APPENDIX C

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SCOPING LEVEL ECOLOGICAL RISK ASSESSMENT WORK PLAN FOR BALLFIELDS PARCELS AT DODHF NOVATO, CALIFORNIA

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ACRONYMS AND ABBREVIATIONS

AE	assessment endpoint
AOPC	area of potential concern
BAF	bioaccumulation factor
BRAC	Base Realignment and Closure
BTAG	Biological Technical Assistance Group
CAFG	California Fish and Game
COPEC	contaminant of potential ecological concern
CSM	conceptual site model
CRWQCB	California Regional Water Quality Control Board
DDT	dichlorodiphenyltrichloroethane
DON	Department of the Navy
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
FWS	Fish and Wildlife Service
HAAF	Hamilton Army Airfield
HERD	Human and Ecological Risk Division
HQ	hazard quotient
LOAEL	low observed adverse effects level
NOAEL	no observed adverse effects level
PDD	perimeter drainage ditch
PRG	preliminary remedial goal
RDX	1,3,5-trinitrohexahydro-1,3,5-triazine
ROC	receptor of concern
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SLERA	Scoping-Level Ecological Risk Assessment
SUF	site use factor
TNT	trinitrotoluene
TRV	toxicity reference value
UCL	upper confidence level
VOC	volatile organic compound

Section 1.0: ECOLOGICAL RISK ASSESSMENT APPROACH

An ecological risk assessment will be conducted using existing and new chemical data from the Ballfields Parcels to evaluate the potential for adverse effects to ecological receptors resulting from exposure to contaminants in soil under current conditions. To evaluate these potential risks, multiple guidance manuals were considered: Department of Toxic Substance Control's (DTSC) 1996 *Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities*; U.S. EPA's 1992 *Framework for Ecological Risk Assessment* and 1997 *Ecological Risk Assessment Guidance for Superfund*; and the Navy's 2001 *Guidance for Conducting Ecological Risk Assessments*. DTSC is the lead regulatory agency for the Navy's Ballfields Parcels; therefore, the ecological risk assessment approach will closely follow DTSC and Navy guidance.

A phased approach will be followed for the ecological risk assessment at the Ballfields Parcels. The first phase consists of the scoping level ecological risk assessment (SLERA), which includes the development of a conceptual site model (CSM), identification of contaminants of potential ecological concern (COPECs), receptors of concern (ROCs), and potential exposure pathways. If the results of the scoping assessment indicate that ecological receptors may be exposed to contaminants present at the site, either directly or indirectly, then a Phase I predictive assessment will be conducted. Conservative exposure assumptions are made for ROCs and COPECs in a Phase I predictive assessment to estimate risk to biota at the site. If the Phase I assessment indicates that a Phase II validation study is warranted, assumptions used to estimate risk to exposed biota in Phase I will be refined and validated, where necessary, with site-specific sampling data. After the Phase II study, a Phase III impact assessment can be conducted to assess the severity and extent of population and community effects as input to the evaluation of remedial alternatives and refinement of remediation goals (DTSC, 1996). It is expected that the ecological risk assessment for the Ballfields Parcels will proceed through the SLERA and into the Phase I predictive assessment.

The overall objectives of the ecological risk assessment activities for the Ballfields Parcels are to:

1. Evaluate potential risks associated with exposure to COPECs detected in soil samples from the Ballfields Parcels using existing data and data collected during sampling activities;
2. Determine if further assessments are warranted and, if so, identify any additional data needs to support the assessments; and,
3. Conduct the additional ecological assessments, as required.

The following sections describe the recommended approach for conducting the ecological risk assessment at the Ballfields Parcels. The SLERA describes the CSM including a biological evaluation of the site, COPECs, fate and transport of those COPECs, potential exposure pathways, assessment endpoints, and ROCs. A description of the Phase I predictive assessment approach is provided, in addition to a preliminary Phase I predictive assessment of the risks associated with exposure to dichlorodiphenyltrichloroethane (DDT) concentrations previously measured in soil at the Ballfields Parcels.

1.1 Scoping Level Ecological Risk Assessment

As part of the SLERA, a CSM has been developed for the Ballfields Parcels. The preliminary CSM (Figure 1-1) identifies the receptors potentially at risk, the exposure media, and the

potentially complete exposure pathways present at the Ballfields Parcels. The following subsections provide a summary of the biological evaluation and applicable exposure pathways that exist at the Ballfields Parcels. Preliminary assessment endpoints that are recommended as the focus of the ecological risk assessment are presented and COPECs and ROCs are identified.

1.1.1 Biological Evaluation. The 18.37 acres comprising the Navy Ballfields Parcels is currently characterized as a terrestrial, grassland habitat with some developed areas (JSA, 1998). Annual grassland provides important habitat for wildlife. Because this land is fragmented by old service roads and the entire property encompasses a relatively small area, the quality of wildlife habitat is considered moderate (IT, 2001). The Ballfields Parcels are over 4,000 feet from San Pablo Bay, and in the 100-year floodplain. Therefore, this area is not tidally influenced and is characterized by upland flora and fauna. The grassland provides foraging habitat for a variety of animals, including deer, rodents, raptors, snakes, lizards, and songbirds. Ecological surveys have been conducted in the grasslands on the burrowing owl (LSA, 1997a) and bats (LSA, 1997b).

Plant Community

Common species of nonwoody plants have been considered representative of the Hamilton Army Airfield (HAAF) because they are important as primary producers and as prey sources to herbivorous animals. The Ballfields Parcels are dominated by blackberry bushes, although other weedy upland plants also grow in the area. These include yellow star thistle, wild radish, wild oat, black mustard, as well as grasses such as barley, ryegrass, and tall fescue (IT, 2001). The vegetation on the Ballfields Parcels provides habitat to terrestrial animal species as described below

Invertebrate Community

The invertebrate community on the Ballfields Parcels is expected to be typical of any terrestrial environment and consists of earthworms and various insects. These invertebrates play a variety of important roles in ecosystems. Their feeding and burrowing activities can enhance decomposition and nutrient cycling. Earthworm burrows can enhance water infiltration, and gas exchange. In addition, invertebrates serve the dietary needs of upper trophic species of birds and other omnivorous animals.

Avian Community

A variety of bird species have been observed on the Ballfields Parcels. These include scrub jays, swallows, meadowlarks, harriers, red-tailed hawks, sparrows, California quail, red-necked pheasant, turkey vulture, and American robins (Jolliffe, personal communication, 2004). Some bird species inhabit the property year-round, whereas others are migratory and make transient visits to the area for foraging or nesting.

Mammal Community

The Ballfields Parcels provide foraging and nesting habitats for several terrestrial species of mammals: coyote, striped skunk, desert cottontail, and black-tailed jack rabbit. The black-tailed deer (*Odocoileus hemionus*) is a large mammalian herbivore that is also known to occur at HAAF, feeding on non-woody plants within the Ballfields Parcels. The California vole (*Microtus californicus*) is a small common rodent that is abundant in dense annual grasslands, such as the Ballfields Parcels. It feeds on grasses, sedges, and herbs, and provides prey for hawks, owls, and snakes. Finally, the raccoon (*Procon lotor*) is a medium-sized omnivorous mammal that is an inhabitant of the Ballfields Parcels and other grassland areas where it often builds its home in the abandoned dens of other animals.

