Assessment Criteria

FOR THE FORMER BENICIA ARSENAL

March 2002

Engineers

RSGREN ASSOCIATES/
BROWN and CALDWELL
A Joint Venture

SOIL ASSESSMENT CRITERIA

FOR

THE FORMER BENICIA ARSENAL
BENICIA, CALIFORNIA

FUDS Site Number: J09CA075600

FINAL

Prepared For

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Assessment Criteria

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LIST OF ACRONYMS

ABS	absoprtion soil value
bgs	below ground surface
BSL	Benicia Screening Level
Cal/EPA	California Environmental Protection Agency
cm^2/day	square centimeters per day
COI	chemical of interest
COPC	chemical of potential concern
CSF	cancer slope factor
DCE	dichloroethene
DDD	1,1-bis(chlorophenyl)-2,2-dichloroethane
DDE	1,1-bis(chlorophenyl)-2,2-dichloroethene
DDT	1,1-bis(chlorophenyl)-2,2,2-trichloroethane
DIPE	diisopropyl ether
DoD	Department of Defense
DTSC	Cal/EPA Department of Toxic Substances Control
FA/BC	Forsgren Associates/Brown and Caldwell
FSIP	field site investigation plan
FUDS	formerly used defense site
HEAST	USEPA Health Effects Assessment Summary Tables
ISBC	infinite source building concentration
IRIS	USEPA Integrated Risk Information System
kg	kilogram
m^3/day	cubic meters per day
m^3/kg	cubic meters per kilogram
mg/cm^2	milligrams per square centimeter
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram-day
mg-yr/kg-day	milligram-year per kilogram-day
MTBE	methyl tertiary butyl ether
NC	noncarcinogen
NCEA	USEPA National Criteria Effects Assessment Office
NFA	No further action
OEHHA	Cal/EPA Office of Environmental Health Hazard Assessment
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEF	particulate emission factor
PID	photoionization detector
ppm	parts per million
PRG	preliminary remediation goal
QAPP	quality assurance project plan
RfC	reference concentration
RfD	reference dose
RWQCB	California Regional Water Quality Control Board, San Francisco Bay Region
SVOC	semi-volatile organic chemical
TAME	tertiary-amyl methyl ether
TBA	tertiary butyl alcohol
TCE	trichloroethene

SECTION 1
INTRODUCTION

This document was prepared by Forsgren Associates/Brown and Caldwell (FA/BC) as an initial step in the development of assessment criteria for chemical constituents detected in soil at the Benicia Arsenal Formerly Used Defense Site (FUDS), Benicia, California. Assessment criteria are numerical values that, when approved, will be used to evaluate analytical results obtained during site investigations. As described in the *Arsenal-Wide Investigation Workplan for Environmental Investigation at the Formerly Used Defense Site (FUDS) Benicia Arsenal, Benicia, California* (Brown and Caldwell, 1999), final soil assessment criteria will be based on considerations of human health risk, supplemented by an evaluation of site-specific background concentrations.

The purpose of this document is to develop and present the health-based assessment criteria only. These values will be used by the FUDS program to evaluate chemicals in soil at the former Arsenal. The assessment criteria presented herein were developed assuming several potential land uses and exposure scenarios: residents, commercial/industrial workers, construction/utility workers, and visitors to open space.

This document does not evaluate or develop soil assessment criteria that are protective of groundwater quality or potential ecological receptors at the site. Groundwater protection and ecological receptors will be considered and separate focused evaluations conducted for specific sites as appropriate.

In addition, this document does not provide assessment criteria based on site-specific background concentrations. Assessment criteria for metals will be developed based on site-specific data in accordance with the *Plan for Determining Ambient Metals Concentrations in Area I Soils* (FA/BC, 2000). Site-specific ambient concentrations of metals in soil will be presented in a separate companion report to this document.

The soil assessment criteria developed in this document are referred to as Benicia Screening Levels (BSLs). BSLs are intended to identify concentrations of chemicals in soil that are protective given the exposure scenarios assumed. These criteria allow for screening of site investigation data and identification of locations at the former Arsenal where chemicals in soil do not present a human health concern given the intended land use.

It is also important to note that detection of a chemical in soil at concentrations above an appropriate BSL does not necessarily represent a human health risk. However, such a finding does indicate that further evaluation may be warranted. Such further evaluation may include additional sampling, consideration of ambient or background levels, reassessment of exposure assumptions, or completion of a site-specific risk assessment.

The remaining sections of this document are organized as follows:

- Section 2 describes the selection of chemicals of interest (COIs) and chemicals of potential concern (COPCs) for soil investigations at the former Arsenal.
- Section 3 summarizes the toxicity criteria used to develop BSLs for the COIs.
- Section 4 presents an exposure assessment for chemicals in soil at the Arsenal, including a description of the conceptual exposure model used for this document.

- **Dioxins:** SW8280A or SW8290
- **Furans:** SW8280A or SW8290
- **Metals:** SW6010B and SW7000 series
- **Nitrate and Nitrite:** E300
- **Nitroaromatics:** SW8330
- **Nitroglycerine:** SW8332
- **Pesticides:** SW8081A
- **Polychlorinated Biphenyls (PCBs):** SW8082
- **Polynuclear Aromatic Hydrocarbons (PAHs):** SW8310
- **SVOCs:** SW8270C
- **VOCs:** SW8260B

Methods SW8280A for dioxins and SW8290 for furans use additional quality control to allow more sophisticated determinations of detection limits and matrix spike recoveries than other routine gas chromatography and gas chromatography/mass spectrometry methods. Dioxins and furans will be evaluated on a site-by-site basis. If there is evidence to suspect the presence of dioxins and furans at a WIRMS area due to former DoD operations, then their congeners will be analyzed and they will be evaluated using USEPA's Toxicity Equivalency Factor approach.

Following USEPA guidance, essential nutrients (such as magnesium, calcium, potassium, and sodium), chloride, and sulfate were not considered as COIs (USEPA, 1989).

SECTION 3
TOXICITY CRITERIA

Table B-1 in Appendix B presents the oral and inhalation cancer slope factors (CSFs), reference doses (RfDs), and dermal absorption soil values (ABS) used to develop BSLs for the COIs. The toxicity criteria used in this document are those presented in the USEPA Region 9 Preliminary Remediation Goals (PRGs) 2000 Update (USEPA, 2000b). In general, the toxicity criteria presented in the USEPA Region 9 PRGs table are from the USEPA Integrated Risk Information System (IRIS), USEPA Health Effects Assessment Summary Tables (HEAST); the USEPA National Criteria Effects Assessment (NCEA) Office; and those modified from California Environmental Protection Agency (Cal/EPA) toxicity criteria. Chronic RfDs were used to develop BSLs for potential construction/utility worker and open space visitor exposures.

Volatilization factors (VFs) are also presented in Table B-1. VFs recommended by USEPA (2000b) were used to develop BSLs for potential inhalation of VOCs in outdoor air. COIs were identified as VOCs based on USEPA (2000b) criteria.

BSLs for lead in soil are based on the USEPA's Integrated Exposure Uptake Biokinetic Model and recommendations of USEPA's Technical Review Workgroup for Lead. The values for lead presented in the USEPA (2000b) PRG table were used in this document.

Table B-2 lists the COIs for which the USEPA does not have established toxicity criteria. BSLs were not derived for these chemicals. Procedures for addressing these chemicals will be established during specific site investigations at the former Arsenal.

SECTION 4
EXPOSURE ASSESSMENT

Historical Background

The former Arsenal was situated on a total of 2,728 acres located in the City of Benicia.

Commercial/industrial workers on the site may be directly exposed to COIs in soil via ingestion, dermal contact, and inhalation of dust and outdoor vapors while they work. BSLs were developed for this potentially complete exposure pathway even though intrusive soil activities are not typical for office workers.

Construction/utility workers at the former Arsenal may be directly exposed to COIs in soil while they work. Construction and utility workers are individuals who may conduct intrusive soil activities, such as might occur during installation of a building foundation or excavation of a trench to install utility lines. Because the manner in which construction and utility workers might be exposed to chemicals is similar, i.e., incidental soil ingestion, dermal contact with soil, and inhalation of fugitive dust particles and vapors, the BSLs developed for these potential receptors are the same.

BSLs were developed for residents who may be directly exposed to COIs in soil via ingestion, dermal contact, and inhalation of dust and vapors while they work in home gardens or exposed soil excavation areas, such as may occur during installation of a swimming pool. The Cal/EPA Department of Toxic Substances Control (DTSC) typically recommends that BSLs for this exposure scenario be developed by assuming that residents are exposed to chemicals in soil to a depth of 10 feet below ground surface. BSLs were developed for both adult and child residents because different exposure assumptions are used for these age groups.

It was assumed that individuals who visit open spaces at the former Arsenal might be exposed to chemicals in outdoor air released from excavated areas by wind erosion. Neither Cal/EPA nor USEPA have recommended exposure parameter values for this type of exposure. To evaluate this scenario, for exposures to carcinogenic chemicals it was assumed that visitors are 6 to 12 years of age and would spend 20 days per year for 7 years in an area of affected soil, breathing dust particles and soil-derived vapors in outdoor air. For exposures to noncarcinogenic chemicals both adults and children are evaluated. Activities in which visitors may participate include dog walking and kite flying. It was further assumed that open space visitors would not perform intrusive activities, such as soil excavation.

Exposure Parameters

Table D-1 in Appendix D presents a summary of the exposure assumptions used to develop BSLs for each of the potentially complete exposure pathways. The exposure parameter values used are consistent with those recommended by the California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB, 2001), and USEPA (1989; 1991a; 1991b; 1997a; 2000a, and 2000b). That is, with the exception of open space visitors, default exposure assumptions and fate and transport parameter values recommended by these regulatory agencies were used to develop BSLs for each potentially complete exposure pathway at the former Arsenal.

Examples of exposure assumptions include the following:

- Commercial workers were assumed to work 8 hours per day, 250 days per year, for 25 years.

- Construction/utility workers were assumed to work on site for 8 hours per day, 20 days per year, for 7 years, consistent with the exposure assumptions of RWQCB (2001). These values are shorter than those for commercial/industrial worker and adult resident exposures and reflect the fact that construction/utility workers are usually employed at multiple job sites over the course of their working lifetimes.

approach used by the USEPA Region 9. For soils only, noncarcinogens are evaluated in children separately from adults. The focus on children is considered protective of the higher daily intake rates of soil by children and their lower body weight.

BSLs for carcinogens were developed assuming an acceptable excess cancer risk level of 1×10^{-6}. For non-carcinogens, a hazard quotient of 1.0 was used. Although a range of acceptable cancer risk levels is commonly considered in human health risk assessments, for example 1×10^{-6} to 1×10^{-4}, only the lower-end of the USEPA-established risk range was used in this document.

