Environmental Health Decisions

Mr. Ray Poulter
Advanced Group 99-SJ
23792 Rockfield Blvd., Suite 100
Lake Forest, California 92630
September 15, 2009

RE: Human Health Risk Assessment – San Juan Meadows / Distrito La Novia

Dear Mr. Poulter:

This risk assessment is prepared to address potential human health risk associated with exposures at the San Juan Meadows / Distrito La Novia Project. The risk assessment contained herein has been prepared by Environmental Health Decisions (EHD) at the request of Advanced Group 99-SJ to utilize Project characterization sampling results and evaluate those results for potential risk to human health. The Project is currently vacant. The proposed San Juan Meadows development will take place in the area of the former Forster Landfill. EHD understands that the San Juan Meadows site will be utilized for single family housing and equestrian center purposes. The Distrito La Novia site will be utilized for condominiums, apartments, and commercial and office purposes.

This risk assessment evaluates that potential for health effects from volatile organic compounds (VOCs) in groundwater that may migrate as vapors into indoor or outdoor air. Soil at the project area is not known to be contaminated to depths (at the completion of the project) greater than ten feet below ground surface (the depth typically evaluated for a residential setting). Potential issues associated with exposures to air are being addressed through the South Coast Air Quality Management District's permit requirements. Methane issues are being addressed through the Landfill Closure Plan. The results of the risk assessment indicate that VOCs detected in groundwater should not present an unacceptable health risk to residents, workers or visitors to the project. Furthermore, when the cancer risks and noncancer hazards from exposure to chemicals in groundwater are added to cancer risks and noncancer hazards from exposures to chemicals in the air (from the Landfill Gas Treatment Facility), the cancer risks and noncancer hazard are in the range that is acceptable to the California Environmental Assessment Agency and the United States Environmental Assessment Agency.

Sincerely,

Jill E. Ryer-Powder

Jill E. Ryer-Powder, Ph.D. DABT

HUMAN HEALTH RISK ASSESSMENT

The purpose of this Human Health Risk Assessment is to evaluate whether historical activities in the area of the proposed Distrito La Novia / San Juan Meadows Project (herein referred to as "the Project") have resulted in releases of chemicals that have the potential to impact the health of future populations that may reside, work, or visit the area comprised by the Project. The Project is located along the east side of Valle Road south of San Juan Creek Road and La Novia Avenue extending to the Lomas San Juan RV storage lot to the east, Capistrano Terrace Mobile Home Park to the west, City open space to the south, and the Pacifica San Juan project to the southwest. The development plans for the Project comprise two sites, the 18.8 acre Distrito La Novia site and the 135.1 acre San Juan Meadows site. Together, the two sites comprise the 153.9 acre project. The San Juan Meadows site is proposed to consist of 105 single-family detached homes, a 950 horse equestrian center, and 90 acres of open space. The Distrito La Novia site is proposed to consist of 90 condominiums, 50 apartment units, commercial uses, and office use.

There are no known contamination issues at the future Distrito La Novia site. Of the 18 acres at this site, the eastern 9 acres was always a part of the San Juan Meadows property and has remained vacant. The western 9 acres was once entitled by the City to construct a four story hotel with attendant banquet and commercial activities. This entitlement was granted in the 1980's and became known as the "Parador Site". No construction was ever undertaken but the entitlement remains today and is part of what will be changed by the re-zone and General Plan Amendment now being processed for the current Project (personal communication, R.N. Poulter, September, 2009).

The future San Juan Meadows site formerly housed a landfill, which accepted municipal waste from south Orange County cities. This landfill, called the Forster Canyon Sanitary Landfill, ceased operations in 1976. The landfill was covered with scraped soil from the slopes south of the landfill. As the San Juan Meadows site is proposed to consist of residential housing and an equestrian center, it is prudent to conduct a health risk assessment to assure that residual chemicals, if present, will not pose a potential health risk to users of the San Juan Meadows site.

Exposures at a residential area and equestrian center at the San Juan Meadows site (herein referred to as "the Site") could potentially occur via the soil, air and groundwater. The former landfill is currently covered with from two to eight feet of native soil and development plans incorporate the addition of four to five feet of soil (Final Landfill Closure Plan and Post-Closure Maintenance Plan, 2009). Given the projected uses of the San Juan Meadows site, it is not likely that exposure will occur to soil beneath the clean fill. Potential issues associated with air exposures from landfill emissions are currently being addressed by the permitting process required by the South Coast Air Quality Management District (SCAQMD)[1]. Potential issues

[1] Bryan A. Stirrat and Associates (BAS) have prepared the *"Landfill Gas Treatment Facility Permit to Construct and Operate Application Package"* (BAS, 2009a). This application presents a health risk screening assessment that addresses potential health risks associated with emissions from the proposed landfill gas treatment facility. The risk assessment was conducted in accordance with guidelines presented in SCAQMD's "Risk Assessment Procedures for Rules 1401 and 212", Version 7.0, July 2005. The results of the risk assessment indicated that the health risks associated with the emissions from the proposed treatment facility were in compliance with SCAQMD's Rules 1401 and 212.

associated with methane emissions from the former landfill are being addressed by the Final Landfill Closure Plan and Post-Closure Maintenance Plan being prepared by Bryan A. Stirrat and Associates. Groundwater will not be used as a potable source or irrigation source for residents at the San Juan Meadows (or Distrito La Novia) sites. However, groundwater is present at depths as shallow as 18 feet below ground surface (OC Waste & Recycling 2009). It is therefore possible that volatile chemicals, if present in groundwater, can migrate upwards into indoor air in homes (referred to as vapor intrusion) or into ambient (outdoor) air at the equestrian center. The indoor air vapor intrusion from groundwater pathway is evaluated in this risk assessment. It should be noted that if indoor air is deemed as safe, then outdoor air, which is less concentrated than indoor air due to dilution, will also be deemed as safe.

