Sampling Depth (inches)</th>
<th>Qualitative Sheening Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 6</td>
<td>Medium Sheen</td>
</tr>
<tr>
<td>6 – 12 *</td>
<td>Lighter Sheen</td>
</tr>
</tbody>
</table>

* = Varies for some samples
PTS Laboratory Report
April 29, 2014

Barbara Orchard, PE
ARCADIS U.S., Inc.
1100 Olive Way, Suite 800
Seattle, WA, 98101

Re: PTS File No: 44215
Physical Properties Data
EMES XOM Mayflower Pipeline 2014; 84949

Dear Ms. Orchard:

Please find enclosed report for Physical Properties analyses conducted upon samples received from your EMES XOM Mayflower Pipeline 2014; 84949 project. All analyses were performed by applicable ASTM, EPA, or API methodologies. An electronic version of the report has previously been sent to your attention via the internet. The cores remain in frozen storage and will be held indefinitely. Please note that core storage will be billed quarterly.

PTS Laboratories appreciates the opportunity to be of service. If you have any questions or require additional information, please give me a call at (562) 347-2502.

Sincerely,
PTS Laboratories, Inc.

[Signature]

[ Stamp] Michael Mark Brady, P.G.
District Manager

Encl.
## TEST PROGRAM - 20140415

<table>
<thead>
<tr>
<th>CORE ID</th>
<th>Depth ft.</th>
<th>Core Recovery ft.</th>
<th>Slab and Core Photo</th>
<th>Pore Fluid Saturation Package</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>OW-16R-041014</td>
<td>NA</td>
<td>1.0</td>
<td>1</td>
<td>0.1-0.3</td>
<td></td>
</tr>
<tr>
<td>OW-19R-041014</td>
<td>NA</td>
<td>1.2</td>
<td></td>
<td></td>
<td>HOLD - NO ANALYSES</td>
</tr>
<tr>
<td>OW-20R-041014</td>
<td>NA</td>
<td>1.0</td>
<td></td>
<td></td>
<td>HOLD - NO ANALYSES</td>
</tr>
<tr>
<td>OW-24R-041014</td>
<td>NA</td>
<td>1.3</td>
<td></td>
<td></td>
<td>HOLD - NO ANALYSES</td>
</tr>
<tr>
<td>OW-27R-041014</td>
<td>NA</td>
<td>1.2</td>
<td>2</td>
<td>0.1-0.3, 0.5-0.7</td>
<td></td>
</tr>
<tr>
<td>OW-32R-041014</td>
<td>NA</td>
<td>1.0</td>
<td></td>
<td></td>
<td>HOLD - NO ANALYSES</td>
</tr>
<tr>
<td>OW-34R-041014</td>
<td>NA</td>
<td>1.3</td>
<td>2</td>
<td>0.0-0.2, 0.3-0.5</td>
<td></td>
</tr>
<tr>
<td>OW-40R-041014</td>
<td>NA</td>
<td>1.2</td>
<td>2</td>
<td>0.0-0.2</td>
<td></td>
</tr>
<tr>
<td>OW-46R-041014</td>
<td>NA</td>
<td>1.7</td>
<td>2</td>
<td>0.0-0.2</td>
<td></td>
</tr>
<tr>
<td>OW-49R-041014</td>
<td>NA</td>
<td>1.2</td>
<td>2</td>
<td>0.0-0.2, 0.2-0.4</td>
<td></td>
</tr>
<tr>
<td><strong>TOTALS:</strong></td>
<td>10 cores</td>
<td>12.0</td>
<td>11</td>
<td>9</td>
<td>12</td>
</tr>
</tbody>
</table>

**Laboratory Test Program Notes**
- Contaminant identification:
  - Standard TAT for basic analysis is 10 business days.
  - Sample locations to be selected by ARCADIS personnel from core photography.
- **Pore Fluid Saturation Package**: API RP40 Dean-Stark Method: Includes initial pore fluid saturations, total porosity, air-filled porosity, grain density, dry bulk density and moisture content.
- Pore Fluid Saturation sample locations added 20140415 by B. Orchard/URS.
### PHYSICAL PROPERTIES DATA - PORE FLUID SATURATIONS

