APPENDIX M

HUMAN HEALTH RISK ASSESSMENT, BROADWAY NORTH LANDFILL, BROADWAY-PANTANO WATER QUALITY ASSURANCE REVOLVING FUND SITE, DATED JULY 6, 2010

HUMAN HEALTH RISK ASSESSMENT
BROADWAY NORTH LANDFILL

BROADWAY-PANTANO WATER QUALITY ASSURANCE REVOLVING FUND SITE

TUCSON, ARIZONA

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Executive Summary

As requested by the Arizona Department of Environmental Quality, Superfund Programs Unit (ADEQ), this report has been prepared by Stantec Consulting Corporation (Stantec), formerly SECOR International Incorporated (SECOR), to present the results of a human health risk assessment (HHRA) using the shallow soil vapor data collected in December 2002 and April/May 2006 near the western and southwestern perimeter of the closed Broadway North Landfill (BNL) located in Tucson, Arizona (hereafter referred to as the Site). The primary goal of this HHRA is to estimate potential human health risks to current residents on the properties located adjacent to the western and southwestern perimeter of the BNL ("adjacent residents") posed by volatile organic chemicals (VOCs) detected in the shallow soil gas using risk assessment methods generally accepted by regulatory agencies in the state of Arizona and by United States Environmental Protection Agency (USEPA).

As indicated below, the cumulative reasonable maximum exposure (RME) indoor health risk results are less than USEPA's trigger levels for remediation (i.e., an excess cancer risk [ECR] of 1.0×10^{-4}, or 1E-04, and a segregated hazard index [HI] of one) and even below or at the *de minimis* risk of 1E-06, indicating no unacceptable health effects to current onsite residents. This indicates that, even if no further remediation takes place at the Site, provided that conditions currently existing at the landfill do not change or are altered, current onsite residents will not incur any unacceptable health risks from VOCs present in vadose zone soils beneath the Site.

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1.0 Introduction

The scope of work of the HHRA is based on the teleconference call between Stantec and ADEQ project managers and risk assessors on May 9, 2008 (SECOR, 2008). Exposure to VOCs from indoor vapor intrusion was assessed using the 2006 shallow soil gas data collected from the Site and the Advanced Johnson and Ettinger (J&E) Soil Gas Model as distributed by USEPA (USEPA, 2004a). The potential health risks using the 2002 shallow soil gas data also were evaluated to identify any correlations between the two groups of data.

Subsequent sections in this report include:

2.0 Selection of Chemicals of Potential Concern
3.0 Exposure Assessment
4.0 Toxicity Assessment
5.0 Risk Characterization
6.0 Uncertainty Analysis
7.0 Conclusions and Recommendations

2.0 Selection of Chemicals of Potential Concern

This section presents sampling events that were conducted at the Site and analytical results leading to the selection of chemicals of potential concern (COPC) for the HHRA.

2.1 SHALLOW GAS PROBE SAMPLING EVENT, DECEMBER 2002

Soil gas samples were collected from 17 existing BN-series (BN-1 to BN-9, and BN-11 to BN-18) and six GP-series (GP-1, GP-2, GP-5, GP-6, GP-10, and GP-12) shallow vapor probe locations at depths ranging from 5 to 25 feet on December 17 and 18, 2002. Each probe location was sampled at two depths, except BN-2. The locations of the vapor probes are depicted in Figure 1. A total of 39 primary and 6 duplicate soil gas samples were collected in laboratory-supplied Summa® canisters for laboratory analysis of VOCs utilizing USEPA Method TO-15. The filled Summa® canisters were delivered under chain-of-custody documentation to Precision Analytical Laboratories (PAL) in Tempe, Arizona for USEPA Method TO-15 analysis. The PAL laboratory reports, chain-of-custody documentation, and Level 2 Data Validation Report by Quality by Design for the well/probe samples were submitted in SECOR (2007).

USEPA Method TO-15 can be used to detect the presence of 38 non-methane VOCs, but it can not be used to detect the typical landfill gas (LFG) constituents (i.e., methane [CH_4], carbon dioxide [CO_2]; and oxygen [O_2]; ammonia; and sulfides). The LFG constituents were monitored in the field using a Lantec GA-90 combustible gas indicator. By volume, LFG typically contains primarily 45% to 60% methane and 40% to 60% carbon dioxide (Agency for Toxic Substances and Disease Registry [ATSDR], 2001). Non-methane VOCs typically constitute only 0.01% to 0.6% by volume. LFG is produced from three processes: bacterial decomposition, volatilization, and chemical reactions. The rate and volume of LFG produced at a specific landfill depend on the characteristics of the waste (e.g., composition and age of the refuse) and a number of environmental factors (e.g., the presence of oxygen in the landfill, moisture content, and temperature). From a public health standpoint, primary LFG constituents such as methane and carbon dioxide are routinely monitored at landfills for explosion and asphyxiation hazards (ATSDR, 2001). Methane is highly explosive when mixed with air at a volume between its lower explosive limit (LEL) of 5% and its upper explosive limit (UEL) of 15%. At concentrations below 5% and above 15%, methane is not explosive. Carbon dioxide is not flammable or explosive, but can cause asphyxiation hazards. For example, at concentrations of 10% or more, carbon dioxide can cause unconsciousness or death. Municipal solid waste landfills operating under

Subtitle D of the Resource Conservation and Recovery Act (RCRA) are required to have concentrations of methane gas not to exceed the LEL (5%) at the facility property boundary (ATSDR, 2001). All 2006 BN-samples collected from the BNL had 0.0% of methane and less than 10% of carbon dioxide concentrations.

VOC results for the December 2002 sampling event are summarized in Table 1. LFG results were included in SECOR (2007) and are not evaluated in this HHRA. Twenty-four non-methane VOCs (the most prevalent being tetrachloroethene [PCE], trichloroethene [TCE], and many of their anaerobic biodegradation products; Freons; and such fuel-related compounds as benzene, toluene, ethylbenzene, and xylenes [BTEX]) were detected in one or more of the 45 soil gas samples collected. Some VOCs were detected only once at concentrations near the sample quantitation limit (SQL) and are not of significance (e.g., ethylene dibromide [EDB] and 1,1-dichloroethane [1,1-DCA]). At certain probe locations (specifically BN-1 and BN-9 to BN-12), several VOCs were detected at higher concentrations in the shallow samples than the deeper samples. This indicates shallow surface contamination related to motor fuel hydrocarbon releases. The location with the highest benzene (200 parts per billion per volume [ppbv]), ethylbenzene (1,200 ppbv), and vinyl chloride (14 ppbv) concentrations is GP-2 at 20 feet below ground surface (bgs). Table 1 also summarizes the VOCs detected, maximum detected analyte concentrations, minimum detected analyte concentrations, and the number of detections for each analyte. For comparison purposes, Table 1 also lists two VOCs (e.g., 1,2-dichloropropane and trans-1,3-dichloropropene) that were detected in the 2006 but not 2002 soil gas samples (yellow color) and several VOCs that were target analytes for the 2006 but not 2002 soil gas samples (blue color).

2.2 SURFACE FLUX CHAMBER TESTING, APRIL 2003

In April 2003, SECOR subcontracted Dr. Charles Schmidt to conduct surface flux chamber testing at selected locations bordering the southwest perimeter of the BNL. The objective of the surface flux chamber testing was to obtain soil gas data representative of VOC and CH4 emissions from open surfaces and pavement within areas proximal to the BNL. Flux chamber test locations were selected on the basis of December 2002 shallow probe soil gas data to monitor areas with emissions representative of the BNL (SECOR, 2007). Two types of flux chamber results (i.e., open soil and infiltration) were obtained from 16 separate locations, as shown on Figure 1. The open soil flux samples were collecting by placing the flux chamber directly on top of exposed, unpaved soil. For this method, soil gas vapors are assumed to be transmitted across the entire permeable surface area contained within the flux chamber. The infiltration flux samples were obtained by placing the flux chamber on top of fully-penetrating

cracks in concrete or asphalt pavement. For this method, soil gas vapors are assumed to be transmitted only through the cracks in the covered surface.

Samples collected during the open soil and infiltration flux chamber testing were delivered to Environmental Analytical Services, Inc. (EASI) of San Luis Obispo, California for VOC analysis using USEPA Test Method TO-14, and CH_4 analysis utilizing American Society for Testing Materials (ASTM) Test Method 3416. Details regarding the test methodology, laboratory testing procedures, analytical testing results, investigative findings, and conclusions are included in Dr. Schmidt's May 2003 *Technical Memorandum, Results of Surface Flux Chamber Testing at the Broadway Landfill North Site Located in Tucson, Arizona* (Schmidt, 2003). ADEQ decided that the flux data were not suitable for use in a risk assessment and decided instead to use shallow subsurface soil gas data for this HHRA.

2.3 SOIL GAS PROBE SAMPLING EVENT, APRIL 2006

Shallow soil gas sampling and testing was conducted in April/May 2006 at the Site to determine the presence and degree of vapor phase VOCs residing near the surface of BNL and to compare then-current VOC soil gas analyte concentrations to those collected in December 2002 from the same set of shallow soil gas probes (SECOR, 2006; 2007).

Soil gas samples were collected on April 5-6, 2006 from existing BN-series vapor probes (BN-1 through BN-18) and GP-series vapor probes (GP-1, GP-2, GP-5 through GP-7, and GP-10 through GP-12). The locations of these probes are depicted on Figure 1. These probes range in depth from 5 to 25 feet bgs and are constructed of 0.5-inch diameter Schedule 40 polyvinyl chloride (PVC) blank and slotted casing. Forty-four primary samples, three field duplicate samples, and three laboratory equipment blanks (laboratory supplied air-filled Summa®-type canisters) were collected for laboratory analysis of VOCs utilizing USEPA Method TO-15. Two samples were re-collected in conjunction with other field activities on April 26, 2006 and May 23, 2006. An equipment blank canister that was not properly labeled as such by the laboratory was used to collect sample BN-3-10 (i.e., the sample from the 10-foot deep probe at BN-3). The laboratory was contacted when the error was noted and the sample was not analyzed. Sample BN-3-10 was re-collected on April 26, 2006. Sample BN-1-20 (the sample from the 20-foot deep probe at BN-1) inadvertently was not collected. A replacement sample was collected on May 23, 2006.

In addition to samples collected for TO-15 analysis, LFG component measurements and VOC concentration measurements were collected at each soil gas monitoring probe using an LFG

meter (Lantec GA-90) and a flame ionization detector (FID) respectively. Field equipment blanks were not collected as planned because disposable tubing was used to connect the sample canisters to the sample ports at the well heads and the tubing was not re-used. The three canisters of laboratory-supplied air that were originally intended for use in collecting field equipment blanks were returned to the laboratory unopened. Samples from these canisters were then analyzed and reported as laboratory equipment blanks to evaluate laboratory contamination (BLANK-1 EB 040506, BLANK-2 EB 040606, and BLANK-3). Since there were no field equipment blanks collected, there is no evaluation of the potential impact on Site samples during sample collection. This should not affect the overall quality of the data since field equipment contamination is rarely observed at contaminated sites and most analytes that are found in these blanks are not carcinogenic chemicals. In fact, even if some analytes may be detected in field equipment blanks, no detected concentrations will be eliminated from the pertinent dataset because of their presence in the field equipment blank for conservative purposes. The “unplanned” laboratory equipment blanks also turn out to be a combined trip blank, which allows for identification of canister handling and transportation.

The 2006 soil gas samples were analyzed for 59 VOCs by Environmental Science Corporation (ESC) of Mt. Juliet, Tennessee using USEPA Method TO-15. Level IV laboratory reports were provided for all samples except BN-1-20, for which a Level II laboratory report was provided. Laboratory analysis of the 44 primary and 3 duplicate soil gas samples collected from the BN- and GP-series probes detected the presence of 31 VOCs at concentrations at or above the laboratory reporting limit. The sample results are summarized in Table 2 for the BN-series and GP-series. Table 2 also summarizes the VOC analytes detected, their maximum detected concentrations, their minimum detected concentrations, and the number of detections. For comparison purposes, Table 2 also indicates six VOCs that were detected in the 2002 but not 2006 soil gas sampling events (light green color). Vinyl chloride is one of these six VOCs.

Level IV laboratory data were validated and Level II data were verified in accordance with the *Quality Assurance Project Plan for Collection and Analysis of Soil and Soil Gas Samples* (QAPP) prepared by SECOR and dated October 29, 2002 (SECOR, 2002). All of the data were considered useable; however, a number of the analyses did not meet one or more of the criteria specified in the QAPP. Therefore, the referenced results are considered to be estimated values and are flagged as follows: with a “J" to indicate that the analyte was positively identified and the associated numerical value is an estimated concentration; with a “UJ” to indicate that the analyte was not detected above an adjusted estimated reporting level; or with a “UJB” to indicate the analyte was detected in a blank sample, the reporting limit has been raised

accordingly, and the analyte was not detected above the adjusted estimated reporting level. Concentrations that were highlighted in light blue color in Table 2 are values that were changed from the original laboratory reports, as a result of data validation.

Comparing the 2002 and 2006 soil gas analytical results, it is apparent that the April 2006 maximum concentrations were significantly less (by as much as two to three orders of magnitude) than their respective December 2002 values for most commonly detected VOCs (Table 3). For example, vinyl chloride was detected at a maximum concentration of 14 ppbv at GP-2-20 in 2002 but was non-detectable (<0.20 ppbv) at the same location in 2006. Benzene was found at a maximum concentration of 200 ppbv at GP-2-20 in 2002 but was detected only at 0.34 ppbv at the same location in 2006. Similarly, Freon 12 was found at 4,700 ppbv at GP-12-10 in 2002, but was detected only at 6 ppbv at the same location in 2006. Cis-1,2-dichloroethene (c-1,2-DCE) was detected at a maximum concentration of 330 ppbv in 2002 at BN-12-5, but was non-detectable (<0.20 ppbv) at the same location in 2006. Although the PCE maximum soil gas concentration seems to have increased in 2006 (from 2.6 ppbv to 9.6 ppbv), the highest 2006 concentration of 9.6 ppbv was detected at a vapor probe (BN-10-20) which was not sampled in 2002. Based on probe-by-probe comparisons, it is apparent that PCE concentrations randomly increased at some locations and decreased at others. Although other Freon and VOC analyte concentrations decreased substantially, the maximum soil gas concentrations in 2002 and 2006 for Freon 11 (15 ppbv vs. 11 ppbv), and methyl chloride (1.1 ppbv vs. 0.85 ppbv) did not change substantially. This fact should not be of concern, since all of these levels are low and none of these VOCs are risk-driving chemicals at the Site. Also, some of these VOCs could be present due to laboratory contamination. For example, ethanol was detected at a maximum concentration of 63 ppbv in sample BN-13-20 duplicate but was detected at only 2.6 ppbv in sample BN-13-20. Data validation results of 2006 soil gas data also indicated that 11 VOCs (acetone; carbon disulfide; 4-dichlorobenzene; ethanol; 4-ethyltoluene; Freon 11; Freon 12; methyl ethyl ketone [MEK]; methyl chloride; 1,2,4-trimethylbenzene; and 1,3,5-trimethylbenzene) were found in blanks.

The Table 3 color code is the same that was used for Tables 1 and 2 to designate specific groups of VOCS: yellow color designates VOCs that were detected during the 2006 but not 2002 soil gas sampling events; light green color designates VOCs that were detected during the 2002 but not 2006 soil gas sampling events; and blue color designates VOCs that were not analyzed during the 2002 soil gas sampling event. This color code is also used on Tables 4, 5, 8, 9 and 11 (which will be described in following sections of this report).

2.4 CHEMICALS OF POTENTIAL CONCERN

COPCs are defined as chemicals that are potentially site-related and for which data are of sufficient quality for use in a quantitative risk assessment (USEPA, 1989a). For this HHRA, all 36 detected analytes in 5- to 25-foot bgs soil gas samples analyzed via USEPA Method TO-15 were included in the HHRA for completeness purposes (Table 3). Since most soil gas probe locations are situated between the former BNL and current residences adjacent to the western boundary of the landfill, each probe is considered as a separate exposure point (SECOR, 2008). In addition, both sampling depths at each probe location are considered in the fate-and-transport modeling effort for comparison purposes. As such, no statistical analysis of the data is required.

3.0 Exposure Assessment

Exposure is defined in the USEPA risk assessment guidelines as the contact of a receptor with a chemical or physical agent (USEPA, 1989a; 1992a). The goal of the exposure assessment is to identify and quantify known and hypothetical exposure pathways relevant to an assessment of public health risk at a site, and to determine the quantities or concentrations of the risk agents received by the potentially exposed populations (USEPA, 1992a). Because exposure assessment is used to determine the need for a remedial action to protect human health under current (and future) land use conditions, exposure assessment emphasizes calculating risk to individuals or small population groups (USEPA, 1990a; 1992a) based on exposure scenario evaluations instead of actual exposure dose measurements. Thus, exposure assessment generally is performed by determining the concentrations of chemicals in a medium at a location of interest (termed exposure point concentrations [EPCs]) and linking this information with the time (in years) that individuals or populations remain in contact with the chemicals (time of contact). Exposure assessment at a hazardous waste site also involves estimating human exposures from relevant intake route(s) through a combination of direct measurements of COPC concentrations in environmental media and mathematical models.

A complete exposure assessment consists of the following components (USEPA, 1989a):

- characterization of the exposure setting;
- identification of complete/potentially complete exposure pathways (as indicated in the site conceptual model [SCM]);
- fate and transport modeling; and
- quantification of exposure, including EPCs and intake/uptake doses.

3.1 EXPOSURE SETTINGS

The Site is a stretch of land between old residential developments along Flamenco Drive, Laguna Place, Elbow Bay Place, Montego Drive, Avenue de la Vista, and Calle Managua and the southwestern boundary of the former BNL in Tucson, Arizona. There are about 40 residences along this stretch of the Site. Tucson Electric Power Substation is located north of the residential developments. Tucson is located within a broad valley, with mountains on each side – Santa Catalinas to the north, the Rincons to the east, the Tucson Mountains to the west, and the Santa Ritas to the south. Tucson has an annual average of 11.14 inches/year of precipitation (Western Regional Climate Center (WRCC) (WRCC, 2008). The

precipitation arrives in two distinct seasons: 52 percent as rainfall events during the summer "monsoon" (July-September), and 28 percent as rainfall events from December through March. About 14% of rainfall events occur in October and November. Summer "monsoon" rains are characterized by brief but intense thunderstorms with highly localized precipitation (University of Arizona, Water Resources Research Center [WRRC], 2008). Clear skies and a relatively low latitude (i.e., closer to the equator) make Tucson one of the warmest areas in the U.S. The average maximum temperature is up to 100.1 degrees Fahrenheit (^{o}F) in July (WRCC, 2008), with peaks above 110°F. These high temperatures, along with low relative humidity, contribute to very high water loss through evapotranspiration (WRRC, 2008). The potential evapotranspiration rate averages about 77 inches per year, which is about 6.5 times greater than the approximate total annual precipitation in the area. Most of the precipitation that falls in the summer storms evaporates without being used by plants or people or being recharged into the aquifer (WRRC, 2008). A climate summary for Tucson (WRCC, 2008) is presented below, which covers the period from September 1, 1894 to April 30, 2007.

UNIVERSITY OF ARIZONA, TUCSON, ARIZONA (028815)

Period of Record Monthly Climate Summary, Period of Record : 09/ 01/1894 to 04/30/2007

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (^{o}F)	65.5	68.9	74.3	82.2	90.7	99.8	100.1	97.9	95.2	85.9	74.3	66.2	83.4
Average Min. Temperature (^{o}F)	37.6	40.2	44.0	49.9	57.5	66.8	73.9	72.4	66.9	54.9	43.8	38.1	53.8
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Total Precipitation (in.)	0.89	0.83	0.76	0.39	0.18	0.27	2.02	2.16	1.16	0.75	0.77	0.96	11.14
Average Total SnowFall (in.)	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

There are no boring logs prepared for the Site vapor probe wells. However, information on soils at the Site can be taken from available reports for the general area. Native soils at the BNL, which has not been disturbed by historical sand and gravel quarrying and subsequent backfilling with municipal solid waste, is Mohave soil (U.S. Department of Agriculture, Soil Conservation Service [USDA-SCS], 1972). This is a very deep and well drained soil consisting of sandy loam to sandy clay loam (loam is `a general term for a mixture of top soil, clay, and silt, with some sand). The corresponding Unified Soil Classification System

(USCS) classification for soils at the Site would be silty sand to sandy silt (or sandy silt) with clay (SM to ML or OL). For purposes of this HHRA, soils at the Site are assumed to be loamy sand (LS), which is silty sand or clayey sand with 12-25% fines (USDA-SCS, 1972; USEPA, 2004a), which is consistent with the fact that soils at the Site, as well as much of Arizona, have very little to no organic content.

3.2 SITE CONCEPTUAL MODEL (SCM)

Typically, a receptor comes into contact with COPCs only if a complete or potentially complete exposure pathway exists under current (or future) land use conditions (USEPA, 1989a). According to USEPA, only complete or potentially complete exposure pathways need to be quantitatively evaluated in an HHRA (USEPA, 1989a). The fact that a chemical is transported in different environmental media may or may not result in human exposure to that chemical. For an exposure pathway to be considered complete, it must be possible for a chemical to be transported via an environmental medium to a potential receptor location, and then for receptors to come in contact with the chemical and assimilate it into their bodies via one or more exposure routes (e.g., ingestion, inhalation, or dermal contact).

A complete exposure pathway consists of the following elements (USEPA, 1989a):

- A contaminated source of chemical;
- A mechanism by which the chemical is released;
- A retention or transport medium through which a chemical travels from the point of release to the receptor location; and
- A route of exposure (e.g., ingestion, inhalation, or dermal contact) by which the chemical enters the receptors' body and causes potential adverse health effect.

If any of these elements does not exist, then the exposure pathway is considered incomplete and further evaluation of the health risks associated with that incomplete pathway is not required. In some instances, a complete or potentially complete exposure pathway may be considered to be a "minor" or "insignificant" pathway (i.e., a pathway that is not expected to contribute significantly to the overall exposure and risk) (USEPA, 1992a). Further quantitative evaluation of the health risks associated with minor or insignificant pathways with a clearly *de minimis* risk is not required (USEPA, 1992a).

Due to decomposition and degradation of wastes placed in a municipal solid waste (MSW) landfill, most MSW landfills--with the passage of sufficient time--may contain various chemicals

in soil, groundwater, and soil gas. Modern surface cap design, waste cell liner technology, and leachate recovery systems may protect MSW landfills against rainfall percolation, leachate generation, and impacts to the underlying aquifer; however, VOC migration in the form of soil gases is much more difficult to control (USEPA, 2002a). Dense chlorinated VOCs can "sink" and migrate laterally, resulting in their presence at significant depths and lateral distances from the MSW landfill. For buildings located near the MSW landfill, the migrating gases can diffuse upward through cracks in concrete slab foundations to enter occupied indoor spaces. These vapors can be inhaled by the building occupants, completing the inhalation exposure pathway.

The air exposure pathways evaluated in this HHRA for current adjacent residents include:

- Indoor inhalation of VOCs that enter the adjacent buildings (using soil gas data collected at a distance from these buildings and the Advanced J&E Model).

The outdoor inhalation of VOCs in ambient air was not evaluated in this HHRA since indoor air VOC concentrations are always higher than VOC levels in outdoor air.

3.3 QUANTIFICATION OF EXPOSURE

According to USEPA, when exposures are estimated from a series of factors, such as environmental concentrations, intake rates, and individual activities (USEPA, 1990b; 1997a), not all of the factors should be set at values that maximize exposure or dose (USEPA, 1991a) since this practice will almost always lead to an estimate that is much too conservative (USEPA, 1992a). USEPA recommends (USEPA, 1989a; 1992a; 1992b) that the central tendency exposure (CTE, or average exposure) be quantified in a HHRA in addition to the typical high-end exposure (i.e., the RME that is reasonably expected at a site). This practice provides a range of exposures as context for risk management decisions. For this Site, due to the large amount of J&E modeling effort that would be required, only the CTE risks for the probe location (BN-13-20) with the highest risk levels have been estimated to provide a range of possible risks.

According to USEPA (USEPA, 1989a), the RME pathway-specific exposure case is based on the RME EPC--the lesser of the 95% upper confidence limit [UCL] of the arithmetic mean or the maximum concentrations (USEPA, 1992c; 2002b) of COPCs in the environment--and on the 90th to 95th upper percentile levels or best professional judgment, for other exposure assumptions (e.g., contact rate, exposure frequency, and duration). USEPA defines an EPC as the average chemical concentration a receptor may contact at an exposure area over the exposure period of interest (USEPA, 1989a). The exposure condition at the Site is one in which a receptor randomly, or not so randomly, moves through the residence and remains located within certain rooms for purposive periods of time. Since indoor air concentrations were not measured, the goal of this HHRA was to predict the average overall indoor air

concentration from modeling of vapor intrusion. An EPC in this specific case could only have been determined if data were available over a chronological period to measure the temporal fluctuations in soil gas concentration at any one residential location during the exposure period of interest, coupled with multiple sample locations around each dwelling. To date, the variability in subsurface soil characteristics and the variable nature of gas migration from landfills do not allow us to reasonably group the spatially segregate data currently available. Since each probe location and sampling depth has been evaluated, the detected concentrations are conservatively considered to be EPCs for both RME and CTE cases. Analytes that were non-detectable at each probe location and depth have not been included in the health risk calculations. Table 4 and Table 5 present probe-specific and depth-specific EPCs--based on 2002 and 2006 soil gas data, respectively, in units of parts per million per volume (ppmv)--that are used as input EPCs in the Advanced J&E Model.

3.4 FATE AND TRANSPORT MODELING

For conservative purposes, the Advanced J&E Soil Gas Model (USEPA, 2004a) was used in this HHRA to estimate indoor air concentrations at the exposure points of interest, making the conservative assumption that the soil gas probes are next to the foundations of adjacent residences with concrete slab on grade.

USEPA (USEPA, 2004a) has adapted the 1991 J&E Model to provide a set of screening-level, one-dimensional analytical models (hereafter referred to as the Advanced J&E Model) that incorporate both vapor convection and vapor diffusion mechanisms for estimating the transport of contaminant vapors emanating from either subsurface soils or groundwater into indoor spaces located directly above the source of contamination. Inputs to the Advanced J&E Model include chemical properties of many chemicals, saturated and unsaturated zone soil properties, and structural properties of the building. However, as is discussed in Section 4.3 (Toxicity Values for COPCs), some of the COPCs identified at the Site are not included in VLOOKUP spreadsheet of the Advanced J&E Model. Appendix A provides a list of these COPCs and suggested physical/chemical and toxicity parameters for each of these COPCs.

The Advanced J&E Model is provided as Microsoft Excel spreadsheets, and each model run has the following five worksheets:

1) DATAENTER (Data entry sheet for single chemical of interest);
2) CHEMPROPS (Chemical properties sheet for single chemical of interest);
3) INTERCALCS (Intermediate calculations sheet);
4) RESULTS (Results sheet); and
5) VLOOKUP (Lookup tables which provide physical and chemical data for a list of chemicals).

Unsaturated soil zone properties and structural properties of buildings are as follows:

- Depth below grade to bottom of enclosed space floor, L_F (centimeters, or cm): model default, 15 cm (typical 6-inch concrete slab in commercial buildings, Advanced J&E Model default).
- Soil gas sampling depth below grade, L_s (cm): Probe-specific depths, in cm, such as 152.4 cm (5 feet), 304.8 cm (10 feet), 457.2 cm (15 feet), 487.7 cm (16 feet), 579.1 cm (19 feet), 609.6 cm (20 feet, and 762 cm (25 feet).
- Average soil temperature: 22.2 degrees Centigrade (^oC) (Figure 8 of USEPA [2004a], site-specific for Tucson, AZ).
- Vadose zone SCS soil type: LS for loamy sand.
- Vadose zone soil dry bulk density, ρ^A_b: 1.62 grams per cubic centimeter (g/cm^3), J&E Model default for loamy sand (USEPA, 2004a).
- Vadose zone soil total porosity, n^V: 0.39 (dimensionless, or cm^3/cm^3), Advanced J&E Model default for loamy sand (USEPA, 2004a).
- Stratum A soil water-filled porosity θ^V_w: 0.076 (dimensionless, or cm^3/cm^3), Advanced J&E Model default for loamy sand (USEPA, 2004a).
- Average vapor flow rate into building Q_{soil}: 5 liters per minute (L/m), model default for residential scenario.
- Enclosed space floor thickness = 10 cm (model default).
- Soil pressure differential = 40 (default).
- Enclosed space floor length = 1,181 cm (or 38.7 feet), assuming a square residence of 1,500 square feet (SECOR, 2008).
- Enclosed space floor width = 1,181 cm (or 38.7 feet), assuming a square residence of 1,500 square feet (SECOR, 2008).
- Enclosed space height: conservatively set at 243.8 (or 8 feet) for older residences. Note that the Advanced J&E Model default is 366 cm (12 feet).
- Floor-wall seam crack width = 0.1 cm (model default);
- Indoor air exchange rate = estimated at 0.5 exchanges per hour, per ADEQ's recommendation (SECOR, 2008).
- Averaging time for carcinogenic effects: 70 years for residents (model default).
- Averaging time for noncarcinogenic effects: 30 years (USEPA, 1991a) and 12 years (USEPA, 1990b; 1997a) for RME and CTE residents (3 years for children from 0-6 years old and 9 years for adults), respectively.
- Exposure duration: 30 years (USEPA, 1991a) and 12 years (3 years for children plus 9 years for adults – USEPA, 1990b; 1997a) for RME and CTE residents, respectively.

- Exposure frequency: 350 days/year (USEPA, 1991a) for RME and CTE residents.

The model run spreadsheets for the Advanced J&E Model using Site-specific parameters and the CTE and/or RME EPCs are provided in Appendix B.

The model default Q_{soil} value of 5 liters per minute (L/m) is a conservative number that was used in the Site-specific Advanced J&E Model effort. In Table 9 (Building-related Parameters for the Vapor Intrusion Model, Page 36 [USEPA, 2004a]), USEPA specifically states that the Q_{soil} parameter is a variable, and that it is specific to soil texture. According to Dr. Paul Johnson (American Petroleum Institute [API], 2002), one of the differences between his original 1991 J&E Model and the USEPA-modified model (i.e., the Advanced J&E Model) is that USEPA allows the Q_{soil} parameter to be calculated from user's inputs for soil permeability, pressure differential, and perimeter crack length, etc. Dr. Johnson further notes that, since the Q_{soil} parameter in his J&E Model is left blank to be calculated by the model based on site-specific parameters, the potential indoor air concentrations and consequently the potential health risks should be lower. Dr. Johnson (API, 2002) recommends that the $Q_{soil}/Q_{building}$ ratio stay within the reasonable range of 0.0001 to 0.01 for all J&E Model runs. Using a Q_{soil} of 5 L/m resulted in the $Q_{soil}/Q_{building}$ ratio falling below the minimum reasonable range of 0.0001.

4.0 Toxicity Assessment

Toxicity assessment is the process of using the existing toxicity information from human or animal studies to identify potential health risks at various dose levels in exposed populations (USEPA, 1989a). The purpose of toxicity assessment is to collect and weigh the available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals and to provide an estimate of the relationship between the extent of exposure to a contaminant and the increase likelihood and/or severity of adverse effects. To estimate these potential health risks, the relationship between exposure to a chemical (in terms of intake dose to individuals) and an adverse effect (in terms of bodily response to a specific intake dose level) must be quantified. Without these dose-response (i.e., toxicity) values, risk-based decision-making for human health protection purposes can not be achieved.

Toxicity assessments for COPCs found at hazardous waste sites generally consist of two steps: 1) hazard identification; and 2) dose-response assessment (USEPA, 1989a). Each is discussed below.

4.1 HAZARD IDENTIFICATION

The hazard identification step is a qualitative process of determining whether exposure to a chemical agent can cause adverse health effects, especially in humans. This is addressed in the format of a toxicity summary for each risk-driving COPC identified for a contaminated site.

4.2 DOSE-RESPONSE ASSESSMENT

The dose-response assessment step of the HHRA process involves characterizing the relationship between the administered and/or the absorbed dose of a chemical agent and the magnitude or likelihood of the adverse health effects (USEPA, 1989a). For chemicals that are known or suspected to cause cancer, the dose-response assessment process defines the relationship between the dose of the risk agent and the probability of induction of carcinogenic effects in humans or animal species of interest. For systemic toxicants, or chemicals that give rise to toxic endpoints other than cancer and gene mutations (called noncarcinogenic effects), the dose-response assessment process determines a threshold value below which the adverse noncarcinogenic effects are not expected in the general population, including sensitive subgroups. The dose-response assessment process is accomplished by the search for

USEPA-derived or ADEQ-approved toxicity values to be used in the risk characterization process.

