Lane Park Commercial Property
Mountain Brook, Alabama
ADEM VCP Site #: 461-9585

Fact Sheet

A Voluntary Cleanup Program (VCP) Cleanup Plan has been found to be technically adequate by the Alabama Department of Environmental Management (ADEM) for the Lane Park Commercial Property site in Mountain Brook, Alabama. This fact sheet has been prepared to briefly advise the public of the principal legal and policy issues of the VCP.

I. VCP PROCESS

The VCP provides a mechanism for the implementation of a cleanup program that encourages applicants to voluntarily assess, remediate, and reuse rural and urban areas of actual or perceived contamination. The program does not relieve any "responsible person" for the liability for administrative, civil, or criminal fines or penalties which are otherwise authorized by law and imposed as a result of the illegal or unpermitted disposal of solid waste, hazardous waste, hazardous constituents, hazardous substances, petroleum products, and/or pollutants to the land, air, or waters of the State on an identified property. The program is designed to expedite the voluntary cleanup process and has been designed for entry at any stage of the cleanup process as long as all applicable criteria have been met up to the point of entry.

II. PROCEDURES FOR REACHING A FINAL DECISION

ADEM is proposing to issue Evson, Inc. a final decision for the site remediation. The Cleanup Plan includes installation of a vapor barrier system and implementation of an environmental covenant with use restrictions.

ADEM Admin Code R. 335-15-6-.02 requires that the public be given a 30-day comment period from the date of the notice. The comment period will begin on February 12, 2020 which is the date of publication of the public notice in major local newspaper(s) of general circulation and will end on March 13, 2020.

All persons wishing to comment on any of the conditions of the VCP Remediation should submit their comments in writing to ADEM, Permits and Services Division, 1400 Coliseum Blvd. (Zip 36110). P.O. Box 301463 (Zip 36130-1463) Montgomery, Alabama, ATTENTION: Mr. Russell Kelly. Written comments on the VCP activities should be submitted to ADEM and be received by 5:00 p.m. on March 13, 2020.

ADEM will consider all written comments received during the comment period while making a final decision on this issue. When ADEM makes its final decision, notice will be given to the applicant and each person who has submitted written comments or requested notice of the final decision.

III. FACILITY DESIGN

Goodwyn, Mills and Cawood, Inc. has completed Site Investigation activities under the VCP at the Lane Park Commercial Property site located at 2700 Culver Road, Mountain Brook, Jefferson County, Alabama. The site was historically used as a shopping center that was constructed on the property in 1952. One of the former tenants in the shopping center, Utopia Cleaners, was a dry-cleaning operation. The site operated as a retail and commercial space until 2018. The shopping center structures have been demolished in preparation for a new development. Due to the presence of elevated levels of chlorinated solvents in the groundwater, a vapor barrier system will be installed in any new construction. Also as part of the remedial strategy an environmental covenant will be placed on the property with restrictions on groundwater use and a prohibition on use of the property for residential purposes on the ground-floor.

IV. TECHNICAL CONTACT

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Redevelopment Section
Industrial Hazardous Waste Branch
Land Division
Alabama Department of Environmental Management
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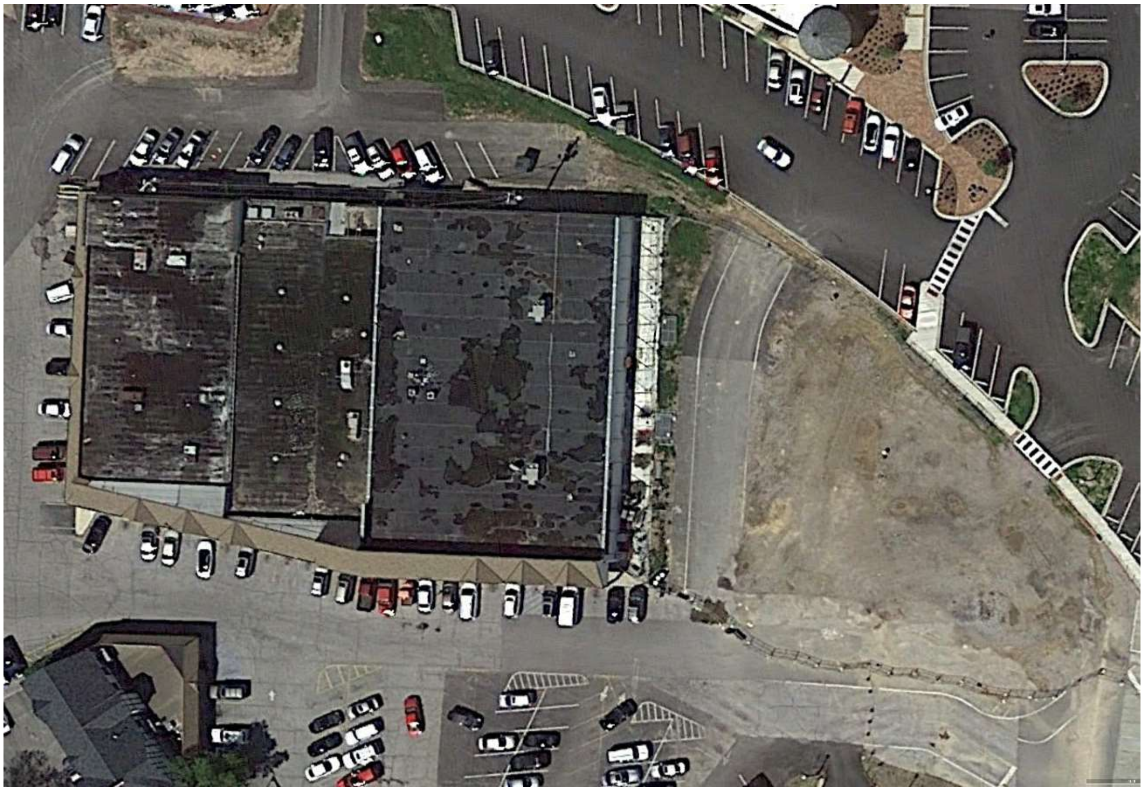
REVISED VOLUNTARY CLEANUP WORK PLAN
ALRERA SITE # 461- 9585
Lane Park Shopping Center - Approximately 5.04 Acres
Mountain Brook, Jefferson County, Alabama



Prepared For:

Mr. John Evans
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Birmingham, AL 5233

Prepared By:

GMC

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Birmingham, Alabama 35233

January 20, 2020

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1.0 INTRODUCTION

Goodwyn, Mills, and Cawood, Inc. (GMC) was retained by Evson, Inc. to prepare this updated Voluntary Cleanup Work Plan (VCWP) to reduce risks associated with contaminant impacts to soil and groundwater due to previous dry-cleaning operations on the subject property. The constituents of concern (COCs) at the subject property include Volatile Organic Compounds (VOCs). GMC previously submitted a VCWP for the subject property in 2010 during the application process. This updated VCWP includes revised recommendations for the mitigation of potential vapor intrusion into the proposed structures associated with the future development. This revised VCWP is intended to supersede the previous VCWP.

1.1 Location and Description

The Lane Park Commercial Property (LPCP) site is approximately 5.04± acres in size and is located at 2700 Culver Road in Mountain Brook, Alabama. This location is east of Lane Park Road and north of the intersection of Culver Road and Montevallo Road (see Figures). The approximate center coordinates of the site are latitude 33-29'12" and longitude 86-46'24". It is located in the Cahaba Watershed (HUC 03150202) in Section 8, Township-18-South, Range-2-West, in Jefferson County, Alabama. The adjoining land use of the 5.04± acre site is mixed commercial and residential in nature. The following is the legal description of the property, excluding the exceptions (easements, dedications, rights of way).

A parcel of land being situated in the Northeast quarter of the Northwest quarter and the Southeast quarter of the Northwest quarter of Section 8 Township 18 South Range 2 West more particularly described as follows:

Begin at the Southwest corner of the Northeast quarter of the Northwest quarter of Section 8 Township 18 South Range 2 West; thence run southerly along the west line of said quarter – quarter a distance of 367.38 feet to the Point of Beginning; thence left 89°-29' -00" a distance of 197.80 feet; thence left 90°-00' -00" a distance of 5.7 feet; thence right 90°-00' -00" a distance of 57.54 feet; thence left 00°-11' -51" a distance of 350.00 feet; thence right 90°-29' -26" a distance of 139.13 feet; thence right 89°-27' -49" a distance of 14.61 feet; thence left 117°-30' -00" a distance of 175.92 feet; thence right 84°-32' -17" a distance of 46.85 feet; thence tangent to a curve to the left having a radius of 1243.26 and a central angle of 9°-20' -05" along the curve of an arc distance of 202.55 feet; thence right 62°-49' -52" from the tangent of said curve a distance of 329.33 feet; thence tangent to a curve to the left having a central angle of 18°-00' -50" and a radius of 66.12 feet an arc distance of 20.79 feet; thence right 52°-16' -55" from the tangent of said curve a distance of 112.24 feet; thence left 90° -00' -00" a distance of 78.01 feet; thence right 91°-05' -28" a distance of 19.49 feet; thence right 33° - 25' -36" a distance of 245.11 feet; thence right 0°-00' -42" a distance of 10.44 feet to the Point of Beginning. Said parcel contains 5.04 acres more or less.