**Project Name:** EMES XOM Mayflower Pipeline 2014  
**Project No:** 84949

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>DEPTH, ft</th>
<th>SAMPLE ORIENTATION (1)</th>
<th>MOISTURE CONTENT, % weight</th>
<th>DRY BULK, g/cc</th>
<th>GRAIN, g/cc</th>
<th>POROSITY, %Vb (2)</th>
<th>PORE FLUID SATURATIONS, % Pv (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OW-16R-041014</td>
<td>0.2</td>
<td>V</td>
<td>59.8</td>
<td>0.94</td>
<td>2.47</td>
<td>62.0</td>
<td>5.6</td>
</tr>
<tr>
<td>OW-27R-041014</td>
<td>0.2</td>
<td>V</td>
<td>132.3</td>
<td>0.54</td>
<td>2.29</td>
<td>76.4</td>
<td>3.9</td>
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<tr>
<td>OW-27R-041014</td>
<td>0.6</td>
<td>V</td>
<td>63.8</td>
<td>0.90</td>
<td>2.48</td>
<td>63.8</td>
<td>6.3</td>
</tr>
<tr>
<td>OW-34R-041014</td>
<td>0.1</td>
<td>V</td>
<td>125.5</td>
<td>0.53</td>
<td>2.53</td>
<td>79.2</td>
<td>13.0</td>
</tr>
<tr>
<td>OW-34R-041014</td>
<td>0.4</td>
<td>V</td>
<td>157.3</td>
<td>0.46</td>
<td>2.42</td>
<td>80.8</td>
<td>7.4</td>
</tr>
<tr>
<td>OW-40R-041014</td>
<td>0.1</td>
<td>V</td>
<td>102.4</td>
<td>0.63</td>
<td>2.58</td>
<td>75.4</td>
<td>10.1</td>
</tr>
<tr>
<td>OW-46R-041014</td>
<td>0.1</td>
<td>V</td>
<td>118.5</td>
<td>0.57</td>
<td>2.55</td>
<td>77.6</td>
<td>9.3</td>
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<tr>
<td>OW-49R-041014</td>
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<td>V</td>
<td>119.2</td>
<td>0.55</td>
<td>2.40</td>
<td>77.3</td>
<td>11.7</td>
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<tr>
<td>OW-49R-041014</td>
<td>0.3</td>
<td>V</td>
<td>155.2</td>
<td>0.46</td>
<td>2.27</td>
<td>79.5</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Note: Review of the cores shows little or no physical evidence of hydrocarbon saturation presence: 1) UV fluorescence appears to be from mineral or organic material, 2) no presence of hydrocarbon odor, only organic odor, 3) no visual presence of hydrocarbon or NAPL, 4) the core material consists of very fine grained sediments and/or organic material which may yield false-positive NAPL saturation results.

NAPL/hydrocarbon saturations determined by Dean-Stark Extraction method are based on weight difference of sample material pre-extraction versus post-extraction. Very fine grained or organic material may be lost or dissolved during extraction yielding exaggerated weight differences resulting in false positive test results. Chemical analytical test methods should be employed to verify presence of NAPL/hydrocarbon. Michael Mark Brady, P.G., Laboratory Director

---

(1) Sample Orientation: H = horizontal; V = vertical; R = remold  
(2) Total Porosity = all interconnected pore channels; Air Filled = pore channels not occupied by pore fluids.  
(3) Fluid density used to calculate pore fluid saturations: Water = 0.9996 g/cc, NAPL = 0.8600 g/cc.  
Vb = Bulk Volume, cc; Pv = Pore Volume, cc; ND = Not Detected
**CHAIN OF CUSTODY & LABORATORY**

**ANALYSIS REQUEST FORM**

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<td>Sediment</td>
<td>Core</td>
<td>1 X X</td>
<td>6-1/2&quot; / Medium</td>
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**Requested Analyses**

1. Photolog Digital Core Photography white light and UV
2. Pore Fluid Saturation Package API RP 40

**Special Instructions/Comments:**

Samples preserved with dry ice.

Contact ARCADIS for details on Pore Fluid Saturation Sample Interval.

(Contact: Barbara Orchard; 206 726 4723; barbara.orchard@arcadis-us.com)

**Laboratory Information and Receipt**

<table>
<thead>
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