4.2.1 Carcinogenic Dose-Response Assessment Methodology

It has been demonstrated that certain chemicals can cause cancer as a result of occupational or environmental exposure. To be protective of human health, USEPA assumes that a relatively small number of molecular events can elicit changes in a cell, ultimately resulting in uncontrolled cell proliferation and cancer. This is referred to as the nonthreshold theory of chemical carcinogenesis. On the basis of this theory, USEPA uses a two-part evaluation in evaluating the carcinogenic effects of contaminants: 1) assigning a weight-of-evidence classification; and 2) calculating a slope factor (SF) (USEPA, 1989a).

The system for assigning a weight-of-evidence classification is adapted from the approach taken by the International Agency for Research on Cancer (IARC). It describes the likelihood that a chemical is a human carcinogen, based on the supporting evidence of carcinogenicity in human and animal studies (USEPA, 1986). The USEPA weight-of-evidence classification system for carcinogenicity is as follows (USEPA, 1989a; 2008):

A	Known human carcinogen;
B1 or B2	Probable human carcinogen;
C	Possible human carcinogen;
D	Not classifiable as to human carcinogenicity; and
E	Evidence of noncarcinogenicity for humans.

In general, SFs have been calculated and are available for potential carcinogens in Groups A, B1, and B2, but are calculated only on a case-by-case basis for Group C (USEPA, 1989a). The SF is defined as a plausible upper bound estimate of the probability of a response per unit intake of a chemical over a lifetime. It is based on a linear, continuous exposure, nonthreshold extrapolation model, usually the linearized multi-stage model (LMS), and is expressed in risk per milligram per kilogram per day ($[mg/kg\text{-}day]^{-1}$). A chemical-specific SF is then used in the risk characterization process in conjunction with the exposure intakes to estimate an upper bound lifetime probability of an individual developing cancer as a result of exposure to a particular carcinogenic agent. Because the SF is often an upper 95th percentile confidence limit of the probability of response based on experimental animal data used in the LMS model, the carcinogenic risk estimate will generally be an upper bound estimate. Thus, one can always be

reasonably confident that the true risk will not exceed the risk estimate derived through the use of this model. Instead, the true risk is likely to be less than that predicted or may even be zero (USEPA, 1989a).

For each medium of concern (i.e., air, drinking water, etc.), USEPA has estimated a chemical-specific unit risk factor (URF), in units of ECR per unit of chemical concentration in the medium, to be compared directly with chemical concentrations in the environment. The URF for air that is used in the Advanced J&E Model is expressed as ECR per microgram (µg) of chemical per cubic meter of air $(\mu g/m^3)^{-1}$ (USEPA, 2004a).

4.2.2 Non-Carcinogenic Dose-Response Assessment Methodology

Chemical-causing toxic endpoints other than cancer and gene mutations are health effects pertaining to the function of various organ systems, and are referred to as systemic or noncarcinogenic effects. Based on the scientific understanding of homeostatic and adaptive mechanisms, systemic or noncarcinogenic toxicity is assumed to have an identifiable threshold for both the individual and the population, which means that the organisms or receptors can tolerate a range of exposures without adverse effects. The benchmark value for this threshold is the reference dose (RfD, to be compared with intake doses) or reference concentration (RfC, to be compared with chemical concentrations in air, as in the Advanced J&E Model) (USEPA, 1988a; 1989b; 1996). In general, the RfD is the estimated daily exposure that is considered to pose no appreciable risk of deleterious effects to humans, including sensitive population subgroups. The uncertainty associated with an RfD may span as high as an order of magnitude.

Usually, exposures that are less than the RfD are not likely to be associated with adverse health effects. As the frequency and level of exposures exceeding the RfD increases, the likelihood for adverse effects also increases. A clear distinction that could categorize all exposures below the RfD as acceptable (risk-free) and all exposures in excess of the RfD as unacceptable (causing adverse effects) can not be made (USEPA, 1996).

The RfD, in mg/kg-day, or RfC, in mg/m^3, is derived by using the following equation (USEPA, 1996):

$$RfD = \frac{NOAEL}{UF \times MF} \qquad \text{(Eq. 1)}$$

Where:

NOAEL = No-observed-adverse-effect-level;
UF = Uncertainty factor; and
MF = Modifying factor.

The NOAEL is the key datum in the noncarcinogenic dose-response assessment process. It is defined as the highest experimental dose of a chemical at which there is no statistical or biologically significant increase in frequency or severity of adverse effects between the exposed population and its appropriate control. That is, effects may be produced at this level, but they are not considered to be adverse. Adverse effects are defined as functional impairment or pathological lesions which may affect the performance of the whole organism, or which reduce an organism's ability to respond to an additional challenge (USEPA, 1989b). In short, the RfD approach is based on the assumption that if the critical toxic effect is prevented, then all other toxic effects are prevented.

Standard UFs are ten-fold factors that address various types of uncertainty in extrapolation; these typically include the following:

- 10H: A ten-fold factor to account for the variation in sensitivity among members of the human population, especially children, pregnant women, and the elderly.
- 10A: A ten-fold factor to account for the uncertainty involved in extrapolating from animal data to humans, assuming that humans are the most sensitive species.
- 10S: A ten-fold factor to account for the uncertainty involved in extrapolating from less than chronic NOAEL (or subchronic NOAEL) to chronic NOAEL.
- 10L: A ten-fold factor to account for the uncertainty involved in extrapolating from the lowest-observed-adverse-effect-level (LOAEL) to NOAEL.

In addition, a variable UF is often used when there is a lack of supporting reproductive or developmental toxicity data or toxicity data in a second species. In other words, when there is uncertainty because of the lack of data, the USEPA further reduces the RfD (by using an additional UF) to be more protective of human health. MFs, varying from greater than zero (0) to 10, are used to address the scientific uncertainties of the study and database that are not explicitly treated by uncertainty factors. The default value for MFs is one (USEPA, 1988a). In addition to UFs and MFs, NOAELs obtained from animal studies, especially inhalation studies, must be adjusted for the human equivalent NOAEL for exposure duration and other factors, including body weight and difference in bodily uptake (USEPA, 1989b).

Use of the NOAEL in the RfD derivation is limited to one of the doses in the study and is dependent on the study design, in particular on dose selection and spacing. The NOAEL therefore does not account for variability in the data (a study with limited number of animals will often result in a higher NOAEL than the one which has more animals) and the slope of the dose-response curve.

4.3 TOXICITY VALUES FOR COPCs

The hierarchy to select toxicity values for COPCs (i.e., three tiers) follows USEPA's recommendations (USEPA, 2003), with the first tier being USEPA's Integrated Risk Information System (IRIS) database (USEPA, 2010). The second tier is USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) established by USEPA's Office of Research and Development/National Center for Environmental Assessment/Superfund Heath Risk Technical Support Center (STSC), as shown in the USEPA Region 9 Preliminary Remediation Goals (PRGs) Table (USEPA, 2004b) and the USEPA Regional Screening Levels (RSLs) Table (USEPA, 2008). The third tier includes other sources of information, such as Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997b; since HEAST has not been updated since 1997).

For each COPC considered in this HHRA, the weight-of-evidence classification toxicity values for carcinogenic and noncarcinogenic effects for the inhalation exposure route (i.e., URF and RfC) are presented in Table 6. ADEQ recommended that the California Environmental Protection Agency (Cal-EPA) derived URF for TCE (Cal-EPA, 2010) be used in this HHRA (SECOR, 2008). There are seven COPCs (i.e., cyclohexane; Freon 114; trans-1,3-dichloropropene; ethanol; 4-ethyltoluene; n-heptane; and 2-propanol) detected in soil gas at the Site that were not included in the Advanced J&E Model. These are highlighted in Table 7 as a light purple color. USEPA's RfC for cyclohexane is 6 mg/m^3, and n-heptane was reported to be about 38 times less toxic than n-hexane (TPH Criteria Working Group [TPHCWG], 1997). Therefore, the RfC for n-heptane could be 7.6 mg/m^3. Isopropylbenzene (C_9H_{12}), with an RfC of 0.4 mg/m^3, can be used as a surrogate for 4-ethyltoluene (C_9H_{12}). Toxicity values of 1,3-dichloropropene (an URF of 4E-06 [µg/m^3]$^{-1}$ and an RfC of 2E-02 mg/m^3) can be used for trans-1,3-dichloropropene. Toxicity values for ethanol, 2-propanol, and Freon 114 were researched and derived. Physical/chemical parameters and proposed toxicity values for COPCs that are not included in the Advanced J&E Model are presented in Table 7 and Appendix A.

5.0 Risk Characterization

Risk characterization is the culmination of the risk assessment process (USEPA, 1992a); it integrates the results of the identification of COPCs, exposure assessment, and toxicity assessment to describe the risks to individuals and populations in terms of extent and severity of probable adverse health risks under both current and future land-use conditions. The overall quality of the assessment, including the confidence on the risk estimates, is discussed later in Section 6.0 -- Uncertainties Related to Risk Characterization.

In the HHRA, the health risk characterization process involves integrating the exposure intakes and the toxicity values to estimate two types of potential health effects, carcinogenic and noncarcinogenic. Because the development of carcinogenic and noncarcinogenic effects is assumed to be caused by different mechanisms of action, different methods are used to evaluate these effects, as described below.

5.1 CARCINOGENIC RISK CHARACTERIZATION METHODOLOGY

The carcinogenic risk characterization methodology stems from the current regulatory assumption that chemicals causing tumors through direct interaction with DNA may not have a threshold. The reason for the assumption is that people are exposed to numerous chemicals from natural to man-made sources, and this background exposure may generally exceed whatever threshold exists for a particular cancer-causing mechanism (Harvard Center for Risk Analysis [HCRA], 1993a). Moreover, some people may be more susceptible to cancer than others, which means that background levels of exposure may already exceed the threshold values for those individuals. Also, even if carcinogens exhibit threshold doses, the levels may be too small to be meaningful to the risk assessment process. On the basis of these reasons, USEPA scientists emphasize that background levels of exposure to cancer-causing agents are already initiating the carcinogenic process (HCRA, 1993a; USEPA, 1989a).

In assessing the carcinogenic effects resulting from exposures to COPCs, the ECR, in addition to the background fatal cancer risk, is calculated using the following equation (USEPA, 1989a):

$$ECR = LADD \times SF \qquad \text{(Eq. 2)}$$

Where:

ECR = Excess cancer risk;
LADD = Lifetime average daily dose, averaged over a lifetime of 70 years, in mg/kg-day;
SF = Slope factor, in $(mg/kg\text{-}day)^{-1}$

In the Advanced J&E Model, since the inhalation URF--instead of the SF--was used in the risk calculation, the following equation was used to estimate the ECR (USEPA, 2004a):

$$ECR = \frac{URF \times EF \times ED \times C_{building}}{AT_c \times 365\ days/year} \qquad \text{(Eq. 3)}$$

Where:
ED = Exposure duration (years);
EF = Exposure frequency (days/year);
$C_{building}$ = Chemical-specific J&E modeled indoor air concentration, $\mu g/m^3$;
AT_c = Averaging time for carcinogenic effects, equals a lifetime 70 years.

Other parameters have previously been described.

It should be noted that use of URF in a risk equation does not require the age-specific exposure parameters such as intake rate (e.g., inhalation rate) and body weight.

In the HHRA, ECRs from Group A (Known Human Carcinogens) and Groups B-C (Probable or Possible Human Carcinogens) were combined. The Group A ECRs are for benzene and vinyl chloride; and the Group B1, B2, and C ECRs are for PCE, TCE, etc.). These ECR values are expressed in terms such as one-in-one hundred-thousand (1×10^{-5}, 10^{-5}, 1E-05, or 0.00001) or one-in-a-million (1×10^{-6}, 10^{-6}, 1E-06, or 0.000001). An ECR of 1E-05 means that an exposed individual may have an added one-in-one hundred-thousand chance of developing cancer over a lifetime, or one person among one-hundred-thousand exposed people might be expected to develop cancer as a result of exposure to Site-related COPCs. Calculation of the ECR is based on the assumption that the dose-response relationship is linear in the low-dose portion of the LMS model curves due to the low levels of environmental exposures. This linear equation is valid only at ECR levels below 1E-02 (USEPA, 1989a).

For multiple chemical or mixture exposures, the total ECR is conservatively estimated by summing the ECRs for all chemicals for each exposure route, using the following simple additive equation (USEPA, 1989a):

$$\text{Multiple Substance Risk} = \sum_{i=1}^{N} \text{Risk}_i \qquad \text{(Eq. 4)}$$

Where:

Multiple Substance Risk = Total ECR from multiple substances, unitless probability;

Risk_i = ECR for the ith chemical (a total of N).

The additive model is based on the assumption that the chemicals being considered independently have the same mode of action and elicit the same effects. Although the additive model has been shown to predict the acute toxicities of many mixtures of similar and dissimilar compounds (U.S. Council on Environmental Quality, 1989), it can lead to substantial errors in risk estimates if synergistic or antagonistic interactions occur. For carcinogenic effects, the total ECR estimate might become artificially conservative because the upper 95th percentile SFs are not strictly additive. Also, the above equation sums all carcinogens with different weight-of-evidence and tumor sites equally. Due to the conservatism of current cancer risk assessment methodologies, the estimated risks associated with exposure to site-related COPCs may even be zero (USEPA, 1989a; Kostecki et al., 1993; ASTM, 2002).

Several states (including Cal-EPA's *Safe Drinking Water and Toxic Enforcement Act of 1986* [Proposition 65], Alabama, Iowa, Michigan, Missouri, Ohio, South Dakota, Texas, and Utah) and USEPA are using 1E-05 as the risk level of concern when the regulating bodies have derived risk-based cleanup levels. For example, USEPA has selected a single risk level of 1E-05 in its *Hazardous Waste Management System Toxicity Characteristics Revisions* (USEPA, 1995). USEPA (1995) cites the following rationale for its justification:

"The chosen risk level of 1E-05 is at midpoint of the reference risk range for carcinogens (1E-04 to 1E-06) generally used to evaluate CERCLA actions. Furthermore, by setting the risk level at 1E-05 for carcinogens, EPA believes that it is the highest risk level that is likely to experienced, and most if not all risks will be below this level due to the generally conservative nature of the exposure scenario and the underlying health criteria. For these reasons, the Agency regards a 1E-05 risk level for Group A, B, and C carcinogens as adequate to delineate, under the Toxicity Characteristics, wastes that clearly pose a hazard when mismanaged."

Cumulative carcinogenic risk of 1E-04 must not be exceeded to the exposed populations, including sensitive subgroups.

5.2 NONCARCINOGENIC RISK CHARACTERIZATION METHODOLOGY

To assess the potential adverse noncarcinogenic effects resulting from exposure to contaminants, the pathway-specific and chemical-specific chronic daily intake (CDI) is compared with the appropriate chronic RfD to arrive at a ratio called the hazard quotient (HQ) (USEPA, 1989a), as presented below:

$$\text{Hazard Quotient} = \frac{\text{CDI}}{\text{RfD}} \qquad \text{(Eq. 5)}$$

Where:

CDI = Chronic daily intake, in mg/kg-day;

RfD = Chronic reference dose, in mg/kg-day.

In the Advanced J&E Model, since the inhalation RfC--instead of the RfD--was used in the HQ calculation, the following equation was used to estimate the HQ (USEPA, 2004a):

$$\text{HQ} = \frac{\text{EF} \times \text{ED} \times \frac{1}{\text{RfC}} \times \text{C}_{\text{building}}}{\text{AT}_{\text{nc}} \times 365\ \text{days/year}} \qquad \text{(Eq. 6)}$$

Where:

AT_{nc} = Averaging time for noncarcinogenic effects, equals the exposure duration (years).

Other parameters have been previously described.

As with the case of carcinogenic effects, the potential additivity of noncarcinogenic hazards due to exposure to multiple substances is quantified as a hazard index (HI), which is the sum of all possible chemical-specific HQs (USEPA, 1989a).

Usually, if the HQ or HI is greater than unity or one, meaning the exposure level exceeds the threshold RfD, a potential for adverse noncarcinogenic health effects may exist. If the HQ or HI is equal to or less than one, exposures to the COPCs are not expected to result in a systemic toxic response. As the frequency of exposures exceeding the RfD increases and the size of the excess increases, the probability for adverse effects also increases. However, a clear distinction that could categorize all exposures below the RfD as acceptable (risk-free) and all exposures in excess of the RfD as unacceptable (causing adverse effects) can not be made (USEPA, 1996).

It should be noted that HQs and HIs are not statistical probabilities, such as ECR, and the level of concern does not increase linearly as the RfD is approached or exceeded. For regulatory purposes, an HI of 1 or less is considered to be an acceptable noncarcinogenic risk level (USEPA, 1989a; 1990a; 1991b). If the pathway-specific or cumulative exposure HI is greater than one, segregation of the HI, based on the type of effects or mechanisms of action, may be considered in the HHRA (USEPA, 1989a).

5.3 HEALTH RISK RESULTS

Chemical-specific and pathway-specific RME potential indoor health risks to current adjacent residents are presented in Tables 8 and 9 of this HHRA, based on 2002 and 2006 soil gas data (including duplicate samples), respectively. As shown in Table 8, the 2002 RME HIs are all below one. The 2002 RME ECRs range from NA (meaning “Not Available” or COPCs detected are not considered to be carcinogenic at this time) at four probe locations (BN-2-10, BN-4-5, BN-4-15, and GP-10-10) to 2E-06 (at BN-7-5, with the risk-driving COPC being chloroform). The second highest 2002 RME ECR is 1E-06 at BN-7-20 (with risk-driving COPC also being chloroform) and at GP-2-20 (with risk-driving COPC being benzene). There is no distinctive pattern of 2002 RME ECRs with regard to depth of soil gas samples. For example, the shallower soil gas samples can have higher risks than the deeper soil gas samples (at BN-3, BN-5, BN-6, BN-7, BN-8, BN-9, BN-12, and BN-18, with the predominant risk-driving COPC being chloroform) or vice versa (at BN-11, BN-13, BN-14, BN-15, BN-16, and BN-17). At some probe locations, the RME ECRs can be the same for both shallower and deeper soil gas samples (BN-1, BN-15).

As shown in Table 9, all of the 2006 RME HIs are also below one. The 2006 RME ECRs range from 0E+00 (meaning that the COPCs detected are not carcinogenic) at nine probe locations (BN-4-5, BN-4-15, BN-5-10, BN-5-20, BN-16-10, BN-16-20, BN-17-10, GP-11-10,GP-12-10) to 2E-07 (at BN-13-20, with the risk-driving COPCs being chloroform, 1,2-dichloropropane, PCE, and benzyl chloride). The second highest 2006 RME ECR is 1E-07 at BN-13-10, with the risk-driving COPCs being chloroform and PCE. From 2002 to 2006, the highest RME ECRs decreased by one order of magnitude. Similar to the 2002 risk results, there is no distinctive pattern of 2006 RME ECRs with regard to depth of soil gas samples. For example, the shallower soil gas samples have higher risks than the deeper soil gas samples at six vapor probe locations (BN-3, BN-6, BN-7, BN-8, BN-9, and BN-18), with the predominant risk-driving COPCs being chloroform or benzene. By contrast, the deeper soil samples have higher risks than the shallower soil gas samples at six other vapor probes locations (BN-10, BN-11, BN-13, BN-14, BN-15, and BN-17); and the RME ECRs are the same for both shallower and deeper soil gas

samples at five probe locations (BN-2, BN-4, BN-5, BN-12, and BN-16). At the 2006 location with the highest risk (probe BN-13-20), the RME ECR for a resident living for 48 years at the Site will be 4E-07, or a factor of two times higher than the RME exposure of 30 years. At this same location, the CTE ECR for a 12-year residential exposure will be 9E-08, or a factor of 2.2 times less than the RME exposure of 30 years (Table 9a).

Table 10 compares the 2002 and 2006 RME ECRs. For most probe locations, the 2006 RME ECRs are significantly lower than the 2002 RME ECRs (up to 100% of decrease in RME ECRs), except at BN-1-20, BN-6-20, and BN-12-25. At these three probe locations, there was a change in risk-driving COPCs. Also, the increased risks are from 2E-08 to 4E-08 and are way below the lower end of the acceptable ECR range of 1E-06. In summary, all these 2006 RME ECRs discussed above are less than the USEPA trigger levels for remediation (an ECR of 1E-04 and a segregated HI of one) and even below the *de minimis* ECR of 1E-06, indicating no unacceptable health effects to current adjacent residents. This indicates that even if no remediation takes place at the Site, current adjacent residents will not incur any unacceptable health risks from detected VOCs in the soil gas.

6.0 Uncertainties Related to Risk Characterization

Uncertainties in the HHRA are essentially the accumulated uncertainties associated with the methodologies used in estimating the health risk results. They are the product of many factors affecting each component of the HHRA process, namely data collection/evaluation and selection of COPCs, exposure assessment, and toxicity assessment. These factors generally include, at a minimum, measurement errors, conservative exposure and modeling assumptions, and uncertainty and variability of the values used in the assessment. Part of the compounding effects can be seen as the range observed between the CTE and RME health risk values (a factor of two). This section presents a qualitative discussion of the uncertainties, assumptions, and limitations as well as the scientific basis and rationale for the HHRA.

6.1 GENERAL

On the basis of a qualitative method suggested by USEPA (USEPA, 1989a), the magnitude of uncertainties and variabilities inherent in the HHRA are discussed and determined as low, moderate, and high. Uncertainty with a rating of low means, exposures and risk estimates are affected by less than an order of magnitude, while moderate indicates between one and two orders of magnitude, and high is associated with more than two orders of magnitude.

In general, uncertainties associated with the sampling and analysis and COPC selection are related to the assumptions that the sampling activities adequately characterized the contamination problems at the Site, and that the EPCs were representative of the chemicals occurring in the shallow soil gas. For the HHRA, this type of uncertainty results in a low underestimation of the potential health risks. Data evaluated in the HHRA were collected during the 2002 and 2006 SECOR soil gas sampling programs. Thus, there are limited differences in the sample collection procedures, packing and shipping procedures, and analytical procedures. Since the 2006 data were collected in April, before the “monsoon” rainfalls from July to September, the collected data can be representative of the annual average levels. Inclusion of all detected analytes in the HHRA as COPCs provides a conservative and complete risk evaluation.

Exposure and toxicity assessment, on the other hand, have been recognized by USEPA as the largest sources of uncertainties in the health risk assessment process (USEPA, 1992a). Uncertainties associated with exposure assessment in this HHRA involve, at a minimum, estimation of EPCs, identification of complete or potentially complete pathways, use of

conservative fate and transport models and assumptions and use of upper bound exposure parameters in intake dose and health risk calculations.

6.2 SITE-SPECIFIC EXPOSURE ASSESSMENT UNCERTAINTIES

Use of the detected concentrations in individual soil gas probes located at a large distance from the foundations of adjacent residences presents the first uncertainty in this HHRA. This process has low to moderate effects on the exposure assessment because COPC concentrations can decrease significantly at a distance from the source. It is noted that most risk-driving COPCs have high detection frequencies in soil gas at the Site; therefore, the range of risks estimated for these soil gas probes provides a complete assessment of potential health risks to adjacent residents.

Another uncertainty may include the conservative assumption that COPC concentrations do not decrease over time in the environment due to source depletion and biodegradation, but remain at the concentrations measured during the recent 2006 SECOR soil gas investigation. This assumption has a moderate to high effect on the health risk results for soil where risk drivers include biodegradable VOCs. For example, the use of the original 1991 J&E Model--as distributed by USEPA (USEPA, 2004a)--to estimate indoor air concentrations of petroleum hydrocarbons constituents and chlorinated solvents, is extremely conservative. The Massachusetts Department of Environmental Protection (MDEP) has conducted a field study (Fitzpatrick and Fitzgerald, 1997) and found that the J&E Model over-predicted (by one and up to three orders of magnitude, respectively) the soil gas concentrations of chlorinated solvents (e.g., PCE, TCE, and vinyl chloride) and of petroleum-based VOCs (e.g., benzene) in the vadose zone. Fitzpatrick and Fitzgerald (1997) concluded that the overestimation reflects substantial, natural biodegradation of the vapor phase of these VOCs in the subsurface.

Recent efforts by the original 1991 J&E Model developers have been made to address the conservative nature of vapor intrusion modeling at petroleum-contaminated sites (Ettinger, 2006). For example, Johnson et al. (API, 1998) present refinements to the 1991 J&E Model--referred to as the Dominant Layer Model, or DLM--to account for attenuation due to biodegradation (USEPA, 2005a; Ettinger, 2006). The DLM was applied by Ettinger (2006) in various case studies and the results indicated up to two to three orders of magnitude reduction in predicted indoor COPC concentrations, as compared to the results from the 1991 J&E Model. As such, the possible indoor RME ECRs to adjacent residents evaluated in the HHRA should be at least more than ten times less than the estimated values for petroleum hydrocarbons, if biodegradation is taken into account in USEPA's Advanced J&E Model (USEPA, 2004a).

In addition, the pathways quantitatively evaluated in the HHRA are considered to be the primary exposure pathways at the site. Minor or secondary pathways that may exist (e.g., exposure to outdoor air) were not considered in the analysis. The contribution of these minor and secondary pathways to the cumulative risks for the Site is not likely to be significant. Therefore, it is expected that the pathways addressed in the HHRA account for the vast majority of potential human exposure at the Site, and the potential for underestimation of risks by not considering some minor or secondary pathways is estimated to be low.

Another source of uncertainty in estimating exposures is the assumption that individuals within a particular receptor population (or subpopulation) will receive the same intake doses. Variability in parameters such as absorption rates, ingestion rates, dermal contact rate, skin surface area, frequency and duration of exposure, body weight, and activity pattern will exist even in a narrowly defined age group or identified sensitive subpopulation (USEPA, 1992a). This range of uncertainty and variability is difficult to assess. However, many of the USEPA standard default factors used in this HHRA represent the upper limit of these exposure parameters for the RME case; consequently, their use in the RME case is deemed to have overestimated the potential health risks in most cases. A partial indication of this fact is the range of CTE and RME health risks. Since the J&E methodology does not rely on inhalation rate and body weight, the uncertainties associated with these factors were not included.

Other uncertainties are related to the averaging times selected in estimating average daily intakes for potential carcinogenic and noncarcinogenic effects, and the assumption that the same receptor will be exposed daily to low levels of site-related contaminants. On the basis of the information discussed above,
the net overall uncertainty associated with the exposure assessment is rated as low to moderate with a bias toward overestimation of risks.

6.3 SITE-SPECIFICT TOXICITY ASSESSMENT UNCERTAINTIES

Uncertainties in this HHRA are also related to the use of USEPA-derived or Stantec-proposed toxicity values. At the Site, animal data served as the principal basis of the toxicity values evaluated in this HHRA for most of the chemical risk drivers (e.g., chloroform, PCE, TCE). The exceptions are benzene and vinyl chloride. The uncertainties associated with extrapolation from animals exposed to high doses to humans potentially exposed to much lower doses may be quite significant in this HHRA.

Finally, USEPA assumed in the risk characterization step that the health effects of multi-chemical exposure are additive. In the HHRA, chemical-specific ECRs and HIs were summed. This assumption is most properly applied only to compounds that produce the same toxic effect by the same mechanism of action. Because the risk drivers (e.g., benzene, chloroform, PCE, and TCE) addressed in this HHRA are not known to have pronounced synergistic or antagonistic effects, summing the risk driver ECRs and HIs across different types of tumors, weights-of-evidence, and toxic end points adds a low bias to the estimation of cumulative risks. Therefore, the net overall uncertainty associated with risk characterization is given a rating of moderate to high with a bias toward overestimation of risks. Consequently, the cumulative uncertainty associated with the multi-chemical health risk results in this HHRA should have a rating of moderate to high on the conservative side. Again, the estimated health risks using USEPA's risk assessment approach are useful under the regulatory context in which they are applied. These risk values are not intended to be used to predict definitive actual morbidity or mortality in the potentially exposed populations.

6.4 COMPARISON MODELED INDOOR AIR CONCENTRATIONS WITH BACKGROUND INDOOR AIR DATA

The majority of VOCs detected in the shallow soil gas at the Site are also present in the background indoor environment of industrialized countries. For example, gasoline-related compounds can be brought indoor through the fresh air intake of the ventilation system. In addition, VOCs found in the indoor environment originate from building materials (e.g., carpet or flooring materials, paints, adhesives and sealants, insulation, ceiling tiles), indoor furnishings (e.g., office furniture, carbinetry, textile furnishings, computers), cleaning supply products, and processes such as printing, cooking, hobbies, cleaning, interior renovations, and pesticide applications. Table 11 presents the comparison of the J&E modeled indoor air concentrations at the Site, based on the maximum 2006 soil gas concentrations and conservative 5-foot sample depth. For six chemicals that were not detected in 2006 (chlorobenzene; EDB; 1,1-DCA; 1,1-DCE; c-1,2-DCE; and vinyl chloride), the maximum 2002 concentrations were used. Background indoor air concentrations of VOCs in existing residences were taken from the 2003 Lawrence Berkeley National Laboratory (LBNL) study, which synthesized VOC indoor air concentrations that were reported in 12 studies published between 1990 and 2002 (LBNL, 2003). For comparison purposes, VOC indoor air concentrations for office buildings also were presented (LBNL, 2003; USEPA, 2005b). The USEPA Building Assessment Survey and Evaluation (BASE) Study (USEPA, 2005b) included 100 randomly selected public and commercial office buildings in 37 cities in 25 states. These buildings were randomly selected from cities with populations greater than 100,000 within ten climate regions in either winter or

summer, excluding buildings with highly publicized indoor environmental quality problems (USEPA, 2005c).

As shown in Table 11, the maximum calculated indoor air concentrations using the Advanced J&E Model and the 2006 soil gas data are all below background levels reported in the literature for existing residences and existing office buildings. The sole exception is 4-ethyltoluene, which is a non-carcinogenic component of hydrocarbon fuel that does not pose any significant non-carcinogenic health risk. Therefore, this background exceedance does not indicate any concern. Modeled maximum vinyl chloride indoor air concentrations (based on 2002 soil vapor data) are close to the mean background value detected in existing residences (LBNL, 2003).

Table 12 shows that the background risk ECR and HI which are associated with the mean background indoor air concentrations of 20 COPCs that have available background data (LBNL, 2003) are 2E-05 and 3.4, respectively. Also, the background risk ECR and HI associated with the 95th percentile or geometric maximum background indoor air concentrations of 15 COPCs that have available background data (LBNL, 2003) are 5E-05 and 8.0, respectively. NOTE: LBNL (2003) did not report the 95th percentile for five chemicals (cyclohexane; 4-ethyltoluene; heptane; hexane; and 1,2,4-trimethylbenzene) which are found in shallow soil gas at the Site. Site-related 2006 RME risks are several orders of magnitude below background levels reported in the literature, and they are below the acceptable *de minimis* risk levels. These facts indicate that there are no potential health concerns.

7.0 Conclusions and Recommendations

This HHRA was performed to provide a consistent basis for evaluating Site-specific potential human health risks to current residents on the properties located adjacent to the western boundary of the BNL ("adjacent residents") posed by VOCs detected during the 2002 and 2006 shallow soil gas sampling events. The HHRA results indicate the highest RME ECRs at the Site have decreased by one order of magnitude from 2002 to 2006. All of the 2006 RME ECRs are much lower than the *de minimis* risk of 1E-06 based on the 2006 soil gas data, which indicates that there are no unacceptable health effects to current adjacent residents. Even if no remediation takes place at the Site, current adjacent residents should not incur any unacceptable health risks from exposure to detected VOCs in the shallow soil gas.