The lower risk level was used because the BSLs developed in this document are intended to be used to screen sites at the former Arsenal for purposes of further evaluation and investigation. If further investigation is considered necessary for a particular site, then it would be more appropriate to present cancer risk estimates in terms of an acceptable cancer risk range, such as 1×10^{-6} to 1×10^{-4}.

Every COI identified at each site will be compared with the appropriate BSL. For sites with multiple COIs, the cumulative impact of chemicals will be evaluated following the USEPA (2000b) approach for screening sites with multiple chemicals and the DTSC (1994) recommended outline for using USEPA Region 9 PRGs in screening risk assessments at military facilities. A cumulative risk approach will also be used if a focused investigation is necessary to estimate overall COPC exposure risks.

Table 1 shows soil BSLs for 20 of the more common COIs, by exposure scenario. For each potential receptor group, the lowest BSL is presented for each COI.

Lead Screening Levels

BSLs for lead are based on USEPA's Integrated Exposure Uptake Biokinetic Model for residents and recommendations of the USEPA Technical Review Workgroup for Lead for industrial exposures. BSLs for lead in soil are based on the USEPA (2000b) Region 9 PRGs.

Application of BSLs

BSLs are tools that may be used as part of the risk-based decision-making process for the WIRMS areas across the former Arsenal. BSLs should not be used as cleanup criteria. Rather, they should be used as part of a site prioritization and screening process. Because BSLs represent COI concentrations in soil that are unlikely to pose a significant risk of adverse health effects, they may be used to decide if additional site investigation is needed or to determine that an NFA decision is warranted.

BSLs should be compared with appropriate site soil concentrations. That is, for screening purposes BSLs should be compared with maximum COI concentrations. If a focused investigation is performed, then representative concentrations of COPCs in soil, such as 95th percent upper confidence limit concentrations should be used to estimate risks.

The BSLs presented in this document are comparable to direct contact exposure Risk-Based Screening Levels (RBSLs) developed by the RWQCB (2001). The same general exposure equations and parameters are used to develop the BSLs.

Use of the BSLs presented in this document will be decided on a site-by-site basis. BSLs are specific to the exposure pathways assumed in deriving these values. A more detailed assessment of relevant exposure pathways will need to be completed for each site at the Arsenal before the appropriate BSL can be selected.

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USEPA. 2000a. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance. Dermal Risk Assessment Interim Guidance. EPA/540/R-99/005 cited in USEPA (2000b).

USEPA. 2000b. Region 9 Preliminary Remediation Goals (PRGs) 2000 Update. S. Smucker.

USEPA. 2001. Integrated Risk Information System. Cincinnati, Ohio.

Tables

Table 1. Summary of Soil BSLs for Selected COIs by Potential Exposure Scenario
Former Benicia Arsenal, Benicia, California

Chemical of Interest	Commercial/Industrial Workers (mg/kg)		Construction/Utility Workers (mg/kg)		Residential (mg/kg)		Open Space Visitors (mg/kg)	
1,1,2-Trichloroethane	1.9E+00	c	7.3E+01	c	8.4E-01	c	8.3E+01	c
1,2-Dichloroethane	7.6E-01	c	3.1E+01	c	3.5E-01	c	3.3E+01	c
Benzo(a)pyrene	2.9E-01	c	2.0E+00	c	6.2E-02	c	6.2E-02	c
Cadmium	1.0E+03	nc	1.5E+02	c	3.9E+01	nc	1.3E+05	c
Carbon Tetrachloride	5.2E-01	c	2.1E+01	c	2.4E-01	c	1.9E+01	nc
Cis-1,2-Dichloroethylene	1.5E+02	nc	1.7E+03	nc	4.3E+01	nc	4.0E+02	nc
Chloroform	5.2E-01	c	1.6E+01	nc	2.4E-01	c	3.5E+00	nc
Ethylbenzene	6.0E+03	nc	6.0E+04	nc	1.5E+03	nc	1.6E+04	nc
Lead	7.5E+02	nc	NA	-	4.0E+02	nc	NA	-
m,p,o Xylenes	4.5E+03	nc	5.5E+04	nc	1.4E+03	nc	1.2E+04	nc
Methylene Chloride	2.1E+01	c	7.6E+02	c	9.1E+00	c	9.2E+02	c
Naphthalene	1.9E+02	nc	2.3E+03	nc	5.6E+01	nc	5.1E+02	nc
Pyrene	5.4E+04	nc	7.9E+04	nc	2.3E+03	nc	1.3E+06	nc
Tetrachloroethylene	1.9E+01	c	3.4E+02	c	5.7E+00	c	9.7E+02	c
Tetryl	0.0E+00		0.0E+00		0.0E+00		0.0E+00	
Toluene	2.0E+03	nc	2.4E+04	nc	5.9E+02	nc	5.3E+03	nc
TPH-Diesel Range Organics	1.0E+02	nc	1.6E+04	nc	1.0E+02	nc	NA	-
TPH-Gasoline Range Organics	1.0E+02	nc	1.6E+04	nc	1.0E+02	nc	NA	-
TPH-Residual Range Organics	1.0E+03	nc	1.6E+04	nc	5.0E+02	nc	NA	-
Trans-1,2-Dichloroethene	2.1E+02	nc	2.6E+03	nc	6.3E+01	nc	5.8E+02	nc
Trichloroethylene	6.1E+00	c	2.5E+02	c	2.8E+00	c	2.1E+02	nc

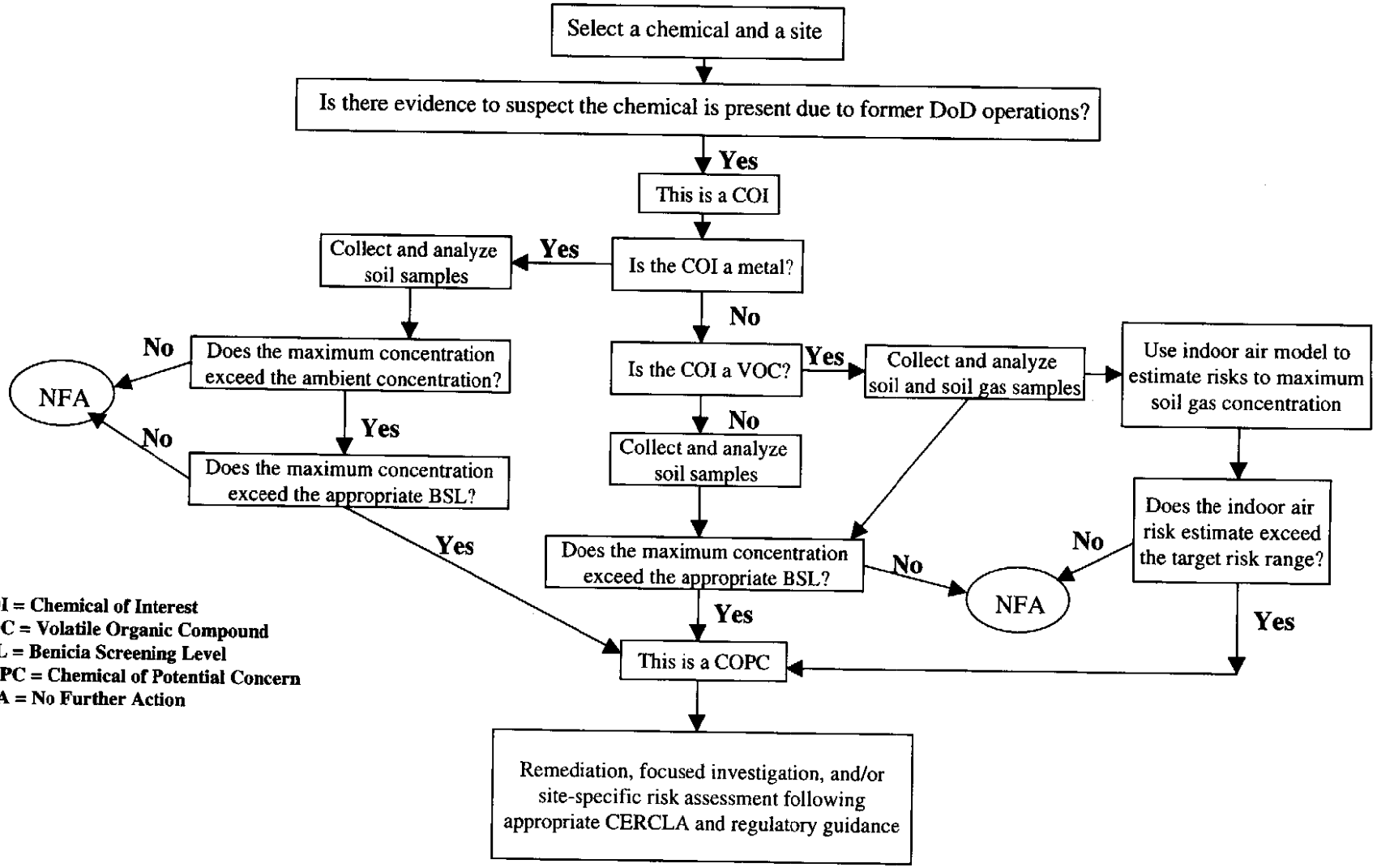
c = BSL based on cancer endpoint

nc = BSL based on noncancer endpoint

NA = Not available.

