# Report of Groundwater Sampling

**Former ATL Site No. 42**
**2757 Hopewood Road**
**Asheboro, Randolph County, North Carolina**

*Prepared for*

**North Carolina Department of Transportation**
**Raleigh, North Carolina**

*Prepared by*

**Duncklee & Dunham, P.C.**
**Cary, North Carolina**

**October 5, 2016**

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October 5, 2016

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Reference: **Report of Groundwater Sampling**
**Former ATL Site No. 42 (34613.3.15)**
**2757 Hopewood Road**
**Asheboro, Randolph County, North Carolina**

Dear Mr. Niver:

Duncklee & Dunham, P.C. (Duncklee & Dunham) is pleased to submit this *Report of Groundwater Sampling* for the former asphalt testing laboratory (ATL) Site 42, located at the Martin Marietta Quarry approximately four miles north of Asheboro, North Carolina. The ATL was located on a portion of the property formerly used by APAC Carolinas, Inc. as an asphalt plant. Duncklee & Dunham completed the groundwater sampling event pursuant to the scope of work authorized by the North Carolina Department of Transportation Roadside Environmental Unit. This report describes the methods used to complete these tasks, the results of these activities, and our findings and recommendations.

Duncklee & Dunham appreciates the opportunity to complete this assignment for NCDOT. Please contact us at 919-858-9898 or at ernie@dunckleedunham.com if you have any questions or comments.

Sincerely,

**Duncklee & Dunham, P.C.**

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## List of Acronyms

| | |
|---|---|
| APAC | APAC Carolinas, Inc. |
| AS/SVE | Air sparging/Soil Vapor Extraction |
| ASTM | ASTM International |
| ATL | Asphalt Testing Laboratory |
| CAP | Corrective Action Plan |
| cis-1,2-DCE | cis-1,2-dichloroethene |
| CSA | Comprehensive Site Assessment |
| CT | Carbon Tetrachloride |
| DO | Dissolved Oxygen |
| EC | Electrical Conductivity |
| EPA | United States Environmental Protection Agency |
| ESC | ESC Lab Sciences |
| I-73 | United States Highway I-73/I-74/US 220 |
| J-Value | Estimated lab result below lowest calibration point |
| MMM | Martin Marietta Materials, Inc. |
| MNA | Monitored Natural Attenuation |
| MOA | Memorandum of Agreement |
| NCDENR | North Carolina Department of Environment and Natural Resources |
| NCDEQ | North Carolina Department of Environmental Quality |
| NCDOT | North Carolina Department of Transportation |
| ORP | Oxidation/Reduction Potential |
| PCE | tetrachloroethene |
| QA/QC | quality assurance/quality control |
| SU | standard units, pH |
| TCE | trichloroethene |
| trans-1,2-DCE | trans-1,2-dichloroethene |
| VC | vinyl chloride |
| VOCs | volatile organic compounds |
| 1,1-DCA | 1,1-dichloroethane |
| 1,1-DCE | 1,1-dichloroethene |
| 1,1,1-TCA | 1,1,1-trichloroethane |
| 2L Standard | North Carolina Administrative Code 2L Groundwater Quality Standard |
| µg/L | micrograms per liter |

**Report of Groundwater Sampling**
**Former ATL Site 42**
**Asheboro, Randolph County, North Carolina**
**October 5, 2016**

# 1 Introduction

Duncklee & Dunham, P.C. (Duncklee & Dunham) completed a groundwater-sampling event pursuant to the scope of work authorized by NCDOT, in accordance with our *Scope of Work and Cost Proposal* dated April 27, 2016. The scope of work included the sampling of 15 monitoring wells and 10 off-site potable water-supply wells. Attempts to sample three additional potable wells and a surface-water sampling point were unsuccessful due to a lack of available water or access. Monitoring well 42MW-3 has been damaged by site activities since the last sampling event and could not be sampled. This report includes a summary of the work completed, a description of the methods used, and the analytical and other results obtained during our activities.

## *1.1 Site Description*

The site is located within the Martin Marietta Materials (MMM) rock quarry property located off Hopewood Road approximately 4 miles north of Asheboro, Randolph County, North Carolina (Figure 1). United States (US) Interstate/Highway I-73/US 220 (I-73) is immediately west of the site, beyond which is largely wooded, vacant land (Figure 2). A few residences are located in subdivisions off Spero Road to the southwest of the site. The MMM quarry pit is immediately east of the former asphalt plant site. The remaining area to the east of I-73 is a lightly developed industrial area with a few scattered residences. An Energizer Battery facility is located northeast of the quarry pit at 419 Art Bryan Drive. A TCE and 1,1,1-TCA groundwater plume, also containing PCE originates at the Energizer facility, extending to the south and to the west toward the MMM quarry. The former ATL site with development west of I-73 is shown on Figure 3.