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ACRONYMS

ADEQ	Arizona Department of Environmental Quality
API	American Petroleum Institute
ASTM	American Society for Testing Materials
AT	Averaging Time
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BNL	Broadway North Landfill
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
Cal-EPA	California Environmental Protection Agency
CDI	Chronic Daily Intake
CH_4	Methane
CO_2	Carbon Dioxide
COPC	Chemicals of Potential Concern
CTE	Central Tendency Exposure
1,1-DCA	1,1-Dichloroethane
1,1-DCE	1,1-Dichloroethene
c-1,2-DCE	cis-1,2-Dichloroethene
DLM	Dominant Layer Model
EASI	Environmental Analytical Services, Inc.
ECR	Excess Cancer Risk
ED	Exposure Duration
EDB	Ethylene Dibromide
EF	Exposure Frequency
EPC	Exposure Point Concentration
ESC	Environmental Science Corporation
FID	Flame Ionization Detector
HCRA	Harvard Center for Risk Analysis
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IARC	International Agency for Research on Cancer
IRIS	Integrated Risk Information System
J&E	Johnson and Ettinger
LADD	Lifetime Average Daily Dose
LBNL	Lawrence Berkeley National Laboratory
LEL	Lower Explosive Limit
LFG	Landfill Gas

LMS	Linearized Multi-stage Model
LOAEL	Lowest-Observed-Adverse-Effect-Level
MDEP	Massachusetts Department of Environmental Protection
MEK	Methyl Ethyl Ketone
MF	Modifying Factor
mg/kg-day	Milligrams per Kilogram per Day
$(mg/kg\text{-}day)^{-1}$	Risk per Milligrams per Kilogram per Day
MSW	municipal solid waste
NOAEL	No-Observed-Adverse-Effect-Level
O_2	Oxygen
PAL	Precision Analytical Laboratories
PCE	Tetrachloroethene, also called Perchloroethene
ppbv	Parts per Billion per Volume
ppmv	Parts per Million per Volume
PPRTV	Provisional Peer Reviewed Toxicity Values
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SCM	Site Conceptual Model
SCS	Soil Conservation Service
SECOR	SECOR International Incorporated
SF	Slope Factor
Site	Broadway-Pantano WQARF Site BNL
SQL	Sample Quantitation Limit
STSC	Superfund Heath Risk Technical Support Center
Stantec	Stantec Consulting Services
TCE	Trichloroethene
UCL	Upper Confidence Limit
UEL	Upper Explosive Limit
UF	Uncertainty Factor
URF	Unit Risk Factor
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WQARF	Water Quality Assurance Revolving Fund

WRCC	Western Regional Climate Center
WRRC	Water Resources Research Center
$\mu g/m^3$	Micrograms per Cubic Meter

TABLES
Human Health Risk Assessment

Broadway North Landfill
Broadway-Pantano Water Quality Assurance Revolving Fund Site
Stantec Job Number 185902026

TABLE 1
December 2002 Volatile Organic Compound Concentrations in Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

A Analyte detected in 2006 but not detected in 2002

B Analyte detected in 2002 but not detected in 2006

C Analyte not analyzed in 2002

ppbv = Parts per Billion per Volume

Constituent	Maximum	Minimum	No. Detects	Location of Max	BN-1-10	BN-1-20	BN-1-20D	BN-2-10	BN-3-10	BN-3-20	BN-4-05
	ppbv	ppbv		Detect	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv
Acetone[C]											
Benzene	200	0.53	26	GP-2-20	<0.5	0.86	0.65	<0.5	<0.5	<0.5	<0.5
Benzyl Chloride[C]											
Carbon Disulfide[C]											
Chlorobenzene[B]	190	4.2	5	GP-2-20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloroform	60	0.51	24	BN-7-20	<0.5	<0.5	<0.5	<0.5	8.8	3.3	<0.5
Chloromethane (Methyl Chloride)	1.1	0.53	5	BN-7-5	<0.5	0.64	<0.5	<0.5	<0.5	<0.5	<0.5
Cyclohexane[C]											
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]	0.5	0.5	1	BN-14-16 (Near SQL)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	140	0.56	30	GP-2-20	<0.5	<0.5	<0.5	<0.5	0.56	<0.5	<0.5
Dichlorobenzene (1,4-) (p)	880	0.55	11	GP-2-20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichlorodifluoromethane (Freon 12)	4700	0.78	44	GP-12-10	0.88	0.82	0.98	0.84	14	7.7	0.82
Dichloroethane (1,1-) (1,1-DCA)[B]	0.72	0.72	1	BN-9-10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichloroethene (1,1-) (1,1-DCE)[B]	0.88	0.68	2	BN-1-20	<0.5	0.88	<0.5	<0.5	<0.5	<0.5	<0.5
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	330	0.54	20	BN-12-5	<0.5	0.62	<0.5	1.2	<0.5	<0.5	<0.5
Dichloromethane (Methylene Chloride)	110	0.5	14	GP-12-10	0.75	<0.5	0.96	<0.5	<0.5	<0.5	<0.5
Dichloropropane (1,2-)[A]	0	0	0		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichloropropene (trans-1,3-)[A]	0	0	0		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethanol[C]											
Ethylbenzene	1,200	0.51	22	GP-2-20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethyltoluene (4-)[C]											
Heptane[C]											
Hexane (n-)[C]											
Methyl Ethyl Ketone[C]											
Naphthalene[C]											
Propanol (2-)[C]											
Styrene	1.7	0.56	2	GP-1-19	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Tetrachloroethene (PCE)	2.6	0.52	17	GP-5-20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	46	0.51	26	BN-16-10	0.59	1.7	1.5	<0.5	<0.5	<0.5	<0.5
Trichloroethane (1,1,1-) (1,1,1-TCA)	9.4	0.61	5	BN-15-20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trichloroethene (TCE)	33	0.59	10	BN-12-5	<0.5	3.1	<0.5	<0.5	<0.5	<0.5	<0.5
Trichlorofluoromethane (Freon 11)	15	0.66	12	BN-13-20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trimethylbenzene (1,2,4-)	41	0.51	33	GP-1-19	12	0.81	0.9	1.2	0.88	0.63	<0.5
Trimethylbenzene (1,3,5-)	17	0.51	13	GP-1-19	2.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Vinyl chloride[B]	14	0.5	7	GP-2-20	1.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene (o-)	18	0.51	12	GP-1-19	0.93	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylenes (m,p-)	27	1.2	16	GP-1-19	2	<1	<1	<1	<1	<1	<1

TABLE 1
December 2002 Volatile Organic Compound Concentrations in Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppbv = Parts per Billion per Volume

Sample Name-D = Duplicate sample

Constituent	BN-4-15	BN-5-10	BN-5-20	BN-6-10	BN-6-20	BN-7-05	BN-7-20	BN-8-10	BN-8-10D	BN-8-20	BN-9-10	BN-9-20	BN-11-10
	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv
Acetone[C]													
Benzene	7.4	<0.5	0.62	1.2	<0.5	1.2	1.9	<0.5	0.69	1.2	1.5	1	1.5
Benzyl Chloride[C]													
Carbon Disulfide[C]													
Chlorobenzene[B]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloroform	<0.5	0.51	<0.5	0.77	<0.5	37	60	2.1	1.8	1.7	<0.5	<0.5	<0.5
Chloromethane (Methyl Chloride)	0.54	<0.5	0.53	<0.5	<0.5	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cyclohexane[C]													
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	<0.5	<0.5	<0.5	32	47	1.2	2	<0.5	<0.5	<0.5	<0.5	<0.5	14
Dichlorobenzene (1,4-) (p)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.58
Dichlorodifluoromethane (Freon 12)	0.81	0.92	0.9	9.7	13	2.1	2.9	0.93	0.91	0.91	0.9	1.4	11
Dichloroethane (1,1-) (1,1-DCA)[B]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.72	<0.5	<0.5
Dichloroethene (1,1-) (1,1-DCE)[B]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	<0.5	2.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	7.2	<0.5	2.3	<0.5
Dichloromethane (Methylene Chloride)	1.6	<0.5	0.64	<0.5	<0.5	<0.5	<0.5	<0.5	0.56	<0.5	2.2	<0.5	<0.5
Dichloropropane (1,2-)[A]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichloropropene (trans-1,3-)[A]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethanol[C]													
Ethylbenzene	1.7	<0.5	<0.5	0.76	<0.5	3.7	2.1	<0.5	0.65	<0.5	3.3	<0.5	0.99
Ethyltoluene (4-)[C]													
Heptane[C]													
Hexane (n-)[C]													
Methyl Ethyl Ketone[C]													
Naphthalene[C]													
Propanol (2-)[C]													
Styrene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Tetrachloroethene (PCE)	<0.5	<0.5	<0.5	0.69	0.85	<0.5	<0.5	0.78	0.63	0.53	<0.5	0.85	0.79
Toluene	0.86	<0.5	0.94	<0.5	<0.5	0.76	0.72	0.51	0.84	0.55	<0.5	0.56	1.6
Trichloroethane (1,1,1-) (1,1,1-TCA)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trichloroethene (TCE)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.9	<0.5	0.83	<0.5
Trichlorofluoromethane (Freon 11)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.6
Trimethylbenzene (1,2,4-)	3.7	<0.5	<0.5	1	<0.5	2	4.9	0.94	1.2	0.82	14	0.68	7.3
Trimethylbenzene (1,3,5-)	0.56	<0.5	<0.5	<0.5	<0.5	<0.5	0.51	<0.5	<0.5	<0.5	3	<0.5	0.95
Vinyl chloride[B]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5
Xylene (o-)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.99	<0.5	0.53
Xylenes (m,p-)	3.2	<1	<1	<1	<1	1.6	1.2	<1	<1	<1	6.7	<1	2.3

TABLE 1
December 2002 Volatile Organic Compound Concentrations in Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppbv = Parts per Billion per Volume

Sample Name-D = Duplicate sample

Constituent	BN-11-20	BN-12-05	BN-12-25	BN-13-10	BN-13-20	BN-14-05	BN-14-16	BN-15-10	BN-15-10D	BN-15-20	BN-16-10
	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv
Acetone[C]											
Benzene	0.76	5.9	0.98	<0.5	11	<0.5	<0.5	0.53	<0.5	0.61	0.58
Benzyl Chloride[C]											
Carbon Disulfide[C]											
Chlorobenzene[B]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloroform	1.4	1	<0.5	10	16	0.67	2.2	0.58	0.71	17	<0.5
Chloromethane (Methyl Chloride)	<0.5	<0.5	0.61	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cyclohexane[C]											
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	22	10	<0.5	22	35	4.9	8	14	17	37	2.1
Dichlorobenzene (1,4-) (p)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.67	<0.5	<0.5	0.55
Dichlorodifluoromethane (Freon 12)	17	10	0.78	14	33	19	34	7.1	8.9	16	6.9
Dichloroethane (1,1-) (1,1-DCA)[B]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichloroethene (1,1-) (1,1-DCE)[B]	0.68	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	2.7	330	3	<0.5	<0.5	<0.5	<0.5	0.54	1.3	1.3	2.5
Dichloromethane (Methylene Chloride)	0.92	0.5	0.91	<0.5	<0.5	<0.5	<0.5	<0.5	0.63	<0.5	<0.5
Dichloropropane (1,2-)[A]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichloropropene (trans-1,3-)[A]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethanol[C]											
Ethylbenzene	0.51	8.4	<0.5	<0.5	5.2	<0.5	0.62	3.3	<0.5	<0.5	2.8
Ethyltoluene (4-)[C]											
Heptane[C]											
Hexane (n-)[C]											
Methyl Ethyl Ketone[C]											
Naphthalene[C]											
Propanol (2-)[C]											
Styrene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.56	<0.5	<0.5	<0.5
Tetrachloroethene (PCE)	1.4	0.52	<0.5	1.5	2.2	0.84	0.95	<0.5	<0.5	1.3	<0.5
Toluene	<0.5	3.9	1.7	<0.5	<0.5	<0.5	<0.5	10	1.5	0.65	46
Trichloroethane (1,1,1-) (1,1,1-TCA)	0.81	<0.5	<0.5	<0.5	<0.5	<0.5	0.61	2.8	3.5	9.4	<0.5
Trichloroethene (TCE)	1.5	33	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trichlorofluoromethane (Freon 11)	1.5	2.6	<0.5	13	15	0.77	1.4	<0.5	<0.5	0.83	<0.5
Trimethylbenzene (1,2,4-)	1.6	12	0.51	0.66	21	0.52	8.3	17	0.96	<0.5	1.7
Trimethylbenzene (1,3,5-)	<0.5	2.3	<0.5	<0.5	3.3	<0.5	<0.5	3.2	<0.5	<0.5	0.54
Vinyl chloride[B]	<0.5	10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene (o-)	<0.5	3.8	<0.5	<0.5	0.51	<0.5	<0.5	1.4	<0.5	<0.5	1.6
Xylenes (m,p-)	<1	22	<1	<1	11	<1	<1	7	<1	<1	3.9

TABLE 1
December 2002 Volatile Organic Compound Concentrations in Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppbv = Parts per Billion per Volume

Sample Name-D = Duplicate sample

Constituent	BN-16-20	BN-17-10	BN-17-20	BN-18-10	BN-18-20	GP-1-19	GP-2-20	GP-2-20D	GP-5-20	GP-5-20D	GP-6-20	GP-10-10
	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv
Acetone[C]												
Benzene	<0.5	<1	<0.5	<0.5	<2.5	1.3	200	170	41	32	32	<2.5
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]	<0.5	<1	<0.5	<0.5	<2.5	<1	190	150	12	8.4	4.2	<2.5
Chloroform	5.8	<1	1.2	8.2	5.8	<1	<5	<10	<5	0.63	<0.5	<2.5
Chloromethane (Methyl Chloride)	<0.5	<1	<0.5	<0.5	<2.5	<1	<5	<10	<5	<0.5	<0.5	<2.5
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]	<0.5	<1	<0.5	<0.5	<2.5	<1	<5	<10	<5	<0.5	<0.5	<2.5
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	0.77	61	86	2.2	3.1	5.9	140	120	42	31	68	36
Dichlorobenzene (1,4-) (p)	<0.5	<1	<0.5	<0.5	<2.5	7.2	880	570	130	60	20	12
Dichlorodifluoromethane (Freon 12)	6.6	230	220	31	59	<1	81	120	81	40	130	27
Dichloroethane (1,1-) (1,1-DCA)[B]	<0.5	<1	<0.5	<0.5	<2.5	<1	<5	<10	<5	<0.5	<0.5	<2.5
Dichloroethene (1,1-) (1,1-DCE)[B]	<0.5	<1	<0.5	<0.5	<2.5	<1	<5	<10	<5	<0.5	<0.5	<2.5
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	0.83	1.3	<0.5	<0.5	<2.5	1.6	25	19	6.2	5.2	4.7	<2.5
Dichloromethane (Methylene Chloride)	<0.5	1.1	<0.5	<0.5	<2.5	<1	<5	<10	<5	1.8	<0.5	<2.5
Dichloropropane (1,2-)[A]	<0.5	<1	<0.5	<0.5	<2.5	<1	<5	<10	<5	<0.5	<0.5	<2.5
Dichloropropene (trans-1,3-)[A]	<0.5	<1	<0.5	<0.5	<2.5	<1	<5	<10	<5	<0.5	<0.5	<2.5
Ethanol[C]												
Ethylbenzene	0.53	<1	<0.5	<0.5	<2.5	30	1200	750	15	11	23	7.4
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene	<0.5	<1	<0.5	<0.5	<2.5	1.7	<5	<10	<5	<0.5	<0.5	<2.5
Tetrachloroethene (PCE)	<0.5	<1	0.85	<0.5	<2.5	1.2	<5	<10	<5	2.6	<0.5	<2.5
Toluene	3.1	<1	<0.5	<0.5	<2.5	9.2	40	44	16	12	15	<2.5
Trichloroethane (1,1,1-) (1,1,1-TCA)	<0.5	<1	<0.5	<0.5	<2.5	<1	<5	<10	<5	<0.5	<0.5	<2.5
Trichloroethene (TCE)	<0.5	<1	<0.5	<0.5	<2.5	1.1	<5	<10	<5	3.4	0.59	<2.5
Trichlorofluoromethane (Freon 11)	<0.5	<1	0.66	5.2	8	<1	<5	<10	<5	<0.5	<0.5	<2.5
Trimethylbenzene (1,2,4-)	<0.5	<1	<0.5	<0.5	<2.5	41	<5	<10	26	16	5.3	4
Trimethylbenzene (1,3,5-)	<0.5	<1	<0.5	<0.5	<2.5	17	<5	<10	10	6.4	<0.5	<2.5
Vinyl chloride[B]	<0.5	<1	<0.5	<0.5	<2.5	<1	14	10	<5	0.87	<0.5	<2.5
Xylene (o-)	<0.5	<1	<0.5	<0.5	<2.5	18	<5	<10	<5	2.7	2.8	2.5
Xylenes (m,p-)	<1	<2	<1	<1	<5	27	27	27	<10	6.1	4.6	<5

TABLE 1
December 2002 Volatile Organic Compound Concentrations in Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppbv = Parts per Billion per Volume

Sample Name-D = Duplicate sample

Constituent	GP-12-10	GP-12-10D
	ppbv	ppbv
Acetone[C]		
Benzene	<5	0.63
Benzyl Chloride[C]		
Carbon Disulfide[C]		
Chlorobenzene[B]	<5	<0.5
Chloroform	<5	0.85
Chloromethane (Methyl Chloride)	<5	<0.5
Cyclohexane[C]		
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]	<5	<0.5
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	29	22
Dichlorobenzene (1,4-) (p)	<5	1.5
Dichlorodifluoromethane (Freon 12)	4700	2300
Dichloroethane (1,1-) (1,1-DCA)[B]	<5	<0.5
Dichloroethene (1,1-) (1,1-DCE)[B]	<5	<0.5
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	<5	<0.5
Dichloromethane (Methylene Chloride)	110	49
Dichloropropane (1,2-)[A]	<5	<0.5
Dichloropropene (trans-1,3-)[A]	<5	<0.5
Ethanol[C]		
Ethylbenzene	<5	0.6
Ethyltoluene (4-)[C]		
Heptane[C]		
Hexane (n-)[C]		
Methyl Ethyl Ketone[C]		
Naphthalene[C]		
Propanol (2-)[C]		
Styrene	<5	<0.5
Tetrachloroethene (PCE)	<5	<0.5
Toluene	<5	1.6
Trichloroethane (1,1,1-) (1,1,1-TCA)	<5	<0.5
Trichloroethene (TCE)	<5	1.3
Trichlorofluoromethane (Freon 11)	<5	1.8
Trimethylbenzene (1,2,4-)	21	2.7
Trimethylbenzene (1,3,5-)	<5	0.92
Vinyl chloride[B]	<5	1.3
Xylene (o-)	<5	0.85
Xylenes (m,p-)	<10	3

TABLE 2
April 2006 Volatile Organic Compound Concentrations in Shallow Soil Gas Samples from BN- and GP- Probes
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

[D] Value changed due to data validati

ppbv = Parts per Billion per Volume

Sample Name-D = Duplicate sample

Constituent	Maximum	Minimum	No. Detects	Location of Max	BN-1-10	BN-1-20	BN-2-10	BN-2-20	BN-3-10	BN-3-20	BN-4-05	BN-4-15
	ppbv	ppbv		Detect	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv
Acetone[C]	1.8	1.6	4	BN-10-20	<1.3	<5.0	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
Benzene	0.89	0.34	14	BN-14-15	**0.63**	<0.80	**0.58**	<0.20	<0.20	<0.20	<0.20	<0.20
Benzyl Chloride[C]	0.28	0.26	2	BN-13-20	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Carbon Disulfide[C]	1.3	0.32	20	BN-4-15	**0.34**	<1.2	**0.32**	<0.31	<0.31	**0.95**	**1.2**	**1.3**
Chlorobenzene[B]	0	0	0									
Chloroform	5	0.2	19	BN-13-20	<0.20	<0.80	<0.20	<0.20	**1.3**	**1.5**	<0.20	<0.20
Chloromethane (Methyl Chloride)	0.85	0.23	22	BN-13-20D	**0.57**	<0.80	**0.54**	<0.20	<0.20	<0.20	<0.20	**0.25**
Cyclohexane[C]	0.68	0.35	9	GP-7-20	**0.58**	<1.2	**0.49**	<0.31	<0.31	<0.31	<0.31	<0.31
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]	0	0	0	Not detected in 2006	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	29	0.72	24	BN-13-20	<0.63	<2.5	<0.63	<0.63	**0.89**	**0.80**	<0.63	<0.63
Dichlorobenzene (1,4-) (p)	1.8	0.21	10	GP-6-20	<0.20	**0.87**	<0.20	**0.59**	<0.20	<0.20	<0.20	<0.20
Dichlorodifluoromethane (Freon 12)	24	0.64	33	BN-13-20	<0.63	**2.9**	<0.63	**2.3**	**3.6**	**3.4**	**1.3**	**0.64**
Dichloroethane (1,1-) (1,1-DCA)[B]	0	0	0	Not detected in 2006	<0.20	<0.4	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloroethene (1,1-) (1,1-DCE)[B]	0	0	0	Not detected in 2006	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	0	0	0	Not detected in 2006	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloromethane (Methylene Chloride)	1.5	1	12	BN-10-10	**1.0**	<2.5	**1.0**	<0.63	<0.63	<0.63	<0.63	<0.63
Dichloropropane (1,2-)[A]	3.5	3.5	1	BN-13-20	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloropropene (trans-1,3-)[A]	0.21	0.21	1	BN-13-10	<0.20	<0.80.	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethanol[C]	63	0.72	30	BN-13-20D (BN-13-20	<0.63	**4.8**	<0.63	**0.94**	**0.72**	**1.8**	<0.63	**1.1**
Ethylbenzene	2.1	0.24	18	GP-6-20	**0.29**	<0.80	**0.25**	**0.29**	<0.20	<0.20	<0.20	<0.20
Ethyltoluene (4-)[C]	1.2	0.2	34	BN-11-20	**0.26**	<0.80	**0.26**	<0.20	**0.36**	**0.33**	<0.20	<0.20
Heptane[C]	6.3	0.33	14	GP-5-20	**2.0**	<1.2	**1.6**	<0.31	<0.31	<0.31	<0.31	<0.31
Hexane (n-)[C]	0.88	0.31	10	GP-6-20	**0.36**	<1.2	**0.32**	<0.31	<0.31	<0.31	<0.31	<0.31
Methyl Ethyl Ketone[C]	33	2.6	21	BN-5-20	<1.3	<5.0	<1.3	**2.8**	**8.2**	**3.3**	<1.3	**<2.4[D]**
Naphthalene[C]	1.2	0.87	4	GP-6-20	<0.63	<2.5	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
Propanol (2-)[C]	440	1.3	18	BN-1-20	**26.0**	**440**	**24.0**	<1.3	<1.3	<1.3	<1.3	<1.3
Styrene	0.24	0.21	3	BN-11-20 (Near SQL)	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tetrachloroethene (PCE)	9.6	0.2	15	BN-10-20 (not sampled	<0.20	**6.7**	<0.20	**0.71**	**0.21**	<0.20	<0.20	<0.20
Toluene	1.9	0.23	45	BN-13-20D	**1.2**	**1.6**	**1.1**	**0.40**	**0.42**	**0.41**	**0.23**	**0.31**
Trichloroethane (1,1,1-) (1,1,1-TCA)	0.88	0.23	3	BN-18-20	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Trichloroethene (TCE)	1.4	0.53	3	BN-12-5	<0.20	<0.80	<0.20	<0.20	**0.53**	**0.91**	<0.20	<0.20
Trichlorofluoromethane (Freon 11)	11	0.67	8	BN-13-20	<0.63	<2.5	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
Trimethylbenzene (1,2,4-)	2.1	0.2	41	BN-11-20	**0.43**	<0.80	**0.40**	**0.24**	**0.59**	**0.49**	<0.20	<0.20
Trimethylbenzene (1,3,5-)	0.43	0.23	4	BN-11-20	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Vinyl chloride[B]	0	0	0	Not detected in 2006	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Xylene (o-)	0.76	0.22	22	BN-5-20	**0.37**	<0.80	**0.31**	<0.20	<0.20	<0.20	<0.20	<0.20
Xylenes (m,p-)	2	0.41	29	BN-5-20	**1.1**	<1.6	**0.94**	<0.40	**0.56**	<0.40	<0.40	<0.40

TABLE 2
April 2006 Volatile Organic Compound Concentrations in Shallow Soil Gas Samples from BN- and GP- Probes
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

[D] Value changed due to data validation

ppbv = Parts per Billion per Volume

Sample Name-D = Duplicate sample

Constituent	BN-5-10	BN-5-20	BN-6-10	BN-6-20	BN-6-20D	BN-7-05	BN-7-20	BN-8-10	BN-8-20	BN-9-10	BN-9-20	BN-10-10	BN-10-20	BN-11-10
	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv
Acetone[C]	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	**1.8**	**1.6**
Benzene	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	**0.52**	**0.47**	**0.44**	**0.43**	**0.42**	<0.20	<0.20
Benzyl Chloride[C]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Carbon Disulfide[C]	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	**0.43**
Chlorobenzene[B]														
Chloroform	<0.20	<0.20	**1.1**	**1.0**	**1.2**	**0.62**	**0.20**	<0.20	<0.20	<0.20	<0.20	<0.20	**0.28**	<0.20
Chloromethane (Methyl Chloride)	<0.20	**<0.25[D]**	**<0.25[D]**	<0.20	<0.20	**<0.25[D]**	**0.25**	**0.56**	**0.55**	**0.52**	**0.52**	**0.51**	<0.20	<0.20
Cyclohexane[C]	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	**0.45**	**0.38**	**0.38**	**0.38**	**0.38**	<0.31	<0.31
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	**0.72**	<0.63	**2.4**	**9.0**	**10.0**	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	**1.0**	**7.9**
Dichlorobenzene (1,4-) (p)	<0.20	<0.20	<0.20	<0.20	**0.21**	**0.22**	**0.22**	<0.20	<0.20	<0.20	<0.20	<0.20	**0.52**	**0.37**
Dichlorodifluoromethane (Freon 12)	**5.3**	**1.2**	**1.4**	**3.7**	**4.3**	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	**19.0**	**6.9**
Dichloroethane (1,1-) (1,1-DCA)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloroethene (1,1-) (1,1-DCE)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloromethane (Methylene Chloride)	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	**1.0**	**1.1**	**1.1**	**1.3**	**1.5**	<0.63	<0.63
Dichloropropane (1,2-)[A]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloropropene (trans-1,3-)[A]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethanol[C]	<0.63	**2.4**	**1.0**	<0.63	<0.63	**<0.91[D]**	**2.1**	<0.63	<0.63	<0.63	<0.63	<0.63	**5.2**	**5.1**
Ethylbenzene	<0.20	**0.48**	<2.0	<2.0	<2.0	<2.0	<2.0	**0.25**	**0.24**	**0.24**	**0.24**	**0.24**	**0.27**	<0.20
Ethyltoluene (4-)[C]	<0.20	**0.73**	**0.25**	**0.29**	**0.57**	**0.55**	**0.55**	**0.22**	**0.22**	**0.21**	**0.22**	**0.22**	**0.89**	**0.58**
Heptane[C]	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	**1.4**	**1.1**	**1.0**	**0.94**	**0.89**	<0.31	**0.33**
Hexane (n-)[C]	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	**0.34**	<0.31	<0.31	**0.33**	**0.46**	<0.31	<0.31
Methyl Ethyl Ketone[C]	<1.3	**33.0**	**4.5**	**<2.4[D]**	**7.0**	**3.4**	**3.1**	<1.3	<1.3	<1.3	<1.3	<1.3	**7.1**	**3.2**
Naphthalene[C]	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	**1.1**	**0.87**
Propanol (2-)[C]	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	**23.0**	**22.0**	**29.0**	**27.0**	**28.0**	**1.6**	**1.3**
Styrene	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	**0.22**	<0.20
Tetrachloroethene (PCE)	<0.20	<0.20	<0.20	<0.20	**0.20**	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	**9.6**	**0.37**
Toluene	<0.20	**1.4**	**0.54**	**0.27**	**0.70**	**0.87**	**0.84**	**1.0**	**0.96**	**0.98**	**0.99**	**1.0**	**1.4**	**0.50**
Trichloroethane (1,1,1-) (1,1,1-TCA)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Trichloroethene (TCE)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Trichlorofluoromethane (Freon 11)	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	**0.84**	**0.96**
Trimethylbenzene (1,2,4-)	**0.20**	**1.3**	**0.33**	**0.46**	**0.85**	**0.87**	**0.79**	**0.40**	**0.36**	**0.37**	**0.37**	**0.37**	**1.4**	**1.1**
Trimethylbenzene (1,3,5-)	<0.20	**0.31**	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	**0.34**	**0.23**
Vinyl chloride[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Xylene (o-)	<0.20	**0.76**	<0.20	<0.20	**0.24**	**0.22**	**0.22**	**0.32**	**0.28**	**0.31**	**0.29**	**0.30**	**0.41**	<0.20
Xylenes (m,p-)	<0.40	**2.0**	<0.40	<0.40	**0.59**	**0.57**	**0.58**	**0.97**	**0.87**	**0.92**	**0.92**	**0.91**	**1.0**	**0.48**

TABLE 2
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Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

[D] Value changed due to data validation

ppbv = Parts per Billion per Volume

Sample Name-D = Duplicate sample

Constituent	BN-11-20	BN-12-05	BN-12-25	BN-13-10	BN-13-20	BN-13-20D	BN-14-05	BN-14-15	BN-15-10	BN-15-20	BN-16-10	BN-16-20	BN-17-10	BN-17-20
	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv
Acetone[C]	<1.3	<1.3	<1.3	**1.8**	**1.7**	<5.0	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
Benzene	<0.20	<0.20	<0.20	<0.20	<0.20	<0.80	<0.20	**0.89**	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Benzyl Chloride[C]	**0.26**	<0.20	<0.20	<0.20	**0.28**	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Carbon Disulfide[C]	**1.2**	<0.31	**0.32**	<0.31	<0.31	<1.2	<0.31	<0.31	<0.31	<0.31	**0.69**	**0.70**	<0.31	**0.48**
Chlorobenzene[B]														
Chloroform	**0.28**	**0.38**	**0.90**	**2.0**	**5.0**	**5.0**	<0.20	<0.20	<0.20	**0.74**	<0.20	<0.20	<0.20	**0.22**
Chloromethane (Methyl Chloride)	<0.20	**0.38**	**0.41**	<0.20	<0.20	**0.85**	<0.20	**<0.25[D]**	<0.20	<0.20	**0.28**	**0.30**	<0.20	<0.20
Cyclohexane[C]	<0.31	<0.31	<0.31	<0.31	<0.31	<1.2	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	**17.0**	**3.5**	**7.3**	**18.0**	**29.0**	**27.0**	**1.6**	<0.63	**6.1**	**4.9**	<0.63	<0.63	**2.5**	**5.7**
Dichlorobenzene (1,4-) (p)	**0.51**	<0.20	<0.20	<0.20	**0.28**	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichlorodifluoromethane (Freon 12)	**19.0**	**2.3**	**4.2**	**17.0**	**24.0**	**22.0**	**1.1**	**0.64**	**3.4**	**10.0**	**1.3**	**1.2**	**2.8**	**8.1**
Dichloroethane (1,1-) (1,1-DCA)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloroethene (1,1-) (1,1-DCE)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloromethane (Methylene Chloride)	<0.63	<0.63	<0.63	<0.63	<0.63	<2.5	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
Dichloropropane (1,2-)[A]	<0.20	<0.20	<0.20	<0.20	**3.5**	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloropropene (trans-1,3-)[A]	<0.20	<0.20	<0.20	**0.21**	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethanol[C]	**8.9**	**3.9**	**2.0**	**6.0**	**2.6**	**63.0**	**1.6**	**1.4**	**3.2**	**1.7**	**3.1**	**3.0**	**1.2**	**0.90**
Ethylbenzene	**0.25**	<0.20	<0.20	**0.24**	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethyltoluene (4-)[C]	**1.2**	**0.21**	**0.37**	**0.72**	**0.66**	<0.80	**0.26**	**0.28**	**0.21**	<0.20	<0.20	<0.20	**0.20**	**0.36**
Heptane[C]	<0.31	<0.31	<0.31	<0.31	<0.31	<1.2	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31
Hexane (n-)[C]	<0.31	<0.31	<0.31	<0.31	<0.31	<1.2	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31
Methyl Ethyl Ketone[C]	**5.0**	**2.8**	**2.7**	**5.1**	**3.5**	**5.9**	**<2.4[D]**	**<2.4[D]**	**2.6**	**<2.4[D]**	<2.4	**3.0**	**7.5**	**5.9**
Naphthalene[C]	**0.97**	<0.63	<0.63	<0.63	<0.63	<2.5	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
Propanol (2-)[C]	<1.3	**1.5**	<1.3	**1.5**	<1.3	**56.0**	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
Styrene	**0.24**	<0.20	<0.20	**0.21**	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tetrachloroethene (PCE)	**0.48**	<0.20	**0.22**	**2.0**	**4.0**	**5.4**	**0.22**	<0.20	**1.4**	**7.4**	<0.20	<0.20	<0.20	**0.23**
Toluene	**1.5**	**0.26**	**0.58**	**1.4**	**0.85**	**1.9**	**0.54**	**0.35**	**0.53**	**0.43**	**0.32**	**0.47**	**0.40**	**0.55**
Trichloroethane (1,1,1-) (1,1,1-TCA)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.80	<0.20	<0.20	**0.88**	**0.23**	<0.20	<0.20	<0.20	<0.20
Trichloroethene (TCE)	<0.20	<0.20	**<0.33[D]**	<0.20	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Trichlorofluoromethane (Freon 11)	**2.1**	**0.67**	**1.1**	**9.7**	**11.0**	**9.6**	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
Trimethylbenzene (1,2,4-)	**2.1**	**0.41**	**0.55**	**0.82**	**0.91**	**1.1**	**0.46**	**0.45**	**0.24**	**0.21**	**0.29**	**0.26**	**0.28**	**0.65**
Trimethylbenzene (1,3,5-)	**0.43**	<0.20	<0.20	**<0.2[D]**	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Vinyl chloride[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Xylene (o-)	**0.44**	<0.20	<0.20	**0.36**	**0.28**	<0.80	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	**0.31**
Xylenes (m,p-)	**1.0**	<0.40	**0.48**	**0.94**	**0.76**	**1.7**	<0.40	**0.41**	<0.40	**0.70**	<0.40	**0.51**	<0.40	**0.74**

