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February 1, 2016

Ms. Dilan Roe, PE
Alameda County Department of Environmental Health
1131 Harbor Bay Parkway
Alameda, California 94502

Re: Approval of the Petroleum Vapor Intrusion Risk Evaluation and Addendum for 3093 Broadway, Oakland, CA

Dear Ms. Roe:

As requested by the Alameda County Department of Environmental Health (ACEH), I have performed technical reviews of the October 1, 2015 Petroleum Vapor Intrusion (PVI) Risk Evaluation and the January 28, 2016 Petroleum Vapor Intrusion Risk Evaluation Addendum for the fuel release case at 3093 Broadway, Oakland, California (the site). The risk assessment reports were prepared by Langan Treadwell Rollo (Langan), on behalf of the property owner and developer, 3093 Broadway L.L.C. Langan evaluated potential human health risk at the future development from vapor intrusion of petroleum compounds in groundwater and soil gas to indoor air.

Petroleum compound concentrations in soil gas were assessed based on sampling results from 13 soil gas wells, sampled in November 2014 and August 2015. The risk evaluation also considered future off-gassing of residual petroleum in groundwater as an ongoing source to soil gas. Routine groundwater monitoring at the site has been ongoing since 1991. The models developed in Langan's risk evaluation consider site construction details planned for 2016. Specifically, the automobile dealership will be demolished, the site will be graded with a resulting reduction in ground surface elevation of 1 to 18 feet, a concrete foundation will be poured, and a new building will be constructed. The development will include two levels of parking structure on the ground and first floors, with overlying residential units, and ground floor commercial/retail units fronting Broadway.

The risk evaluation was conducted in accordance with the United States Environmental Protection Agency (EPA) and the California Department of Toxic Substances Control (DTSC) guidelines for assessing vapor intrusion and human health risk. Langan's evaluation is based on conservative assumptions and includes a sensitivity analysis that concludes there is sufficient margin for error in the model input parameters. Langan concludes that residual petroleum compounds in soil vapor and groundwater beneath the site do not pose an unacceptable carcinogenic risk or non-carcinogenic hazard by potential PVI to future residents or commercial workers at the proposed development. I concur with Langan's risk evaluation approach and conclusions.

Sincerely,

Xuannga "Sonia" Mahini, MPH

1076 Carol Lane #90, Lafayette, CA 94549 ◆ 925.272.8811 Phone ◆ 888.882.1780 Fax ◆ www.norzod.com

February 1, 2016

Mr. Karel Detterman, P.G.
Hazardous Materials Specialist
Alameda County Department of Environmental Health
1131 Harbor Bay Parkway
Alameda, CA 94502
San Francisco, CA 94102

Re: Petroleum Vapor Intrusion Risk Evaluation Addendum
3093 Broadway, Oakland, CA
Site Cleanup Program Case No. Ro0000199

Dear Ms. Detterman,

Please find attached *Petroleum Vapor Intrusion Risk Evaluation Addendum* for the Former Connell Oldsmobile site, located at 3093 Broadway in Oakland, California. The Report has been prepared by Langan Treadwell Rollo.

I declare, under penalty of perjury, that the information and/or recommendations contained in the attached document or report is true and correct to the best of my knowledge.

OWNER:

3093 BROADWAY HOLDINGS, L.L.C.

By: 

Name: Stephen Siri

Title: Principal - CV 3093 Broadway, LLC

28 January 2016

Ms. Karel Detterman, P.G.
Hazardous Materials Specialist
Alameda County Department of Environmental Health
1131 Harbor Bay Parkway
Alameda, California 94502

Re: Petroleum Vapor Intrusion Risk Evaluation Addendum
3093 Broadway Street
Oakland, California
Project No.: 731637001

Dear Ms. Detterman,

On behalf of 3093 Broadway Holdings, L.L.C., Langan Treadwell Rollo (Langan) prepared this Addendum to the Petroleum Vapor Intrusion (PVI) Risk Evaluation dated October 1, 2015 for the development at 3093 Broadway in Oakland, California (the site). As discussed with the Alameda County Department of Environmental Health (ACEH), this Addendum incorporates additional site-specific details into the supplemental vapor intrusion model runs. In addition, this Addendum presents a table of vapor intrusion model input parameters used in the October 2015 PVI Risk Evaluation and a sensitivity analysis for model inputs. The sensitivity analysis was conducted in the supplemental model runs.

The supplemental model runs provide further risk analysis of the soil gas and groundwater data for the site. Concentration data from additional groundwater and soil vapor wells were used as inputs to the models and the resultant potential future human health risk was evaluated to demonstrate temporal and spatial trends. Also, site-specific features of the development were incorporated in the analysis, including residential units on the third floor and above. The results of the additional modeling indicate that the updated risk and hazard index values are lower than the original estimates from the October 2015 PVI Risk Evaluation.

This Addendum includes the following report sections:

Vapor Intrusion Pathway and Potential Receptors: The potential exposure pathway is further described in this section of the Addendum. The conceptual site model (CSM) for the October 2015 PVI Risk Evaluation is unchanged in this Addendum.

Data Evaluation: This Addendum discusses the differences in soil gas concentrations detected in November 2014 and in August 2015. In addition, ambient air and groundwater concentrations are discussed.

Vapor Intrusion Modeling: Supplemental model runs were performed, including modeling of the detected volatile organic compounds (VOCs) at three site locations. These locations were selected based on the availability of both groundwater and soil vapor data in order to provide comparison of health risk results generated by both the BioVapor and Johnson and Ettinger

(J&E) models. Additional vapor intrusion model runs were also performed as part of the sensitivity analysis.

Summary and Conclusions: This Addendum concludes that the residual petroleum concentrations at the site do not pose an unacceptable risk to human receptors at the future development via vapor intrusion and that the original health risk results presented in the October 2015 PVI Risk Evaluation were very conservative.

VAPOR INTRUSION PATHWAY AND POTENTIAL RECEPTORS

Residual petroleum compounds in soil gas have the potential to migrate upward via seams and cracks in a foundation into an overlying structure. Petroleum compounds in groundwater are a potential contributing source of VOCs detected in soil gas. After construction, building occupants could potentially be exposed to petroleum compounds infiltrated into indoor air via vapor intrusion. These human receptors will include ground floor commercial workers (e.g., garage attendants and retail workers at future shops along Broadway) and residents on the third floor, above two levels of parking. The vapor intrusion model inputs used in the October 2015 PVI Risk Evaluation conservatively assumed the residents would be on the second floor. The supplemental model runs presented in this Addendum accurately consider that future residents will occupy the third floor of the development.

DATA EVALUATION

Groundwater data has been collected from groundwater monitoring wells at the site since 1991. Soil vapor wells were installed and sampled in November 2014 and August 2015. Two deep soil gas samples were collected from groundwater monitoring wells MW-1 and MW-4 during the August 2015 sampling event. The October 2015 PVI Risk Evaluation discusses biodegradation of petroleum compounds in groundwater and in soil gas at the site.

Groundwater Temporal Trends

The twenty-five year history of groundwater monitoring at the site showed petroleum compound concentration reductions of up to several orders of magnitude. Ongoing enhanced biodegradation of petroleum compounds is expected to expedite the reduction of the residual petroleum mass in site groundwater. Recent groundwater monitoring data at the site showed a continuing decreasing trend or stable trend (Langan, 2014; Langan, 2015a). For example, benzene was detected at 4,400 micrograms per liter (μg/L) in well MW-4 in June 2013, and at 1,900 μg/L in May 2014. Petroleum concentrations in wells MW-1 and MW-16B, which are both located in the service bay, increased from 2013 through 2014 following shutdown of an air-sparge/dual-phase extraction (AS/DPE) system; however, levels in well MW-1 subsequently stabilized in 2015. An evaluation of temporal trends in the calculated risk for select groundwater sampling locations is included in Attachment A.

Soil Gas Temporal Trends

Petroleum analytical results from soil vapor wells SV-4 and SV-10 collected in August 2015 are generally lower than levels measured in November 2014 for these same wells. For example, benzene was detected in soil gas at SV-10 at 4,300 micrograms per cubic meter ($\mu g/m^3$) in

November 2014 (cool fall month) and at only 2.3 μg/m^3 in August 2015 (dry summer month). Petroleum constituents detected in soil gas include benzene, toluene, and ethylbenzene (Langan, 2015b). An evaluation of temporal trends for select soil gas sampling locations is included in Attachment A.

Ambient Air Data

Site receptors could also be potentially exposed to site-related chemicals in outdoor air; however, it is expected that outdoor air concentrations are lower than levels in indoor air due to wind dispersion. In addition, regional atmospheric pollutants are likely to affect ambient air concentrations. Accordingly, only indoor air is considered in the PVI Risk Evaluation and this Addendum. Toluene was the only site-related chemical detected in outdoor air (i.e., ambient air). The detected toluene concentrations in outdoor air (2.7 μg/m^3 in November 2014 and 2.0 μg/m^3 in August 2015) are below the San Francisco Regional Water Quality Control Board (Water Board) Environmental Screening Level (ESL) for indoor air for residential and commercial receptors by at least two orders of magnitude.

VAPOR INTRUSION MODELING

In the October 2015 PVI Risk Evaluation, Langan utilized two vapor intrusion models to evaluate potential human health risks posed by petroleum compounds at the site. Langan used the American Petroleum Institute (API) BioVapor Model (API 2010, version 2.1) to quantitatively evaluate future human health risk from potential migration of petroleum compounds from groundwater into indoor air. BioVapor is a steady-state, one-dimensional spreadsheet that incorporates first-order aerobic biodegradation with the heuristic vapor intrusion model developed by Johnson and Ettinger. In addition, Langan used the J&E SG-SCREEN model to evaluate potential human health risk from 1,2-dichloroethane detected in soil vapor.

This section of the Addendum includes the following subsections:

- October 2015 Model Input Parameters: the model input parameters applied in the October 2015 PVI Risk Evaluation are described, as requested by the ACEH.

- Foundation Specifications: Discussion of the foundation specifications described in engineering plans for the site.

- Depth to Groundwater Beneath the Development: The depth to groundwater beneath the future development is assessed based on the development plans.

- Vapor Attenuation Estimates in the Models: The vapor attenuation factors are reported, and the suitability of these estimates as they relate to estimated indoor air concentrations is discussed.

- Supplemental Residential Model Runs: Supplemental model run inputs, input rationale, and the associated risk characterization are presented.

- Supplemental Model Run Results

- Sensitivity Analysis: The sensitivity analysis includes identification of critical input parameters, adjustments to critical inputs, risk characterization, and interpretation of results.

- Discussion of J&E Model Sensitivity Analysis

- Discussion of BioVapor Model Sensitivity Analysis

October 2015 Model Input Parameters

In the California Department of Toxic Substances Control (DTSC) version of the soil gas screening level J&E model, Langan selected input values for:

(1) The soil gas sampling depth below grade,

(2) Soil gas concentrations, and

(3) The vadose zone soil type.

The building mixing height default value is integrated into the J&E SG-SCREEN model algorithm via the "intercalcs" spreadsheet tab and was not modified in the soil gas models. Effective total fluid saturation, effective diffusion and total porosity are model default values for the selected soil type at the site, as classified by the Unified Soil Conservation System (USCS), and the chemical-specific Henry's constant. User-defined inputs to the BioVapor models included:

(1) Mixing height,

(2) Depth-to-groundwater (from bottom of foundation),

(3) Chemical concentrations in groundwater, and

(4) Vadose zone parameters including soil porosity, soil water content, and soil bulk density.

Values designated by the DTSC and U.S. Environmental Protection Agency (EPA) as "default," reflect conservative assumptions, specific to the United States or California. Default values are used by the EPA and the DTSC to develop regulatory risk-based screening levels for soil gas and groundwater. Accordingly, Langan's use of default values where indicated below results in a reasonably protective analysis.

