FINAL SUBSURFACE VAPOR INTRUSION METHODOLOGY LETTER REPORT FOR PROPOSED ACTIVE SOIL GAS SAMPLING AT INSTALLATION RESTORATION SITE 17 AND BUILDING 503 AREA, MARE ISLAND NAVAL SHIPYARD, VALLEJO, CALIFORNIA
OCTOBER 10, 2008

1.0 INTRODUCTION

The vapor intrusion (VI) risk evaluation in the final remedial investigation (RI) is incomplete for Mare Island Naval Shipyard (Mare Island) Installation Restoration Site 17 (IR17) and Building 503 Area. Initially, the Navy and regulatory agencies agreed to re-evaluate subsurface VI risks after the remedial actions proposed in the draft final remedial action plan/record of decision (RAP/ROD) had been implemented. Subsequently, the Navy and agencies agreed to re-evaluate VI risks before the RAP/ROD was finalized to avoid amending a final RAP/ROD and to provide additional information for a removal action and risk-based support for institutional controls, if necessary.

The Department of the Navy (Navy) collected additional data at IR17 and Building 503 Area to determine current site conditions; verify the presence, location, and extent of free product at the site; and complete the VI risk evaluation. This additional sampling was conducted in two phases: Phase 1, passive soil gas (PSG) survey (July 16 to 31, 2008); and Phase 2, additional soil, groundwater, and active soil gas (ASG) sampling (September 29 to October 10, 2008). The results of the Phase 1 PSG survey were qualitative and helped focus the subsequent Phase 2 soil, groundwater, and active soil gas sampling activities. For purposes of completing the VI risk evaluation, only the results of the ASG samples collected during Phase 2 will be used. This letter report discusses the proposed approach for the VI risk evaluation to facilitate agreement by the Base Realignment and Closure Cleanup Team (BCT) and approval of the VI risk evaluation methodology. The proposed methodology for the VI risk evaluation is consistent U.S. Environmental Protection Agency (EPA 2002), California Environmental Protection Agency's (Cal/EPA) Department of Toxic Substances Control (DTSC) (DTSC 2005a), Navy (2008), and U.S. Air Force, U.S. Navy, and U.S. Army (2008) guidance for VI evaluations. Specific details for how the ASG samples were collected were set forth in the sampling and analysis plan/quality assurance project plan (SAP/QAPP) (ChaduxTt 2008).

Based on previous investigations, site characterization, and the Phase 1 PSG survey, ASG samples were analyzed for a full suite of polycyclic aromatic hydrocarbons (PAH) and volatile organic compounds (VOC) (including 1,4-dioxane).

2.0 PROPOSED APPROACH FOR ACTIVE SOIL GAS SAMPLING AND ANALYSIS

The Navy collected ASG samples using individually certified 1-liter Summa canisters for analysis using EPA Methods TO-15 and 8260B for VOCs and 1,4-dioxane. Sorbent tubes were also used to collect samples for analysis of PAHs using EPA Method TO-17. The Navy

submitted samples to a Navy-approved fixed laboratory for analysis. Soil borings completed in support of ASG sample collection were advanced using direct-push technology. Specific ASG sampling details were described in the SAP/QAPP for Phase 2 field activities (ChaduxTt 2008).

Sample collection occurred on the edge of the rainy season from September 29 to October 10, 2008. The depth to groundwater in the area was expected to be shallow and was typically observed between 5 to 6 feet below ground surface (bgs). ASG samples were collected from the vadose zone, immediately above the capillary fringe.

Planned future land use for the IR17 and Building 503 Area is primarily commercial/industrial, with open space/recreational near the wetland. Therefore, the VI risk evaluation will evaluate a future industrial exposure scenario. In addition, a hypothetical future residential exposure scenario will also be evaluated. According to the City of Vallejo, the development plan for the IR17 and Building 503 Area consists of commercial parking structures, surface parking lots, and open space. It is estimated that the risk will be negligible under the current development scenario because no enclosed structures, such as office buildings, are planned. In general, ASG samples will be collected on a grid at 100-foot intervals in areas where the results of the PSG survey indicated potential VI impacts (DTSC 2005a).

The Navy also collected quality control samples such as field duplicates, ambient air blanks, and equipment blanks during the ASG sampling. The SAP/QAPP presents specific information associated with the planned quality control samples and data validation (ChaduxTt 2008).