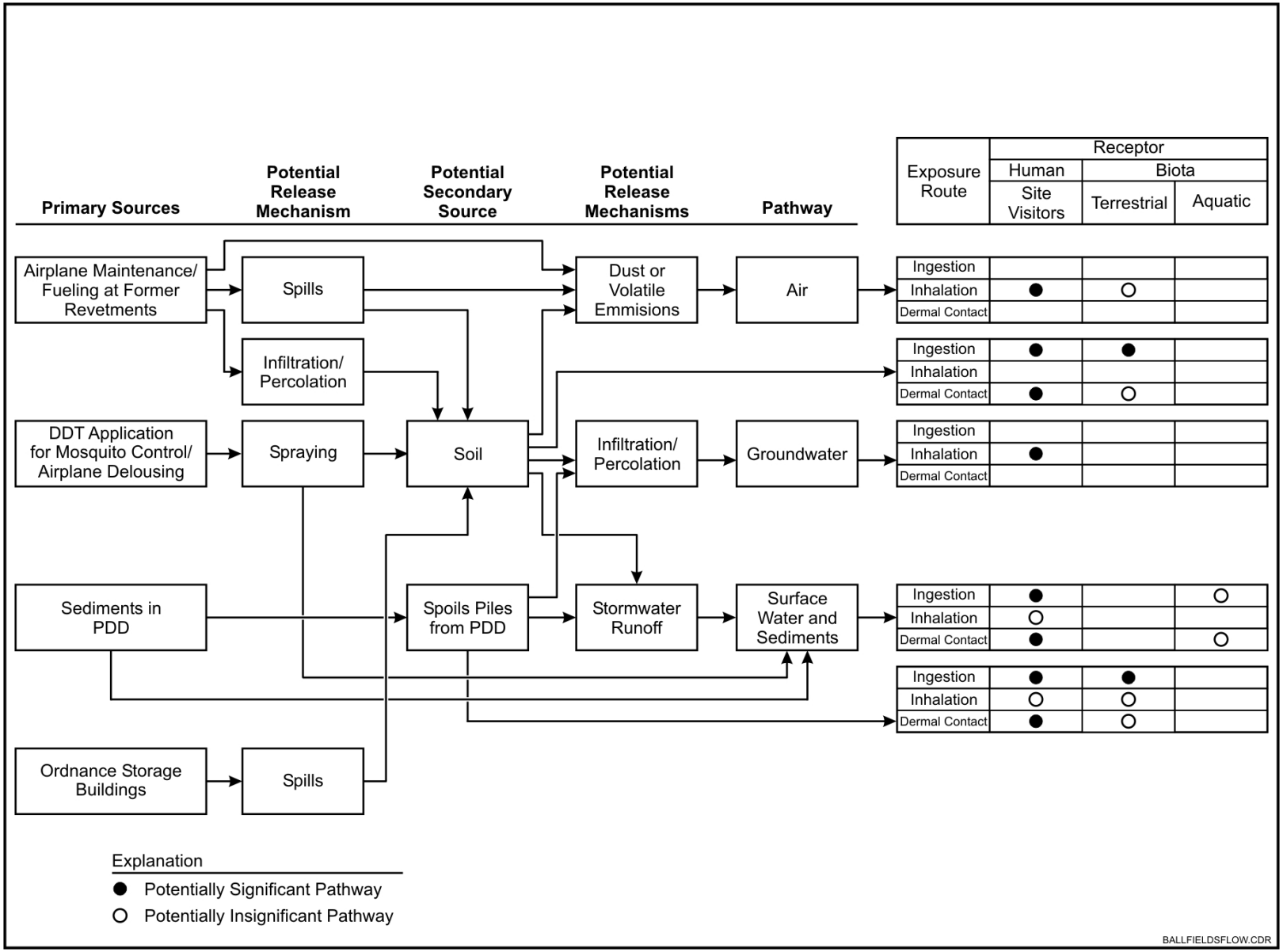

Figure 1-1. Conceptual Site Model

Special Status Species

The salt-marsh harvest mouse (*Reithrodontomys raviventris)* is listed as a federally endangered species by the US Fish and Wildlife Service (FWS) and inhabits the San Francisco, San Pablo, and Suisun Bays. Salt marsh harvest mice are critically dependent on dense cover and their preferred habitat is pickleweed, a common salt-marsh plant (*Salicornia virginica)*. Due to the lack of pickleweed within the Ballfields Parcels, these animals are not expected to inhabit the area. Based on biological surveys conducted by the Army Base Realignment and Closure (BRAC) Program and the Coastal Conservancy on the former HAAF property, there are no threatened or endangered species or habitats located in the area (Jolliffe, 2004). There are, however, several species of special concern, designated by the State of California. These include the northern harrier (*Circus cyaneus)* and the burrowing owl (*Speotyto cunicularia*). Given this special status designation, these two species are proposed as ROCs and will be discussed further in Section 1.1.5

1.1.2 Preliminary Exposure Pathways. The CSM is a framework for relating ecological receptors to contaminated media in order to identify and evaluate the significance of complete exposure pathways. In general, an exposure pathway describes the course a chemical takes from the source to the environmental media and then to the exposed receptor. An exposure pathway analysis links the source, location, and type of environmental release with population location and activity patterns to determine the primary pathways of exposure. If potentially complete and significant exposure pathways exist between contaminants and receptors, an assessment of potential effects and exposure is conducted. Only those potentially complete exposure pathways likely to contribute to the total exposure will be evaluated.

An exposure pathway is considered complete and significant if all four of the following elements are present:

1. A source and mechanism of chemical release to the environment;
2. An environmental transport medium (e.g., water or soil) for the released chemical;
3. A point of potential physical contact of a receptor with the contaminated medium (exposure point); and,
4. An exposure route (e.g., ingestion of contaminated prey, incidental ingestion of soil).

Terrestrial wildlife may be exposed to chemical contaminants through three major pathways: ingestion, dermal contact, or inhalation. The contaminants potentially present on the Ballfields Parcels that are most likely to present a risk through inhalation exposure are volatile organic compounds (VOCs), which rapidly volatilize from soil into the air where they are diluted and dispersed. Active uses of the Ballfields Parcels that could result in VOC impacts to soil were discontinued in the 1940s; therefore, risk through inhalation is unlikely. In addition, much of the contaminated soil is vegetated, further reducing exposure of soil to winds and, consequently, reducing aerial suspension of potentially contaminated dust particles. Thus, exposure through inhalation for ecological receptors is considered minor and will not be addressed in the ecological risk assessment.

Dermal exposure to soil contaminants for birds and mammals, although likely to occur, is considered to be minimal. The significant route of exposure for higher trophic level organisms is associated with ingestion of contaminated prey and direct /incidental ingestion of soil. Although established methods are available to assess dermal exposure to humans, only limited data is available to quantitatively assess dermal exposure to wildlife. In addition, the presence of feathers and fur along with grooming and preening activities greatly reduces soil contact with skin.

Groundwater has historically not been considered a significant pathway for contaminant transport at HAAF because of the extremely low hydraulic conductivity of the Bay Mud that underlies the site (IT, 2001). Periodic standing water may occur on the Ballfields Parcels resulting from severe storms which may cause minor pooling of surface water in the perimeter drainage ditch (PDD). However, these pools are temporary and do not support a sustainable habitat for aquatic wildlife. Furthermore, the PDD provides marginal quality habitat due to its hard (concrete) substrate and intermittent flow (extreme flow conditions are sometimes present during storms). These qualities would limit the abundance of aquatic receptors, and provide minimal sources of prey for piscivorous wildlife. The marginal habitat of the PDD is even more apparent when compared to alternative habitats in the vicinity of the Ballfield Parcels, including the estuarine and freshwater habitats within HAAF and proximity to San Pablo Bay.