1.2 Site History

The current owner, John Evans, indicated that the property was purchased in the late 1940s by his grandfather, A.A. Evans. The site was undeveloped pasture and forestland at the time of purchase. A shopping center of approximately 5.04 acres was constructed on the property in 1952. Mr. Evans indicated that he and his father, F.A. Evans, took ownership of the property in 1995. One of the former tenants in the shopping center, Utopia Cleaners, was a dry-cleaning operation. According to Mr. Evans, the boiler unit utilized in the dry-cleaning operation was removed prior to commercial occupation of the space. Based on the known presence of the former dry-cleaning operation, GMC was retained in 2010 to conduct a Phase I ESA, Limited Phase II Assessment and a Phase III Investigation. The purpose of these assessments was to define the impacts to soil and groundwater on the site. On November 1, 2010, the Alabama Department of Environmental Management (ADEM) approved the subject property for inclusion into the Voluntary Cleanup Program (VCP) and it was assigned ALRERA Site Number 461-9585. The subject property operated as a shopping center with retail and commercial space until 2018. The shopping center structures have since been demolished in preparation for new development.

2.0 SUMMARY OF PREVIOUS SITE ASSESSMENT AND REMEDIAL ACTIVITIES

The following sections include a brief summary of the assessment and remedial activities that have occurred on the site and the resulting conclusions. A detailed summary of site assessment activities that were completed (following acceptance into the program) can be found in the report submitted to ADEM titled "Site Assessment Summary" dated November 20, 2018.

2.1 Gallet Phase I ESA

GMC reviewed a previous Phase I ESA on the subject property that was conducted in July 1994. The findings and conclusions of the report indicate that there was a former gas station located on an outparcel on the southwest corner of the property. This gas station was reportedly in business for a short period of time and was abandoned prior to ADEM tank closure regulations. Gallet was unable to determine if there were any leaks, spills, or if the tanks have been removed. In addition, another gas station was formerly located on the south side of Culver Road. Gallet concluded that both former gas stations are located down gradient and it appeared that the subject site would not be affected. Based on these findings, Gallet indicated that no further investigation of soils and groundwater was required; therefore, there are no analytical data resulting from this investigation.

2.2 Asbestos Survey

ERG Environmental, Inc. conducted a limited asbestos survey for suspect materials in July 1994. The report notes that prior to renovation or demolition, the U.S. EPA requires that all friable asbestos containing building materials (ACBM) or non-friable ACBM that might become friable, must be removed and disposed of as asbestos waste. Report results indicate that building materials determined to or assumed to contain asbestos were found in the exterior of the shopping center, Western Supermarket, Smith's, Casual Aire, Tom Myers, Little Hardware, Dande Lion, U.S. Post Office, and the Barbershop. The only sample considered to be friable was a 12"x12" Pinhole ceiling tile found in Smith's. The remaining ACBM found during the survey was considered non-friable. ERS concluded that the non-friable ACBM may be left in place, but should be monitored until such time as removal or demolition requires abatement. Furthermore, ERS recommended that prior to demolition or renovation of the ACBM, appropriate notification should be made and a licensed asbestos abatement contractor will be required.

2.3 GMC Phase I ESA/Limited Phase II Assessment

GMC conducted a Phase I ESA and Limited Phase II Assessment of the subject property in March 2010. The assessment revealed that a former dry cleaner operated on the property, constituting a Recognized Environmental Condition (REC). Based on the sampling results of the Limited Phase II Assessment, it was determined that further assessment was needed to define the limits of contaminated soils and groundwater. In addition, GMC recommended that remediation or removal of contaminated soils and/or groundwater for the redevelopment of the property.

2.4 GMC Phase III Investigation

In August 2010, GMC completed a Limited Phase III Investigation on the subject site. This assessment was conducted based on the known presence of a former dry-cleaning operation on site and on the results of the Limited Phase II conducted by GMC in March 2010. The purpose of the Phase III Investigation was to obtain data to further define the impacts to soil and groundwater at the site. A passive soil gas investigation was conducted to identify the location and extent of contaminants on the property in accordance with U.S. EPA Method 8260C (modified). The results of this analysis were utilized to designate the location of four (4) monitoring wells and to aid in the development of a conceptual model of the site's contamination.

GMC drilled a total of five (5) soil borings; one in each location of the proposed monitoring wells, prior to their installation and one beneath the former Lane Park Dy Cleaners (LCDC) building. At least two (2) soil samples, one shallow and one deep, were collected from each of the monitoring well borings and analyzed at a certified lab. COCs detected in the soil samples including tetrachloroethene, trichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride. Each of these five COCs were detected in samples W4-S shallow and deep, as well as the sample taken from beneath the former LPDC building. Four soil sample locations had contaminant concentrations that exceeded the U.S. EPA Regional Screening Levels (RSLs) for residential soil.

Following the installation of the monitoring wells, groundwater samples were collected and analyzed at a certified lab. Tetrachloroethene, trichloroethene, cis-1,2-dichloroethene, trans-1,2-dichlorethene, and vinyl chloride were detected in the groundwater samples taken from MW-3 and MW-4. Tetrachloroethene was also detected in the groundwater sample taken from MW-1. Contaminant concentrations at all three groundwater sample locations exceeded the U.S. EPA Maximum Contaminant Levels (MCLs) for tap water.

The results of this investigation indicated that chlorinated solvents were located in a limited area on the site under the former dry-cleaning operation and at the rear entrance of the former dry-cleaning operation. The results suggested that the application of chemical oxidant could be utilized to force a chemical reaction to degrade the tetrachloroethene into its daughter products. The chemical oxidant would catalyze the natural degradation process and reduce contaminant concentrations through the chemical dichlorination of the chlorinated solvents from the former dry-cleaning operation. Based on the results of this investigation, it was recommended that the site be entered into the ADEM Voluntary Cleanup Program (VCP).

2.5 Remedial Activities – Chemical Oxidant Application and Vapor Extraction

As part of the approved cleanup plan, vapor extraction units were installed on MW-3 and MW-4 in September of 2012 to reduce the potential for any off-gassing of contaminants to the businesses at the site. The vapor extraction units ran continuously from September 2012 to May 2018. The remedial approach for this project included in-situ chemical oxidation utilizing sodium persulfate. A total of four (4) separate groundwater injections of sodium persulfate were conducted in monitoring wells in the areas closest to the former dry cleaner. The injections occurred in February 2013, October 2013, February 2015, and July 2018. The purpose of the groundwater injections was to accelerate and complete the degradation process to reduce the contaminant concentrations of the chlorinated solvents. Soil and groundwater samples were collected prior to the injections to establish baseline conditions at the site and following injections to determine the effectiveness of the chemical injections over a period of time (see Section 2.5 and 2.6).

2.6 Soil Gas and Soil Sampling Activities (2010-2018)

A number of soil sampling activities have occurred at the LPCP following the initial investigation in 2010. These activities include passive gas sampling, soil sampling concurrent with soil excavation activities associated with the installation of a sanitary sewer culvert, soil sampling conducted inside the former shopping center (pre-demolition), and soil sampling conducted in the area of the former dry cleaner (post-demolition).

Passive Gas Analysis - A passive gas soil study was conducted as part of the initial investigation in 2010. The eastern half of the building structure was demolished in late 2016. A second passive soil gas study was conducted in December 2016 to update information on site conditions. The 2016 study included the eastern portion of the site that was not included in the 2010 study and was used in the evaluation of the effectiveness of groundwater injections of sodium persulfate in areas closest to the dry cleaner site of operations. The 2010 study indicated that degradation was occurring evidenced by the elevated presence of the breakdown products dichloroethene and vinyl chloride. The degradation process of chlorinated solvents proceeds from tetrachloroethene, to trichloroethene, to dichloroethene to vinyl chloride. In many instances, degradation stalls with persistent survival of dichloroethylene and vinyl chloride. The 2016 study indicated low levels of dry-cleaning solvents on the eastern portion of the property. In addition, the isopleth maps indicated that degradation products were detectible on the eastern portion of the property. The eastern end of the development had relatively low concentrations when compared to the area of the dry-cleaning establishment. It was concluded that the 2016 study indicated that the plume had not migrated significantly or increased in size. In addition, the 2016 study, in conjunction with groundwater sampling indicated that there had likely been a reduction in plume concentrations on the whole.