3.0 EVALUATION OF ACTIVE SOIL GAS RESULTS

Per DTSC (2005a), the Johnson and Ettinger VI model for soil gas (DTSC 2003) will be the basis for the estimate of indoor air concentrations. Slab-on-grade construction will be assumed, and site-specific soil properties will be used where possible. Each ASG sample location will be considered a separate exposure point, with locations based on the results of the PSG survey. The VI risk calculated for each of the approximately 40 exposure points will be used to make risk management decisions, as needed, to address potential VI exposures for the 100-foot by 100-foot area surrounding each point. All detected chemicals at a specific exposure point will be included as chemicals of potential concern (COPCs) for that exposure point and will be quantitatively evaluated for risk. Nondetected chemicals will be discussed in the uncertainty analysis. No exposure point concentration (EPC) or statistical calculations will be performed for the VI risk evaluation since the ASG results for each location will be used as the EPC in the VI model for that exposure point.

Total petroleum hydrocarbon (TPH) compounds (such as TPH as diesel or gasoline) will not be selected as a COPC, as current DTSC guidelines specifically exclude evaluations of TPH. Rather, data for specific TPH indicator chemicals (for example, benzene, toluene, ethylbenzene, and toluene [BTEX] and naphthalene) will be used to assess potential human health risk from TPH contamination. Non-chemical-specific data for TPH will be excluded from evaluation in the risk assessment because they are considered inadequate and insufficient to evaluate risk from TPH contamination.

In the event that soil gas sampling fails because of the low permeability of soils at the site, risks will be estimated using groundwater and bulk soil data collected during the Phase 2 sampling event rather than soil gas data. The correlation between groundwater, bulk soil, and soil gas results also will be evaluated. This additional evaluation will help characterize risk and potential uncertainty.

Two sets of risks will be calculated, consistent with the dual tracking methodology previously used in the human health risk assessment for IR17 and Building 503 Area (SulTech 2006). The first set of risks will be calculated using the standard 2003 EPA Office of Solid Waste and Emergency Response (OSWER) toxicity value hierarchy, as shown below (EPA 2003):

- EPA's Integrated Risk Information System (IRIS) (EPA 2008).
- EPA's provisional peer-reviewed toxicity values (PPRTV) (EPA 2004).
- Other EPA and non-EPA sources of toxicity information, including, but not limited to:
  - Cal/EPA's Office of Environmental Health Hazard Assessment (OEHHA) online database contains approved toxicity criteria (OEHHA 2008).
  - EPA's Health Effects Assessment Summary Tables (HEAST) (EPA 1997).
  - EPA's National Center for Environmental Assessment (NCEA) papers (chemical-specific references).
- For noncancer effects from inhalation route exposures, OEHHA chronic reference exposure levels (REL) (OEHHA 2005).

The second set of risks will be calculated using a similar toxicity factor hierarchy, whereby the Cal/EPA toxicity values take precedence, as shown below:

- Cal/EPA's OEHHA online database.
  - Carcinogenic toxicity criteria: OEHHA online database.
  - Noncarcinogenic toxicity criteria:
    - EPA's IRIS reference concentration (RfC) or inhalation reference dose (RfD) will be used if EPA's IRIS RfD was based on an inhalation study (and is not extrapolated from an oral study).
    - OEHHA REL will be used if EPA's IRIS inhalation RfD was extrapolated from an oral study.
    - OEHHA REL will be used if EPA's IRIS RfC or inhalation RfD are unavailable.

- Alternative source will be used if EPA's IRIS RfC or inhalation RfD or OEHHA REL are unavailable:
  - EPA's IRIS inhalation RfD (oral to inhalation route-extrapolated value).
  - EPA's PPRTV database.
  - EPA's HEAST.
- EPA's IRIS online database.
- EPA's PPRTV database.

The DTSC 2003 Advanced Vapor Intrusion Model (DTSC 2003) will be used to estimate indoor air concentrations from concentrations of volatile COPCs in the soil gas. For each ASG sample location, concentrations of all detected volatile chemicals will be modeled using the DTSC VI model to estimate indoor air concentrations. The advanced version is based on Johnson and Ettinger (1991) and presents more rigorous estimates by using site-specific input parameters. Certain default values will also be adjusted to make the model consistent with current DTSC (2005a) recommendations. The model is constructed to estimate either a steady-state solution to vapor transport (infinite or nondiminishing source) or as a quasi-steady-state solution (finite or diminishing source). As a conservative approach, it will be assumed that the contaminant source is infinite (with respect to the modeling time of interest) for soil gas. Input parameters proposed for the VI modeling are discussed in Table 1.