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Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

[D] Value changed due to data validation

ppbv = Parts per Billion per Volume

Sample Name-D = Duplicate sample

Constituent	BN-18-10	BN-18-20	GP-1-19	GP-2-20	GP-5-20	GP-6-20	GP-7-20	GP-10-10	GP-11-10	GP-12-10	GP-12-10D
	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv	ppbv
Acetone[C]	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
Benzene	<0.20	<0.20	**0.56**	**0.34**	**0.37**	**0.78**	**0.67**	**0.35**	<0.20	<0.20	<0.20
Benzyl Chloride[C]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Carbon Disulfide[C]	**1.1**	**0.41**	**0.42**	**0.41**	**0.43**	**0.42**	**0.40**	**0.42**	<0.31	**0.42**	<0.31
Chlorobenzene[B]											
Chloroform	**2.1**	<0.20	<0.20	<0.20	**0.20**	<0.20	**0.20**	<0.20	<0.20	<0.20	<0.20
Chloromethane (Methyl Chloride)	<0.20	**0.25**	**0.55**	**0.54**	**0.55**	**0.34**	**0.56**	**0.55**	<0.20	**<0.25[D]**	**0.23**
Cyclohexane[C]	<0.31	<0.31	<0.31	<0.31	<0.31	**0.35**	**0.68**	<0.31	<0.31	<0.31	<0.31
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	**3.1**	<0.63	<0.63	<0.63	<0.63	**4.7**	<0.63	<0.63	**1.5**	**1.7**	**1.2**
Dichlorobenzene (1,4-) (p)	<0.20	<0.20	<0.20	<0.20	<0.20	**1.8**	<0.20	<0.20	<0.20	<0.20	<0.20
Dichlorodifluoromethane (Freon 12)	**5.7**	**0.94**	<0.63	<0.63	<0.63	**2.6**	<0.63	<0.63	**0.80**	**6.0**	**4.2**
Dichloroethane (1,1-) (1,1-DCA)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloroethene (1,1-) (1,1-DCE)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloromethane (Methylene Chloride)	<0.63	<0.63	**1.0**	**1.0**	**1.0**	<0.63	**1.0**	**1.0**	<0.63	<0.63	<0.63
Dichloropropane (1,2-)[A]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dichloropropene (trans-1,3-)[A]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethanol[C]	**0.85**	**0.91**	<0.63	<0.63	<0.63	**2.3**	<0.63	<0.63	**1.2**	**1.5**	**2.2**
Ethylbenzene	<0.20	<0.20	**0.32**	**0.25**	**0.26**	**2.1**	**0.33**	**0.24**	<0.20	<0.20	<0.20
Ethyltoluene (4-)[C]	<0.20	**0.24**	**0.29**	**0.22**	**0.28**	**0.24**	**0.28**	**0.24**	<0.20	<0.20	<0.20
Heptane[C]	<0.31	<0.31	**2.9**	**4.4**	**6.3**	**4.7**	**2.4**	**3.4**	<0.31	<0.31	<0.31
Hexane (n-)[C]	<0.31	<0.31	**0.38**	**0.31**	**0.33**	**0.88**	**0.40**	<0.31	<0.31	<0.31	<0.31
Methyl Ethyl Ketone[C]	**<2.4[D]**	**<2.4[D]**	<1.3	<1.3	<1.3	**7.3**	<1.3	<2.4	**<2.4[D]**	**<2.4[D]**	<2.4
Naphthalene[C]	<0.63	<0.63	<0.63	<0.63	<0.63	**1.2**	<0.63	<0.63	<0.63	<0.63	<0.63
Propanol (2-)[C]	<1.3	<1.3	**28.0**	**30.0**	**33.0**	<1.3	**26.0**	**29.0**	<1.3	<1.3	<1.3
Styrene	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tetrachloroethene (PCE)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Toluene	<0.20	**0.57**	**1.3**	**0.96**	**1.0**	**1.0**	**1.3**	**0.94**	**0.35**	**0.37**	**0.57**
Trichloroethane (1,1,1-) (1,1,1-TCA)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	**0.60**	<0.20	<0.20
Trichloroethene (TCE)	<0.20	**1.4**	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Trichlorofluoromethane (Freon 11)	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
Trimethylbenzene (1,2,4-)	<0.20	**0.26**	**0.48**	**0.40**	**0.43**	**0.66**	**0.47**	**0.39**	**0.22**	<0.20	<0.20
Trimethylbenzene (1,3,5-)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Vinyl chloride[B]	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Xylene (o-)	<0.20	<0.20	**0.39**	**0.33**	**0.35**	**0.31**	**0.39**	**0.30**	<0.20	<0.20	<0.20
Xylenes (m,p-)	<0.40	<0.40	**1.2**	**0.94**	**1.0**	**0.62**	**1.2**	**0.87**	<0.40	<0.40	<0.40

TABLE 3
Comparison of Chemical Concentrations Detected in 2002 and 2006 Soil Gas Sampling Events
Broadway North Landfill
Tucson, Arizona

	December 2002 Sampling Event				April 2006 Sampling Event			
Constituent	**Maximum**	**Minimum**	**# Detects**	**Location of Max**	**Maximum**	**Minimum**	**# Detects**	**Location of Max**
	ppbv	**ppbv**		**Detect**	**ppbv**	**ppbv**		**Detect**
Acetone[C]					1.8	1.6	4	BN-10-20
Benzene	200	0.53	26	GP-2-20 (0.34 ppbv in 2006)	0.89	0.34	14	BN-14-15
Benzyl Chloride[C]					0.28	0.26	2	BN-13-20
Carbon Disulfide[C]					1.3	0.32	20	BN-4-15
Chlorobenzene[B]	190	4.2	5	GP-2-20 (Not detected in 2006)	0	0	0	Not detected in 2006
Chloroform	60	0.51	24	BN-7-20	5	0.2	19	BN-13-20
Chloromethane (Methyl Chloride)	1.1	0.53	5	BN-7-5	0.85	0.23	22	BN-13-20D
Cyclohexane[C]					0.68	0.35	9	GP-7-20
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]	0.5	0.5	1	BN-14-16 (Near SQL)	0	0	0	Not detected in 2006
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	140	0.56	30	GP-2-20 (<0.63 ppbv in 2006)	29	0.72	24	BN-13-20
Dichlorobenzene (1,4-) (p)	880	0.55	11	GP-2-20 (<0.2 ppbv in 2006)	1.8	0.21	10	GP-6-20
Dichlorodifluoromethane (Freon 12)	4,700	0.78	44	GP-12-10 (6 ppbv in 2006)	24	0.64	33	BN-13-20
Dichloroethane (1,1-) (1,1-DCA)[B]	0.72	0.72	1	BN-9-10	0	0	0	Not detected in 2006
Dichloroethene (1,1-) (1,1-DCE)[B]	0.88	0.68	2	BN-1-20	0	0	0	Not detected in 2006
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	330	0.54	20	BN-12-5	0	0	0	Not detected in 2006
Dichloromethane (Methylene Chloride)	110	0.5	14	GP-12-10(<0.63 ppbv in 2006)	1.5	1	12	BN-10-10
Dichloropropane (1,2-)[A]	0	0	0	Not detected in 2002	3.5	3.5	1	BN-13-20
Dichloropropene (trans-1,3-)[A]	0	0	0	Not detected in 2002	0.21	0.21	1	BN-13-10
Ethanol[C]					63	0.72	30	BN-13-20D (BN-13-20 has 2.6 ppbv)
Ethylbenzene	1,200	0.51	22	GP-2-20 (0.25 ppbv in 2006)	2.1	0.24	18	GP-6-20
Ethyltoluene (4-)[C]					1.2	0.2	34	BN-11-20
Heptane[C]					6.3	0.33	14	GP-5-20
Hexane (n-)[C]					0.88	0.31	10	GP-6-20
Methyl Ethyl Ketone[C]					33	2.6	21	BN-5-20
Naphthalene[C]					1.2	0.87	4	GP-6-20
Propanol (2-)[C]					440	1.3	18	BN-1-20
Styrene	1.7	0.56	2	GP-1-19 (<0.2 ppbv in 2006)	0.24	0.21	3	BN-11-20 (Near SQL)
Tetrachloroethene (PCE)	2.6	0.52	17	GP-5-20D	9.6	0.2	15	BN-10-20 (not sampled in 2002)
Toluene	46	0.51	26	BN-16-10 (0.32 ppbv in 2006)	1.9	0.23	45	BN-13-20D
Trichloroethane (1,1,1-) (1,1,1-TCA)	9.4	0.61	5	BN-15-20 (0.23 ppbv in 2006)	0.88	0.23	3	BN-18-20
Trichloroethene (TCE)	33	0.59	10	BN-12-5 (<0.2 ppbv in 2006)	1.4	0.53	3	BN-12-5
Trichlorofluoromethane (Freon 11)	15	0.66	12	BN-13-20	11	0.67	8	BN-13-20
Trimethylbenzene (1,2,4-)	41	0.51	33	GP-1-19 (0.48 ppbv in 2006)	2.1	0.2	41	BN-11-20
Trimethylbenzene (1,3,5-)	17	0.51	13	GP-1-19 (<0.2 ppbv in 2006)	0.43	0.23	4	BN-11-20
Vinyl Chloride[B]	14	0.5	7	GP-2-20 (<0.2 ppbv in 2006)	0	0	0	Not detected in 2006
Xylene (o-)	18	0.51	12	GP-1-19 (0.39 ppbv in 2006)	0.76	0.22	22	BN-5-20
Xylenes (m,p-)	27	1.2	16	GP-1-19 (1.2 ppbv in 2006)	2	0.41	29	BN-5-20

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppbv = Parts per Billion per Volume

TABLE 4
December 2002 Volatile Organic Compound Detected Concentrations in Shallow Soil Gas Samples Used in the Human Health Risk Assessment
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppmv = Parts per Million per Volume

Sample Name-D = Duplicate sample

Constituent	BN-1-10	BN-1-20	BN-1-20 DUP	BN-2-10	BN-3-10	BN-3-20	BN-4-05	BN-4-15	BN-5-10	BN-5-20	BN-6-10	BN-6-20
	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv
Acetone[C]												
Benzene		0.00086	0.00065					0.0074		0.00062	0.0012	
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]												
Chloroform					0.0088	0.0033			0.00051		0.00077	
Chloromethane (Methyl Chloride)		0.00064						0.00054		0.00053		
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)					0.00056						0.032	0.047
Dichlorobenzene (1,4-) (p)												
Dichlorodifluoromethane (Freon 12)	0.00088	0.00082	0.00098	0.00084	0.014	0.0077	0.00082	0.00081	0.00092	0.0009	0.0097	0.013
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]		0.00088										
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]		0.00062		0.0012					0.0021			
Dichloromethane (Methylene Chloride)	0.00075		0.00096					0.0016		0.00064		
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]												
Ethylbenzene								0.0017			0.00076	
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene												
Tetrachloroethene (PCE)											0.00069	0.00085
Toluene	0.00059	0.0017	0.0015					0.00086		0.00094		
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)		0.0031										
Trichlorofluoromethane (Freon 11)												
Trimethylbenzene (1,2,4-)	0.012	0.00081	0.0009	0.0012	0.00088	0.00063		0.0037			0.001	
Trimethylbenzene (1,3,5-)	0.0026							0.00056				
Vinyl chloride[B]	0.0014											
Xylene (o-)	0.00093											
Xylenes (m,p-)	0.002							0.0032				

TABLE 4
December 2002 Volatile Organic Compound Detected Concentrations in Shallow Soil Gas Samples Used in the Human Health Risk Assessment
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppmv = Parts per Million per Volume

Sample Name-D = Duplicate sample

Constituent	BN-7-05	BN-7-20	BN-8-10	BN-8-10DUP	BN-8-20	BN-9-10	BN-9-20	BN-11-10	BN-11-20	BN-12-05	BN-12-25	BN-13-10
	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv
Acetone[C]												
Benzene	0.0012	0.0019		0.00069	0.0012	0.0015	0.001	0.0015	0.00076	0.0059	0.00098	
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]												
Chloroform	0.037	0.06	0.0021	0.0018	0.0017				0.0014	0.001		0.01
Chloromethane (Methyl Chloride)	0.0011										0.00061	
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	0.0012	0.002						0.014	0.022	0.01		0.022
Dichlorobenzene (1,4-) (p)								0.00058				
Dichlorodifluoromethane (Freon 12)	0.0021	0.0029	0.00093	0.00091	0.00091	0.0009	0.0014	0.011	0.017	0.01	0.00078	0.014
Dichloroethane (1,1-) (1,1-DCA)[B]						0.00072						
Dichloroethene (1,1-) (1,1-DCE)[B]									0.00068			
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]					0.0072		0.0023		0.0027	0.33	0.003	
Dichloromethane (Methylene Chloride)				0.00056		0.0022			0.00092	0.0005	0.00091	
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]												
Ethylbenzene	0.0037	0.0021		0.00065		0.0033		0.00099	0.00051	0.0084		
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene												
Tetrachloroethene (PCE)			0.00078	0.00063	0.00053		0.00085	0.00079	0.0014	0.00052		0.0015
Toluene	0.00076	0.00072	0.00051	0.00084	0.00055		0.00056	0.0016		0.0039	0.0017	
Trichloroethane (1,1,1-) (1,1,1-TCA)									0.00081			
Trichloroethene (TCE)					0.0019		0.00083		0.0015	0.033	0.001	
Trichlorofluoromethane (Freon 11)								0.0016	0.0015	0.0026		0.013
Trimethylbenzene (1,2,4-)	0.002	0.0049	0.00094	0.0012	0.00082	0.014	0.00068	0.0073	0.0016	0.012	0.00051	0.00066
Trimethylbenzene (1,3,5-)		0.00051				0.003		0.00095		0.0023		
Vinyl chloride[B]						0.0005				0.01		
Xylene (o-)						0.00099		0.00053		0.0038		
Xylenes (m,p-)	0.0016	0.0012				0.0067		0.0023		0.022		

TABLE 4
December 2002 Volatile Organic Compound Detected Concentrations in Shallow Soil Gas Samples Used in the Human Health Risk Assessment
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppmv = Parts per Million per Volume

Sample Name-D = Duplicate sample

Constituent	BN-13-20	BN-14-05	BN-14-16	BN-15-10	BN-15-10DUP	BN-15-20	BN-16-10	BN-16-20	BN-17-10	BN-17-20	BN-18-10	BN-18-20
	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv
Acetone[C]												
Benzene	0.011			0.00053		0.00061	0.00058					
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]												
Chloroform	0.016	0.00067	0.0022	0.00058	0.00071	0.017		0.0058		0.0012	0.0082	0.0058
Chloromethane (Methyl Chloride)												
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]			0.0005									
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	0.035	0.0049	0.008	0.014	0.017	0.037	0.0021	0.00077	0.061	0.086	0.0022	0.0031
Dichlorobenzene (1,4-) (p)				0.00067			0.00055					
Dichlorodifluoromethane (Freon 12)	0.033	0.019	0.034	0.0071	0.0089	0.016	0.0069	0.0066	0.23	0.22	0.031	0.059
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]				0.00054	0.0013	0.0013	0.0025	0.00083	0.0013			
Dichloromethane (Methylene Chloride)					0.00063				0.0011			
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]												
Ethylbenzene	0.0052		0.00062	0.0033			0.0028	0.00053				
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene				0.00056								
Tetrachloroethene (PCE)	0.0022	0.00084	0.00095			0.0013				0.00085		
Toluene				0.01	0.0015	0.00065	0.046	0.0031				
Trichloroethane (1,1,1-) (1,1,1-TCA)			0.00061	0.0028	0.0035	0.0094						
Trichloroethene (TCE)												
Trichlorofluoromethane (Freon 11)	0.015	0.00077	0.0014			0.00083				0.00066	0.0052	0.008
Trimethylbenzene (1,2,4-)	0.021	0.00052	0.0083	0.017	0.00096		0.0017					
Trimethylbenzene (1,3,5-)	0.0033			0.0032			0.00054					
Vinyl chloride[B]												
Xylene (o-)	0.00051			0.0014			0.0016					
Xylenes (m,p-)	0.011			0.007			0.0039					

TABLE 4
December 2002 Volatile Organic Compound Detected Concentrations in Shallow Soil Gas Samples Used in the Human Health Risk Assessment
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppmv = Parts per Million per Volume

Sample Name-D = Duplicate sample

Constituent	GP-1-19 ppmv	GP-2-20 ppmv	GP-2-20D ppmv	GP-5-20 ppmv	GP-5-20D ppmv	GP-6-20 ppmv	GP-10-10 ppmv	GP-12-10 ppmv	GP-12-10D ppmv	Max Detect	Min Detect	No. Detects
Acetone[C]												
Benzene	0.0013	0.2	0.17	0.041	0.032	0.032			0.00063	**0.2**	**0.00053**	**26**
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]		0.19	0.15	0.012	0.0084	0.0042				**0.19**	**0.0042**	**5**
Chloroform					0.00063				0.00085	**0.06**	**0.00051**	**24**
Chloromethane (Methyl Chloride)										**0.0011**	**0.00053**	**5**
Cyclohexane[C]										**0**	**0**	**0**
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]										**0.0005**	**0.0005**	**1**
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	0.0059	0.14	0.12	0.042	0.031	0.068	0.036	0.029	0.022	**0.14**	**0.00056**	**30**
Dichlorobenzene (1,4-) (p)	0.0072	0.88	0.57	0.13	0.06	0.02	0.012		0.0015	**0.88**	**0.00055**	**11**
Dichlorodifluoromethane (Freon 12)		0.081	0.12	0.081	0.04	0.13	0.027	4.7	2.3	**4.7**	**0.00078**	**44**
Dichloroethane (1,1-) (1,1-DCA)[B]										**0.00072**	**0.00072**	**1**
Dichloroethene (1,1-) (1,1-DCE)[B]										**0.00088**	**0.00068**	**2**
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	0.0016	0.025	0.019	0.0062	0.0052	0.0047				**0.33**	**0.00054**	**20**
Dichloromethane (Methylene Chloride)					0.0018			0.11	0.049	**0.11**	**0.0005**	**14**
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]												
Ethylbenzene	0.03	1.2	0.75	0.015	0.011	0.023	0.0074		0.0006	**1.2**	**0.00051**	**22**
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene	0.0017									**0.0017**	**0.00056**	**2**
Tetrachloroethene (PCE)	0.0012				0.0026					**0.0026**	**0.00052**	**17**
Toluene	0.0092	0.04	0.044	0.016	0.012	0.015			0.0016	**0.046**	**0.00051**	**26**
Trichloroethane (1,1,1-) (1,1,1-TCA)										**0.0094**	**0.00061**	**5**
Trichloroethene (TCE)	0.0011				0.0034	0.00059			0.0013	**0.033**	**0.00059**	**10**
Trichlorofluoromethane (Freon 11)									0.0018	**0.015**	**0.00066**	**12**
Trimethylbenzene (1,2,4-)	0.041			0.026	0.016	0.0053	0.004	0.021	0.0027	**0.041**	**0.00051**	**33**
Trimethylbenzene (1,3,5-)	0.017			0.01	0.0064				0.00092	**0.017**	**0.00051**	**13**
Vinyl chloride[B]		0.014	0.01		0.00087				0.0013	**0.014**	**0.0005**	**7**
Xylene (o-)	0.018				0.0027	0.0028	0.0025		0.00085	**0.018**	**0.00051**	**12**
Xylenes (m,p-)	0.027	0.027	0.027		0.0061	0.0046			0.003	**0.027**	**0.0012**	**16**

TABLE 5
April 2006 Volatile Organic Compound Detected Concentrations Used in the Human Health Risk Assessment
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppmv = Parts per Million per Volume

Sample Name-D = Duplicate sample

Constituent	BN-1-10	BN-1-20	BN-2-10	BN-2-20	BN-3-10	BN-3-20	BN-4-05	BN-4-15	BN-5-10	BN-5-20	BN-6-10	BN-6-20	BN-6-20D	BN-7-05
	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv
Acetone[C]														
Benzene	0.00063		0.00058											
Benzyl Chloride[C]														
Carbon Disulfide[C]	0.00034		0.00032			0.00095	0.0012	0.0013						
Chlorobenzene[B]														
Chloroform					0.0013	0.0015					0.0011	0.001	0.0012	0.00062
Chloromethane (Methyl Chloride)	0.00057		0.00054					0.00025						
Cyclohexane[C]	0.00058		0.00049											
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]														
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)					0.00089	0.0008			0.00072		0.0024	0.009	0.01	
Dichlorobenzene (1,4-) (p)		0.00087		0.00059									0.00021	0.00022
Dichlorodifluoromethane (Freon 12)		0.0029		0.0023	0.0036	0.0034	0.0013	0.00064	0.0053	0.0012	0.0014	0.0037	0.0043	
Dichloroethane (1,1-) (1,1-DCA)[B]														
Dichloroethene (1,1-) (1,1-DCE)[B]														
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]														
Dichloromethane (Methylene Chloride)	0.001		0.001											
Dichloropropane (1,2-)[A]														
Dichloropropene (trans-1,3-)[A]														
Ethanol[C]		0.0048		0.00094	0.00072	0.0018		0.0011		0.0024	0.001			
Ethylbenzene	0.00029		0.00025	0.00029						0.00048				
Ethyltoluene (4-)[C]	0.00026		0.00026		0.00036	0.00033				0.00073	0.00025	0.00029	0.00057	0.00055
Heptane[C]	0.002		0.0016											
Hexane (n-)[C]	0.00036		0.00032											
Methyl Ethyl Ketone[C]				0.0028	0.0082	0.0033				0.033	0.0045		0.007	0.0034
Naphthalene[C]														
Propanol (2-)[C]	0.026	0.44	0.024											
Styrene														
Tetrachloroethene (PCE)		0.0067		0.00071	0.00021								0.0002	
Toluene	0.0012	0.0016	0.0011	0.0004	0.00042	0.00041	0.00023	0.00031		0.0014	0.00054	0.00027	0.0007	0.00087
Trichloroethane (1,1,1-) (1,1,1-TCA)														
Trichloroethene (TCE)					0.00053	0.00091								
Trichlorofluoromethane (Freon 11)														
Trimethylbenzene (1,2,4-)	0.00043		0.0004	0.00024	0.00059	0.00049			0.0002	0.0013	0.00033	0.00046	0.00085	0.00087
Trimethylbenzene (1,3,5-)										0.00031				
Vinyl chloride[B]														
Xylene (o-)	0.00037		0.00031							0.00076			0.00024	0.00022
Xylenes (m,p-)	0.0011		0.00094		0.00056					0.002			0.00059	0.00057

TABLE 5
April 2006 Volatile Organic Compound Detected Concentrations Used in the Human Health Risk Assessment
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

ppmv = Parts per Million per Volume

Sample Name-D = Duplicate sample

Constituent	BN-7-20	BN-8-10	BN-8-20	BN-9-10	BN-9-20	BN-10-10	BN-10-20	BN-11-10	BN-11-20	BN-12-05	BN-12-25	BN-13-10	BN-13-20
	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv
Acetone[C]							0.0018	0.0016				0.0018	0.0017
Benzene		0.00052	0.00047	0.00044	0.00043	0.00042							
Benzyl Chloride[C]									0.00026				0.00028
Carbon Disulfide[C]								0.00043	0.0012		0.00032		
Chlorobenzene[B]													
Chloroform	0.0002						0.00028		0.00028	0.00038	0.0009	0.002	0.005
Chloromethane (Methyl Chloride)	0.00025	0.00056	0.00055	0.00052	0.00052	0.00051				0.00038	0.00041		
Cyclohexane[C]		0.00045	0.00038	0.00038	0.00038	0.00038							
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]													
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)							0.001	0.0079	0.017	0.0035	0.0073	0.018	0.029
Dichlorobenzene (1,4-) (p)	0.00022						0.00052	0.00037	0.00051				0.00028
Dichlorodifluoromethane (Freon 12)							0.019	0.0069	0.019	0.0023	0.0042	0.017	0.024
Dichloroethane (1,1-) (1,1-DCA)[B]													
Dichloroethene (1,1-) (1,1-DCE)[B]													
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]													
Dichloromethane (Methylene Chloride)		0.001	0.0011	0.0011	0.0013	0.0015							
Dichloropropane (1,2-)[A]													0.0035
Dichloropropene (trans-1,3-)[A]												0.00021	
Ethanol[C]	0.0021						0.0052	0.0051	0.0089	0.0039	0.002	0.006	0.0026
Ethylbenzene		0.00025	0.00024	0.00024	0.00024	0.00024	0.00027		0.00025			0.00024	
Ethyltoluene (4-)[C]	0.00055	0.00022	0.00022	0.00021	0.00022	0.00022	0.00089	0.00058	0.0012	0.00021	0.00037	0.00072	0.00066
Heptane[C]		0.0014	0.0011	0.001	0.00094	0.00089		0.00033					
Hexane (n-)[C]		0.00034			0.00033	0.00046							
Methyl Ethyl Ketone[C]	0.0031						0.0071	0.0032	0.005	0.0028	0.0027	0.0051	0.0035
Naphthalene[C]							0.0011	0.00087	0.00097				
Propanol (2-)[C]		0.023	0.022	0.029	0.027	0.028	0.0016	0.0013		0.0015		0.0015	
Styrene							0.00022		0.00024			0.00021	
Tetrachloroethene (PCE)							0.0096	0.00037	0.00048		0.00022	0.002	0.004
Toluene	0.00084	0.001	0.00096	0.00098	0.00099	0.001	0.0014	0.0005	0.0015	0.00026	0.00058	0.0014	0.00085
Trichloroethane (1,1,1-) (1,1,1-TCA)													
Trichloroethene (TCE)													
Trichlorofluoromethane (Freon 11)							0.00084	0.00096	0.0021	0.00067	0.0011	0.0097	0.011
Trimethylbenzene (1,2,4-)	0.00079	0.0004	0.00036	0.00037	0.00037	0.00037	0.0014	0.0011	0.0021	0.00041	0.00055	0.00082	0.00091
Trimethylbenzene (1,3,5-)							0.00034	0.00023	0.00043				
Vinyl chloride[B]													
Xylene (o-)	0.00022	0.00032	0.00028	0.00031	0.00029	0.0003	0.00041		0.00044			0.00036	0.00028
Xylenes (m,p-)	0.00058	0.00097	0.00087	0.00092	0.00092	0.00091	0.001	0.00048	0.001		0.00048	0.00094	0.00076

TABLE 5
April 2006 Volatile Organic Compound Detected Concentrations Used in the Human Health Risk Assessment
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ppmv = Parts per Million per Volume	A
B	Analyte detected in 2002 but not detected in 2006	Sample Name-D = Duplicate sample	B
C	Analyte not analyzed in 2002		C

Constituent	BN-13-20D	BN-14-05	BN-14-15	BN-15-10	BN-15-20	BN-16-10	BN-16-20	BN-17-10	BN-17-20	BN-18-10	BN-18-20	GP-1-19	GP-2-20
	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv	ppmv
Acetone[C]													
Benzene			0.00089									0.00056	0.00034
Benzyl Chloride[C]													
Carbon Disulfide[C]						0.00069	0.0007		0.00048	0.0011	0.00041	0.00042	0.00041
Chlorobenzene[B]													
Chloroform	0.005				0.00074				0.00022	0.0021			
Chloromethane (Methyl Chloride)	0.00085					0.00028	0.0003				0.00025	0.00055	0.00054
Cyclohexane[C]													
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]													
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	0.027	0.0016		0.0061	0.0049			0.0025	0.0057	0.0031			
Dichlorobenzene (1,4-) (p)													
Dichlorodifluoromethane (Freon 12)	0.022	0.0011	0.00064	0.0034	0.01	0.0013	0.0012	0.0028	0.0081	0.0057	0.00094		
Dichloroethane (1,1-) (1,1-DCA)[B]													
Dichloroethene (1,1-) (1,1-DCE)[B]													
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]													
Dichloromethane (Methylene Chloride)												0.001	0.001
Dichloropropane (1,2-)[A]													
Dichloropropene (trans-1,3-)[A]													
Ethanol[C]	0.063	0.0016	0.0014	0.0032	0.0017	0.0031	0.003	0.0012	0.0009	0.00085	0.00091		
Ethylbenzene												0.00032	0.00025
Ethyltoluene (4-)[C]		0.00026	0.00028	0.00021				0.0002	0.00036		0.00024	0.00029	0.00022
Heptane[C]												0.0029	0.0044
Hexane (n-)[C]												0.00038	0.00031
Methyl Ethyl Ketone[C]	0.0059			0.0026			0.003	0.0075	0.0059				
Naphthalene[C]													
Propanol (2-)[C]	0.056											0.028	0.03
Styrene													
Tetrachloroethene (PCE)	0.0054	0.00022		0.0014	0.0074				0.00023				
Toluene	0.0019	0.00054	0.00035	0.00053	0.00043	0.00032	0.00047	0.0004	0.00055		0.00057	0.0013	0.00096
Trichloroethane (1,1,1-) (1,1,1-TCA)				0.00088	0.00023								
Trichloroethene (TCE)											0.0014		
Trichlorofluoromethane (Freon 11)	0.0096												
Trimethylbenzene (1,2,4-)	0.0011	0.00046	0.00045	0.00024	0.00021	0.00029	0.00026	0.00028	0.00065		0.00026	0.00048	0.0004
Trimethylbenzene (1,3,5-)													
Vinyl chloride[B]													
Xylene (o-)									0.00031			0.00039	0.00033
Xylenes (m,p-)	0.0017		0.00041		0.0007		0.00051		0.00074			0.0012	0.00094

TABLE 5
April 2006 Volatile Organic Compound Detected Concentrations Used in the Human Health Risk Assessment
Broadway North Landfill
Tucson, Arizona

