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Since 1994 - Environmental Excellence

July 26, 1994

Mr. Mike Grimm  
Amoco Production Company  
501 West Lake Boulevard  
Houston, Texas 77079

Re: Air Sparging / Vapor Extraction Pilot Test  
South Sprint Facility, Texas  
ENTRIX Project No. 146704

Dear Mike:

The following report describes field activities during the air sparging / vapor extraction pilot tests as part of a groundwater monitoring and remediation program at Amoco Production Company's (Amoco) South Sprint facility on North Padre Island, Texas.

## Objectives and Scope

The objective of the pilot study was to determine whether a full-scale air sparging and soil vapor extraction (SVE) system would be effective in containing and remediating a hydrocarbon plume dissolved in groundwater underlying the site. This was to be accomplished through the collection and interpretation of chemical, geologic, water level, vacuum and pressure data from on-site testing. The formation hydraulic conductivity will be calculated based on performing limited slug tests.

The activities performed in achieving the objective of the pilot study investigation included:

- Installation of a 12.5-foot horizontal vapor recovery well two feet deep;
- Performance of SVE pilot tests to determine the radius of influence under varying flow conditions;
- Performance of air sparging pilot tests to determine the radius of influence of the sparging well under varying flow conditions;
- Performance of continuous 36-hour SVE and air sparging pilot studies;

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- Collection of groundwater and QA/QC samples for laboratory analyses of BTEX;
- Collection of groundwater level data in surrounding wells to evaluate the amount of mounding in the area surrounding the air sparging; and
- Perform slug tests to calculate hydraulic conductivity.

See Figure 1 for well locations.

The activities listed above are discussed in detail in subsequent sections of this report.

### **Background**

The South Sprint Facility is a gas gathering facility located on North Padre Island. The facility collects natural gas from two wells, one onshore and one offshore, and transports the gas inland.

Releases of gas condensate have penetrated the sandy soil and impacted the shallow groundwater at a depth of approximately three feet below the ground surface. Seventeen monitor wells are being utilized to monitor groundwater levels and groundwater quality. In addition, six free-phase skimming wells have been installed to remove free-phase hydrocarbons. Three possible plumes have been identified and Amoco has voluntarily offered to begin remediation.

### **Geology and Hydrogeology**

The site is located on North Padre Island. The native soil consists of very fine-grained, well sorted sands with lenses of poorly sorted fine- to medium-grained sand and shell material (storm deposits). The static groundwater level is approximately three feet below the ground surface in the pilot study area. Other areas contain deeper groundwater due to sand dune elevation changes. The groundwater consists of fresh water recharged by the infiltration of rain. Although the site is only a few hundred yards from the gulf coast, the monitor wells do not appear to be tidally influenced.

### **Pilot Study**

Amoco personnel installed a single line of wells in the following order: one air sparge (SP-1) well, four observation wells (OW-2, OW-3, OW-4, OW-5), and one SVE well (SVE-1), each spaced 10 feet apart (Figure 1). The pilot study was conducted in the southwest corner of the facility. The entire site is underlain by very fine-grained sands.

Silt is present as fill material in the old pit area. The pilot study results are assumed to be representative of conditions throughout the site.

### **SVE Pilot Tests**

A SVE pilot test was first conducted at SVE-1 to determine the maximum flow rate allowable and to estimate a radius of influence. The 7.5-foot well screen was placed at approximately 1.5 to 9.0 feet below the ground surface. At the time of the pilot test, the water table was approximately two and one-half feet below the ground surface. The test was conducted at a flow rate of five actual cubic feet per minute (ACFM), at a vacuum of 12 inches of water column (iwc). After approximately one minute of operation the vacuum had lifted the water table above the exposed screen. The vacuum blower began to pump groundwater and the SVE test was terminated.

An alternative SVE pilot test was conducted by placing a 1.5-inch horizontal well screen at a depth of 2.0 feet below the ground surface. A 13-foot trench was dug with a backhoe and a 12.5-foot section of screened PVC was placed in the trench. Monitor points were spaced every 2.5 feet to record the vacuum along the trench. To encourage air flow from the bottom of the well screen and help prevent short circuiting to the surface the two uppermost rows of slots were sealed with tape. The trench was then backfilled with one foot of the soils (previously removed from the trench), covered with plastic, and backfilled to the original grade.

The first SVE test conducted on the horizontal SVE well was at a flow rate of 5 ACFM at a vacuum of 14 iwc (Table 1). After 40 minutes the flow rate was increased to 10 ACFM at a vacuum of 26 iwc, and conducted for an additional 40 minutes. OVM readings were recorded during both tests. The OVM readings consistently decreased during the 5 ACFM flow rate (Table 1), and rebounded when increased to 10 ACFM. During the 40-minute SVE test at 10 ACFM, the OVM readings decreased as the test proceeded.

### **Air Sparging Pilot Tests**

An air sparging test was conducted at SP-1. Four observation wells (OW-2, OW-3, OW-4, OW-5) in-line and spaced 10 feet apart were monitored during the testing (Figure 1). Wells were monitored for an increase in pressures at each well, and visual observations were also conducted between each test for the presence of air bubbles produced by the sparging point. The visual observation is used as a verification tool since an increase in pressure may be due to sparged air travelling along the vadose zone and then entering the well screen.