Soil Sampling During Construction Activities - Construction activities to replace an existing sanitary sewer line were conducted at LPCP between the months of March and July in 2017. Soil excavation began on March 2nd and, due to contamination from the former dry cleaner, the soil excavation was supervised by GMC representatives to ensure the proper handling of any potentially contaminated soils. Throughout the sewer line installation, excavated soils were either placed in piles atop two layers of plastic or in roll-off boxes approximately 4-5 feet away from the excavated sewer trench. The soil was divided into approximately 20 yd^3 sections and flagged A-V and roll-off boxes 1-7. Roll-off boxes were utilized when the excavated soils were located in areas where detection of tetrachloroethene at contained-in levels were anticipated. Soil samples were collected from all excavation piles and roll-off boxes and tested for VOCs and TCLP VOCs. Data were collected to allow characterization of the soils for comparison to both U.S. EPA Residential and Non-Cancer Screening levels. Samples were collected from soils which came from a range of depths of 1 to 8 feet deep depending on the location. Results from the analyses of stockpiled soils indicated concentrations below detection limits and/or below the U.S. EPA residential and industrial soil RSLs for all VOCs commonly associated with a dry-cleaning operation (tetrachloroethylene, trichloroethylene, dichloroethylene and vinyl chloride). The only detectible constituents were tetrachloroethylene, trichlorethylene, and cis-1,2-dichloroethene. The highest total tetrachloroethylene concentration was 0.224 mg/kg from ROB3. The residential screening level for tetrachloroethylene is 8.1 mg/kg as listed the U.S. EPA November 2018 Screening Table (39mg/kg for industrial soils). All soil piles were sampled for TCLP VOCs and all results were below detection limit (<0.005).

<u>Soil Sampling Under Building Slab</u> - Shallow soil samples were collected from beneath the building slab, and deeper sediment samples were collected from just above the bedrock during exploratory drilling and well installation. These locations were chosen due to the proximity to potential spills and sources of contamination. The objective of soil sampling and analysis was to confirm or refute the presence of VOCs in the soils beneath the former dry-cleaning establishment and down gradient in the direction of groundwater flow. GMC collected seventeen (17) subsurface soil samples from fourteen (14) locations and two (2) deeper sediment samples during the week of March 12, 2018. Samples were analyzed for VOCs using U.S. EPA method 8260B. Various VOCs were present in the shallow and deep soil samples. None of the samples contained concentrations of VOCs that exceed the U.S. EPA RSLs for industrial or residential soil.

<u>Soil Sampling Post Demolition</u> - Shallow soil samples were collected from beneath the former dry cleaner structure following the demolition of the building. Sample locations were chosen based on the proximity to potential spills and sources of contamination. The objective of soil sampling and analysis was to confirm or refute the presence of VOCs. GMC collected four (4) subsurface soil samples from four (4) locations on August 22, 2018. Samples were analyzed for VOCs using U.S. EPA method 8260B. Various VOCs were present in the soil samples, but not at concentrations that exceeded the U.S. EPA RSLs for residential or industrial soil.

Results of the analyses determined that none of the soil samples contained concentrations of chlorinated solvents that exceeded the applicable U.S. EPA RSLs for industrial or residential soil. Considering that the planned development is commercial in nature and based on results of analyses as detailed above, it is our opinion that no further sampling of shallow soils is necessary at this time.

2.7 Groundwater Sampling Activities (2010-2018)

GMC has conducted numerous groundwater monitoring events since 2010. All groundwater samples were collected and analyzed for VOCs (chlorinated solvents). As previously noted, the groundwater samples were collected prior to and after the injection events to determine the effectiveness of remedial actions. GMC conducted a trend analysis based on the results of the groundwater analyses. The results of trend analysis indicate that several constituents of concern were still present at concentrations that exceeded the U.S. EPA Regional Screening Levels or Maximum Contaminant Levels. However, MW-3, MW-6, MW-9, and MW-10 show a decrease in concentrations of COCs. MW-4 was initially the furthest away from the area of the most aggressive injection treatment until July 2018 when multiple injections were performed in MW-4 and into newly drilled wells in the vicinity of MW-4. The October 2018 groundwater sampling shows a significant decrease in concentrations of chlorinated solvents in MW-4. This is an indication that the injection of chemical oxidants into the groundwater have been successful at reducing the concentrations of chlorinated solvents in the groundwater. A more detailed description of the injection process and groundwater sampling results can be found in the report submitted to ADEM titled "Site Assessment Summary" dated November 20, 2018.

3.0 VOLUNTARY CLEANUP WORK PLAN IMPLEMENTATION

With this submittal, GMC seeks ADEM's approval to move forward with the implementation of this Voluntary Cleanup Work Plan. Elements of the Cleanup Plan are summarized in this section. Considering that the facility access road/parking is largely located over the area of concern (Figure 4), it is our opinion that the cleanup actions discussed below, are adequate for the mitigation of potential vapor intrusion into the proposed structures. It is GMCs opinion that no further environmental assessments of the subject property are warranted.

3.1 Site Work Permits and Plans

Site work permits and plans will be obtained by the general contractor prior to construction.

3.2 Vapor Barrier System and Soil Capping

GMC recommends the installation of the Drago Wrap Vapor Intrusion Barrier system on the building located immediately west of the source location identified in Figure 4. Information regarding this vapor barrier product (including testing results and installation guidelines) can be found in Attachment 2 and the product will be installed in accordance with manufacturing specifications. On the remaining buildings, standard vapor barriers will be installed over the compacted earthen building foundation and footings prior to placement of concrete on the foundation and in the footings. GMC recommends a composite thickness of no less than 15-mils for the standard vapor barrier system. GMC representatives will be on-site to oversee the installation of the vapor barrier.

As an added measure of risk mitigation, it is expected that the current site grade will be elevated by the placement of at least two feet of compacted engineered fill prior to building construction. GMC anticipates that the soil excavated on-site will be managed and re-used within the boundaries of the subject property during construction activities. Should soil need to be disposed of off-site, GMC will initiate the required process for characterization of the soils, complete the ADEM notification and approval process, and document the offsite disposal of the soils to a Subtitle D landfill.

3.3 Post-Construction Monitoring

As construction of the development is completed, GMC will conduct two (2) air quality assessments on the completed buildings. One assessment will be conducted in the summer months (June – August) and one will be conducted in the winter months (December – February). Summa canisters will be installed in each of the proposed buildings on site. The cannisters will be placed approximately four to five feet above the ground surface in order to collect representative air samples. Each cannister will be six liters in volume with an eight-hour flow valve. GMC will submit the canisters to ESC Laboratories in Mt. Juliet, Tennessee for analysis of VOCs. The results of the air quality assessment will be submitted to ADEM.