The following table presents the input parameters for the residential and commercial SG-SCREEN and BioVapor models used to estimate risks and hazards associated with exposure VOCs in indoor air:

Vapor Intrusion Input Parameters

Parameter	Residential Value	Commercial Value	Basis
Depth below grade to bottom of space floor (L_F)	15 cm	15 cm	EPA/DTSC Default for slab-on-grade construction (the building foundation plans are discussed in detail in the subsequent report section)
Soil gas concentration (C_g)	Highest detected concentration ($\mu g/m^3$)	Highest detected concentration ($\mu g/m^3$)	Two sampling events were conducted
Groundwater concentration (C_w)	Highest detected concentration $\mu g/L$	Highest detected concentration $\mu g/L$	Three sampling events (between 2013 and 2014) were conducted after shutdown of the air sparging/dual phase extraction system
Soil gas sampling depth (L_S) J&E Models	182.88 cm (6 feet)	182.88 cm (6 feet)	Sample Depth at SV-10 (this depth selection is described in the October 2015 PVI Risk Evaluation)
Depth to groundwater (L_T), BioVapor Models	274.32 cm (9 feet)	274.32 cm (9 feet)	90th Percentile Projected Post-Construction Depth-to-Water below the bottom of the foundation
Annual Median Soil Temperature (T_S)	24°C	24°C	DTSC Default, appropriate for the San Francisco Bay Area
Soil-building pressure differential (ΔP)	40 g/cm-s^2	40 g/cm-s^2	EPA/DTSC Default
USCS Soil Type	Sandy Clay	Sandy Clay	Site Boring Logs
Mixing height J&E Models	2.44 m (8 feet)	3.66 m (12 feet)	EPA/DTSC Default/Integrated
Mixing height BioVapor Models	3.66 m (12 feet)	3.66 m (12 feet)	Site-Specific

Parameter	Residential Value	Commercial Value	Basis
Dry bulk density (ρb^A)	1.63 g/cm^3	1.63 g/cm^3	EPA/DTSC generic from USCS classification for site soil
Soil total porosity (n^V)	0.385 unitless	0.385 unitless	EPA/DTSC default value, based on USCS classification for site soil
Soil water-filled porosity ($\theta_W{}^V$)	0.197 cm^3/cm^3	0.197 cm^3/cm^3	EPA/DTSC default value based on USCS classification for site soil
Average vapor flow rate into building (Q_{SOIL})	5 L/min	5 L/min	EPA/DTSC Default
Air Exchange Rate (AER), J&E Models	0.5 (hour)$^{-1}$	1.0 (hour)$^{-1}$	DTSC Default
(AER), BioVapor Models	0.25 (hour)$^{-1}$	0.5 (hour)$^{-1}$	EPA Default
Exposure Duration (ED)	26 years	25 years	EPA/DTSC Default
Exposure Frequency (EF)	350 days/year	250 days/year	EPA/DTSC Default
Carcinogen Average Time (AT_c)	70 years	70 years	EPA/DTSC Default
Non-Carcinogen Averaging Time (AT_{nc})	26 years	25 years	EPA/DTSC Default

Notes: DTSC Default = California DTSC Vapor Intrusion Guidance recommended default value
EPA Default = EPA User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings recommended default value

Foundation Specifications

The foundation design is described in the plans prepared by Hoogerwerf Engineering Group, Inc., dated 10 August 2015. These plans have been submitted to the City of Oakland (the City). Although the building permit has not been obtained, the City did not have any comments to the foundation design in its plan check review. The garage floor will be slab-on-grade, with concrete thickness alternately 5 inches (12.7 centimeter [cm]) or 18 inches (38.1 cm). The 18-inch thick mat slab sections (of which there will be five) comprise a structural element of the foundation design. An 18-inch thick mat slab will be placed over an approximately 3,500 square foot area south of the former underground storage tanks (USTs), where the groundwater treatment system was installed. At the locations of structural columns, the concrete floor slab will be supported by footings. The footings are generally spaced on an approximately 20 feet by 20 feet grid and range in thickness from 18 to 48 inches. Generally, many of the footings over the

area with petroleum-impacted groundwater will be 26 inches thick and 8 ½ feet by 8 ½ feet square. The combined thickness of the floor slab, subbase, and these footings will be 48 inches. The commercial and residential J&E and BioVapor models each assume the floor slab thickness (i.e., depth below grade to the bottom of the enclosed floor space) will be 15 cm, representing a conservative assumption given the approved plans described above.

Depth to Groundwater Beneath the Development

Based on the structural plans, the post-development depth to source from the floor elevation of the lower level garage on the western side of the property is estimated to be 10 to 12 feet. The soil column beneath the sub-base will be thicker beneath the eastern portion of the property; the depth to groundwater from the floor elevation is estimated to range from 20 to 26 feet beneath the portion of the future development that will be located near Broadway. The BioVapor models assume a post-development vadose zone thickness of 9 feet as described in the October 2015 PVI Risk Evaluation. The depth-to-source applied in the October 2015 SV-10 soil gas models was the sampling depth, specified as six feet below ground surface (bgs).

Vapor Attenuation Estimates in the Models

The J&E model calculates a vapor concentration attenuation factor for soil gas through the soil column between the groundwater table and the bottom of the overlying building foundation into indoor air. This factor is dependent on the soil moisture content. In lieu of site specific soil moisture data, J&E employs the van Genuchten water retention model to approximate soil moisture content. This model generates a lower soil moisture content for all soil types than those predicted by other available water retention models, resulting in more conservative attenuation factors. Langan selected the values for soil porosity, soil moisture content, and dry bulk density from the J&E default values for sandy clay soil type, the predominant soil type in the subsurface. Use of the generic soil-dependent parameters corresponding to sandy clay is also likely to provide a conservative estimate of vapor attenuation. The effects of soil type selection are further discussed in the sensitivity analysis.

The BioVapor vapor intrusion models apply a default groundwater-to-deep-soil-gas attenuation factor of 0.1 based on empirical data indicating VOC concentrations in deep soil gas are lower than would be predicted by equilibrium partitioning (API 2012). Although the EPA does not specify a default groundwater-to-deep-soil-gas attenuation factor, the various subsurface to indoor air attenuation factors imply a default groundwater-to-deep-soil gas attenuation factor of 0.1 (EPA 2002). This assumption is consistent with the USEPA use of a groundwater-to-indoor-air attenuation factor α_{gw} of 0.001 and the soil gas-to-indoor air attenuation factor α_{sg} of 0.03 for soil gas in the "*Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites"* (EPA 2015).

Supplemental Residential Model Runs

Supplemental J&E and BioVapor model runs were performed to address the third residential floor of the future development. The model spreadsheets are included in Attachment B. The supplemental model runs incorporate the following parameters:

1) Langan evaluated potential residential health risks derived from soil gas data using the J&E ADVANCED (ADV model), and from groundwater data using BioVapor. When the J&E SG-ADV model was used to evaluate location-specific soil gas data, a 1,000-fold bioattenuation of petroleum vapor was assumed for petroleum constituents (SWRBC 2012). VOC concentration data from three pairs of co-located soil vapor and groundwater wells were input to the vapor intrusion models: MW-4 and SV-12, MW-18 and SV-10, and MW-6 and SV-4. For each of these locations, the results from all sampling events were used to calculate the incremental lifetime cancer risk and the hazard index. For wells SV-12, SV-10, and SV-4, post-development projected soil gas sampling depths of 12.5, 6, and 8 feet bgs, respectively were used as inputs. For groundwater, depth was assumed to be 9 feet bgs, as described in the October 2015 PVI Risk Evaluation.

2) To account for the reduction in concentrations from the first floor garage and second floor retail spaces to the third floor residential units, modification of the mixing height is endorsed by EPA to represent such scenarios in which vapor concentrations attenuate between floors (EPA, 2002). The residential scenario at higher floors (e.g., third floor and above) was evaluated using a 20 foot mixing height (609.6 cm) to account for the attenuation of concentrations during migration from the ground to the third floor. The use of a larger mixing height (i.e., larger residential unit volume) is a surrogate for approximating migration across two lower floors.

3) There is significant variation in building ventilation rates, ranging from 0.1 air exchanges per hour (AEH) for "air-tight" houses to over 2 AEH, depending on season and climactic region (USEPA, 2002). The air exchange rate (AER) is inversely related to indoor air concentrations; therefore, use of a lower ventilation rate will result in higher risk and hazard estimates. The AER in the BioVapor models was set to the EPA default of 0.25/hour in the PVI Risk Evaluation. The supplemental models incorporate the Cal-EPA default value of 0.5/hour for the residential scenario. This change reduces the risk estimates by a factor of 2.

4) The body weight of residential adults in the supplemental models was adjusted upward from 70 kg to 80 kg, consistent with recent DTSC and EPA values.

Supplemental Model Run Results

Cancer risk estimates were compared to an acceptable cumulative risk threshold of 1E-06 for multiple chemicals and a single-chemical target risk of 1E-06. The EPA's acceptable incremental lifetime cancer risk range is 1E-06 to 1E-04, with 1E-06 as the point of departure for risk management decisions. This represents an incremental increase of 1 in 1,000,000 in the chance of developing cancer over a lifetime. Systemic hazards were compared to a hazard quotient (HQ) of 1 for single chemicals and an unsegregated hazard index of 1 (HI) for multiple chemicals. If the site-specific cumulative HI exceeds the effects-based threshold (i.e. HI exceeds 1), segregation of HI based on target organs may be needed, before a conclusion as to whether or not there may be concern for potential non-carcinogenic effects may be made.

Gasoline Range Total Petroleum Hydrocarbon (TPHg) and Diesel Range TPH (TPHd) are not included in the J&E SG-ADV models because these bulk quantities were not measured in soil

gas. TPHg and TPHd are evaluated as non-carcinogens and their exclusion does not significantly affect the health risk results and recommendations. TPHg, minus concentrations of target analytes that are already included in the TPHg concentration, and TPHd data were included in the BioVapor groundwater models because they represent an oxygen demand, thus reducing the biodegradation potential for risk drivers.

The following table summarizes the results of the BioVapor and J&E models for each of the paired locations:

Risk Characterization for Supplemental Model Runs

Location/Date	Model	Cumulative Cancer Risk	Hazard Index	Acceptable
SV-04 (November 2014)	J&E Residential Soil Gas Advanced	1E-10	7E-06	Yes
SV-04 (August 2015)	J&E Residential Soil Gas Advanced	2E-11	8E-06	Yes
MW-06 (June 2013)	BioVapor Residential Groundwater	5E-19	1E-14	Yes
MW-06 (May 2014)	BioVapor Residential Groundwater	5E-19	1E-14	Yes
MW-06 (November 2014)	BioVapor Residential Groundwater	7E-18	3E-13	Yes
SV-10 (November 2014)	J&E Residential Soil Gas Advanced	8E-09	3E-04	Yes
SV-10 (August 2015)	J&E Residential Soil Gas Advanced	4E-10	2E-06	Yes
MW-18 (May 2015)	BioVapor Residential Groundwater	6E-21	2E-16	Yes
SV-12 (November 2014)	J&E Residential Soil Gas Advanced	5E-10	2E-06	Yes
SV-12 (August 2015)	J&E Residential Soil Gas Advanced	2E-09	3E-05	Yes
MW-04 (June 2013)	BioVapor Residential Groundwater	1E-10	4E-06	Yes
MW-04 (May 2014)	BioVapor Residential Groundwater	2E-14	7E-10	Yes

Results of the supplemental BioVapor and J&E SG-ADV model runs indicate acceptable cumulative excess cancer risk and HI at each modeled location for residential receptors using both soil gas and groundwater data. The individual HQs and HIs associated with the vapor intrusion pathway do not exceed the threshold level of 1. Individual excess cancer risks and cumulative cancer risk estimates associated with indoor air inhalation are below the *de minimis*

risk level of 1E-06. It should be noted that the potential health risks estimated from soil gas data and the J&E model for three pairs of co-located soil vapor and groundwater wells (MW-4 and SV-12, MW-18 and SV-10, and MW-6 and SV-4) are higher than levels predicted from groundwater and the BioVapor model. These J&E model results confirmed the insignificant health risks to future site occupants at current residual levels of petroleum in soil gas. These supplemental model runs also depict a consistent decreasing temporal trend in health risks at the site, based on both soil gas and groundwater data.

Sensitivity Analysis

Consistent with DTSC recommendations (DTSC, 2011), a sensitivity analysis was performed on the supplemental model runs to identify and evaluate the most sensitive model input parameters and determine their effects on the model results. The input parameters for the J&E and BioVapor models used in the PVI risk evaluation are the same; however, BioVapor includes oxygen limited chemical biodegradation. In the absence of aerobic biodegradation, the BioVapor model is equivalent to the J&E vapor intrusion model.

In an assessment of predicted vapor transport characteristics, Johnson (2005) determined that the critical (i.e., most sensitive) parameters in the J&E model are the source depth, effective diffusion coefficient, AER, and the building mixing height. Additional analysis (Tillman & Weaver, 2006) demonstrated that the effective total fluid saturation and total porosity are also significant model input parameters that are dependent on soil type.

Selections for each of these input parameters are discussed below.

Effective diffusion coefficient, total fluid saturation and total porosity: These three parameters are accounted for in the model based on the selected soil type. Based on site-specific boring logs, the site is predominantly underlain by clayey to sandy silts and silty clay, with occasional thin beds of sand and silty sand. Thus, sensitivity analysis model runs were performed using a silty clay soil type. Silty clay has a higher total effective diffusion coefficient than sandy clay. Sandy clay was the soil type used in the PVI Risk Evaluation and in the supplemental model runs.