**Table 1**  
**Soil Vapor Extraction Pilot Test**  
**Amoco - S. Sprint, Texas**

Time: 2:08

Date: 2-28-1994

| Time<br>(Min) | Flow Rate<br>SVE1 - ACFM | Vacuum (in. of wc) |      |      |      |      |      | OVM (V1)      |
|---------------|--------------------------|--------------------|------|------|------|------|------|---------------|
|               |                          | HSVE-1             | MP-1 | MP-2 | MP-3 | MP-4 | MP-5 | (ppm)         |
| 0             | 0                        |                    |      |      |      |      |      | <b>BKG=75</b> |
| 10            | 5                        | 14.0               | 2.6  | 6.0  | 4.8  | 5.5  | 3.0  | 120           |
| 20            | 5                        | 14.0               | 2.6  | 6.0  | 4.8  | 6.0  | 3.0  | 95            |
| 30            | 5                        | 14.0               | 2.6  | 6.0  | 4.6  | 6.0  | 3.0  | 60            |
| 40            | 5                        | 14.0               | 2.6  | 6.0  | 4.8  | 6.0  | 3.0  | 12            |
| 50            | 10                       | 26.0               | 5.4  | 10.0 | 9.2  | 11.5 | 5.6  | 165           |
| 60            | 10                       | 26.0               | 5.0  | 8.0  | 8.6  | 11.3 | 5.1  | 180           |
| 70            | 10                       | 26.0               | 4.8  | 9.0  | 8.4  | 10.7 | 5.1  | 160           |
| 80            | 10                       | 26.0               | 4.8  | 9.0  | 8.4  | 10.2 | 5.0  | 120           |

- NOTES: (1) Columns are arranged as they physically appear in the field and are spaced approximately 3 feet apart.
- (2) ACFM = Actual cubic feet per minute.
- (3) in. of wc = inches of water column.
- (4) OVM = organic vapor monitor.
- (5) ppm = parts per million.

An air sparging pilot test was first conducted at SP-1 to determine the maximum flow rate allowable and to estimate a radius of influence. The 2.5-foot well screen was placed at approximately 19.5 to 22.0 feet below the ground surface. The well was set at this depth to increase the radius of influence during the tests. At the time of the pilot test the water table was approximately two and one-half feet below the ground surface.

The test was first conducted with a flow rate of 1.5 ACFM, at a pressure of approximately 8.7 pounds per square inch (psi). After approximately 90 minutes very low pressures were observed at OW-2 and OW-3 at distances of 10 and 20 feet respectively. Air bubbles were not observed in any wells during the first 90 minute test, but the water table surrounding the sparge point had increased at each of the four observation wells.

The flow rate was increased after 90 minutes to 3.0 ACFM at a pressure of approximately 9.0 psi. After approximately 90 minutes at 3.0 ACFM very low pressures were observed at OW-2 and OW-3 at distances of 10 and 20 feet respectively. Vigorous air bubbles were observed in OW-2 at a distance of 10 feet.

The flow rate was increased after 180 minutes to 5.0 ACFM at a pressure of approximately 9.0 psi. After approximately 90 minutes very low pressures were observed at OW-2 and OW-3 at distances of 10 and 20 feet respectively. Vigorous air bubbles were observed in OW-2 and some air bubbles were recorded in OW-3. Water levels again increased from the previous 90 minute test in each of the four observation wells (Table 2).

### **Extended 36-Hour Air Sparging/SVE Pilot Study**

Water levels, dissolved oxygen (DO) readings, and groundwater samples were collected from observation wells prior to the system start-up, and at regular intervals throughout the pilot study. In addition, flow rates, vacuum and pressure readings, and visual observation were recorded throughout the testing period and are presented in Table 3.

Air sparging and SVE parameters for the extended test were selected based on data collected during the individual pilot tests. The SVE flow rate of 5 ACFM was selected instead of 10 ACFM based on the lower vacuum of 14 iwc compared to 26 iwc. The 26 iwc vacuum at the higher flow rate would likely lift water into the system over an extended period of time.

The air sparging flow rate of 3.0 ACFM was selected instead of the 5 ACFM based on the amount of excessive bubbling observed in OW-2 during the 5 ACFM pilot test. The

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**Table 2**  
**Air Sparging Pilot Test**  
**Amoco - S. Sprint, Texas**

Time: 3:30 pm

Date: 2-28-1994

| Time<br>(Min) | Flow<br>(ACFM) | Pressure<br>(PSI) | Pressure (in. of wc) |      |      |      |       |
|---------------|----------------|-------------------|----------------------|------|------|------|-------|
|               |                |                   | OW-2                 | OW-3 | OW-4 | OW-5 | SVE-1 |
|               | SP-1           | SP-1              |                      |      |      |      |       |
| 0             | 0              | 0                 | ---                  | ---  | ---  | ---  | ---   |
| 15            | 1.5            | 9.0               | 0.00                 | 0.00 | 0.00 | 0.00 | 0.00  |
| 30            | 1.5            | 8.7               | 0.00                 | 0.00 | 0.00 | 0.00 | 0.00  |
| 45            | 1.5            | 8.7               | 0.00                 | 0.00 | 0.00 | 0.00 | 0.00  |
| 60            | 1.5            | 8.7               | 0.00                 | 0.00 | 0.00 | 0.00 | 0.00  |
| 75            | 1.5            | 8.7               | 0.01                 | 0.00 | 0.00 | 0.00 | 0.00  |
| 90            | 1.5            | 8.7               | 0.01                 | 0.01 | 0.00 | 0.00 | 0.00  |

