March 23, 2018

HMFH Architects, Inc.
130 Bishop Allen Drive
Cambridge, MA 02139

Attention: Ms. Lori Cowles

Reference: Arlington High School – Arlington, Massachusetts
Phase II Site Investigation - Evaluation of Vapor Intrusion Pathway

Ladies and Gentlemen:

The following summarizes the results of our Phase II Site Investigation that was performed to evaluate the vapor intrusion pathway which was previously identified at the Arlington High School located in Arlington, Massachusetts. Refer to the Project Location Plan (**Figure 1**) for the general site locus.

The Phase II Site Investigation was conducted in accordance with our proposal to HMFH Architects, Inc. for geoenvironmental engineering services dated February 16, 2018 and the subsequent authorization of Ms. Lori Cowles. These services are subject to the limitations in **Appendix A**.

In summary, the results of our evaluation indicate that chlorinated volatile organic compounds (CVOCs) are present in soil gas and indoor air at the Arlington High School. The concentrations of CVOCs that were detected in sub-slab soil gas and indoor air are generally lower than those that were previously detected by the DEP in 2011 and 2014. An evaluation of exposure risks indicates that the highest concentrations of CVOCs that were detected in indoor air do not pose a Significant Risk for long term exposure to teachers and administrators and short term exposure to students.

Given that elevated concentrations of CVOCs are present in sub-slab soil gas and groundwater beneath a majority of the current school building, the potential for their migration to indoor air exists within new structures that may be constructed and structures that may be renovated for the proposed Arlington High School project. Specifically, the construction of new buildings and renovation of existing buildings create pressure differentials as well as new entry points that may increase the migration rate of subsurface CVOC contamination into indoor air. In addition, the concentrations of CVOCs in groundwater and soil gas may change over time with the migration of the contaminant plume and seasonal fluctuations such as groundwater depths and temperature. As a result, the installation of a vapor mitigation system is recommended beneath newly constructed buildings and/or the renovation of existing buildings that are proposed for the Arlington High School project.

Background

During August 2011, the Massachusetts Department of Environmental Protection (DEP) conducted a vapor intrusion evaluation at the Arlington High School to further assess potential impacts from a former dry cleaners located to the west of the school building on the opposite side of Massachusetts Avenue. As part of the vapor intrusion evaluation, DEP analyzed groundwater, soil gas and indoor air samples for the presence of chlorinated volatile organic compounds (CVOCs) that were collected from locations adjacent to, beneath and within the school building. The results of the evaluation identified a Condition of Substantial Release Migration related to an off-site release of CVOCs in groundwater which had volatilized into indoor air of the school building. Pursuant to Section 40.013(4) of the Massachusetts Contingency Plan (MCP), the DEP reported a 72-hour release condition related to the Condition Substantial Release Migration to which Release Tracking Number (RTN) 3-30236 was assigned to Arlington High School.

Specifically, DEP's analysis of groundwater samples from locations adjacent to and beneath the southern portion of the school building identified concentrations of CVOCs, in particular tetrachloroethene (PCE), which exceeded the applicable MCP Method 1 GW-2 risk standards. The analysis of sub-slab soil gas collected from beneath the southern portion of the school building also detected elevated concentrations of the same CVOCs that were identified in groundwater. In addition, DEP's analysis of indoor air within the southern portion of the school building identified concentrations PCE (as well as other CVOCs) which exceeded the DEP commercial/industrial threshold values for indoor air which are modeled to capture exposure risks to the occupants of school buildings. Reportedly, the highest concentrations of PCE were present in indoor air within areas of the school which were not considered occupied for significant periods of the day such as the former Autoshop and Room 105. At the time, the DEP concluded that an immediate risk to the occupants of the building was not present.

As a result of their assessment activities in 2011, the DEP provided recommendations to mitigate the vapor intrusion pathway some of which were implemented including the sealing of floor slab penetrations as well as a sump identified at the southern portion of the school building's lowest level, isolating the former Auto Shop and Room 105 (areas most affected by CVOC concentrations) and adding fresh air into the affected portions of the school building.

In mid-January 2014, DEP conducted a supplemental vapor intrusion evaluation which involved a physical inspection of the property as well as the analysis of additional groundwater, soil gas and indoor air samples from beneath and within the school building for the presence of PCE. The results of the analyses indicated concentrations of PCE that were similar to and/or lower than those that were detected by the DEP in 2011. Further, the DEP concluded that the maximum concentrations of PCE that were detected in indoor air were below the long term exposure risk values for teachers, administrators, and custodial staff over a 27 year period. As a result, the DEP concluded that a Condition of No Significant Risk exists in the school for the identified indoor air pathway.