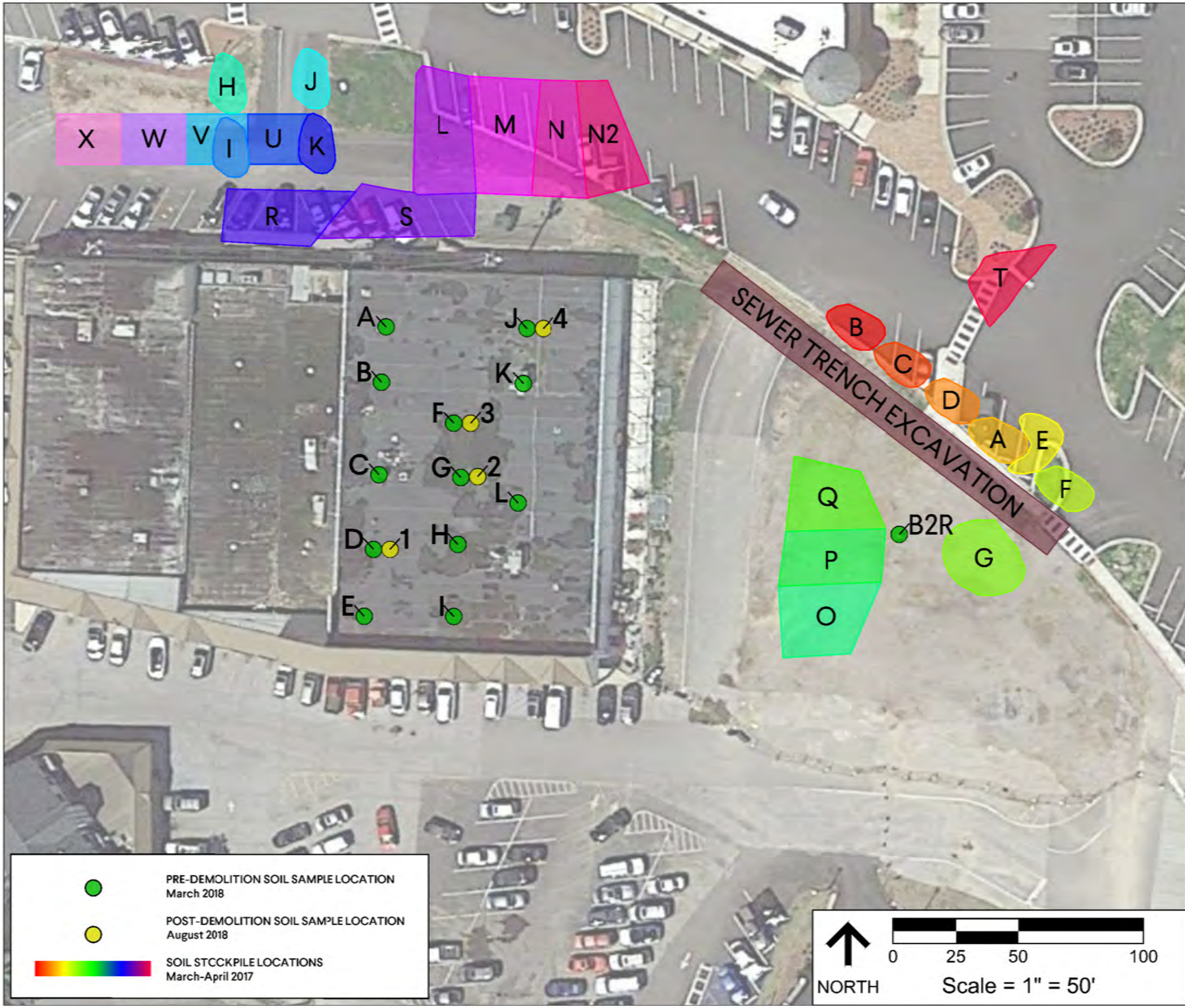
3.4 Environmental Covenant

GMC recommends that an Environmental Covenant be implemented on the subject property to mitigate the risk to human health posed by the identified contaminants. The Environmental Covenant shall include a restriction on the use of groundwater for potable use or irrigation purposes for the entire subject property. In addition, the covenant will include a restriction on the use of the ground floor of the buildings for residential purposes. The ground level of the buildings can be used for commercial and industrial purposes and future residential use is allowed for the second floor and higher levels.

3.5 Certification of Compliance

Upon completion of the activities outlined in this Voluntary Cleanup Work Plan, GMC will submit a Certification of Compliance indicating that the activities are complete and a request that the ADEM Conditional Letter of Concurrence be issued for the site.

ATTACHMENT I
FIGURES



GMC

2701 1st Avenue S
Birmingham, AL 35233
T 205.879.4462
GMCNETWORK.COM

FIGURE 1

SOIL SAMPLE LOCATIONS

GMC #

DATE: 11/20/2018

DRAWN BY: SDD

REF. SHEET: GOOGLE EARTH WORLD IMAGERY

DESCRIPTION: SITE ASSESSMENT SUMMARY

LANE PARK

MOUNTAIN BROOK, JEFFERSON COUNTY, ALABAMA

VCP SITE #461-9585

2701 1st Avenue S
Birmingham, AL 35233
T 205.879.4462
GMCNETWORK.COM

FIGURE 2

UIC LOCATIONS

GMC #

DATE: 11/20/2018

DRAWN BY: SDD

REF. SHEET: GOOGLE EARTH WORLD IMAGERY

DESCRIPTION: SITE ASSESSMENT SUMMARY

LANE PARK

MOUNTAIN BROOK, JEFFERSON COUNTY, ALABAMA

VCP SITE #461-9585

FIGURE 3

GW SAMPLE LOCATIONS

GMC #

DATE: 11/20/2018

DRAWN BY: SDD

2701 1st Avenue S
Birmingham, AL 35233
T 205.879.4462
GMCNETWORK.COM

REF. SHEET: GOOGLE EARTH WORLD IMAGERY

DESCRIPTION: SITE ASSESSMENT SUMMARY

LANE PARK

MOUNTAIN BROOK, JEFFERSON COUNTY, ALABAMA

VCP SITE #461-9585

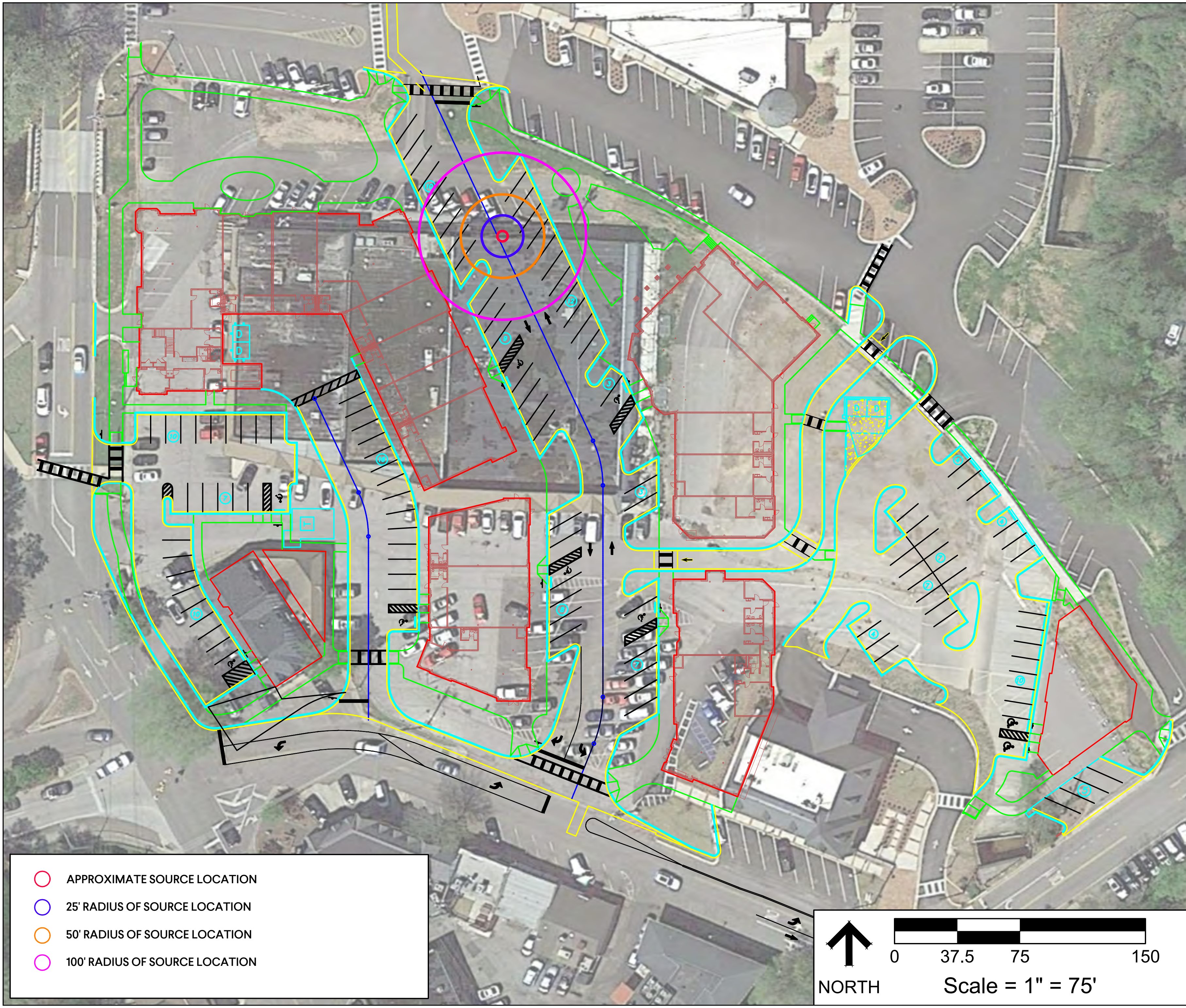


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FIGURE 4

AERIAL PHOTO
GMC #
DATE: 12/2/2019
DRAWN BY: SAB

REF. SHEET: GOOGLE EARTH WORLD IMAGERY
DESCRIPTION: PROPOSED DEVELOPMENT PLAN

LANE PARK

MOUNTAIN BROOK, JEFFERSON COUNTY, ALABAMA
VCP SITE #461-9585

ATTACHMENT 2
DRAGO WRAP VAPOR INTRUSION INFORMATION

DRAGO® WRAP VAPOR INTRUSION BARRIER
RESISTANCE TO DEGRADATION – ADDITIONAL CONSIDERATIONS

Drago Wrap Vapor Intrusion Barrier, and the technologies that underlie this game-changing vapor intrusion protection product, has undergone extensive testing to determine its ability to attenuate VOCs and other relevant material properties. These tests exposed Drago Wrap to a host of deleterious chemicals that may exist at or below a project site, including various petroleum distillates, chlorinated solvents, etc. The results of these tests are positive and telling; they show that Drago Wrap is extremely impermeable to a wide range of chemical vapors and, more importantly for our current considerations, maintains such impermeability over the course of years of exposure to these deleterious compounds.

While the results of such testing speak extensively to Drago Wrap's ability to resist degradation in extreme exposure conditions, we wished to pursue multiple exposure scenarios to further increase the confidence project team members should have in Drago Wrap as a critical component of the vapor intrusion systems they utilize on their projects. The following pages detail these measures. The conclusions indicate that there were no significant changes in mass or volume of Drago Wrap when exposed to direct contact with soils contaminated with benzene, toluene, ethylbenzene, xylene (collectively known as BTEX), trichloroethylene (TCE), perchloroethylene (PCE, or tetrachloroethylene), cis-1,2-dichloroethylene (C-DCE), trans-1,2-dichloroethylene (T-DCE), and sulfates. Additionally, we tested the post-exposure samples to determine their tensile strength (ASTM E882) and permeance to water vapor (F1249), and we observed that Drago Wrap maintains its ability to meet each corresponding performance threshold for high-performance water vapor barriers: for D882, Drago Wrap remains a Class A Vapor Barrier per ASTM E1745; for F1249, Drago Wrap maintains a permeance well below 0.01 perms.