Consistent with standard risk assessment guidance for sites in California (Cal/EPA 1992 and DTSC 1999) and the United States of America (USEPA 1989), this human health risk assessment consists of five major steps:

- Identification of Potentially Exposed Populations and Exposure Pathways;
- Chemical Selection and Quantification of Exposure;
- Toxicity Assessment;
- Risk Characterization; and
- Uncertainty Analysis.

The first step in this risk assessment is to identify the populations who may be exposed to chemicals detected at the San Juan Meadows site and describe the complete pathways through which the exposures may occur. The second step is to identify the chemicals to be included in the risk assessment and quantify the amount of chemical exposure that the populations may incur. The third step involves the selection of the appropriate toxicity values for each of the chemicals of potential concern. The fourth step integrates the exposure components and the toxicity information to calculate the risk and hazard for each chemical included in this assessment. The final step summarizes the basic assumptions and uncertainties of the human health screening evaluation.

Development plans for the San Juan Meadows site include single family residences and an equestrian center. As a conservative assessment, the potential risks are calculated based on a residential land-use scenario. If risks are deemed as acceptable (in accordance with California Environmental Protection Agency and United States Environmental Protection Agency guidelines) to residents[2] (the population that would experience the greatest amount of exposure at the Site), then exposures would be acceptable to lesser exposed populations, such as those that visit or work at the equestrian center.

[2] The California Environmental Protection Agency and the United States Environmental Protection Agency consider a cancer risk of 1 in 1 million as de minimis, or insignificant, and acceptable for residential dwelling. These government agencies consider a noncancer hazard index of 1 as acceptable for residential dwelling.

1.0 Identification of Potentially Exposed Populations and Exposure Pathways

To assess whether the chemicals present at the Site may pose a risk to human populations, it is necessary to identify both the populations that may be present at the Site and the pathways through which the potential exposures may occur. The identification of the potentially exposed populations is traditionally based on the human activities and land use patterns at and around the Site. As previously stated, this risk assessment makes the assumption that the Site will be used for residential purposes.

Once the potentially exposed populations are identified, the complete exposure pathways by which the individuals may be exposed to chemicals present in the environmental media must be identified. An exposure pathway is defined as "the course a chemical or pollutant takes from the source to the organism exposed" (USEPA 1989). An exposure route is defined as "the way a chemical or pollutant enters an organism after contact" (USEPA 1989). A complete exposure pathway for chemicals requires four elements: chemical sources, migration routes (i.e., environmental transport), an exposure point for contact (i.e., soil, air or water; or collectively, "media"), and human exposure routes (i.e. oral, dermal, inhalation). A pathway is not considered to be complete unless all four elements are present. The source-pathway-receptor relationships provide the basis for the quantitative exposure assessment. These relationships are illustrated in Figure 1, the Conceptual Site Model. Only those complete source-pathway-receptor relationships are included in this risk assessment.

1.1 Chemical Sources and Potential Transport Mechanisms

The San Juan Meadows Site was formerly the location of the Forster Canyon Sanitary Landfill (FCSL). The following information regarding the FCSL is extracted from the *"Application for Alteration/Modification to Permitted Equipment Landfill Gas Extraction System Permit to Construct and operate"* (BAS 2009b).

> *The former FCSL is a 50-acre canyon fill located in San Jan Capistrano, California, immediately east of I-5 and south of La Novia Avenue. The FCSL was a Class 2 site (under the old Water Resources control Board classification)), operated by the County of Orange between 1958 and 1976. An estimated 2.5 to 3.0 million cubic yards of residential and commercial refuse was deposited in two former canyons comprising the fill area. Landfill records for Orange County indicate a waste composition of residential, commercial, demolition, agricultural, street sweeping and bulky items. No liquids or hazardous wastes in quantities greater than household amounts were accepted at the site. The irregularly shaped site is approximately 1,000 feet wide, 2,500 feet long, up to 110 feet deep, with an average depth of refuse between 40 and 50 feet.*
>
> *The Integrated Waste Management District ceased landfill operations at the site in 1976 and placed final cover under the prevailing provisions of Division 7 of the Water Code for a Class II-2 disposal facility. The site currently has a 2- to 8-foot final cover placed over the entire landfill and has an open space end use. The County's lease agreement expired in 1976*

and the property was subsequently sold. The current owner of the property is AG 99-SJ.

In accordance with The Regional Water Quality Control Board – San Diego (RWQCB) No. 94-106, OC Waste & Recycling (previously County of Orange Integrated Waste Management Department) conducts groundwater monitoring on a semi-annual basis (OC Waste & Recycling 2009). The current monitoring system consists of three downgradient monitoring wells (MW-A, MW-B, and MW-C), one upgradient monitoring well (MW-D), and three lysimeters (SB-1, SB-2, and SB-4) (OC Waste & Recycling 2009). The most recent results of the monitoring, as presented in the February 5, 2009 "*Forster Canyon Landfill – 2009 First Semi-Annual Groundwater Monitoring Report* "(OC Waste & Recycling, 2009), showed the presence of metals and volatile organic chemicals (VOCs) in the groundwater. As the groundwater is not used for potable purposes, the only potential exposure pathway would be the migration of vapors into indoor and ambient air from VOCs in the groundwater[3]. The results of the VOC sampling and analysis are presented in detail in the above referenced report. The results of data used in the risk assessment (i.e., VOCs detected in groundwater) are presented in Table 1 of this report.

1.2 Potentially Exposed Populations

The planned use for the San Juan Meadows Site is for residential dwelling and an equestrian center. To render the most conservative assessment (due to the largest air concentration, longest duration of exposure and the highest frequency of exposure), the risk evaluation assumes that the Site will be used for residential purposes. As residential populations are assumed to live at the Site for an extended 30–year period, they will incur greater exposures than populations that will either attend or work at the equestrian center. Accordingly, a finding that the Site is appropriate and safe for future residential use conservatively assumes that use of the Site for the proposed equestrian center will not adversely impact the health of workers and visitors.

1.3 Exposure Pathways

The following section identifies the potentially complete exposure pathways through which the future on-Site residents could be exposed to chemicals detected at the Site. The section also provides the rationale for excluding certain pathways from further consideration.