Air Exchange Rate and Mixing Height: The EPA's default building AER for residential use is 0.25 hr^{-1}, representing approximately the 10^{th} percentile value for southern California. The default residential AER was reduced to the EPA value to characterize model sensitivity for residential use in both the J&E SG-ADV and BioVapor models for soil gas at SV-10 and groundwater at MW-4. The building mixing height was set to default values in the J&E SG-ADV and BioVapor models. These default values in the sensitivity analysis are lower than the proposed height of indoor space for the residential scenario, assuming residential units are on the third floor.

Source Depth: To evaluate model sensitivity to source depth, 3 feet of vadose zone was subtracted from the assumed depth-to-groundwater (9 feet) and the post-redevelopment soil gas sampling depth at SV-10 (5 feet) to model indoor air concentrations should the building foundation be closer to the VOC source. In addition, the 1000X attenuation factor was not applied to petroleum constituents to account for the possibility that vadose zone thickness would not be sufficient to permit biological processes to this degree.

The adjustments to model inputs and rationale are presented in the table below:

Model Input Parameters for Sensitivity Analysis

Parameter	Residential Value, Supplemental Model Runs	Revised Residential Value, Sensitivity Analysis	Rationale
L_S	Groundwater: 9 feet bgs Soil Gas: 5 feet bgs	Groundwater: 6 feet bgs Soil Gas: 2 feet bgs	Adjusted by -3 feet Reduced source depth results in higher indoor air VOC concentrations
USCS Soil Type	Sandy Clay	Silty Clay	Silty clay has a higher total effective diffusion than sandy clay
ρb^A	1.63 g/cm^3	1.38 g/cm^3	Generic values from USCS
n^V	0.385 unitless	0.481 unitless	Generic values from USCS
$\theta_W{}^V$	0.197 cm^3/cm^3	0.216 cm^3/cm^3	Generic values from USCS
Mixing Height	6.096 m	2.44 m	Residential Default is 244 cm, or 8 feet
AER	0.5 (hour)$^{-1}$	0.25 (hour)$^{-1}$	EPA default value is lower than the DTSC default

Notes: DTSC Default = California DTSC Vapor Intrusion Guidance recommended default value
EPA Default = EPA User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings recommended default value

The table below presents the incremental excess cancer risk and hazard estimates associated with of the various iterations of the vapor intrusion models compared to the supplemental model results without any adjustments to critical inputs. The sensitivity analysis was conducted for the models using the data from wells SV-10 and MW-4. The sensitivity analysis results are expected to be similar for each well pair used in the supplemental models. The model spreadsheets are included in Attachment C.

Risk Characterization

Location/Model	Adjustment	Cumulative Cancer Risk	Hazard Index	Acceptable
SV-10/J&E Supplemental Model Run Result	--	4E-10	2E-06	Yes
SV-10/J&E Sensitivity Analysis	AER	9E-10	4E-06	Yes
	Mixing Height	1E-09	5E-06	Yes
	Soil Type	7E-10	3E-06	Yes
	Source Depth	9E-09	3E-04	Yes
MW-4/BioVapor Supplemental Model Run Result	--	2E-14	7E-10	Yes
MW-4/BioVapor Sensitivity Analysis	AER	4E-14	1E-09	Yes
	Mixing Height	5E-14	1E-09	Yes
	Soil Type	1E-08	4E-04	Yes
	Source Depth	6E-11	2E-06	Yes

Discussion of J&E Model Sensitivity Analysis

Adjustment of the source depth in the J&E SG-ADV models resulted in the largest increase in estimated cumulative excess cancer risk for future residential receptors due to the loss of biodegradation potential. Cancer risk rose slightly more than an order of magnitude from 4E-10 to 9E-09 as a result of this input parameter change. Similarly, the HI increased from 2E-06 to 3E-04 subsequent to the adjustment in source depth. This sensitivity analysis demonstrates that the vadose zone thickness may be 3 feet less than assumed in the supplemental models without resulting in unacceptable risks and hazards. Second to source depth, the adjustment in building mixing height resulted in some increase in estimated risks, with cumulative cancer risk rising from 4E-10 to 1E-09 and the HI increasing from 2E-06 to 5E-06. In all cases, the modeled cumulative excess cancer risks are below the *de minimis* risk point of departure (i.e., 1E-06) and the HI for systemic toxicants is below the threshold level of unity.

Discussion of BioVapor Model Sensitivity Analysis

Adjustment of the soil type resulted in the largest increase in estimated cumulative excess cancer risk for future residential receptors using groundwater data in the BioVapor model. Cancer risk increased six orders of magnitude from 2E-14 to 1E-08. Similarly, applying a higher permeability soil type in the BioVapor model resulted in a significant increase in the predicted HI (7E-10 to 4E-04). Secondary to soil type, decreased source depth resulted in higher risk and hazard estimates associated with groundwater data. Assuming groundwater underlies the future structure at a depth of 6 feet bgs results in an approximately three order of magnitude increase in the risk and hazard estimates. The sensitivity analysis demonstrates that the vadose zone thickness may be 3 feet less than assumed in the supplemental models without resulting in unacceptable risks and hazards. In all cases, the modeled cumulative excess cancer risks are below the *de minimis* risk level and the HI for non-cancer endpoints is below the threshold level of unity.

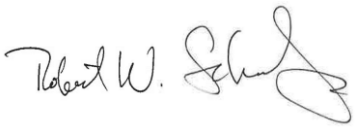
The results of the sensitivity analysis indicate that the BioVapor model is more sensitive than the J&E model when input parameters change.

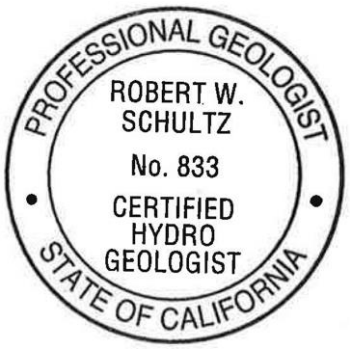
SUMMARY AND CONCLUSIONS

The objectives of the PVI Risk Evaluation were to determine whether the existing petroleum concentrations in groundwater and soil vapor would pose unacceptable risks to human health under the future development scenario via the vapor intrusion pathway. The sensitivity analysis demonstrates that there is sufficient margin for variation of the key model inputs, including source depth, AER, building mixing height, effective diffusion coefficient, total fluid saturation, and total porosity, without resulting in estimates of adverse health effects or lifetime risks above acceptable levels. Langan concludes that residual hydrocarbons in soil vapor and groundwater beneath the site do not pose an unacceptable carcinogenic risk or non-carcinogenic hazard by potential PVI to future residents or commercial workers at the proposed development.

As requested by the ACEH, Langan retained a Ms. Xuannga "Sonia" P. Mahini, MPH, of Norzod, LLC (Norzod) to review the risk evaluation conducted by Langan. Ms. Mahini will prepare a letter to the ACEH summarizing the findings of her review.

Sincerely,
Langan Treadwell Rollo





Emily Strake
Senior Project Chemist/Risk Assessor

Robert W. Schultz, CHG
Senior Project Manager

cc: Mr. Stephen Siri – 3093 Broadway Holdings L.L.C., 44 Montgomery Street, Suite 4050, San Francisco, CA 94104

Attachments:

Attachment A – Temporal Trends
Attachment B – Supplemental Models
Attachment C – Sensitivity Models

731637001.22 RS

REFERENCES

API, 2012, User Manual, BioVapor, A 1-D Vapor Intrusion Model with Oxygen-Limited Biodegradation, Version 2.1. American Petroleum Institute. November.

DTSC, 2011, Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Department of Toxic Substances Control, California Environmental Protection Agency. October.

Langan, 2014, Conceptual Site Model, 3093 Broadway, Oakland, California. October 17.

Langan, 2015a, Groundwater Well Installation and Monitoring Report, 3093 Broadway, Oakland, California, October 7.

Langan, 2015b, Petroleum Vapor Intrusion Risk Evaluation, 3093 Broadway, Oakland, California, October 1.

SWRBC, 2012, Technical Justification for Vapor Intrusion Media-Specific Criteria. State Water Resources Control Board. March.

Johnson, P., 2002, Identification of Application-specific Critical Inputs for the 1991 Johnson and Ettinger Vapor Intrusion Algorithm. Groundwater Monitoring & Remediation, Volume 25, Issue 1 pages 63-78. February.

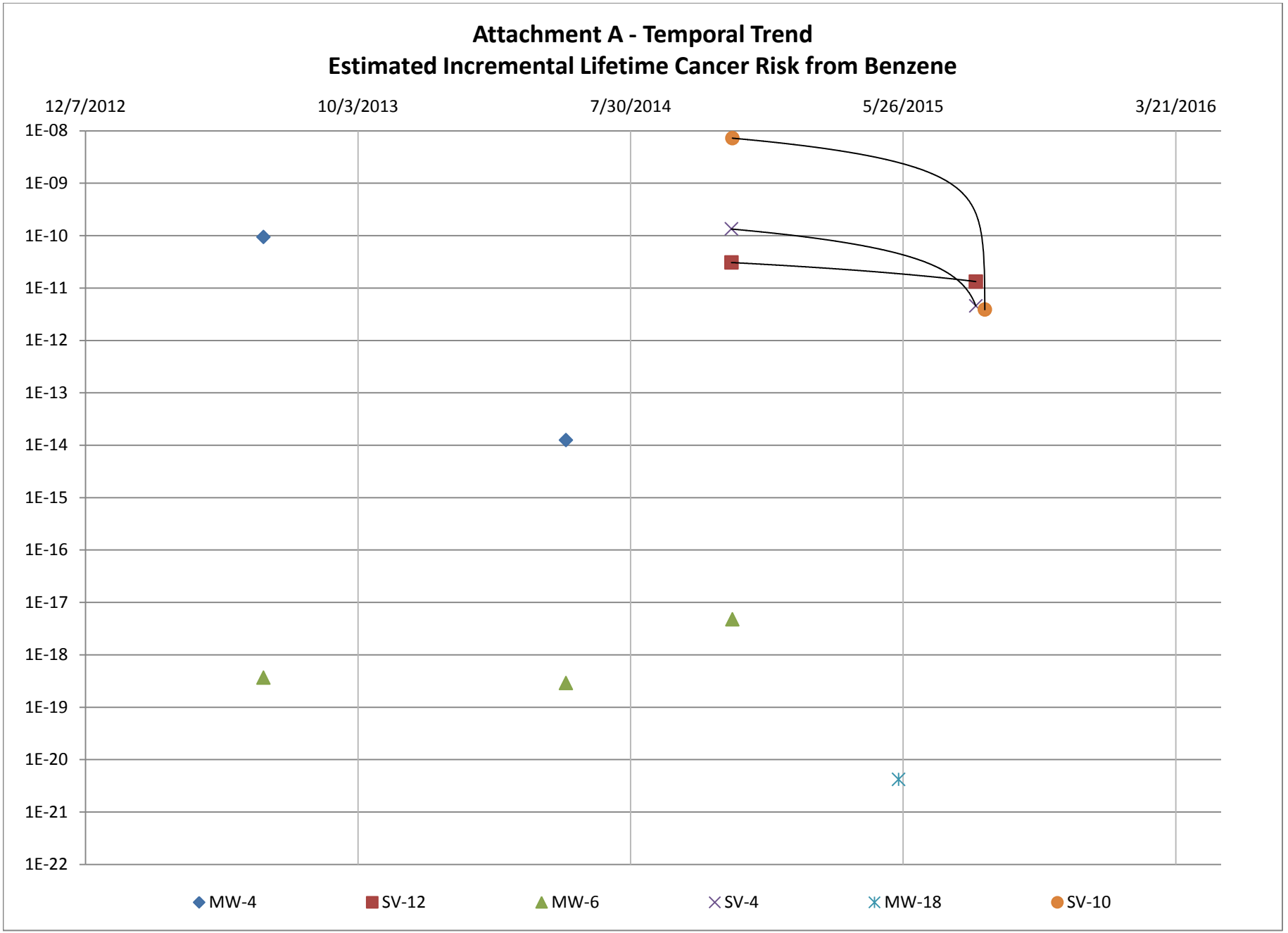
USEPA, 2002, Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance) EPA/530-D-02-20. Office of Superfund Programs, Hazardous Waste Management Division. Washington, DC. November.