| Time<br>(Min) | Water Level (TOC) (feet) |      |      |      |       | Dissolved Oxygen/<br>Visual Observation of Sparged Air |      |      |      |       |
|---------------|--------------------------|------|------|------|-------|--------------------------------------------------------|------|------|------|-------|
|               | OW-2                     | OW-3 | OW-4 | OW-5 | SVE-1 | OW-2                                                   | OW-3 | OW-4 | OW-5 | SVE-1 |
| 0             | 4.36                     | 4.20 | 4.65 | 4.51 | ---   | 0.37                                                   | 0.41 | 0.30 | 0.26 | 0.32  |
| 15            | ---                      | ---  | ---  | ---  | ---   | ---                                                    | ---  | ---  | ---  | ---   |
| 30            | ---                      | ---  | ---  | ---  | ---   | ---                                                    | ---  | ---  | ---  | ---   |
| 45            | ---                      | ---  | ---  | ---  | ---   | ---                                                    | ---  | ---  | ---  | ---   |
| 60            | ---                      | ---  | ---  | ---  | ---   | ---                                                    | ---  | ---  | ---  | ---   |
| 75            | ---                      | ---  | ---  | ---  | ---   | ---                                                    | ---  | ---  | ---  | ---   |
| 90            | ---                      | ---  | ---  | ---  | ---   | NB                                                     | NB   | NB   | NB   | NB    |

Time: 5:15 pm

| Time<br>(Min) | Flow<br>(ACFM) | Pressure<br>(PSI) | Pressure (in. of wc) |      |      |      |       |
|---------------|----------------|-------------------|----------------------|------|------|------|-------|
|               |                |                   | OW-2                 | OW-3 | OW-4 | OW-5 | SVE-1 |
|               | SP-1           | SP-1              |                      |      |      |      |       |
| 0             | 1.5            | 9.1               | ---                  | ---  | ---  | ---  | ---   |
| 15            | 3              | 9.1               | 0.03                 | 0.02 | 0.00 | 0.01 | 0.00  |
| 30            | 3              | 9.1               | 0.05                 | 0.02 | 0.00 | 0.01 | 0.00  |
| 45            | 3              | 9.0               | 0.04                 | 0.02 | 0.00 | 0.01 | 0.00  |
| 60            | 3              | 9.0               | 0.04                 | 0.01 | 0.00 | 0.00 | 0.00  |
| 75            | 3              | 8.8               | 0.05                 | 0.01 | 0.00 | 0.00 | 0.00  |
| 90            | 3              | 8.8               | 2.70                 | 0.02 | 0.00 | 0.00 | 0.00  |

| Time<br>(Min) | Water Level (TOC) (feet) |      |      |      |       | Visual Observation of Sparged Air |      |      |      |       |
|---------------|--------------------------|------|------|------|-------|-----------------------------------|------|------|------|-------|
|               | OW-2                     | OW-3 | OW-4 | OW-5 | SVE-1 | OW-2                              | OW-3 | OW-4 | OW-5 | SVE-1 |
| 0             | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 15            | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 30            | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 45            | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 60            | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 75            | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 90            | 2.90                     | 3.46 | 4.29 | 4.37 | 4.38  | VB                                | NB   | NB   | NB   | NB    |

- NOTES: (1) Columns are arranged as they physically appear in the field and are spaced approximately 5 feet apart.  
 (2) NB = No bubbles observed/FB = Few bubbles observed/B = Consistent bubbles observed/VB = Very many bubbles observed.  
 (3) TOC = depth of water to top of casing.  
 (4) ACFM = Actual cubic feet per minute.  
 (5) PSI = Pounds per square inch.  
 (6) in. of wc = inches of water column.

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Table 2 (Cont'd)  
Air Sparging Pilot Test  
Amoco - S. Sprint, Texas

| Time<br>(Min) | Flow<br>(ACFM) | Pressure<br>(PSI) | Pressure (in. of wc) |      |      |      |       |
|---------------|----------------|-------------------|----------------------|------|------|------|-------|
|               |                |                   | OW-2                 | OW-3 | OW-4 | OW-5 | SVE-1 |
| 0             | 0              | 0                 | ---                  | ---  | ---  | ---  | ---   |
| 15            | 5              | 9.2               | 6.80                 | 0.02 | 0.00 | 0.01 | 0.00  |
| 30            | 5              | 9.0               | 8.80                 | 0.10 | 0.00 | 0.01 | 0.00  |
| 45            | 5              | 9.0               | 9.20                 | 0.16 | 0.00 | 0.01 | 0.00  |
| 60            | 5              | 9.0               | 9.20                 | 0.14 | 0.00 | 0.01 | 0.00  |
| 75            | 5              | 9.0               | 8.80                 | 0.39 | 0.00 | 0.01 | 0.00  |
| 90            | 5              | 9.0               | 8.50                 | 1.20 | 0.00 | 0.01 | 0.00  |

| Time<br>(Min) | Water Level (TOC) (feet) |      |      |      |       | Visual Observation of Sparged Air |      |      |      |       |
|---------------|--------------------------|------|------|------|-------|-----------------------------------|------|------|------|-------|
|               | OW-2                     | OW-3 | OW-4 | OW-5 | SVE-1 | OW-2                              | OW-3 | OW-4 | OW-5 | SVE-1 |
| 0             | 2.90                     | 3.46 | 4.29 | 4.37 | 4.38  | ---                               | ---  | ---  | ---  | ---   |
| 15            | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 30            | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 45            | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 60            | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 75            | ---                      | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 90            | 2.61                     | 2.96 | 4.07 | 4.24 | 4.24  | VB                                | SB   | FB   | NB   | NB    |

- NOTES: (1) Columns are arranged as they physically appear in the field and are spaced approximately 5 feet apart.  
(2) NB = No bubbles observed/FB = Few bubbles observed/B = Consistent bubbles observed/VB = Very many bubbles observed.  
(3) TOC = depth of water to top of casing.  
(4) ACFM = Actual cubic feet per minute.  
(5) PSI = Pounds per square inch.  
(6) in. of wc = inches of water column.

excessive bubbling may increase the risk of a less controlled system over an extended period of time.