Analyte detected in 2006 but not detected in 2002

Analyte detected in 2002 but not detected in 2006

Analyte not analyzed in 2002

ppmv = Parts per Million per Volume

Sample Name-D = Duplicate sample

Constituent	GP-5-20 ppmv	GP-6-20 ppmv	GP-7-20 ppmv	GP-10-10 ppmv	GP-11-10 ppmv	GP-12-10 ppmv	GP-12-10D ppmv	Max Detect	Min Detect	No. Detects
Acetone[C]								**0.0018**	**0.0016**	**4**
Benzene	0.00037	0.00078	0.00067	0.00035				**0.00089**	**0.00034**	**14**
Benzyl Chloride[C]								**0.00028**	**0.00026**	**2**
Carbon Disulfide[C]	0.00043	0.00042	0.0004	0.00042		0.00042		**0.0013**	**0.00032**	**20**
Chlorobenzene[B]										
Chloroform	0.0002		0.0002					**0.005**	**0.0002**	**19**
Chloromethane (Methyl Chloride)	0.00055	0.00034	0.00056	0.00055			0.00023	**0.00085**	**0.00023**	**22**
Cyclohexane[C]		0.00035	0.00068					**0.00068**	**0.00035**	**9**
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]								**0**	**0**	**0**
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)		0.0047			0.0015	0.0017	0.0012	**0.029**	**0.00072**	**24**
Dichlorobenzene (1,4-) (p)		0.0018						**0.0018**	**0.00021**	**10**
Dichlorodifluoromethane (Freon 12)		0.0026			0.0008	0.006	0.0042	**0.024**	**0.00064**	**33**
Dichloroethane (1,1-) (1,1-DCA)[B]								**0**	**0**	**0**
Dichloroethene (1,1-) (1,1-DCE)[B]								**0**	**0**	**0**
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]								**0**	**0**	**0**
Dichloromethane (Methylene Chloride)	0.001		0.001	0.001				**0.0015**	**0.001**	**12**
Dichloropropane (1,2-)[A]								**0.0035**	**0.0035**	**1**
Dichloropropene (trans-1,3-)[A]								**0.00021**	**0.00021**	**1**
Ethanol[C]		0.0023			0.0012	0.0015	0.0022	**0.063**	**0.00072**	**30**
Ethylbenzene	0.00026	0.0021	0.00033	0.00024				**0.0021**	**0.00024**	**18**
Ethyltoluene (4-)[C]	0.00028	0.00024	0.00028	0.00024				**0.0012**	**0.0002**	**34**
Heptane[C]	0.0063	0.0047	0.0024	0.0034				**0.0063**	**0.00033**	**14**
Hexane (n-)[C]	0.00033	0.00088	0.0004					**0.00088**	**0.00031**	**10**
Methyl Ethyl Ketone[C]		0.0073						**0.033**	**0.0026**	**21**
Naphthalene[C]		0.0012						**0.0012**	**0.00087**	**4**
Propanol (2-)[C]	0.033		0.026	0.029				**0.44**	**0.0013**	**18**
Styrene								**0.00024**	**0.00021**	**3**
Tetrachloroethene (PCE)								**0.0096**	**0.0002**	**15**
Toluene	0.001	0.001	0.0013	0.00094	0.00035	0.00037	0.00057	**0.0019**	**0.00023**	**45**
Trichloroethane (1,1,1-) (1,1,1-TCA)					0.0006			**0.00088**	**0.00023**	**3**
Trichloroethene (TCE)								**0.0014**	**0.00053**	**3**
Trichlorofluoromethane (Freon 11)								**0.011**	**0.00067**	**8**
Trimethylbenzene (1,2,4-)	0.00043	0.00066	0.00047	0.00039	0.00022			**0.0021**	**0.0002**	**41**
Trimethylbenzene (1,3,5-)								**0.00043**	**0.00023**	**4**
Vinyl chloride[B]								**0**	**0**	**0**
Xylene (o-)	0.00035	0.00031	0.00039	0.0003				**0.00076**	**0.00022**	**22**
Xylenes (m,p-)	0.001	0.00062	0.0012	0.00087				**0.002**	**0.00041**	**29**

TABLE 6
Toxicity Values of Chemicals of Potential Concern Detected in 2002 and 2006 Soil Gas Sampling Events
Broadway North Landfill
Tucson, Arizona

Chemical	CAS	Cancer Weight of Evidence USEPA (IARC)	Inhalation Unit Risk ($\mu g/m^3)^{-1}$		Chronic Reference Concentration (mg/m^3)	
Acetone	67-64-1				3.15E+00	1,2,13
Benzene	71-43-2	A (1)	7.8E-06	1,3	3.0E-02	1
Benzyl Chloride	100-44-7	B2 (2B)	4.9E-05	1,2	1.0E-02	4,14
Carbon Disulfide	75-15-0				7.0E-01	1
Chlorobenzene	108-90-7				5.0E-02	12
Chloroform	67-66-3	B2 (2B)	2.3E-05	1	4.9E-02	4,15
Chloromethane (Methyl chloride)	74-87-3	D (None)			9.0E-02	1
Cyclohexane[A]	110-82-7				6.0E+00	1
Dibromoethane (1,2-) (Ethylene dibromide)	106-93-4	B2 (2A)	6.0E-04	1,5	9.0E-03	1
Dichloro-1,1,2-2-tetrafluoroethane (1,2-) (Freon 114)[A]	76-14-2				1.7E+01	7
Dichlorobenzene (1,4-) (p)	106-46-7				8.0E-01	1
Dichlorodifluoromethane (Freon 12)	75-71-8				2.0E-01	4
Dichloroethane (1,1-) (1,1-DCA)	75-34-3	C			4.9E-01	2,4
Dichloroethene (1,1-) (1,1-DCE)	75-35-4	C	-		2.0E-01	1
Dichloroethene (c-1,2-)(c-1,2-DCE)	156-59-2	D (None)	-		3.5E-02	2,4
Dichloromethane (Methylene Chloride)	75-09-2	B2 (2B)	4.7E-07	1	3.0E+00	4
Dichloropropane (1,2-)	78-87-5		1.9E-05	2,4,16	4.0E-03	1
Dichloropropene (trans-1,3-)[A]	10061-02-6	B2 (2B)	4.0E-06	1,6	2.0E-02	1,6
Ethanol[A]	64-17-5				1.0E+02	7
Ethylbenzene	100-41-4	D (None)	-		1.0E+00	1
Ethyltoluene (4-)[A]	622-96-8	D (None)			4.0E-01	8
Heptane[A]	142-82-5	D (None)			2.7E+01	9
Hexane (n-)	110-54-3				7.0E-01	1
Methyl Ethyl Ketone (2-Butanone)	78-93-3				5.0E+00	1
Naphthalene	91-20-3				3.0E-03	1
Propanol (2-)[A]	71-23-8				9.8E+00	7
Styrene	100-42-5				1.0E+00	1
Tetrachloroethene (PCE)	127-18-4	None (B2)	5.9E-06	4,11,12	3.5E-02	1,2,17
Toluene	108-88-3		-		5.0E+00	1
Trichloroethane (1,1,1-)	71-55-6		-		5.0E+00	1
Trichloroethene (TCE)	79-01-6	None (2A)	2.0E-06	4,10,12	3.5E-02	4
Trichlorofluoromethane (Freon 11)	75-69-4		-		7.0E-01	4
Trimethylbenzene (1,2,4-)	95-63-6				6.0E-03	4,18
Trimethylbenzene (1,3,5-)	108-67-8				6.0E-03	4
Vinyl Chloride	75-01-4	A	8.8E-06	1,11,19	1.0E-01	1
Xylene (o)	95-47-6		-		1.0E-01	1,20
Xylenes (m,p)	108-38-3		-		1.0E-01	1,20

A Chemicals to be added to the J&E model

TABLE 6
Toxicity Values of Chemicals of Potential Concern Detected in 2002 and 2006 Soil Gas Sampling Events
Broadway North Landfill
Tucson, Arizona

Notes:

1. USEPA Integrated Risk Information System (USEPA, 2010).
2. Route-to-route extrapolation from the oral slope factor (USEPA, 2004b).
3. Upper value of the acceptable URF range of 2.2E-06 to 7.8E-06 for benzene (USEPA, 2010).
4. Other Sources, Listed in USEPA Region IX PRG Table (USEPA, 2004b).
5. Upper value of the acceptable URF range of 3E-04 to 6E-04 for 1,2-dibromoethane (USEPA, 2010).
6. Use toxicity values of 1,3-dichloropropene (542-75-6) as surrogate.
7. See text of Appendix B.
8. Use toxicity values of isopropylbenzene C_9H_{12} (or cumene, CAS No. 98-82-8) as surrogate.
9. Heptane was reported to be about 38 times less toxic than hexane (TPHCWG, 1997).
10. California EPA (OEHHA) Toxicity Criteria Database (Cal-EPA, 2008). Available at: http://www.oehha.ca.gov/risk/ChemicalDB/
11. Upper value of the acceptable URF range of 4.4E-06 to 8.8E-06 for vinyl chloride (USEPA, 2010).
12. Toxicity values listed in the USEPA Regional Screening Levels (RSLs) Table (USEPA< 2008).
13. Chronic RfC for acetone was adopted by USEPA from ATSDR's value of 31 mg/m^3 (USEPA, 2008).
14. Chronic RfC for benzyl chloride was adopted by USEPA from PPRTV's value of 1E-03 mg/m^3 (USEPA, 2008).
15. Chronic RfC for chloroform was adopted by USEPA from ATSDR's value of 9.8E-02 mg/m^3 (USEPA, 2008).
16. Numerical inhalation unit risk for 1,2-dichloropropane was adopted from Cal-EPA (1E-05) (USEPA, 2008).
17. Chronic RfC for PCE was adopted by USEPA from ATSDR's value of 2.7E-01 mg/m^3 (USEPA, 2008).
18. Chronic RfC for 1,2,4-trimethylbenzene was adopted by USEPA from PPRTV's value of 7E-03 mg/m^3 (USEPA, 2008).
19. Numerical inhalation unit risk for vinyl chloride was adopted by USEPA to be at the lower end of the range (4.4E-06) (USEPA, 2008).
20. Chronic RfC for o- and m,p-xylenes was adopted by USEPA to be 7E-01 mg/m^3 while value for mixed xylenes is 1E-01 mg/m^3 (USEPA, 2008).

$(\mu g/m^{3)\ -1}$ = Risk per micrograms per cubic meter

mg/m^3 = milligrams per cubic meter

IARC = International Agency for Research on Cancer

1 = This chemical is carcinogenic to humans.

2A = This chemical is probably carcinogenic to humans.

2B = This chemical is possibly carcinogenic to humans.

Table 7
Physical/Chemical Properties and Toxicity Values of Additional COPCs To Be Used in the Advanced Johnson and Ettinger Model
Broadway North Landfill
Tucson, Arizona

CAS No.	Chemical	carbon partition coefficient (1) K_{oc} (cm^3/g)	Diffusivity in air (2) D_a (cm^2/s)	Diffusivity in water (2) D_w (cm^2/s)	component water solubility (3) S (mg/L)	Henry's law constant (3) H' (unitless)	law constant at reference temperature, H (3) (atm-m^3/mol)	law constant reference temperature, T_R (^oC)	Normal boiling point (3) T_B (^oK)	Critical Temperature (4) T_C (^oK)	Enthalpy of vaporization at normal boiling point (4) $\Delta H_{v,b}$ (cal/mol)	Unit Risk Factor (5) URF ($\mu g/m^3)^{-1}$	Reference conc. (5) RfC (mg/m^3)	Molecular Weight (3) MW
110-82-7	Cyclohexane	1.60E+02	8.39E-02	9.10E-06	5.50E+01	6.15E+00	1.50E-01	25	354	554	7,163		6.0E+00	8.42E+01
76-14-2	Dichloro-1,1,2-2-tetrafluoroethane (1,2-) (Freon 114	8.15E+02	8.17E-02	8.59E-06	1.30E+02	1.15E+02	2.80E+00	25	276.8	418.9	5,600		1.7E+01	1.71E+02
10061-02-6	Dichloropropene (trans-1,3-)	4.57E+01	6.26E-02	1.00E-05	2.80E+03	7.24E-01	1.77E-02	25	381.15	587.38	7900	4.0E-06	2.0E-02	1.11E+02
64-17-5	Ethanol	1.00E+00	1.09E-01	1.18E-05	1.00E+06	2.05E-04	5.00E-06	25	351.2	514	9,216		1.0E+02	4.61E+01
622-96-8	Ethyltoluene (4-)	1.38E+03	6.50E-02	7.10E+06	9.49E+01	2.05E-01	5.00E-03	25	435	640.2	11,100		4.0E-01	1.20E+02
142-82-5	Heptane	8.20E+03	6.59E-02	7.59E-06	1.00E+02	8.20E+01	2.00E+00	25	371.5	540	7,593		2.7E+01	1.00E+02
67-63-0	Propanol (2-) (Isopropanol)	2.50E+01	9.55E-02	1.03E-05	1.00E+06	3.23E-04	7.88E-06	25	355.2	509	11,000		9.8E+00	6.01E+01

Notes:

1. Reference: HSDB, 2008 for all COPCs listed, except value for 4-ethyltoluene was assumed to be equal to that of isopropylbenzene (same MW) (TPHCWG, 1997).
2. Reference: TPHCWG, 1997 for cyclohexane, 4-ethyltoluene (use isopropylbenzene), and heptane; for others, extrapolated using equations in Appendix B.
3. Reference: SRC, 2008, PhysProp Database.
4. Reference: NIST, 2008.
5. See Table 6 and Appendix A text.

TABLE 8
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds in the 2002 Shallow Soil Gas BN-Probe Samples
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ECR--Excess cancer risk
B	Analyte detected in 2002 but not detected in 2006	HQ--Hazard quotient
C	Analyte not analyzed in 2002	RME--Reasonable maximum exposure

Constituent	BN-1-10		BN-1-20		BN-1-20D		BN-2-10		BN-3-10		BN-3-20	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene			4.2E-09	4.2E-05	3.1E-09	3.1E-05						
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]												
Chloroform									3.4E-07	7.0E-04	8.1E-08	1.7E-04
Chloromethane (Methyl Chloride)			NA	8.6E-06								
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)									NA	1.6E-07		
Dichlorobenzene (1,4-) (p)												
Dichlorodifluoromethane (Freon 12)	NA	1.3E-05	NA	7.4E-06	NA	8.9E-06	NA	1.3E-05	NA	2.1E-04	NA	7.0E-05
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]			NA	8.0E-06								
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]			NA	2.8E-05			NA	8.9E-05				
Dichloromethane (Methylene Chloride)	4.1E-10	6.8E-07			3.4E-10	5.5E-07						
Dichloropropane (1,2-)[A]		g										
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]												
Ethylbenzene												
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene												
Tetrachloroethene (PCE)												
Toluene	NA	3.2E-07	NA	5.8E-07	NA	5.1E-07						
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)			6.0E-09	2.0E-04								
Trichlorofluoromethane (Freon 11)												
Trimethylbenzene (1,2,4-)	NA	5.7E-03	NA	2.3E-04	NA	2.5E-04	NA	5.7E-04	NA	4.2E-04	NA	1.8E-04
Trimethylbenzene (1,3,5-)	NA	1.2E-03										
Vinyl chloride[B]	1.1E-08	2.9E-05										
Xylene (o-)	NA	2.9E-05										
Xylenes (m,p-)	NA	5.5E-05										
TOTAL	**1.E-08**	**7.1E-03**	**1.E-08**	**5.2E-04**	**3.E-09**	**2.9E-04**	**NA**	**6.7E-04**	**3.E-07**	**1.3E-03**	**8.E-08**	**4.2E-04**

TABLE 8
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds in the 2002 Shallow Soil Gas BN-Probe Samples
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ECR--Excess cancer risk
B	Analyte detected in 2002 but not detected in 2006	HQ--Hazard quotient
C	Analyte not analyzed in 2002	RME--Reasonable maximum exposure

Constituent	BN-4-05		BN-4-15		BN-5-10		BN-5-20		BN-6-10		BN-6-20	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene							3.0E-09	3.0E-05	9.3E-09	9.3E-05		
Benzyl Chloride[C]												
Carbon Disulfide[C]			NA	3.6042E-06								
Chlorobenzene[B]												
Chloroform					2.0E-08	4.1E-05			3.0E-08	6.1E-05		
Chloromethane (Methyl Chloride)			NA	4.0211E-06			NA	7.1E-06				
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)									NA	9.4E-06	NA	8.5E-06
Dichlorobenzene (1,4-) (p)												
Dichlorodifluoromethane (Freon 12)	NA	1.9E-05	NA	7.2636E-06	NA	1.4E-05	NA	8.2E-06	NA	1.5E-04	NA	1.2E-04
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]					NA	1.6E-04						
Dichloromethane (Methylene Chloride)							2.2E-10	3.7E-07				
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]			NA	0.0								
Ethylbenzene									NA	2.2E-06		
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene												
Tetrachloroethene (PCE)									7.6E-09	8.6E-05	5.7E-09	6.4E-05
Toluene			NA	1.2956E-07			NA	3.2E-07				
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)												
Trichlorofluoromethane (Freon 11)												
Trimethylbenzene (1,2,4-)									NA	4.8E-04		
Trimethylbenzene (1,3,5-)												
Vinyl chloride[B]												
Xylene (o-)												
Xylenes (m,p-)												
TOTAL	**NA**	**1.9E-05**	**NA**	**1.5E-05**	**2.E-08**	**2.1E-04**	**3.E-09**	**4.6E-05**	**5.E-08**	**8.8E-04**	**6.E-09**	**1.9E-04**

TABLE 8
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds in the 2002 Shallow Soil Gas BN-Probe Samples
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002 — ECR--Excess cancer risk

[B] Analyte detected in 2002 but not detected in 2006 — HQ--Hazard quotient

[C] Analyte not analyzed in 2002 — RME--Reasonable maximum exposure

Constituent	BN-7-05		BN-7-20		BN-8-10		BN-8-10D		BN-8-20		BN-9-10	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene	1.3E-08	1.3E-04	9.2E-09	9.2E-05			5.4E-09	5.3E-05	5.8E-09	5.8E-05	1.2E-08	1.2E-04
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]												
Chloroform	2.0E-06	4.1E-03	1.5E-06	3.1E-03	8.1E-08	1.7E-04	6.9E-08	1.4E-04	4.2E-08	8.7E-05		
Chloromethane (Methyl Chloride)	NA	3.0E-05										
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	NA	5.1E-07	NA	3.6E-07								
Dichlorobenzene (1,4-) (p)												
Dichlorodifluoromethane (Freon 12)	NA	4.8E-05	NA	2.6E-05	NA	1.4E-05	NA	1.4E-05	NA	8.2E-06	NA	1.4E-05
Dichloroethane (1,1-) (1,1-DCA)[B]											NA	3.9E-06
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]									NA	3.2E-04		
Dichloromethane (Methylene Chloride)							3.1E-10	5.1E-07			1.2E-09	2.0E-06
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]												
Ethylbenzene	NA	1.6E-05	NA	3.7E-06			NA	1.9E-06			NA	9.5E-06
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene												
Tetrachloroethene (PCE)					8.6E-09	9.8E-05	7.0E-09	7.9E-05	3.5E-09	4.0E-05		
Toluene	NA	5.9E-07	NA	2.4E-07	NA	2.8E-07	NA	4.6E-07	NA	1.9E-07		
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)									3.7E-09	1.2E-04		
Trichlorofluoromethane (Freon 11)												
Trimethylbenzene (1,2,4-)	NA	1.5E-03	NA	1.4E-03	NA	4.5E-04	NA	5.7E-04	NA	2.3E-04	NA	6.7E-03
Trimethylbenzene (1,3,5-)			NA	1.4E-04							NA	1.4E-03
Vinyl chloride[B]											3.9E-09	1.0E-05
Xylene (o-)											NA	3.1E-05
Xylenes (m,p-)	NA	6.6E-05	NA	2.0E-05							NA	1.8E-04
TOTAL	**2.E-06**	**5.8E-03**	**1.E-06**	**4.7E-03**	**9.E-08**	**7.3E-04**	**8.E-08**	**8.6E-04**	**5.E-08**	**8.7E-04**	**2.E-08**	**8.5E-03**

TABLE 8
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds in the 2002 Shallow Soil Gas BN-Probe Samples
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002 — ECR--Excess cancer risk

[B] Analyte detected in 2002 but not detected in 2006 — HQ--Hazard quotient

[C] Analyte not analyzed in 2002 — RME--Reasonable maximum exposure

Constituent	BN-9-20		BN-11-10		BN-11-20		BN-12-05		BN-12-25		BN-13-10	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene	4.8E-09	4.8E-05	1.2E-08	1.2E-04	3.7E-09	3.7E-05	6.6E-08	6.5E-04	4.0E-09	4.0E-05		
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]												
Chloroform					3.4E-08	7.1E-05	5.3E-08	1.1E-04			3.8E-07	8.0E-04
Chloromethane (Methyl Chloride)									NA	7.0E-06		
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)			NA	4.1E-06	NA	4.0E-06	NA	4.3E-06			NA	6.5E-06
Dichlorobenzene (1,4-) (p)			NA	2.7E-06								
Dichlorodifluoromethane (Freon 12)	NA	1.3E-05	NA	1.7E-04	NA	1.5E-04	NA	2.3E-04	NA	5.9E-06	NA	2.1E-04
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]					NA	6.2E-06						
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	NA	1.0E-04			NA	1.2E-04	NA	3.6E-02	NA	1.1E-04		
Dichloromethane (Methylene Chloride)					3.2E-10	5.3E-07	3.8E-10	6.3E-07	2.7E-10	4.5E-07		
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]												
Ethylbenzene			NA	2.8E-06	NA	8.9E-07	NA	3.6E-05				
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene												
Tetrachloroethene (PCE)	5.7E-09	6.4E-05	8.7E-09	9.9E-05	9.4E-09	1.1E-04	8.6E-09	9.7E-05			1.7E-08	1.9E-04
Toluene	NA	1.9E-07	NA	8.7E-07			NA	3.0E-06	NA	4.8E-07		
Trichloroethane (1,1,1-) (1,1,1-TCA)					NA	3.7E-07						
Trichloroethene (TCE)	1.6E-09	5.3E-05			2.9E-09	9.6E-05	1.5E-07	5.1E-03	1.6E-09	5.4E-05		
Trichlorofluoromethane (Freon 11)			NA	9.3E-06	NA	5.4E-06	NA	2.2E-05			NA	7.5E-05
Trimethylbenzene (1,2,4-)	NA	1.9E-04	NA	3.5E-03	NA	4.5E-04	NA	8.8E-03	NA	1.2E-04	NA	3.2E-04
Trimethylbenzene (1,3,5-)			NA	4.5E-04			NA	1.7E-03				
Vinyl chloride[B]							1.1E-07	2.9E-04				
Xylene (o-)			NA	1.7E-05			NA	1.7E-04				
Xylenes (m,p-)			NA	6.3E-05			NA	9.1E-04				
TOTAL	**1.E-08**	**4.7E-04**	**2.E-08**	**4.4E-03**	**5.E-08**	**1.1E-03**	**4.E-07**	**5.4E-02**	**6.E-09**	**3.4E-04**	**4.E-07**	**1.6E-03**

TABLE 8
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds in the 2002 Shallow Soil Gas BN-Probe Samples
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ECR--Excess cancer risk
B	Analyte detected in 2002 but not detected in 2006	HQ--Hazard quotient
C	Analyte not analyzed in 2002	RME--Reasonable maximum exposure

Constituent	BN-13-20		BN-14-05		BN-14-16		BN-15-10		BN-15-10D		BN-15-20	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene	5.3E-08	5.3E-04					4.1E-09	4.1E-05			3.0E-09	2.9E-05
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]												
Chloroform	3.9E-07	8.2E-04	3.6E-08	7.4E-05	6.3E-08	1.3E-04	2.2E-08	4.6E-05	2.7E-08	5.6E-05	4.2E-07	8.7E-04
Chloromethane (Methyl Chloride)												
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]					1.7E-07	7.4E-05						
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	NA	6.3E-06	NA	2.1E-06	NA	1.7E-06	NA	4.1E-06	NA	5.0E-06	NA	6.7E-06
Dichlorobenzene (1,4-) (p)							NA	3.2E-06				
Dichlorodifluoromethane (Freon 12)	NA	3.0E-04	NA	4.3E-04	NA	3.7E-04	NA	1.1E-04	NA	1.4E-04	NA	1.5E-04
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]							NA	4.0E-05	NA	9.6E-05	NA	5.8E-05
Dichloromethane (Methylene Chloride)									3.5E-10	5.7E-07		
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]												
Ethylbenzene	NA	9.1E-06			NA	1.3E-06	NA	9.5E-06				
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene							NA	1.5E-06				
Tetrachloroethene (PCE)	1.5E-08	1.7E-04	1.4E-08	1.6E-04	7.5E-09	8.5E-05					8.7E-09	9.8E-05
Toluene							NA	5.4E-06	NA	8.2E-07	NA	2.2E-07
Trichloroethane (1,1,1-) (1,1,1-TCA)					NA	3.3E-07	NA	2.1E-06	NA	2.6E-06	NA	4.3E-06
Trichloroethene (TCE)												
Trichlorofluoromethane (Freon 11)	NA	5.4E-05	NA	6.4E-06	NA	6.0E-06					NA	3.0E-06
Trimethylbenzene (1,2,4-)	NA	5.9E-03	NA	3.8E-04	NA	2.8E-03	NA	8.1E-03	NA	4.6E-04		
Trimethylbenzene (1,3,5-)	NA	9.2E-04					NA	1.5E-03				
Vinyl chloride[B]												
Xylene (o-)	NA	1.0E-05					NA	4.4E-05				
Xylenes (m,p-)	NA	1.8E-04					NA	1.9E-04				
TOTAL	**5.E-07**	**8.9E-03**	**5.E-08**	**1.1E-03**	**2.E-07**	**3.5E-03**	**3.E-08**	**1.0E-02**	**3.E-08**	**7.5E-04**	**4.E-07**	**1.2E-03**

TABLE 8
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds in the 2002 Shallow Soil Gas BN-Probe Samples
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ECR--Excess cancer risk
B	Analyte detected in 2002 but not detected in 2006	HQ--Hazard quotient
C	Analyte not analyzed in 2002	RME--Reasonable maximum exposure

Constituent	BN-16-10		BN-16-20		BN-17-10		BN-17-20		BN-18-10		BN-18-20	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene	4.5E-09	4.5E-05										
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]												
Chloroform			1.4E-07	3.0E-04			3.0E-08	6.1E-05	3.1E-07	6.5E-04	1.4E-07	3.0E-04
Chloromethane (Methyl Chloride)												
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	NA	6.2E-07	NA	1.4E-07	NA	1.8E-05	NA	1.6E-05	NA	6.5E-07	NA	5.6E-07
Dichlorobenzene (1,4-) (p)	NA	2.6E-06										
Dichlorodifluoromethane (Freon 12)	NA	1.0E-04	NA	6.0E-05	NA	3.5E-03	NA	2.0E-03	NA	4.7E-04	NA	5.3E-04
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	NA	1.9E-04	NA	3.7E-05	NA	9.6E-05						
Dichloromethane (Methylene Chloride)					6.0E-10	1.0E-06						
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]												
Ethylbenzene	NA	8.0E-06	NA	9.3E-07								
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene												
Tetrachloroethene (PCE)							5.7E-09	6.4E-05				
Toluene	NA	2.5E-05	NA	1.1E-06								
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)												
Trichlorofluoromethane (Freon 11)							NA	2.4E-06	NA	3.0E-05	NA	2.9E-05
Trimethylbenzene (1,2,4-)	NA	8.1E-04										
Trimethylbenzene (1,3,5-)	NA	2.6E-04										
Vinyl chloride[B]												
Xylene (o-)	NA	5.0E-05										
Xylenes (m,p-)	NA	1.1E-04										
TOTAL	**5.E-09**	**1.6E-03**	**1.E-07**	**3.9E-04**	**6.E-10**	**3.6E-03**	**4.E-08**	**2.1E-03**	**3.E-07**	**1.2E-03**	**1.E-07**	**8.6E-04**

TABLE 8
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds in the 2002 Shallow Soil Gas BN-Probe Samples
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002 — ECR--Excess cancer risk

[B] Analyte detected in 2002 but not detected in 2006 — HQ--Hazard quotient

[C] Analyte not analyzed in 2002 — RME--Reasonable maximum exposure

Constituent	GP-1-19		GP-2-20		GP-2-20D		GP-5-20		GP-5-20D		GP-6-20	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene	6.5E-09	6.5E-05	9.7E-07	9.7E-03	8.2E-07	8.2E-03	2.0E-07	2.0E-03	1.6E-07	1.5E-03	1.6E-07	1.5E-03
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]			NA	6.9E-03	NA	5.4E-03	NA	4.4E-04	NA	3.0E-04	NA	1.5E-04
Chloroform									1.6E-08	3.2E-05		
Chloromethane (Methyl Chloride)												
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	NA	1.1E-06	NA	2.5E-05	NA	2.2E-05	NA	7.6E-06	NA	5.6E-06	NA	1.2E-05
Dichlorobenzene (1,4-) (p)	NA	2.1E-05	NA	2.5E-03	NA	1.6E-03	NA	3.7E-04	NA	1.7E-04	NA	5.7E-05
Dichlorodifluoromethane (Freon 12)			NA	7.3E-04	NA	1.1E-03	NA	7.3E-04	NA	3.6E-04	NA	1.2E-03
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]	NA	7.5E-05	NA	1.1E-03	NA	8.5E-04	NA	2.8E-04	NA	2.3E-04	NA	2.1E-04
Dichloromethane (Methylene Chloride)									6.3E-10	1.0E-06		
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]												
Ethylbenzene	NA	5.5E-05	NA	2.1E-03	NA	1.3E-03	NA	2.6E-05	NA	1.9E-05	NA	4.0E-05
Ethyltoluene (4-)[C]												
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]												
Naphthalene[C]												
Propanol (2-)[C]												
Styrene	NA	2.9E-06										
Tetrachloroethene (PCE)	8.4E-09	9.4E-05							1.7E-08	2.0E-04		
Toluene	NA	3.2E-06	NA	1.4E-05	NA	1.5E-05	NA	5.4E-06	NA	4.1E-06	NA	5.1E-06
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)	2.2E-09	7.4E-05							6.6E-09	2.2E-04	1.1E-09	3.8E-05
Trichlorofluoromethane (Freon 11)												
Trimethylbenzene (1,2,4-)	NA	1.2E-02					NA	7.3E-03	NA	4.5E-03	NA	1.5E-03
Trimethylbenzene (1,3,5-)	NA	5.0E-03					NA	2.8E-03	NA	1.8E-03		
Vinyl chloride[B]			7.0E-08	1.9E-04	5.0E-08	1.3E-04			4.3E-09	1.2E-05		
Xylene (o-)	NA	3.7E-04							NA	5.3E-05	NA	5.5E-05
Xylenes (m,p-)	NA	4.7E-04	NA	4.5E-04	NA	4.5E-04			NA	1.0E-04	NA	7.6E-05
TOTAL	**2.E-08**	**1.8E-02**	**1.E-06**	**2.4E-02**	**9.E-07**	**1.9E-02**	**2.E-07**	**1.4E-02**	**2.E-07**	**9.6E-03**	**2.E-07**	**4.9E-03**

TABLE 8
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds in the 2002 Shallow Soil Gas BN-Probe Samples
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ECR--Excess cancer risk
B	Analyte detected in 2002 but not detected in 2006	HQ--Hazard quotient
C	Analyte not analyzed in 2002	RME--Reasonable maximum expos

Constituent	GP-10-10		GP-12-10		GP-12-10D	
	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]						
Benzene					4.9E-09	4.9E-05
Benzyl Chloride[C]						
Carbon Disulfide[C]						
Chlorobenzene[B]						
Chloroform					3.3E-08	6.8E-05
Chloromethane (Methyl Chloride)						
Cyclohexane[C]						
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]						
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	NA	1.1E-05	NA	8.5E-06	NA	6.5E-06
Dichlorobenzene (1,4-) (p)	NA	5.7E-05			NA	7.1E-06
Dichlorodifluoromethane (Freon 12)	NA	4.1E-04	NA	7.1E-02	NA	3.5E-02
Dichloroethane (1,1-) (1,1-DCA)[B]						
Dichloroethene (1,1-) (1,1-DCE)[B]						
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]						
Dichloromethane (Methylene Chloride)			6.0E-08	1.0E-04	2.7E-08	4.4E-05
Dichloropropane (1,2-)[A]						
Dichloropropene (trans-1,3-)[A]						
Ethanol[C]						
Ethylbenzene	NA	2.1E-05			NA	1.7E-06
Ethyltoluene (4-)[C]						
Heptane[C]						
Hexane (n-)[C]						
Methyl Ethyl Ketone[C]						
Naphthalene[C]						
Propanol (2-)[C]						
Styrene						
Tetrachloroethene (PCE)						
Toluene					NA	8.7E-07
Trichloroethane (1,1,1-) (1,1,1-TCA)						
Trichloroethene (TCE)					4.1E-09	1.4E-04
Trichlorofluoromethane (Freon 11)					NA	1.0E-05
Trimethylbenzene (1,2,4-)	NA	1.9E-03	NA	1.0E-02	NA	1.3E-03
Trimethylbenzene (1,3,5-)					NA	4.4E-04
Vinyl chloride[B]					1.0E-08	2.7E-05
Xylene (o-)	NA	7.8E-05			NA	2.7E-05
Xylenes (m,p-)					NA	8.3E-05
TOTAL	**NA**	**2.5E-03**	**6.E-08**	**8.1E-02**	**8.E-08**	**3.7E-02**