Phase II Site Investigation

On February 23, 2018, an additional assessment of the vapor intrusion pathway was completed by McPhail Associates, LLC (McPhail) at Arlington High School. The purpose of this assessment was to evaluate the following: (i) the cumulative exposure risk of CVOCs in indoor air within portions of the building generally occupied by sensitive receptors (i.e. children) which were not assessed by the DEP, (ii) the extent of impacted soil gas beneath the school building, and (iii) design considerations of a vapor mitigation system for the Arlington High School Building project. The assessment of the vapor intrusion pathway included the sampling and laboratory analysis of sub-slab soil gas and indoor air for the presence of CVOCs that were previously identified by the DEP during the above referenced assessment activities.

In summary, the results of our evaluation indicate that CVOCs are present in soil gas and indoor air at the Arlington High School. The concentrations of CVOCs that were detected in sub-slab soil gas and indoor air are generally lower than those that were previously detected by the DEP in 2011 and 2014. An evaluation of exposure risks indicates that the highest concentrations of CVOCs that were detected in indoor air do not pose a Significant Risk for long term exposure to teachers and administrators and short term exposure to students. However, given that elevated concentrations of CVOCs are present in sub-slab soil gas beneath a majority of the school building and the resulting potential for migration to indoor air, installation of a vapor mitigation system is recommended beneath any new and/or existing buildings that will be constructed or renovated as part the Arlington High School Building project.

Indoor Air

A total of eight (8) samples of indoor air, identified as IA-1 through IA-8, were obtained from the lowest level and second floor of the Arlington High School building. Of the eight indoor air samples, a total of four samples were collected from classrooms which serve as a daycare center and pre-school as well as a locker room which occupy lowest level of the school building. The remaining samples were obtained from overlying rooms (which include a classroom and gymnasium) located on the southern portion of the second floor to assess the diffusion of CVOCs. The approximate locations of the indoor air samples are shown on **Figure 2A** and **2B**.

Pursuant to the DEP Vapor Intrusion Guidance dated October 2016, the indoor air was sampled using a Summa canister equipped with a flow regulator which obtained a composite sample over a 24-hour time period. The indoor air samples were analyzed for the presence of CVOCs by the TO-15 Method SIM, the results of which are summarized in **Table 1**. The detected concentrations of CVOCs were compared to DEP's commercial/indoor air threshold values which assess adult long term exposure periods and short term exposure durations for children. The associated laboratory data report is included in **Appendix B**.

With the exception of PCE that was detected in two samples, the results of the indoor air testing did not indicate concentrations of CVOCs in excess of the applicable commercial/industrial indoor air threshold values. The highest concentration of PCE, was detected in sample IA-6 at 6.49 micrograms per cubic meter (ug/m3) which was obtained from a classroom located within the southwestern portion of the second floor. In addition, indoor air sample IA-2 that was obtained from the pre-school classroom located at southeastern portion of lowest level exhibited a PCE concentrations at 4.34 ug/m^3. The concentrations of PCE that were detected in samples IA-2 and IA-6 exceed the commercial/industrial threshold value of 4.1 ug/m^3. The remaining indoor air samples did not exhibit concentrations of CVOCs in excess of the DEP commercial/industrial threshold value.

Risk Characterization

Exposure risks to the current occupants of the school were evaluated using the DEP Shortform for indoor air in Offices and Schools in accordance with the MADEP Shortform User's Guide dated April 2014 and applicable provisions of the MCP. For the evaluation of current exposures at a school, the evaluation addressed both the students (based on the actual school schedule, such as 8 hours/day, 180 days/year, and 6 years) and teachers/administrators (based on the actual school schedule, for 27 years). The maximum concentration for each CVOC that was detected in indoor air was utilized as an Exposure Point Concentrations (EPCs) in the exposure evaluation. A copy of the Shortform Risk Characterization calculation tables is included in **Appendix C**.

In summary, a Condition of No Significant Risk exists when the cumulative receptor non-carcinogenic risk hazard index (HI) does not exceed 1 and the cumulative excess lifetime cancer risk (ELCR) is below the $1x10^{-5}$. As indicated on the Shortform worksheets contained in **Appendix C**, the cumulative HI level for the indoor air pathway is less than 1. In addition, the cumulative ECLR is below $1x10^{-5}$. Hence, the highest concentrations of CVOCs that were detected in indoor air within the school building do not pose a Significant Risk to the students, teachers and administrators that occupy the school.