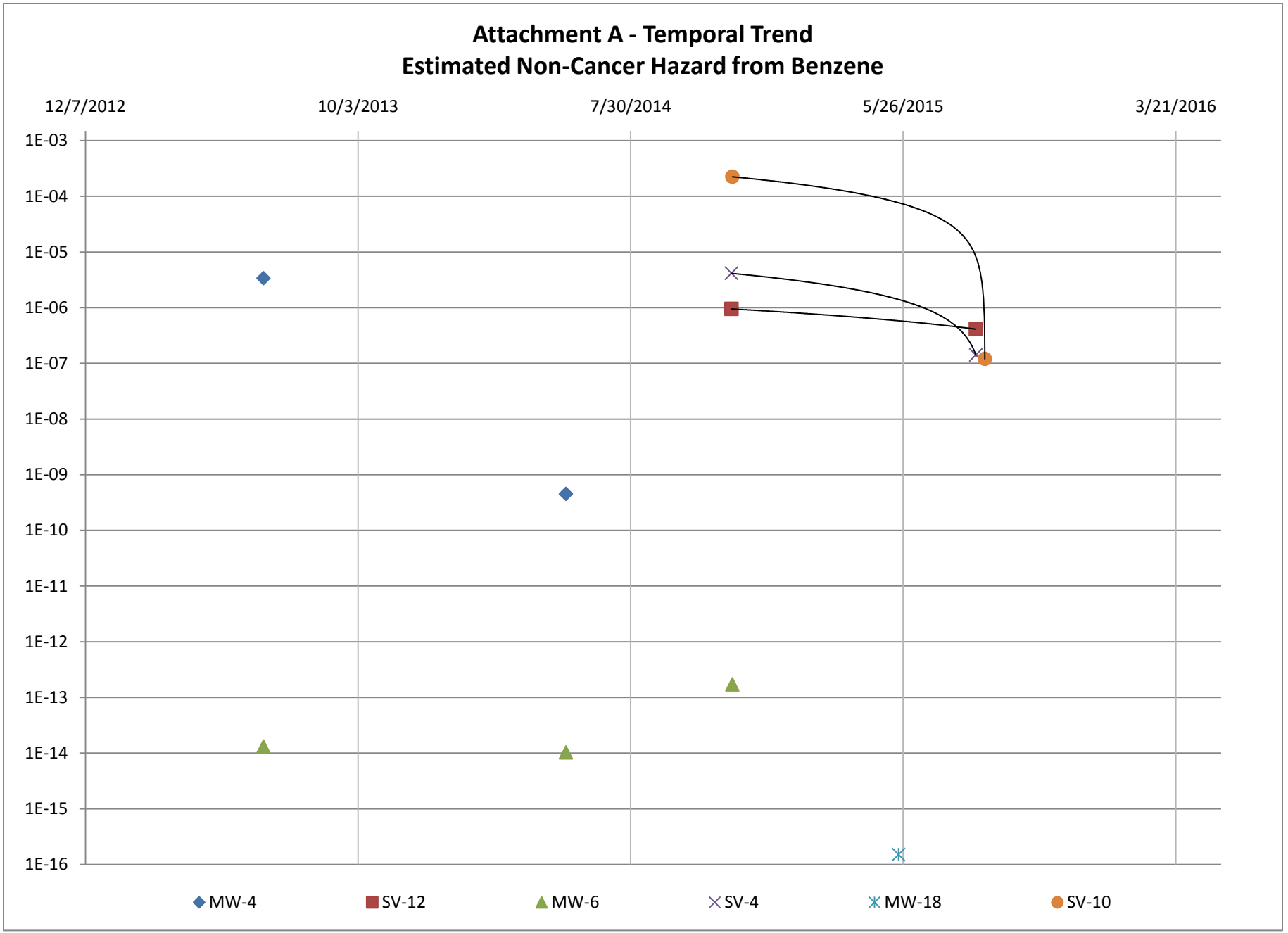
USEPA, 2004, User's Guide for Evaluating Subsurface Vapor Intrusion Into Buildings. Office of Emergency and Remedial Response, Washington, DC. February.

USEPA, 2015, Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites. EPA/510-R-15-001. Office of Underground Storage Tanks. Washington, DC. June.

Weaver, J.W. and Tillman, F.D, 2005, Uncertainty and the Johnson-Ettinger Model for Vapor Intrusion Calculations: U.S. Environmental Protection Agency Publication No. EPA/600/R-05/110.

ATTACHMENT A
TEMPORAL TRENDS


Attachment A - Temporal Trend
Estimated Incremental Lifetime Cancer Risk from Benzene
12/7/2012
10/3/2013
7/30/2014
5/26/2015
3/21/2016
1E-08
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
1E-15
1E-16
1E-17
1E-18
1E-19
1E-20
1E-21
1E-22
MW-4
SV-12
MW-6
SV-4
MW-18
SV-10

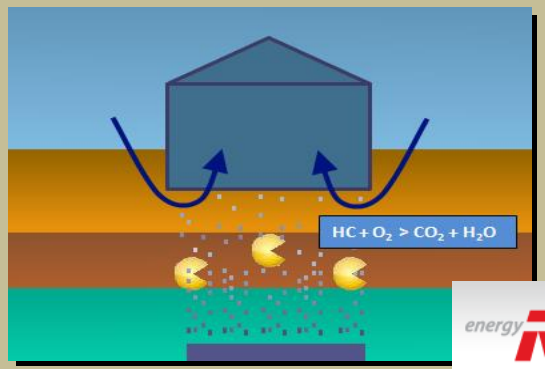

Attachment A - Temporal Trend
Estimated Non-Cancer Hazard from Benzene
12/7/2012
10/3/2013
7/30/2014
5/26/2015
3/21/2016
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
1E-15
1E-16
MW-4
SV-12
MW-6
SV-4
MW-18
SV-10

ATTACHMENT B
SUPPLEMENTAL MODELS

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



1) PROJECT INFORMATION

Site ID #:	City View
Address:	3093 Broadway, Oakland, CA
Completed by:	E. Strake
Date:	11-Dec-15
Job ID:	731637001

BioVapor Version 2.1 beta

2) INPUT SCREENS

1) **Environmental**

2) **Chemicals**

3) **Chemical**

Chemical

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface**

3) **Detailed**

BioVapor Input

Model Input Screens: 1 Environmental Factors | 2 Chemicals | 3 Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

2. Indoor Target Criteria

- (●) Do not perform backward Calculation
- ( ) Based on Indoor Risk / Hazard Target
- ( ) Specified Indoor Air Concentration Target

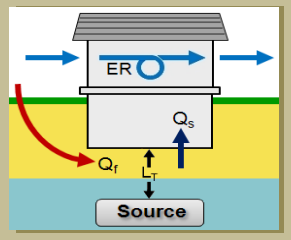
Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-06	(-)
Carcinogen Averaging Time	AT_C	70.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	26.00	yrs
Body Weight - Adult	BW	80.00	kg
Exposure Duration	ED	26.00	yrs
Exposure Frequency	EF	350.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
80.00	User Input Value
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	609.60	cm
Air Exchange Rate	ER	12.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	5.00E-03	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.08	cm/sec

5. Vadose Zone Parameters

Soil Porosity	$\theta_{T\text{-}soil}$	0.39	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.20	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	5.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.63	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	24.00	°C
Baseline Soil Oxygen Respiration Rate: Calculated from Foc	Λ_{base}	9.780E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	274.32	cm
Minimum O_2 Conc. For Aerobic Biodegradation		1.00	%

6. Commands and Options

Default Values

- (●) Residential
- ( ) Commercial / Industrial

Paste | Reset | Print | Next

Site Name: Test
Address: 999 Here

BioVapor Results

Date: Today
Completed By: TEM
Job ID: 9999

Model Input Screens

Environmental Factors | Chemicals | Chemical Concentrations

Chemical Database

2. Commands and Options

Home | Print

Previous | Next :: Results

1. Ground Water Source Chemical Concentrations

Chemical	ug/L
benzene	4.40E+03
ethylbenzene	1.70E+03
toluene	1.50E+04
xylenes (mixed isomers)	1.30E+04
TPH-GRO (C6-C10)	7.59E+04

1.10E+05 Total Entered Hydrocarbon Concentration (ug/L)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

3. Attenuation Factor

0.1 Groundwater to Deep Soil Gas Attenuation Factor

BioVapor Results

Model Output Screens

VI Risk | Subsurface Profile | Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-06

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration ug/L	Soil Gas Source Concentration ug/m³	Soil Gas to Indoor Air Attenuation Factor (-)	Target Indoor Air Concentration ug/m³-air	Predicted Indoor Air Concentration ug/m³-air	Hazard Quotient (-)	Risk Level (-)
benzene	4.40E+03	9.59E+04	1.10E-10	3.10E-01	1.06E-05	3.38E-06	9.40E-11
ethylbenzene	1.70E+03	5.28E+04	3.58E-10	9.70E-01	1.89E-05	1.81E-08	1.46E-11
toluene	1.50E+04	3.95E+05	3.36E-10	5.20E+03	1.33E-04	4.24E-07	-
xylenes (mixed isomers)	1.30E+04	2.69E+05	1.65E-11	7.30E+02	4.44E-06	4.26E-08	-
					3.860E-06	1.09E-10	

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: Not Selected

Chemical Name	Target Hazard Quotent (-)	Target Cancer Risk (-)	Target Indoor Air Concentration ug/m³-air	Soil Gas Source Concentration ug/m³	Effective Saturated Vapor Concentration ug/m³	Groundwater Source Concentration ug/L	Effective Solubility ug/L
benzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
ethylbenzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
toluene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
xylenes (mixed isomers)	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

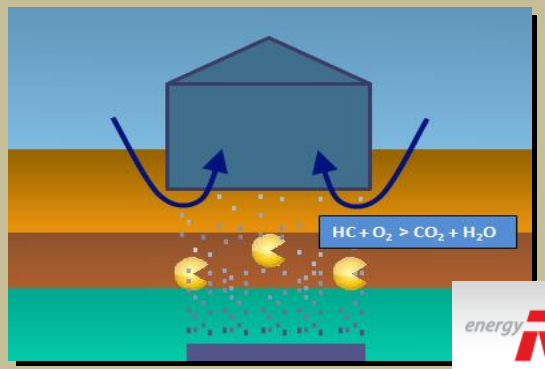
NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



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Site ID #:	City View
Address:	3093 Broadway, Oakland, CA
Completed by:	E. Strake
Date:	11-Dec-15
Job ID:	731637001

BioVapor Version 2.1 beta

2) INPUT SCREENS

1) **Environmental**

2) **Chemicals**

3) **Chemical**

Chemical

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface**

3) **Detailed**

BioVapor Input

Model Input Screens: 1 Environmental Factors | 2 Chemicals | 3 Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

2. Indoor Target Criteria

- (●) Do not perform backward Calculation
- ( ) Based on Indoor Risk / Hazard Target
- ( ) Specified Indoor Air Concentration Target

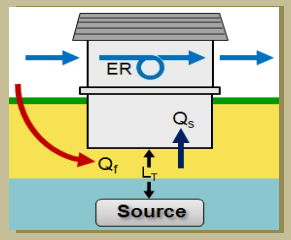
Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-06	(-)
Carcinogen Averaging Time	AT_C	70.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	26.00	yrs
Body Weight - Adult	BW	80.00	kg
Exposure Duration	ED	26.00	yrs
Exposure Frequency	EF	350.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
80.00	User Input Value
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	609.60	cm
Air Exchange Rate	ER	12.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	5.00E-03	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.08	cm/sec

5. Vadose Zone Parameters

Soil Porosity	$\theta_{T\text{-}soil}$	0.39	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.20	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	5.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.63	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	24.00	°C
Baseline Soil Oxygen Respiration Rate: Calculated from Foc	Λ_{base}	9.780E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	274.32	cm
Minimum O_2 Conc. For Aerobic Biodegradation		1.00	%

6. Commands and Options

Default Values

- (●) Residential
- ( ) Commercial / Industrial

Paste | Home | Print | Reset | Next

Site Name: Test
Address: 999 Here

BioVapor Results

Date: Today
Completed By: TEM
Job ID: 9999

Model Input Screens

Environmental Factors | Chemicals | Chemical Concentrations

Chemical Database

2. Commands and Options

Home | Print

Previous | Next :: Results

1. Ground Water Source Chemical Concentrations

Chemical	ug/L
benzene	1.90E+03
ethylbenzene	1.40E+03
toluene	1.50E+04
xylenes (mixed isomers)	9.40E+03
TPH-GRO (C6-C10)	4.56E+04
naphthalene	1.10E+03
trimethylbenzene, 1,2,4-	4.20E+03
trimethylbenzene, 1,3,5-	1.10E+03

7.97E+04 Total Entered Hydrocarbon Concentration (ug/L)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