TABLE 9
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds Detected in 2006 BN- and GP-Probe Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ECR--Excess cancer risk
B	Analyte detected in 2002 but not detected in 2006	HQ--Hazard quotient
C	Analyte not analyzed in 2002	RME--Reasonable maximum exposure

Constituent	BN-1-10		BN-1-20		BN-2-10		BN-2-20		BN-3-10		BN-3-20	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene	3.2E-09	3.2E-05			4.5E-09	4.5E-05						
Benzyl Chloride[C]												
Carbon Disulfide[C]	NA	8.2E-07			NA	1.1E-06					NA	2.2E-06
Chlorobenzene[B]												
Chloroform									5.0E-08	1.0E-04	3.7E-08	7.6E-05
Chloromethane (Methyl Chloride)	NA	8.0E-06			NA	1.1E-05						
Cyclohexane[C]	NA	1.6E-07			NA	2.0E-07						
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)									NA	2.6E-07	NA	1.4E-07
Dichlorobenzene (1,4-) (p)			NA	2.5E-06			NA	1.7E-06				
Dichlorodifluoromethane (Freon 12)			NA	2.6E-05			NA	2.1E-05	NA	5.5E-05	NA	3.1E-05
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]												
Dichloromethane (Methylene Chloride)	3.7E-10	6.1E-07			5.5E-10	9.1E-07						
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]			NA	4.8E-08			NA	9.4E-09	NA	1.1E-08	NA	1.8E-08
Ethylbenzene	NA	5.4E-07			NA	7.2E-07	NA	5.1E-07				
Ethyltoluene (4-)[C]	NA	3.2E-03			NA	3.0E-03			NA	4.2E-03	NA	3.8E-03
Heptane[C]	NA	1.2E-07			NA	1.5E-07						
Hexane (n-)[C]	NA	1.4E-06			NA	1.7E-06						
Methyl Ethyl Ketone[C]							NA	7.0E-07	NA	3.3E-06	NA	8.3E-07
Naphthalene[C]												
Propanol (2-)[C]	NA	4.6E-06	NA	5.3E-05	NA	4.6E-06						
Styrene												
Tetrachloroethene (PCE)			4.5E-08	5.1E-04			4.7E-09	5.4E-05	2.3E-09	2.6E-05		
Toluene	NA	4.3E-07	NA	5.4E-07	NA	6.0E-07	NA	1.4E-07	NA	2.3E-07	NA	1.4E-07
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)									1.7E-09	5.6E-05	1.8E-09	5.8E-05
Trichlorofluoromethane (Freon 11)												
Trimethylbenzene (1,2,4-)	NA	1.3E-04			NA	1.9E-04	NA	6.8E-05	NA	2.8E-04	NA	1.4E-04
Trimethylbenzene (1,3,5-)												
Vinyl chloride[B]												
Xylene (o-)	NA	7.7E-06			NA	9.7E-06						
Xylenes (m,p-)	NA	1.9E-05			NA	2.6E-05			NA	1.5E-05		
TOTAL	**4.E-09**	**3.4E-03**	**4.E-08**	**5.9E-04**	**5.E-09**	**3.3E-03**	**5.E-09**	**1.5E-04**	**5.E-08**	**4.7E-03**	**4.E-08**	**4.2E-03**

TABLE 9
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds Detected in 2006 BN- and GP-Probe Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ECR--Excess cancer risk
B	Analyte detected in 2002 but not detected in 2006	HQ--Hazard quotient
C	Analyte not analyzed in 2002	RME--Reasonable maximum exposure

Constituent	BN-4-05		BN-4-15		BN-5-10		BN-5-20		BN-6-10		BN-6-20	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene												
Benzyl Chloride[C]												
Carbon Disulfide[C]	NA	5.9E-06	NA	3.6E-06								
Chlorobenzene[B]												
Chloroform									4.2E-08	8.7E-05	2.5E-08	5.1E-05
Chloromethane (Methyl Chloride)			NA	4.0E-06								
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)					NA	2.1E-07			NA	7.0E-07	NA	1.6E-06
Dichlorobenzene (1,4-) (p)												
Dichlorodifluoromethane (Freon 12)	NA	3.0E-05	NA	7.3E-06	NA	8.0E-05	NA	1.1E-05	NA	2.1E-05	NA	3.4E-05
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]												
Dichloromethane (Methylene Chloride)												
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]			NA	1.3E-08			NA	2.4E-08	NA	1.5E-08		
Ethylbenzene							NA	8.4E-07				
Ethyltoluene (4-)[C]							NA	8.5E-03	NA	2.9E-03	NA	3.4E-03
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]							NA	8.3E-06	NA	1.8E-06		
Naphthalene[C]												
Propanol (2-)[C]												
Styrene												
Tetrachloroethene (PCE)												
Toluene	NA	1.8E-07	NA	1.3E-07			NA	4.7E-07	NA	2.9E-07	NA	9.2E-08
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)												
Trichlorofluoromethane (Freon 11)												
Trimethylbenzene (1,2,4-)					NA	9.5E-05	NA	3.7E-04	NA	1.6E-04	NA	1.3E-04
Trimethylbenzene (1,3,5-)							NA	8.7E-05				
Vinyl chloride[B]												
Xylene (o-)							NA	1.5E-05				
Xylenes (m,p-)							NA	3.3E-05				
TOTAL	**NA**	**3.6E-05**	**NA**	**1.5E-05**	**NA**	**1.8E-04**	**NA**	**9.0E-03**	**4.E-08**	**3.2E-03**	**2.E-08**	**3.6E-03**

TABLE 9
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds Detected in 2006 BN- and GP-Probe Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ECR--Excess cancer risk
B	Analyte detected in 2002 but not detected in 2006	HQ--Hazard quotient
C	Analyte not analyzed in 2002	RME--Reasonable maximum exposure

Constituent	BN-6-20D		BN-7-05		BN-7-20		BN-8-10		BN-8-20		BN-9-10	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene							4.0E-09	4.0E-05	2.3E-09	2.3E-05	3.4E-09	3.4E-05
Benzyl Chloride[C]												
Carbon Disulfide[C]												
Chlorobenzene[B]												
Chloroform	3.0E-08	6.1E-05	3.3E-08	6.8E-05	4.9E-09	1.0E-05						
Chloromethane (Methyl Chloride)					NA	3.3E-06	NA	1.1E-05	NA	7.4E-06	NA	1.0E-05
Cyclohexane[C]							NA	1.8E-07	NA	9.5E-08	NA	1.5E-07
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	NA	1.8E-06										
Dichlorobenzene (1,4-) (p)	NA	6.0E-07	NA	1.6E-06	NA	6.2E-07						
Dichlorodifluoromethane (Freon 12)	NA	3.9E-05										
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]												
Dichloromethane (Methylene Chloride)							5.5E-10	9.1E-07	3.9E-10	6.4E-07	6.0E-10	1.0E-06
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]					NA	2.1E-08						
Ethylbenzene							NA	7.2E-07	NA	4.2E-07	NA	6.9E-07
Ethyltoluene (4-)[C]	NA	6.6E-03	NA	6.4E-03	NA	6.4E-03	NA	2.6E-03	NA	2.6E-03	NA	2.5E-03
Heptane[C]							NA	1.3E-07	NA	6.1E-08	NA	9.3E-08
Hexane (n-)[C]							NA	1.8E-06				
Methyl Ethyl Ketone[C]	NA	1.8E-06	NA	2.0E-06	NA	7.8E-07						
Naphthalene[C]												
Propanol (2-)[C]							NA	4.4E-06	NA	2.7E-06	NA	5.6E-06
Styrene												
Tetrachloroethene (PCE)	1.3E-09	1.5E-05										
Toluene	NA	2.4E-07	NA	6.8E-07	NA	2.8E-07	NA	5.4E-07	NA	3.3E-07	NA	5.3E-07
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)												
Trichlorofluoromethane (Freon 11)												
Trimethylbenzene (1,2,4-)	NA	2.4E-04	NA	6.4E-04	NA	2.2E-04	NA	1.9E-04	NA	1.0E-04	NA	1.8E-04
Trimethylbenzene (1,3,5-)												
Vinyl chloride[B]												
Xylene (o-)	NA	4.7E-06	NA	9.9E-06	NA	4.3E-06	NA	1.0E-05	NA	5.5E-06	NA	9.7E-06
Xylenes (m,p-)	NA	9.8E-06	NA	2.3E-05	NA	9.6E-06	NA	2.7E-05	NA	1.4E-05	NA	2.5E-05
TOTAL	**3.E-08**	**7.0E-03**	**3.E-08**	**7.2E-03**	**5.E-09**	**6.7E-03**	**5.E-09**	**2.9E-03**	**3.E-09**	**2.7E-03**	**4.E-09**	**2.7E-03**

TABLE 9
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds Detected in 2006 BN- and GP-Probe Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002 — ECR--Excess cancer risk

[B] Analyte detected in 2002 but not detected in 2006 — HQ--Hazard quotient

[C] Analyte not analyzed in 2002 — RME--Reasonable maximum exposure

Constituent	BN-9-20		BN-10-10		BN-10-20		BN-11-10		BN-11-20		BN-12-05	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]					NA	7.8E-07	NA	1.1E-06				
Benzene	2.1E-09	2.1E-05	3.3E-09	3.3E-05								
Benzyl Chloride[C]									1.1E-08	5.4E-05		
Carbon Disulfide[C]							NA	1.5E-06	NA	2.7E-06		
Chlorobenzene[B]												
Chloroform					6.9E-09	1.4E-05			6.9E-09	1.4E-05	2.0E-08	4.2E-05
Chloromethane (Methyl Chloride)	NA	7.0E-06	NA	1.0E-05							NA	1.0E-05
Cyclohexane[C]	NA	9.5E-08	NA	1.5E-07								
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)					NA	1.8E-07	NA	2.3E-06	NA	3.1E-06	NA	1.5E-06
Dichlorobenzene (1,4-) (p)					NA	1.5E-06	NA	1.7E-06	NA	1.4E-06		
Dichlorodifluoromethane (Freon 12)					NA	1.7E-04	NA	1.0E-04	NA	1.7E-04	NA	5.3E-05
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]												
Dichloromethane (Methylene Chloride)	4.6E-10	7.5E-07	8.2E-10	1.4E-06								
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]					NA	5.2E-08	NA	7.9E-08	NA	8.9E-08	NA	8.3E-08
Ethylbenzene	NA	4.2E-07	NA	6.9E-07	NA	4.7E-07			NA	4.4E-07		
Ethyltoluene (4-)[C]	NA	2.6E-03	NA	2.6E-03	NA	1.0E-02	NA	6.8E-03	NA	1.4E-02	NA	2.5E-03
Heptane[C]	NA	5.2E-08	NA	8.2E-08			NA	3.1E-08				
Hexane (n-)[C]	NA	1.3E-06	NA	2.5E-06								
Methyl Ethyl Ketone[C]					NA	1.8E-06	NA	1.3E-06	NA	1.3E-06	NA	1.7E-06
Naphthalene[C]					NA	6.4E-04	NA	8.6E-04	NA	5.6E-04		
Propanol (2-)[C]	NA	3.3E-06	NA	5.4E-06	NA	1.9E-07	NA	2.5E-07			NA	4.1E-07
Styrene					NA	3.6E-07			NA	3.9E-07		
Tetrachloroethene (PCE)					6.4E-08	7.3E-04	4.1E-09	4.6E-05	3.2E-09	3.6E-05		
Toluene	NA	3.4E-07	NA	5.4E-07	NA	4.7E-07	NA	2.7E-07	NA	5.1E-07	NA	2.0E-07
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)												
Trichlorofluoromethane (Freon 11)					NA	3.0E-06	NA	5.6E-06	NA	7.6E-06	NA	5.6E-06
Trimethylbenzene (1,2,4-)	NA	1.0E-04	NA	1.8E-04	NA	3.9E-04	NA	5.3E-04	NA	5.9E-04	NA	3.0E-04
Trimethylbenzene (1,3,5-)					NA	9.5E-05	NA	1.1E-04	NA	1.2E-04		
Vinyl chloride[B]												
Xylene (o-)	NA	5.7E-06	NA	9.4E-06	NA	8.0E-06			NA	8.6E-06		
Xylenes (m,p-)	NA	1.5E-05	NA	2.5E-05	NA	1.7E-05	NA	1.3E-05	NA	1.7E-05		
TOTAL	**3.E-09**	**2.7E-03**	**4.E-09**	**2.8E-03**	**7.E-08**	**1.2E-02**	**4.E-09**	**8.4E-03**	**2.E-08**	**1.6E-02**	**2.E-08**	**2.9E-03**

TABLE 9
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds Detected in 2006 BN- and GP-Probe Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002 — ECR--Excess cancer risk

[B] Analyte detected in 2002 but not detected in 2006 — HQ--Hazard quotient

[C] Analyte not analyzed in 2002 — RME--Reasonable maximum exposure

Constituent	BN-12-25		BN-13-10		BN-13-20		BN-13-20D		BN-14-05		BN-14-15	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]			NA	1.2E-06	NA	7.4E-07						
Benzene											5.3E-09	5.3E-05
Benzyl Chloride[C]					1.2E-08	5.8E-05						
Carbon Disulfide[C]	NA	6.2E-07										
Chlorobenzene[B]												
Chloroform	1.9E-08	3.9E-05	7.7E-08	1.6E-04	1.2E-07	2.5E-04	1.2E-07	2.5E-04				
Chloromethane (Methyl Chloride)	NA	4.7E-06					NA	1.1E-05				
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	NA	1.1E-06	NA	5.3E-06	NA	5.2E-06	NA	4.9E-06	NA	6.8E-07		
Dichlorobenzene (1,4-) (p)					NA	7.9E-07						
Dichlorodifluoromethane (Freon 12)	NA	3.2E-05	NA	2.6E-04	NA	2.2E-04	NA	2.0E-04	NA	2.5E-05	NA	7.3E-06
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]												
Dichloromethane (Methylene Chloride)												
Dichloropropane (1,2-)[A]					5.6E-08	1.7E-03						
Dichloropropene (trans-1,3-)[A]			9.6E-10	2.8E-05								
Ethanol[C]	NA	1.7E-08	NA	9.3E-08	NA	2.6E-08	NA	6.3E-07	NA	3.4E-08	NA	1.7E-08
Ethylbenzene			NA	6.9E-07								
Ethyltoluene (4-)[C]	NA	4.3E-03	NA	8.4E-03	NA	7.7E-03			NA	3.0E-03	NA	3.3E-03
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]	NA	5.7E-07	NA	2.1E-06	NA	8.8E-07	NA	1.5E-06				
Naphthalene[C]												
Propanol (2-)[C]			NA	2.9E-07			NA	6.8E-06				
Styrene			NA	5.7E-07								
Tetrachloroethene (PCE)	1.2E-09	1.4E-05	2.2E-08	2.5E-04	2.7E-08	3.0E-04	3.6E-08	4.1E-04	3.6E-09	4.1E-05		
Toluene	NA	1.7E-07	NA	7.6E-07	NA	2.9E-07	NA	6.4E-07	NA	4.2E-07	NA	1.5E-07
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)												
Trichlorofluoromethane (Freon 11)	NA	3.3E-06	NA	5.6E-05	NA	4.0E-05	NA	3.5E-05				
Trimethylbenzene (1,2,4-)	NA	1.3E-04	NA	3.9E-04	NA	2.6E-04	NA	3.1E-04	NA	3.4E-04	NA	1.6E-04
Trimethylbenzene (1,3,5-)												
Vinyl chloride[B]												
Xylene (o-)			NA	1.1E-05	NA	5.5E-06						
Xylenes (m,p-)	NA	6.6E-06	NA	2.6E-05	NA	1.3E-05	NA	2.8E-05			NA	8.5E-06
TOTAL	**2.E-08**	**4.5E-03**	**1.E-07**	**9.6E-03**	**2.E-07**	**1.1E-02**	**2.E-07**	**1.3E-03**	**4.E-09**	**3.4E-03**	**5.E-09**	**3.5E-03**

TABLE 9
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds Detected in 2006 BN- and GP-Probe Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

[A] Analyte detected in 2006 but not detected in 2002 — ECR--Excess cancer risk

[B] Analyte detected in 2002 but not detected in 2006 — HQ--Hazard quotient

[C] Analyte not analyzed in 2002 — RME--Reasonable maximum exposure

Constituent	BN-15-10		BN-15-20		BN-16-10		BN-16-20		BN-17-10		BN-17-20	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene												
Benzyl Chloride[C]												
Carbon Disulfide[C]					NA	2.4E-06	NA	1.6E-06			NA	1.1E-06
Chlorobenzene[B]												
Chloroform			1.8E-08	3.8E-05							5.4E-09	1.1E-05
Chloromethane (Methyl Chloride)					NA	5.7E-06	NA	4.0E-06				
Cyclohexane[C]												
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	NA	1.8E-06	NA	8.9E-07					NA	7.3E-07	NA	1.0E-06
Dichlorobenzene (1,4-) (p)												
Dichlorodifluoromethane (Freon 12)	NA	5.2E-05	NA	9.1E-05	NA	2.0E-05	NA	1.1E-05	NA	4.2E-05	NA	7.3E-05
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]												
Dichloromethane (Methylene Chloride)												
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]	NA	4.9E-08	NA	1.7E-08	NA	4.8E-08	NA	3.0E-08	NA	1.9E-08	NA	9.0E-09
Ethylbenzene												
Ethyltoluene (4-)[C]	NA	2.5E-03							NA	2.3E-03	NA	4.2E-03
Heptane[C]												
Hexane (n-)[C]												
Methyl Ethyl Ketone[C]	NA	1.1E-06					NA	7.5E-07	NA	3.1E-06	NA	1.5E-06
Naphthalene[C]												
Propanol (2-)[C]												
Styrene												
Tetrachloroethene (PCE)	1.5E-08	1.8E-04	4.9E-08	5.6E-04							1.5E-09	1.7E-05
Toluene	NA	2.9E-07	NA	1.5E-07	NA	1.7E-07	NA	1.6E-07	NA	2.2E-07	NA	1.9E-07
Trichloroethane (1,1,1-) (1,1,1-TCA)	NA	6.5E-07	NA	1.0E-07								
Trichloroethene (TCE)												
Trichlorofluoromethane (Freon 11)												
Trimethylbenzene (1,2,4-)	NA	1.1E-04	NA	5.9E-05	NA	1.4E-04	NA	7.3E-05	NA	1.3E-04	NA	1.8E-04
Trimethylbenzene (1,3,5-)												
Vinyl chloride[B]												
Xylene (o-)											NA	6.1E-06
Xylenes (m,p-)			NA	1.2E-05			NA	8.4E-06			NA	1.2E-05
TOTAL	**2.E-08**	**2.8E-03**	**7.E-08**	**7.6E-04**	**NA**	**1.7E-04**	**NA**	**9.9E-05**	**NA**	**2.5E-03**	**7.E-09**	**4.5E-03**

TABLE 9
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds Detected in 2006 BN- and GP-Probe Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ECR--Excess cancer risk
B	Analyte detected in 2002 but not detected in 2006	HQ--Hazard quotient
C	Analyte not analyzed in 2002	RME--Reasonable maximum exposure

Constituent	BN-18-10		BN-18-20		GP-1-19		GP-2-20		GP-5-20		GP-6-20	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]												
Benzene					2.8E-09	2.8E-05	1.6E-09	1.6E-05	1.8E-09	1.8E-05	3.8E-09	3.8E-05
Benzyl Chloride[C]												
Carbon Disulfide[C]	NA	3.9E-06	NA	9.3E-07	NA	9.9E-07	NA	9.3E-07	NA	9.8E-07	NA	9.6E-07
Chlorobenzene[B]												
Chloroform	8.1E-08	1.7E-04							4.9E-09	1.0E-05		
Chloromethane (Methyl Chloride)			NA	3.3E-06	NA	7.6E-06	NA	7.2E-06	NA	7.4E-06	NA	4.5E-06
Cyclohexane[C]											NA	8.8E-08
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]												
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	NA	9.1E-07									NA	8.5E-07
Dichlorobenzene (1,4-) (p)											NA	5.1E-06
Dichlorodifluoromethane (Freon 12)	NA	8.6E-05	NA	8.5E-06							NA	2.4E-05
Dichloroethane (1,1-) (1,1-DCA)[B]												
Dichloroethene (1,1-) (1,1-DCE)[B]												
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]												
Dichloromethane (Methylene Chloride)					3.6E-10	6.0E-07	3.5E-10	5.8E-07	3.5E-10	5.8E-07		
Dichloropropane (1,2-)[A]												
Dichloropropene (trans-1,3-)[A]												
Ethanol[C]	NA	1.3E-08	NA	9.1E-09							NA	2.3E-08
Ethylbenzene					NA	5.8E-07	NA	4.4E-07	NA	4.5E-07	NA	3.7E-06
Ethyltoluene (4-)[C]			NA	2.8E-03	NA	3.4E-03	NA	2.6E-03	NA	3.3E-03	NA	2.8E-03
Heptane[C]					NA	1.7E-07	NA	2.4E-07	NA	3.5E-07	NA	2.6E-07
Hexane (n-)[C]					NA	1.5E-06	NA	1.2E-06	NA	1.3E-06	NA	3.4E-06
Methyl Ethyl Ketone[C]											NA	1.8E-06
Naphthalene[C]											NA	7.0E-04
Propanol (2-)[C]					NA	3.5E-06	NA	3.6E-06	NA	4.0E-06		
Styrene												
Tetrachloroethene (PCE)												
Toluene			NA	1.9E-07	NA	4.6E-07	NA	3.3E-07	NA	3.4E-07	NA	3.4E-07
Trichloroethane (1,1,1-) (1,1,1-TCA)												
Trichloroethene (TCE)			2.7E-09	9.0E-05								
Trichlorofluoromethane (Freon 11)												
Trimethylbenzene (1,2,4-)			NA	7.3E-05	NA	1.4E-04	NA	1.1E-04	NA	1.2E-04	NA	1.9E-04
Trimethylbenzene (1,3,5-)												
Vinyl chloride[B]												
Xylene (o-)					NA	7.9E-06	NA	6.4E-06	NA	6.8E-06	NA	6.1E-06
Xylenes (m,p-)					NA	2.1E-05	NA	1.6E-05	NA	1.7E-05	NA	1.0E-05
TOTAL	**8.E-08**	**2.6E-04**	**3.E-09**	**3.0E-03**	**3.E-09**	**3.6E-03**	**2.E-09**	**2.7E-03**	**7.E-09**	**3.5E-03**	**4.E-09**	**3.8E-03**

TABLE 9
Potential RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds Detected in 2006 BN- and GP-Probe Shallow Soil Gas Samples
Broadway North Landfill
Tucson, Arizona

A	Analyte detected in 2006 but not detected in 2002	ECR--Excess cancer risk
B	Analyte detected in 2002 but not detected in 2006	HQ--Hazard quotient
C	Analyte not analyzed in 2002	RME--Reasonable maximum exposure

Constituent	GP-7-20		GP-10-10		GP-11-10		GP-12-10		GP-12-10D	
	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ	ECR	HQ
Acetone[C]										
Benzene	3.2E-09	3.2E-05	2.7E-09	2.7E-05						
Benzyl Chloride[C]										
Carbon Disulfide[C]	NA	9.1E-07	NA	1.5E-06			NA	1.5E-06		
Chlorobenzene[B]										
Chloroform	4.9E-09	1.0E-05								
Chloromethane (Methyl Chloride)	NA	7.5E-06	NA	1.1E-05					NA	4.6E-06
Cyclohexane[C]	NA	1.7E-07								
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]										
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)					NA	4.4E-07	NA	5.0E-07	NA	3.5E-07
Dichlorobenzene (1,4-) (p)										
Dichlorodifluoromethane (Freon 12)					NA	1.2E-05	NA	9.1E-05	NA	6.4E-05
Dichloroethane (1,1-) (1,1-DCA)[B]										
Dichloroethene (1,1-) (1,1-DCE)[B]										
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]										
Dichloromethane (Methylene Chloride)	3.5E-10	5.8E-07	5.5E-10	9.1E-07						
Dichloropropane (1,2-)[A]										
Dichloropropene (trans-1,3-)[A]										
Ethanol[C]					NA	1.9E-08	NA	2.3E-08	NA	3.4E-08
Ethylbenzene	NA	5.8E-07	NA	6.9E-07						
Ethyltoluene (4-)[C]	NA	3.3E-03	NA	2.8E-03						
Heptane[C]	NA	1.3E-07	NA	3.1E-07						
Hexane (n-)[C]	NA	1.6E-06								
Methyl Ethyl Ketone[C]										
Naphthalene[C]										
Propanol (2-)[C]	NA	3.1E-06	NA	5.6E-06						
Styrene										
Tetrachloroethene (PCE)										
Toluene	NA	4.4E-07	NA	5.1E-07	NA	1.9E-07	NA	2.0E-07	NA	3.1E-07
Trichloroethane (1,1,1-) (1,1,1-TCA)					NA	4.4E-07				
Trichloroethene (TCE)										
Trichlorofluoromethane (Freon 11)										
Trimethylbenzene (1,2,4-)	NA	1.3E-04	NA	1.9E-04	NA	1.1E-04				
Trimethylbenzene (1,3,5-)										
Vinyl chloride[B]										
Xylene (o-)	NA	7.6E-06	NA	9.4E-06						
Xylenes (m,p-)	NA	2.0E-05	NA	2.4E-05						
TOTAL	**9.E-09**	**3.5E-03**	**3.E-09**	**3.1E-03**	**NA**	**1.2E-04**	**NA**	**9.3E-05**	**NA**	**6.9E-05**

TABLE 9a
Potential CTE and RME Residential Health Risks from Indoor Inhalation of Volatile Organic Compounds Detected in 2006 BN-13-20 ProbeSoil Gas Sample
Broadway North Landfill
Tucson, Arizona

ECR--Excess cancer risk
HQ--Hazard quotient
RME--Reasonable maximum exposure
CTE--Central tendency exposure

[A] Analyte detected in 2006 but not detected in 2002

[B] Analyte detected in 2002 but not detected in 2006

[C] Analyte not analyzed in 2002

Constituent	BN-13-20 RME Risks		BN-13-20 CTE Risks	
	ECR	HQ	ECR	HQ
Acetone[C]	NA	7.4E-07	NA	7.4E-07
Benzene				
Benzyl Chloride[C]	1.2E-08	5.8E-05	4.9E-09	5.8E-05
Carbon Disulfide[C]				
Chlorobenzene[B]				
Chloroform	1.2E-07	2.5E-04	4.9E-08	2.5E-04
Chloromethane (Methyl Chloride)				
Cyclohexane[C]				
Dibromoethane (1,2-) (EDB, Ethylene Dibromide)[B]				
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	NA	5.2E-06	NA	5.2E-06
Dichlorobenzene (1,4-) (p)	NA	7.9E-07	NA	7.9E-07
Dichlorodifluoromethane (Freon 12)	NA	2.2E-04	NA	2.2E-04
Dichloroethane (1,1-) (1,1-DCA)[B]				
Dichloroethene (1,1-) (1,1-DCE)[B]				
Dichloroethene (cis-1,2-) (cis-1,2-DCE)[B]				
Dichloromethane (Methylene Chloride)				
Dichloropropane (1,2-)[A]	5.6E-08	1.7E-03	2.2E-08	1.7E-03
Dichloropropene (trans-1,3-)[A]				
Ethanol[C]	NA	2.6E-08	NA	2.6E-08
Ethylbenzene				
Ethyltoluene (4-)[C]	NA	7.7E-03	NA	7.7E-03
Heptane[C]				
Hexane (n-)[C]				
Methyl Ethyl Ketone[C]	NA	8.8E-07	NA	8.8E-07
Naphthalene[C]				
Propanol (2-)[C]				
Styrene				
Tetrachloroethene (PCE)	2.7E-08	3.0E-04	1.1E-08	3.0E-04
Toluene	NA	2.9E-07	NA	2.9E-07
Trichloroethane (1,1,1-) (1,1,1-TCA)				
Trichloroethene (TCE)				
Trichlorofluoromethane (Freon 11)	NA	4.0E-05	NA	4.0E-05
Trimethylbenzene (1,2,4-)	NA	2.6E-04	NA	2.6E-04
Trimethylbenzene (1,3,5-)				
Vinyl chloride[B]				
Xylene (o-)	NA	5.5E-06	NA	5.5E-06
Xylenes (m,p-)	NA	1.3E-05	NA	1.3E-05
TOTAL	**2.E-07**	**1.1E-02**	**9.E-08**	**1.1E-02**

TABLE 10
Comparison of Probe-specific 2002 and 2006 RME Excess Cancer Risks
Broadway North Landfill
Tucson, Arizona

Probe Location	2002 ECR--Total	Risk-driving COPC	2006 ECR--Total	% Decrease	Risk-driving COPC
BN-1-10	1.E-08	Vinyl chloride	4.E-09	60%	Benzene
BN-1-20	1.E-08	TCE, benzene	4.E-08	-300%	PCE
BN-1-20D	3.E-09	Benzene			
BN-2-10	NA	None	5.E-09		Benzene
BN-2-20			5.E-09		PCE
BN-3-10	3.E-07	Chloroform	5.E-08	83%	Chloroform
BN-3-20	8.E-08	Chloroform	4.E-08	50%	Chloroform
BN-4-05	NA	None	NA		None
BN-4-15	NA	None	NA		None
BN-5-10	2.E-08	Chloroform	NA	100%	None
BN-5-20	3.E-09	Benzene	NA	100%	None
BN-6-10	5.E-08	Chloroform, benzene, PCE	4.E-08	20%	Chloroform
BN-6-20	6.E-09	PCE	2.E-08	-233%	Chloroform
BN-6-20D			3.E-08		Chloroform
BN-7-05	2.0E-06[A]	Chloroform	3.E-08	99%	Chloroform
BN-7-20	1.0E-06[B]	Chloroform	5.E-09	100%	Chloroform
BN-8-10	9.E-08	Chloroform	5.E-09	94%	Benzene
BN-8-10D	8.E-08	Chloroform			
BN-8-20	5.E-08	Chloroform, benzene, PCE	3.E-09	94%	Benzene
BN-9-10	2.E-08	Benzene	4.E-09	80%	Benzene
BN-9-20	1.E-08	PCE, benzene	3.E-09	70%	Benzene
BN-10-10			4.E-09		Benzene
BN-10-20			7.E-08		PCE
BN-11-10	2.E-08	Benzene, PCE	4.E-09	80%	PCE
BN-11-20	5.E-08	Chloroform, PCE. Benzene, TCE	2.E-08	60%	Benzene, chloroform, PCE
BN-12-05	4.E-07	TCE, vinyl chloride, benzene, chloroform	2.E-08	95%	Chloroform
BN-12-25	6.E-09	Benzene, TCE	2.E-08	-233%	Chloroform
BN-13-10	4.E-07	Chloroform	1.0E-07[A]	75%	Chloroform, PCE
BN-13-20	5.E-07	Chloroform, benzene, PCE	2.0E-07[B]	80%	Chloroform, PCE & others
BN-13-20D			2.E-07		Chloroform, PCE
BN-14-05	5.E-08	Benzene, PCE	4.E-09	92%	PCE
BN-14-15	2.E-07	EDB	5.E-09	98%	Benzene
BN-15-10	3.E-08	Chloroform, benzene	2.E-08	33%	PCE
BN-15-10D	3.E-08	Chloroform			
BN-15-20	4.E-07	Chloroform	7.E-08	83%	PCE, chloroform
BN-16-10	5.E-09	Benzene	NA	100%	None
BN-16-20	1.E-07	Chloroform	NA	100%	None
BN-17-10	6.E-10	Methylene chloride	NA	100%	None
BN-17-20	4.E-08	Chloroform, PCE	7.E-09	83%	Chloroform, PCE
BN-18-10	3.E-07	Chloroform	8.E-08	73%	Chloroform
BN-18-20	1.E-07	Chloroform	3.E-09	97%	TCE
GP-1-19	2.E-08	PCE, benzene TCE	3.E-09	85%	Benzene
GP-2-20	1.0E-06[B]	Benzene	2.E-09	100%	Benzene
GP-2-20D	9.E-07	Benzene			
GP-5-20	2.E-07	Benzene	7.E-09	97%	Chloroform, benzene
GP-5-20D	2.E-07	Benzene			
GP-6-20	2.E-07	Benzene	4.E-09	98%	Benzene
GP-7-20			9.E-09		Chloroform, benzene
GP-10-10	NA	None	3.E-09		Benzene
GP-11-10			NA		None
GP-12-10	6.E-08	Methylene chloride	NA	100%	None
GP-12-10D	8.E-08	Chloroform, methylene chloride	NA	100%	None