The complete pathways through which future on-Site residents may be exposed to chemicals detected at the Site include the following:

- Inhalation of vapors in indoor air from chemicals in groundwater
- Inhalation of vapors in ambient (outdoor) from chemicals in groundwater

These are the pathways that are initially included in the risk assessment. These pathways are consistent with the relevant pathways described in the California Environmental Protection Agency and United States Environmental Protection Agency risk assessment guidance. If the evaluation of indoor air shows that there is no unacceptable cancer risk or noncancer hazard, the evaluation of outdoor air will not be conducted. This is because indoor air concentrations will be more concentrated and therefore present a higher risk than outdoor air. A detailed description of each pathway follows.

[3] Metals are not volatile chemicals, Therefore, there is no potential for metals to migrate as vapors into indoor air.

1.3.1 Inhalation of Vapors in Indoor Air

In accordance with California Environmental Protection Agency (Cal/EPA 1992, 2004a, 2004b) and United States Environmental Protection Agency risk assessment guidance (USEPA 1989), residents could be exposed to chemicals at the Site through inhalation of chemicals in groundwater that migrate upwards as vapors into indoor air and ambient (outdoor) air. The indoor air pathway is evaluated in this risk assessment. This pathway is evaluated using the Department of Toxic Substances Control's version of the Johnson and Ettinger Model for Subsurface Vapor Intrusion into Buildings (DTSC 2009). This model is entitled GW_Screen, Version 3/0; 04/03 and was revised in February of 2009. The model is available at www.dtsc.ca.gov.

1.3.2 Inhalation of Vapors in Outdoor Air

Concentrations of vapors in indoor air would be greater than those in outdoor air because vapors would concentrate in indoor air. If the cancer risk and noncancer hazard index are deemed as acceptable for indoor air exposures, they will be acceptable for outdoor exposures as well. This pathway will not be evaluated in this risk assessment if the indoor air risk and hazard are within acceptable ranges.

1.4 Exposure Assumptions

Intake of a chemical is dependent on various exposure assumptions, including exposure duration, inhalation rate, body weight, and averaging time. The residential exposure assumptions used to estimate exposure to the chemicals detected in groundwater at the Site are embedded in DTSC's version of the Johnson and Ettinger Vapor Intrusion Model (see Section 2.2.1). Exposure assumptions used in this risk evaluation correspond directly to those recommended by California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA 2005).

2.0 Chemical Selection and Estimation of Exposure Concentrations

The purpose of this section is to (1) identify the chemicals of potential concern (COPCs) to be included in the risk assessment; and (2) present the method for estimating the exposure concentrations for each of the COPCs.

2.1 Chemical Selection

Detected chemicals in groundwater included metals and VOCs. The groundwater is not available for potable purposes. Therefore, there is no direct exposure (i.e., ingestion or dermal contact) anticipated. There is the potential for vapors from volatile chemicals to migrate upwards into indoor and outdoor air. Metals are not volatile and are therefore not evaluated in this risk assessment. The VOCs that were detected in groundwater include 1,1 dichloroethane, 1,1 dichloroethylene, trans 1,2 dichloroethylene, 1,2 dichloropropane, tetrachloroethylene (PCE), and trichloroethylene (TCE). These chemicals are evaluated in the risk assessment.

2.2 Estimation of Representative Exposure Concentrations

The estimation of the exposure point concentration of each COPC in groundwater utilized the sampling results described in the "*Forster Canyon Landfill – 2009 First Semi-Annual Groundwater Monitoring Report*" (OC Waste & Recycling 2009). As a conservative measure, the maximum detected concentration of each chemical detected in groundwater has been used to estimate the exposure point concentration. A summary of the chemicals detected in groundwater is presented in Table 1. Table 1 also presents the maximum detected concentration of each chemical in groundwater.

To estimate the concentration of volatile chemicals in indoor air due to volatile chemicals detected in groundwater, the United States Environmental Protection Agency (USEPA) developed a model in 1998 which estimates human health risks from subsurface vapor intrusion into buildings. This model is based on the work of Johnson and Ettinger, and is revised periodically to incorporate different assumptions about soil properties as well as new human health criteria developed by US EPA. The USEPA model for vapor intrusion from groundwater, fact sheet, and users Guide are available for use and download at: http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm. The Cal/EPA's Department of Toxic Substances Control's Human and Ecological Risk Division has taken this model and incorporated human health toxicity criteria specific to California, as developed by the Cal/EPA Office of Environmental Health Hazard Assessment (OEHHA) (see Section 3.0). DTSC's version of the model (DTSC 2004) is distributed and can be downloaded at: http://www.dtsc.ca.gov/assessingrisk/JE_models.cfm.

The model incorporates both convective and diffusive mechanisms for estimating the transport of chemical vapors emanating from groundwater into indoor spaces located directly above the source of contamination. The model provides an estimated attenuation coefficient that relates the vapor concentration in the indoor space to the vapor concentration at the source of contamination. Inputs to the model include chemical properties of the chemical, toxicological values (cancer unit risk factors and noncancer reference concentrations) saturated and unsaturated zone soil properties, and structural properties of a residence. Model results are provided as an estimate of cancer risk and noncancer hazard. Models are presented in Attachment 1. Modeled concentrations of chemicals in indoor air are presented in Table 2.

3.0 Toxicity Values for COPCs

The toxicity assessment characterizes the relationship between the magnitude of exposure to a chemical and the potential adverse health effects. More specifically, the toxicity assessment identifies or derives toxicity values that can be used to estimate that the likelihood that the predicted exposures will result in adverse health effects.

Chemicals are typically evaluated for their potential health effects in two categories, carcinogenic and noncarcinogenic. Carcinogens are those chemicals that have been shown to cause cancer, either in people or animals. Noncarcinogens may cause other kinds of health impacts, affecting such processes such as development, reproduction, respiration, the liver, kidney or other organs. Groups of experts at government agencies, such as USEPA and California EPA , are brought together to look at all of the studies done on the health effects of a chemical, and to recommend toxicity values that can be used to evaluate public exposure to that chemical. These toxicity values are known as unit risk factors and reference concentrations.