3. Attenuation Factor

0.1 Groundwater to Deep Soil Gas Attenuation Factor

BioVapor Results

Model Output Screens

1 VI Risk | 2 Subsurface Profile | 3 Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-06

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration ug/L	Soil Gas Source Concentration ug/m^3	Soil Gas to Indoor Air Attenuation Factor (-)	Target Indoor Air Concentration ug/m^3-air	Predicted Indoor Air Concentration ug/m^3-air	Hazard Quotient (-)	Risk Level (-)
benzene	1.90E+03	4.14E+04	3.39E-14	3.10E-01	1.41E-09	4.49E-10	1.25E-14
ethylbenzene	1.40E+03	4.35E+04	2.35E-13	9.70E-01	1.02E-08	9.80E-12	7.91E-15
toluene	1.50E+04	3.95E+05	2.07E-13	5.20E+03	8.17E-08	2.61E-10	-
xylenes (mixed isomers)	9.40E+03	1.94E+05	1.62E-15	7.30E+02	3.14E-10	3.01E-12	-
naphthalene	1.10E+03	2.05E+03	4.29E-34	7.00E-02	8.81E-31	2.81E-31	9.41E-36
trimethylbenzene, 1,2,4-	4.20E+03	9.21E+04	4.03E-16	7.30E+00	3.71E-11	5.08E-12	-
trimethylbenzene, 1,3,5-	1.10E+03	3.31E+04	1.67E-14	6.30E+00	5.53E-10	1.52E-11	-
					7.232E-10	2.04E-14	

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: Not Selected

Chemical Name	Target Hazard Quotent (-)	Target Cancer Risk (-)	Target Indoor Air Concentration ug/m^3-air	Soil Gas Source Concentration ug/m^3	Effective Saturated Vapor Concentration ug/m^3	Groundwater Source Concentration ug/L	Effective Solubility ug/L
benzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
ethylbenzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
toluene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
xylenes (mixed isomers)	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
naphthalene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,2,4-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,3,5-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

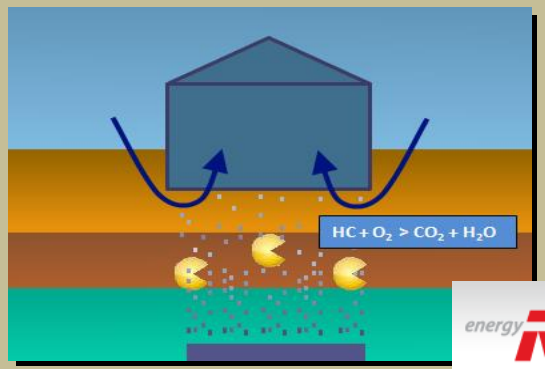
NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



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BioVapor Version 2.1 beta

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2) **Chemicals**

3) **Chemical**

Chemical

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface**

3) **Detailed**

BioVapor Input

Model Input Screens: 1 Environmental Factors | 2 Chemicals | 3 Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

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- ( ) Based on Indoor Risk / Hazard Target
- ( ) Specified Indoor Air Concentration Target

Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-06	(-)
Carcinogen Averaging Time	AT_C	70.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	26.00	yrs
Body Weight - Adult	BW	80.00	kg
Exposure Duration	ED	26.00	yrs
Exposure Frequency	EF	350.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
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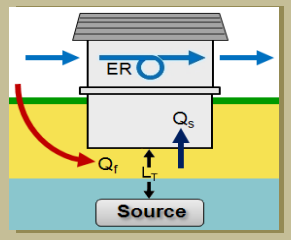
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	609.60	cm
Air Exchange Rate	ER	12.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	5.00E-03	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.08	cm/sec

5. Vadose Zone Parameters

Soil Porosity	$\theta_{T\text{-}soil}$	0.39	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.20	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	5.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.63	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	24.00	°C
Baseline Soil Oxygen Respiration Rate: Calculated from Foc	Λ_{base}	9.780E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	274.32	cm
Minimum O_2 Conc. For Aerobic Biodegradation		1.00	%

6. Commands and Options

Default Values

- (●) Residential
- ( ) Commercial / Industrial

Paste | Home | Print | Reset | Next

Site Name: Test
Address: 999 Here

BioVapor Results

Date: Today
Completed By: TEM
Job ID: 9999

Model Input Screens

Environmental Factors | Chemicals | Chemical Concentrations

Chemical Database

2. Commands and Options

Home | Print | Previous | Next :: Results

1. Ground Water Source Chemical Concentrations

Chemical	ug/L
benzene	2.40E+03
ethylbenzene	3.70E+02
toluene	3.00E+02
xylenes (mixed isomers)	6.80E+02
TPH-GRO (C6-C10)	1.13E+04

1.50E+04 Total Entered Hydrocarbon Concentration (ug/L)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

3. Attenuation Factor

0.1 Groundwater to Deep Soil Gas Attenuation Factor

BioVapor Results

Model Output Screens

VI Risk | Subsurface Profile | Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-06

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration (ug/L)	Soil Gas Source Concentration (ug/m^3)	Soil Gas to Indoor Air Attenuation Factor (-)	Target Indoor Air Concentration (ug/m^3-air)	Predicted Indoor Air Concentration (ug/m^3-air)	Hazard Quotient (-)	Risk Level (-)
benzene	2.40E+03	5.23E+04	7.86E-19	3.10E-01	4.11E-14	1.31E-14	3.66E-19
ethylbenzene	3.70E+02	1.15E+04	1.48E-17	9.70E-01	1.70E-13	1.63E-16	1.32E-19
toluene	3.00E+02	7.89E+03	1.20E-17	5.20E+03	9.47E-14	3.03E-16	-
xylenes (mixed isomers)	6.80E+02	1.41E+04	8.17E-21	7.30E+02	1.15E-16	1.10E-18	-
					1.360E-14	4.98E-19	

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: Not Selected

Chemical Name	Target Hazard Quotent (-)	Target Cancer Risk (-)	Target Indoor Air Concentration (ug/m^3-air)	Soil Gas Source Concentration (ug/m^3)	Effective Saturated Vapor Concentration (ug/m^3)	Groundwater Source Concentration (ug/L)	Effective Solubility (ug/L)
benzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
ethylbenzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
toluene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
xylenes (mixed isomers)	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

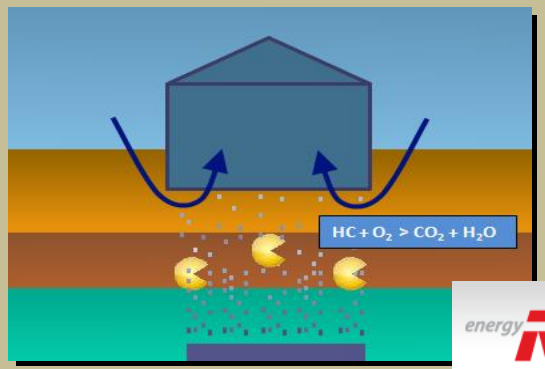
NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



1) PROJECT INFORMATION

Site ID #:	City View
Address:	3093 Broadway, Oakland, CA
Completed by:	E. Strake
Date:	11-Dec-15
Job ID:	731637001

BioVapor Version 2.1 beta

2) INPUT SCREENS

1) **Environmental**

2) **Chemicals**

3) **Chemical**

Chemical

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface**

3) **Detailed**

BioVapor Input

Model Input Screens: 1 Environmental Factors | 2 Chemicals | 3 Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

2. Indoor Target Criteria

- (●) Do not perform backward Calculation
- ( ) Based on Indoor Risk / Hazard Target
- ( ) Specified Indoor Air Concentration Target

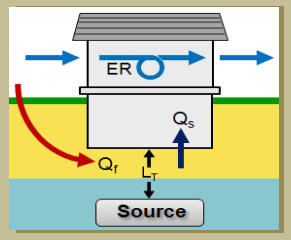
Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-06	(-)
Carcinogen Averaging Time	AT_C	70.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	26.00	yrs
Body Weight - Adult	BW	80.00	kg
Exposure Duration	ED	26.00	yrs
Exposure Frequency	EF	350.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
80.00	User Input Value
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	609.60	cm
Air Exchange Rate	ER	12.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	5.00E-03	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.08	cm/sec

5. Vadose Zone Parameters

Soil Porosity	$\theta_{T\text{-}soil}$	0.39	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.20	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	5.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.63	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	24.00	°C
Baseline Soil Oxygen Respiration Rate: Calculated from Foc	Λ_{base}	9.780E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	274.32	cm
Minimum O_2 Conc. For Aerobic Biodegradation		1.00	%

6. Commands and Options

Default Values

- (●) Residential
- ( ) Commercial / Industrial

Paste | Home | Print | Reset | Next

Site Name: Test
Address: 999 Here

BioVapor Results

Date: Today
Completed By: TEM
Job ID: 9999

Model Input Screens

Environmental Factors | Chemicals | Chemical Concentrations

Chemical Database

2. Commands and Options

Home | Print

Previous | Next :: Results

1. Ground Water Source Chemical Concentrations

Chemical	ug/L
benzene	3.70E+03
ethylbenzene	8.30E+02
toluene	5.30E+02
xylenes (mixed isomers)	8.40E+02
TPH-GRO (C6-C10)	9.31E+03
naphthalene	2.00E+02
trimethylbenzene, 1,2,4-	1.00E+03
trimethylbenzene, 1,3,5-	9.60E+01

1.65E+04 Total Entered Hydrocarbon Concentration (ug/L)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

3. Attenuation Factor

0.1 Groundwater to Deep Soil Gas Attenuation Factor

BioVapor Results

Model Output Screens

1 VI Risk | 2 Subsurface Profile | 3 Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-06

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration ug/L	Soil Gas Source Concentration ug/m^3	Soil Gas to Indoor Air Attenuation Factor (-)	Target Indoor Air Concentration ug/m^3-air	Predicted Indoor Air Concentration ug/m^3-air	Hazard Quotient (-)	Risk Level (-)
benzene	3.70E+03	8.06E+04	4.01E-19	3.10E-01	3.23E-14	1.03E-14	2.88E-19
ethylbenzene	8.30E+02	2.58E+04	8.06E-18	9.70E-01	2.08E-13	1.99E-16	1.61E-19
toluene	5.30E+02	1.39E+04	6.49E-18	5.20E+03	9.05E-14	2.89E-16	-
xylenes (mixed isomers)	8.40E+02	1.74E+04	3.79E-21	7.30E+02	6.58E-17	6.31E-19	-
naphthalene	2.00E+02	3.73E+02	6.29E-50	7.00E-02	2.35E-47	7.50E-48	2.51E-52
trimethylbenzene, 1,2,4-	1.00E+03	2.19E+04	4.53E-22	7.30E+00	9.94E-18	1.36E-18	-
trimethylbenzene, 1,3,5-	9.60E+01	2.89E+03	1.42E-19	6.30E+00	4.09E-16	1.12E-17	-
					1.083E-14	4.49E-19	

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: Not Selected

Chemical Name	Target Hazard Quotent (-)	Target Cancer Risk (-)	Target Indoor Air Concentration ug/m^3-air	Soil Gas Source Concentration ug/m^3	Effective Saturated Vapor Concentration ug/m^3	Groundwater Source Concentration ug/L	Effective Solubility ug/L
benzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
ethylbenzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
toluene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
xylenes (mixed isomers)	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
naphthalene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,2,4-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,3,5-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

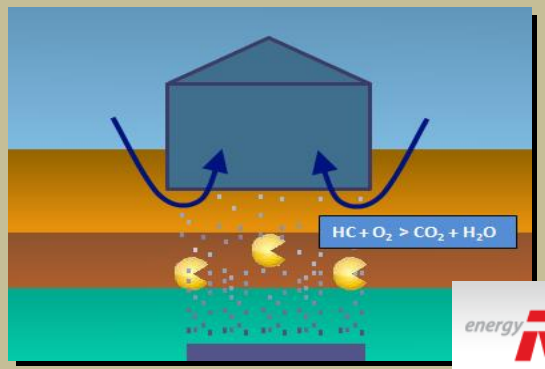
NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



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Site ID #:	City View
Address:	3093 Broadway, Oakland, CA
Completed by:	E. Strake
Date:	11-Dec-15
Job ID:	731637001

BioVapor Version 2.1 beta

2) INPUT SCREENS

1) **Environmental**

2) **Chemicals**

3) **Chemical**

Chemical

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface**

3) **Detailed**

BioVapor Input

Model Input Screens: 1 Environmental Factors | 2 Chemicals | 3 Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

2. Indoor Target Criteria

- (●) Do not perform backward Calculation
- ( ) Based on Indoor Risk / Hazard Target
- ( ) Specified Indoor Air Concentration Target

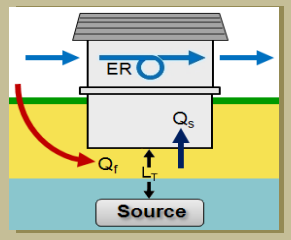
Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-06	(-)
Carcinogen Averaging Time	AT_C	70.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	26.00	yrs
Body Weight - Adult	BW	80.00	kg
Exposure Duration	ED	26.00	yrs
Exposure Frequency	EF	350.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
80.00	User Input Value
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	609.60	cm
Air Exchange Rate	ER	12.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	5.00E-03	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.08	cm/sec