## *1.2 Regulatory Status*

The former ATL was operated by APAC Carolina, Inc., designated APAC No. 6, as an active asphalt production plant from at least 1971 until about 2003. An on-site asphalt testing laboratory (ATL) was associated with this operation and was used for the quantitative extraction of bitumen from bituminous asphalt-paving mixtures, in accordance with ASTM D-2172. Chlorinated solvents were used in this procedure to extract the bitumen. The chlorinated solvents used in this process were carbon tetrachloride (CT), trichloroethene (TCE), and 1,1,1-trichloroethane (1,1,1-TCA). Few records are available about the use and frequency of use of these chlorinated solvents at the ATL. NCDOT personnel periodically used this laboratory. However, the site has never been owned or controlled by NCDOT and is currently owned by MMM.

A memorandum of agreement (MOA) was signed by NCDOT and NCDENR (now NCDEQ) that addressed the assessment and remediation of former ATL sites. In accordance with this MOA, the target compounds for these sites include the compounds associated with asphalt testing at the lab and their associated degradation products.

The primary target compounds are CT, TCE, and 1,1,1-TCA. For purposes of this report, the "target compounds" consist of the primary target compounds and the secondary degradation products of these compounds. Non-target compounds are those VOCs included as analytes under USEPA Method 8260 and, if present, may be associated with non-ATL releases. The primary target compounds and their degradation products are:

| NCDOT Target Compounds<br>Former ATL Site 42<br>Asheboro, North Carolina | | | |
|---|---|---|---|
| **Primary Compounds** | **TCE** | **CT** | **1,1,1-TCA** |
| **Degradation Products** | cis-1,2-DCE | chloroform | 1,1-DCA |
| | trans-1,2-DCE | methylene chloride | chloroethane |
| | 1,1-DCE | methyl chloride | |
| | vinyl chloride | | |

### *1.3 Site Investigation and Remedial Action History*

The primary documents related to environmental activities at the site are summarized in the table below. This table includes the type of document, author, year of the submittal, and a brief summary of the findings of the document.

| Summary of Historical Site Investigation and Remedial Action Activities<br>Former ATL Site 42<br>Asheboro, North Carolina | | | |
|---|---|---|---|
| **Document** | **Author** | **Date** | **Summary** |
| Initial Site Assessment | NCDOT | 1989 | This preliminary survey included a limited soil vapor survey around the ATL building and collection of a water sample from the on-site water-supply well (42PW-1). Results from this survey identified target compounds in the potable well water. |
| Comprehensive Site Assessment (CSA) | Geraghty & Miller | 1997 | The CSA included an evaluation of soil and groundwater contamination, as well as site hydrology. The scope included a soil vapor survey, soil sampling around the building, groundwater sampling of the shallow and deep aquifer, and slug testing. Type II monitor wells (42MW-1 through 42MW-6) and a Type III monitor well (42DW-1) were constructed. |
| Corrective Action Plan (CAP) | Arcadis | 2000 | Two additional monitor wells (42MW-7 and 42DW-2) were constructed as part of the CAP development. The CAP recommended using MNA to address the groundwater contamination, abandonment of the on-site supply well (42PW-1), and connection of nearby residences to the public water system. Groundwater from on-site replacement potable well 42PW-2 was initially not contaminated but in 2003 was found to be contaminated, and the well was subsequently abandoned. |

**Summary of Historical Site Investigation and Remedial Action Activities**
**Former ATL Site 42**
**Asheboro, North Carolina**