Unit risk factors (URFs), presented in units of the inverse of micrograms per cubic meter $(ug/m^3)^{-1}$, are toxicity values used for carcinogens that estimate the increased risk of getting cancer associated with the concentration of the chemical in the air that an individual may breathe. A risk of less than one in a million (expressed as 1E-06 or 1×10^{-6}) is usually considered by government agencies to be negligible. California-specific URFs are embedded into DTSC's version of the Johnson and Ettinger model. California URFs are also presented in the Office of Environmental Health Hazard Evaluation's (OEHHA) Toxicity Criteria Database (OEHHA 2009). URFs for COPCs are presented in Table 3. The database is available at www.oehha.ca.gov.

Reference concentrations (RfCs), presented in units of milligrams per cubic meter (mg/m^3) are toxicity values developed for noncarcinogens. Exposure to a chemical below its reference concentration, even over a long period of time, is not expected to have any negative effect on health. California RfCs (referred to in California as Reference Exposure Levels, or RELs) are presented in the Office of Environmental Health Hazard Evaluation's (OEHHA) Toxicity Criteria Database (OEHHA 2009). California-specific RfCs (RELs) are embedded into DTSC's version of the Johnson and Ettinger model. RfCs for COPCs are presented in Table 3. The database is available at www.oehha.ca.gov.

4.0 Risk Characterization

This section presents the results and conclusions of the health risk evaluation under the assumptions of residential exposure. The risk characterization represents the final step in the risk assessment process. In this step, the results of the exposure and toxicity assessment are integrated into quantitative estimates of potential health risks. The risk characterization is presented for carcinogenic and noncarcinogenic health effects. A cancer risk of less than or equal to 1 in 1 million is considered as insignificant, or de minimis. A noncancer hazard index less than or equal to 1.0 indicates that the predicted exposures would not be expected to cause adverse noncancer health effects in exposed individuals.

Table 4 presents the estimated cancer risk and noncancer HI for future on-Site residents assuming exposures to vapors from the maximum concentration of chemicals in groundwater detected at the Site. The total cancer risk for the on-Site resident was calculated to be 0.8 in 1 million (8E-07, or 8 x 10^{-7}). The total Hazard Index (HI) for the on-Site resident was calculated to be 0.003. The cancer risk and noncancer HI for the on-Site resident are less than the USPEA and DTSC benchmarks for acceptable cancer risk and noncancer hazard. Exposures associated with an equestrian center will be less than those associated with a residential dwelling due to lower air concentrations, shorter frequency of exposure, and shorter duration of exposure. Therefore, cancer risks and noncancer hazards for users of the equestrian center will be less than those calculated for future residents.

5.0 Uncertainty Analysis

Risk assessments include several uncertainties that warrant discussion. Many of the assumptions used in this risk assessment, regarding the representativeness of the sampling data, human exposures, and chemical toxicity are conservative, follow agency guidance, and reflect a 95% percentile or greater, rather than a typical or average value (a 50% percentile) for a given parameter. The use of conservative exposure and toxicity assumptions can introduce considerable uncertainty into the risk assessment. By using conservative exposure or toxicity estimates, the assessment can develop significant conservative bias that may result in the calculation of significantly higher noncancer hazard index than is actually posed by the chemicals present in Site soils.

Some of the assumptions made in the risk assessment that contribute to the overall uncertainty in the evaluation are briefly outlined in the following paragraphs:

- Cancer risks and noncancer hazards presented in this evaluation are based on the assumption that a future resident would be exposed to the maximum detected concentration continuously, for a 30-year exposure period. As the maximum concentrations likely significantly overestimate an individual’s average exposure, the actual risks posed by the chemicals present at the Site may be lower than those presented here.
- Cancer risks and noncancer hazards presented in this evaluation are based on residential land-use assumptions, under the assumption that a child is born on the Site, resides at the Site for a continuous 30-year period, and is exposed to vapors from chemicals in groundwater for 24 hours per day on a daily basis. It is likely that a resident would spend at least part of the day outside of the home. In addition, given that the proposed use of part of the Site is for an equestrian center, workers and visitors would actually only be exposed to chemicals on-Site for a fraction of the total time assumed in this analysis.
- The migration of vapors from groundwater, which is approximately 18 feet below ground surface, does not take into account the future use of methane barriers. The methane barriers are likely to attenuate a portion of the vapors that may migrate into indoor air. This would render the actual concentration of vapors as less than that assumed in this risk assessment.
- In order to adjust for uncertainties that arise from the use of animal data, regulatory agencies of often base the unit risk factor and reference concentration effects on the most sensitive animal species (i.e., the species that experiences adverse effects at the lowest dose) and adjust the dose via the use of safety or uncertainty factors. The adjustment compensates for the lack of knowledge regarding interspecies extrapolation and possibility that humans are more sensitive than the most sensitive experimental animal species tested. The use of uncertainty factors is considered to be health protective. Risk assessments assume that adverse effects observed in animal toxicity experiments would also be observed in humans (animal-to-human extrapolation), and that the toxic effect observed after exposure by one route would occur following exposure by a different route (route-to-route extrapolation).

Although it is difficult to quantify the uncertainties associated with all the assumptions made in this health risk assessment, the use of conservative assumptions is likely to contribute to a substantial overestimate exposure and, hence, of risk.

6.0 Conclusions

A human health risk assessment was conducted for the future San Juan Meadows / Distrito La Novia project. There are no known contamination issues associated with the land upon which the Distrito La Novia will be developed. A portion of the San Juan Meadows site was formerly the Forster Canyon Sanitary Landfill. The Forster Canyon Sanitary Landfill is currently covered with two to eight feet of native soil. Development plans (into an equestrian center and residential housing) include the addition of four to five feet of soil. It is therefore not likely that direct contact with residual chemicals in soil could occur. Issues associated with methane migration from the former Landfill are being addressed through the Landfill Closure Plan currently being prepared by Bryan A. Stirrat & Associates. Issues associated with emissions from the Landfill Gas Treatment Facility are being addressed by the permitting process required by the South Coast Air Quality Management District.