5. Vadose Zone Parameters

Soil Porosity	$\theta_{T\text{-}soil}$	0.39	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.20	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	5.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.63	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	24.00	°C
Baseline Soil Oxygen Respiration Rate: Calculated from Foc	Λ_{base}	9.780E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	274.32	cm
Minimum O_2 Conc. For Aerobic Biodegradation		1.00	%

6. Commands and Options

Default Values

- (●) Residential
- ( ) Commercial / Industrial

Paste | Home | Print | Reset | Next

Site Name: Test
Address: 999 Here

BioVapor Results

Date: Today
Completed By: TEM
Job ID: 9999

Model Input Screens

Environmental Factors | Chemicals | Chemical Concentrations

Chemical Database

2. Commands and Options

Home | Print | Previous | Next :: Results

1. Ground Water Source Chemical Concentrations

Chemical	ug/L
benzene	3.50E+03
ethylbenzene	9.00E+02
toluene	4.00E+02
xylenes (mixed isomers)	9.70E+02
TPH-GRO (C6-C10)	1.42E+04
TPH-DRO (>C10-C28)	3.20E+03

2.32E+04 Total Entered Hydrocarbon Concentration (ug/L)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

3. Attenuation Factor

0.1 Groundwater to Deep Soil Gas Attenuation Factor

BioVapor Results

Model Output Screens

VI Risk | Subsurface Profile | Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-06

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration (ug/L)	Soil Gas Source Concentration (ug/m³)	Soil Gas to Indoor Air Attenuation Factor (-)	Target Indoor Air Concentration (ug/m³-air)	Predicted Indoor Air Concentration (ug/m³-air)	Hazard Quotient (-)	Risk Level (-)
benzene	3.50E+03	7.63E+04	6.98E-18	3.10E-01	5.32E-13	1.70E-13	4.74E-18
ethylbenzene	9.00E+02	2.79E+04	1.07E-16	9.70E-01	3.00E-12	2.87E-15	2.32E-18
toluene	4.00E+02	1.05E+04	8.83E-17	5.20E+03	9.29E-13	2.97E-15	-
xylenes (mixed isomers)	9.70E+02	2.00E+04	9.92E-20	7.30E+02	1.99E-15	1.91E-17	-
					1.760E-13	7.06E-18	

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: Not Selected

Chemical Name	Target Hazard Quotent (-)	Target Cancer Risk (-)	Target Indoor Air Concentration (ug/m³-air)	Soil Gas Source Concentration (ug/m³)	Effective Saturated Vapor Concentration (ug/m³)	Groundwater Source Concentration (ug/L)	Effective Solubility (ug/L)
benzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
ethylbenzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
toluene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
xylenes (mixed isomers)	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

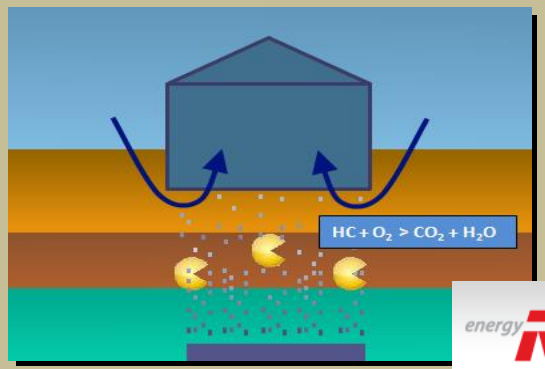
NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



1) PROJECT INFORMATION

Site ID #:	City View
Address:	3093 Broadway, Oakland, CA
Completed by:	E. Strake
Date:	11-Dec-15
Job ID:	731637001

BioVapor Version 2.1 beta

2) INPUT SCREENS

1) **Environmental**

2) **Chemicals**

3) **Chemical**

Chemical

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface**

3) **Detailed**

BioVapor Input

Model Input Screens: 1 Environmental Factors | 2 Chemicals | 3 Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

2. Indoor Target Criteria

- (●) Do not perform backward Calculation
- ( ) Based on Indoor Risk / Hazard Target
- ( ) Specified Indoor Air Concentration Target

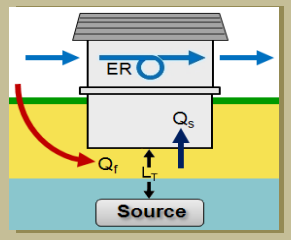
Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-06	(-)
Carcinogen Averaging Time	AT_C	70.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	26.00	yrs
Body Weight - Adult	BW	80.00	kg
Exposure Duration	ED	26.00	yrs
Exposure Frequency	EF	350.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
80.00	User Input Value
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	609.60	cm
Air Exchange Rate	ER	12.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	5.00E-03	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.08	cm/sec

5. Vadose Zone Parameters

Soil Porosity	$\theta_{T\text{-}soil}$	0.39	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.20	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	5.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.63	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	24.00	°C
Baseline Soil Oxygen Respiration Rate: Calculated from Foc	Λ_{base}	9.780E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	274.32	cm
Minimum O_2 Conc. For Aerobic Biodegradation		1.00	%

6. Commands and Options

Default Values

- (●) Residential
- ( ) Commercial / Industrial

Paste | Home | Print | Reset | Next

Site Name: Test
Address: 999 Here

BioVapor Results

Date: Today
Completed By: TEM
Job ID: 9999

Model Input Screens

Environmental Factors | Chemicals | Chemical Concentrations

Chemical Database

2. Commands and Options

Home | Print | Previous | Next :: Results

1. Ground Water Source Chemical Concentrations

Chemical	ug/L
benzene	2.40E+02
ethylbenzene	4.20E+01
xylenes (mixed isomers)	2.60E+01
TPH-GRO (C6-C10)	2.88E+03
TPH-DRO (>C10-C28)	2.00E+03
naphthalene	1.40E+01

5.20E+03 Total Entered Hydrocarbon Concentration (ug/L)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

3. Attenuation Factor

0.1 Groundwater to Deep Soil Gas Attenuation Factor

BioVapor Results

Model Output Screens

VI Risk | Subsurface Profile | Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-06

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration (ug/L)	Soil Gas Source Concentration (ug/m^3)	Soil Gas to Indoor Air Attenuation Factor (-)	Target Indoor Air Concentration (ug/m^3-air)	Predicted Indoor Air Concentration (ug/m^3-air)	Hazard Quotient (-)	Risk Level (-)
benzene	2.40E+02	5.23E+03	8.93E-20	3.10E-01	4.67E-16	1.49E-16	4.16E-21
ethylbenzene	4.20E+01	1.30E+03	2.07E-18	9.70E-01	2.70E-15	2.58E-18	2.09E-21
xylenes (mixed isomers)	2.60E+01	5.37E+02	6.81E-22	7.30E+02	3.66E-19	3.51E-21	-
naphthalene	1.40E+01	2.61E+01	5.00E-52	7.00E-02	1.31E-50	4.17E-51	1.39E-55
					1.519E-16		6.25E-21

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: Not Selected

Chemical Name	Target Hazard Quotent (-)	Target Cancer Risk (-)	Target Indoor Air Concentration (ug/m^3-air)	Soil Gas Source Concentration (ug/m^3)	Effective Saturated Vapor Concentration (ug/m^3)	Groundwater Source Concentration (ug/L)	Effective Solubility (ug/L)
benzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
ethylbenzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
xylenes (mixed isomers)	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
naphthalene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

DATA ENTRY SHEET

SV-4, August 2015 Data

SG-ADV
Version 3.1; 02/04

Reset to

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
107062	0.0075	1000 X Attenuation		1,2-Dichloroethane
75150	20			Carbon disulfide
67641	470			Acetone
108883	0.0061	1000 X Attenuation		Toluene
71432	0.0032	Reporting Limit, 1000 X Attenuation		Benzene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of Ls (cell F24)					
15	182.88	24	182.88			SC		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil				Lookup Soil				Lookup Soil			
SC	1.63	0.385	0.197								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	609.6	0.1	0.5	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	26	26	350

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
1.1E-11	1.6E-07	1,2-Dichloroethane
NA	4.3E-06	Carbon disulfide
NA	2.8E-06	Acetone
NA	2.7E-09	Toluene
4.5E-12	1.4E-07	Benzene
Total 1.6E-11	7.5E-06	

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

SV-4, November 2014 Data

SG-ADV
Version 3.1; 02/04

Reset to

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432	0.094	1000 X Attenuation		Benzene
78933	84			Butanone (2-) (Methyl Ethyl Ketone)
67641	140			Acetone
108883	0.064	1000 X Attenuation		Toluene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of Ls (cell F24)					
15	182.88	24	182.88			SC		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil				Lookup Soil				Lookup Soil			
SC	1.63	0.385	0.197								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	609.6	0.1	0.5	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	26	26	350

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
1.3E-10	4.1E-06	Benzene
NA	2.2E-06	Butanone (2-) (Methyl Ethyl Ketone)
NA	8.4E-07	Acetone
NA	2.8E-08	Toluene
Total 1.3E-10	7.2E-06	

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

SV-10, August 2015 Data

SG-ADV
Version 3.1; 02/04

Reset to

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432	0.0023	1000 X Attenuation		Benzene
78933	6.2			Butanone (2-) (Methyl Ethyl Ketone)
67641	220			Acetone
74873	4.3			Methyl chloride (chloromethane)
108883	0.047	1000 X Attenuation		Toluene
64175	28			Ethanol

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	Thickness of soil stratum B, (Enter value or 0) h_B (cm)	Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	152.4	24	152.4			SC		

MORE ↓

Stratum A SCS soil type (Lookup Soil)	Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	Stratum A soil total porosity, n^A (unitless)	Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	Stratum B SCS soil type (Lookup Soil)	Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	Stratum B soil total porosity, n^B (unitless)	Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	Stratum C SCS soil type (Lookup Soil)	Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	Stratum C soil total porosity, n^C (unitless)	Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SC	1.63	0.385	0.197								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	609.6	0.1	0.5	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	26	26	350

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
3.9E-12	1.2E-07	Benzene
NA	1.9E-07	Butanone (2-) (Methyl Ethyl Ketone)
NA	1.5E-06	Acetone
4.3E-10	9.0E-08	Methyl chloride (chloromethane)
NA	2.4E-08	Toluene
NA	7.6E-08	Ethanol
Total 4.4E-10	2.0E-06	

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

SG-ADV
Version 3.1; 02/04

SV-10, November 2014 Data

Reset to

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432	4.3	1000 X Attenuation		Benzene
78933	270			Butanone (2-) (Methyl Ethyl Ketone)
67641	33			Acetone
100414	0.39	1000 X Attenuation		Ethylbenzene
108883	0.11	1000 X Attenuation		Toluene
95476	0.36	1000 X Attenuation		o-Xylene
622968	43			4-Ethyltoluene
95636	0.094	1000 X Attenuation		1,2,4-Trimethylbenzene
107062	0.29	1000 X Attenuation		1,2-Dichloroethane
108678	0.051	1000 X Attenuation		1,3,5-Trimethylbenzene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	152.4	24	152.4			SC		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil				Lookup Soil				Lookup Soil			
SC	1.63	0.385	0.197								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	609.6	0.1	0.5	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	26	26	350

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
7.2E-09	2.2E-04	Benzene
NA	8.3E-06	Butanone (2-) (Methyl Ethyl Ketone)
NA	2.3E-07	Acetone
4.9E-11	5.3E-08	Ethylbenzene
NA	5.7E-08	Toluene
NA	5.6E-07	o-Xylene
NA	1.3E-05	4-Ethyltoluene
NA	1.5E-06	1,2,4-Trimethylbenzene
5.0E-10	7.4E-06	1,2-Dichloroethane
Total 7.8E-09	2.6E-04	

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

SG-ADV
Version 3.1; 02/04

SV-12, August 2015 Data

Reset to

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432	0.013	1000 X Attenuation		Benzene
100414	0.0065	1000 X Attenuation		Ethylbenzene
75150	23			Carbon disulfide
75092	31			Methylene chloride (dichloromethane)
108883	0.045	1000 X Attenuation		Toluene
95476	0.0077	1000 X Attenuation		o-Xylene
108383	0.022	1000 X Attenuation		m-Xylene
127184	5.6			Tetrachloroethylene
64175	65			Ethanol

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	259.08	24	259.08			SC		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil				Lookup Soil				Lookup Soil			
SC	1.63	0.385	0.197								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	609.6	0.1	0.5	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	26	26	350

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
1.3E-11	4.1E-07	Benzene
5.0E-13	5.3E-10	Ethylbenzene
NA	3.6E-06	Carbon disulfide
1.2E-09	8.3E-06	Methylene chloride (dichloromethane)
NA	1.4E-08	Toluene
NA	7.2E-09	o-Xylene
NA	1.7E-08	m-Xylene
9.7E-10	1.3E-05	Tetrachloroethylene
NA	1.1E-07	Ethanol
Total 2.2E-09	2.5E-05	