A small pond of standing water exists on the site during the wet season (November to March), in a valley to the northwest of Revetment 2. This water body, which is no larger than 15 feet in diameter, did not exist until the City of Novato began depositing fill materials on the former revetments in the late 1990s, in preparation for improvement of the New Hamilton Partners Levee. It is noteworthy that although this pond exists during the winter, it is dry during the summer months. This pond collects runoff from the Coast Guard-owned hillside to the west and from the City of Novato-placed clean fill material to the east and south. This surface water body likely supports a few aquatic species, but is not considered an AOPC because 1) it did not exist during military activities at the site, 2) it is not present for a large portion of the year, and 3) any water runoff or surface soils that might be deposited into the pond are likely to be associated with the hillside to the west or the clean fill material owned by the City of Novato. Therefore, it is unlikely that there are any contaminants in the water; if any are present, they are not related to military activities. For this reason, water is not considered in this assessment. Ingestion of prey and incidental ingestion of soil is, therefore, considered the primary route of exposure for mammals and birds within the terrestrial site.

Exposure to contaminants from ingestion of sediments from the PDD was not considered an exposure pathway because 1) the presence of receptors is unlikely, and 2) all sediments were removed down to the concrete lining of the PDD in 1998. Any sediment currently present in the PDD is not likely to be associated with historical military activities; rather, the majority of sediment present in the PDD is likely associated with the City of Novato permitted storm water discharge outfall. Although input from upland erosion may be possible, the dense vegetation and groundcover throughout the property will bind the soils, limiting soil erosion and transport to the ditch.

A review of major exposure pathways indicates that there are potentially complete exposure pathways to avian receptors, including the American robin, burrowing owl, and northern harrier. Exposure pathways for omnivorous mammals, such as the raccoon, also appear to be complete. The rationale for selecting the receptors of concern is provided in Section 1.1.5.

1.1.3 Preliminary Assessment Endpoints. Based on the ecological resources and complete exposure pathways identified in the CSM, assessment endpoints (AEs) were developed to identify the ecological resources at the site that should be protected. In general, AE selection considers the ecosystem, communities, and species relevant to a specific site. AEs are defined based on technical considerations, including the:

- Chemicals present and their concentration;
- Mechanisms of toxicity of the chemicals to different groups of organisms;
- Ecologically relevant receptor groups that are potentially sensitive or highly exposed to the chemicals; and,

- Potentially complete exposure pathways.

The AEs selected to represent the resources to be protected at the Ballfields Parcels are:

1. Sufficient rates of survival, growth, and reproduction to sustain omnivorous mammal communities at the Ballfields Parcels.
2. Sufficient rates of survival, growth, and reproduction to sustain the avian community at the Ballfields Parcels.
3. The survival, growth, and reproduction of individuals of species of special concern at the Ballfields Parcels.

1.1.4 Preliminary COPEC Screening Process. COPECs will be screened during the SLERA because the CSM indicates that complete exposure pathways exist for the assessment endpoints identified in Section 1.1.3. DDT and the analytes detected in additional soil samples that are to be collected from the Ballfields Parcels will be examined using the following COPEC screening process:

1. Conservative soil screening benchmark values that are protective of plants will be compiled and compared to data from the Ballfields Parcels. Soil screening benchmarks will be obtained from the following sources: *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater* (CRWQCB, 2004) and Oak Ridge National Laboratory Toxicological Benchmarks (Efroymson et at., 1997); toxicity databases such as PHYTOTOX (1996) and relevant toxicity studies in the literature will be used when relevant toxicological data are not readily available. Table 1-1 outlines the preliminary soil screening benchmarks that have been identified for the COPEC screening.
2. Comparison of maximum detected soil concentrations to the identified benchmarks, and retain or exclude as part of the COPEC list according to the following:

    - Retain analytes with maximum detected concentration greater than the benchmark;
    - Retain detected analytes that are reasonably linked to past land uses, and for which there are no benchmarks; and,
    - Retain detected analytes that are on the U.S. EPA Region 9 list of bioaccumulative substances (Table 1-1) and are reasonably linked to past land uses for evaluation in the dose assessment exposure to upper trophic level organisms.
    - Retain detected analytes that do not have an established soil screening benchmark.

3. Comparison of non-detected concentrations to the conservative benchmarks, and retain as part of the COPEC list if the maximum reported detection limit exceeds the benchmark. Exclude if maximum detection limit is below benchmark.

4. Use of professional judgment to evaluate those constituents that are retained to this point. Analytes are considered for exclusion if seldom detected, or not detected but retained due to the lack of benchmarks to evaluate the adequacy of detection limits. Analytes such as PAHs are considered for exclusion when no ecological benchmarks exist and there are no known Navy sources, or there is unlikely to be a significant pathway to ecological

receptors. Any such exclusions would be clearly identified and considered in the uncertainty analysis of the risk assessment step.

Table 1-1. Preliminary Soil Screening Benchmarks for COPECs at the Ballfields Parcels

Chemical	Soil Concentration (mg/kg)	Reference
PAHs		
Acenaphthene	19	CRWQCB, 2004
Acenapthylene	13	CRWQCB, 2004
Anthracene[(a)]	2.8	CRWQCB, 2004
Benzo(a)anthracene[(a)]	0.38	CRWQCB, 2004
Benzo(a)pyrene[(a)]	0.04	CRWQCB, 2004
Benzo(b)fluoranthene[(a)]	0.38	CRWQCB, 2004
Benzo(g,h,i)perylene[(a)]	27	CRWQCB, 2004
Benzo(k)fluoranthene[(a)]	0.38	CRWQCB, 2004
Chrysene[(a)]	3.8	CRWQCB, 2004
Dibenzo(a,h)anthracene[(a)]	0.11	CRWQCB, 2004
Fluoranthene[(a)]	40	CRWQCB, 2004
Fluorene	8.9	CRWQCB, 2004
Indeno(1,2,3,-c,d)pyrene[(a)]	0.38	CRWQCB, 2004
Napthalene	4.5	CRWQCB, 2004
Phenanthrene[(a)]	11	CRWQCB, 2004
Pyrene[(a)]	85	CRWQCB, 2004
Pesticides/PCBs		
DDD	2.4	CRWQCB, 2004
DDE	1.7	CRWQCB, 2004
DDT[(a)]	1.7	CRWQCB, 2004
total PCBs[(a)]	0.4	CRWQCB, 2004
TPH		
TPH (gasolines)	100	CRWQCB, 2004
TPH (middle distillates)	500	CRWQCB, 2004
TPH (residual fuels)	500	CRWQCB, 2004
Metals and metalloids		
Arsenic[(a)]	5.5	CRWQCB, 2004
Barium	750	CRWQCB, 2004
Cadmium[(a)]	1.7	CRWQCB, 2004
Chromium[(a)]	58	CRWQCB, 2004
Lead[(a)]	200	CRWQCB, 2004
Mercury[(a)]	2.5	CRWQCB, 2004
Selenium[(a)]	10	CRWQCB, 2004
Silver[(a)]	20	CRWQCB, 2004
Explosives		
2,4-dinitrotoluene	0.86	CRWQCB, 2004
Nitrobenzene	40	Efroymson et al., 1997

(a) EPA Region 9 Bioaccumulator (Hoffman, 1998).