The system was started at approximately 8:45 p.m. on February 28, 1994. After two hours of operation at the 3 ACFM flow rate, vigorous bubbling was observed in OW-2 and OW-3 at a distance of 10 and 20 feet respectively. Visual observations were made during the testing period since volatile organics are physically stripped from the groundwater by air bubbles. The DO meter was malfunctioning for the first 12 hours, probably due to the low ambient temperatures. The DO meter was functioning properly the next morning and DO readings were recorded throughout the remainder of the test (Table 3).

After approximately four and one-half hours the SVE system began to pump groundwater and the SVE portion of the extended pilot study was terminated.

The air sparging system continued at 3 ACFM at a pressure of 8 psi until 9:00 a.m. on March 1. The water levels had risen initially due to the water displacement by the injected air. These water levels had returned to near static conditions by 9:00 a.m. (Table 3). The decision was made to increase the flow rate to determine if a higher flow rate may be the optimal for the air sparging system. The flow rate was increased to 4 ACFM and remained constant throughout the remainder of the test. By the end of the testing period the water levels had returned to static conditions at the 4 ACFM flow rate.

### **Groundwater Analysis**

Samples were collected with PVC bailers placed directly into the appropriate VOA container. Each sample was submitted to GEO Environmental's on-site laboratory for immediate analysis of BTEX components, using EPA Method 8020. Selected duplicate samples were sent off site to Core Labs in Corpus Christi and to Amoco's analytical lab in Oklahoma for confirmation.

The GEO laboratory conducted QA/QC duplicate samples and field blank samples on a regular basis. Field blanks were also ran through the instrumentation after samples containing significant BTEX concentrations to prevent any cross contamination within the instrumentation.

The groundwater results presented in Table 4 are from the Amoco lab. Groundwater samples from observation wells OW-2, OW-3, OW-4, and OW-5 show a moderate decrease in concentrations during the testing period. One sample was also collected from each observation well approximately 24 hours after pilot test had been completed.

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**Table 3**  
**Extended 36-Hour Pilot Study**  
**Soil Vapor Extraction/Air Sparging**  
**Amoco - S. Sprint, Texas**

Date: 2-28-1994

| Elapsed Time (hrs) | Time  | Flow Rate ACFM |      | Pressure |      | Vacuum / Pressure (in. of wc) |      |      |      |       |
|--------------------|-------|----------------|------|----------|------|-------------------------------|------|------|------|-------|
|                    |       |                |      | IN.      | PSI  | OW-2                          | OW-3 | OW-4 | OW-5 | SVE-1 |
|                    |       | SVE-1          | WP-1 | SVE-1    | WP-1 |                               |      |      |      |       |
| 0                  | 20:45 | ---            | ---  | ---      | ---  | ---                           | ---  | ---  | ---  | ---   |
| 1                  | 21:45 | 5.0            | 3.0  | 19.0     | 8.0  | 1.80                          | 0.50 | 0.00 | 0.00 | 0.00  |
| 2                  | 22:45 | 5.0            | 3.0  | 22.0     | 8.0  | 0.80                          | 0.15 | 0.00 | 0.00 | 0.00  |
| 3                  | 23:45 | 5.0            | 3.0  | 22.0     | 8.0  | 0.75                          | 0.07 | 0.00 | 0.00 | 0.00  |
| 4 *                | 00:45 | ---            | 3.0  | ---      | 8.2  | 0.75                          | 0.07 | 0.01 | 0.00 | 0.00  |
| 6                  | 02:45 | ---            | 3.0  | ---      | 8.2  | 0.65                          | 0.06 | 0.01 | 0.00 | 0.00  |
| 8                  | 04:45 | ---            | 3.0  | ---      | 8.2  | 0.65                          | 0.05 | 0.00 | 0.00 | 0.00  |
| 10                 | 06:45 | ---            | 3.0  | ---      | 8.2  | 0.65                          | 0.05 | 0.00 | 0.00 | 0.00  |
| 12                 | 08:45 | ---            | 3.0  | ---      | 8.2  | 0.60                          | 0.05 | 0.00 | 0.00 | 0.00  |
| 14                 | 10:45 | ---            | 4.0  | ---      | 8.2  | 0.55                          | 0.01 | 0.01 | 0.01 | 0.00  |
| 16                 | 12:45 | ---            | 4.0  | ---      | 8.2  | 0.59                          | 0.07 | 0.02 | 0.03 | 0.00  |
| 18                 | 14:45 | ---            | 4.0  | ---      | 8.2  | 0.74                          | 0.07 | 0.02 | 0.04 | 0.05  |
| 20                 | 16:45 | ---            | 4.0  | ---      | 8.2  | 0.79                          | 0.07 | 0.02 | 0.04 | 0.08  |
| 22                 | 18:45 | ---            | 4.0  | ---      | 8.2  | 0.79                          | 0.07 | 0.02 | 0.04 | 0.05  |
| 24                 | 20:45 | ---            | 4.0  | ---      | 8.2  | 0.79                          | 0.07 | 0.01 | 0.01 | 0.02  |
| 28                 | 00:45 | ---            | 4.0  | ---      | 8.2  | 0.72                          | 0.05 | 0.00 | 0.02 | 0.00  |
| 32                 | 04:45 | ---            | 4.0  | ---      | 8.2  | 0.66                          | 0.04 | 0.00 | 0.01 | 0.00  |
| 36                 | 08:45 | ---            | 4.0  | ---      | 8.2  | 0.62                          | 0.04 | 0.00 | 0.01 | 0.00  |