TABLE 1: INPUT PARAMETERS FOR ADVANCED JOHNSON AND ETTINGER VAPOR MODEL FOR SOIL GAS
Subsurface Vapor Intrusion Methodology, IR17 and Building 503 Area, Mare Island Naval Shipyard, Vallejo, California

Parameter	Value [a]	Units	Basis
Soil Properties			
Depth below grade to bottom of enclosed space floor	15	cm	DTSC 2005a default for a building with no basement.
Soil gas sampling depth, below grade	Site-specific	cm	Site-specific
Average soil temperature	24	Celsius	DTSC 2005a default
Thickness of soil stratum A	Site-specific	cm	Site-specific
Stratum A soil type	Sandy Clay Loam	unitless	The most predominant or average value found across the site.
Vadose zone soil dry bulk density	Site-specific	g/cm^3	The Navy will submit bulk soil samples to a laboratory for analysis.
Vadose zone soil total porosity	Site-specific	unitless	The Navy will submit bulk soil samples to a laboratory for analysis.
Vadose zone soil water-filled porosity	Site-specific	cm^3/cm^3	The Navy will submit bulk soil samples to a laboratory for analysis.
Hypothetical Future Residence			
Enclosed space floor thickness	10	cm	The building foundation slab thickness for a residence was based on the EPA (2002) default value of 10 cm (approximately 4 inches).
Soil-building pressure differential	40	$g/cm\text{-}s^2$	DTSC 2005a and EPA 2002 defaults
Enclosed space floor length	1,000	cm	Default typical or mean value established in EPA 2002 for residential structures (see values in Appendix G - Table G-3 of EPA 2002).
Enclosed space floor width	1,000	cm	Default typical or mean value established in EPA 2002 for residential structures (see values in Appendix G - Table G-3 of EPA 2002).
Enclosed space height	244	cm	Default typical or mean value established in EPA 2002 for residential structures (see values in Appendix G - Table G-3 of EPA 2002).
Floor wall seam crack width	0.1	cm	EPA 2002 default
Indoor air exchange rate	0.5	1/h	DTSC 2005a default
Average vapor flow rate into building	5	L/min	DTSC 2005a and EPA 2002 default

TABLE 1: INPUT PARAMETERS FOR ADVANCED JOHNSON AND ETTINGER VAPOR MODEL FOR SOIL GAS (CONTINUED)
Subsurface Vapor Intrusion Methodology, IR17 and Building 503 Area, Mare Island Naval Shipyard, Vallejo, California

Parameter	Value [a]	Units	Basis
Hypothetical Future Industrial Building			
Enclosed space floor thickness	10	cm	The building foundation thickness for a commercial/industrial building was based on the EPA (2002) default value of 10 cm (approximately 4 inches).
Soil-building pressure differential	40	$g/cm\text{-}s^2$	DTSC 2005a and EPA 2002 defaults
Enclosed space floor length	1,414	cm	Default value from upper range of values for a residential structure (EPA 2002).
Enclosed space floor width	1,414	cm	Default value from upper range of values for a residential structure (EPA 2002).
Enclosed space height	305	cm	Default value from upper range of values for a residential structure (EPA 2002).
Floor wall seam crack width	0.1	cm	EPA 2002 default
Indoor air exchange rate	1	1/h	DTSC 2005a default
Average vapor flow rate into building	10	L/min	DTSC 2005a

Notes:

a Where possible, site-specific soil and hydrogeologic data will be used for the vapor intrusion evaluation. The Navy collected three soil samples during Phase 2 for geotechnical evaluation of soil porosity, total organic carbon, bulk density, and particle size to facilitate use of site-specific properties.

cm Centimeter
cm^2 Square centimeter
cm^3 Cubic centimeter
DTSC Department of Toxic Substances Control
EPA U.S. Environmental Protection Agency
g Gram
h Hour
L Liter
min Minute
s^2 Square second