| Document | Author | Date | Summary |
|---|---|---|---|
| CSA Addendum | Arcadis | 2004 | Sampling of potable wells within a 0.5-mile radius of ATL Site 42 and additional assessment on-site and to the west of the property were completed, including the construction of additional monitoring wells. The CSA Addendum concluded that no off-site surface water or potable wells were impacted. |
| CAP Addendum | Arcadis | 2007 | The CAP Addendum was conducted to evaluate the historical trends, resulting in recommendations for in situ chemical oxidation (sodium permanganate) to treat the source area for the plume in groundwater. The CAP Addendum has not yet been approved by NCDENR. |
| Groundwater Monitoring Reports | Arcadis/ AECOM | 2008-2012 | Groundwater monitoring reports were submitted semi-annually to annually in accordance with the recommendations in the CAP to verify the monitored natural attenuation (MNA) remedy. Analysis of TCE data indicated that the source-area concentrations were generally unchanged but the plume extent and down-gradient concentrations were increasing. |
| Energizer Evaluation in Semi Annual GW Monitoring Report | AECOM | 2013 | A file review of the Energizer Battery Facility (formerly Eveready Battery) adjacent to the ATL Site 42 was completed in 2013. The Phase I/II Reports (2012) identified TCE and 1,1,1-TCA and associated degradation products. The review showed that the VOC/1,4-dioxane plume from the Energizer site had not been delineated, and a portion of that plume extended onto the MMM quarry and may be influenced by the dewatering of the quarry. |
| Groundwater Monitoring Reports | Duncklee & Dunham, P.C. | 2014-2015 | Annual sampling of the monitoring well network shows that limited natural degradation is occurring, as evidenced by the presence of TCE and 1,1,1-TCA degradation products. The VOC plume has continued to slowly migrated to the west, toward I-73. There was no evidence of impact to the off-site residential potable wells sampled. |

## 1.4 Summary of Recent Findings

The most-recent findings from the historical groundwater monitoring reports and previously submitted site information are summarized as follows:

- Groundwater in both the shallow and deep portions of the water-table aquifer flows from the site generally to the west toward I-73. Vertical gradients in the plume area are downward from the saprolite into the bedrock. Upward gradients are observed in some areas near the plume perimeter.

- The laboratory detected three ATL target compounds – TCE, 1,1-DCE, and 1,1-DCA – at concentrations that exceeded the respective 2L Standards, and one additional non-target VOC - PCE - at concentrations that exceeded the respective 2L Standards.

- PCE is a non-target VOC since it was not used for asphalt testing. It is noted that TCE is one of the degradation products of PCE. Degradation of PCE may be contributing to the detected concentrations of TCE and its degradation products.

- VOC concentrations have increased in samples from several of the on-site and down-gradient monitor wells during recent monitoring events.

- Geochemical conditions of groundwater are not conducive to reductive dechlorination within the saprolitic shallow surficial aquifer and are marginal in the bedrock zone. However, the presence of 1,1-DCE and 1,1-DCA suggests that limited degradation of TCE is occurring.

- The VOC plume has been defined horizontally but has not been defined vertically.

- The TCE and 1,1,1-TCA plume at the Energizer Battery Manufacturing facility is currently under remediation under the voluntary remedial action program, using AS/SVE.

## 2 Water Sampling

In 2016, Duncklee & Dunham sampled 15 groundwater monitor wells and 10 off-site potable wells. The purpose of this sampling event was to evaluate the extent and migration of the target-compound plume and to assess the progress of MNA. The locations of the monitoring wells are shown on Figure 2 and the locations of the potable wells are shown on Figure 3. The properties where potable wells were sampled are listed on Figure 3 and also on Table 1. Duncklee & Dunham collected groundwater samples in accordance with our standard operating procedures, which are based on EPA Region IV Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual and on NCDEQ guidelines.

### *2.1 Groundwater Sampling Procedures*

On July 19 through 22, 2016, Duncklee & Dunham collected groundwater samples from the 15 monitor wells. Nine of these wells, designated as shallow wells, are screened in saprolite and weathered rock at about 30 to 90 feet below ground surface (bgs). The remaining six wells, designated as deep, are screened in the underlying rock at depths of 78 to 201 feet bgs. One of the monitoring wells previously sampled, 42MW-3, was found to have been damaged since the last sampling event and could not be sampled. The well construction details are summarized on Table 2.

Prior to collecting groundwater samples from each monitor well, Duncklee & Dunham used an electric water-level meter to measure the depth of the static water level from the top of the casing. The current and recent historical water-table elevations are shown in Table 3. We purged the wells of standing water with submersible and peristaltic pumps using low-flow purging and sampling techniques. During this purging, we measured and recorded the field geochemical parameters of temperature, pH, EC, DO, turbidity, and ORP with a portable YSI meter fitted with a flow-through cell. Duncklee & Dunham purged each well until the groundwater parameters stabilized.

We considered the parameters to be stabilized when the recorded value between three consecutive readings varied by less than or equal to 10 percent. The field notes and data sheets with these field parameters are in Appendix A. The final field parameter readings, measured prior to sample collection, are provided in Table 4. We discharged the purge water generated during the well sampling onto the ground in areas where shallow groundwater exhibits contaminants at concentrations that exceed the 2L standards.