| Time | Water Level (TOC) (feet) |      |      |      |       | Dissolved Oxygen |      |      |      |       | Visual Observation of Sparged Air |      |      |      |       |
|------|--------------------------|------|------|------|-------|------------------|------|------|------|-------|-----------------------------------|------|------|------|-------|
|      | OW-2                     | OW-3 | OW-4 | OW-5 | SVE-1 | OW-2             | OW-3 | OW-4 | OW-5 | SVE-1 | OW-2                              | OW-3 | OW-4 | OW-5 | SVE-1 |
|      |                          |      |      |      |       |                  |      |      |      |       |                                   |      |      |      |       |
| 0    | 4.36                     | 4.2  | 4.65 | 4.51 | ---   | 0.37             | 0.41 | 0.3  | 0.26 | 0.32  | ---                               | ---  | ---  | ---  | ---   |
| 1    | 3.28                     | 3.32 | 4.12 | 4.24 | 4.24  | ---              | ---  | ---  | ---  | ---   | VB                                | SB   | FB   | NB   | NB    |
| 2    | 3.82                     | 3.77 | 4.24 | 4.27 | 4.27  | ---              | ---  | ---  | ---  | ---   | VB                                | VB   | FB   | NB   | NB    |
| 3    | 4.05                     | 3.88 | 4.33 | 4.28 | 4.29  | ---              | ---  | ---  | ---  | ---   | VB                                | VB   | NB   | NB   | NB    |
| 4    | 4.08                     | 3.92 | 4.35 | 4.29 | 4.31  | ---              | ---  | ---  | ---  | ---   | VB                                | NB   | NB   | NB   | NB    |
| 6    | 4.16                     | 4.03 | 4.45 | 4.32 | 4.37  | ---              | ---  | ---  | ---  | ---   | VB                                | VB   | NB   | NB   | NB    |
| 8    | 4.18                     | 4.07 | 4.51 | 4.36 | 4.42  | ---              | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 10   | 4.2                      | 4.09 | 4.55 | 4.39 | 4.49  | ---              | ---  | ---  | ---  | ---   | ---                               | ---  | ---  | ---  | ---   |
| 12   | 4.24                     | 4.11 | 4.59 | 4.41 | 4.46  | 7.55             | 4.38 | 0.25 | 0.26 | 0.41  | VB                                | VB   | NB   | NB   | NB    |
| 14   | 3.72                     | 3.84 | 4.42 | 4.37 | 4.40  | 8.44             | 4.67 | 0.36 | 0.24 | 0.21  | VB                                | VB   | NB   | NB   | NB    |
| 16   | 3.75                     | 3.82 | 4.38 | 4.34 | 4.38  | 8.37             | 5.45 | 0.26 | 0.20 | 0.19  | VB                                | VB   | NB   | NB   | NB    |
| 18   | 3.90                     | 3.94 | 4.42 | 4.35 | 4.38  | 8.22             | 5.74 | 0.21 | 0.19 | 0.17  | VB                                | VB   | NB   | NB   | NB    |
| 20   | 4.14                     | 4.10 | 4.55 | 4.40 | 4.44  | 8.60             | 5.93 | 0.28 | 0.24 | 0.18  | ---                               | ---  | ---  | ---  | ---   |
| 22   | 4.26                     | 4.16 | 4.63 | 4.45 | 4.52  | 8.60             | 6.10 | 0.35 | 0.33 | 0.20  | VB                                | VB   | NB   | NB   | NB    |
| 24   | 4.28                     | 4.19 | 4.65 | 4.47 | 4.55  | 8.76             | 6.15 | 0.31 | 0.24 | 0.29  | VB                                | VB   | NB   | NB   | NB    |
| 28   | 4.28                     | 4.19 | 4.63 | 4.49 | 4.53  | 8.65             | 6.30 | 0.30 | 0.26 | 0.19  | VB                                | VB   | NB   | NB   | NB    |
| 32   | 4.32                     | 4.22 | 4.65 | 4.49 | 4.53  | 8.83             | 6.48 | 0.28 | 0.26 | 0.22  | VB                                | VB   | NB   | NB   | NB    |
| 36   | 4.37                     | 4.27 | 4.69 | 4.52 | 4.58  | 8.81             | 6.62 | 0.35 | 0.28 | 0.25  | VB                                | VB   | NB   | NB   | NB    |

- NOTES: (1) NB = No bubbles observed/FB = Few bubbles observed/B = Consistent bubbles observed/VB = Very many bubbles observed.  
 (2) ACFM = Actual cubic feet per minute.  
 (3) in. of wc = inches of water column.  
 (4) ppm = Parts per million.  
 (5) TOC = Top of casing (depth to water).  
 (6) psi = Pounds per square inch.  
 (7) \* - At 12:15 a.m. (2/29), the vapor extraction system began pumping water and was shut down.