This risk assessment addresses the potential for exposures from volatile organic chemicals in groundwater that may migrate upwards as vapors into indoor air. The risk assessment utilizes the groundwater data obtained during the groundwater monitoring events that occurred in September of 2008 and January of 2009. The maximum concentration of each detected volatile organic chemical was input into DTSC's version of the Johnson and Ettinger GW-Screen vapor intrusion model. The model calculates the projected indoor air concentration of each chemical along with the associated potential cancer risk and noncancer hazard. The cancer risk and noncancer hazard calculated for each chemical are summed and presented as a final cancer risk and noncancer hazard. A cancer risk of less than or equal to 1 in 1 million is considered as insignificant and would be acceptable to regulatory agencies. A noncancer hazard index of less than or equal to 1 would be acceptable to regulatory agencies.

The results of this risk assessment indicate that the cancer risk to future residents is 0.8 in 1 million (8×10^{-7}). This value is less than the insignificant risk value of 1 in 1 million. The noncancer hazard index for future residents is 0.003. This value is less than the benchmark value of 1. Based on the input parameters used for this assessment along with the proposed mitigation measures which include vapor barriers (for the attenuation of methane vapors) for the San Juan Meadows site, the values for cancer risk and noncancer hazard are likely overestimated.

7.0 References

Bryan A. Stirrat & Associates, 2009a. *Landfill Gas Treatment Facility Permit to Construct and Operate Application Package*. August.

Bryan A. Stirrat & Associates, 2009b. *Application for Alteration/Modification to Permitted Equipment (Permit No. F20557) Landfill Gas Extraction System Permit to Construct and Operate.* August.

Bryan A. Stirrat & Associates, IN PREPARATION. Final Closure Plan Amendment (FCPA) for the Forster Canyon Landfill (FCL).

California Environmental Protection Agency (Cal/EPA) 1992, Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities, Dept. of Toxic Substances Control, Office of Science Advisor, Sacramento, CA.

California Environmental Protection Agency Department of Toxic Substances Control (DTSC), 1999 (originally printed in 1994). *Preliminary Endangerment Assessment Guidance Manual.* June.

California Environmental Protection Agency (Cal/EPA) 2004a, Revised February 7, 2005, *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion into Indoor Air*, Dept. of Toxic Substances Control, Sacramento, CA.

California Environmental Protection Agency (Cal/EPA) 2004b, Revised January, 2005, *Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil*, Office of Environmental Health Hazard Assessment, Sacramento, CA.

California Environmental Protection Agency Department of Toxic Substances Control (DTSC), 2009. GW-SCREEN, Version 3.0, 04/04, last modified 2009.

National Research Council (NRC), 1983. Committee on the Institutional Means for Assessment of Risks to Public Health, Commission on Life Sciences. *Risk in the federal government: Managing the Process.* Washington, DC: National Academy Press. March.

Office of Environmental Health Hazard Assessment (OEHHA), 2005. *Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil.* January.

Office of Environmental Health Hazard Assessment (OEHHA), 2009. *Toxicity Criteria Database*.

Orange County Waste & Recycling, 2009. *Forster Canyon Landfill – 2009 First Semi-Annual Groundwater Monitoring Report.* February 25.

United States Environmental Protection Agency (USEPA), 2009. *Integrated Risk Information System (IRIS) Database*. http://www.epa.gov/iriswebp/iris/index.html.

United States Environmental Protection Agency (USEPA), 2008. *Risk-Based Concentration Table: Mid-Atlantic Risk Assessment.* September 19.

United States Environmental Protection Agency (USEPA), 2004. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*. Final. July.

United States Environmental Protection Agency (USEPA), 1990. *National Oil and Hazardous Substances Pollution Contingency Plan,* Final Rule, Federal Register, Vol. 55, No. 46, Rules and Regulations, March 8.

United States Environmental Protection Agency (USEPA), 1989. Office of Emergency and Remedial Response. *Risk Assessment Guidance for Superfund (RAGS). Volume I, Human Health Evaluation Manual (Part A)*. Interim Final. EPA/540/1-89/002. Washington, D.C. December.

TABLES

TABLE 1
GROUNDWATER MONITORING DATA
FORSTER CANYON SANITARY LANDFILL

Concentration in Groundwater in micrograms per liter (ug/l)

Well	**Depth to Groundwater (feet)**	**1,1 DCA**	**1,1 DCE**	**trans 1,2 DCE**	**1,2 DCP**	**PCE**	**TCE**	**Vinyl Chloride**
MW-a	19.57	6	1.1	2.8	1.8	0.9	24	0.5
MW-a	18.97	3.1	nd	1.1	0.8	nd	11	nd
MW-b	51.23	nd	nd	nd	nd	nd	nd	nd
MW-b	51.8	nd	nd	nd	nd	nd	nd	nd
MW-c	25.63	nd	nd	nd	nd	nd	nd	nd
MW-c	24.77	nd	nd	nd	nd	nd	nd	nd
MW-d	153.05	nd	nd	nd	nd	nd	nd	nd
MW-d	156.7	nd	nd	nd	nd	nd	nd	nd
	MAXIMUM	6	1.1	2.8	1.8	0.9	24	0.5

1,1 DCA - 1,1 dichloroethane
1,1 DCE - 1,1 dichloroethylene
trans 1,2 dce - trans 1,2 dichloroethylene
1,2 DCP - 1,2 dichloropropane
PCE - tetrachloroethylene
TCE - trichlroroethylene
nd - not detected
Note: MW-a, b, and c are located downgradient of the landfill (near Valle Road). MW-d is located upgradient of the landfill.