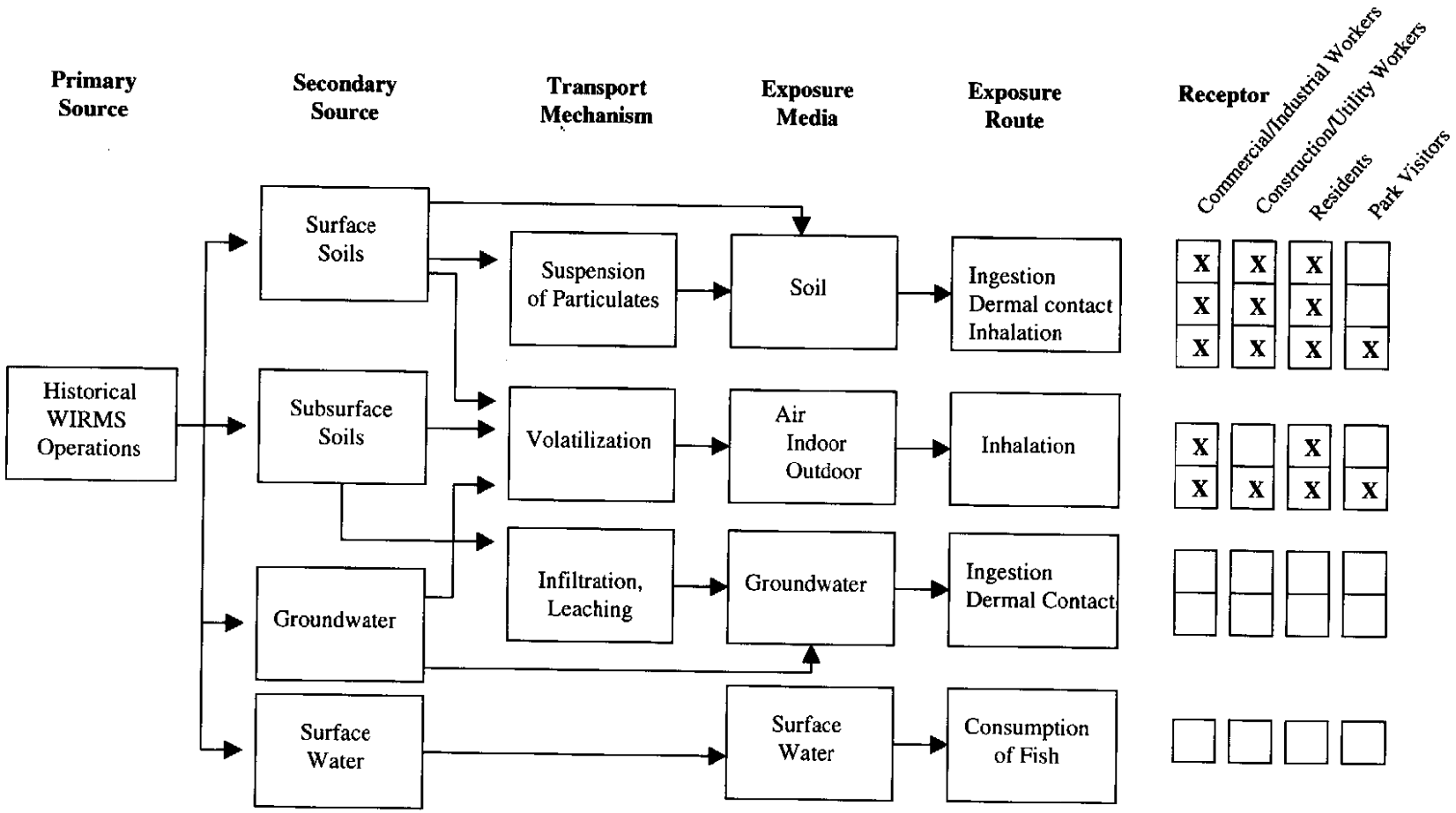
Figures

Figure 1
Flowchart for Use of Assessment Criteria
Former Benicia Arsenal, Benicia, California



COI = Chemical of Interest
VOC = Volatile Organic Compound
BSL = Benicia Screening Level
COPC = Chemical of Potential Concern
NFA = No Further Action

Figure 2
Conceptual Exposure Model
Former Benicia Arsenal, Benicia, California



APPENDIX A

CHEMICALS OF INTEREST IN SOIL

Table A-1. Chemicals of Interest in Soil
Former Benicia Arsenal, Benicia, California

USEPA Method	Chemical of Interest
SW8260B	1,1,1,2-Tetrachloroethane
SW8260B	1,1,1-Trichloroethane
SW8260B	1,1,2,2-Tetrachloroethane
SW8260B	1,1,2-Trichloroethane
SW8260B	1,1-Dichloroethane
SW8260B	1,1-Dichloroethene
SW8260B	1,1-Dichloropropene
SW8260B	1,2,3-Trichlorobenzene
SW8260B	1,2,3-Trichloropropane
SW8270C	1,2,4-Trichlorobenzene
SW8260B	1,2,4-Trimethylbenzene
SW8260B	1,2-Dibromo-3-Chloropropane
SW8260B	1,2-Dibromoethane
SW8270C	1,2-Dichlorobenzene
SW8260B	1,2-Dichloroethane
SW8260B	1,2-Dichloropropane
SW8260B	1,3,5-Trimethylbenzene
SW8330	1,3,5-Trinitrobenzene
SW8270C	1,3-Dichlorobenzene
SW8260B	1,3-Dichloropropane
SW8330	1,3-Dinitrobenzene
SW8270C	1,4-Dichlorobenzene
SW8260B	2,2-Dichloropropane
SW8280A	2,3,7,8-Tetrachlorodibenzo-p-Dioxin
SW8280A	1,2,3,7,8-Pentaachlorodibenzo-p-Dioxin
SW8280A	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin
SW8280A	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin
SW8280A	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin
SW8280A	1,2,3,4,7,8,9-Heptachlorodibenzo-p-Dioxin
SW8290	2,3,7,8-Tetrachlorodibenzofuran
SW8290	1,2,3,7,8-Pentachlorodibenzofuran
SW8290	2,3,4,7,8-Pentachlorodibenzofuran
SW8290	1,2,3,4,7,8-Hexachlorodibenzofuran
SW8290	1,2,3,6,7,8-Hexachlorodibenzofuran
SW8290	2,3,4,6,7,8-Hexachlorodibenzofuran
SW8290	1,2,3,7,8,9-Hexachlorodibenzofuran
SW8290	1,2,3,4,6,7,8-Heptachlorodibenzofuran
SW8290	1,2,3,4,7,8,9-Heptachlorodibenzofuran
SW8290	Octachlorodibenzofuran
SW8270C	2,4,5-Trichlorophenol
SW8270C	2,4,6-Trichlorophenol
SW8330	2,4,6-Trinitrotoluene
SW8270C	2,4-Dichlorophenol
SW8270C	2,4-Dimethylphenol
SW8270C	2,4-Dinitrophenol
SW8330	2,4-Dinitrotoluene
SW8330	2,6-Dinitrotoluene

Table A-1. Chemicals of Interest in Soil
Former Benicia Arsenal, Benicia, California

USEPA Method	Chemical of Interest
SW8270C	Bis(2-Chloroethyl) Ether
SW8270C	Bis(2-Chloroisopropyl) Ether
SW8270C	Bis(2-Ethylhexyl) Phthalate
SW8260B	Bromobenzene
SW8260B	Bromochloromethane
SW8260B	Bromodichloromethane
SW8260B	Bromoform
SW8260B	Bromomethane
SW6010B	Cadmium
SW8260B	Carbon Disulfide
SW8260B	Carbon Tetrachloride
SW8081A	Chlordane (Alpha)
SW8081A	Chlordane (Gamma)
SW8260B	Chlorobenzene
SW8260B	Chloroethane
SW8260B	Chloroform
SW8260B	Chloromethane
SW6010B	Chromium, Total
SW8310	Chrysene
SW8260B	Cis-1,2-Dichloroethylene
SW8260B	Cis-1,3-Dichloropropene
SW6010B	Cobalt
SW6010B	Copper
SW9014	Cyanide
SW8081A	Delta BHC
SW8310	Dibenz(a,h)anthracene
SW8270C	Dibenzofuran
SW8260B	Dibromochloromethane
SW8260B	Dibromomethane (1,2)
SW8260B	Dichlorodifluoromethane
SW8081A	Dieldrin
SW8270C	Diethyl Phthalate
SW8270C	Dimethyl Phthalate
SW8270C	Di-n-Butyl Phthalate
SW8270C	Di-n-Octylphthalate
SW8081A	Endosulfan (Alpha)
SW8081A	Endosulfan (Beta)
SW8081A	Endosulfan Sulfate
SW8081A	Endrin
SW8081A	Endrin Aldehyde
SW8260B	Ethyl Methacrylate
SW8260B	Ethylbenzene
SW8310	Fluoranthene
SW8310	Fluorene
SW8081A	Gamma BHC (Lindane)
SW8081A	Heptachlor
SW8081A	Heptachlor Epoxide

Table A-1. Chemicals of Interest in Soil
Former Benicia Arsenal, Benicia, California

USEPA Method	Chemical of Interest
SW8260B	Sec-Butylbenzene
SW7740	Selenium
SW6010B	Silver
SW8260B	Styrene
SW8260B	Tert-Amyl Methyl Ether
SW8260B	Tert-Butyl Ethyl Ether
SW8260B	Tert-Butyl Methyl Ether
SW8260B	Tert-Butylbenzene
SW8260B	Tetrachloroethylene
SW8330	Tetryl
SW7841	Thallium
SW6010B	Tin
SW8260B	Toluene
SW8081A	Toxaphene
SW8015B	TPH-Diesel Range Organics
SW8015B	TPH-Gasoline Range Organics
SW8015B	TPH-Residual Range Organics
SW8260B	Trans-1,2-Dichloroethene
SW8260B	Trans-1,3-Dichloropropene
SW8260B	Trichloroethylene
SW8260B	Trichlorofluoromethane
SW6010B	Vanadium
SW8260B	Vinyl Acetate
SW8260B	Vinyl Chloride
SW6010B	Zinc

APPENDIX B

TOXICITY CRITERIA FOR CHEMICALS OF INTEREST

Table B-1. Toxicity Criteria for Chemicals of Interest in Soil
Former Benicia Arsenal, Benicia, California