1.1.5 ROC Selection. Following DTSC guidance, the selection of ROCs takes into account species of special concern within California; the likelihood of the species expected to occur based on

existing conditions at the Ballfields Parcels; significance of the species to ecosystem function; availability of toxicity and life history data; and species sensitivity to expected COPECs. Because it is impractical to assess exposure to all potentially exposed species within a trophic group, representative species were selected as conservative surrogates for exposure to a group of taxonomically related and ecologically similar receptors. Representative species were chosen that have physiological, behavioral, and life history characteristics that represent chosen assessment endpoints for the ecological risk assessment (ERA). The following sections provide details about the selection of ROCs for mammals, insectivorous birds, and birds of prey, and include short descriptions of pertinent life history characteristics.

Mammals

Mammals, such as the raccoon, the California vole, and the black-tailed deer are seen foraging for prey on the Ballfields Parcels. These animals may be exposed to potential contaminants through the consumption of plants and incidental ingestion of contaminated soil. Herbivorous mammals such as the California vole (*Microtus californicus*) were not considered an ROC because they are accounted for during the assessment for upper-trophic predatory birds. The raccoon (*Procyon lotor*) was chosen to represent an omnivorous ROC for the following reasons:

- Raccoons inhabit dens in hollow trees lined with leaves, but may also use culverts, downed trees, woodchuck dens, and burrows of other animals (IT, 2001);

- These animals are omnivorous opportunistic feeders that will consume fruits and blackberries, nuts, insects, earthworms, eggs, and virtually any animal and vegetable matter (EPA, 1993). It was assumed for the purposes of the dose assessment model that the raccoon's diet was limited to terrestrial habitats, although raccoons will probably utilize a variety of habitats including wetlands and marshes which are present on the former Army BRAC-administered property;

- Raccoons are medium-sized mammals with a high percentage of lipid reserves (20-30% or more of body weight in the autumn) (EPA, 1993). Their high fat content makes them more likely to accumulate high concentrations of organic contaminants, such as DDT;

- The home range for raccoons varies depending on season and sex of the animal. Females tend to stay close to their den when nursing their young, while males tend to forage for prey further from their den. During winter months, hibernating animals travel little, while in the summer raccoons will travel up to several hundred acres. For the scoping-level assessment, the raccoon is assumed to spend all of its time on the Ballfields Parcels, to achieve the most conservative exposure.

Carnivorous Birds

A review of major exposure pathways to higher trophic levels indicates that there are potentially complete exposure pathways to carnivorous birds such as harriers, owls, and hawks. Exposure to these secondary and tertiary trophic consumers is through ingestion of prey that has been exposed to COPEC in the soil, as well as through incidental ingestion of surface soil during foraging and preening.

The northern harrier (*Circus cyaneus)* and burrowing owl (*Speotyto cunicularia*) have been observed frequently at the Ballfields Parcels and were chosen as ROCs for the following reasons:

- Both are listed as "species of concern" by the State of California;
- The burrowing owl builds its nest in burrows in the ground, thus making it more susceptible to incidental ingestion of contaminated soil than tree-nesting birds;
- Diets of both species are assumed to be 100% small mammals, thus bioaccumulation of contaminants up the prey chain from small mammals is possible;
- The burrowing owl has a small home range of less than 2.5 acres (CAFG, 1999), while the site area is approximately 18 acres;
- Although the northern harrier has a large home range, over 975 acres (CAFG, 1999), the scoping assessment assumes that harriers will forage and feed on small mammals and vegetation solely in the area of the Ballfields Parcels (i.e., site use factor =1).

Insectivorous Birds

Insectivorous birds may be potentially exposed to COPECs in soils at the Ballfields Parcels through foraging on prey that have bioaccumulated contaminants, or from incidental ingestion of contaminated soil or plants. Several species of songbirds have been observed including robins, cliff swallows, meadow larks, sparrows, and scrub-jays. Of these species, the American robin (*Turdus migratorius*) was selected as the ROC for the following reasons:

- The species is widespread in the area, building nests of mud lined with fine grass on a loose foundation of twigs and grass in any tree, shrub, or other supporting structure (Kaufman, 1996);
- Robins forage for earthworms by sight in shallow soil, running and pausing on open lawns and grassy fields (Kaufman, 1996);
- Robins are small birds with a home range of approximately 1.2 acres, indicating they may forage only within the property boundaries (i.e., site use factor = 1) once they are nested in the area of the Ballfields Parcels,
- For the scoping-level assessment, the robin's diet is assumed to consist of 100% earthworms as conservative assessment of exposure. However, the actual diet of a robin consists of at least 50% berries, such as blackberries, which are plentiful on the Ballfields Parcels (EPA, 1993).

The outcome of the SLERA will include a conceptual site model, COPEC list, list of ROCs, and potential exposure pathways. This information will be used in a Phase I predictive assessment to estimate the risk to ROCs at the Ballfields Parcels.

1.2 Phase I Predictive Assessment

To evaluate potential risks from the complete exposure pathways to ROCs at the Ballfields Parcels that are identified in the SLERA, a dose assessment will be performed using a prey-chain model. Dose estimates will be calculated for all COPECs in soils at the Ballfields Parcels and for the receptors of concern using the methods described below.

1.2.1 Exposure Assessment. The exposure assessment estimates potential exposure of ROCs to COPECs identified at the site. An exposure model incorporating natural history information and species characteristics (including diet composition, ingestion rates, body weights, and foraging ranges) for each receptor was developed to evaluate the exposure of ROCs to COPECs. It was assumed that ROCs are exposed to site contaminants through consumption of contaminated prey and incidental ingestion of soil.

The following dose model is used to assess exposure to upper trophic level ROCs and to characterize exposure:

$$Dose = \{[(C_{soil} \times IR_{soil}) + (C_{prey} \times IR_{prey})] \times SUF\}/BW \quad (1\text{-}1)$$

where,

Dose = daily dose resulting from ingestion of soil and prey (milligrams COPEC per kilograms body weight per day)
C_{soil} = concentration of COPEC in surface soil (milligrams COPEC per kilograms soil)
C_{prey} = concentration of COPEC in prey (milligrams COPEC per kilograms prey)
IR_{soil} = estimate of receptor's daily ingestion rate of surface soil (kilograms soil per day)
IR_{prey} = estimate of daily ingestion rate of prey (kilograms prey per day)
SUF = site use factor (unitless)
BW= body weight (kilograms).

Because the exposure (and therefore dose) for each ROC is different, the exposure factors used in the dose equation vary slightly based on the receptor being evaluated. For example, the estimated COPEC concentrations in prey tissue (C_{prey}) will be calculated based on soil chemistry data and chemical- and media-specific bioaccumulation factors (BAFs) reflective of the foraging habits of each receptor. The dose equations for each ROC are discussed below. The exposure factors proposed for the Phase 1 predictive assessment for each ROC are summarized in Table 1-2.

Table 1-2. Preliminary Selection of ROCs and Exposure Factors

Species Community	Preliminary ROC	Site Use Factor[a]	IR soil[b] (kg/day)	Fraction of Diet[c]	IR prey[d] (kg prey ww/day)	BW[e] (kg)
Mammals	Raccoon (*Procyon lotor)*	1	0.0308	1	1.18	5.7
Carnivorous Birds	Northern Harrier (*Circus cyaneus)*	1	0.000481	1	0.0707	0.349
	Burrowing Owl (*Speotyto cunicularia)*	1	0.0000795	1	0.0117	0.156
Insectivorous Birds	American Robin (*Turdus migratorius*)	1	0.0014	1	0.00089	0.0833
Prey Mammal[f]	California Vole (*Microtus californicus*)	1	0.00008	1	0.019	0.057

(a) Site Use Factor, most conservative at 1 (unitless).
(b) Ingestion rate of soil from Beyer et.al., 1994.
(c) Fraction of diet that is plant or worm (unitless).