Blank means no data ECR = Excess cancer risk COPC = Chemical of Potential Concern
RME = Reasonable maximum exposure

[A] Highest ECR is shallower soil gas samples during the same sampling period

[B] Highest ECR in deeper soil gas samples during the same sampling period

PCE = Tetrachloroethene, TCE = Trichloroethene, EDB = ethylene dibromide

Table 11
Comparison of 2006 Maximum Modeled Indoor Air Concentrations with Indoor Air Background Levels in the Literature
Broadway North Landfill, Tucson, Arizona

Chemical	Molecular Weight	Site 2006 Maximum (1)		LBNL, 2003 - Existing residences (2)				USEPA, 2005 (BASE) (3)			LBNL, 2003 - Existing Off. Buildings (4)			
		Soil Gas	J&E Indoor Air	95th or Max	Mean	95th or Max	Mean	Frequency	95th	Mean	Maximum	Central T.	Maximum	Central T.
		ppmv	µg/m^3	ppbv	ppbv	µg/m^3	µg/m^3	Detection	µg/m^3	µg/m^3	ppbv	ppbv	µg/m^3	µg/m^3
Acetone	58.1	0.0018	5.24E-03					100%	110	42				
Benzene	78.1	0.00089	3.09E-03	4	1.5	13.0	4.9	100%	9.1	4.2	3.8	1	12.4	3.3
Benzyl chloride	126.6	0.00028	1.48E-03											
Carbon disulfide	76.1	0.0013	4.68E-03					67%	6.4	2	5.8		18.4	
Chlorobenzene	112.6	0.19[A]	8.80E-01	0.11		0.5		13%	0.26	0.18	0.15		0.7	
Chloroform	119.4	0.005	2.82E-02	1.2	0.37	6.0	1.8	29%	1.3	0.59	2		10.0	
Methyl chloride (chloromethane)	50.5	0.00085	2.16E-03					100%	4.3	2.9				
Cyclohexane	84.2	0.00068	2.50E-03		0.18		0.6							
Dibromoethane (1,2-) (ethylene dibromide)	187.9	0.0005[A]	1.91E-03					1.2%	ND	1.1				
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)	170.9	0.029	2.14E-01					0%	ND	ND				
Dichlorobenzene (1,4-)	147.0	0.0018	1.06E-02	0.57	1.3	3.5	8.0[C]	77%	13	2.8	7	0.03	42.9	0.2
Dichlorodifluoromethane (Freon 12)	120.9	0.024	1.15E-01					97%	36	33				
Dichloroethane (1,1-)	99.0	0.00072[A]	2.95E-03					0%	ND	ND				
Dichloroethene (1,1-)	96.9	0.00088[A]	3.83E-03					0%	ND	ND				
Dichloroethene (c-1,2-)	96.9	0.33[A]	1.32E+00											
Methylene chloride (dichloromethane)	84.9	0.0015	5.96E-03	4.6	6.4	16.3	22.6[C]	81%	16	21[C]	65	0.4	229.9	1.4
Dichloropropane (1,2-)	113.0	0.0035	1.68E-02											
Dichloropropene (1,3-) (for t-1,3-dichloropropene)	111.0	0.00021	8.95E-04					0%	ND	ND				
Ethanol	46.1	0.063	1.40E-01					100%	260	89	130	19	249.5	36.5
Ethylbenzene	106.2	0.0021	9.28E-03	11[B]	1.4	48.7	6.2	100%	6.2	2.4	2.6	0.48	11.5	2.1
Ethyltoluene (4-)	120.2	0.0012	5.84E+00		0.55		2.8	96%	4.1	1.3	2.2		11.0	
Heptane	100.2	0.0063	2.48E-02		0.26		1.1				0.72	0.4	3.0	1.7
Hexane	86.2	0.00088	4.31E-03		0.28		1.0	98%	12	3.9	3.1	0.62	11.1	2.2
Methyl ethyl ketone (2-butanone)	72.1	0.033	1.02E-01					99%	7.8	3.3	6.1		18.3	
Naphthalene	128.2	0.0012	5.74E-03	0.95	0.35	5.1	1.9	90%	2.6	0.95	1.9		10.1	
Propanol (2-)	60.1	0.44	1.21E+00					100%	320	73	62	2.3	155.3	5.8
Styrene	104.2	0.00024	1.02E-03	0.56	0.35	2.4	1.5	99%	3	1.3	1.2	0.4	5.2	1.7
Tetrachloroethene	165.8	0.0096	6.51E-02	1	0.41	6.9	2.8	100%	18	3.8	3.8	0.47	26.3	3.2
Toluene	92.1	0.0019	7.75E-03	47[B]	6.7	180.4	25.7	100%	39	16	40	2.1	153.5	8.1
Trichloroethane (1,1,1-)	133.4	0.00088	4.97E-03	3.2	2.4	17.8	13.3	100%	21	11	77	1.6	428.0	8.9
Trichloroethene	131.4	0.0014	7.83E-03	0.26	0.23	1.4	1.3	66%	2.6	0.76	4.8	1.8	26.3	9.9
Trichlorofluoromethane (Freon 11)	137.4	0.011	6.69E-02					73%	51	19	13	0.75	74.4	4.3
Trimethylbenzene (1,2,4-)	120.2	0.0021	9.54E-03		2.4		12.0	100%	12	3.3	2.9	0.88	14.5	4.4
Trimethylbenzene (1,3,5-)	120.2	0.00043	1.95E-03	6.5[B]	0.42	32.6	2.1	93%	3.9	1	1.1	0.29	5.5	1.5
Vinyl chloride (chloroethene)	62.5	0.014[A]	3.01E-02	0.13[B]	0.01	0.3	0.026	1.2%	ND	0.78[C]				
Xylene (o-)	106.2	0.00076	3.57E-03	1.6	1.1	7.1	4.9	100%	8.2	3.1	3.5	0.66	15.5	2.9
Xylene (m- & p-)	106.2	0.002	8.58E-03	5	2.9	22.1	12.8	100%	24	8.4	10	1.4	44.3	6.2

Color Code

A	Chemical not detected in 2006, so maximum 2002 data were used.
B	GM Max was used
C	Mean is higher than 95th, possibly highly skewed data.

1. Maximum 2006 (or 2002 - in yellow color) soil gas data were used in the J&E model at a conservative depth of 5 feet bgs.
2. LBNL, 2003. Data on existing residences based on 12 studies from 1992 to 2002.
3. USEPA. 2005. Time-integrated air sampling for VOCs was collected in all 100 study (public or commercial) office buildings (1994-1998).
4. LBNL, 2003. Data on existing office buildings based on 3 studies from 1994 to 1999.

Table 12
Potential Health Risks Associated with Indoor Air Background Levels in the Literature
Broadway North Landfill, Tucson, Arizona

Chemical	LBNL, 2003 - Existing residences (1)					
	95th or Max (2)			Mean		
	µg/m^3	ECR	HQ	µg/m^3	ECR	HQ
Acetone						
Benzene	13.0	1.7E-05	4.2E-01	4.9	6.3E-06	1.6E-01
Benzyl chloride						
Carbon disulfide						
Chlorobenzene						
Chloroform	6.0	2.3E-05	1.2E-01	1.8	7.0E-06	3.6E-02
Methyl chloride (chloromethane)						
Cyclohexane				0.6	NA	1.0E-04
Dibromoethane (1,2-) (ethylene dibromide)						
Dichloro-1,1,2,2-tetrafluoroethane (1,2-) (Freon 114)						
Dichlorobenzene (1,4-)	3.5	NA	4.2E-03	8.0[A]	NA	9.5E-03
Dichlorodifluoromethane (Freon 12)						
Dichloroethane (1,1-)						
Dichloroethene (1,1-)						
Dichloroethene (c-1,2-)						
Methylene chloride (dichloromethane)	16.3	1.3E-06	5.2E-03	22.6[A]	1.7E-06	7.2E-03
Dichloropropane (1,2-)						
Dichloropropene (1,3-) (for t-1,3-dichloropropene)						
Ethanol						
Ethylbenzene	48.7[B]	NA	4.7E-02	6.2	NA	5.9E-03
Ethyltoluene (4-)				2.8	NA	6.6E-03
Heptane				1.1	NA	3.9E-05
Hexane				1.0	NA	1.4E-03
Methyl ethyl ketone (2-butanone)						
Naphthalene	5.1	NA	1.6E+00	1.9	NA	6.0E-01
Propanol (2-)						
Styrene	2.4	NA	2.3E-03	1.5	NA	1.5E-03
Tetrachloroethene	6.9	6.7E-06	1.9E-01	2.8	2.7E-06	7.8E-02
Toluene	180.4[B]	NA	3.5E-02	25.7	NA	4.9E-03
Trichloroethane (1,1,1-)	17.8	NA	3.4E-03	13.3	NA	2.6E-03
Trichloroethene	1.4	4.7E-07	3.9E-02	1.3	4.1E-07	3.5E-02
Trichlorofluoromethane (Freon 11)						
Trimethylbenzene (1,2,4-)				12.0	NA	1.9E+00
Trimethylbenzene (1,3,5-)	32.6[B]	NA	5.2E+00	2.1	NA	3.4E-01
Vinyl chloride (chloroethene)	0.3[B]	4.9E-07	3.2E-03	0.026	3.8E-08	2.5E-04
Xylene (o-)	7.1	NA	6.8E-02	4.9	NA	4.7E-02
Xylene (m- & p-)	22.1	NA	2.1E-01	12.8	NA	1.2E-01
TOTAL		**5.E-05**	**8.0E+00**		**2.E-05**	**3.4E+00**

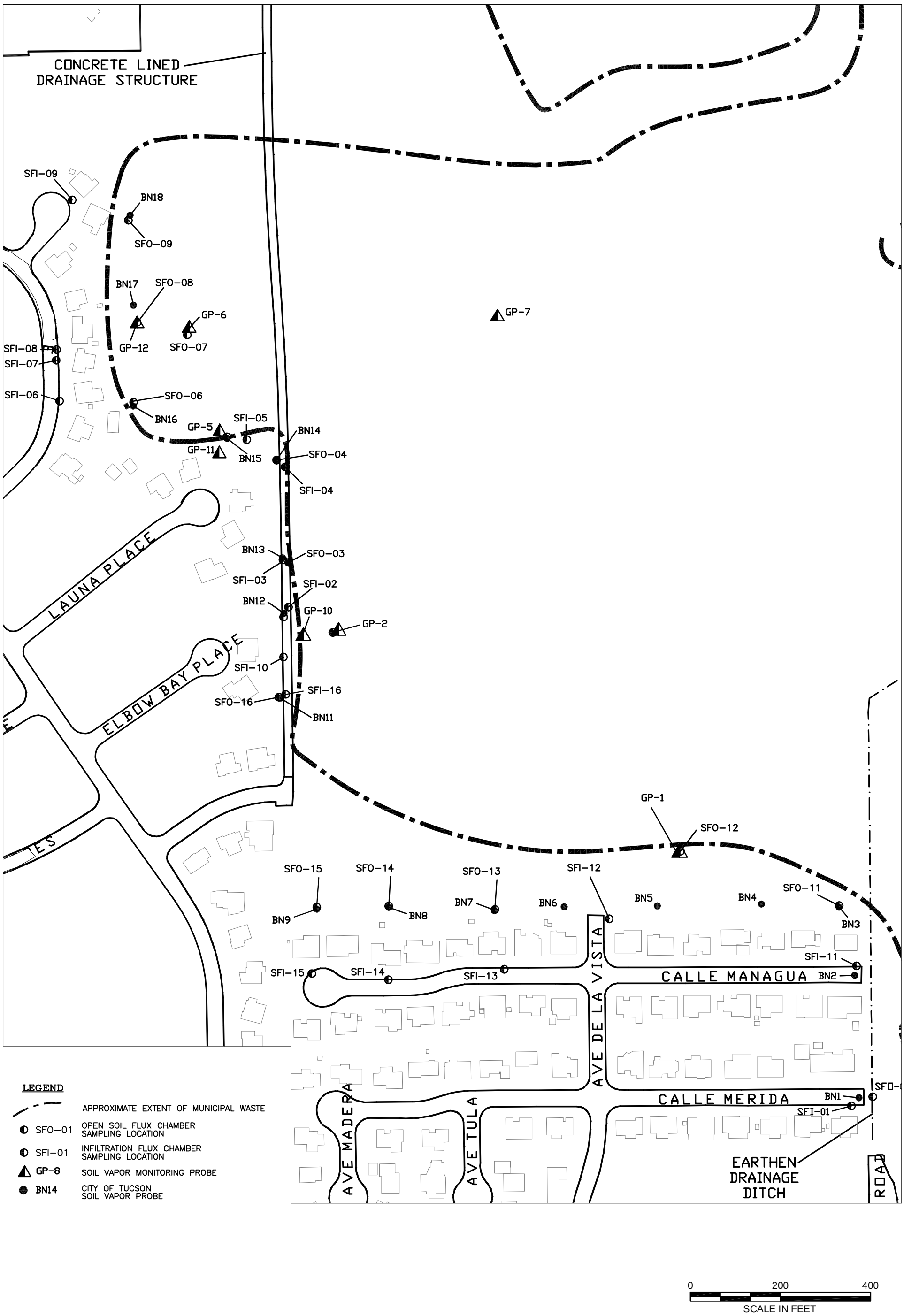
Color Code

A	Mean is higher than 95th, possibly highly skewed data.
B	GM Max was used

1. LBNL, 2003. Data on existing residences based on 12 studies from 1992 to 2002.
2. LBNL (2003) did not report the 95th percentile or max for 5 chemicals: cyclohexane, 4-ethyltoluene, heptane, hexane, and 1,2,4-trimethylbenzene.

FIGURES
Human Health Risk Assessment

Broadway North Landfill
Broadway-Pantano Water Quality Assurance Revolving Fund Site
Stantec Job Number 185902026



LEGEND

- APPROXIMATE EXTENT OF MUNICIPAL WASTE
- SFO-01 — OPEN SOIL FLUX CHAMBER SAMPLING LOCATION
- SFI-01 — INFILTRATION FLUX CHAMBER SAMPLING LOCATION
- GP-8 — SOIL VAPOR MONITORING PROBE
- BN14 — CITY OF TUCSON SOIL VAPOR PROBE

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FOR:
BROADWAY - PANTANO
WQARF SITE
LANDFILL OPERABLE UNIT

TUCSON, ARIZONA

SHALLOW SOIL GAS
SAMPLING LOCATIONS
2002, 2003, AND 2006

FIGURE: 1

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
185902026	CG	TK	TAK	7/2/2010

APPENDIX A
PHYSICAL/CHEMICAL AND TOXICITY PARAMETERS FOR ADDITIONAL COPCs NOT INCLUED IN THE ADVANCED J&E SOIL GAS MODEL

Human Health Risk Assessment

Broadway North Landfill
Broadway-Pantano Water Quality Assurance Revolving Fund Site
Stantec Job Number 185902026

APPENDIX A

PHYSICAL/CHEMICAL PROPERTIES OF ADDITIONAL COPCs NOT INCLUDED IN THE ADVANCED J&E SOIL GAS MODEL

Physical/Chemical Properties of Additional COPCs

Since several COPCs were not included in the VLOOKUP sheet (see Appendix B) of the Advanced J&E Model (including cyclohexane; trans-1,3-dichloropropene; ethanol; 4-ethyltoluene; Freon 114; n-heptane; and 2-propanol), relevant physical and chemical parameters for these COPCs were searched or estimated to be entered into the VLOOKUP sheet of the Advanced J&E Model. Physical/chemical parameters for trans-1,3-dichloropropene were assumed to be equal to that of 1,3-dichloropropene.

- CAS No.: Values from the PhysProp Database (Syracuse Research Corporation [SRC], 2010).

- Organic Carbon Partition Coefficient (K_{oc}): Values are from the Hazardous Substances Data Bank (HSDB) (National Library of Medicine, 2010). For 4-ethyltoluene, value of isopropylbenzene from Table 3 of the TPH Criteria Working Group (TPHCWG) Volume III (Selection of Representative TPH Fractions Based on Fate and Transport Considerations) were used (TPHCWG, 1997).

- Diffusivity in Air (D_a): Values for cyclohexane, 4-ethyltoluene (use isopropylbenzene) and heptane were taken from TPHCWG, 1997. For other COPCs, they were estimated using Equation 2-5 of USEPA, 1988b, based on isobutanol (as presented in the USEPA J&E model [USEPA, 2004a] for ethanol and 2-propanol; and based on Freon 113 for Freon 114.

$$D_i = D'\left(\frac{MW'}{MW_i}\right)^{1/2} \qquad \text{(Eq. 1)}$$

  Where:

  D_i = Diffusivity in air of the unknown COPC estimated from the known chemical, in cm^2/sec;

  MW_i = Molecular weight of the unknown COPC (SRC, 2010);

  MW' = Molecular weight of the known chemical (USEPA, 2004a);

  D' = Diffusivity in air of the known chemical, in cm^2/sec (USEPA, 2004a).

- Diffusivity in Water (D_w): Using the same equation above, with D values to be D_w (USEPA, 2004a).

- Pure Component Water Solubility: Values are from the PhysProp Database (SRC, 2010).

- Henry's Law Constant H' (unitless): Values are from the PhysProp Database (SRC, 2010) at 25°C converted to unitless by multiplying by a factor of 41.

- Critical Temperature (T_C): Values are from National Institute of Standard and Technology (NIST) (NIST, 2010).

- Normal Boiling Point (T_B): Values are from the PhysProp Database (SRC, 2010).

- Enthalpy of Vaporization at the Normal Boiling Point ($\Delta H_{v,b}$): Values are from NIST (2010).

Proposed Toxicity Values for Additional COPCs

Cyclohexane: RfC for cyclohexane (6 mg/m^3) is taken from IRIS (USEPA, 2010).

n-Heptane: n-Heptane was reported to be about 38 times less toxic than n-hexane (TPHCWG, 1997). Therefore, the RfC for n-heptane could be 7.6 mg/m^3.

Trans-1,3-Dichloropropene: Toxicity values for trans-1,3-dichloropropene (CAS No. 10061-02-6) are assumed to be equal to those of URF and RfC for 1,3-dichloropropene (CAS No. 542-75-6) (USEPA, 2010).

Ethanol: Ethanol is formed by the fermentation of carbohydrates by various microorganisms. It is also produced synthetically from various petrochemical feedstocks, especially ethylene. The most quantitatively important source of human exposure to ethanol is consumption of alcoholic beverages. Due to the ubiquitous occurrence of microorganisms capable of ethanolic fermentation, virtually all sugar-containing foodstuffs are liable to contain a low level of ethanol. Ethanol is also a minor product of general metabolism in plants and animals, so a certain amount of endogenous exposure occurs even in the absence of external exposure (Lawrence Livermore National Laboratory [LLNL], 1999; Cal-EPA, 2000).

There is an enormous literature on the health effects of ethanol in alcoholic beverages. Elsewhere in the open literature (NLM, 2010), one can find literally hundreds of experiments in ethanol which laboratory animals were repeatedly dosed with large amounts of ethanol, usually to explore toxic endpoints recognized from the human experience, such as liver damage, central nervous system toxicity, and alcoholism, or other endpoints of interest such as hematologic or immunologic change.

At high vapor concentrations, ethanol is irritating to the eyes and the respiratory system. In humans, vapor concentrations above 40,000 mg/m^3 (20,000 ppm) were considered intolerable. Similar concentrations caused sensory irritation in mice, evidenced by reduction in the breathing rate. Lester and Greenberg (1951) reported transient symptoms of respiratory and eye irritation in volunteers exposed to 10,000-20,000 mg/m^3 (5,300 – 10,600 ppm) of ethanol vapor. Large

oral or inhaled doses of ethanol cause narcosis, ataxia, and incoordination. These effects are observed in animals after exposure to 4,000 – 10,000 ppm for 8 hours.
Adverse effects on the liver have been noted in both animals and humans chronically exposed to ethanol. Symptoms initially include fatty infiltration and inflammation, and may progress to focal necrosis and/or fibrosis. Chronic oral doses to animals initiating these effects were typically 8,000 to 15,000 mg/kg-day (rats, dogs). In humans these symptoms are well known, and are characterized as alcoholic hepatitis and cirrhosis. They are typically seen in abusers of alcoholic beverages. However, it is known that concurrent exposure to some other chemicals (such as carbon tetrachloride), and infection with hepatitis B virus, increase sensitivity to the liver damaging effects of ethanol. In chronic abusers of alcoholic beverages, neurological and behavioral changes typical of peripheral and central nervous system damage are known. Some of the chronic neurological changes in alcohol abusers may be a result of altered patterns of nutrition.

Ethanol has not been clearly shown to be carcinogenic in laboratory animals, but acts as a promoter or co-carcinogen in animals concurrently exposed to other (carcinogenic) chemicals. For instance, long-term exposure to ethanol in drinking water promotes liver tumors in rats exposed to N-nitrosodiethylamine. Heavy consumption of alcoholic beverages is known to be associated with increased incidences of some cancers, including those of the oral cavity (especially with concurrent exposure to other carcinogens, e.g., in smokers) and of the liver (in subjects with evidence of advanced alcohol-related liver disease). Ethanol is not genotoxic in most test systems, although a few equivocal or positive results have been reported, particularly in certain tests examining effects on chromosomes.

Ethanol (specifically, alcohol abuse) was recognized as a human teratogen well before experimental studies in animals were undertaken (Cambridge Environmental Inc., 2001). Fetal alcohol syndrome (FAS) (which includes retardation of growth and development, certain characteristic physical malformations, and also behavioral and cognitive problems) has been extensively studied. For example, a search of the MEDLINE database for studies in English on fetal alcohol syndrome elicits more than 1,500 bibliographic citations. Hundreds of studies using laboratory animals have explored the physical, neurologic, and neurobehavioral abnormalities caused by in *utero* exposure to ethanol, using in vivo and in vitro models and acute and chronic exposures.

Currently, there are no health assessment values being used by USEPA for estimating potential health impacts from ethanol exposure through air or drinking water. Therefore, Cal-EPA Office of Environmental Health and Hazard Assessment (OEHHA) calculated draft health protective concentrations (HPC) for ethanol as follows. For inhalation exposures, Lester and Greenberg (1951) reported inhalation exposures of volunteers to ethanol vapor, and reported transient (sensory) irritation effects, with a lowest-observed-adverse-effect-level (LOAEL) of 5,300 ppm (10,000 mg/m^3). It is unclear from the experimental account whether a NOAEL for irritant effects was established. The reported LOAEL is consistent with other human studies cited by ACGIH (1991). Although other chronic effects result at much higher exposure levels, the short-term

LOAEL for irritation is expected to be protective from these chronic effects also. As such, Cal-EPA OEHHA proposed the draft HPC to be:

$$HPC = \frac{LOAEL}{UF} = \frac{10{,}000 mg/m^3}{100} = 100 mg/m^3 \qquad \text{(Eq. 2)}$$

The Uncertainty Factor (UF) used is 100, consisting of an intraspecies factor of 10H (reflecting the fact that the study population was selected to consist of healthy adult volunteers), and a LOAEL to NOAEL extrapolation factor of 10L. Other factors are not required since the experimental level is determined in humans, and duration adjustments are not appropriate for the transient sensory response. Since this effect appears from the data to be concentration dependent and does not represent a cumulative damage process, adjustment for duration of exposure is not appropriate (Cal-EPA, 2010).

For the purpose of this HHRA, the RfC for ethanol was proposed to be equal to the HPC of 100 mg/m^3. This level is considered protective since Rydberg and Skerfving (1977) have proposed an acceptable daily intake (ADI) for ethanol to be 7,000 mg per day (mg/day), based on the toxic range of ethanol consumption of 35,000 to 200,000 mg/day. Using an adult body weight of 70 kg, the oral RfD can be estimated at 100 mg/kg-day. This RfD is converted into an inhalation RfC of 350 mg/m^3 based on route-to-route extrapolation and using an adult body weight of 70 kg and an adult inhalation rate of 20 m^3/day.

<u>4-Ethyltoluene</u>: RfC for 4-ethyltoluene (C_9H_{12}) is assumed to be equivalent to that of isopropylbenzene (C_9H_{12}) or cumene (CAS No. 98-82-8).

<u>Freon 114</u>: Freon 114 and other chlrorofluorocarbons are not known to occur naturally in the environment. They are known to be readily absorbed after in halation but regardless of the route of entry, they are eliminated almost exclusively through the respiratory tract via exhaled air (International Programme on Chemical Safety [IPCS], 1990). Short-term inhalation studies on Freon 114 and other chlrorofluorocarbons showed low toxicity, and the effects observed were related mainly to the central nervous system (CNS), respiratory tract, and the liver (NLM, 2010). Oral toxicity studies have also confirmed low toxicity. Rabbits and rats exposed to Freon 114 for up to 9 months at 10,000 ppmv showed no evidence of any tumorigenic response (NLM, 2010).

Using the Leuschner et al. (1983) study, in which 40 rats were exposed to Freon 114 at 71,000 mg/m^3 (or 10,000 ppmv) for 6 hours/day for 90 days with no adverse effects, the no-observed-adverse-effect-level (NOAEL) of 71,000 mg/m^3 was set. Chronic inhalation RfC for Freon 114 can be calculated as follows.

Dose adjustment for discontinuous exposure protocols (USEPA, 1989b): The adjusted NOAEL ($NOAEL_{ADJ}$) is estimated at 17,750 mg/m^3 using the equation below:

$$NOAEL_{ADJ} = NOAEL \times \frac{6hr}{24hr} \qquad \text{(Eq. 3)}$$

Dose adjustment for extrarespiratory effects (USEPA, 1989b): For gases and vapors that exhibit their toxic effects outside the respiratory tract, an approach for the scenario when the arterial concentration (leaving the lung) of the gas in the animal was periodic (or could be expected to be) with respect to time. As such, the NOAEL human equivalent concentration ($NOAEL_{HEC}$) can be calculated assuming periodicity was attained, using the equation below (USEPA, 1989b):

$$NOAEL_{HEC} = NOAEL_{ADJ} \times \frac{\lambda_A}{\lambda_B} \qquad \text{(Eq. 4)}$$

Where:

λ_A / λ_H = The ratio of the blood to air partition coefficient of the chemical for the animal species to the human value, used only if $\lambda_A \leq \lambda_H$. For situation in which $\lambda_A > \lambda_H$ or in which λ values are unknown, $\lambda_A / \lambda_H = 1$ is recommended.

For Freon 114, $\lambda_A / \lambda_H = 1$ is used since these values are unknown. Using Eq. 5 in which $NOAEL_{HEC}$ is 17,750 mg/m^3 and using an UF of 1,000 (10H for interspecies extrapolation, 10A for intraspecies extrapolation, and 10L for extrapolation from a subchronic study to a chronic study) and an MF of 1, the chronic RfC for Freon 114 is proposed to be 17.75 mg/m^3.

$$\text{RfC} = \frac{\text{NOAEL}_{\text{HEC}}}{\text{UF} \times \text{MF}} \qquad \text{(Eq. 5)}$$

For Freon 114, a time-weighted average (TWA) threshold limit value (TLV) of 6,990 mg/m^3 (or 1,000 ppmv) is recommended for occupational exposure. This recommendation should minimize the potential for reduction of ventilatory lung capacity, arrhythmia/cardiac sensitization, and at extremely high concentrations (>200,000 ppmv), narcosis and asphysia. This TLV of 6,990 mg/m^3 can be converted to a chronic RfC of 16.6 mg/m^3 using the following dose adjustment from healthy workers to the general residential populations:

$$NOAEL_{ADJ} = NOAEL \times \frac{8hr}{24hr} \times \frac{5days}{7days} \times \frac{1}{10H} \times \frac{1}{10L} \qquad \text{(Eq. 6)}$$

Since a chronic RfC of 16.6 mg/m^3 is less than the value 17.75 mg/m^3 derived in Equation 5, 16.6 mg/m^3 was proposed to be chronic RfD for Freon 114 in this HHRA.

<u>2-Propanol</u>: The main entry of 2-propanol into the environment is through its emission into the atmosphere during production, processing, storage, transport, use, and disposal. 2-Propanol is readily biodegradable, both aerobically and anaerobically. The acute toxicity of 2-propanol for mammals, based on mortality is low, whether exposure is via the oral, dermal, or inhalation route (NLM, 2008). It has been reported that 2-propanol depresses the CNS about twice as much as ethanol. A group of male volunteers, when exposed to 2-propanol vapor at concentrations of 490,

980, or 1,970 mg/m^3 for 3-5 minutes, judged irritation to be "mild" at 980 mg/m^3 and to be "satisfactory" for their own 8-hour occupational exposure (NLM, 2010).

Using the approach similar to Cal-EPA OEHHA's on ethanol, a chronic RfC for 2-propanol is proposed to be:

$$RfC = \frac{LOAEL}{UF} = \frac{980 mg/m^3}{100} = 9.8 mg/m^3 \qquad \text{(Eq. 7)}$$

The UF used is 100, consisting of an intraspecies factor of 10H (reflecting the fact that the study population was selected to consist of healthy adult volunteers), and a LOAEL to NOAEL extrapolation factor of 10L. Other factors are not required since the experimental level is determined in humans, and duration adjustments are not appropriate for the transient sensory response. Since this effect appears from the data to be concentration dependent and does not represent a cumulative damage process, adjustment for duration of exposure is not appropriate (Cal-EPA, 2001).