**Table 4**  
**BTEX Groundwater Laboratory Results**  
**Amoco - S. Sprint, Texas**

| Sample I.D. Number | Elapsed Time (Approx.) (Hours) | Date    | Benzene | Toluene | Ethylbenzene | Xylenes | Total BTEX |
|--------------------|--------------------------------|---------|---------|---------|--------------|---------|------------|
| OW-1-28            | 0                              | 2/28/94 | ND      | 0.002   | ND           | ND      | 0.002      |
| OW-1-1-8           | 21                             | 3/1/94  | ND      | 0.002   | ND           | ND      | 0.002      |
| OW-1-5             | 30                             | 3/1/94  | ND      | 0.002   | ND           | ND      | 0.002      |
| OW-1-2             | 46                             | 3/2/94  | ND      | 0.001   | ND           | ND      | 0.001      |
| OW-1-3             | 70                             | 3/3/94  | ND      | 0.003   | ND           | ND      | 0.003      |
| OW-2-28-10         | 0                              | 2/28/94 | 0.034   | 0.016   | 0.127        | 0.497   | 0.674      |
| OW-2-28-8          | 10                             | 2/28/94 | 0.031   | 0.008   | 0.076        | 0.294   | 0.409      |
| OW-2-28-11         | 13                             | 2/28/94 | 0.037   | 0.043   | 0.295        | 1.42    | 1.8        |
| OW-2-1             | 31                             | 3/1/94  | 0.024   | 0.002   | 0.033        | 0.165   | 0.224      |
| OW-2-2             | 38                             | 3/2/94  | 0.02    | 0.006   | 0.033        | 0.242   | 0.301      |
| OW-2-3             | 59                             | 3/3/94  | 0.013   | 0.008   | 0.024        | 0.209   | 0.254      |
| OW-3-28            | 0                              | 2/28/94 | 0.088   | 0.009   | 0.133        | 0.278   | 0.508      |
| OW-3-1             | 18                             | 3/1/94  | 0.023   | 0.011   | 0.047        | 0.246   | 0.327      |
| OW-3-2             | 34                             | 3/2/94  | 0.018   | 0.012   | 0.048        | 0.204   | 0.282      |
| OW-3-3             | 58                             | 3/3/94  | 0.028   | 0.014   | 0.066        | 0.27    | 0.378      |
| OW-4-28            | 0                              | 2/28/94 | 0.039   | 0.005   | 0.083        | 0.359   | 0.486      |
| OW-4-1             | 18                             | 3/1/94  | 0.037   | 0.003   | 0.058        | 0.24    | 0.338      |
| OW-4-2             | 38                             | 3/2/94  | 0.026   | 0.013   | 0.082        | 0.382   | 0.503      |
| OW-4-3             | 58                             | 3/3/94  | 0.024   | 0.011   | 0.075        | 0.359   | 0.469      |
| OW-5-28            | 0                              | 2/28/94 | 0.177   | 0.007   | 0.067        | 0.211   | 0.462      |
| OW-5-1             | 18                             | 3/1/94  | 0.141   | 0.019   | 0.099        | 0.361   | 0.62       |
| OW-5-2             | 38                             | 3/2/94  | 0.105   | 0.004   | 0.039        | 0.182   | 0.33       |
| OW-5-3             | 58                             | 3/3/94  | 0.05    | 0.019   | 0.072        | 0.356   | 0.497      |
| OW-6               | 0                              | 2/28/94 | 0.514   | 0.007   | 0.32         | 0.409   | 1.25       |
| OW-12-28           | 0                              | 2/28/94 | ND      | 0.001   | ND           | ND      | 0.001      |
| OW-12-1            | 22                             | 3/1/94  | ND      | 0.001   | ND           | ND      | 0.001      |
| OW-12-2            | 47                             | 3/2/94  | ND      | 0.001   | ND           | ND      | 0.001      |
| OW-12-3            | 71                             | 3/3/94  | ND      | 0.001   | ND           | ND      | 0.001      |
| OW-13              | 0                              | 3/3/94  | 0.002   | 0.003   | 0.015        | 0.111   | 0.131      |
| OW-14              | 0                              | 3/2/94  | 0.001   | ND      | ND           | ND      | 0.001      |
| Trip Blank         | NA                             | 3/2/94  | ND      | ND      | ND           | ND      | ND         |
| Equipment Blank    | NA                             | 3/2/94  | ND      | ND      | ND           | ND      | ND         |
| Equipment Blank 2  | NA                             | 3/3/94  | ND      | 0.001   | ND           | ND      | 0.001      |
| FL-1               | NA                             | ?       | ND      | 0.001   | ND           | ND      | 0.001      |

Notes:

- (1) ND indicates that the compound was not detected.  
(2) NA = Not applicable.

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Decontamination procedures consisted of scrubbing with a stiff brush and non-phosphate solution any bailers and equipment coming in contact with the monitor wells. The equipment was then triple rinsed with distilled water to prevent any potential cross-contamination.

Disposable surgical gloves were worn at all times during the sampling and decontamination procedures. Disposable nylon cord was used during the bailing and was discarded between samples.

### **Slug Tests**

Slug tests were performed at well RW-3. The test was performed by quickly lowering a PVC "slug" into the eight-inch well and recording the change in water levels as they returned to static conditions. A similar test was then conducted by removing the slug and again recording the change in water levels. The data was recorded by a Hermit data logger and later transferred to a floppy disk.

The recovery data was analyzed using a commercially available software package. This software package plots the data points and calculates hydraulic conductivity (permeability) in feet per minute (ft/min). The plots and results are presented in Appendix A.

The slug-in and slug-out results for RW-3 are 0.004595 and 0.004993 ft/min, respectively. These values correspond to the more commonly used units of 0.00234 and 0.00254 centimeters per second (cm/sec), respectively. The slug-in and slug-out data correlate very well, and suggest the data collected is representative of aquifer conditions surrounding the well. One reason for this may be attributed to the natural sandpack surrounding the well screen.