(d) Ingestion rate of prey from EPA, 1993.
(e) Body weight of receptors: robin and northern harrier (DTSC, 2004); raccoon (EPA, 1993); burrowing owl (Plumpton and Lutz, 1994); vole (Silva and Downing, 1995).
(f) California Vole is not being considered as a ROC, exposure parameters are provided for prey-chain carnivorous bird dose models.

The following receptor-specific dose models (Equations 1-2 through 1-5) are all based on the basic dose equation (Equation 1-1) discussed above. These equations account for differences in exposure by incorporating species-specific (e.g., dietary composition) and chemical-specific (e.g., BAF) factors into the dose calculations.

Robin Dose Assessment Model

$$Dose_{robin} = \{(C_{soil} * IR_{soil}) + [((C_{soil} * f_{plant} * BAF_{plant}) + (C_{soil} * f_{worm} * BAF_{worm}))* IR_{prey}]\} /BW_{robin} \quad (1\text{-}2)$$

where:

$Dose_{robin}$ = daily dose of COPEC for a robin (mg/kg-day)
C_{soil} = concentration of COPEC in the soil (mg/kg)
IR_{soil} = incidental ingestion rate of soil for a robin (kg/day)
f_{worm} = fraction of diet that is worm
BAF_{worm} = COPEC bioaccumulation factor for worm
f_{plant} = fraction of diet that is plant
BAF_{plant} = bioaccumulation factor for plant
IR_{prey} = ingestion rate of worm tissue by robin (kg/day)
BW_{robin} = body weight of robin (kg)

Raccoon Dose Assessment Model

$$Dose_{rac} = [(C_{soil} * IR_{soil})+ (((C_{soil} * f_{plant} * BAF_{plant}) + (C_{soil} * f_{worm} * BAF_{worm}))*IR_{prey})]/BW_{rac} \quad (1\text{-}3)$$

where:

$Dose_{rac}$ = daily dose of COPEC for a raccoon (mg/kg-day)
C_{soil} = concentration of COPEC in the soil (mg/kg)
IR_{soil} = incidental ingestion rate of soil for the raccoon (kg/day)
f_{plant} = fraction of diet that is plant tissue (unitless)
f_{worm} = fraction of diet that is worm tissue (unitless)
BAF_{plant} = soil to plant bioaccumulation factor for COPEC
BAF_{worm} = soil to worm bioaccumulation factor for COPEC
IR_{prey} = ingestion rate of prey items for the raccoon (kg/day)
BW = body weight of raccoon (kg)

To determine the COPEC concentration associated with vole tissue (assumed to comprise 100% of the diet for the northern harrier and the burrowing owl), the following model will be used.

Vole

$$C_{vole} = [(C_{soil} * BAF_{plant} * IR_{plant}) + (C_{soil} * IR_{soil})]/BW \quad (1\text{-}4)$$

where:

C_{vole} = concentration of COPEC to which a vole is exposed on a daily basis (mg/kg-day)
C_{soil} = concentration of COPEC in the soil (mg/kg)
BAF_{plant} = bioaccumulation factor of soil to plant transfer of COPEC
IR_{plant} = vole's ingestion rate of plant (kg/day)

IR_{soil} = vole's ingestion rate of soil (kg/day)
BW = body weight of vole (kg)

To assess the exposure for the avian receptors of concern, the following dose models, incorporating the exposure factors proposed in Table 1-2, will be used:

Burrowing Owl and Northern Harrier Dose Assessment

$$Dose_{bird} = [(C_{vole} * BTF_{sm} * IR_{prey}) + (C_{soil} * IR_{soil})]/BW_{bird} \quad (1\text{-}5)$$

where:

$Dose_{bird}$ = daily dose of COPEC for an owl or harrier (mg/kg-day)
C_{soil} = concentration of COPEC in the soil (mg/kg)
BTF_{sm} = plant to small mammal biotransfer factor (kg plant/kg muscle)
IR_{prey} = ingestion rate of prey items for the owl or harrier (kg/day)
IR_{soil} = incidental ingestion rate of soil for the owl or harrier (kg/day)
BW_{bird} = body weight of owl or harrier (kg)

A central element of the Phase I predictive assessment will be a comparison of calculated doses to literature-derived toxicity reference values (TRVs). The dose is determined for each ROC and each COPEC. These results are then evaluated against a species-specific TRV to characterize potential risks. Because this assessment is based on conservative assumptions of exposure, if the Phase I assessment concludes that negligible risk exists, there is strong support for no further action at the site. Exceedances of the risk threshold observed during the Phase I process would indicate that further evaluation may be necessary before a definitive decision regarding the nature and magnitude of risks can be made. The approach for characterizing risks is discussed further in Section 1.2.3.

1.2.2 Effects Assessment. For the purpose of evaluating the potential effects associated with the doses calculated in the exposure assessment, chemical- and receptor-specific TRVs will be compared to the calculated doses. In general, a TRV is defined as a dose level at which a particular biological effect may be expected to occur in an organism, based on laboratory toxicological investigations. It is noteworthy that the calculation of TRVs commonly incorporates both toxicity-based reference doses as well as uncertainty factors to account for a wide range of limitations, including differential interspecies sensitivities.

The Navy, in consultation with the U.S. EPA Region 9 Biological Technical Assistance Group (BTAG) and DTSC (2000), has developed effects-based TRVs. Each of these values represents a critical exposure level from a toxicological study and is supported by a published dataset of toxicological exposures and effects (DON, 1998). Rather than derive a single point estimate associated with specific adverse biological effects, high and low TRVs were derived for each receptor and COPEC to reflect the variability of parameters within an ecological risk context. The low TRV is a conservative value consistent with a chronic, no observed adverse effects level (NOAEL). It represents a level at which adverse effects are unlikely to occur, and is used to identify sites posing little or no risk. Conversely, the high TRV is a less conservative estimator of potential adverse effects, falling approximately mid-range of all of the reported adverse effects. The high TRV represents a level at which adverse effects are highly likely to occur, helping to identify sites posing immediate risks. In some cases, the high and low TRV were derived using a NOAEL and lowest observed adverse effects level (LOAEL) from the same study; in other cases, independent NOAELs and LOAELs were selected as the low and high TRVs, respectively.

For the purpose of the Phase I predictive assessment, the TRVs developed by the Navy (DON, 1998) will be scaled to account for differences in body weights between the organism used to establish the TRVs (high and low) and the ecological ROCs chosen for evaluation at the Ballfields Parcels. This will be accomplished by using the following allometric conversion equation (Sample and Arenal, 1999):

$$TRV_w = TRV_l * (BW_s/BW_r)^a \quad (1\text{-}6)$$

where :

TRV_w = weight-adjusted TRV (mg/kg-day)
TRV_l = literature-based TRV (mg/kg-day)
BW_s = body weight of toxicity study receptor (kg)
BW_r = body weight of ecological ROCs (kg).
a = scaling factor (chemical and receptor specific)

Table 1-3 provides a summary of the available TRVs and the weighted adjusted TRVs for each of the ROCs being considered. For those COPECs for which TRVs have not been published, toxicity data from the literature would be used to develop the necessary TRVs. Available toxicity data would be evaluated as described by DTSC guidance (1996) for predictive risk assessment. Ideally the results of applicable chronic studies in which NOAELs were reported would be used with the appropriate uncertainty factor to derive a toxicity threshold value. In the absence of chronic NOAEL studies, acute NOAEL studies and acute and chronic studies with report LOAELs would be evaluated. DTSC's recommendations for the use of uncertainty factors ranging from 1 to 500 would apply to the derivation of TRVs.