If additional questions remain regarding any aspect of Drago Wrap, please be sure to contact the Stego Technical Department. We are happy to help and look forward to the opportunity to provide an effective and economical solution to your barrier needs.

Regards,

Dan Marks CSI CDT LEED Green Associate
Technical Director | Stego Industries, LLC
O: (949) 325-2035| F: (949) 325-2062
danmarks@stegoindustries.com

SETUP

To simulate a hydrocarbon contaminated brownfield site, a senior chemist at a research and testing lab prepared contaminated water to contain 1,000 ppb of each benzene, toluene, ethylbenzene, and xylene (BTEX). Two liters of this mixture were placed in a chamber, 49 cm x 23.5 cm wide by 27 cm tall. ASTM C778 standard 20-30 sand was added to the vessel until it was 5 cm above the original water line. At this level, the sand was damp with no free-standing water. Drago Wrap samples were placed on top of the damp sand, and the entire surface of the membrane were weighted down with sand-filled plastic bags to ensure full contact of the Drago Wrap with the damp sand. The test vessel was covered and sealed. After 30 days of exposure under ambient laboratory conditions (21-25°C), the samples were removed for evaluation.

Simply stated:
We took relatively large amounts of often-seen hydrocarbons resulting from fuel spills and old service station sites and put them into a water table just 2 inches below a sample of Drago Wrap. This can be considered an extreme situation in that water tables are not typically that close to the slab and vapor barrier membrane. After a 30-day exposure, the mass and volume changes were analyzed, and we subsequently tested the material for its water vapor permeance rating and tensile strength.

RESULTS

<u>Mass and Volume</u>

The chemist conducted mass and volume measurements before and after exposure. The following comes directly from her report: *"All of the test coupons exhibited slight changes in mass and volume, no matter what their exposure conditions were. Statistical analysis by the two-tailed t-test showed that the changes for the BTEX-exposed coupons were not significantly different from the changes for the control-exposed coupons."*

Conclusion: In other words, Drago Wrap mass and volume were not significantly affected by the BTEX exposure.

<u>Tensile Strength</u>

Samples were sent by the lab to our in-house lab and tested per ASTM E882 in both the machine and transverse directions. After the 30-day extreme BTEX solvent exposure, the results were 50.2 lbf/in and 49.6 lbf/in for machine and transverse directions respectively. These results were not significantly different than the water-exposed control samples (48.7 lbf/in, 48.5 lbf/in) or the unexposed samples (48.5 lbf/in, 46.8 lbf/in). For another point of comparison, consider that to be labeled as Class A per ASTM E1745, new-material tensile need only test at 45 lbf/in.

Conclusion: BTEX exposure has little to no effect on Drago Wrap's physical integrity in below-slab applications.

<u>Water Vapor Permeance</u>

The testing lab then sent exposed and control samples to our in-house lab where they were subsequently tested per ASTM F1249. The results were very positive. The permeance of the sample exposed to the BTEX solution (0.00733 perms) increased minimally compared to the control (0.00614 perms), both staying well below the threshold of 0.01 perms.

Conclusion: BTEX exposure had minimal effect on Drago Wrap's ability to retard water vapor.

SETUP

To simulate a dry-cleaning brownfield site, a senior chemist at a research and testing lab prepared contaminated water to contain 3,600 ppb perchloroethylene (PCE), 12,500 PPB trichloroethylene (TCE), 16,200 PPB CIS-1,2-dichloroethylene (C-DCE), AND 1,700 PPB trans-1,2-dichloroethylene (T-DCE). Two liters of this mixture were placed in a chamber, 49 cm x 23.5 cm wide and 27 cm tall. ASTM C778 standard 20-30 sand was added to the vessel until it was 5 cm above the original water line. At this level, the sand was damp with no free-standing water. Drago Wrap samples were placed on top of the damp sand, and the entire surface of the vapor barrier was weighted down with sand-filled plastic bags to ensure full contact of the Drago Wrap with the damp sand. The test vessel was covered and sealed. After 30 days of exposure under ambient laboratory conditions (21-25°C), the samples were removed for evaluation.

Simply stated:
We took an actual soils report from an old dry cleaning site and recreated the conditions, roughly. In the actual scenario the water table was 20 feet below the vapor barrier. In our setup, we created a contaminated water table just 2 *inches* below Drago Wrap. After a 30-day exposure, the mass and volume changes were analyzed, and we subsequently tested the material for its water vapor permeance rating and tensile strength.

RESULTS

Mass and Volume
The chemist conducted mass and volume measurements before and after exposure. The following comes directly from her report: *"All of the test coupons exhibited slight changes in mass and volume, no matter what their exposure conditions were. Statistical analysis by the two-tailed t-test showed that the changes for the chlorinated solvent-exposed coupons were not significantly different from the changes for the control-exposed coupons."*

Conclusion: Drago Wrap's mass and volume were not significantly affected by the chlorinated solvent exposure.

Tensile Strength
Samples were sent by the lab to our in-house lab and tested per ASTM E882 in both the machine and transverse directions. After the 30-day extreme chlorinated solvent exposure, the results were 51.2 lbf/in and 49.7 lbf/in for machine and transverse directions respectively. These results were not significantly different than the water-exposed control samples (48.7 lbf/in, 48.5 lbf/in) or the unexposed samples (48.5 lbf/in, 46.8 lbf/in). For another point of comparison, consider that to be labeled as Class A per ASTM E1745, new-material tensile need only test at 45 lbf/in.

Conclusion: Chlorinated solvent exposure has little to no effect on Drago Wrap's physical integrity in below-slab applications.

Water Vapor Permeance
The testing lab then sent exposed and control samples to our in-house lab where they were subsequently tested per ASTM F1249. The results were very positive. The permeance of the sample exposed to the BTEX solution (0.00713 perms) increased minimally compared to the control (0.00614 perms), both staying well below the threshold of 0.01 perms.

Conclusion: Chlorinated solvent exposure had minimal effect on Drago Wrap's ability to retard water vapor.

SETUP

To simulate the worst possible sulfate exposure, a senior chemist at a research and testing lab prepared water contaminated with 10,000 PPM of SO4 (sulfate.) This sulfate concentration was chosen because it was rated as "very severe" (the highest or worst classification) by UC Berkeley professors conducting research for the Caltrans Long Life Pavement Rehabilitation Strategy (LLPRS) Program. The Chemist took this worst-case scenario concentration and soaked samples of Drago Wrap in it for 28 days. Upon removal, the samples were analyzed for changes in mass and volume, and subsequently the exposed product was tested to determine its tensile strength and water vapor permeance rate.

RESULTS

<u>Mass & Volume</u>

The chemist conducted mass and volume measurements before and after exposure. The following comes directly from her report: *"All of the test coupons exhibited slight changes in mass and volume, no matter what their exposure conditions were. Statistical analysis by the two-tailed t-test showed that the changes for the sulfate-exposed coupons were not significantly different from the changes for the control-exposed coupons."*

Conclusion: In other words, Drago Wrap's mass and volume were not significantly affected by the sulfate exposure.

<u>Tensile</u>

Samples were sent by the lab to our in-house lab and tested per ASTM E882 in both the machine and transverse directions. After the 28-day extreme sulfate exposure, the results were 49.6 lbf/in and 52.3 lbf/in for machine and transverse directions respectively. These results were not significantly different than the water-exposed control samples (48.7 lbf/in, 50.8 lbf/in) or the unexposed samples (48.5 lbf/in, 46.8 lbf/in). For another point of comparison, consider that to be labeled as Class A per ASTM E1745, new-material tensile need only test at 45 lbf/in.

Conclusion: Sulfate exposure has little to no effect on Drago Wrap's physical integrity in below-slab applications.

<u>Water Vapor Permeance</u>

The testing lab then sent exposed and control samples to our in-house lab where they were subsequently tested per ASTM F1249. The results were very positive. The permeance of the sample exposed to the sulfate solution (0.00734 perms) increased minimally compared to the control (0.00698 perms), both staying well below the threshold of 0.01 perms.

Conclusion: Sulfate exposure had no significant effect on Drago Wrap's ability to retard water vapor.

DRAGO® WRAP VAPOR INTRUSION BARRIER
SUMMARY OF PERMEATION AND ATTENUATION TESTING

BACKGROUND

From October 2015 through August 2018, Drago Wrap Vapor Intrusion Barrier was subjected to a series of diffusion and sorption tests to obtain the film's diffusion, partitioning, and permeation characteristics. This testing was designed and overseen by an expert in the permeation of volatile organic compounds (VOCs) at a prominent university. The results of this testing, combined with further modeling and analysis, have been used to empirically determine the attenuation efficacy of Drago Wrap against various hydrocarbons and chlorinated solvents. The purpose of this document is to briefly discuss the theory behind diffusive vapor intrusion (VI); summarize and explain the robust testing protocol utilized; and relay the results of the testing and analysis.