### **Conclusions and Recommendations**

Based on a review of data developed or obtained in this pilot tests, the following conclusions may be made:

- The stratigraphy comprises very fine-grained sands with lenses of fine- to medium-grained sands and shell material (storm deposits);
- The geology and groundwater encountered is consistent throughout the site except for areas which may contain silts in historic pit areas. The groundwater is fresh water, continuous, and apparently not tidally influenced;

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- The optimum air sparge flow rate is 4 ACFM or higher, additional tests can be conducted during the installation of a full scale system;
- The optimum SVE flow rate is 5 ACFM or less. Changes to the well screen and flow rate may create an effective vapor extraction system. Additional testing can be performed during the installation of a full scale system;
- Groundwater mounding is an initial reaction to injection of air and over a period several hours the groundwater water levels return to original static conditions;
- The DO readings are significantly increased in OW-2 and OW-3 and were confirmed by visual observations;
- A conservative radius of influence for the air sparging system would be 20 feet. This twenty feet is representative of observed air bubbles. Physical air bubbles are required to strip volatile organics: Dissolved oxygen will increase bioactivity but will not remove volatile organics by physical stripping. The sparge depth may be increased and/or a properly placed vapor extraction pattern may extend the radius of influence to 30 feet;
- SVE radius of influence is limited by the shallow groundwater. Additional testing will be required to effectively capture the air sparge off-gases. Alternatively, the air sparge flow rate could be reduced to a level that natural biodegradation can reduce emissions prior to venting to atmosphere;
- Analytical results show that a moderate reduction in BTEX has begun during the short duration of this pilot study for observation wells OW-2, OW-3, OW-4, and OW-5;
- Analytical results show that no increase in BTEX concentrations has occurred at the perimeter wells, suggesting the air sparging is not significantly mobilizing dissolved BTEX;
- Hydraulic conductivity calculated from slug tests averaged approximately 0.00244 cm/sec, consistent with sandy soils.

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The pilot study has shown that the air sparging will be effective in removing volatile organics from the first water-bearing zone. However, a full-scale installation should be installed only in areas of the facility in which the free-phase hydrocarbons have been removed.

ENTRIX recommends that additional testing be completed to remove the free-phase product detected in monitor wells around the site. This may consist of a series of temporary wells allowing the free-phase product to be skimmed from the wells.

Pilot tests should be conducted for a shallow free-phase recovery trenching system. These trenches can be easily constructed to a depth of three to four feet and allowed to accumulate groundwater which can be easily skimmed. Tests should also be conducted with inexpensive pervious geo-fabric as a wall-lining material. These liners may stabilize the sloping sandy walls and allow liquids to accumulate in the trench.

ENTRIX appreciates the opportunity to provide Amoco with this report documenting the results of the SVE/air sparging pilot tests. Please call me at (713) 662-1930 if you have any questions or require additional information.

Sincerely,



Craig A. Dockter  
Project Geologist

CAD/mhb

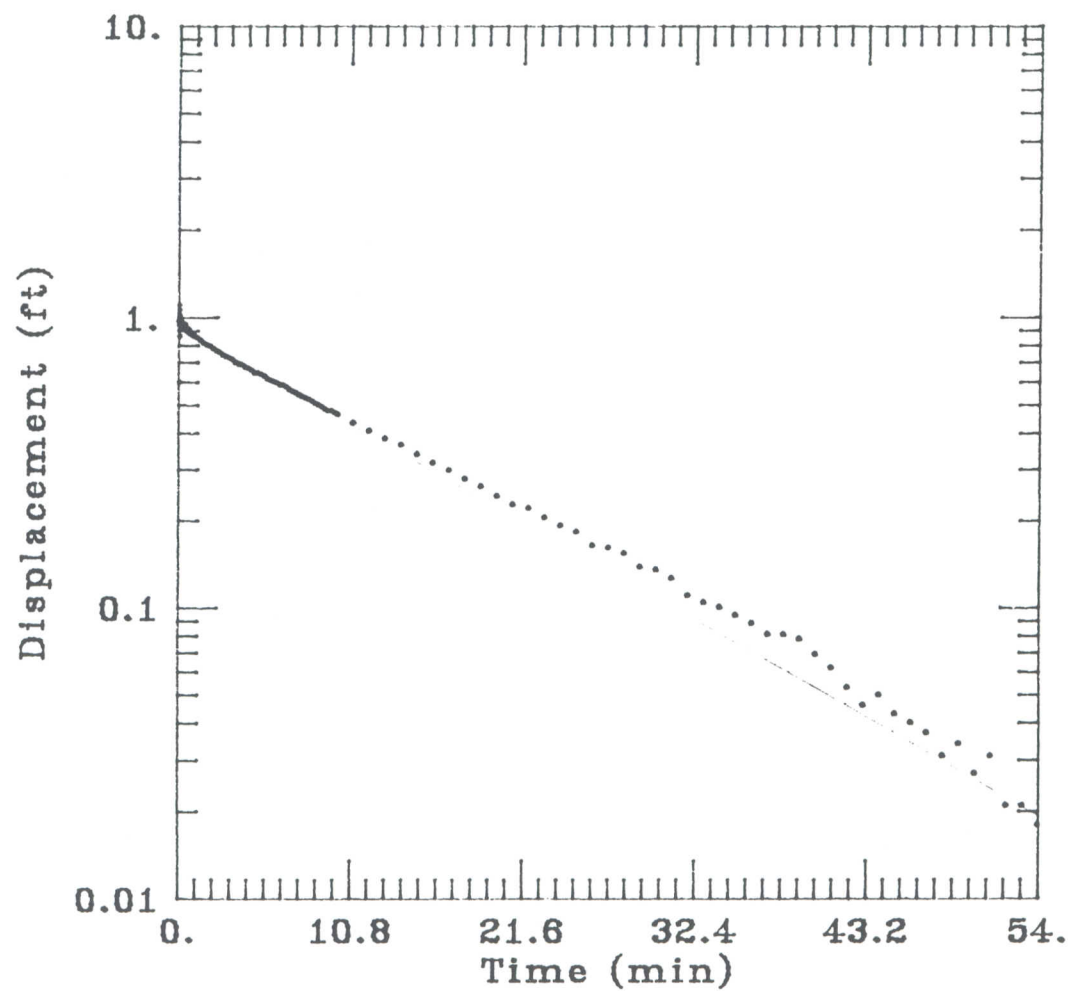
cc: Todd Williams, ENTRIX  
Mike Greenwood, Amoco