Chemical of Interest	Cancer Slope Factor Oral (mg/kg-day)$^{-1}$	Source	Cancer Slope Factor Inhalation (mg/kg-day)$^{-1}$	Source	Reference Dose Oral (mg/kg-day)	Source	Reference Dose Inhalation (mg/kg-day)	Source	Soil-to-Skin Absorption[1]	VOC[1]	VF[1] (m3/kg)
1,1,1,2-Tetrachloroethane	2.6E-02	I	2.6E-02	I	3.0E-02	I	3.0E-02	R	0.0E+00	Yes	1.3E+04
1,1,1-Trichloroethane	NA	NA	NA	NA	2.0E-02	N	2.9E-01	N	0.0E+00	Yes	2.4E+03
1,1,2,2-Tetrachloroethane	2.0E-01	I	2.0E-01	I	6.0E-02	N	6.0E-02	R	0.0E+00	Yes	1.3E+04
1,1,2-Trichloroethane	5.7E-02	I	5.6E-02	I	4.0E-03	I	4.0E-03	R	0.0E+00	Yes	7.6E+03
1,1-Dichloroethane	NA	NA	NA	NA	1.0E-01	H	1.4E-01	H	0.0E+00	Yes	2.9E+03
1,1-Dichloroethene	6.0E-01	I	1.8E-01	I	9.0E-03	I	9.0E-03	R	0.0E+00	Yes	1.5E+03
1,1-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichloropropane	7.0E+00	H	7.0E+00	R	6.0E-03	I	5.0E-03	R	0.0E+00	Yes	1.5E+03
1,2,4-Trichlorobenzene	NA	NA	NA	NA	1.0E-02	I	5.7E-02	H	0.0E+00	Yes	4.2E+04
1,2,4-Trimethylbenzene	NA	NA	NA	NA	5.0E-02	N	1.7E-03	N	0.0E+00	Yes	2.0E+04
1,2-Dibromo-3-Chloropropane	1.4E+00	H	2.4E-03	H	5.7E-05	R	5.7E-05	I	0.0E+00	Yes	2.5E+04
1,2-Dibromoethane	8.5E+01	I	7.7E-01	I	5.7E-05	R	5.7E-05	H	0.0E+00	Yes	9.2E+03
1,2-Dichlorobenzene	NA	NA	NA	NA	9.0E-02	I	5.7E-02	H	0.0E+00	Yes	1.2E+04
1,2-Dichloroethane	9.1E-02	I	9.1E-02	I	3.0E-02	N	1.4E-03	N	0.0E+00	Yes	4.9E+03
1,2-Dichloropropane	6.8E-02	H	6.8E-02	R	1.1E-03	R	1.1E-03	I	0.0E+00	Yes	3.7E+03
1,3,5-Trimethylbenzene	NA	NA	NA	NA	5.0E-02	N	1.7E-03	N	0.0E+00	Yes	8.0E+03
1,3,5-Trinitrobenzene	NA	NA	NA	NA	3.0E-02	I	3.0E-02	R	1.0E-01	No	NA
1,3-Dichlorobenzene	NA	NA	NA	NA	9.0E-04	N	9.0E-04	R	0.0E+00	Yes	1.2E+04
1,3-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dinitrobenzene	NA	NA	NA	NA	1.0E-04	I	1.0E-04	R	1.0E-01	No	NA
1,4-Dichlorobenzene	2.4E-02	H	2.2E-02	N	3.0E-02	N	2.3E-01	I	0.0E+00	Yes	1.3E+04
2,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3-7,8-TCDD (Dioxin)	1.5E+05	H	1.5E+05	H	NA	NA	NA	NA	3.0E-02	No	NA
2,3-7,8-TCDF (Furan)	NA	NA	1.3E+04	CA	NA	NA	NA	NA	NA	No	NA
2,4,5-Trichlorophenol	NA	NA	NA	NA	1.0E-01	I	1.0E-01	R	1.0E-01	No	NA
2,4,6-Trichlorophenol	1.1E-02	I	1.1E-02	I	NA	NA	NA	NA	1.0E-01	No	NA
2,4,6-Trinitrotoluene	3.0E-02	I	3.0E-02	R	5.0E-04	I	5.0E-04	R	1.0E-01	No	NA
2,4-Dichlorophenol	NA	NA	NA	NA	3.0E-03	I	3.0E-03	R	1.0E-01	No	NA
2,4-Dimethylphenol	NA	NA	NA	NA	2.0E-02	I	2.0E-02	R	1.0E-01	No	NA
2,4-Dinitrophenol	NA	NA	NA	NA	2.0E-03	I	2.0E-03	R	1.0E-01	No	NA
2,4-Dinitrotoluene	6.8E-01	I	6.8E-01	R	2.0E-03	I	2.0E-03	R	1.0E-01	No	NA

Table B-1. Toxicity Criteria for Chemicals of Interest in Soil
Former Benicia Arsenal, Benicia, California

Chemical of Interest	Cancer Slope Factor Oral $(mg/kg\text{-}day)^{-1}$	Source	Cancer Slope Factor Inhalation $(mg/kg\text{-}day)^{-1}$	Source	Reference Dose Oral (mg/kg-day)	Source	Reference Dose Inhalation (mg/kg-day)	Source	Soil-to-Skin Absorption[1]	VOC[1]	VF[1] (m3/kg)
Aniline	5.7E-03	I	5.7E-03	R	7.0E-03	N	2.9E-04	I	1.0E-01	No	NA
Anthracene	NA	NA	NA	NA	3.0E-01	I	3.0E-01	R	0.0E+00	Yes	7.0E+05
Antimony	NA	NA	NA	NA	4.0E-04	I	NA	NA	0.0E+00	No	NA
Arsenic	1.5E+00	I	1.5E+01	I	3.0E-04	I	NA	NA	3.0E-02	No	NA
Barium	NA	NA	NA	NA	7.0E-02	I	1.4E-04	H	0.0E+00	No	NA
Benzene	5.5E-02	I	2.7E-02	I	3.0E-03	N	1.7E-03	N	0.0E+00	Yes	2.8E+03
Benzo(a)anthracene	7.3E-01	N	3.1E-01	N	NA	NA	NA	NA	1.3E-01	No	NA
Benzo(a)pyrene	7.3E+00	I	3.1E+00	N	NA	NA	NA	NA	1.3E-01	No	NA
Benzo(b)fluoranthene	7.3E-01	N	3.1E-01	N	NA	NA	NA	NA	1.3E-01	No	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	7.3E-02	N	3.1E-02	N	NA	NA	NA	NA	1.3E-01	No	NA
Benzoic Acid	NA	NA	NA	NA	4.0E+00	I	4.0E+00	R	1.0E-01	No	NA
Benzyl Alcohol	NA	NA	NA	NA	3.0E-01	H	3.0E-01	R	1.0E-01	No	NA
Benzyl Butyl Phthalate	NA	NA	NA	NA	2.0E-01	I	2.0E-01	R	1.0E-01	No	NA
Beryllium	NA	NA	8.4E+00	I	2.0E-03	I	5.7E-06	I	0.0E+00	No	NA
Beta BHC	1.8E+00	I	1.8E+00	I	NA	NA	NA	NA	4.0E-02	No	NA
Bis(2-Chloroethoxy) Methane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-Chloroethyl) Ether	1.1E+00	I	1.2E+00	I	NA	NA	NA	NA	0.0E+00	Yes	5.7E+04
Bis(2-Chloroisopropyl) Ether	7.0E-02	H	3.5E-02	H	4.0E-02	I	4.0E-02	R	0.0E+00	Yes	2.2E+04
Bis(2-Ethylhexyl) Phthalate	1.4E-02	I	1.4E-02	R	2.0E-02	I	2.2E-02	R	1.0E-01	No	NA
Bromobenzene	NA	NA	NA	NA	2.0E-02	N	2.9E-03	N	0.0E+00	Yes	6.3E+03
Bromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromodichloromethane	6.2E-02	I	6.2E-02	R	2.0E-02	I	2.0E-02	R	0.0E+00	Yes	1.0E+04
Bromoform	7.9E-03	I	3.9E-03	I	2.0E-02	I	2.0E-02	R	1.0E-01	No	NA
Bromomethane	NA	NA	NA	NA	1.4E-03	I	1.4E-03	I	0.0E+00	Yes	1.8E+03
Cadmium	NA	NA	6.3E+00	I	5.0E-04	I	NA	NA	1.0E-03	No	NA
Carbon Disulfide	NA	NA	NA	NA	1.0E-01	I	2.0E-01	I	0.0E+00	Yes	1.2E+03
Carbon Tetrachloride	1.3E-01	I	5.3E-02	I	7.0E-04	I	7.0E-04	R	0.0E+00	Yes	2.0E+03
Chlordane (Alpha)	3.5E-01	I	3.5E-01	I	5.0E-04	I	2.0E-04	I	4.0E-02	No	NA
Chlordane (Gamma)	3.5E-01	I	3.5E-01	I	5.0E-04	I	2.0E-04	I	4.0E-02	No	NA
Chlorobenzene	NA	NA	NA	NA	2.0E-02	I	1.7E-02	N	0.0E+00	Yes	6.3E+03

Table B-1. Toxicity Criteria for Chemicals of Interest in Soil
Former Benicia Arsenal, Benicia, California

Chemical of Interest	Cancer Slope Factor Oral (mg/kg-day)$^{-1}$	Source	Cancer Slope Factor Inhalation (mg/kg-day)$^{-1}$	Source	Reference Dose Oral (mg/kg-day)	Source	Reference Dose Inhalation (mg/kg-day)	Source	Soil-to-Skin Absorption[1]	VOC[1]	VF[1] (m3/kg)
Heptachlor	4.5E+00	I	4.6E+00	I	5.0E-04	I	5.0E-04	R	1.0E-01	No	NA
Heptachlor Epoxide	9.1E+00	I	9.1E+00	I	1.3E-05	I	1.3E-05	R	1.0E-01	No	NA
Hexachlorobenzene	1.6E+00	I	1.6E+00	I	8.0E-04	I	8.0E-04	R	1.0E-01	No	NA
Hexachlorobutadiene	7.8E-02	I	7.8E-02	I	3.0E-04	N	3.0E-04	R	1.0E-01	No	NA
Hexachlorocyclopentadiene	NA	NA	NA	NA	7.0E-03	I	2.0E-05	H	1.0E-01	No	NA
Hexachloroethane	1.4E-02	I	1.4E-02	I	1.0E-03	I	1.0E-03	R	1.0E-01	No	NA
Hexahydro-1,3,5-Trinitro-1,3,5-Triazine	1.1E-01	I	1.1E-01	R	3.0E-03	I	3.0E-03	R	1.0E-01	No	NA
Indeno(1,2,3-c,d)pyrene	7.3E-01	N	3.1E-01	N	NA	NA	NA	NA	1.3E-01	No	NA
Iodomethane (Methyl Iodide)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	3.0E-01	N	NA	NA	0.0E+00	No	NA
Isophorone	9.5E-04	I	9.5E-04	R	2.0E-01	I	2.0E-01	R	1.0E-01	No	NA
Isopropylbenzene (Cumene)	NA	NA	NA	NA	1.0E-01	I	1.1E-01	I	0.0E+00	Yes	9.3E+02
Lead[2]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
m,p-Xylene (Sum of Isomers)	NA	NA	NA	NA	2.0E+00	I	2.0E-01	X	1.0E-01	Yes	4.4E+03
Manganese	NA	NA	NA	NA	2.4E-02	I	1.4E-05	I	0.0E+00	No	NA
Mercury	NA	NA	NA	NA	3.0E-04	I	NA	NA	0.0E+00	No	NA
Methoxychlor	NA	NA	NA	NA	5.0E-03	I	5.0E-03	R	1.0E-01	No	NA
Methyl Ethyl Ketone (2-Butanone)	NA	NA	NA	NA	6.0E-01	I	2.9E-01	I	0.0E+00	Yes	1.9E+04
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	NA	NA	NA	NA	8.0E-02	H	2.3E-02	H	0.0E+00	Yes	2.5E+04
Methylene Chloride (Dichloromethane)	7.5E-03	I	1.6E-03	I	6.0E-02	I	8.6E-01	H	0.0E+00	Yes	2.4E+03
Molybdenum	NA	NA	NA	NA	5.0E-03	H	NA	NA	0.0E+00	No	NA
Naphthalene	NA	NA	NA	NA	2.0E-02	I	8.6E-04	I	0.0E+00	Yes	4.3E+04
N-Butylbenzene	NA	NA	NA	NA	1.0E-02	N	1.0E-02	R	0.0E+00	Yes	1.1E+04
Nickel	NA	NA	NA	NA	2.0E-02	I	NA	NA	0.0E+00	No	NA
Nitrobenzene	NA	NA	NA	NA	5.0E-04	I	5.7E-04	H	0.0E+00	Yes	4.4E+04
Nitrogen, Nitrate (As N)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen, Nitrite (As N)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodimethylamine	5.1E+01	I	4.9E+01	I	NA	NA	NA	NA	1.0E-01	No	NA
N-Nitrosodi-n-propylamine	7.0E+00	I	7.0E+00	R	NA	NA	NA	NA	1.0E-01	Yes	2.6E+04
N-Nitrosodiphenylamine	4.9E-03	I	4.9E-03	R	NA	NA	NA	NA	1.0E-01	No	NA
N-Propylbenzene	NA	NA	NA	NA	1.0E-02	N	1.0E-02	R	0.0E+00	Yes	1.1E+04
Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table B-1. Toxicity Criteria for Chemicals of Interest in Soil
Former Benicia Arsenal, Benicia, California