Soil Gas

An assessment of sub-slab soil gas was performed after the completion of the above referenced indoor air testing on February 23, 2018. The purpose of the assessment was to evaluate the extent of CVOC contamination beneath the footprint of the existing school building. Each soil gas sample was obtained from a temporary point installed through the lowest level floor slab of the building and submitted for laboratory analysis for the presence of CVOCs by the TO-15 Method SIM. The location of each soil gas point was selected to provide a representative evaluation of soil gas conditions beneath the footprint of the school building. Each of the temporary soil gas points (SG-1 through SG-6) was installed by personnel from McPhail Associates, LLC in general accordance with the installation procedures provided in the DEP's October 2016 Vapor Intrusion Guidance Policy #WSC 16-435. The detected concentrations of the CVOCs were compared to the applicable commercial/industrial soil gas screening values established by the DEP. The location of

each soil gas point is shown on **Figure 2A**. The results of the soil gas testing are summarized in **Table 2**. Laboratory data reports associated with the soil gas testing are provided in **Appendix D**.

In summary, elevated concentrations of CVOCs were detected in a majority of the soil gas samples that were obtained from beneath the school building. Of the six samples that were analyzed, three soil gas samples (SG-3, SG-4 and SG-6) exhibited concentrations of PCE which exceeded the DEP commercial/industrial soil gas screening value of 290 ug/m^3. While below the DEP screening value, concentrations of PCE that are considered to be elevated were present in soil gas samples SG-2 and SG-5. Although the remaining CVOCs were not detected at concentrations which exceed the DEP commercial/industrial thresholds values, the analysis of each sample indicates that contamination in groundwater is affecting soil gas beneath the entire footprint of the school building.

Design Considerations for Vapor Mitigation

Given that elevated concentrations of CVOCs are present in sub-slab soil gas and groundwater beneath a majority of the current school building, the potential for their migration to indoor air exists within new structures that may be constructed and structures that may be renovated for the proposed Arlington High School project. Specifically, the construction of new buildings and renovation of existing buildings create pressure differentials as well as new entry points that may increase the migration rate of subsurface CVOC contamination into indoor air. In addition, the concentrations of CVOCs in groundwater and soil gas may change over time with the migration of the contaminant plume and seasonal fluctuations such as groundwater depths and temperature. As a result, the installation of a vapor mitigation system is recommended beneath newly constructed buildings and/or the renovation of existing buildings that are proposed for the Arlington High School project.

As referenced above, the potential for vapor intrusion will exist within any newly constructed and/or the renovated structures which may be proposed for the Arlington High School project. Three primary factors that drive the occurrence of vapor intrusion in buildings include:

- contaminant properties, concentrations and locations;
- potential entry routes (e.g., floor drains, French drains, sumps, seams or cracks in the floor slab, utility penetrations, and open top blocks in the foundation walls); and
- pressure differentials between the building and the subsurface that could draw contaminants from the soil into the building.

Design considerations for the mitigation of the potential vapor intrusion condition can be passive (such as vapor barriers and sub-slab venting systems) or active (using fan to depressurize the sub-slab area). However, the elements of both passive and active systems are typically combined (e.g., a vapor barrier may be installed along with active sub-slab depressurization) or a passive ventilation system may be designed to allow for conversion to an active system (e.g., by adding blowers) at a later time if the passive system fails to mitigate the vapor intrusion condition.

For construction of new buildings, there are five basic design considerations for an effective vapor intrusion mitigation system:

- permeable sub-slab support material (e.g., gravel);
- venting all sub-slab areas below occupied spaces;
- properly-sized sub-slab and riser piping;
- a sealed vapor barrier; and
- if an active system is considered necessary, a properly-sized blower to maintain sufficient negative pressure beneath the slab.

For the renovation of existing buildings, vapor mitigation design considerations that are referenced above for the construction of new buildings may be incorporated as well as the following design components;

- sealing of potential vapor intrusion pathways (i.e. existing cracks in slab, sumps, and floor penetrations);
- construction of new floor slabs that are raised above existing floor slabs to facilitate installation of a sub-slab depressurization system and/or vapor membrane; and
- building pressurization (HVAC system creating positive pressure loads).

We trust that the above information is sufficient for your present requirements. Should you have any questions concerning the information presented herein, please do not hesitate to call us.

Very truly yours,

McPHAIL ASSOCIATES, LLC

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