TABLE 2

INDOOR AIR CONCENTRATIONS - COMPARISON TO CALIFORNIA

HUMAN HEALTH SCREENING LEVELS FOR INDOOR AIR (CHHSLs)*

VAPOR INTRUSION FROM CHEMICALS IN GROUNDWATER

FORSTER CANYON SANITARY LANDFILL

Chemical	**Maximum Groundwater Concentration (ug/l)**	**Indoor Air Concentration (ug/m^3)**	**California Human Health Screening Level for Indoor Air - Residential Land Use (ug/m3)**
1,1 DCA	6.0	0.032	na
1,1 DCE	1.1	0.030	na
trans 1,2 DCE	2.8	0.023	73
1,2 DCP	1.8	0.005	na
PCE	0.9	0.014	0.41
TCE	24.0	0.232	1.22
Vinyl Chloride	0.5	0.016	0.0311

*A CHHSL is a concentration of a chemical that the California EPA considers to be below below thresholds of concern for human health (California EPA, 2005)

1,1 DCA - 1,1 dichloroethane

1,1 DCE - 1,1 dichloroethylene

trans 1,2 dce - trans 1,2 dichloroethylene

1,2 DCP - 1,2 dichloropropane

PCE - tetrachloroethylene

TCE - trichlroroethylene

nd - not detected

na - not available

ug/l - micrograms per liter

ug/m^3 - micrograms per cubic meter

TABLE 3
TOXICITY VALUES
CHEMICALS DETECTED IN GROUNDWATER
FORSTER CANYON SANITARY LANDFILL

Chemical	**Unit Risk Factor (URF) $(ug/m^3)^{-1}$**	**Reference Concentration (RfC) (ug/m^3)**
1,1 DCA	1.6E-06	7.0E-01
1,1 DCE	na	7.0E-02
trans 1.,2 DCE	na	6.0E-02
1,2 DCP	1.0E-05	4.0E-03
PCE	5.9E-06	3.5E-02
TCE	2.0E-06	6.0E-01
Vinyl Chloride	7.8E-05	1.0E-01

1,1 DCA - 1,1 dichloroethane
1,1 DCE - 1,1 dichloroethylene
trans 1,2 dce - trans 1,2 dichloroethylene
1,2 DCP - 1,2 dichloropropane
PCE - tetrachloroethylene
TCE - trichlroroethylene
$(ug/m^3)^{-1}$ - inverse of micrograms per cubic meter
(ug/m^3) - micrograms per cubic meter

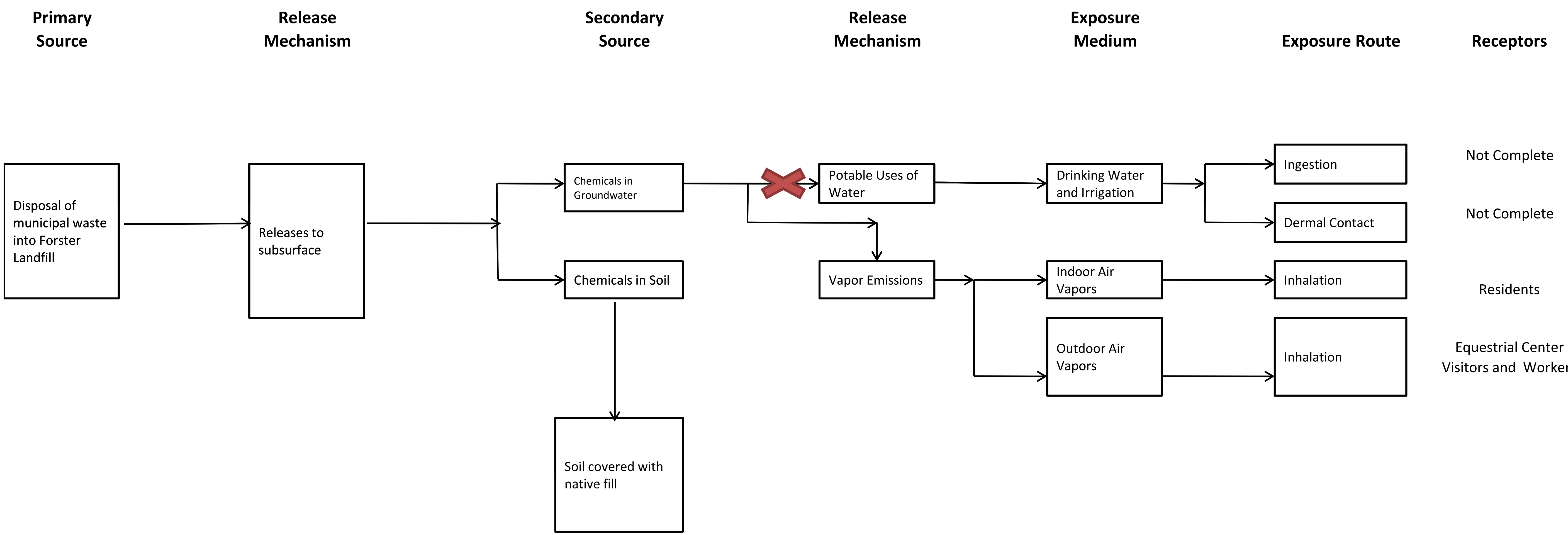
TABLE 4
CANCER RISK AND NONCANCER HAZARD
VAPOR INTRUSION FROM CHEMICALS IN GROUNDWATER
FORSTER CANYON SANITARY LANDFILL

Chemical	Cancer Risk	Noncancer Hazard
1,1 DCA	2.10E-08	4.40E-05
1,1 DCE	na	4.10E-04
trans 12 DCE	na	3.70E-04
1,2 DCP	2.20E-08	1.30E-03
PCE	3.30E-08	3.80E-04
TCE	1.90E-07	3.70E-04
Vinyl Chloride	5.30E-07	1.60E-04
TOTAL	**8E-07**	**3E-03**