Chemical of Interest	Cancer Slope Factor Oral (mg/kg-day)$^{-1}$	Source	Cancer Slope Factor Inhalation (mg/kg-day)$^{-1}$	Source	Reference Dose Oral (mg/kg-day)	Source	Reference Dose Inhalation (mg/kg-day)	Source	Soil-to-Skin Absorption[1]	VOC[1]	VF[1] (m3/kg)
Trans-1,3-Dichloropropene	1.0E-01	I	1.4E-02	I	3.0E-02	I	5.7E-03	I	0.0E+00	Yes	1.6E+03
Trichloroethylene	1.1E-02	N	6.0E-03	N	6.0E-03	X	6.0E-03	R	0.0E+00	Yes	2.6E+03
Trichlorofluoromethane (Freon 11)	NA	NA	NA	NA	3.0E-01	I	2.0E-01	H	0.0E+00	Yes	1.3E+03
Vanadium	NA	NA	NA	NA	7.0E-03	H	NA	NA	0.0E+00	No	NA
Vinyl Acetate	NA	NA	NA	NA	1.0E+00	H	5.7E-02	I	0.0E+00	Yes	4.8E+03
Vinyl Chloride	1.5E+00	I	3.1E-02	I	3.0E-03	I	2.9E-02	I	0.0E+00	Yes	1.0E+03
Zinc	NA	NA	NA	NA	3.0E-01	I	NA	NA	0.0E+00	No	NA

NA = Not available

CA = Cal-Modified PRG as presented in USEPA (2000b).

I = USEPA (2001) Integrated Risk Information System as presented in USEPA (2000b).

H = USEPA (1997b) Health Effects Assessment Summary Tables as presented in USEPA (2000b).

N = USEPA National Criteria Effects Assessment Office as presented in USEPA (2000b).

R = Route extrapolation as presented in USEPA (2000b).

X = Withdrawn by USEPA and under review as presented in USEPA (2000b).

[1] Based on definition of VOC in USEPA (2000b).

[2] BSLs are based on the USEPA's Integrated Exposure Uptake Biokinetic Model and recommendations of USEPA's Technical Review Workgroup.

[3] Endosulfan used as a surrogate.

VF = Volatiliaztion factor for soil.

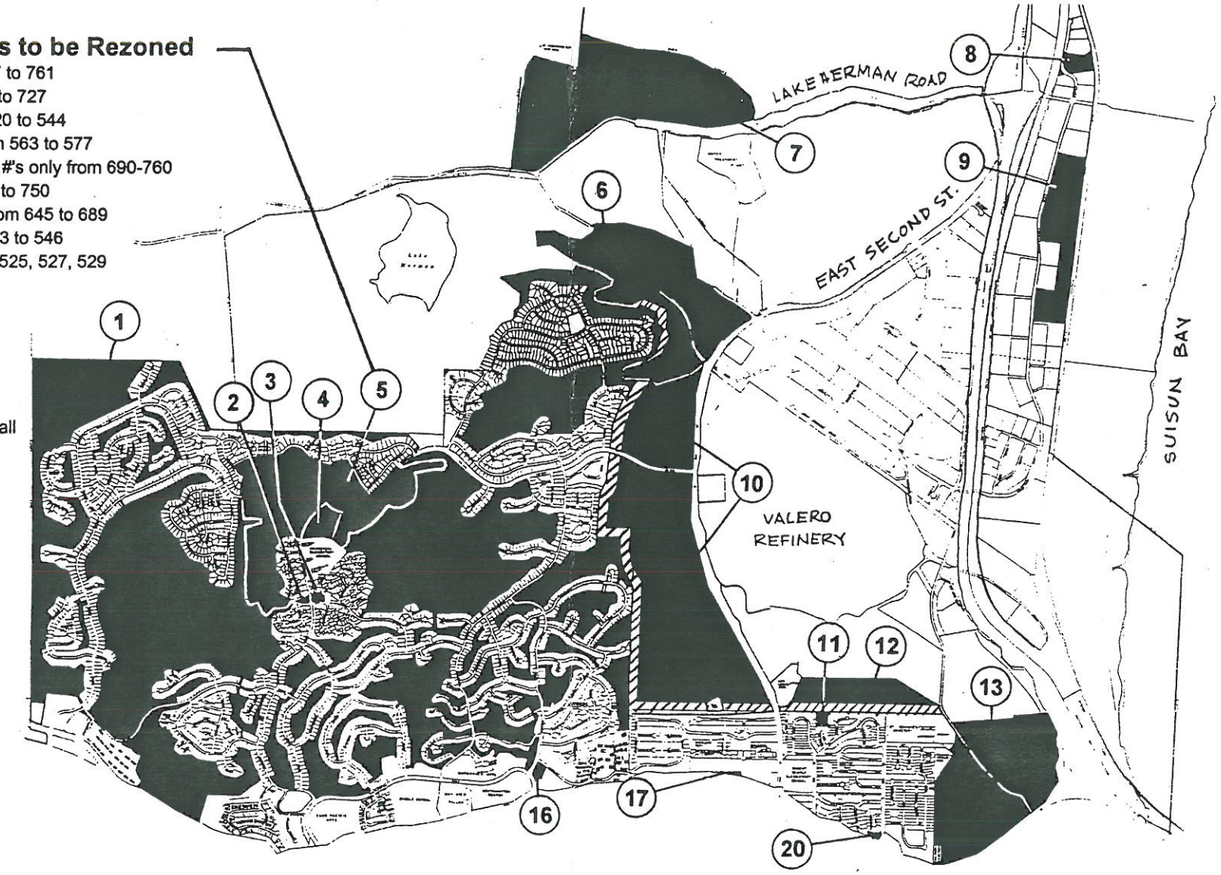
APPENDIX C

CITY OF BENICIA ZONING MAP

Site Location	Current Zoning	Proposed Zoning
1 Southampton Open Space	Single Family Residential	Open Space
2 Fire Station, Hastings & Solano Dr.	Medium Density Residential	Public & Semi Public
3 Park Solano, Hastings & Solano Dr.	Single Family Residential	Open Space
4 Jack London Park, Hastings & Rose	Medium Density Residential	Open Space
5 Tempo Homes, see attachment	Medium Density Residential	Single Family Residential
6 West Channel Rd. & California Court	General Industrial	Limited Industrial with an Open Space buffer averaging 200'.
7 IT undeveloped parcels, Lake Herman Rd.	Business & Professional office	Open Space
8 Egret Court Wetlands	Limited Industrial	Open Space
9 Fleetside Wetlands, Industrial Way	General Industrial	Open Space
10 Valero parcels, East Second St & Rose Dr.	General Industrial, Industrial Park	Limited Industrial with a 200' Open Space buffer
11 Highlands reservoir site	Single Family Residential	Open Space
12 Valero parcel, east of East Second Street	General Industrial	Limited Industrial with a 200' Open Space buffer
13 Upper Arsenal area, former Pine Lake	General Indurtrial	Limited Industrial
15 Undeveloped parcel between West Seventh Street and Carolina Drive	Single Family Residential	General Plan Amendment from Medium Density Residential to Single Family Residential
16 Southampton Swim Club, Chelsea Hills Dr.	Medium Density Residential	Public & Semi Public
17 Sterling Height Apartments freeway frontage	General Commercial	Multiple Family Residential
18 City Park, First Street	Public & Semi-Public	Open Space
19 Eunice Jensen Park, Public Library	General Commercial	Public & Semi Public
20 Fast & Easy Mart, East Fifth at I-780	Neighborhood Commercial	General Commercial
21 375, 385 Military East	Neighborhood Commercial	General Commercial
22 470, 484, 490 East L, 1125 East Fifth	Neighborhood Commercial	General Commercial
533 East N	Medium Density Residential	General Plan Amendment from Single Family Residential to Medium Density Residential
24 650 - 658 East N Street	Medium Density Residential	General Plan Amendment from Single Family Residential to Medium Density Residential
25 Commandant's House & Clocktower	Business & Professional office	Public & Semi Public
26 West L Street Public Access	No current zoning	Open Space
27 West 14th Street Public Access	No current zoning	Open Space
28 West 12th Street Public Access	No current zoning	Open Space
29 West 11th Street Public Access	No current zoning	Open Space
30 Cliff's Pleasant View, West 9th Street	Single Family Residential	Community Commercial
31 West 8th Street Public Access	No current zoning	Open Space
32 Willow Glen Creek, West K Street	Single Family Residential	Open Space
33 Benicia Fitness Center, Military West @ 7th	Neighborhood Commercial	Community Commercial
34 Taco Bell, Military West at Seventh	General Commercial	Community Commercial
35 Tackle Shop, etal, Claverie Way	Neighborhood Commercial	Community Commercial
36 Bob's Food & Liquor, West J Street	Neighborhood Commercial	Community Commercial
37 West Fourth Street Public Access	No current zoning	Open Space
38 Gull Point Court Park	Single Family Residential	Open Space
39 State Capitol, Fisher Hanlon House, West G	Medium Density Residential	Public & Semi Public
40 Foot of First Street	Waterfront Commercial & Open Space	Downtown Commercial
41 Marina Marsh	Waterfront Commercial	Open Space
42 Girl Scout House, East J Street	Public & Semi-Public	Single Family Residential Both rezoning & General Plan Amendment
43 Offices at East H & Third Streets	Neighborhood Commercial	Community Commercial
44 Casa deVillarasa, East I Street	Single Family Residential	High Density Residential. Both rezoning & General Plan Amendment
'uba Area, East H Street	General Industrial	Limited Industrial