1.2.3 Risk Characterization. The risk characterization combines the exposure and effects assessments to provide a quantitative estimate of the potential risks to the ROCs. For the Phase I risk characterization, estimated daily doses will be calculated for COPECs using the maximum site soil concentrations or 95% upper confidence limit (UCL), whichever is lower (as per U.S. EPA, 2002), and then compared to the high and low TRVs (weight-adjusted for the receptor) according to the following equation:

$$HQ = dose/TRV \quad (1\text{-}7)$$

As noted previously, conservative exposure parameters will be used to calculate doses for each ROC and each COPEC. These doses will be used to derive two hazard quotients (HQs) for each COPEC at each sample location, an HQ_{low} using the low TRV and an HQ_{high} using the high TRV. When the dose is lower than the low TRV (i.e., $HQ_{low} < 1$), it is likely that no risk is present from the specific COPEC. When the dose exceeds the low TRV (i.e., $HQ_{low} > 1$) in a Phase I predictive assessment, it indicates that further evaluation is warranted. When the dose exceeds the high TRV (i.e., $HQ_{high} > 1$), it may indicate that remedial action is warranted; however, the HQ_{high} changes when conservative exposure parameters are adjusted to be more site-specific in the refined ERA, and therefore should be re-evaluated.

1.3 Phase II: Validation Study

In the SLERA and Phase I predictive assessment, potentially complete and significant exposure pathways were defined from soil to ROCs foraging at the Ballfields Parcels. If there is an indication of potential adverse effects to upper trophic level birds or mammals when conservative exposure parameters are used in the Phase I, then a more in-depth evaluation of risk may be required in the form of a Phase II validation study.

Table 1-3. Summary of the Available TRVs and Weight-Adjusted TRVs for Each ROC at the Ballfields Parcel

Chemical	DTSC (mg/kg-day)[a]				Novato Ballfields Parcels (mg/kg-day)[b]							
	Mammals		Birds		Mammal		Birds					
					raccoon		robin		burrowing owl		northern harrier	
	TRV-high	TRV-low	TRV-high	TRV-low	TRV-high	TRV-low	TRV-high	TRV-low	TRV-high	TRV-low	TRV-high	TRV-low
PAHs												
DDT (total)[c]	16	0.8	1.5	0.009	36.95	1.85	0.7	0.004	0.8	0.005	0.95	0.006
Napthalene	150	50	NA	NA	126.9	42.3	NA	NA	NA	NA	NA	NA
PCB (total)	1.28	0.36	1.27	0.09	1.1	0.3	0.6	0.04	0.7	0.05	0.8	0.06
Metals and Metalloids												
Arsenic	4.7	0.32	22.01	5.5	3.98	0.3	10.4	2.6	11.8	2.95	13.9	3.5
Cadmium[d]	2.64	0.06	10.43	0.08	0.55	0.01	4.94	0.04	5.6	0.04	6.6	0.05
Lead	240.64	0.002	8.75	0.014	203.5	0.001	4.1	0.007	4.7	0.008	5.5	0.009
Mercury (total)	0.27	0.027	0.18	0.039	0.23	0.02	0.09	0.02	0.1	0.02	0.11	0.03
Selenium	1.21	0.05	0.93	0.23	1.02	0.04	0.44	0.11	0.5	0.1	0.59	0.15
Explosives												
2,4,6-trinitrotoluene[e] (TNT)	0.3	0.2	1.8	0.07	0.25	0.17	0.85	0.03	0.97	0.04	1.1	0.04
RDX [f]	2.73	1.19	8.14	3.65	2.3	1	3.9	1.7	4.4	2.0	5.1	2.3

NA = Not available.

(a) California Department of Toxic Substances Control (DTSC) Human and Ecological Risk Division (HERD) Ecological Risk Assessment Note, December 8, 2000. NAVY/BTAG Toxicity Reference Values.

(b) All TRVs for birds at Novato Ballfields Parcel were scaled to a factor of (1-1.2); all COPECs for raccoon (except DDT and cadmium; see footnotes c and d) were scaled to a factor of (1-0.94) per Sample and Arenal, 1999.

(c) For Novato Ballfields Parcel, raccoon DDT values were scaled to a factor of (1-1.3) per Sample and Arenal, 1999.

(d) For Novato Ballfields Parcel, raccoon cadmium values were scaled to a factor of (1-0.44) per Sample and Arenal, 1999.

(e) U.S. Center for Health Promotion and Preventive Medicine. *Wildlife Toxicity Assessment for 2,4,6-trinitrotoluene (TNT)*. October, 2000.

(f) U.S. Center for Health Promotion and Preventive Medicine. *Wildlife Toxicity Assessment for 1,3,5-trinitrohexahydro-1,3,5-triazine (RDX*). July, 2002.

In the Phase II validation study, the preliminary problem formulation developed in the SLERA/Phase I will be examined and refined based on sampling and analysis data and site-specific information to validate the results of the Phase I predictive assessment. The sampling and analysis plan (SAP), given as Appendix A to the work plan, includes provisions to collect additional soil chemistry data from the site that may be necessary when conducting the Phase II assessment. DTSC (1996) also recommends consideration of data that would assist in reducing uncertainties in the estimates of fate and transport, exposure, and toxicity. The results of the Phase I assessment will determine the types of data that may be necessary, but could include conducting toxicity tests to determine the effects of contaminants on soil invertebrate or plant receptors, chemical analysis of prey tissue (such as earthworms) to more accurately evaluate chemical exposures, or additional chemistry data to more accurately define the extent of soil contamination and exposures.

The Phase II assessment would include the following elements:

- Refinement of the COPECs;
- Refinement of the exposure and effects assessment;
- Risk characterization; and,
- Uncertainty analysis.

These elements are discussed further in the following sections.

1.3.1 Phase II COPEC Selection. A refined COPEC screen will focus on the list of COPECs requiring additional evaluation in the validation study by comparing site COPEC soil concentrations with ambient concentrations to identify COPECs that are within ambient or background levels. Distribution shift tests can be performed to compare the concentration distributions of the site and ambient datasets.

If adequate data are present at both the site and ambient stations, distribution shift tests will be performed consistent with Navy guidance (e.g., the t-test, Gehan test, quantile test, and slippage test). If one or more tests fail, the chemical will be retained for full evaluation in the ERA. No further evaluation in the ERA is necessary for constituents where all tests pass and chemical concentrations are found to be consistent with ambient conditions. The risk calculations for these chemicals would be presented and qualitatively discussed in the risk characterization step.

1.3.2 Phase II Exposure and Effects Assessment. For each of the assessment endpoints identified in the SLERA, further evaluation of exposure and effects would be conducted. Measurement endpoints for each AE would be proposed. The measurement endpoint is a quantitative expression of an observed or measured effect of the COPEC related to the assessment endpoint. Additional data collection may be required to quantify the measurement endpoints.

Refinement of Exposure Point Concentrations

Exposure point concentrations (EPC) may also be refined in Phase II. If sufficient data are available, an estimate of the central tendency of the soil concentrations of the COPECs from the Ballfields Parcels would be used. The central tendency would be estimated as the 95% UCL of the mean. The EPC would be either the 95% UCL or the maximum soil concentration, whichever was lower (as per EPA, 2002). When the calculated 95% UCL exceeds the maximum detected concentration, the EPC defaults to the maximum concentration.