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

SV-12, November 2014 Data

SG-ADV
Version 3.1; 02/04

Reset to

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432	0.03	1000 X Attenuation		Benzene
78933	20			Butanone (2-) (Methyl Ethyl Ketone)
67641	86			Acetone
74873	7.7			Methyl chloride (chloromethane)
108883	0.041	1000 X Attenuation		Toluene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of Ls (cell F24)					
15	259.08	24	259.08			SC		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil				Lookup Soil				Lookup Soil			
SC	1.63	0.385	0.197								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	609.6	0.1	0.5	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	26	26	350

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
3.1E-11	9.5E-07	Benzene
NA	3.7E-07	Butanone (2-) (Methyl Ethyl Ketone)
NA	3.8E-07	Acetone
4.8E-10	1.0E-07	Methyl chloride (chloromethane)
NA	1.3E-08	Toluene
Total 5.1E-10	1.8E-06	

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

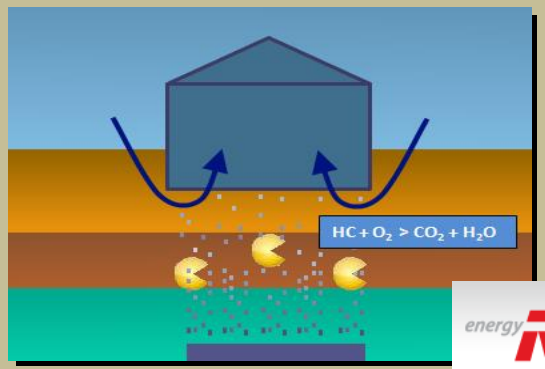
END

ATTACHMENT C
SENSITIVITY MODELS

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



1) PROJECT INFORMATION

Site ID #:	City View
Address:	3093 Broadway, Oakland, CA
Completed by:	E. Strake
Date:	11-Dec-15
Job ID:	731637001

BioVapor Version 2.1 beta

2) INPUT SCREENS

1) **Environmental**

2) **Chemicals**

3) **Chemical**

Chemical

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface**

3) **Detailed**

BioVapor Input

Model Input Screens: 1 Environmental Factors | 2 Chemicals | 3 Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

2. Indoor Target Criteria

- (●) Do not perform backward Calculation
- ( ) Based on Indoor Risk / Hazard Target
- ( ) Specified Indoor Air Concentration Target

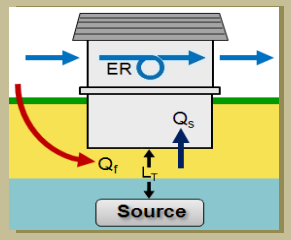
Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-06	(-)
Carcinogen Averaging Time	AT_C	70.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	26.00	yrs
Body Weight - Adult	BW	80.00	kg
Exposure Duration	ED	26.00	yrs
Exposure Frequency	EF	350.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
80.00	User Input Value
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	609.60	cm
Air Exchange Rate	ER	6.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	5.00E-03	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.04	cm/sec

5. Vadose Zone Parameters

Soil Porosity	$\theta_{T\text{-}soil}$	0.39	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.20	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	5.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.63	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	24.00	°C
Baseline Soil Oxygen Respiration Rate (Calculated from Foc)	Λ_{base}	9.780E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	274.32	cm
Minimum O_2 Conc. For Aerobic Biodegradation		1.00	%

6. Commands and Options

Default Values

- (●) Residential
- ( ) Commercial / Industrial

Paste

Home | Print | Reset | Next

Site Name: Test
Address: 999 Here

BioVapor Results

Date: Today
Completed By: TEM
Job ID: 9999

Model Input Screens

Environmental Factors | Chemicals | Chemical Concentrations

Chemical Database

2. Commands and Options

Home | Print | Previous | Next :: Results

1. Ground Water Source Chemical Concentrations

Chemical	ug/L
benzene	1.90E+03
ethylbenzene	1.40E+03
toluene	7.30E+03
xylenes (mixed isomers)	9.40E+03
TPH-GRO (C6-C10)	4.56E+04
trimethylbenzene, 1,2,4-	4.20E+03
trimethylbenzene, 1,3,5-	1.10E+03
naphthalene	1.10E+03

7.20E+04 Total Entered Hydrocarbon Concentration (ug/L)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

3. Attenuation Factor

0.1 Groundwater to Deep Soil Gas Attenuation Factor

BioVapor Results

Model Output Screens

1 VI Risk | 2 Subsurface Profile | 3 Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-06

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration ug/L	Soil Gas Source Concentration ug/m^3	Soil Gas to Indoor Air Attenuation Factor (-)	Target Indoor Air Concentration ug/m^3-air	Predicted Indoor Air Concentration ug/m^3-air	Hazard Quotient (-)	Risk Level (-)
benzene	1.90E+03	4.14E+04	6.72E-14	3.10E-01	2.78E-09	8.90E-10	2.48E-14
ethylbenzene	1.40E+03	4.35E+04	4.66E-13	9.70E-01	2.03E-08	1.94E-11	1.57E-14
toluene	7.30E+03	1.92E+05	4.11E-13	5.20E+03	7.88E-08	2.52E-10	-
xylenes (mixed isomers)	9.40E+03	1.94E+05	3.20E-15	7.30E+02	6.21E-10	5.95E-12	-
trimethylbenzene, 1,2,4-	4.20E+03	9.21E+04	7.96E-16	7.30E+00	7.33E-11	1.00E-11	-
trimethylbenzene, 1,3,5-	1.10E+03	3.31E+04	3.31E-14	6.30E+00	1.10E-09	3.00E-11	-
naphthalene	1.10E+03	2.05E+03	8.32E-34	7.00E-02	1.71E-30	5.46E-31	1.82E-35
					1.177E-09		4.05E-14

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: Not Selected

Chemical Name	Target Hazard Quotent (-)	Target Cancer Risk (-)	Target Indoor Air Concentration ug/m^3-air	Soil Gas Source Concentration ug/m^3	Effective Saturated Vapor Concentration ug/m^3	Groundwater Source Concentration ug/L	Effective Solubility ug/L
benzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
ethylbenzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
toluene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
xylenes (mixed isomers)	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,2,4-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,3,5-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
naphthalene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

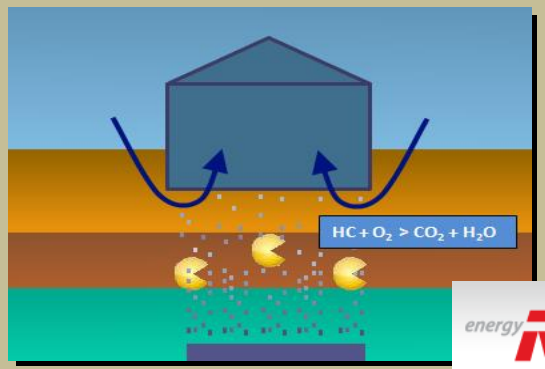
NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



1) PROJECT INFORMATION

Site ID #:	City View
Address:	3093 Broadway, Oakland, CA
Completed by:	E. Strake
Date:	11-Dec-15
Job ID:	731637001

BioVapor Version 2.1 beta

2) INPUT SCREENS

1) **Environmental**

2) **Chemicals**

3) **Chemical**

Chemical

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface**

3) **Detailed**

Site Name: test1
Address: test1

BioVapor Input

Date: 10/2/2009
Completed By: tes1
Job ID: 3395

Model Input Screens: 1 Environmental Factors | 2 Chemicals | 3 Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

2. Indoor Target Criteria

- (●) Do not perform backward Calculation
- ( ) Based on Indoor Risk / Hazard Target
- ( ) Specified Indoor Air Concentration Target

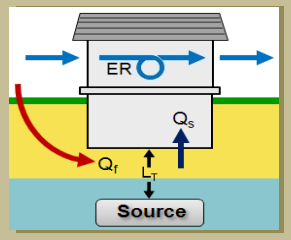
Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-06	(-)
Carcinogen Averaging Time	AT_C	70.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	26.00	yrs
Body Weight - Adult	BW	80.00	kg
Exposure Duration	ED	26.00	yrs
Exposure Frequency	EF	350.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
80.00	User Input Value
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	244.00	cm
Air Exchange Rate	ER	12.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	5.00E-03	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.03	cm/sec

5. Vadose Zone Parameters

Soil Porosity	$\theta_{T\text{-}soil}$	0.39	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.20	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	5.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.63	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	24.00	°C
Baseline Soil Oxygen Respiration Rate: Calculated from Foc	Λ_{base}	9.780E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	274.32	cm
Minimum O_2 Conc. For Aerobic Biodegradation		1.00	%

6. Commands and Options

Default Values

- (●) Residential
- ( ) Commercial / Industrial

Paste

Home | Print | Reset | Next

Site Name: Test
Address: 999 Here

BioVapor Results

Date: Today
Completed By: TEM
Job ID: 9999

Model Input Screens

Environmental Factors | Chemicals | Chemical Concentrations

Chemical Database

2. Commands and Options

Home | Print | Previous | Next :: Results

1. Ground Water Source Chemical Concentrations

Chemical	ug/L
benzene	1.90E+03
ethylbenzene	1.40E+03
toluene	7.30E+03
xylenes (mixed isomers)	9.40E+03
TPH-GRO (C6-C10)	4.56E+04
trimethylbenzene, 1,2,4-	4.20E+03
trimethylbenzene, 1,3,5-	1.10E+03
naphthalene	1.10E+03

7.20E+04 Total Entered Hydrocarbon Concentration (ug/L)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

3. Attenuation Factor

0.1 Groundwater to Deep Soil Gas Attenuation Factor

BioVapor Results

Model Output Screens

1 VI Risk | 2 Subsurface Profile | 3 Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-06

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration ug/L	Soil Gas Source Concentration ug/m^3	Soil Gas to Indoor Air Attenuation Factor (-)	Target Indoor Air Concentration ug/m^3-air	Predicted Indoor Air Concentration ug/m^3-air	Hazard Quotient (-)	Risk Level (-)
benzene	1.90E+03	4.14E+04	8.40E-14	3.10E-01	3.48E-09	1.11E-09	3.10E-14
ethylbenzene	1.40E+03	4.35E+04	5.82E-13	9.70E-01	2.53E-08	2.43E-11	1.96E-14
toluene	7.30E+03	1.92E+05	5.13E-13	5.20E+03	9.85E-08	3.15E-10	-
xylenes (mixed isomers)	9.40E+03	1.94E+05	3.99E-15	7.30E+02	7.76E-10	7.44E-12	-
trimethylbenzene, 1,2,4-	4.20E+03	9.21E+04	9.94E-16	7.30E+00	9.16E-11	1.25E-11	-
trimethylbenzene, 1,3,5-	1.10E+03	3.31E+04	4.13E-14	6.30E+00	1.37E-09	3.75E-11	-
naphthalene	1.10E+03	2.05E+03	1.04E-33	7.00E-02	2.13E-30	6.82E-31	2.28E-35
					1.470E-09		5.06E-14

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: Not Selected

Chemical Name	Target Hazard Quotent (-)	Target Cancer Risk (-)	Target Indoor Air Concentration ug/m^3-air	Soil Gas Source Concentration ug/m^3	Effective Saturated Vapor Concentration ug/m^3	Groundwater Source Concentration ug/L	Effective Solubility ug/L
benzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
ethylbenzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
toluene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
xylenes (mixed isomers)	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,2,4-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,3,5-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
naphthalene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

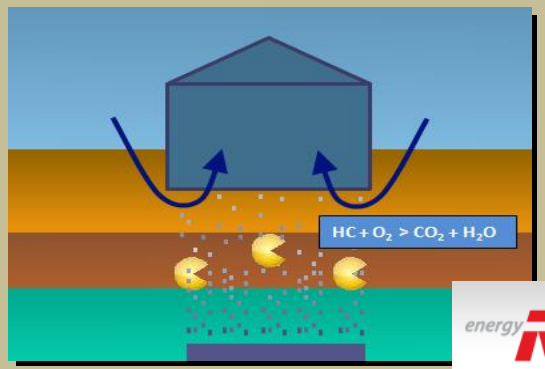
NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



1) PROJECT INFORMATION

Site ID #:	City View
Address:	3093 Broadway, Oakland, CA
Completed by:	E. Strake
Date:	11-Dec-15
Job ID:	731637001

BioVapor Version 2.1 beta

2) INPUT SCREENS

1) **Environmental**

2) **Chemicals**

3) **Chemical**

Chemical

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface**

3) **Detailed**

BioVapor Input

Model Input Screens: 1 Environmental Factors | 2 Chemicals | 3 Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

2. Indoor Target Criteria

- (●) Do not perform backward Calculation
- ( ) Based on Indoor Risk / Hazard Target
- ( ) Specified Indoor Air Concentration Target