Duncklee & Dunham discharged the groundwater samples from the sampling tubing into laboratory-provided containers, labeled the containers, placed the containers in a cooler with ice, and shipped the cooler under chain of custody to ESC Lab Sciences (ESC), a laboratory certified in North Carolina. Two duplicate samples, an equipment rinse blank and a trip blank were also collected. Table 5 summarizes the analytical results for the target compounds for these samples.

During the sampling event, Duncklee & Dunham attempted to collect a surface-water sample from the location we sampled in 2014. However, this seep was dry and no other available seep locations were found in the immediate area. Therefore, no surface-water sample was collected.

### *2.2 Potable Well Sampling Procedures*

On July 19-22, 2016, Duncklee & Dunham sampled potable-water wells that are located within and just outside of a 0.5-mile radius of ATL Site 42. We identified 13 residences in this area served by potable wells. The residences with potable-water wells are listed on Table 1. The residence at 2539 Lamb Country Road has a hand-dug potable well that is approximately 60 feet deep. The residents reported they use this well water for only washing and bathing, and purchase bottled water for drinking.

Duncklee & Dunham sampled 10 of these 13 potable wells. The two potable wells at 2477 and 2508 Lamb Country Road are at residences with no electrical power at the time of our sampling event and thus could not be sampled. Repeated attempts were made to access the property at 2471 Lamb Country Road but residents were not found at home.

Duncklee & Dunham sampled the private wells from available outside spigots. We allowed the water to run for approximately 15 minutes to provide a fresh sample through the plumbing system. We labeled the containers with the water samples, placed the containers in a cooler with ice, and shipped the cooler to ESC under chain of custody. Duncklee & Dunham collected duplicate samples from the potable wells at 2621 and 2539 Lamb Country Road. The results of testing the potable-well samples are summarized in Table 1.

### *2.3 Laboratory Sample Analysis*

ESC tested the samples for the target compounds according to EPA Method 8260, using Level 2 QA/QC procedures. ECS also tested one trip blank, one equipment blank, and four duplicate samples. Duncklee & Dunham reviewed the results for all samples, and validated the results for compliance with QA/QC procedures. The ESC laboratory report is in Appendix B.

# 3 Results

## *3.1 Hydrogeology Results*

Water elevations recorded during the 2015 sampling event were noted to be approximately 0.5-feet lower than historical norms. These water elevations at the time of the current sampling event had returned to levels consistent with previous measurements. Water levels during the current sampling event were near historical high values. Water elevations have historically fluctuated over a range of about 1 to 2 feet, likely reflecting variations in precipitation rates.

Groundwater flow in both the saprolite and bedrock is to the west toward I-73, reflecting variations in surface elevations and indicative of unconfined groundwater conditions. The horizontal gradient east of I-73 (0.100) is greater than to the west (0.048), corresponding to surface topography. Although water elevations in the wells fluctuate as described above, horizontal gradients remain consistent. Gradients calculated for the 2016 sampling event correspond closely with those calculated for previous sampling events.

Vertical gradients also correspond closely with the previous results. Across most of the site within the area of the plume, there is a downward gradient from the saprolite to the bedrock in the approximate range of 0.01 to 0.13. Upward gradients were observed at well pairs around the perimeter of the plume, at well pairs 42MW-9/42DW-9; 42MW-10/42DW-10; and 42MW-11/42DW-11. These upward gradients are likely associated with the nearby quarry to the east and low, flat topography of the area to the west of I-73.

The details of the vertical- and horizontal-gradient calculations are presented on Table 6.

## *3.2 Groundwater Geochemistry Results*

Duncklee & Dunham used geochemical measurements of samples from the monitor wells to evaluate the potential for degradation of the target compounds in the natural aquifer setting. The readings and measurements collected during the recent sampling events are shown on Table 4. The readings collected from the monitoring well samples were compared to established ranges for each of the parameters that are conducive to natural degradation. We also observed whether these parameters demonstrated substantial changes over time between sampling events. In general, groundwater conditions in the saprolite matrix are not conducive to natural degradation of the target compounds, while conditions in the deeper rock matrix are marginally supportive of degradation.

Measured pH levels in samples from several wells were noted at the 2015 sampling event to be about 0.5 standard units (SU) lower (more acidic) than typical results. Readings taken for this sampling event show that the groundwater pH is more typical of historical measurements. The remaining geochemical conditions are relatively consistent and within historical ranges across the aquifer. The target pH range for optimal degradation is between 5 and 9 SU (EPA, 1998).