In Phase I, all dose calculations conducted were performed using a site use factor (SUF) of 1.0, assuming that a receptor feeds within the Ballfields parcels 100% of the time. For those receptors

that have a home range greater than the area of the Ballfields parcels, a SUF less than 1.0 would be considered. Alternative SUFs would be discussed with the regulatory agencies, if necessary. In some cases, multiple SUFs may be proposed to provide upper and lower bounds of exposures. One method would be to reduce the SUF incrementally: 1, 0.5, 0.25, and use the estimated actual SUF for each ROC.

1.3.3 Phase II Risk Characterization. The Phase II risk characterization would be conducted in the same manner as the SLERA risk characterization. However, the exposure parameters would be refined as previously discussed and a refined estimate of daily doses would be calculated and compared to the high and low TRVs (weight-adjusted for the receptor) according to Equation 1-7 described above.

A summary of the results would be provided for each ROC in any Phase II risk assessment and the relative contributions of each chemical to the total risk would be identified and discussed. In addition, an uncertainty analysis would be provided that discusses any uncertainties associated with exposure concentrations, toxicity thresholds, exposure factors, and risk characterizations. Where possible, these discussions would include lower and upper bounds on the uncertainty to assist risk managers in making informed evaluations of these results.

Section 2.0: PRELIMINARY PHASE I PREDICTIVE ASSESSMENT FOR DDT EXPOSURE

The general approach of the ecological risk assessment described in Section 1.0 indicates that there are complete exposure pathways to ROCs at the Ballfields Parcels. A preliminary assessment was conducted to evaluate the potential ecological risks from DDT exposures at Spoils Pile N and the Ballfields Parcels to assist in the development of the field sampling plan. If current DDT concentrations in soil present a potential risk to ecological receptors, further sampling may be warranted to better characterize and delineate exposures as well as the extent of concern. Based on the ROCs and methodology described previously for the SLERA (Sections 1.1 and 1.2), a preliminary assessment was conducted and is described the following sections.

2.1 Summary of Existing DDT Data

In March and October 2003, the Army Corps of Engineers conducted an investigation of area-wide DDT (USACE, 2003a). The investigation focused on determining the total DDT concentrations in surface and subsurface soils throughout the airfield area. Samples were collected from a total of 116 locations over approximately 600 acres, or 1 sampling location per 6 acres. Of the 116 locations that were sampled, three were located on Navy property, corresponding to a density of approximately 1 sampling location per six acres in the Ballfields Parcels. Table 4 summarizes the DDT data for soil samples collected from the Ballfields Parcels. Although the DDT concentrations reported are well below EPA's residential soil preliminary remedial goals (PRGs) for humans, their potential toxicity to ecological wildlife must be determined. It should be noted that the Record of Decision (ROD) developed for the nearby Army property (CH2M Hill, 2003) indicates that fill material for the foundation of the seasonal wetland that is planned for the Ballfields Parcels may contain DDT concentrations in the range of 0.024 and 0.99 ppm. Although material used for the top 3 feet of fill must meet stringent concentration guidelines, materials used for the first 5-7 feet of wetlands foundation are not required to meet such stringent contaminant levels. Regardless of the final design of the seasonal wetlands area, clean fill will be used for the top 3 feet of wetlands cover, but it is certainly possible that soils containing higher concentrations of DDT than are currently found on the Ballfields Parcels could be placed in the area. It is noteworthy that the DDT concentrations that currently exist on the Ballfields Parcels (Table 2-1) are well below 0.99 ppm.

2.2 Predictive Assessment Calculations for DDT

To evaluate potential risks from the complete exposure pathways to ROCs at the Ballfields Parcels that are identified in the SLERA, a dose assessment was performed using the mathematical models described previously in Section 1.2. Dose estimates for DDT were calculated for the ROCs at the Ballfields Parcels using the equations presented in Section 1.2. The dose estimates were calculated using the maximum DDT concentrations detected during: (1) confirmation sampling activities at Spoils Pile N, and (2) Army Corps sampling activities over the entire HAAF property.

The ROC-specific exposure factors and dose estimates for the preliminary assessment of the maximum DDT concentrations detected at Spoils Pile N and throughout the Ballfields Parcels are presented in Tables 2-2 and 2-3, respectively. The exposure parameters used to calculate DDT body burden for the California vole (a mammalian prey item for the harrier and owl) are also included in the tables. Two exposure scenarios were considered for the American Robin; one in which the robin consumes 100% earthworms, and a second exposure model that assumes 50% earthworms and 50% berries. The presence of dense areas of blackberry bushes on the Ballfields Parcels in addition to the fact that a 50:50 ratio of earthworms to berries is more reflective of a robin's actual diet (EPA, 1993) warranted an evaluation of both exposure scenarios.

Table 2-1. DDT Concentrations on Navy Ballfields Parcels

Sample Name	Depth (inches bgs)	Total DDT (ppm)	Region 9 Residential Soil PRG[(a)] (ppm)
SO-86[(b)]	Surface-2	0.0184	1.7
	6-8	0.0112	1.7
	14-16	0.004	1.7
	22-24	0.0008	1.7
SO-87[(b)]	Surface-2	0.0651	1.7
	6-8	0.0075	1.7
	14-16	0.001	1.7
	22-24	0.001	1.7
SO-88[(b)]	Surface-2	0.0398	1.7
	6-8	0.0103	1.7
	14-16	0.0033	1.7
Spoils Pile N[(c)]	Surface	0.088	1.7
	Surface	0.087	1.7

(a) Source: EPA, 2002
(b) Source: USACE, 2003
(c) Source: IT, 2000

For the purpose of the preliminary scoping-level assessment of DDT at the Ballfields Parcels, the DDT TRVs developed by the Navy (DON, 1998) were scaled to account for differences in body weights between the organism used in the studies and the ROCs for the Ballfields Parcels. This was accomplished by using the following equations (Sample and Arenal, 1999), and the results are presented in Table 2-4:

Avian receptors: $TRV_w = TRV_l * (BW_s/BW_r)^{1-1.2}$
Mammalian receptors (raccoon): $TRV_w = TRV_l * (BW_s/BW_r)^{1-1.3}$

where:

TRV_w = weight-adjusted TRV (mg/kg-day)
TRV_l = literature-based TRV (mg/kg-day)
BW_s = body weight of toxicity study receptor (kg)
BW_r = body weight of ecological receptor (kg).

2.3 Results and Conclusions of the DDT Preliminary Assessment

The HQs (Equation 1-7) for DDT were calculated for each ROC using the doses presented in Tables 2-2 and 2-3, and the weight-adjusted TRVs presented in Table 7. HQ results associated with the maximum DDT concentrations detected at Spoils Pile N and throughout the Ballfields Parcels are provided in Tables 2-5 and 2-6, respectively. These tables summarize the calculated dose using the maximum concentration detected, the high and low weight-adjusted TRVs, and high and low HQs for DDT.