Additional References

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APPENDIX B
ADVANCED J&E SOIL GAS MODEL RUN SPREADSHEETS
Human Health Risk Assessment

Broadway North Landfill

Broadway-Pantano Water Quality Assurance Revolving Fund Site

Stantec Job Number 185902026

Table B-1: DATAENTER Sheet for BN-13-20 (2006 Data), Reasonable Maximum Exposure Residential Scenario

SG-ADV
Version 3.1; 02/04

Reset to Defaults

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
67641			0.0017	Acetone
71432				Benzene
100447			0.00028	Benzylchloride
75150				Carbon disulfide
108907				Chlorobenzene
67663			0.005	Chloroform
74873				Methyl chloride (chloromethane)
110827				Cyclohexane
106934				1,2-Dibromoethane (ethylene dibromide)
76142			0.029	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)
106467			0.00028	1,4-Dichlorobenzene
75718			0.024	Dichlorodifluoromethane (Freon 12)
75343				1,1-Dichloroethane
75354				1,1-Dichloroethylene
156592				cis-1,2-Dichloroethylene
75092				Methylene chloride (dichloromethane)
78875			0.0035	1,2-Dichloropropane
10061026				1,3-Dichloropropene (for t-1,3-dichloropropene)
64175			0.0026	Ethanol
100414				Ethylbenzene
622968			0.00066	4-Ethyltoluene
142825				Heptane
110543				Hexane
78933			0.0035	Methylethylketone (2-butanone)
91203				Naphthalene
71238				Propanol (2-)
100425				Styrene
127184			0.004	Tetrachloroethylene
108883			0.00085	Toluene
71556				1,1,1-Trichloroethane
79016				Trichloroethylene
75694			0.011	Trichlorofluoromethane (Freon 11)
95636			0.00091	1,2,4-Trimethylbenzene
108678				1,3,5-Trimethylbenzene
75014				Vinyl chloride (chloroethene)
95476			0.00028	o-Xylene
108383			0.00076	m-Xylene

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 (°C)	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)
15.2	609.6	22.2	609.6	0	0	LS		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	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 Parameters)	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 Parameters)	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)
LS	1.62	0.39	0.076	SI	1.43	0.459	0.215	C	1.43	0.459	0.215

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)
10	40	1181	1181	243.8	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	30	30	350

END

INTERMEDIATE CALCULATIONS SHEET

Table B-2: INTERCALS Sheet for BN-13-20 (2006 Data), Reasonable Maximum Exposure Residential Scenario

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	4.07E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.46E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	2.46E+01	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	2.05E+02	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.70E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.20E+02	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.63E+01	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	4.94E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	3.27E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.04E+01	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	2.74E+01	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	3.23E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	6.24E+01	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	4.51E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.23E+00	4.72E+04
9.46E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	3.33E+00	4.72E+04

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. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.47E+06	3.22E-04	15.2	7,407	3.44E-05	1.42E-03	1.79E-04	1.72E-02	0.00E+00	0.00E+00	1.72E-02	594.4
1.47E+06	3.22E-04	15.2	7,996	4.87E-03	2.01E-01	1.79E-04	1.22E-02	0.00E+00	0.00E+00	1.22E-02	594.4

1.47E+06	3.22E-04	15.2	10,624	3.49E-04	1.44E-02	1.79E-04	1.04E-02	0.00E+00	0.00E+00	1.04E-02	594.4
1.47E+06	3.22E-04	15.2	6,586	2.72E-02	1.12E+00	1.79E-04	1.44E-02	0.00E+00	0.00E+00	1.44E-02	594.4
1.47E+06	3.22E-04	15.2	9,679	3.16E-03	1.30E-01	1.79E-04	1.01E-02	0.00E+00	0.00E+00	1.01E-02	594.4
1.47E+06	3.22E-04	15.2	7,427	3.25E-03	1.34E-01	1.79E-04	1.44E-02	0.00E+00	0.00E+00	1.44E-02	594.4
1.47E+06	3.22E-04	15.2	4,600	8.17E-03	3.37E-01	1.79E-04	1.75E-02	0.00E+00	0.00E+00	1.75E-02	594.4
1.47E+06	3.22E-04	15.2	7,846	1.32E-01	5.46E+00	1.79E-04	1.17E-02	0.00E+00	0.00E+00	1.17E-02	594.4
1.47E+06	3.22E-04	15.2	10,048	6.31E-04	2.60E-02	1.79E-04	3.01E-03	0.00E+00	0.00E+00	3.01E-03	594.4
1.47E+06	3.22E-04	15.2	5,315	2.57E+00	1.06E+02	1.79E-04	1.13E-02	0.00E+00	0.00E+00	1.13E-02	594.4
1.47E+06	3.22E-04	15.2	11,117	2.00E-03	8.27E-02	1.79E-04	9.58E-03	0.00E+00	0.00E+00	9.58E-03	594.4
1.47E+06	3.22E-04	15.2	8,018	3.01E-01	1.24E+01	1.79E-04	9.24E-03	0.00E+00	0.00E+00	9.24E-03	594.4
1.47E+06	3.22E-04	15.2	7,315	4.99E-03	2.06E-01	1.79E-04	1.03E-02	0.00E+00	0.00E+00	1.03E-02	594.4
1.47E+06	3.22E-04	15.2	6,311	2.35E-02	9.71E-01	1.79E-04	1.25E-02	0.00E+00	0.00E+00	1.25E-02	594.4
1.47E+06	3.22E-04	15.2	7,610	3.60E-03	1.49E-01	1.79E-04	1.02E-02	0.00E+00	0.00E+00	1.02E-02	594.4
1.47E+06	3.22E-04	15.2	6,903	1.96E-03	8.07E-02	1.79E-04	1.40E-02	0.00E+00	0.00E+00	1.40E-02	594.4
1.47E+06	3.22E-04	15.2	8,498	2.44E-03	1.01E-01	1.79E-04	1.09E-02	0.00E+00	0.00E+00	1.09E-02	594.4
1.47E+06	3.22E-04	15.2	8,967	1.53E-02	6.31E-01	1.79E-04	8.69E-03	0.00E+00	0.00E+00	8.69E-03	594.4
1.47E+06	3.22E-04	15.2	10,338	4.24E-06	1.75E-04	1.79E-04	1.52E-02	0.00E+00	0.00E+00	1.52E-02	594.4
1.47E+06	3.22E-04	15.2	10,015	6.70E-03	2.76E-01	1.79E-04	1.04E-02	0.00E+00	0.00E+00	1.04E-02	594.4
1.47E+06	3.22E-04	15.2	13,568	4.02E-03	1.66E-01	1.79E-04	5.27E+04	0.00E+00	0.00E+00	5.27E+04	594.4
1.47E+06	3.22E-04	15.2	8,792	1.74E+00	7.17E+01	1.79E-04	9.15E-03	0.00E+00	0.00E+00	9.15E-03	594.4
1.47E+06	3.22E-04	15.2	7,574	1.47E+00	6.08E+01	1.79E-04	2.78E-02	0.00E+00	0.00E+00	2.78E-02	594.4
1.47E+06	3.22E-04	15.2	8,267	4.89E-05	2.02E-03	1.79E-04	1.12E-02	0.00E+00	0.00E+00	1.12E-02	594.4
1.47E+06	3.22E-04	15.2	12,786	3.93E-04	1.62E-02	1.79E-04	8.19E-03	0.00E+00	0.00E+00	8.19E-03	594.4
1.47E+06	3.22E-04	15.2	12,547	6.45E-06	2.66E-04	1.79E-04	1.33E-02	0.00E+00	0.00E+00	1.33E-02	594.4
1.47E+06	3.22E-04	15.2	10,315	2.33E-03	9.60E-02	1.79E-04	9.86E-03	0.00E+00	0.00E+00	9.86E-03	594.4
1.47E+06	3.22E-04	15.2	9,429	1.58E-02	6.51E-01	1.79E-04	1.00E-02	0.00E+00	0.00E+00	1.00E-02	594.4
1.47E+06	3.22E-04	15.2	9,021	5.73E-03	2.37E-01	1.79E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	594.4
1.47E+06	3.22E-04	15.2	7,752	1.52E-02	6.25E-01	1.79E-04	1.08E-02	0.00E+00	0.00E+00	1.08E-02	594.4
1.47E+06	3.22E-04	15.2	8,405	8.98E-03	3.71E-01	1.79E-04	1.10E-02	0.00E+00	0.00E+00	1.10E-02	594.4
1.47E+06	3.22E-04	15.2	6,015	8.79E-02	3.63E+00	1.79E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	594.4
1.47E+06	3.22E-04	15.2	11,539	5.11E-03	2.11E-01	1.79E-04	8.42E-03	0.00E+00	0.00E+00	8.42E-03	594.4
1.47E+06	3.22E-04	15.2	11,519	4.88E-03	2.01E-01	1.79E-04	8.36E-03	0.00E+00	0.00E+00	8.36E-03	594.4
1.47E+06	3.22E-04	15.2	4,861	2.49E-02	1.03E+00	1.79E-04	1.47E-02	0.00E+00	0.00E+00	1.47E-02	594.4
1.47E+06	3.22E-04	15.2	10,266	4.39E-03	1.81E-01	1.79E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	594.4
1.47E+06	3.22E-04	15.2	10,112	6.23E-03	2.57E-01	1.79E-04	9.72E-03	0.00E+00	0.00E+00	9.72E-03	594.4

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)
15.2	4.07E+00	0.10	8.33E+01	1.72E-02	4.72E+02	2.89E+44	5.96E-04	2.43E-03	NA	3.2E+00
15.2	0.00E+00	0.10	8.33E+01	1.22E-02	4.72E+02	4.84E+62	4.69E-04	0.00E+00	7.8E-06	3.0E-02
15.2	1.46E+00	0.10	8.33E+01	1.04E-02	4.72E+02	3.51E+73	4.16E-04	6.08E-04	4.9E-05	1.0E-02
15.2	0.00E+00	0.10	8.33E+01	1.44E-02	4.72E+02	1.10E+53	5.29E-04	0.00E+00	NA	7.0E-01
15.2	0.00E+00	0.10	8.33E+01	1.01E-02	4.72E+02	3.67E+75	4.07E-04	0.00E+00	NA	5.0E-02
15.2	2.46E+01	0.10	8.33E+01	1.44E-02	4.72E+02	1.10E+53	5.29E-04	1.30E-02	2.3E-05	4.9E-02
15.2	0.00E+00	0.10	8.33E+01	1.75E-02	4.72E+02	6.03E+43	6.02E-04	0.00E+00	NA	9.0E-02
15.2	0.00E+00	0.10	8.33E+01	1.17E-02	4.72E+02	5.60E+65	4.53E-04	0.00E+00	NA	6.0E+00
15.2	0.00E+00	0.10	8.33E+01	3.01E-03	4.72E+02	1.44E+254	1.45E-04	0.00E+00	6.0E-04	9.0E-03
15.2	2.05E+02	0.10	8.33E+01	1.13E-02	4.72E+02	3.50E+67	4.44E-04	9.07E-02	NA	1.7E+01
15.2	1.70E+00	0.10	8.33E+01	9.58E-03	4.72E+02	8.81E+79	3.90E-04	6.62E-04	NA	8.0E-01
15.2	1.20E+02	0.10	8.33E+01	9.24E-03	4.72E+02	8.95E+82	3.79E-04	4.54E-02	NA	2.0E-01
15.2	0.00E+00	0.10	8.33E+01	1.03E-02	4.72E+02	2.20E+74	4.13E-04	0.00E+00	NA	4.9E-01
15.2	0.00E+00	0.10	8.33E+01	1.25E-02	4.72E+02	1.96E+61	4.77E-04	0.00E+00	NA	2.0E-01
15.2	0.00E+00	0.10	8.33E+01	1.02E-02	4.72E+02	8.89E+74	4.10E-04	0.00E+00	NA	3.5E-02

15.2	0.00E+00	0.10	8.33E+01	1.40E-02	4.72E+02	4.13E+54	5.18E-04	0.00E+00	4.7E-07	3.0E+00
15.2	1.63E+01	0.10	8.33E+01	1.09E-02	4.72E+02	3.47E+70	4.29E-04	7.01E-03	1.9E-05	4.0E-03
15.2	0.00E+00	0.10	8.33E+01	8.69E-03	4.72E+02	1.32E+88	3.61E-04	0.00E+00	4.0E-06	2.0E-02
15.2	4.94E+00	0.10	8.33E+01	1.52E-02	4.72E+02	1.84E+50	5.49E-04	2.71E-03	NA	1.0E+02
15.2	0.00E+00	0.10	8.33E+01	1.04E-02	4.72E+02	3.55E+73	4.16E-04	0.00E+00	NA	1.0E+00
15.2	3.27E+00	0.10	8.33E+01	5.27E+04	4.72E+02	1.00E+00	9.81E-01	3.21E+00	NA	4.0E-01
15.2	0.00E+00	0.10	8.33E+01	9.15E-03	4.72E+02	5.09E+83	3.76E-04	0.00E+00	NA	2.7E+01
15.2	0.00E+00	0.10	8.33E+01	2.78E-02	4.72E+02	3.81E+27	7.96E-04	0.00E+00	NA	7.0E-01
15.2	1.04E+01	0.10	8.33E+01	1.12E-02	4.72E+02	1.72E+68	4.40E-04	4.58E-03	NA	5.0E+00
15.2	0.00E+00	0.10	8.33E+01	8.19E-03	4.72E+02	3.09E+93	3.45E-04	0.00E+00	NA	3.0E-03
15.2	0.00E+00	0.10	8.33E+01	1.33E-02	4.72E+02	3.62E+57	4.99E-04	0.00E+00	NA	9.8E+00
15.2	0.00E+00	0.10	8.33E+01	9.86E-03	4.72E+02	4.94E+77	3.99E-04	0.00E+00	NA	1.0E+00
15.2	2.74E+01	0.10	8.33E+01	1.00E-02	4.72E+02	4.12E+76	4.03E-04	1.10E-02	5.9E-06	3.5E-02
15.2	3.23E+00	0.10	8.33E+01	1.21E-02	4.72E+02	2.54E+63	4.65E-04	1.50E-03	NA	5.0E+00
15.2	0.00E+00	0.10	8.33E+01	1.08E-02	4.72E+02	5.27E+70	4.28E-04	0.00E+00	NA	5.0E+00
15.2	0.00E+00	0.10	8.33E+01	1.10E-02	4.72E+02	6.70E+69	4.33E-04	0.00E+00	2.0E-06	3.5E-02
15.2	6.24E+01	0.10	8.33E+01	1.21E-02	4.72E+02	2.54E+63	4.65E-04	2.90E-02	NA	7.0E-01
15.2	4.51E+00	0.10	8.33E+01	8.42E-03	4.72E+02	1.06E+91	3.52E-04	1.59E-03	NA	6.0E-03
15.2	0.00E+00	0.10	8.33E+01	8.36E-03	4.72E+02	4.29E+91	3.50E-04	0.00E+00	NA	6.0E-03
15.2	0.00E+00	0.10	8.33E+01	1.47E-02	4.72E+02	1.10E+52	5.36E-04	0.00E+00	8.8E-06	1.0E-01
15.2	1.23E+00	0.10	8.33E+01	1.21E-02	4.72E+02	2.54E+63	4.65E-04	5.70E-04	NA	1.0E-01
15.2	3.33E+00	0.10	8.33E+01	9.72E-03	4.72E+02	6.36E+78	3.94E-04	1.31E-03	NA	1.0E-01

END

RESULTS SHEET

Table B-3: RESULTS Sheet for BN-13-20 (2006 Data), Reasonable Maximum Exposure Residential Scenario
INCREMENTAL RISK CALCULATIONS:

	Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
	NA	7.4E-07	Acetone
	0.0E+00	0.0E+00	Benzene
	1.2E-08	5.8E-05	Benzylchloride
	NA	0.0E+00	Carbon disulfide
	NA	0.0E+00	Chlorobenzene
	1.2E-07	2.5E-04	Chloroform
	NA	0.0E+00	Methyl chloride (chloromethane)
	NA	0.0E+00	Cyclohexane
	0.0E+00	0.0E+00	1,2-Dibromoethane (ethylene dibromide)
	NA	5.2E-06	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)
	NA	7.9E-07	1,4-Dichlorobenzene
	NA	2.2E-04	Dichlorodifluoromethane (Freon 12)
	NA	0.0E+00	1,1-Dichloroethane
	NA	0.0E+00	1,1-Dichloroethylene
	NA	0.0E+00	cis-1,2-Dichloroethylene
	0.0E+00	0.0E+00	Methylene chloride (dichloromethane)
	5.6E-08	1.7E-03	1,2-Dichloropropane
	0.0E+00	0.0E+00	1,3-Dichloropropene (for t-1,3-dichloropropene)
	NA	2.6E-08	Ethanol
	NA	0.0E+00	Ethylbenzene
	NA	7.7E-03	4-Ethyltoluene
	NA	0.0E+00	Heptane
	NA	0.0E+00	Hexane
	NA	8.8E-07	Methylethylketone (2-butanone)
	NA	0.0E+00	Naphthalene
	NA	0.0E+00	Propanol (2-)
	NA	0.0E+00	Styrene
	2.7E-08	3.0E-04	Tetrachloroethylene
	NA	2.9E-07	Toluene
	NA	0.0E+00	1,1,1-Trichloroethane
	0.0E+00	0.0E+00	Trichloroethylene
	NA	4.0E-05	Trichlorofluoromethane (Freon 11)
	NA	2.6E-04	1,2,4-Trimethylbenzene
	NA	0.0E+00	1,3,5-Trimethylbenzene
	0.0E+00	0.0E+00	Vinyl chloride (chloroethene)
	NA	5.5E-06	o-Xylene
	NA	1.3E-05	m-Xylene
Total	2.2E-07	1.1E-02	

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

MESSAGE: Risk/HQ or risk-based soil concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

Table B-4: RESULTS Sheet for BN-13-20 (2006 Data), Central Tendency Exposure Residential Scenario

SG-ADV
Version 3.1; 02/04

Reset to Defaults

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
67641			0.0017	Acetone
71432				Benzene
100447			0.00028	Benzylchloride
75150				Carbon disulfide
108907				Chlorobenzene
67663			0.005	Chloroform
74873				Methyl chloride (chloromethane)
110827				Cyclohexane
106934				1,2-Dibromoethane (ethylene dibromide)
76142			0.029	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)
106467			0.00028	1,4-Dichlorobenzene
75718			0.024	Dichlorodifluoromethane (Freon 12)
75343				1,1-Dichloroethane
75354				1,1-Dichloroethylene
156592				cis-1,2-Dichloroethylene
75092				Methylene chloride (dichloromethane)
78875			0.0035	1,2-Dichloropropane
10061026				1,3-Dichloropropene (for t-1,3-dichloropropene)
64175			0.0026	Ethanol
100414				Ethylbenzene
622968			0.00066	4-Ethyltoluene
142825				Heptane
110543				Hexane
78933			0.0035	Methylethylketone (2-butanone)
91203				Naphthalene
71238				Propanol (2-)
100425				Styrene
127184			0.004	Tetrachloroethylene
108883			0.00085	Toluene
71556				1,1,1-Trichloroethane
79016				Trichloroethylene
75694			0.011	Trichlorofluoromethane (Freon 11)
95636			0.00091	1,2,4-Trimethylbenzene
108678				1,3,5-Trimethylbenzene
75014				Vinyl chloride (chloroethene)
95476			0.00028	o-Xylene
108383			0.00076	m-Xylene

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 (°C)	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)
15.2	609.6	22.2	609.6	0	0	LS		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	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 Parameters)	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 Parameters)	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)
LS	1.62	0.39	0.076	SI	1.43	0.459	0.215	C	1.43	0.459	0.215

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)
10	40	1181	1181	243.8	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	12	12	350

END

INTERMEDIATE CALCULATIONS SHEET

Table B-5: RESULTS Sheet for BN-13-20 (2006 Data), Central Tendency Exposure Residential Scenario

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	4.07E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.46E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	2.46E+01	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	2.05E+02	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.70E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.20E+02	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.63E+01	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	4.94E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	3.27E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.04E+01	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	2.74E+01	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	3.23E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	6.24E+01	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	4.51E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	0.00E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	1.23E+00	4.72E+04
3.78E+08	594.4	0.314	0.244	0.244	0.079	1.66E-08	0.957	1.59E-08	4,724	3.33E+00	4.72E+04

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. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.47E+06	3.22E-04	15.2	7,407	3.44E-05	1.42E-03	1.79E-04	1.72E-02	0.00E+00	0.00E+00	1.72E-02	594.4
1.47E+06	3.22E-04	15.2	7,996	4.87E-03	2.01E-01	1.79E-04	1.22E-02	0.00E+00	0.00E+00	1.22E-02	594.4

1.47E+06	3.22E-04	15.2	10,624	3.49E-04	1.44E-02	1.79E-04	1.04E-02	0.00E+00	0.00E+00	1.04E-02	594.4
1.47E+06	3.22E-04	15.2	6,586	2.72E-02	1.12E+00	1.79E-04	1.44E-02	0.00E+00	0.00E+00	1.44E-02	594.4
1.47E+06	3.22E-04	15.2	9,679	3.16E-03	1.30E-01	1.79E-04	1.01E-02	0.00E+00	0.00E+00	1.01E-02	594.4
1.47E+06	3.22E-04	15.2	7,427	3.25E-03	1.34E-01	1.79E-04	1.44E-02	0.00E+00	0.00E+00	1.44E-02	594.4
1.47E+06	3.22E-04	15.2	4,600	8.17E-03	3.37E-01	1.79E-04	1.75E-02	0.00E+00	0.00E+00	1.75E-02	594.4
1.47E+06	3.22E-04	15.2	7,846	1.32E-01	5.46E+00	1.79E-04	1.17E-02	0.00E+00	0.00E+00	1.17E-02	594.4
1.47E+06	3.22E-04	15.2	10,048	6.31E-04	2.60E-02	1.79E-04	3.01E-03	0.00E+00	0.00E+00	3.01E-03	594.4
1.47E+06	3.22E-04	15.2	5,315	2.57E+00	1.06E+02	1.79E-04	1.13E-02	0.00E+00	0.00E+00	1.13E-02	594.4
1.47E+06	3.22E-04	15.2	11,117	2.00E-03	8.27E-02	1.79E-04	9.58E-03	0.00E+00	0.00E+00	9.58E-03	594.4
1.47E+06	3.22E-04	15.2	8,018	3.01E-01	1.24E+01	1.79E-04	9.24E-03	0.00E+00	0.00E+00	9.24E-03	594.4
1.47E+06	3.22E-04	15.2	7,315	4.99E-03	2.06E-01	1.79E-04	1.03E-02	0.00E+00	0.00E+00	1.03E-02	594.4
1.47E+06	3.22E-04	15.2	6,311	2.35E-02	9.71E-01	1.79E-04	1.25E-02	0.00E+00	0.00E+00	1.25E-02	594.4
1.47E+06	3.22E-04	15.2	7,610	3.60E-03	1.49E-01	1.79E-04	1.02E-02	0.00E+00	0.00E+00	1.02E-02	594.4
1.47E+06	3.22E-04	15.2	6,903	1.96E-03	8.07E-02	1.79E-04	1.40E-02	0.00E+00	0.00E+00	1.40E-02	594.4
1.47E+06	3.22E-04	15.2	8,498	2.44E-03	1.01E-01	1.79E-04	1.09E-02	0.00E+00	0.00E+00	1.09E-02	594.4
1.47E+06	3.22E-04	15.2	8,967	1.53E-02	6.31E-01	1.79E-04	8.69E-03	0.00E+00	0.00E+00	8.69E-03	594.4
1.47E+06	3.22E-04	15.2	10,338	4.24E-06	1.75E-04	1.79E-04	1.52E-02	0.00E+00	0.00E+00	1.52E-02	594.4
1.47E+06	3.22E-04	15.2	10,015	6.70E-03	2.76E-01	1.79E-04	1.04E-02	0.00E+00	0.00E+00	1.04E-02	594.4
1.47E+06	3.22E-04	15.2	13,568	4.02E-03	1.66E-01	1.79E-04	5.27E+04	0.00E+00	0.00E+00	5.27E+04	594.4
1.47E+06	3.22E-04	15.2	8,792	1.74E+00	7.17E+01	1.79E-04	9.15E-03	0.00E+00	0.00E+00	9.15E-03	594.4
1.47E+06	3.22E-04	15.2	7,574	1.47E+00	6.08E+01	1.79E-04	2.78E-02	0.00E+00	0.00E+00	2.78E-02	594.4
1.47E+06	3.22E-04	15.2	8,267	4.89E-05	2.02E-03	1.79E-04	1.12E-02	0.00E+00	0.00E+00	1.12E-02	594.4
1.47E+06	3.22E-04	15.2	12,786	3.93E-04	1.62E-02	1.79E-04	8.19E-03	0.00E+00	0.00E+00	8.19E-03	594.4
1.47E+06	3.22E-04	15.2	12,547	6.45E-06	2.66E-04	1.79E-04	1.33E-02	0.00E+00	0.00E+00	1.33E-02	594.4
1.47E+06	3.22E-04	15.2	10,315	2.33E-03	9.60E-02	1.79E-04	9.86E-03	0.00E+00	0.00E+00	9.86E-03	594.4
1.47E+06	3.22E-04	15.2	9,429	1.58E-02	6.51E-01	1.79E-04	1.00E-02	0.00E+00	0.00E+00	1.00E-02	594.4
1.47E+06	3.22E-04	15.2	9,021	5.73E-03	2.37E-01	1.79E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	594.4
1.47E+06	3.22E-04	15.2	7,752	1.52E-02	6.25E-01	1.79E-04	1.08E-02	0.00E+00	0.00E+00	1.08E-02	594.4
1.47E+06	3.22E-04	15.2	8,405	8.98E-03	3.71E-01	1.79E-04	1.10E-02	0.00E+00	0.00E+00	1.10E-02	594.4
1.47E+06	3.22E-04	15.2	6,015	8.79E-02	3.63E+00	1.79E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	594.4
1.47E+06	3.22E-04	15.2	11,539	5.11E-03	2.11E-01	1.79E-04	8.42E-03	0.00E+00	0.00E+00	8.42E-03	594.4
1.47E+06	3.22E-04	15.2	11,519	4.88E-03	2.01E-01	1.79E-04	8.36E-03	0.00E+00	0.00E+00	8.36E-03	594.4
1.47E+06	3.22E-04	15.2	4,861	2.49E-02	1.03E+00	1.79E-04	1.47E-02	0.00E+00	0.00E+00	1.47E-02	594.4
1.47E+06	3.22E-04	15.2	10,266	4.39E-03	1.81E-01	1.79E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	594.4
1.47E+06	3.22E-04	15.2	10,112	6.23E-03	2.57E-01	1.79E-04	9.72E-03	0.00E+00	0.00E+00	9.72E-03	594.4

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)
15.2	4.07E+00	0.10	8.33E+01	1.72E-02	4.72E+02	2.89E+44	5.96E-04	2.43E-03	NA	3.2E+00
15.2	0.00E+00	0.10	8.33E+01	1.22E-02	4.72E+02	4.84E+62	4.69E-04	0.00E+00	7.8E-06	3.0E-02
15.2	1.46E+00	0.10	8.33E+01	1.04E-02	4.72E+02	3.51E+73	4.16E-04	6.08E-04	4.9E-05	1.0E-02
15.2	0.00E+00	0.10	8.33E+01	1.44E-02	4.72E+02	1.10E+53	5.29E-04	0.00E+00	NA	7.0E-01
15.2	0.00E+00	0.10	8.33E+01	1.01E-02	4.72E+02	3.67E+75	4.07E-04	0.00E+00	NA	5.0E-02
15.2	2.46E+01	0.10	8.33E+01	1.44E-02	4.72E+02	1.10E+53	5.29E-04	1.30E-02	2.3E-05	4.9E-02
15.2	0.00E+00	0.10	8.33E+01	1.75E-02	4.72E+02	6.03E+43	6.02E-04	0.00E+00	NA	9.0E-02
15.2	0.00E+00	0.10	8.33E+01	1.17E-02	4.72E+02	5.60E+65	4.53E-04	0.00E+00	NA	6.0E+00
15.2	0.00E+00	0.10	8.33E+01	3.01E-03	4.72E+02	1.44E+254	1.45E-04	0.00E+00	6.0E-04	9.0E-03
15.2	2.05E+02	0.10	8.33E+01	1.13E-02	4.72E+02	3.50E+67	4.44E-04	9.07E-02	NA	1.7E+01
15.2	1.70E+00	0.10	8.33E+01	9.58E-03	4.72E+02	8.81E+79	3.90E-04	6.62E-04	NA	8.0E-01
15.2	1.20E+02	0.10	8.33E+01	9.24E-03	4.72E+02	8.95E+82	3.79E-04	4.54E-02	NA	2.0E-01
15.2	0.00E+00	0.10	8.33E+01	1.03E-02	4.72E+02	2.20E+74	4.13E-04	0.00E+00	NA	4.9E-01
15.2	0.00E+00	0.10	8.33E+01	1.25E-02	4.72E+02	1.96E+61	4.77E-04	0.00E+00	NA	2.0E-01
15.2	0.00E+00	0.10	8.33E+01	1.02E-02	4.72E+02	8.89E+74	4.10E-04	0.00E+00	NA	3.5E-02

15.2	0.00E+00	0.10	8.33E+01	1.40E-02	4.72E+02	4.13E+54	5.18E-04	0.00E+00	4.7E-07	3.0E+00
15.2	1.63E+01	0.10	8.33E+01	1.09E-02	4.72E+02	3.47E+70	4.29E-04	7.01E-03	1.9E-05	4.0E-03
15.2	0.00E+00	0.10	8.33E+01	8.69E-03	4.72E+02	1.32E+88	3.61E-04	0.00E+00	4.0E-06	2.0E-02
15.2	4.94E+00	0.10	8.33E+01	1.52E-02	4.72E+02	1.84E+50	5.49E-04	2.71E-03	NA	1.0E+02
15.2	0.00E+00	0.10	8.33E+01	1.04E-02	4.72E+02	3.55E+73	4.16E-04	0.00E+00	NA	1.0E+00
15.2	3.27E+00	0.10	8.33E+01	5.27E+04	4.72E+02	1.00E+00	9.81E-01	3.21E+00	NA	4.0E-01
15.2	0.00E+00	0.10	8.33E+01	9.15E-03	4.72E+02	5.09E+83	3.76E-04	0.00E+00	NA	2.7E+01
15.2	0.00E+00	0.10	8.33E+01	2.78E-02	4.72E+02	3.81E+27	7.96E-04	0.00E+00	NA	7.0E-01
15.2	1.04E+01	0.10	8.33E+01	1.12E-02	4.72E+02	1.72E+68	4.40E-04	4.58E-03	NA	5.0E+00
15.2	0.00E+00	0.10	8.33E+01	8.19E-03	4.72E+02	3.09E+93	3.45E-04	0.00E+00	NA	3.0E-03
15.2	0.00E+00	0.10	8.33E+01	1.33E-02	4.72E+02	3.62E+57	4.99E-04	0.00E+00	NA	9.8E+00
15.2	0.00E+00	0.10	8.33E+01	9.86E-03	4.72E+02	4.94E+77	3.99E-04	0.00E+00	NA	1.0E+00
15.2	2.74E+01	0.10	8.33E+01	1.00E-02	4.72E+02	4.12E+76	4.03E-04	1.10E-02	5.9E-06	3.5E-02
15.2	3.23E+00	0.10	8.33E+01	1.21E-02	4.72E+02	2.54E+63	4.65E-04	1.50E-03	NA	5.0E+00
15.2	0.00E+00	0.10	8.33E+01	1.08E-02	4.72E+02	5.27E+70	4.28E-04	0.00E+00	NA	5.0E+00
15.2	0.00E+00	0.10	8.33E+01	1.10E-02	4.72E+02	6.70E+69	4.33E-04	0.00E+00	2.0E-06	3.5E-02
15.2	6.24E+01	0.10	8.33E+01	1.21E-02	4.72E+02	2.54E+63	4.65E-04	2.90E-02	NA	7.0E-01
15.2	4.51E+00	0.10	8.33E+01	8.42E-03	4.72E+02	1.06E+91	3.52E-04	1.59E-03	NA	6.0E-03
15.2	0.00E+00	0.10	8.33E+01	8.36E-03	4.72E+02	4.29E+91	3.50E-04	0.00E+00	NA	6.0E-03
15.2	0.00E+00	0.10	8.33E+01	1.47E-02	4.72E+02	1.10E+52	5.36E-04	0.00E+00	8.8E-06	1.0E-01
15.2	1.23E+00	0.10	8.33E+01	1.21E-02	4.72E+02	2.54E+63	4.65E-04	5.70E-04	NA	1.0E-01
15.2	3.33E+00	0.10	8.33E+01	9.72E-03	4.72E+02	6.36E+78	3.94E-04	1.31E-03	NA	1.0E-01

END

RESULTS SHEET

Table B-6: RESULTS Sheet for BN-13-20 (2006 Data), Central Tendency Exposure Residential Scenario

INCREMENTAL RISK CALCULATIONS:

	Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)	COPC
	NA	7.4E-07	Acetone
	0.0E+00	0.0E+00	Benzene
	4.9E-09	5.8E-05	Benzylchloride
	NA	0.0E+00	Carbon disulfide
	NA	0.0E+00	Chlorobenzene
	4.9E-08	2.5E-04	Chloroform
	NA	0.0E+00	Methyl chloride (chloromethane)
	NA	0.0E+00	Cyclohexane
	0.0E+00	0.0E+00	1,2-Dibromoethane (ethylene dibromide)
	NA	5.2E-06	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)
	NA	7.9E-07	1,4-Dichlorobenzene
	NA	2.2E-04	Dichlorodifluoromethane (Freon 12)
	NA	0.0E+00	1,1-Dichloroethane
	NA	0.0E+00	1,1-Dichloroethylene
	NA	0.0E+00	cis-1,2-Dichloroethylene
	0.0E+00	0.0E+00	Methylene chloride (dichloromethane)
	2.2E-08	1.7E-03	1,2-Dichloropropane
	0.0E+00	0.0E+00	1,3-Dichloropropene (for t-1,3-dichloropropene)
	NA	2.6E-08	Ethanol
	NA	0.0E+00	Ethylbenzene
	NA	7.7E-03	4-Ethyltoluene
	NA	0.0E+00	Heptane
	NA	0.0E+00	Hexane
	NA	8.8E-07	Methylethylketone (2-butanone)
	NA	0.0E+00	Naphthalene
	NA	0.0E+00	Propanol (2-)
	NA	0.0E+00	Styrene
	1.1E-08	3.0E-04	Tetrachloroethylene
	NA	2.9E-07	Toluene
	NA	0.0E+00	1,1,1-Trichloroethane
	0.0E+00	0.0E+00	Trichloroethylene
	NA	4.0E-05	Trichlorofluoromethane (Freon 11)
	NA	2.6E-04	1,2,4-Trimethylbenzene
	NA	0.0E+00	1,3,5-Trimethylbenzene
	0.0E+00	0.0E+00	Vinyl chloride (chloroethene)
	NA	5.5E-06	o-Xylene
	NA	1.3E-05	m-Xylene
Total	8.7E-08	1.1E-02	

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

MESSAGE: Risk/HQ or risk-based soil concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END