1,1 DCA - 1,1 dichloroethane
1,1 DCE - 1,1 dichloroethylene
trans 1,2 dce - trans 1,2 dichloroethylene
1,2 DCP - 1,2 dichloropropane
PCE - tetrachloroethylene
TCE - trichlroroethylene
na - not applicable; chemical not considered as a carcinogen

FIGURES

Site Conceptual Model
San Juan Meadows



ATTACHMENT 1
VAPOR INTRUSION MODELS

DATA ENTRY SHEET

GW-SCREEN
Version 3.0; 04/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION
(enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

DTSC
Vapor Intrusion Guidance
Interim Final 12/04
(last modified 2/4/09)

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
75343	6.00E+00	1,1-Dichloroethane

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER SCS soil type directly above water table	ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) Q_{soil} (L/m)
15	579.12	CL	24	

MORE ↓

ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vandose zone soil vapor permeability, k_v (cm^2)	ENTER Vadose zone SCS soil type (Lookup Soil Parameters)	ENTER Vadose zone soil dry bulk density, ρ_b^V (g/cm^3)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm^3/cm^3)
CL			CL	1.48	0.442	0.168

MORE ↓

ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)	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)
1.0E-06	1	70	30	30	350

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

ABC

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc., RfC (mg/m^3)
7.42E-02	1.05E-05	5.61E-03	25	6,895	330.55	523.00	3.16E+01	5.06E+03	1.6E-06	7.0E-01

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
564.12	0.274	0.245	1.29E-09	0.865	1.12E-09	46.88	0.442	0.067	0.375	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)
3.39E+04	1.00E+06	5.00E-03	15	7,294	5.38E-03	2.21E-01	1.80E-04	5.10E-03	5.58E-05	6.00E-04

Diffusion path length, L_d (cm)	Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
564.12	15	1.32E+03	1.25	1.96E+00	5.10E-03	5.00E+03	2.16E+00	2.43E-05	3.22E-02	1.6E-06	7.0E-01

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	5.06E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
2.1E-08	4.4E-05

MESSAGE SUMMARY BELOW:

END

]

DATA ENTRY SHEET

GW-SCREEN
Version 3.0; 04/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION
(enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

DTSC
Vapor Intrusion Guidance
Interim Final 12/04
(last modified 2/4/09)

ENTER Chemical CAS No. (numbers only, no dashes)	**ENTER** Initial groundwater conc., C_W (μg/L)	Chemical
75354	1.10E+00	1,1-Dichloroethylene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	**ENTER** Depth below grade to water table, L_{WT} (cm)	**ENTER** SCS soil type directly above water table	**ENTER** Average soil/ groundwater temperature, T_S (°C)	**ENTER** Average vapor flow rate into bldg. (Leave blank to calculate) Q_{soil} (L/m)
15	579.12	CL	24	

MORE ↓

ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	**ENTER** User-defined vandose zone soil vapor permeability, k_v (cm^2)	**ENTER** Vadose zone SCS soil type (Lookup Soil Parameters)	**ENTER** Vadose zone soil dry bulk density, ρ_b^V (g/cm^3)	**ENTER** Vadose zone soil total porosity, n^V (unitless)	**ENTER** Vadose zone soil water-filled porosity, θ_w^V (cm^3/cm^3)
CL			CL	1.48	0.442	0.168

MORE ↓

ENTER Target risk for carcinogens, TR (unitless)	**ENTER** Target hazard quotient for noncarcinogens, THQ (unitless)	**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)
1.0E-06	1	70	30	30	350

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

ABC

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc., RfC (mg/m^3)
9.00E-02	1.04E-05	2.60E-02	25	6,247	304.75	576.05	5.89E+01	2.25E+03	0.0E+00	7.0E-02

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
564.12	0.274	0.245	1.29E-09	0.865	1.12E-09	46.88	0.442	0.067	0.375	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)
3.39E+04	1.00E+06	5.00E-03	15	6,299	2.51E-02	1.03E+00	1.80E-04	6.18E-03	5.84E-05	6.37E-04

Diffusion path length, L_d (cm)	Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
564.12	15	1.13E+03	1.25	1.96E+00	6.18E-03	5.00E+03	1.89E+00	2.62E-05	2.97E-02	NA	7.0E-02

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	2.25E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	4.1E-04

MESSAGE SUMMARY BELOW:

END

]

DATA ENTRY SHEET

GW-SCREEN
Version 3.0; 04/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION
(enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

DTSC
Vapor Intrusion Guidance
Interim Final 12/04
(last modified 2/4/09)

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
78875	1.80E+00	1,2-Dichloropropane

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER SCS soil type directly above water table	ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) Q_{soil} (L/m)
15	579.12	CL	24	

MORE ↓

ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vandose zone soil vapor permeability, k_v (cm²)	ENTER Vadose zone SCS soil type (Lookup Soil Parameters)	ENTER Vadose zone soil dry bulk density, ρ_b^V (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)
CL			CL	1.48	0.442	0.168

MORE ↓

ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)	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)
1.0E-06	1	70	30	30	350

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

ABC

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3$)$^{-1}$	Reference conc., RfC (mg/m^3)
7.82E-02	8.73E-06	2.79E-03	25	7,590	369.52	572.00	4.37E+01	2.80E+03	1.0E-05	4.0E-03

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
564.12	0.274	0.245	1.29E-09	0.865	1.12E-09	46.88	0.442	0.067	0.375	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)
3.39E+04	1.00E+06	5.00E-03	15	8,478	2.66E-03	1.09E-01	1.80E-04	5.37E-03	6.47E-05	6.87E-04

Diffusion path length, L_d (cm)	Convection path length, L_p (cm)	Source vapor conc., C_{source} (μg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m^3)	Unit risk factor, URF (μg/m^3)$^{-1}$	Reference conc., RfC (mg/m^3)
564.12	15	1.96E+02	1.25	1.96E+00	5.37E-03	5.00E+03	2.08E+00	2.72E-05	5.34E-03	1.0E-05	4.0E-03

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	2.80E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
2.2E-08	1.3E-03

MESSAGE SUMMARY BELOW:

END

]