Tempo Homes to be Rezoned

Barton Way from 717 to 761
Daffodil Dr. from 591to 727
Fuschia Drive fron 520 to 544
Periwinkle Place from 563 to 577
Primrose Lane, even #'s only from 690-760
Rose Drive from 556 to 750
Snapdragon Place from 645 to 689
Solano Drive from 503 to 546
Sweetbrier Lane, #'s 525, 527, 529
Alder Court, all
Clyne Court, all
Gardenia Court, all
Iris Court, all
Lupine Court, all
Lyon Court, all
Morning Glory Drive, all
Orchid Court, all
Poppy Court, all
Sorrel Court, all
Toyon Place, all
Wisteria Court, all
Zinnia Court, all



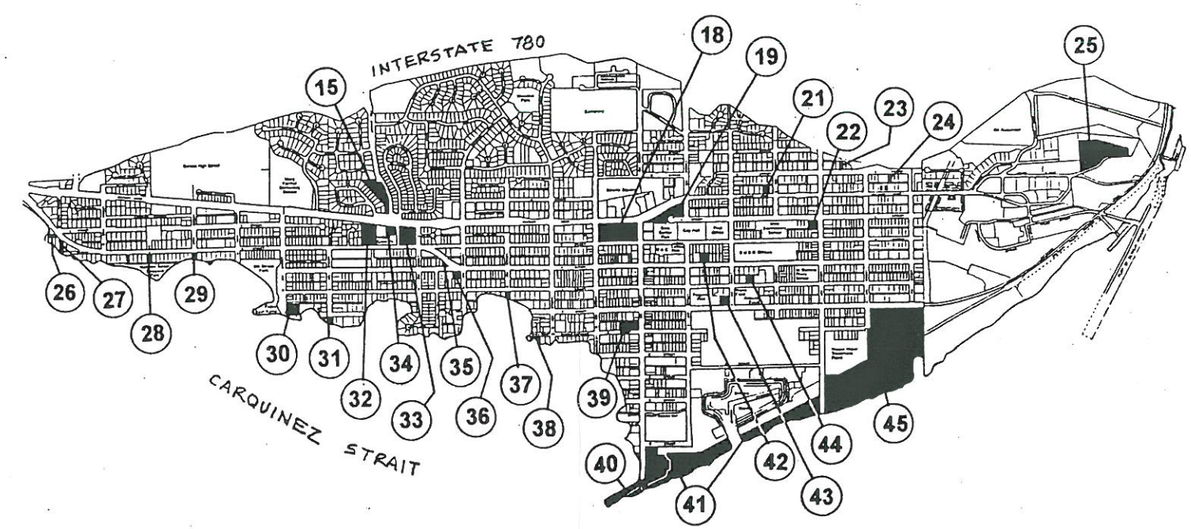
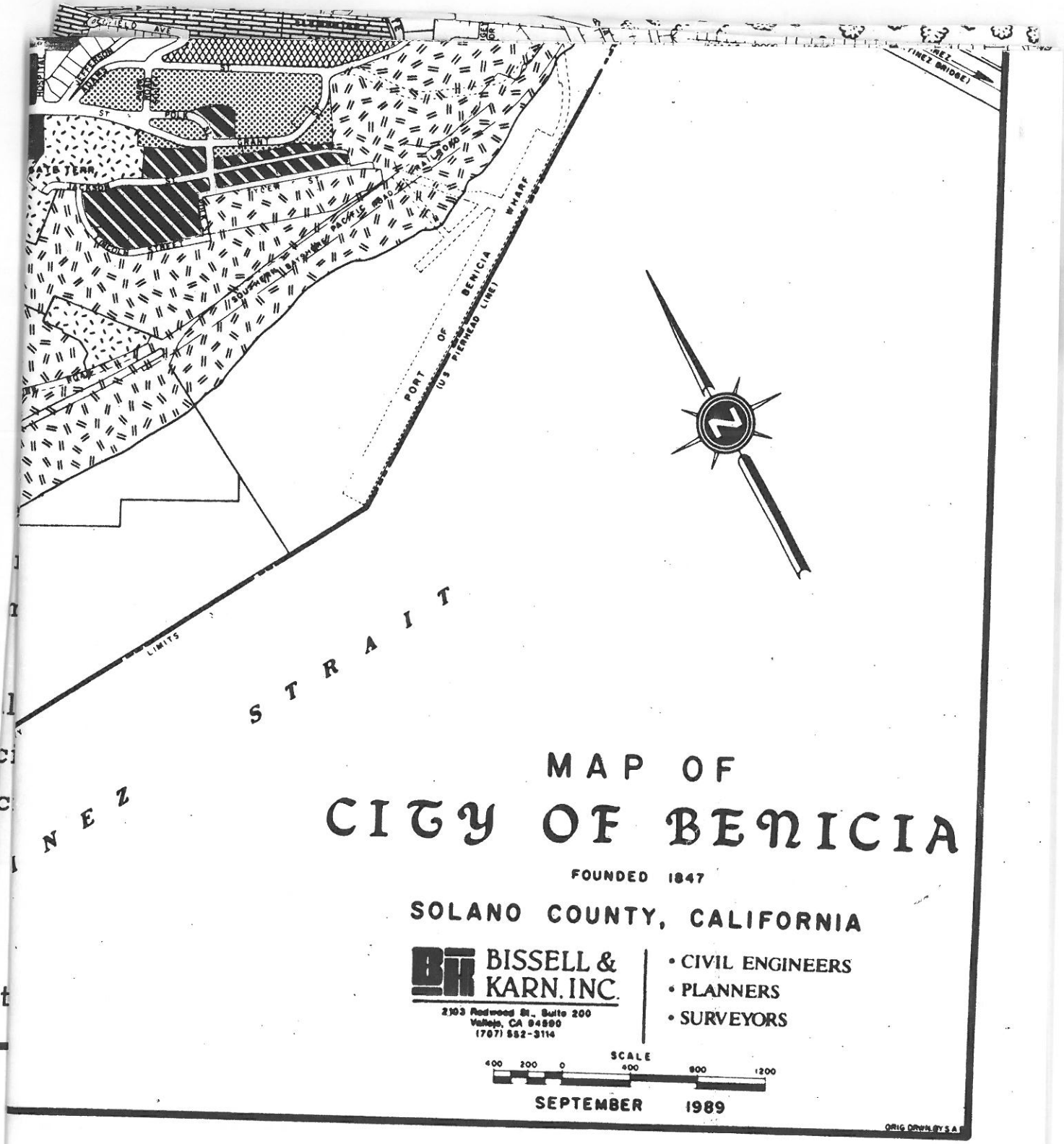


FIGURE C-1a

AVAILABLE FOR VIEWING
IN THE CITY ATTORNEY'S OFFICE.



APPENDIX D

EXPOSURE PARAMETERS AND EQUATIONS

Table D-1. Exposure Parameters Used to Develop Benicia Screening Levels for Soil
Former Benicia Arsenal, Benicia, California

Parameter	Symbol	Units	Value	Source
Target Risk	TR	unitless	1.00E-06	-
Target Hazard Quotient	THQ	unitless	1	-
Ingestion Rate of Soil-Adult Resident	IRS_{adult}	mg/day	100	1
Ingestion Rate of Soil-Child Resident	IRS_{child}	mg/day	200	1
Age-Adjusted Ingestion Rate-Soil, Resident	IFS_{adj}	mg-yr/kg-day	114	2, 1
Ingestion Rate of Soil-Commercial Worker	IRS_{w}	mg/day	50	1
Ingestion Rate of Soil-Construction/Utility Worker	IRS_{cw}	mg/day	480	3
Exposed Surface Area-Soil Contact-Adult Resident	SA_{adult}	cm^2/day	5700	1
Exposed Surface Area-Soil Contact-Child Resident	SA_{child}	cm^2/day	2800	1
Age-Adjusted Surface Area Resident	SFS_{adj}	mg-yr/kg-day	360.8	2, 1
Exposed Surface Area-Soil Contact-Commercial Worker	SA_{w}	cm^2/day	3300	1
Exposed Surface Area-Soil Contact-Construction Worker	SA_{cw}	cm^2/day	5800	3
Adherence Factor-Adult	AF_{adult}	mg/cm^2	0.07	1
Adherence Factor-Child	AF_{child}	mg/cm^2	0.2	1
Adherence Factor-Commercial Worker	AF_{w}	mg/cm^2	0.2	1
Adherence Factor-Construction/Utility Worker	AF_{cw}	mg/cm^2	0.51	3
Soil-to-Skin Absorption Factor	ABS	unitless	CS	1
Inhalation Rate-Adult Resident	IRA_{adult}	m^3/day	20	1
Inhalation Rate-Child Resident	IRA_{child}	m^3/day	10	1
Age-Adjusted Inhalation Rate-Soils, Resident	IF_{adj}	m^3-yr/kg-day	10.9	2, 1
Age-Adjusted Inhalation Rate-Soils, Open Space Visitor	IF_{adj-v}	m^3-yr/kg-day	2.1	4
Inhalation Rate-Commerical Worker	IRA_{w}	m^3/day	20	1
Inhalation Rate-Construction/Utility Worker	IRA_{cw}	m^3/day	20	3
Inhalation Rate-Open Space Visitor	IRA_{v}	m^3/day	20	4
Exposure Frequency-Resident	EF_{r}	days/year	350	1
Exposure Frequency-Commercial Worker	EF_{w}	days/year	250	1
Exposure Frequency-Construction/Utility Worker	EF_{cw}	days/year	20	3
Exposure Frequency-Open Space Visitor	EF_{v}	days/year	20	4
Exposure Duration-Adult Resident	ED_{adult}	years	30	1
Exposure Duration-Child Resident	ED_{child}	years	6	1
Exposure Duration-Commercial Worker	ED_{w}	years	25	1
Exposure Duration-Construction/Utility Worker	ED_{cw}	years	7	3
Exposure Duration-Open Space Child Visitor	ED_{v-c}	years	1	4
Exposure Duration-Open Space Adult Visitor	ED_{v-a}	years	6	4
Averaging Time-Adult (Carcinogens)	AT_{c}	days	25550	1
Averaging Time-Adult Resident (Noncarcinogens)	AT_{nc-a}	days	10950	ED_{adult} x 365
Averaging Time-Child (Noncarcinogens)	AT_{nc-c}	days	2190	ED_{child} x 365
Averaging Time-Commercial Worker (Noncarcinogens)	AT_{nc-w}	days	9125	ED_{w} x 365
Averaging Time-Construction Worker (Noncarcinogens)	AT_{nc-cw}	days	2555	ED_{cw} x 365
Averaging Time-Open Space Child Visitor (Noncarcinogens)	AT_{nc-vc}	days	365	ED_{v-c} x 365
Averaging Time-Open Space Adult Visitor (Noncarcinogens)	AT_{nc-va}	days	2190	ED_{v-a} x 365
Conversion Factor	CF	mg/kg	1.E+06	-
Body Weight-Adult	BW_{adult}	kg	70	1
Body Weight-Child	BW_{child}	kg	15	1
Volatilization Factor	VF	m^3/kg	CS	1
Particulate Emission Factor-Resident/Worker	PEF	m^3/kg	1.32E+09	1
Particulate Emission Factor-Construction/Utility Worker	PEF_{cw}	m^3/kg	1.44E+06	3
Particulate Emission Factor-Open Space Visitor	PEF_{v}	m^3/kg	1.32E+09	4

[1] USEPA (2000b). USEPA Region 9 Preliminary Remediation Goals 2000 Update.
[2] USEPA (1991b) Risk Assessment Guidance for Superfund. Part B, Development of Risk-based Preliminary Remediation Goals.
[3] RWQCB (2001). Risk-Based Screening Levels for Impacted Soil and Goundwater.
[4] Assumed a total exposure duration of 7 years for an individual from 6 to 12 years of age.
CS = Chemical-specific. See Table B-1.