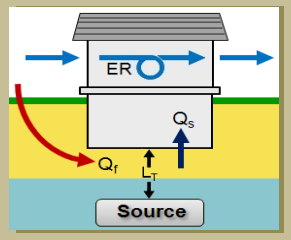
Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-06	(-)
Carcinogen Averaging Time	AT_C	70.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	26.00	yrs
Body Weight - Adult	BW	80.00	kg
Exposure Duration	ED	26.00	yrs
Exposure Frequency	EF	350.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
80.00	User Input Value
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	609.60	cm
Air Exchange Rate	ER	12.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	5.00E-03	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.08	cm/sec

5. Vadose Zone Parameters

Soil Porosity	$\theta_{T\text{-}soil}$	0.48	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.22	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	5.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.38	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	24.00	°C
Baseline Soil Oxygen Respiration Rate: Calculated from Foc	Λ_{base}	9.780E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	274.32	cm
Minimum O_2 Conc. For Aerobic Biodegradation		1.00	%

6. Commands and Options

Default Values

- (●) Residential
- ( ) Commercial / Industrial

Paste | Home | Print | Reset | Next

Site Name: Test
Address: 999 Here

BioVapor Results

Date: Today
Completed By: TEM
Job ID: 9999

Model Input Screens

Environmental Factors | Chemicals | Chemical Concentrations

Chemical Database

2. Commands and Options

Home | Print | Previous | Next :: Results

1. Ground Water Source Chemical Concentrations

Chemical	ug/L
benzene	1.90E+03
ethylbenzene	1.40E+03
toluene	7.30E+03
xylenes (mixed isomers)	9.40E+03
TPH-GRO (C6-C10)	4.56E+04
trimethylbenzene, 1,2,4-	4.20E+03
trimethylbenzene, 1,3,5-	1.10E+03
naphthalene	1.10E+03

7.20E+04 Total Entered Hydrocarbon Concentration (ug/L)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

3. Attenuation Factor

0.1 Groundwater to Deep Soil Gas Attenuation Factor

BioVapor Results

Model Output Screens

1 VI Risk | 2 Subsurface Profile | 3 Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-06

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration ug/L	Soil Gas Source Concentration ug/m^3	Soil Gas to Indoor Air Attenuation Factor (-)	Target Indoor Air Concentration ug/m^3-air	Predicted Indoor Air Concentration ug/m^3-air	Hazard Quotient (-)	Risk Level (-)
benzene	1.90E+03	4.14E+04	2.27E-08	3.10E-01	9.38E-04	3.00E-04	8.35E-09
ethylbenzene	1.40E+03	4.35E+04	4.67E-08	9.70E-01	2.03E-03	1.95E-06	1.57E-09
toluene	7.30E+03	1.92E+05	4.54E-08	5.20E+03	8.72E-03	2.79E-05	-
xylenes (mixed isomers)	9.40E+03	1.94E+05	6.89E-09	7.30E+02	1.34E-03	1.28E-05	-
trimethylbenzene, 1,2,4-	4.20E+03	9.21E+04	4.00E-09	7.30E+00	3.68E-04	5.04E-05	-
trimethylbenzene, 1,3,5-	1.10E+03	3.31E+04	1.65E-08	6.30E+00	5.47E-04	1.50E-05	-
naphthalene	1.10E+03	2.05E+03	8.38E-16	7.00E-02	1.72E-12	5.50E-13	1.84E-17
					3.930E-04		9.93E-09

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: Not Selected

Chemical Name	Target Hazard Quotent (-)	Target Cancer Risk (-)	Target Indoor Air Concentration ug/m^3-air	Soil Gas Source Concentration ug/m^3	Effective Saturated Vapor Concentration ug/m^3	Groundwater Source Concentration ug/L	Effective Solubility ug/L
benzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
ethylbenzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
toluene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
xylenes (mixed isomers)	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,2,4-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,3,5-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
naphthalene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

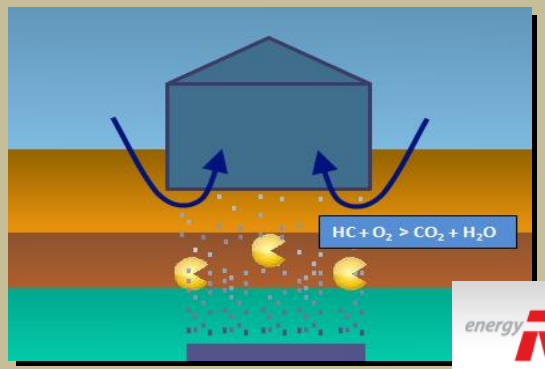
NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



1) PROJECT INFORMATION

Site ID #:	City View
Address:	3093 Broadway, Oakland, CA
Completed by:	E. Strake
Date:	11-Dec-15
Job ID:	731637001

BioVapor Version 2.1 beta

2) INPUT SCREENS

1) **Environmental**

2) **Chemicals**

3) **Chemical**

Chemical

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface**

3) **Detailed**

BioVapor Input

Model Input Screens: 1 Environmental Factors | 2 Chemicals | 3 Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

2. Indoor Target Criteria

- (●) Do not perform backward Calculation
- ( ) Based on Indoor Risk / Hazard Target
- ( ) Specified Indoor Air Concentration Target

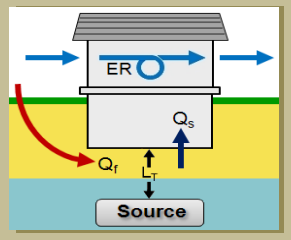
Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-06	(-)
Carcinogen Averaging Time	AT_C	70.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	26.00	yrs
Body Weight - Adult	BW	80.00	kg
Exposure Duration	ED	26.00	yrs
Exposure Frequency	EF	350.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
80.00	User Input Value
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	609.60	cm
Air Exchange Rate	ER	12.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	5.00E-03	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.08	cm/sec

5. Vadose Zone Parameters

Soil Porosity	$\theta_{T\text{-}soil}$	0.39	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.20	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	5.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.63	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	24.00	°C
Baseline Soil Oxygen Respiration Rate (Calculated from Foc)	Λ_{base}	9.780E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	182.88	cm
Minimum O_2 Conc. For Aerobic Biodegradation		1.00	%

6. Commands and Options

Default Values

- (●) Residential
- ( ) Commercial / Industrial

Paste

Home | Print | Reset | Next

Site Name: Test
Address: 999 Here

BioVapor Results

Date: Today
Completed By: TEM
Job ID: 9999

Model Input Screens

Environmental Factors | Chemicals | Chemical Concentrations

Chemical Database

2. Commands and Options

Home | Print | Previous | Next :: Results

1. Ground Water Source Chemical Concentrations

Chemical	ug/L
benzene	1.90E+03
ethylbenzene	1.40E+03
toluene	7.30E+03
xylenes (mixed isomers)	9.40E+03
TPH-GRO (C6-C10)	4.56E+04
trimethylbenzene, 1,2,4-	4.20E+03
trimethylbenzene, 1,3,5-	1.10E+03
naphthalene	1.10E+03

7.20E+04 Total Entered Hydrocarbon Concentration (ug/L)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

3. Attenuation Factor

0.1 Groundwater to Deep Soil Gas Attenuation Factor

BioVapor Results

Model Output Screens

1 VI Risk | 2 Subsurface Profile | 3 Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-06

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration ug/L	Soil Gas Source Concentration ug/m^3	Soil Gas to Indoor Air Attenuation Factor (-)	Target Indoor Air Concentration ug/m^3-air	Predicted Indoor Air Concentration ug/m^3-air	Hazard Quotient (-)	Risk Level (-)
benzene	1.90E+03	4.14E+04	1.21E-10	3.10E-01	5.01E-06	1.60E-06	4.46E-11
ethylbenzene	1.40E+03	4.35E+04	4.07E-10	9.70E-01	1.77E-05	1.70E-08	1.37E-11
toluene	7.30E+03	1.92E+05	3.81E-10	5.20E+03	7.32E-05	2.34E-07	-
xylenes (mixed isomers)	9.40E+03	1.94E+05	1.72E-11	7.30E+02	3.34E-06	3.20E-08	-
trimethylbenzene, 1,2,4-	4.20E+03	9.21E+04	7.03E-12	7.30E+00	6.47E-07	8.87E-08	-
trimethylbenzene, 1,3,5-	1.10E+03	3.31E+04	7.45E-11	6.30E+00	2.47E-06	6.76E-08	-
naphthalene	1.10E+03	2.05E+03	3.57E-23	7.00E-02	7.33E-20	2.34E-20	7.84E-25
					1.972E-06		5.83E-11

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: Not Selected

Chemical Name	Target Hazard Quotent (-)	Target Cancer Risk (-)	Target Indoor Air Concentration ug/m^3-air	Soil Gas Source Concentration ug/m^3	Effective Saturated Vapor Concentration ug/m^3	Groundwater Source Concentration ug/L	Effective Solubility ug/L
benzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
ethylbenzene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
toluene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
xylenes (mixed isomers)	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,2,4-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
trimethylbenzene, 1,3,5-	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected
naphthalene	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected	Not Selected

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

DATA ENTRY SHEET

SG-ADV
Version 3.1; 02/04

SV-10, August 2015 Data

Reset to

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432	0.0023	1000 X Attenuation		Benzene
78933	6.2			Butanone (2-) (Methyl Ethyl Ketone)
67641	220			Acetone
74873	4.3			Methyl chloride (chloromethane)
108883	0.047	1000 X Attenuation		Toluene
64175	28			Ethanol

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	152.4	24	152.4			SC		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SC	1.63	0.385	0.197								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	609.6	0.1	0.25	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	26	26	350

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
7.7E-12	2.4E-07	Benzene
NA	3.8E-07	Butanone (2-) (Methyl Ethyl Ketone)
NA	3.1E-06	Acetone
8.7E-10	1.8E-07	Methyl chloride (chloromethane)
NA	4.9E-08	Toluene
NA	1.5E-07	Ethanol
Total 8.8E-10	4.1E-06	

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

SG-ADV
Version 3.1; 02/04

SV-10, August 2015 Data

Reset to

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432	0.0023	1000 X Attenuation		Benzene
78933	6.2			Butanone (2-) (Methyl Ethyl Ketone)
67641	220			Acetone
74873	4.3			Methyl chloride (chloromethane)
108883	0.047	1000 X Attenuation		Toluene
64175	28			Ethanol

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	152.4	24	152.4			SC		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SC	1.63	0.385	0.197								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	244	0.1	0.5	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	26	26	350

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
9.7E-12	3.0E-07	Benzene
NA	4.8E-07	Butanone (2-) (Methyl Ethyl Ketone)
NA	3.9E-06	Acetone
1.1E-09	2.2E-07	Methyl chloride (chloromethane)
NA	6.1E-08	Toluene
NA	1.9E-07	Ethanol
NA	0.0E+00	4-Ethyltoluene
NA	0.0E+00	1,2,4-Trimethylbenzene
0.0E+00	0.0E+00	1,2-Dichloroethane
Total 1.1E-09	5.1E-06	

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

SV-10, August 2015 Data

SG-ADV
Version 3.1; 02/04

Reset to

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432	0.0023	1000 X Attenuation		Benzene
78933	6.2			Butanone (2-) (Methyl Ethyl Ketone)
67641	220			Acetone
74873	4.3			Methyl chloride (chloromethane)
108883	0.047	1000 X Attenuation		Toluene
64175	28			Ethanol

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	152.4	24	152.4			SIC		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	609.6	0.1	0.5	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	26	26	350

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
6.7E-12	2.1E-07	Benzene
NA	3.2E-07	Butanone (2-) (Methyl Ethyl Ketone)
NA	2.5E-06	Acetone
7.1E-10	1.5E-07	Methyl chloride (chloromethane)
NA	4.2E-08	Toluene
NA	1.0E-07	Ethanol
Total 7.2E-10	3.3E-06	

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

SV-10, August 2015 Data

SG-ADV
Version 3.1; 02/04

Reset to

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432	2.3			Benzene
78933	6.2			Butanone (2-) (Methyl Ethyl Ketone)
67641	220			Acetone
74873	4.3			Methyl chloride (chloromethane)
108883	47			Toluene
64175	28			Ethanol

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	60.96	24	60.96			SC		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SC	1.63	0.385	0.197								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	609.6	0.1	0.5	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	26	26	350

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
8.7E-09	2.7E-04	Benzene
NA	4.3E-07	Butanone (2-) (Methyl Ethyl Ketone)
NA	3.2E-06	Acetone
9.0E-10	1.9E-07	Methyl chloride (chloromethane)
NA	5.5E-05	Toluene
NA	1.5E-07	Ethanol
Total 9.6E-09	3.3E-04	

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END