CHEMICALS TESTED

Drago Wrap has been tested with regard to permeation of the following chemicals: Trichloroethylene (TCE); Perchloroethylene (PCE); the BTEX family: Benzene, Toluene, Ethylbenzene, Xylene; Dichloromethane; 1,4 Dichlorobenzene; Methyl tert-butyl ether (MTBE) and Naphthalene. This list was chosen based on a survey of the most often found chemicals on brownfield projects.

THEORY

The practical purpose behind obtaining permeation, diffusion, and partitioning coefficients is to apply them to the equations governing mass flux per Fick's laws during design of VI mitigation systems. The following briefly explains the theory and physics behind Fick's First Law.

The diffusion coefficient, D_g (units expressed in [m^2/s]), is the parameter defining the membrane's resistance to the diffusive mass flux [g/m^2s] transported within the membrane as governed by Fick's First Law:

$$f = -D_g \frac{dc_g}{d_z} \qquad \text{(Eq. 1)}$$

due to a concentration gradient dc_g/d_z [g/m^4] in the membrane layer. If the contaminant source is an aqueous solution adjacent to the membrane, the concentration of the contaminant in the membrane can be related to that in the fluid (at equilibrium) by the partitioning coefficient, S_{gf} (where S_{gf} is analogous to a Henry's coefficient). It is given by Equation 2 and depends on the solubility of the contaminant in the material:

$$S_{gf} = \frac{c_g}{c_f} \qquad \text{(Eq. 2)}$$

where c_f is the concentration of the contaminant in the fluid, adjacent to and in equilibrium with, the concentration, c_g, in the membrane.

Thus, the mass flux (f) from the fluid on one side of the membrane to the fluid on the other side (at steady state) is given by:

$$f = S_{gf} D_g \frac{dc_g}{d_z} = \frac{P_g}{l} \Delta C \qquad \text{(Eq. 3)}$$

where l is the thickness of the film/membrane, and ΔC is the difference in concentration between the two sides of the film/membrane at steady state, and the product of the two parameters (S_{gf} D_g) is called the permeation coefficient, P_g (m^2/s):

$$P_g = S_{gf} D_g \quad \text{(Eq. 4)}$$

It can be gleaned from Equations 1-4 that the diffusion coefficient, D_g, is not enough to characterize the film's mass transfer properties for contaminants moving from below the membrane to above it. Diffusive mass transfer through an intact geomembrane is a 3-step process: partitioning into the geomembrane; diffusion through the geomembrane; and partitioning out of the geomembrane. Both D_g and S_{gf} (or simply P_g) must be known in order to effectively utilize Fick's steady state mass transfer equations. Therefore, to allow for full and complete analysis, Drago Wrap's permeation was fully characterized with all three values (permeation, diffusion, and partitioning coefficients) for each chemical tested. Those values are contained in Table 2. It is also imperative to understand the differences in methodologies between lab and site-specific field-testing setups. If such differences exist, the addition of the phase transition coefficient between water and air, Henry's coefficient (H), may also be required in the analysis. A deeper discussion on accounting for these differences is beyond the scope of this summary. Please contact the Stego Industries' Technical Department for additional assistance.

TESTING METHODOLOGY

Two types of tests and subsequent modeling have been employed in characterizing Drago Wrap's relevant characteristics: diffusion testing, sorption testing, and the finite layer modeling and analysis program, POLLUTE v7 (Rowe and Booker 2004).

The diffusion testing setup used stainless steel double-compartment cells (Figure 1), such that source and receptor volumes were separated by the Drago Wrap membrane. The cell was screwed together, with the membrane secured using two Viton rings (Figure 2) to prevent the loss of contaminant at the connection between each compartment and the membrane. Both the source and receptor were filled with double deionized (DDI) water, and a septum was inserted into the sampling ports to prevent losses. A stock solution of contaminants was added to the source compartment to form a dilute aqueous solution with a known concentration. Before assembly, and after disassembly, the mass of the membrane was recorded.

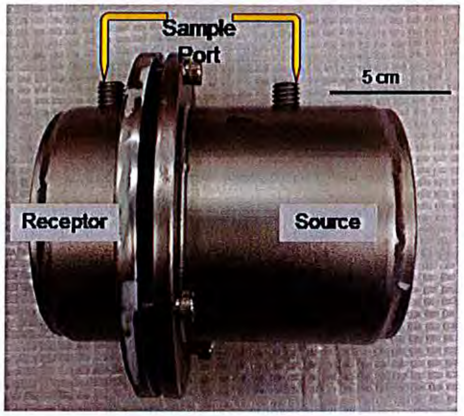


Figure 1: Double Compartment Cell

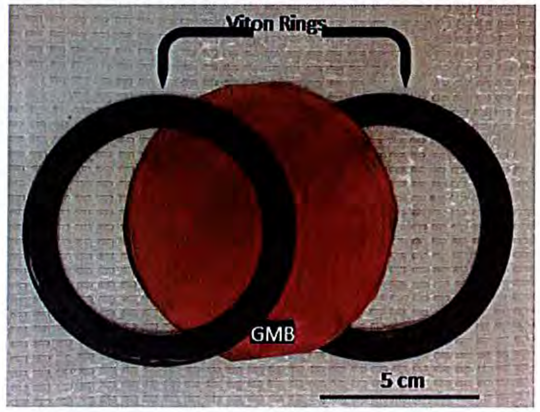


Figure 2: Membrane and Viton Rings

Sorption testing was also performed to directly measure the partitioning coefficients for each chemical. The sorption testing was conducted using 20-ml vials where a specimen was placed in double deionized water. The mass of the specimen was recorded beforehand. The vials were filled with double deionized water so that there was no airspace in the vial. Known masses of contaminants were added and 50 µl samples were taken daily from the vials for analysis and replaced with double deionized water until equilibrium was reached. The chemical analysis of these specimens was performed in the same manner as chemical analysis of the diffusion tests. This analysis is described in Appendix B.

The results from the diffusion and sorption tests were transduced and analyzed using the finite layer modeling and analysis program, POLLUTE v7, to create the results seen in Table 2.

In addition to whole-film testing, the discrete layers that make up Drago Wrap were tested to determine their respective permeation, diffusion and partitioning coefficients. The results obtained from the mathematical modeling of these tests do not necessarily equate to the values obtained from whole-film permeation testing. In other words, the full membrane benefits from a synergistic effect: the whole is greater than the sum of its parts. Due to its unique design, the testing demonstrated a very important feature to Drago Wrap: its ability to degrade chlorinated solvents like TCE. The results show about a 50-day half-life for TCE when the membrane is installed in its intended orientation. The results in Table 2 come from the most conservative approach to analyzing the results and do not consider these synergies.

RESULTS

As described earlier, the values displayed in Table 2 result from a conservative approach to the analysis of data generated from several phases and years of testing, and subsequent numerical modeling. The preferred methodology for obtaining accurate results requires an aqueous-to-aqueous testing scenario. Table 2 depicts these results. There exist scenarios where mass flux design with Drago Wrap requires additional consideration of phase-change analysis beyond what is offered in Table 2. Please contact the Stego Industries' Technical Department for assistance should the need arise.

Table 1 – Descriptions of the Tested Chemicals

Chemical	Abbreviation	Family	Use
Benzene	Btex	Aromatic Hydrocarbon	Gasoline byproduct
Toluene	bTex	Aromatic Hydrocarbon	Gasoline byproduct
Ethylbenzene	btEx	Aromatic Hydrocarbon	Gasoline byproduct
M&P-Xylenes	bteX	Aromatic Hydrocarbon	Gasoline byproduct
O-Xylene	bteX	Aromatic Hydrocarbon	Gasoline byproduct
Trichloroethylene	TCE	Chlorinated Hydrocarbon	Dry Cleaning and Solvent
Tetrachloroethylene	PCE	Chlorinated Hydrocarbon	Dry Cleaning and Solvent
Methyl tert-butyl ether	MTBE	Oxygenate	Octane-increasing additive to fuel
Dichloromethane	DCM	Chlorinated Hydrocarbon	Paint Stripper, Decaffeinate, Aerosol propellant
Naphthalene	Naphthalene	Polycyclic Aromatic Hydrocarbon	Fumigant, Pyrotechnics, Wetting Agent
1,4-Dichlorobenzne	1,4-DCB	Chlorinated Hydrocarbon	Pesticide, Disinfectant, Deodorant

Table 2 – Aqueous Coefficients

Chemical	Diffusion, D_g [x 10^{-15} m^2/s]	Partitioning, S_{gf} [-]	Permeation, P_g [x 10^{-13} m^2/s]
Benzene	2.6	171	4.5
Toluene	1.5	339	5.1
Ethylbenzene	0.41	764	3.1
M&P-Xylenes	0.4	743	2.9
O-Xylene	0.4	670	2.7
TCE	3.9	251	9.8
PCE	1.1	610	6.6
MTBE	1	1	0.01
DCM	0.95	475	4.5
Naphthalene	0.014	1710	0.25
1,4-DCB	0.94	760	7.1

CONCLUSION

Drago Wrap has proven to be a superior barrier to standard geomembranes like HDPE (by a factor of about 10 to 200 – See Appendix A) for all contaminants where comparisons could be made to HDPE and has remarkably low values for BTEX, TCE; PCE; MTBE; Naphthalene; DCM; and 1,4 DCB with permeation coefficients of the order of magnitude of 10^{-13} – 10^{-14} m^2/s. In addition, the testing has shown that chlorinated solvents experience degradation while permeating through the membrane with a half-life of 50 days for TCE when the film is correctly oriented relative to the contaminant source.