APPENDIX E

SCREENING LEVELS FOR SOIL

Table E-1. Benicia Screening Levels For Soil by Potential Exposure Scenario
Former Benicia Arsenal, Benicia, California

Chemical of Interest	Commercial/Industrial Workers		Construction/Utility Workers		Residents[1]	Adult Residents	Child Residents	Open Space Visitors[1]	Adult Open Space Visitors	Child Open Space Visitors
	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Noncarcinogens (mg/kg)
1,1,1,2-Tetrachloroethane	7.0E+00	2.0E+03	2.5E+02	1.9E+04	3.0E+00	1.4E+03	4.9E+02	3.1E+02	2.5E+04	5.4E+03
1,1,1-Trichloroethane	NC	3.2E+03	NC	2.4E+04	NC	2.1E+03	6.4E+02	NC	4.4E+04	9.4E+03
1,1,2,2-Tetrachloroethane	9.1E-01	3.9E+03	3.2E+01	3.8E+04	3.9E-01	2.7E+03	9.8E+02	4.0E+01	5.0E+04	1.1E+04
1,1,2-Trichloroethane	1.9E+00	1.5E+02	7.3E+01	1.6E+03	8.4E-01	1.1E+02	4.1E+01	8.3E+01	1.9E+03	4.2E+02
1,1-Dichloroethane	NC	2.1E+03	NC	2.4E+04	NC	1.5E+03	5.9E+02	NC	2.6E+04	5.6E+03
1,1-Dichloroethene	1.2E-01	6.7E+01	4.8E+00	8.2E+02	5.4E-02	4.8E+01	2.0E+01	5.1E+00	8.5E+02	1.8E+02
1,2,3-Trichloropropane	3.1E-03	3.9E+01	1.3E-01	4.7E+02	1.4E-03	2.7E+01	1.2E+01	1.3E-01	4.8E+02	1.0E+02
1,2,4-Trichlorobenzene	NC	7.6E+03	NC	2.3E+04	NC	4.0E+03	6.5E+02	NC	1.5E+05	3.3E+04
1,2,4-Trimethylbenzene	NC	1.7E+02	NC	2.1E+03	NC	1.2E+02	5.2E+01	NC	2.1E+03	4.6E+02
1,2-Dibromo-3-Chloropropane	4.0E+00	6.9E+00	1.9E+01	5.7E+01	4.5E-01	4.7E+00	1.5E+00	6.4E+03	9.2E+01	2.0E+01
1,2-Dibromoethane	4.8E-02	2.6E+00	3.0E-01	2.7E+01	6.9E-03	1.8E+00	6.9E-01	7.3E+00	3.4E+01	7.2E+00
1,2-Dichlorobenzene	NC	3.3E+03	NC	3.6E+04	NC	2.3E+03	9.0E+02	NC	4.2E+04	9.0E+03
1,2-Dichloroethane	7.6E-01	3.5E+01	3.1E+01	4.4E+02	3.5E-01	2.5E+01	1.1E+01	3.3E+01	4.4E+02	9.4E+01
1,2-Dichloropropane	7.7E-01	2.1E+01	3.2E+01	2.5E+02	3.5E-01	1.5E+01	6.1E+00	3.3E+01	2.7E+02	5.7E+01
1,3,5-Trimethylbenzene	NC	7.0E+01	NC	8.7E+02	NC	5.0E+01	2.1E+01	NC	8.7E+02	1.9E+02
1,3,5-Trinitrobenzene	NC	2.6E+04	NC	4.9E+04	NC	1.6E+04	1.8E+03	NC	2.5E+09	5.4E+08
1,3-Dichlorobenzene	NC	5.2E+01	NC	5.2E+02	NC	3.6E+01	1.3E+01	NC	6.7E+02	1.4E+02
1,3-Dinitrobenzene	NC	8.8E+01	NC	1.6E+02	NC	5.2E+01	6.1E+00	NC	8.4E+06	1.8E+06
1,4-Dichlorobenzene	8.1E+00	1.2E+04	2.8E+02	5.6E+04	3.4E+00	7.2E+03	1.6E+03	3.6E+02	1.9E+05	4.1E+04
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	2.7E-05	C	1.5E-04	C	3.9E-06	C	C	5.3E+00	C	C
2,3,7,8-Tetrachlorodibenzofuran	1.4E+00	C	7.1E-02	C	6.8E-01	C	C	6.2E+01	C	C
2,4,5-Trichlorophenol	NC	8.8E+04	NC	1.6E+05	NC	5.2E+04	6.1E+03	NC	8.4E+09	1.8E+09
2,4,6-Trichlorophenol	2.2E+02	C	1.5E+03	C	4.4E+01	C	C	7.3E+07	C	C
2,4,6-Trinitrotoluene	8.2E+01	4.4E+02	5.4E+02	8.1E+02	1.6E+01	2.6E+02	3.1E+01	2.7E+07	4.2E+07	9.0E+06
2,4-Dichlorophenol	NC	2.6E+03	NC	4.9E+03	NC	1.6E+03	1.8E+02	NC	2.5E+08	5.4E+07
2,4-Dimethylphenol	NC	1.8E+04	NC	3.2E+04	NC	1.0E+04	1.2E+03	NC	1.7E+09	3.6E+08
2,4-Dinitrophenol	NC	1.8E+03	NC	3.2E+03	NC	1.0E+03	1.2E+02	NC	1.7E+08	3.6E+07
2,4-Dinitrotoluene	3.6E+00	1.8E+03	2.4E+01	3.2E+03	7.1E-01	1.0E+03	1.2E+02	1.2E+06	1.7E+08	3.6E+07
2,6-Dinitrotoluene	3.6E+00	C	2.4E+01	C	7.1E-01	C	C	1.2E+06	C	C
2-Chloronaphthalene	NC	2.7E+04	NC	1.4E+05	NC	1.7E+04	3.9E+03	NC	4.1E+05	8.8E+04
2-Chlorophenol	NC	2.4E+02	NC	2.5E+03	NC	1.7E+02	6.3E+01	NC	3.1E+03	6.6E+02
2-Chlorotoluene	NC	5.7E+02	NC	6.3E+03	NC	4.0E+02	1.6E+02	NC	7.2E+03	1.5E+03
2-Methylphenol	NC	4.4E+04	NC	8.1E+04	NC	2.6E+04	3.1E+03	NC	4.2E+09	9.0E+08
2-Nitroaniline	NC	5.0E+01	NC	9.2E+01	NC	3.0E+01	3.5E+00	NC	4.8E+06	1.0E+06
2-Nitrotoluene	NC	2.0E+03	NC	1.4E+04	NC	1.3E+03	3.7E+02	NC	2.8E+04	6.0E+03

Table E-1. Benicia Screening Levels For Soil by Potential Exposure Scenario
Former Benicia Arsenal, Benicia, California