The pH levels in samples from the shallow monitor wells ranged from 5.4 to 6.2 SU, with an average pH of 5.7 SU. The pH range for the deep wells was 6.1 to 9.3 SU, averaging 7.4 SU. Based on this average, the pH levels are considered marginal for the shallow portion of the aquifer in saprolite and weathered rock. Groundwater pH conditions in the rock matrix are more supportive of natural degradation of the target compounds.

Chlorinated solvents such as the target compounds typically degrade naturally under anaerobic conditions. Target ranges for dissolved oxygen for optimal degradation are below 0.5 mg/L (EPA, 1998). As shown on Table 4, the DO of groundwater from only one off-site well (42DW-11) met this criterium. DO in samples from two other wells was at the 0.5 mg/L threshold. DO ranged from 1.9 to 6.1 mg/L, averaging 3.6 mg/L in samples from the remaining wells. These DO levels are not indicative of anaerobic conditions and are not supportive of natural degradation, with the exception of well 42DW-11.

ORP results provide an indication of the electron activity in the aquifer. Reductive dechlorination will occur at as much as 50 millivolts (mV), but optimal degradation occurs at levels of -100 mV or lower. Of these measurements collected during this sampling event, only the sample from off-site well 42DW-11 was negative (-231.4 mV). ORP of samples from at the other 14 wells ranged from 13.7 to 205.3 mV, averaging 119.4 mV. Other than at well 42DW-11, these results do not indicate favorable conditions for significant degradation of the target compounds.

In summary, the current geochemical parameters are consistent with the historical values and are generally not conducive to degradation, with the exception of conditions at well 42DW-11. The continued presence of high concentrations of TCE, lower relative concentrations of 1,1-DCE, and only trace concentrations of other secondary compounds support the interpretation that the potential for natural degradation of the target compounds at this site is low.

### *3.3 Groundwater Analytical Results*

Table 5 and Figure 6 summarize the laboratory analytical results. TCE and 1,1-DCE remain the predominant contaminants, and concentrations substantially exceed 2L standards in samples from a number of monitor wells in and just down-gradient of the source area. Exceedances of respective 2L standards were also detected at one or more locations for target compounds CT, 1,1-DCA and VC. Non-target VOC PCE was also detected in samples from three wells in the source area at concentrations that exceed its 2L standard. The concentrations of the VOCs have generally slightly increased across the site since 2015, although the detections remain within historical ranges.

The highest VOC concentrations and the greatest number of 2L exceedances remain in samples from well 42MW-8, located in the source area of the site. The highest concentrations of TCE and 1,1-DCE were detected in the sample from this well. This is also the only well where CT has been detected in the samples collected in three of the last four years. Elevated concentrations of other target compounds were also detected in samples from wells just down-gradient of this location. Monitor wells 42DW-1, 42DW-2, and 42MW-5 are also located in the core area of the plume, and samples exhibited elevated concentrations of TCE and DCE. The samples from down-gradient wells 42MW-6, 42MW-7, 42DW-4 and 42DW-11 exhibited lower concentrations of TCE and DCE, just above or below the respective 2L standards. Samples from monitor wells located up-gradient and side-gradient, 42MW-4, 42MW-9, 42MW-10 and 42DW-10, generally did not exhibit target compounds, with a J-value for chloroform at 42MW-9.

Plume maps of the TCE and 1,1-DCE results are shown on Figures 7, 8, 9, and 10, and in cross section on Figure 12. In general, these results show a slight increase in target compounds and progression of the plumes beneath I-73 since the previous sampling event.

There is little observed degradation of the target compounds from previous results. However, a J-value for VC but at a concentration that exceeds the 2L standard was reported in the sample from at down-gradient well 42DW-11, where geochemical parameters were found to be more favorable for natural degradation of the VOCs, including pH, DO and ORP.

Tetrachloroethene (PCE), a non-target VOC, was detected above the 2L standard in the sample from wells 42MW-1, 42MW-8 and 42DW-1. Several other non-target VOCs, including 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2-dichloroethane, 1,1,2-trichloroethane and toluene were detected in the source area, all below the respective 2L standards. The source of these compounds in the groundwater is unknown because they are not associated with bitumen extractions at the laboratory.

### *3.4 Potable Well Analytical Results*

ESC did not detect target compounds in any of the samples from the off-site potable water supply wells. A J-value result for MTBE was reported for the sample from 2601 Lamb Country Road. MTBE is not associated with any of the target compounds.