GW-SCREEN
Version 3.0; 04/03

Reset to Defaults

DTSC
Vapor Intrusion Guidance
Interim Final 12/04
(last modified 2/4/09)

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION
(enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
127184	9.00E-01	Tetrachloroethylene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER SCS soil type directly above water table	ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) Q_{soil} (L/m)
15	579.12	CL	24	

MORE ↓

ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vandose zone soil vapor permeability, k_v (cm^2)	ENTER Vadose zone SCS soil type (Lookup Soil Parameters)	ENTER Vadose zone soil dry bulk density, ρ_b^V (g/cm^3)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm^3/cm^3)
CL			CL	1.48	0.442	0.168

MORE ↓

ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)	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)
1.0E-06	1	70	30	30	350

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

ABC

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc., RfC (mg/m^3)
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	1.55E+02	2.00E+02	5.9E-06	3.5E-02

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
564.12	0.274	0.245	1.29E-09	0.865	1.12E-09	46.88	0.442	0.067	0.375	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)
3.39E+04	1.00E+06	5.00E-03	15	9,410	1.74E-02	7.14E-01	1.80E-04	4.95E-03	4.74E-05	5.16E-04

Diffusion path length, L_d (cm)	Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
564.12	15	6.42E+02	1.25	1.96E+00	4.95E-03	5.00E+03	2.21E+00	2.15E-05	1.38E-02	5.9E-06	3.5E-02

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	2.00E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
3.3E-08	3.8E-04

MESSAGE SUMMARY BELOW:

END

]

DATA ENTRY SHEET

GW-SCREEN
Version 3.0; 04/03

Reset to Defaults

DTSC
Vapor Intrusion Guidance
Interim Final 12/04
(last modified 2/4/09)

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION
(enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
79016	2.40E+01	Trichloroethylene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER SCS soil type directly above water table	ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) Q_{soil} (L/m)
15	579.12	CL	24	

MORE ↓

ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vandose zone soil vapor permeability, k_v (cm²)	ENTER Vadose zone SCS soil type (Lookup Soil Parameters)	ENTER Vadose zone soil dry bulk density, ρ_b^V (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)
CL			CL	1.48	0.442	0.168

MORE ↓

ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)	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)
1.0E-06	1	70	30	30	350

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

ABC

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3$)$^{-1}$	Reference conc., RfC (mg/m^3)
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	1.66E+02	1.47E+03	2.0E-06	6.0E-01

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
564.12	0.274	0.245	1.29E-09	0.865	1.12E-09	46.88	0.442	0.067	0.375	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)
3.39E+04	1.00E+06	5.00E-03	15	8,382	9.80E-03	4.02E-01	1.80E-04	5.43E-03	5.40E-05	5.85E-04

Diffusion path length, L_d (cm)	Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
564.12	15	9.64E+03	1.25	1.96E+00	5.43E-03	5.00E+03	2.06E+00	2.41E-05	2.32E-01	2.0E-06	6.0E-01

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	1.47E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.9E-07	3.7E-04

MESSAGE SUMMARY BELOW:

END

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DATA ENTRY SHEET

GW-SCREEN
Version 3.0; 04/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION
(enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

DTSC
Vapor Intrusion Guidance
Interim Final 12/04
(last modified 2/4/09)

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
156605	2.80E+00	trans-1,2-Dichloroethylene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER SCS soil type directly above water table	ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) Q_{soil} (L/m)
15	579.12	CL	24	

MORE ↓

ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vandose zone soil vapor permeability, k_v (cm²)	ENTER Vadose zone SCS soil type (Lookup Soil Parameters)	ENTER Vadose zone soil dry bulk density, ρ_b^V (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)
CL			CL	1.48	0.442	0.168

MORE ↓

ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)	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)
1.0E-06	1	70	30	30	350

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

ABC

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3$)$^{-1}$	Reference conc., RfC (mg/m^3)
7.07E-02	1.19E-05	9.36E-03	25	6,717	320.85	516.50	5.25E+01	6.30E+03	0.0E+00	6.0E-02

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
564.12	0.274	0.245	1.29E-09	0.865	1.12E-09	46.88	0.442	0.067	0.375	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)
3.39E+04	1.00E+06	5.00E-03	15	6,986	8.99E-03	3.69E-01	1.80E-04	4.86E-03	5.07E-05	5.47E-04

Diffusion path length, L_d (cm)	Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
564.12	15	1.03E+03	1.25	1.96E+00	4.86E-03	5.00E+03	2.25E+00	2.25E-05	2.32E-02	NA	6.0E-02

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	6.30E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	3.7E-04

MESSAGE SUMMARY BELOW:

END

]

DATA ENTRY SHEET

GW-SCREEN
Version 3.0; 04/03

Reset to Defaults

DTSC
Vapor Intrusion Guidance
Interim Final 12/04
(last modified 2/4/09)

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION
(enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
75014	5.00E-01	Vinyl chloride (chloroethene)

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER SCS soil type directly above water table	ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) Q_{soil} (L/m)
15	579.12	CL	24	

MORE ↓

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CL			CL	1.48	0.442	0.168

MORE ↓

ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)	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)
1.0E-06	1	70	30	30	350

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

ABC

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3$)$^{-1}$	Reference conc., RfC (mg/m^3)
1.06E-01	1.23E-05	2.69E-02	25	5,250	259.25	432.00	1.86E+01	8.80E+03	7.8E-05	1.0E-01

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
564.12	0.274	0.245	1.29E-09	0.865	1.12E-09	46.88	0.442	0.067	0.375	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)
3.39E+04	1.00E+06	5.00E-03	15	4,840	2.62E-02	1.07E+00	1.80E-04	7.28E-03	6.87E-05	7.49E-04

Diffusion path length, L_d (cm)	Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
564.12	15	5.37E+02	1.25	1.96E+00	7.28E-03	5.00E+03	1.72E+00	3.06E-05	1.64E-02	7.8E-05	1.0E-01

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	8.80E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
5.3E-07	1.6E-04

MESSAGE SUMMARY BELOW:

END

]