References:

DTSC. 2005a. "Guidance for the Evaluation and Migration of Subsurface Vapor Intrusion to Indoor Air." Interim Final. California Environmental Protection Agency. February 7. On-line address: <http://www.dtsc.ca.gov/AssessingRisk/upload/HERD_POL_Eval_Subsurface_Vapor_Intrusion_interim_final.pdf>

EPA. 2002. "Office of Solid Waste and Emergency Response [OSWER] Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)." November. On-line address: <http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf>

4.0 RISK EVALUATION

Future industrial and future hypothetical residential (adult and child) exposure scenarios will be evaluated. The method used to evaluate the risk from inhalation of indoor air is based on the risk assessment framework developed by EPA and DTSC, as documented in "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)" (EPA 1989) and "Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities" (DTSC 1992). The EPA-derived exposure algorithm will be used to estimate the chemical intakes for the inhalation pathway. The equation used for calculating chemical intake is as follows:

$$I = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

where

I	=	Intake (mg/kg-day)
C	=	Modeled indoor air concentration (mg/m^3)
IR	=	Inhalation rate (m^3/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kilograms)
AT	=	Averaging time (days)

The exposure parameter values used in the intake equation above are based on the following factors for the resident (adult and child) and commercial/industrial worker:

- **Modeled indoor air concentration:** The value for $C_{building}$ on the INTERCALCS worksheet of the VI model will be used to represent the modeled indoor air concentration (DTSC 2003).

- **Inhalation Rate**: The inhalation rate used to estimate an inhaled dose or intake for a given chemical depends on the activity level of the potential receptor. Inhalation rates of 20 cubic meters per day (m^3/day) will be used for the adult resident, 10 m^3/day for the child resident, and 14 m^3/day for the commercial/industrial worker receptor (DTSC 2005b).

- **Exposure Frequency**: Exposure frequencies of 350 days/year will be used for the resident receptors (adult and child) and 250 days/year will be used for the commercial/industrial worker receptor (DTSC 2005b).

- **Exposure Duration:** Exposure durations of 24 years will be used for the adult resident, 6 years for the child resident, and 25 years for the commercial/industrial worker receptor (DTSC 2005b).

- **Body Weight:** A default body weight of 70 kilograms will be used for the adult receptors (resident and commercial industrial worker) and a body weight of 15 kilograms will be used for the child resident receptor (DTSC 2005b).

- **Averaging Time**: The averaging time for addressing adverse noncancer health effects is equal to the exposure duration in days, as recommended by EPA (1989). The averaging time for cancer risk estimation is the number of days in a 70-year lifetime or 25,550 days, as recommended by EPA (1989). This cancer risk averaging time is used to remain consistent with the basis for slope factors.

The intakes for carcinogens will be multiplied by chemical-specific inhalation slope factors to estimate a chemical-specific cancer risk. The intakes for noncarcinogens will be divided by chemical-specific inhalation RfDs to estimate a noncancer hazard quotient (HQ). For the future industrial exposure scenario, the cumulative cancer risk and noncancer hazard index (HI) will be calculated by summing the individual cancer risks or noncancer HQs. For the hypothetical future residential receptor, the estimated cancer risk is based on the sum of the risks estimated for the child and adult residential receptors. The total noncancer HI for the future residential receptor is based on the total HI estimated for the child residential receptor because the intake for children of air per unit body mass is higher, thus, noncancer HIs for a child resident are always higher than noncancer HIs for an adult resident.

A HI of less than 1 indicates that adverse noncancer health effects are not expected. If the total HI exceeds 1, further evaluation in the form of a segregation of the HI via a target organ analysis may be performed to assess whether the noncancer HIs are a concern (EPA 1989). Target organ HIs greater than 1 may indicate a potential adverse effect.

The VI risk calculations for the industrial receptor assume an enclosed building with slab-on-grade construction, however, the development plan is to construct open-air parking structures and surface parking lots on the site. As a result, the calculated VI risks will be an overestimate of actual risk and this will be considered during risk management decisions. Though VI risks to a future residential receptor are presented in this evaluation, the results are provided for hypothetical purposes.

The Navy will present the IR17 and Building 503 Area VI risk evaluation as an appendix to the field investigation summary report, which will summarize the additional site investigation and sample results.

5.0 REFERENCES

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