### *3.5 Data Quality Parameters*

All samples arrived at the ESC laboratory in proper condition. The custody seals were intact and the chains-of-custody were properly completed. The temperature of the samples on arrival was 3.1º C. The samples were analyzed within proper laboratory hold times.

The QA/QC samples included four sample duplicates, one trip blank and one equipment rinse blank. Two of the duplicate samples were collected from the monitoring wells and two from the potable water wells at the off-site residences. All of the duplicate results were within acceptable agreement in both reported analytes and concentrations. No detections were reported for the trip or equipment blanks.

Surrogate recovery limits were within the established recovery limits with the exception of one surrogate, Toluene-d8 for samples 42MW-8, 42MW-8 duplicate and 42DW-1, where the recovery was below the established range. The J-note states that surrogate recovery limits have been exceeded; values are outside lower control limits. Method blanks and batch quality control results were within established criteria.

Laboratory hold times and other surrogate recoveries were within established limits.

Potential QA/QC issues include the following:

- Recovery of one surrogate compound was below the established range for two record samples and one sample duplicate. Values of recovery are outside the lower control limits for these three samples.

We do not consider that this issue had an impact on the quality of the results.

# 4 Findings and Recommendations

## *4.1 Hydrogeology*

Water elevations across the site fluctuate within a range of 1 to 2 feet as a result of variations in precipitation rates. These changes in water elevations are generally consistent across the site with little effect on groundwater flow rates and gradients.

Groundwater flows from the site to the west toward I-73. Horizontal and vertical gradients are consistent with previous results. The vertical gradients indicate downward vertical groundwater flow from the saprolite into the bedrock in the source and plume core areas.

## *4.2 Target VOCs in Groundwater*

Groundwater samples from the monitoring wells exhibited target compounds CT, TCE, 1,1-DCA, 1,1-DCE, and VC at concentrations that exceeded the respective 2L standards. Non-target compound PCE was also detected at a concentration that exceeded the 2L standard in a sample from the core area of the plume.

The source of the PCE is unknown. It has been noted that there is a TCE and 1,1,1-TCA groundwater plume undergoing remediation at the Energizer Battery Manufacturing facility northwest of the quarry. Elevated levels of PCE have been reported in the northern portion of that plume.

The contaminant plume source area is in the vicinity of 42MW-8. The groundwater sample from this well exhibited the highest concentrations of target compounds and associated degradation products. The core of the plume extends down-gradient from 42MW-8 to the area of wells 42MW-1, 42DW-1 and 42DW-2. TCE at lower concentrations but in exceedance of the 2L standard was also detected in the samples from wells 42MW-6 and 42MW-7 positioned west and at a topographically lower elevation along the edge of I-73. The exceedances of the 2L standard are limited to the source area and immediately down-gradient to the areas beneath I-73. TCE was detected at concentrations about one-half of the 2L standard in the samples from wells 42MW-11 and 42DW-11, which are positioned farther down-gradient along the western edge of I-73.

Trend analysis of the current analytical results compared to historical findings shows a slow progression of the VOCs toward the west and slight increases in the target compounds in samples at individual wells. Groundwater gradients and analytical results from monitor wells around the perimeter of the plume to the north, south and east indicate that the plume is largely delineated horizontally, although there may be some undetected extension of the plume to the northwest. No groundwater data are available in this direction.

Groundwater parameters indicate that groundwater conditions are generally not conducive to effective natural degradation of the target compounds. These findings are consistent with the analytical results of the groundwater samples. Substantial concentrations of first-order degradation products of the primary target compounds 1,1-DCA and 1,1-DCE continue to be detected in the plume area. As previously noted, the concentrations of the primary and first-order degradation products have been detected at steady or slightly increasing concentrations, indicating that little further degradation of these compounds beyond the first order compounds is occurring.

The exception to these findings is at monitor well 42DW-11 where groundwater conditions supportive of natural degradation have been found and where the single occurrence of VC was located.

Analytical results of groundwater samples from the off-site potable wells show no impact to these wells by the target compounds.

### *4.3 Recommendations*

Duncklee & Dunham recommends continued sampling of the site monitor wells and the off-site potable wells on an annual basis. The construction of a well pair on the eastern side of Highway I-73 to the north of the existing well pair 42MW-6/42MW-7 should be considered to more thoroughly evaluate the extent and direction of off-site migration of the plume.

## 5 References

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