Table 2-2. Exposure Parameters and Resulting Doses for DDT at Spoils Pile N

	Maximum C_{soil} in Spoils Pile N (mg/kg)	IR_{soil} [(a)] (kg/day)	C_{vole} [(b)] (kg/day)	BAF[(c)] soil to worm	BAF[(d)] soil to plant	fraction of diet [(e)]	IR_{prey} [(f)] (kg/prey ww/day)	SUF[(g)]	BTF[(h)] (kg plant/kg muscle)	BW[(i)] (kg)	Dose (mg/kg-day)
American Robin (100% worms)	0.088	0.0014	-	0.26	-	1	0.00089	1	-	0.0833	0.0017
American Robin (50% worms)	0.088	0.0014	-	0.26	0.0065	0.5	0.00089	1	-	0.0833	0.0016
Raccoon	0.088	0.0308	-	0.26	0.00358	0.5	1.18	1	-	5.7	0.0029
Northern Harrier	0.088	0.00048	0.000158	-	-	1	0.0707	1	0.0851	0.349	0.00012
Burrowing Owl	0.088	0.0000795	0.000158	-	-	1	0.0117	1	0.0851	0.156	0.00005
Vole	0.088	0.00008		-	0.00117	1	0.019	1	-	0.057	0.000158

(a) Ingestion rate of soil (Beyer et al., 1994).
(b) Concentration of DDT in the vole,
(c) Bioaccumulation of DDT from soil to worm (Beyer and Gish, 1980).
(d) Bioaccumulation of DDT from soil to plant (EPA, 1995) based on water content of plants specific to receptor's diet.
(e) Fraction of diet that is plant or worm (unitless).
(f) Ingestion rate of prey (EPA, 1993).
(g) Site Use Factor, most conservative at 1 (unitless).
(h) Biotransfer rate of DDT from plant to small mammal (Travis and Arms, 1988).
(i) Body weight of receptors: Body weight of receptors: robin and northern harrier (DTSC, 2004); raccoon (EPA, 1993); burrowing owl (Plumpton and Lutz, 1994); vole (Silva and Downing, 1995).
- = Not applicable.

Table 2-3. Exposure Parameters and Resulting Doses for DDT Throughout the Ballfields Parcels

	Maximum C_{soil} in Spoils Pile N (mg/kg)	IR_{soil}[(a)] (kg/day)	C_{vole}[(b)] (kg/day)	BAF[(c)] soil to worm	BAF[(d)] soil to plant	fraction of diet[(e)]	IR_{prey}[(f)] (kg/prey ww/day)	SUF[(g)]	BTF[(h)] (kg plant/kg muscle)	BW[(i)] (kg)	Dose (mg/kg-day)
American Robin (100% worms)	0.0651	0.0014	-	0.26	-	1	0.00089	1	-	0.0833	0.0013
American Robin (50% worms)	0.0651	0.0014	-	0.26	-	0.5	0.00089	1	-	0.0833	0.0012
Raccoon	0.0651	0.0308	-	0.26	0.00358	0.5	1.18	1	-	5.7	0.0021
Northern Harrier	0.0651	0.00048	0.000117	-	-	1	0.0707	1	0.0851	0.349	0.00009
Burrowing Owl	0.0651	0.0000795	0.000117	-	-	1	0.0117	1	0.0851	0.156	0.00003
Vole	0.0651	0.00008			0.00117	1	0.019	1		0.057	0.000117

(a) Ingestion rate of soil (Beyer et al., 1994).
(b) Concentration of DDT in vole.
(c) Bioaccumulation of DDT from soil to worm (Beyer and Gish, 1980).
(d) Bioaccumulation of DDT from soil to plant (EPA, 1995) based on water content of plants specific to receptor's diet.
(e) Fraction of diet that is plant or worm (unitless).
(f) Ingestion rate of prey (EPA, 1993).
(g) Site Use Factor, most conservative at 1 (unitless).
(h) Biotransfer rate of DDT from plant to small mammal (Travis and Arms, 1988).
(i) Body weight of receptors: Body weight of receptors: robin and northern harrier (DTSC, 2004); raccoon (EPA, 1993); burrowing owl (Plumpton and Lutz, 1994); vole (Silva and Downing, 1995).
- = Not applicable.

Table 2-4. Weight-Adjusted TRVs for DDT

Receptor	Diet	TRV[(a)] (high)	TRV[(a)] (low)	BW[(b)] (kg) (BTAG)	BW[(c)] (kg) (Ballfields)	TRV-low (weight adjusted)	TRV-high (weight adjusted
American Robin	100% worm	1.5	0.009	3.5	0.0833	0.0043	0.710
	50% worm	1.5	0.009	3.5	0.0833	0.0043	0.710
Raccoon	50% worm, 50% plant	16	0.8	0.35	5.7	1.85	36.95
Northern harrier	100% mammals	1.5	0.009	3.5	0.349	0.0057	0.946
Burrowing owl	100% mammals	1.5	0.009	3.5	0.156	0.0048	0.8052

(a) High- and Low- TRVs from Navy/BTAG reference values for mammals and birds, DTSC (HERD) 2000
(b) Body weights of animals from literature studies—birds based on brown pelican, scaling factor of 3.5 kg, Anderson et al., 1975; raccoon based on rat, scaling factor of 0.35 kg, Fitzhugh, et al., 1948
(c) Body weight of receptors: Body weight of receptors: robin and northern harrier (DTSC, 2004); raccoon (EPA, 1993); burrowing owl (Plumpton and Lutz, 1994); vole (Silva and Downing, 1995).

Table 2-5. Hazard Quotients for DDT at Spoils Pile N

Receptor	Diet	TRV-low (weight adjusted)	TRV-high (weight adjusted	Dose (mg/kg-day)	HQ (based on TRV-low)	HQ (based on TRV-high)
American Robin	100% worm	0.0043	0.710	0.0017	4.04E-01	2.43E-03
	50% worm	0.0043	0.710	0.0016	3.76E-01	2.26E-03
Raccoon	50% worm, 50% plant	1.85	36.95	0.0029	1.56E-03	7.78E-05
Northern harrier	100% mammals	0.0057	0.946	0.0001	2.18E-02	1.31E-04
Burrowing owl	100% mammals	0.0048	0.8052	0.00005	9.49E-03	5.69E-05

Table 2-6. Hazard Quotients for DDT at the Ballfields Parcels

Receptor	Diet	TRV-low (weight adjusted)	TRV-high (weight adjusted	Dose (mg/kg-day)	HQ_{low} (based on TRV-low)	HQ_{high} (based on TRV-high)
American Robin	100% worm	0.0043	0.710	0.0013	2.99E-01	1.80E-03
	50% worm	0.0043	0.710	0.0012	2.78E-01	1.67E-03
Raccoon	50% worm, 50% plant	1.85	36.95	0.0021	1.15E-03	5.76E-05
Northern harrier	100% mammals	0.0057	0.946	0.00009	1.94E-02	1.16E-04
Burrowing owl	100% mammals	0.0048	0.8052	0.00003	8.41E-03	5.05E-05

The results presented in Tables 2-5 and 2-6 indicate that all of the HQs for all ROCs were less than 1.0, which means that the DDT concentrations detected in soils at the Ballfields Parcels are at concentrations where adverse effects are not likely to occur. These results also indicate that DDT concentrations that exist in soils at the Ballfields Parcels will pose little or no risk to ecological receptors. The HQs for Spoils Pile N based on the low TRVs for all receptors ranged from to 0.002 to 0.40, and based on the high TRVs the HQs ranged from 5.7×10^{-5} to 0.002. The American robin, with a diet of 100% earthworms, had the greatest exposure to DDT at Spoils Pile N, reflected in an $HQ_{low} = 0.40$. Similarly, for the DDT concentrations measured by the Army Corps of Engineers in 2003 from the Ballfields Parcels area, the HQs based on the low TRVs ranged from 0.0015 to 0.30, and the HQs based on the high TRVs ranged from 5.1×10^{-5} to 0.002. These results indicate that DDT concentrations present in site soils do not pose a significant risk to ecological receptors at the Ballfields Parcels and do not warrant additional sampling for DDT. Note that current sampling design does include one additional DDT sampling location in the area of a former revetment spoils pile that has not been investigated for DDT in the past (see SAP, Appendix A of the work plan). After this data has been collected, the DDT concentration will be compared to those evaluated in this preliminary assessment to ensure no significant risk exists for ecological receptors at the Ballfields Parcels.

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