Chemical of Interest	Commercial/Industrial Workers		Construction/Utility Workers		Residents[1]	Adult Residents	Child Residents	Open Space Visitors[1]	Adult Open Space Visitors	Child Open Space Visitors
	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Noncarcinogens (mg/kg)
Carbon Tetrachloride	5.2E-01	7.0E+00	2.1E+01	8.4E+01	2.4E-01	5.0E+00	2.1E+00	2.3E+01	8.8E+01	1.9E+01
Chlordane (Alpha)	1.1E+01	6.7E+02	6.0E+01	1.0E+03	1.6E+00	3.1E+02	3.5E+01	2.3E+06	1.7E+07	3.6E+06
Chlordane (Gamma)	1.1E+01	6.7E+02	6.0E+01	1.0E+03	1.6E+00	3.1E+02	3.5E+01	2.3E+06	1.7E+07	3.6E+06
Chlorobenzene	NC	5.4E+02	NC	6.1E+03	NC	3.8E+02	1.5E+02	NC	6.9E+03	1.5E+03
Chloroethane	6.5E+00	1.9E+04	2.8E+02	2.0E+05	3.0E+00	1.3E+04	5.0E+03	2.8E+02	2.4E+05	5.2E+04
Chloroform	5.2E-01	1.3E+00	2.3E+01	1.6E+01	2.4E-01	9.2E-01	3.9E-01	2.2E+01	1.6E+01	3.5E+00
Chloromethane	2.7E+00	5.2E+02	1.1E+02	6.5E+03	1.2E+00	3.7E+02	1.6E+02	1.1E+02	6.5E+03	1.4E+03
Chromium, Total	4.5E+02	C	2.2E+01	C	2.1E+02	C	C	1.9E+04	C	C
Chrysene	2.8E+02	C	2.0E+03	C	6.1E+01	C	C	5.4E+05	C	C
Cis-1,2-Dichloroethylene	NC	1.5E+02	NC	1.7E+03	NC	1.0E+02	4.3E+01	NC	1.9E+03	4.0E+02
Cis-1,3-Dichloropropene	1.6E+00	4.7E+01	5.8E+01	5.9E+02	7.0E-01	3.4E+01	1.4E+01	7.1E+01	5.9E+02	1.3E+02
Cobalt	NC	1.2E+05	NC	1.6E+05	NC	4.4E+04	4.7E+03	NC	NA	NA
Copper	NC	7.6E+04	NC	9.9E+04	NC	2.7E+04	2.9E+03	NC	NA	NA
Cyanide	NC	4.1E+04	NC	3.2E+04	NC	1.5E+04	1.6E+03	NC	7.2E+07	1.5E+07
Dibenz(a,h)anthracene	2.9E-01	C	2.0E+00	C	6.2E-02	C	C	2.6E+05	C	C
Dibenzofuran	NC	5.1E+03	NC	1.0E+04	NC	2.2E+03	2.9E+02	NC	1.7E+05	3.6E+04
Dibromochloromethane	2.7E+00	1.6E+03	8.9E+01	1.5E+04	1.1E+00	1.1E+03	3.8E+02	1.2E+02	2.1E+04	4.4E+03
Dichlorodifluoromethane	NC	3.1E+02	NC	3.8E+03	NC	2.2E+02	9.4E+01	NC	3.8E+03	8.2E+02
Dieldrin	1.5E-01	4.4E+01	1.0E+00	8.1E+01	3.0E-02	2.6E+01	3.1E+00	5.0E+04	4.2E+06	9.0E+05
Diethyl Phthalate	NC	7.0E+05	NC	1.3E+06	NC	4.2E+05	4.9E+04	NC	6.7E+10	1.4E+10
Dimethyl Phthalate	NC	8.8E+06	NC	1.6E+07	NC	5.2E+06	6.1E+05	NC	8.4E+11	1.8E+11
Di-n-Butyl Phthalate	NC	2.0E+05	NC	2.6E+05	NC	7.3E+04	7.8E+03	NC	8.4E+09	1.8E+09
Di-n-Octylphthalate	NC	1.8E+04	NC	3.2E+04	NC	1.0E+04	1.2E+03	NC	1.7E+09	3.6E+08
Endosulfan (Alpha)	NC	5.3E+03	NC	9.7E+03	NC	3.1E+03	3.7E+02	NC	5.0E+08	1.1E+08
Endosulfan (Beta)	NC	5.3E+03	NC	9.7E+03	NC	3.1E+03	3.7E+02	NC	5.0E+08	1.1E+08
Endosulfan Sulfate	NC	5.3E+03	NC	9.7E+03	NC	3.1E+03	3.7E+02	NC	5.0E+08	1.1E+08
Endrin	NC	2.6E+02	NC	4.9E+02	NC	1.6E+02	1.8E+01	NC	2.5E+07	5.4E+06
Ethyl Methacrylate	NC	7.0E+02	NC	8.4E+03	NC	5.0E+02	2.1E+02	NC	8.8E+03	1.9E+03
Ethylbenzene	NC	6.0E+03	NC	6.0E+04	NC	4.1E+03	1.5E+03	NC	7.7E+04	1.6E+04
Fluoranthene	NC	3.0E+04	NC	5.8E+04	NC	1.9E+04	2.3E+03	NC	3.4E+09	7.2E+08
Fluorene	NC	3.3E+04	NC	9.2E+04	NC	1.7E+04	2.6E+03	NC	7.0E+05	1.5E+05
Gamma BHC (Lindane)	2.9E+00	4.0E+02	1.6E+01	6.3E+02	4.4E-01	1.9E+02	2.1E+01	6.2E+05	2.5E+07	5.4E+06
Heptachlor	5.5E-01	4.4E+02	3.6E+00	8.1E+02	1.1E-01	2.6E+02	3.1E+01	1.7E+05	4.2E+07	9.0E+06
Heptachlor Epoxide	2.7E-01	1.1E+01	1.8E+00	2.1E+01	5.3E-02	6.8E+00	7.9E-01	8.8E+04	1.1E+06	2.3E+05
Hexachlorobenzene	1.5E+00	7.0E+02	1.0E+01	1.3E+03	3.0E-01	4.2E+02	4.9E+01	5.0E+05	6.7E+07	1.4E+07

Table E-1. Benicia Screening Levels For Soil by Potential Exposure Scenario
Former Benicia Arsenal, Benicia, California

Chemical of Interest	Commercial/Industrial Workers		Construction/Utility Workers		Residents[1]	Adult Residents	Child Residents	Open Space Visitors[1]	Adult Open Space Visitors	Child Open Space Visitors
	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Noncarcinogens (mg/kg)
PCB-1260 (Arochlor 1260)	1.0E+00	C	7.0E+00	C	2.2E-01	C	C	4.0E+05	C	C
Pentachlorophenol	1.1E+01	1.4E+04	8.6E+01	3.1E+04	3.0E+00	1.1E+04	1.4E+03	6.7E+06	2.5E+09	5.4E+08
Phenol	NC	5.3E+05	NC	9.7E+05	NC	3.1E+05	3.7E+04	NC	5.0E+10	1.1E+10
Pyrene	NC	5.4E+04	NC	7.9E+04	NC	2.1E+04	2.3E+03	NC	5.9E+06	1.3E+06
Sec-Butylbenzene	NC	4.2E+02	NC	4.4E+03	NC	2.9E+02	1.1E+02	NC	5.3E+03	1.1E+03
Selenium	NC	1.0E+04	NC	1.3E+04	NC	3.7E+03	3.9E+02	NC	NA	NA
Silver	NC	1.0E+04	NC	1.3E+04	NC	3.7E+03	3.9E+02	NC	NA	NA
Styrene	NC	2.0E+04	NC	1.8E+05	NC	1.4E+04	4.6E+03	NC	2.7E+05	5.8E+04
Tert-Butyl Methyl Ether	3.7E+01	C	1.5E+03	C	1.7E+01	C	C	1.6E+03	C	C
Tert-Butylbenzene	NC	5.0E+02	NC	5.2E+03	NC	3.5E+02	1.3E+02	NC	6.5E+03	1.4E+03
Tetrachloroethylene	1.9E+01	1.7E+03	3.4E+02	1.2E+04	5.7E+00	1.1E+03	3.3E+02	9.7E+02	2.3E+04	5.0E+03
Thallium	NC	1.3E+02	NC	1.8E+02	NC	4.8E+01	5.2E+00	NC	NA	NA
Tin	NC	1.2E+06	NC	1.6E+06	NC	4.4E+05	4.7E+04	NC	NA	NA
Toluene	NC	2.0E+03	NC	2.4E+04	NC	1.4E+03	5.9E+02	NC	2.5E+04	5.3E+03
Toxaphene	2.2E+00	C	1.5E+01	C	4.4E-01	C	C	7.3E+05	C	C
TPH-Diesel Range Organics[3]	NC	1.0E+02	NC	1.6E+04	NC	1.0E+02	NC	NC	NA	NA
TPH-Gasoline Range Organics[3]	NC	1.0E+02	NC	1.6E+04	NC	1.0E+02	NC	NC	NA	NA
TPH-Residual Range Organics[3]	NC	1.0E+03	NC	1.6E+04	NC	5.0E+02	NC	NC	NA	NA
Trans-1,2-Dichloroethene	NC	2.1E+02	NC	2.6E+03	NC	1.5E+02	6.3E+01	NC	2.7E+03	5.8E+02
Trans-1,3-Dichloropropene	1.6E+00	4.7E+01	5.8E+01	5.9E+02	7.0E-01	3.4E+01	1.4E+01	7.1E+01	5.9E+02	1.3E+02
Trichloroethylene	6.1E+00	7.9E+01	2.5E+02	9.4E+02	2.8E+00	5.6E+01	2.3E+01	2.6E+02	9.9E+02	2.1E+02
Trichlorofluoromethane	NC	1.3E+03	NC	1.6E+04	NC	9.1E+02	3.9E+02	NC	1.6E+04	3.4E+03
Vanadium	NC	1.4E+04	NC	1.9E+04	NC	5.1E+03	5.5E+02	NC	NA	NA
Vinyl Acetate	NC	1.4E+03	NC	1.7E+04	NC	1.0E+03	4.3E+02	NC	1.7E+04	3.7E+03
Vinyl Chloride	4.3E-01	1.5E+02	9.7E+00	1.5E+03	1.5E-01	1.0E+02	3.9E+01	2.0E+01	1.9E+03	4.1E+02
Zinc	NC	6.1E+05	NC	8.0E+05	NC	2.2E+05	2.3E+04	NC	NA	NA

[1] Age-adjustment for carcinogenic chemicals takes into account both child and adult soil exposures per USEPA (1991b) guidance.

[2] BSLs for lead are based on the USEPA's Integrated Exposure Uptake Biokinetic Model and recommendations of USEPA's Technical Review Workgroup.

[3] BSLs for TPH from RWQCB, 2001.

Note: BSLs are based on ingestion of soil, dermal contact with soil, and inhalation of dust particles and vapors.

NC = Chemical is a noncarcinogen. No BSL developed for cancer endpoint.

C = Chemical is a carcinogen. No BSL developed for noncancer endpoint.

NA = Not available.

APPENDIX F

EXAMPLE SOIL BSL CALCULATIONS FOR TRICHLOROETHENE

Table F-1. Example Soil BSL Calculations for Trichloroethene
Former Benicia Arsenal, Benicia, California

Chemical of Interest	Commercial/Industrial Workers	
	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)
Trichloroethylene	6.1E+00	7.9E+01

Carcinogenic Chemicals - Commercial/Industrial Workers

Csoil = (TR x BWadult x ATc) / (EFw x EDw [(IRSw x CSFo / CF)
+ (SAw x AFw x ABS x CSFo/ CF) +(IRAw x CSFi / PEF (or VF))])

Csoil = (1E-6 x 70kg x 25550d) / (250(d/yr) x 25yr [(50(mg/d) x 1.1E-2(mg/kg-day)$^{-1}$ / 1E6(mg/kg)
+ (3300(cm^2/d) x 0.2(mg/cm^2) x 0 x 1.1E-2(mg/kg-day)$^{-1}$/ 1E6(mg/kg))+ (20(m^3/d) x 6E-3(mg/kg-day)$^{-1}$ / 2.6E3(m^3/kg))])

Csoil = 6.1 mg/kg

Noncarcinogenic Chemicals - Commerical/Industrial Workers

Csoil = (THQ x BWadult x ATnc-w) / (EFw x EDw [(1 / RfDo x IRSw / CF)
+ (1 / RfDo x SAw x AFw x ABS / CF) + (1 / RfDi x IRAw / PEF (or VF))])

Csoil = (1 x 70kg x 9125d) / (250(d/yr) x 25yr [(1 / 6E-3(mg/kg-day) x 50(mg/d) / 1E6(mg/kg))
+ (1 / 6E-3(mg/kg-day) x 3300(cm^2/d) x 0.2(mg/cm^2) x 0 / 1E6(mg/kg))+ (1 / 6E-3(mg/kg-day) x 20(m^3/day) / 2.6E3(m^3/kg)))]

Csoil = 79 mg/kg