APPENDIX A – COMPARISON TO HDPE (WHERE AVAILABLE)

	Permeation Coefficients- 20-mil Drago Wrap			Permeation Coefficients – 80-mil HDPE[1]			
	D_g (m^2/s)	S_{gf} (-)	P_g (m^2/s)	D_g (m^2/s)	S_{gf} (-)	P_g (m^2/s)	Ratio (P_{gDrago}/P_{gHDPE})
Benzene	2.6×10^{-15}	171	4.5×10^{-13}	3.5×10^{-13}	30	1.05×10^{-11}	23
Toluene	1.5×10^{-15}	339	5.1×10^{-13}	3.0×10^{-13}	100	3.0×10^{-11}	60
Ethylbenzene	4.1×10^{-16}	764	3.0×10^{-13}	1.8×10^{-13}	285	5.1×10^{-11}	170
m&p-Xylenes	4.0×10^{-16}	743	2.9×10^{-13}	1.7×10^{-13}	347	5.9×10^{-11}	200
o-Xylene	4.0×10^{-16}	670	2.7×10^{-13}	1.5×10^{-13}	240	3.6×10^{-11}	130
TCE	3.9×10^{-15}	251	9.8×10^{-13}	4.0×10^{-13}	85	3.4×10^{-11}	35
PCE	1.1×10^{-15}	610	6.6×10^{-13}	-	-	-	-
MTBE	1.0×10^{-15}	1	1.0×10^{-15}	-	-	-	-
DCM	9.5×10^{-16}	475	4.5×10^{-13}	6.5×10^{-13}	6	3.9×10^{-12}	9
Naphthalene	1.4×10^{-17}	1710	2.5×10^{-14}	-	-	-	-
1,4-DCB	9.4×10^{-16}	760	7.1×10^{-13}	-	-	-	-

[1]Sangam & Rowe (2001)

APPENDIX B– CHEMICAL ANALYSIS

The cells were sampled at regular time intervals. During each sampling event, 10 ul to 100 ul was removed from the cell, and that volume was replaced with DDI water so there was no airspace in the cell.

The samples were added to a vial containing 0.4 ml of methanol, 0.01 ml internal standard, and water was added so the total fluid volume in the vial was 1.6 ml. A Solid Phase Micro Extraction (SPME) fiber was inserted into vial headspace and the volatile compounds sorbed onto the fiber. This fiber was analyzed using gas chromatography (GC), and results compared to a certified laboratory standard calibration curve for the contaminant in question. Two types of detectors were used (depending on the cell in question); namely, a mass selective detector and a flame ionization detector. A quality assurance certified lab standard (from a different source to the calibration standards) was assessed during each sampling event.

All laboratory testing was conducted in a Canadian Association for Laboratory Accreditation (CALA) lab and followed CALA methods. This means that rigorous quality assurance practices were followed during chemical analysis. CALA frequently reviews the methods used and the accreditation is renewed every two years.

REFERENCES

Rowe, R. K., and Booker, J. R. (2004). "POLLUTE V.7 - 1D Pollutant Migration through a Non-homogenous Soil." GAEA Environmental Engineering Ltd.

Sangam, H. P., and Rowe, R. K. (2001). "Migration of dilute aqueous organic pollutants through HDPE geomembranes." Geotextiles and Geomembranes, 19(6), 329–357.

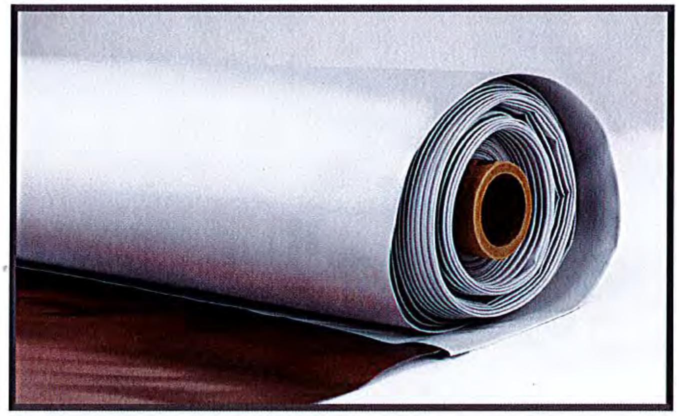
DRAGO DATA

DRAGO® WRAP VAPOR INTRUSION BARRIER

A STEGO TECHNOLOGY, LLC INNOVATION | VAPOR RETARDERS 07 26 00, 03 30 00 | VERSION: 06/23/2017

1. PRODUCT NAME

DRAGO WRAP VAPOR INTRUSION BARRIER



2. MANUFACTURER

c/o Stego® Industries, LLC*
216 Avenida Fabricante, Suite 101
San Clemente, CA 92672
Sales, Technical Assistance
Ph: (877) 464-7834
Fx: (949) 257-4113
www.stegoindustries.com

3. PRODUCT DESCRIPTION

USES: Drago Wrap is specifically engineered to attenuate volatile organic compounds (VOCs) and serve as a below-slab moisture vapor barrier.

COMPOSITION: Drago Wrap is a multi-layered plastic extrusion that combines uniquely designed materials with only high grade, prime, virgin resins.

ENVIRONMENTAL FACTORS: Drago Wrap can be used in systems for the control of various VOCs including hydrocarbons, chlorinated solvents, radon, methane, soil poisons, and sulfates.

4. TECHNICAL DATA

TABLE 4.1: PHYSICAL PROPERTIES OF DRAGO WRAP VAPOR INTRUSION BARRIER

PROPERTY	TEST	RESULTS
Under Slab Vapor Retarders	ASTM E1745 – Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs	ASTM E1745 Compliant
Water Vapor Permeance	ASTM F1249 – Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor	0.0069 perms [gr/(ft^2*hr*in-Hg)]
Push-Through Puncture	ASTM D4833 – Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products	183.9 Newtons
Tensile Strength	ASTM D882 – Test Method for Tensile Properties of Thin Plastic Sheeting	53.5 lbf/in
Permeance After Conditioning (ASTM E1745 Sections 7.1.2 - 7.1.5)	ASTM E154 Section 8, F1249 – Permeance after wetting, drying, and soaking ASTM E154 Section 11, F1249 – Permeance after heat conditioning ASTM E154 Section 12, F1249 – Permeance after low temperature conditioning ASTM E154 Section 13, F1249 – Permeance after soil organism exposure	0.0073 perms 0.0070 perms 0.0062 perms 0.0081 perms
Hydrocarbon Attenuation Factors	Contact Stego Industries' Technical Department	
Chlorinated Solvent Attenuation Factors	Contact Stego Industries' Technical Department	
Methane Transmission Rate	ASTM D1434 – Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting	7.0 GTR (mL(STP)/m^2*day)
Radon Diffusion Coefficient	K124/02/95	9.8 x 10^{-14} m^2/second
Thickness		20 mils
Roll Dimensions		14' x 105' or 1,470 ft^2
Roll Weight		150 lbs

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Note – legal notice on page 2.

DRAGO® WRAP
VAPOR INTRUSION BARRIER

A STEGO TECHNOLOGY, LLC INNOVATION | VAPOR RETARDERS 07 26 00, 03 30 00 | VERSION: 06/23/2017

5. INSTALLATION

UNDER SLAB: Unroll Drago Wrap over a tamped aggregate, sand, or earth base. Overlap all seams a minimum of 12 inches and tape using Drago® Tape. All penetrations must be sealed using a combination of Drago Wrap and Drago Accessories.

Review Drago Wrap's complete installation instructions prior to installation.

6. AVAILABILITY & COST

Drago Wrap is available nationally through our network of building supply distributors. For current cost information, contact your local Drago distributor or Stego Industries' Sales Representative.

7. WARRANTY

Stego Industries, LLC believes to the best of its knowledge, that specifications and recommendations herein are accurate and reliable. However, since site conditions are not within its control, Stego Industries does not guarantee results from the use of the information provided and disclaims all liability from any loss or damage. Stego Technology, LLC does offer a limited warranty on Drago Wrap. Please see www.stegoindustries.com/legal.

8. MAINTENANCE

Store Drago Wrap in a dry and temperate area.

9. TECHNICAL SERVICES

Technical advice, custom CAD drawings, and additional information can be obtained by contacting Stego Industries or by visiting the website.