Enclosures

APPENDIX A

Slug Test Results

# sprint-1



## DATA SET:

sprint1.dat

03/02/94

## AQUIFER TYPE:

Unconfined

## SOLUTION METHOD:

Bower-Rice

## ESTIMATED PARAMETERS:

$K = 0.004595$  ft/min

$y_0 = 0.9449$  ft

## TEST DATA:

$H_0 = 1.1$  ft

$r_c = 0.667$  ft

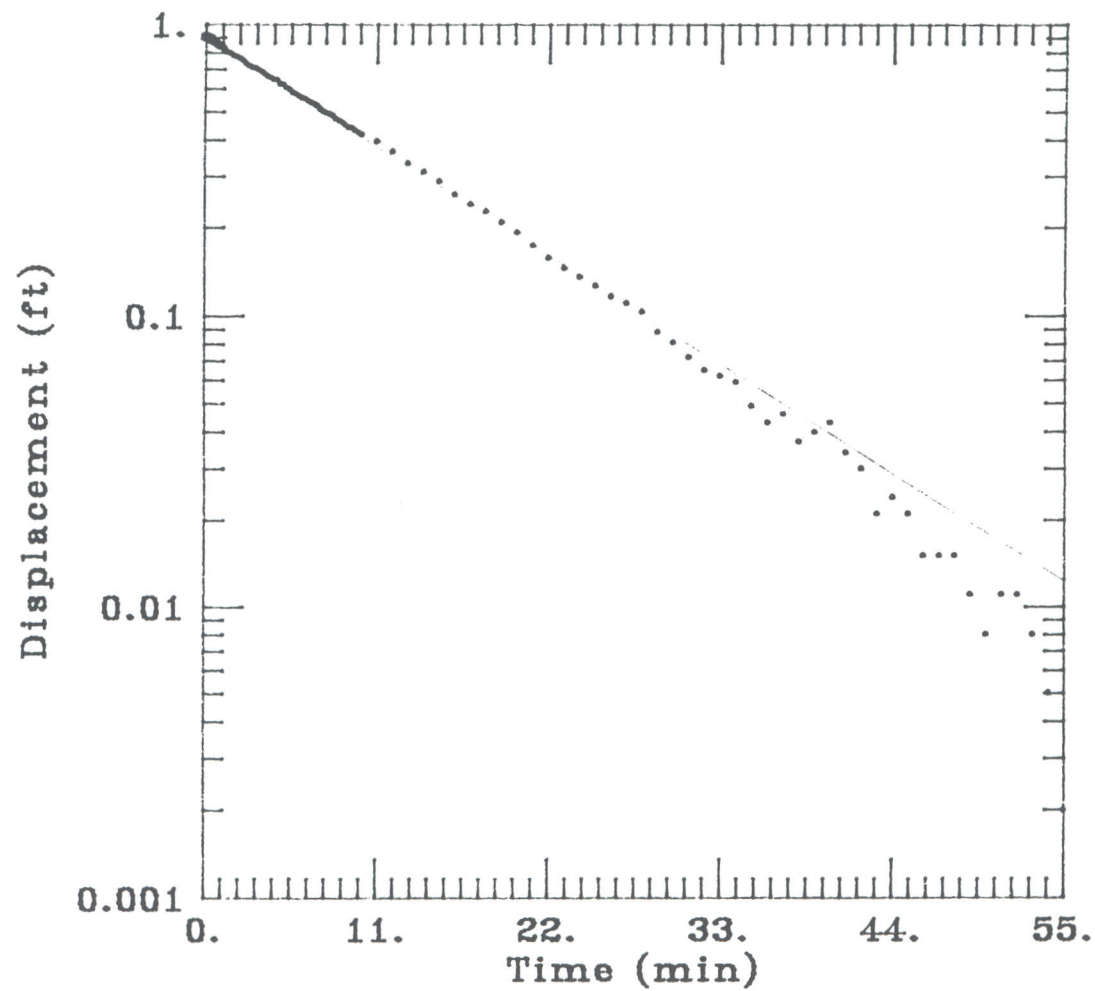
$r_w = 0.667$  ft

$L = 5$  ft

$b = 5$  ft

$H = 5$  ft

## sprint-2



### DATA SET:

sprint2.dat

03/02/94

### AQUIFER TYPE:

Unconfined

### SOLUTION METHOD:

Bouwer-Rice

### ESTIMATED PARAMETERS:

$K = 0.004993$  ft/min

$y_0 = 0.9023$  ft

### TEST DATA:

$H_0 = 1.$  ft

$r_c = 0.667$  ft

$r_w = 0.667$  ft

$L = 5.$  ft

$b = 5.$  ft

$H = 5.$  ft