Contact Number: (877) 464-7834
Website: www.stegoindustries.com

10. FILING SYSTEMS

- www.stegoindustries.com
- Buildsite

DRAGO® WRAP
VAPOR INTRUSION BARRIER

INSTALLATION INSTRUCTIONS

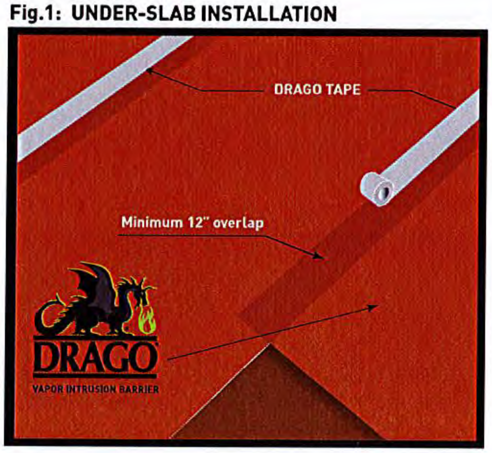
Engineered protection to create a ***healthy*** built environment.

DRAGO® WRAP VAPOR INTRUSION BARRIER
INSTALLATION INSTRUCTIONS

IMPORTANT: Please read these installation instructions completely, prior to beginning any Drago Wrap installation. The following installation instructions are generally based on ASTM E1643 – *Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs.* There are specific instructions in this document that go beyond what is stated in ASTM E1643 to take into account vapor intrusion mitigation. If project specifications call for compliance with ASTM E1643, then be sure to review the specific installation sections outlined in the standard along with the techniques referenced in these instructions.

UNDER-SLAB INSTRUCTIONS:

Fig.1: UNDER-SLAB INSTALLATION



1. Drago Wrap has been engineered to be installed over a tamped aggregate, sand, or earth base. It is not typically necessary to have a cushion layer or sand base, as Drago Wrap is tough enough to withstand rugged construction environments.

NOTE: Drago Wrap must be installed with the gray facing the subgrade.

2. Unroll Drago Wrap over the area where the slab is to be placed. Drago Wrap should completely cover the concrete placement area. All joints/seams both lateral and butt should be overlapped a minimum of 12 inches and taped using Drago® Tape. (Fig. 1)

NOTE: The area of adhesion should be free from dust, dirt, moisture, and frost to allow maximum adhesion of the pressure-sensitive tape. Ensure that all seams are taped with applied pressure to allow for maximum and continuous adhesion of the pressure-sensitive Drago Tape.

3. ASTM E1643 requires sealing the perimeter of the slab. Extend vapor retarder over footings and seal to foundation wall or grade beam at an elevation consistent with the top of the slab or terminate at impediments such as waterstops or dowels. Consult the structural and environmental engineer of record before proceeding.

Fig.2a: SEAL TO PERIMETER WALL

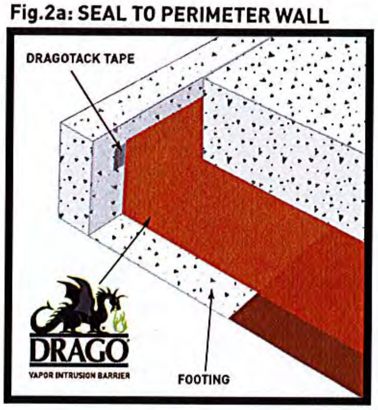


Fig. 2b: SEAL TO FOOTING

SEAL TO PERIMETER WALL OR FOOTING WITH DRAGOTACK™ TAPE: (Fig. 2a and 2b)

- **a.** Make sure area of adhesion is free of dust, dirt, debris, moisture, and frost to allow maximum adhesion.
- **b.** Remove release liner on one side and stick to desired surface.
- **c.** When ready to apply Drago Wrap, remove the exposed release liner and press firmly against DragoTack Tape to secure.

4. In the event that Drago Wrap is damaged during or after installation, repairs must be made. Cut a piece of Drago Wrap to a size and shape that covers any damage by a minimum of 6 inches in all directions. Clean all adhesion areas of dust, dirt, moisture, and frost. Tape down all edges using Drago Tape. (Fig. 3)

Fig. 3: SEALING DAMAGED AREAS

5. **IMPORTANT: ALL PENETRATIONS MUST BE SEALED.** All pipe, ducting, rebar, and block outs should be sealed using Drago Wrap, Drago Tape, and/or Drago® Sealant and Drago® Sealant Form. (Fig. 4a)

Fig. 4a: PIPE PENETRATION SEALING

Fig. 4b: DETAIL PATCH FOR PIPE PENETRATION SEALING

DETAIL PATCH FOR PIPE PENETRATION SEALING: (Fig. 4b)

a. Install Drago Wrap around pipe penetrations by slitting/cutting material as needed. Try to minimize void space created.
b. If Drago Wrap is close to pipe and void space is minimized, proceed to step d.
c. If void space exists, then
 i. Cut a detail patch to a size and shape that creates a 6-inch overlap on all edges around the void space at the base of the pipe.
 ii. Cut an "X" slightly smaller than the size of the pipe diameter in the center of the detail patch and slide tightly over pipe.
 iii. Tape the edges of the detail patch using Drago Tape.
d. Seal around the base of the pipe using Drago Tape and/or Drago Sealant and Drago Sealant Form.
 i. If Drago Sealant is used to seal around pipe, make sure Drago Wrap is flush with the base of the penetration prior to pouring Drago Sealant.

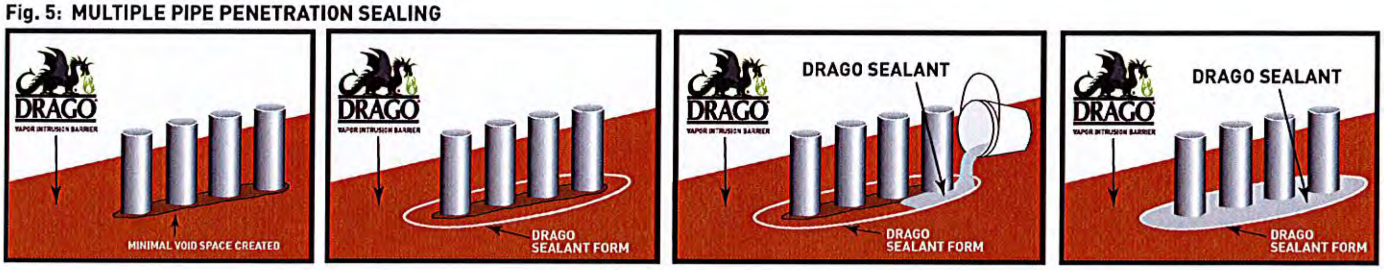
Continued ...
Note - legal notice on page 3

MULTIPLE PIPE PENETRATION SEALING: (Fig. 5)

NOTE: Multiple pipe penetrations in close proximity may be most efficiently sealed using Drago Wrap, Drago Sealant, and Drago Sealant Form for ease of installation.

a. Cut a hole in Drago Wrap such that the membrane fits over and around the base of the pipes as closely as possible, ensuring that it is flush with the base of the penetrations.
b. Install Drago Sealant Form continuously around the entire perimeter of the group of penetrations and at least 1 inch beyond the terminating edge of Drago Wrap.
c. Pour Drago Sealant inside of Drago Sealant Form to create a seal around the penetrations.
d. If the void space between Drago Wrap and the penetrations is not minimized and/or the base course allows for too much drainage of sealant, a second coat of Drago Sealant may need to be poured after the first application has cured.

Fig. 5: MULTIPLE PIPE PENETRATION SEALING



BEAST® CONCRETE ACCESSORIES - VAPOR BARRIER SAFE

Stego Industries recommends the use of BEAST vapor barrier-safe concrete accessories, to help eliminate the use of non-permanent penetrations in Drago Wrap installations.

BEAST® FOOT FORMING UTILITY

BEAST® SCREED

BEAST® HOOK

IMPORTANT: AN INSTALLATION COMPLETED PER THESE INSTRUCTIONS SHOULD CREATE A MONOLITHIC MEMBRANE BETWEEN ALL INTERIOR INTRUSION PATHWAYS AND VAPOR SOURCES BELOW THE SLAB AS WELL AS AT THE SLAB PERIMETER. THE UNDERLYING SUBBASE SHOULD NOT BE VISIBLE IN ANY AREA WHERE CONCRETE WILL BE PLACED. ADDITIONAL INSTALLATION VALIDATION CAN BE DONE THROUGH SMOKE TESTING. SEE DRAGO WRAP VAPOR INTRUSION SYSTEM SMOKE TESTING FIELD GUIDE FOR ADDITIONAL CONSIDERATIONS.

NOTE: While Drago Wrap installation instructions are based on ASTM E1643 - *Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs,* these instructions are meant to be used as a guide, and do not take into account specific job site situations. Consult local building codes and regulations along with the building owner or owner's representative before proceeding. If you have any questions regarding the above-mentioned installation instructions or products, please call us at 877-464-7834 for technical assistance. While Stego Industries' employees and representatives may provide technical assistance regarding the utility of a specific installation practice or Stego product, they are not authorized to make final design decisions.